ARTICLES BY F. L. Browne

ON PAINT SUBJECTS

CLIPPED FROM TRADE MAGAZINES

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1925 TO 1960

CLIPPINGS AND REPRINTS OF ARTICLES ON
PAINT SUBJECTS BY F. L. Browne FROM TRADE MAGAZINES

1. The Role of Paint & Varnish in Wood Conservation, AMERICAN PAINT JOURNAL Aug. 1925
2. How Protective Coatings Retard Moisture Changes in Wood, YATES-AMERICAN QUALITY
3. How to Prevent Decay When Building of Wood, BUILDINGS CONSTRUCTION & MAINTENANCE 1926
4. Woof Finishing - A Glance Ahead, MECHANICAL ENGINEERING, Mid-November 1926
5. Why Wooden Buildings Need Paint Protection, FACTORY, October 1927
6. Principles for Testing Paint on Wood, HARDWARE DEALERS MAGAZINE November 1927
7. Some Causes of Blistering and Peeling of Paint on House Siding, AMERICAN PAINT & VARNISH MFRS. ASSOC., Circ. 317, October 1927
8. Why Some Wood Surfaces Hold Paint Longer Than Others, LEAFLET 62 U.S.D.A. 1930
9. How Properties of Wood Determine the Service Given by Exterior Paint Coatings, AMERICAN PAINT JOURNAL April 7, 1930
10. Developments in the Stabilization of Painting Practice for Wood, TRANSACTIONS AMERICAN SOCIETY OF MECHANICAL ENGINEERS, September 1931
11. Painting of Wood, SOUTHERN CYPRESS MANUFACTURERS' ASSOC., 1931
12. News item, WISCONSIN STATE JOURNAL, February 22, 1931
13. Priming Coat Reductions for Painting New Wood Surfaces, AMER. PAINT & VARN. MFRS. Circ. 445, OIL PAINT & DRUG REPTR., PAINT OIL & CHEM. REV. Nov. 1933
14. Painting Characteristics of Wood, LECTURE TO NEW ENGLAND PAINT & VARNISH PRODUCTION CLUB, 1933
15. Testing House Paints for Durability, JOUR. CHEMICAL EDUCATION September 1933
16. Durability of Paint on Longleaf & Shortleaf Pine, SOUTHERN LUMBERMAN February 1933
17. Painting Exterior Woodwork, PACIFIC PURCHASER February 1934
18. Priming-Coat Reductions for Paintid New Wood Surfaces, AMER. PAINT JOUR. Dec. 1934
19. Durability of Paint on Wood Treated with Zinc Chloride, AMER. WOOD-PRESERVERS ASSOC. 1934
20. A Trouble-Shooter's View of the Gamble in House Paint, PAINT OIL & CHEM. REV. Oct. 1935
21 Don't Let Faulty Painting Jobs Steal Public Confidence!, CANADIAN PAINT & VARNISH MAGAZINE September 1935
22 Stingy Paint Application Often a Danger, NATIONAL PAINTERS MAGAZINE August 1935
23. Repainting Old, Paint-Thursty Surfaces, PAINT OIL & CHEMICAL REVIEW May 1935
24. Repainting Paint-Neglected Frame Houses, NATIONAL PAINTERS MAGAZINE Apr.-June 1935
25. The Preservative Treatment and Staining of Shingles, WISCONSIN CARPENTER AND BUILDER (date ?)
26. How Painters Can Prevent Painting Complaints, NATIONAL PAINTERS MAG. March-June 1936
27. Painting and Finishing Wood, WOOD HANDBOOK OF FOREST PRODUCTS LABTY. (about 1936?)
28. Some Interesting Facts About Paint Complaints, PACIFIC RETAIL LUMBERMAN Vol. IV, No. 1
29. Buy House Paint for a Planned Maintenance Program, PACIFIC PURCHASER February 1937
30. Painting Problems - What are They Today, RAILWAY ENGINEERING & MAINTENANCE Feb. 1937
31. Have you a Paint Maintenance Program?, THE AMERICAN HOME April 1937
32. The Fading of Painted Surfaces, RAILWAY ENGINEERING & MAINTENANCE September 1937
33. The Effect of Climatic Differences on the Behavior of House Paint, PACIFIC PURCHASER February 1938
34. Wood and Paint, THE DECORATOR (London) March 1938
35. Classification of House Paints as a Guide to the Study of Formulation, DRUGS, OILS AND PAINTS March 1938
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37. When and How to Paint Homes and Farm Building, WISCONSIN CARPENTER & BUILDER 1948
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47. Painters From Your Paint Farm, SUCCESSFUL FARMING Sept. 1946
48 Wood Properties and Paint Durability, U.S.E.A. MISCELLANEOUS PUBLICATION 629
49. Painting the Barn, HOARD'S DAIRYMAN July 1948
50. FORMAN FORD AND CO. ANNOUNCES GRADE 1 HOUSE AND BARN PAINTS, from THE MISSISSIPPI VALLEY LUMBERMAN January 1949
51. A Standard of Quality for Paint, BUILDINGS AND BUILDING MANAGEMENT Mar. 1949 also in WESTERN BUILDING March 1949
52. House Paint and Outdoor Furniture, WOOD WORKING DIGEST April 1949
53. How to Use Natural Wood Finishes, NATIONAL REAL ESTATE AND BUILDING JOURNAL November 1951
54. Natural Finishes for Exterior Wood, ARCHITECTURAL RECORD February 1952
55. FPL Studies Natural Finishes, WISCONSIN STATE JOURNAL September 26, 1952
56. Wood Siding Left to Weather Naturally, ARCHITECTURAL RECORD Nov. 1952
57. Selection of Durable Exterior White House Paint, HOUSING RESEARCH Mar. 1953
58. Tests Prove Painting Too Often May Cause Trouble, WISCONSIN STATE JOURNAL March 7, 1954
59. Clear Finishes for Exteriors of Houses, AMERICAN PAINT JOURNAL May 1954
60. Wood Siding, How to Install It, Paint It, Care for It, U.S.D.A. HOME AND GARDEN BULLETIN NO. 52 1956
61. Wood Siding Left to Weather Naturally, SOUTHERN LUMBERMAN December 1960

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THE ROLE
OF
PAINT and VARNISH
IN
WOOD CONSERVATION

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Madison, Wisconsin

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The Role of Paint and Varnish in Wood Conservation

By Dr. F. L. Browne

U. S. Forest Products Laboratory, Madison, Wis.

NOTE:—This is an abstract of an address given at a meeting of the Paint and Varnish Superintendents' Club of Louisville, Ky., on April 28, 1925.

Inasmuch as we are cutting timber in the United States 4 1-3 times as rapidly as it is growing, it will be realized at once that as wood users we are all vitally interested in any means of reducing our demands upon the forests by making wood last longer in service. It is pretty generally understood that paint and varnish have an indispensable part to play in prolonging the useful life of wood, but it is not always understood clearly how and why they do so. The manufacturer can at the same time extend the use of paint and varnish and help in the program of conservation if he will base his advertising upon an accurate conception of the nature of wood, the factors causing its deterioration in service, and the means of combating those influences successfully.

In itself, wood is as durable as almost any other organic material, but it is subject to attack by two powerful enemies. One is a foreign aggressor, the wood-destroying fungi which are responsible for decay; the other is internal dissension, represented by the weathering of the wood as a result of unequal swelling and shrinking on exposure to periodical changes in moisture conditions.

The decay and the weathering of wood differ from each other fundamentally, are not usually encountered in the same places, and must be combatted by entirely different methods.

It is essential to distinguish between them clearly, and to do so we must take into account the nature and certain of the properties of wood.

The Structure and Chemical Properties of Wood

Figure 1 is a greatly enlarged picture of a small piece of a softwood, let us say one of the pines. The whole width (TT) is less than ¼ inch. The vertical dimension is taken parallel to the axis of the log, and the direction (AR) lies along a radius. The top surface is the end grain, the left-hand face is the edge grain, and the right-hand face is the flat grain.

The wood is made up very largely of long tubes composed of cellulose and lignin, most of which lie along the grain but some of which run radially. The fibers are held together by a cementing material and communicate with each other through minute circular membranes or pits. The fibrous structure governs the movement of sap in the living tree and has a great deal to do with the way in which the wood dries out or absorbs water again.

The important properties of wood are consequences of its peculiar structure and of the nature of lignin and cellulose. The celluloses are colloidal materials closely related to the starches and water-soluble gums. A general characteristic of the gums is that they swell in water and then dissolve. The starches swell in cold water and dissolve at least in part, on boiling. It is not at all surprising, therefore, that the lignocellulose of wood has a powerful attraction for water and swells considerably as it absorbs it, although it is quite insoluble in either hot or cold water.

Cellulose and lignin are very resistant to chemical action, yielding only to powerful reagents or to the enzimes secreted by certain living organisms. At ordinary temperatures they are not oxidized except by such strong chemicals as chlorine or concentrated nitric or sulphuric acid. Even the energetic treatment of the chemical processes for making paper pulps seems to leave the greater portion of the cellulose unaffected.

Wood and Moisture

From the practical standpoint, the behavior of wood in relation to moisture is of dominant importance. Water may be held in two different ways. **Hygroscopic moisture** is taken up by the wood substance itself in the same manner as by starch or glue. After the wood substance has become saturated, **free water** may fill up the cavities in the wood structure. Changes in the content of hygroscopic moisture result in swelling and shrinking. Changes in the amount of free water do not, except under certain unusual conditions.

Hygroscopic moisture can be absorbed by wood through contact with water, moist air, or other moist materials such as the soil. It penetrates the wood chiefly by diffusion through the wood substance itself, just as it moves through a glue jelly. Free water may be taken up and may move through the wood by capillary action of the fibrous structure. Through exposed end-grain surfaces wood absorbs moisture or dries out relatively rapidly, but the corresponding effects through exposed edge grain or flat-grain surfaces are astonishingly slow, despite the porous structure of wood. Even if one face of a board is kept wet, many days will pass before the moisture is evenly distributed through the wood. In swelling, wood expands to different extents in the three directions. It changes very little along

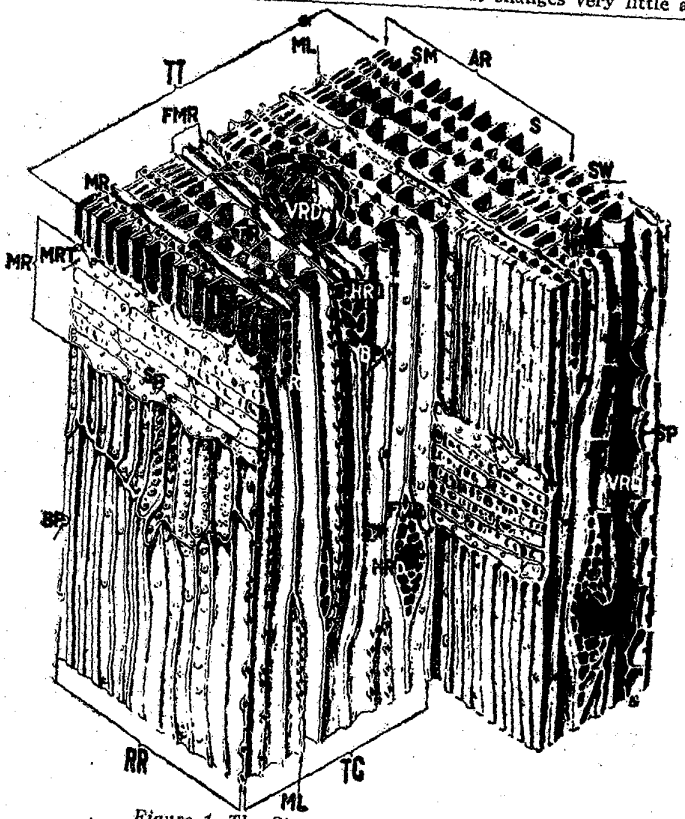

Figure 1. The Structure of a Softwood.

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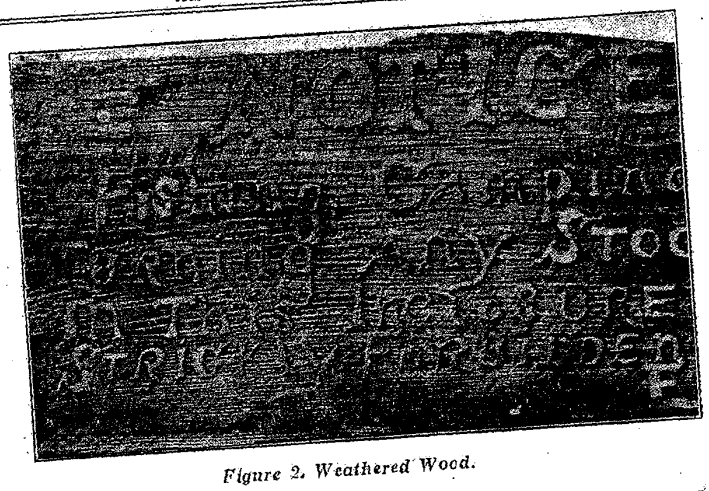

Figure 2. Weathered Wood.

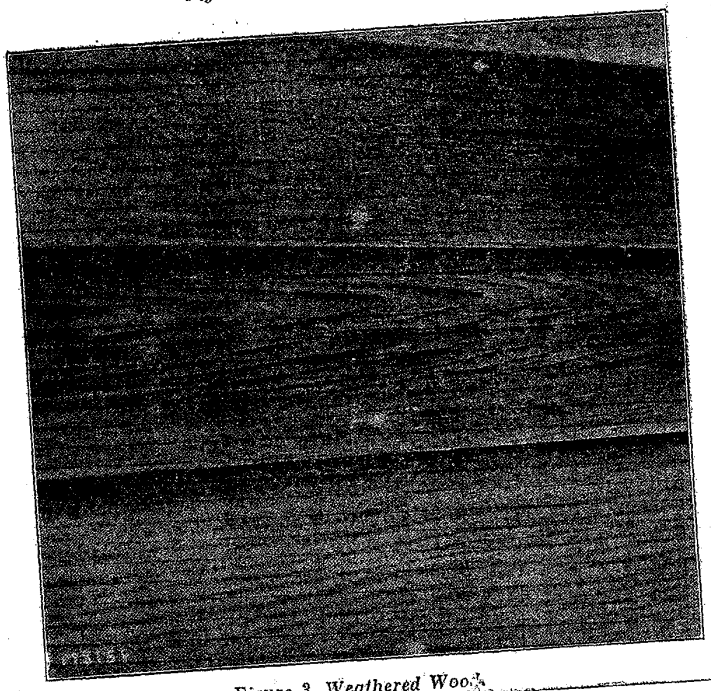

Figure 3. Weathered Wood.

the grain. Across the grain it swells perhaps twice as much tangentially as radially.

Paint and the Weathering of Wood

Figure 2 is an example of the deterioration of inadequately painted wood from exposure to the elements. Careful examination under the microscope shows that decay, that is, the activity of fungi, is not responsible for the condition. The wood has weathered. In Figures 3 and 4, is seen the weathering of house siding on which the paint coating has not been renewed after wearing out. The original smooth, straight surfaces have become rough, as the "grain raises," the wood checked and the checks grew to large cracks; in some places the "grain loosened;" the boards cupped, warped, and pulled away from their nail fastenings; the rough surface has gathered dirt a
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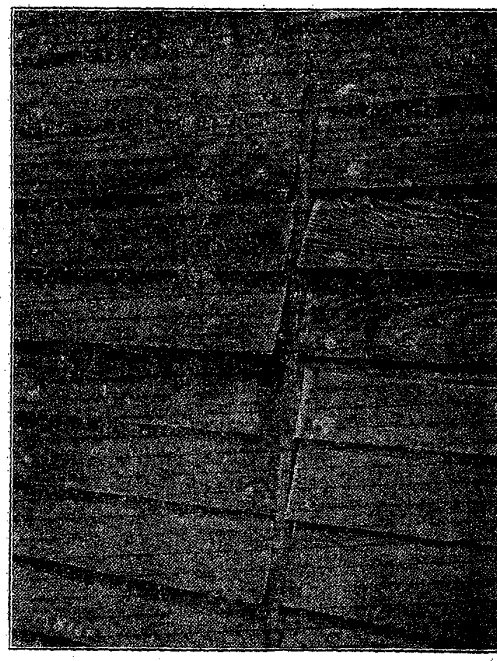

Figure 4. Weathered Wood.

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the interior remains relatively constant sets up large internal stresses which give rise to weathering.

Minor parts in the weathering of wood may be played by mechanical abrasion by wind blown dust and sand and possibly by hydrolysis of the wood, but the outstanding cause of the disintegration is the physical effect of changing moisture content.

The usual cure for weathering is, of course, paint or varnish. Such coatings retard the absorption of water and the drying out of the wood to such an extent that large inequalities of moisture content within the lumber are avoided. Where wood is exposed freely to the atmosphere so

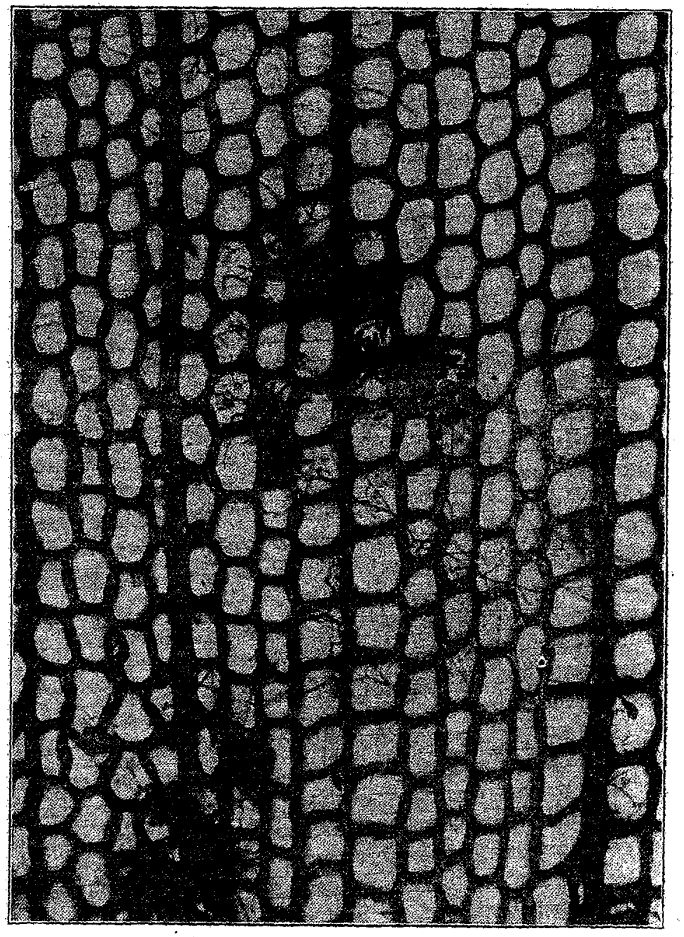

Figure 5. Wood Destroying Fungus in Wood.

that it obtains water only from the elements, a paint coating keeps the moisture content relatively constant; but where wood is exposed to water or damp air continuously for relatively long periods, a paint coating cannot be expected to keep it dry.

Figure 6. Wood Destroying Fungus in Wood.

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Decay in Wood

Decay in wood is brought about by the action of living plants of a low order known as fungi. The wood rots because these fungi feed upon the cell walls and destroy the wood structure. It is believed that no agency other than a fungus is capable of causing the decay of wood in any marked degree. On the other hand, not all fungi can live in wood, and not all of those that can do so are capable of rotting it. Some fungi occur in wood but live only on the extractive substances, or cell contents in general, leaving the ligno-cellulose unaffected. The blue stain in lumber is produced by such fungi. The wood-destroying fungi, on the other hand, live on the wood substance itself.

Figures 5 and 6 are enlarged photographs showing wood-destroying fungi at work. The fungi appear as slender threads or hyphae, spoken of collectively as the mycelium. Figure 5 shows clearly how the hyphae pierce the cell walls and run from cell to cell. The dark spots are masses of these threads. Figure 6 shows very clearly the holes made in the cell walls by the action of the fungus.

A piece of wood may become infected with decay either by extension of the fungus mycelium from decayed wood with which it has been in contact or by means of the spores of the fungus. Spores which are analogous to the seeds of flowering plants, are produced by the fungus for purposes of reproduction. They are very small, and extraordinarily numerous and wide-spread. They are carried about in a number of ways, principally by the wind.

Wood is exposed to infection by fungus spores or mycelium at nearly all stages in its history. Infection may take place in the living tree, in the log after felling, in the lumber during seasoning, in the stacks in the retailer's yard, in the siding during erection, and during subsequent service. Under the circumstances the chances are heavily in favor of every piece of lumber having some or many spores of wood-destroying fungi upon

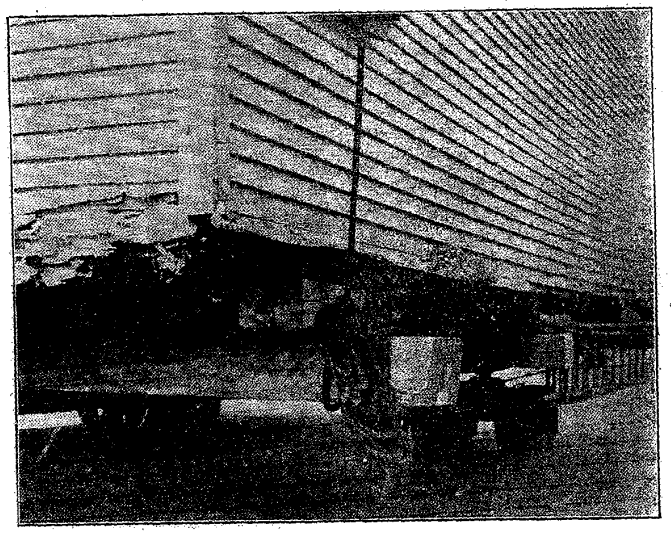

Figure 7. Decay Due to Contact with Ground.

it before it is placed in its final position and painted. Decay may in fact already have started. In the practical sense, therefore, decay is not to be regarded as a surface action like the corrosion of iron or the weathering of wood, but as a condition within the wood brought about by the growth of a plant and occurring whenever the conditions favor that growth.

Conditions Favorable for Decay

Why, then, does not house siding decay more generally? The answer is that as a rule house conditions are unfavorable to fungous growth. The factors essential to the development of decay are four: Temperature, air, food, and moisture. It will be obvious that for most practical purposes the conditions which determine the moisture content of wood in service determine likewise its liability to decay. The air supply is almost always sufficient, the temperature is usually favorable to the fungus, at least during a very large portion of the year, the wood itself is a suitable food, and there remains only the item of moisture content to complete the conditions favorable for decay.

Now we know from practical observation in the various parts of the United States that lumber which is so placed that the air may circulate about it freely and which is not exposed to moisture except when the rain is falling does not ordinarily decay. But if it is placed where it is continually in contact with some source of moisture, so that it is not given an opportunity to dry out after it has once

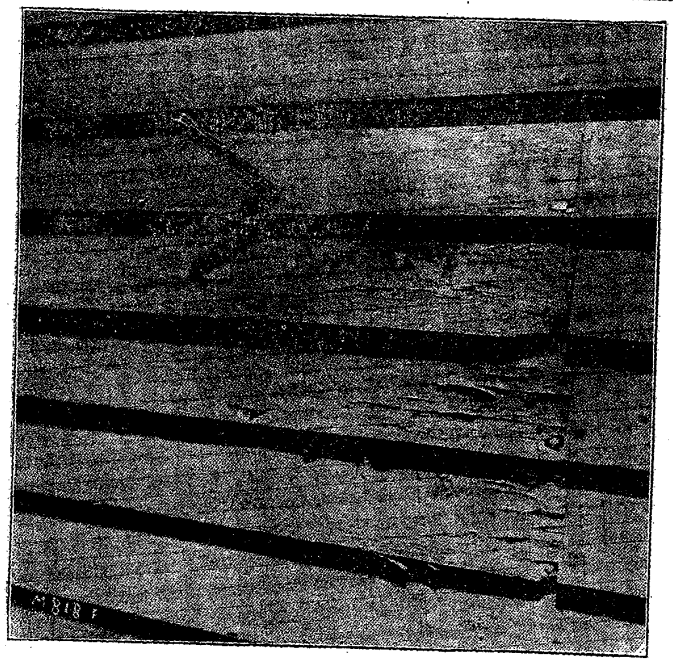

Figure 8. Decay Due to Unprotected Butt Joints in Siding and Lack of Ventilation Underneath a Porch Floor.

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become damp, decay will eventually set in. Thus house siding and shingles do not ordinarily rot, but wood that is resting upon or partly buried in the ground is very likely to do so. Decay must be guarded against in fence posts, railroad cross-ties, mine timbers, and the like.

In those regions of the South where houses are built directly upon pillar foundations without cellars, care is generally taken to provide ample ventilation under the floor in order to give the wood a chance to dry out after periods of rain. If this is not done the wood will retain moisture long enough to begin rotting.

Another place where decay is occasionally observed in ordinary house construction is in outside window sash, especially of the lower window. Here rain water sometimes works its way between the sash and the sill and does not dry out again as quickly as could be desired.

Paint Versus Decay

Paint is not itself toxic to fungi; in fact, a few fungi can even use it as a food. It is essentially a surface coating which penetrates wood very slightly. Even if a coating entirely impervious to the fungus spores were constantly maintained over the surface of the wood, the infection is almost certainly present in the wood to begin with. The influence of a paint or varnish coating on decay is again, therefore, a question of moisture content. The influence of the coating on moisture changes in the wood has already been discussed in connection with weathering, but there the chief

Figure 9. Decay Due to Moisture Seeping Under Column.

interest lay in the moisture gradients between the surface and interior portions of the wood. Here we are concerned with the average moisture content of the wood as a whole.

Figure 7 shows the decay of a house sill that was laid directly upon the ground. Moisture entered the wood from the ground and could dry out only by passing through the house siding, which was painted. The influence of the paint in retarding evaporation was probably a minor factor in decay, but any effect of the coating in this respect was a point in favor of the fungus. Infection of the wood may have occurred before erection, but if not it may have entered from the ground. The sill at the front of the house was several feet above the ground and was sound when this picture was taken.

Figure 8 shows the comparatively rare case of house siding failing from decay. Here again
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Figure 10. Decay Due to Moisture from Leaking Do

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decay was the result.

In so far as the paint coating retards the absorption of rain water and dampness by wood in structures it tends to keep the moisture content of the wood below the point necessary for the development of decay. But many structural conditions are likely to occur in which water can obtain access to the wood through parts which are not painted. In many cases the subsequent drying out of the wood can take place only through the exposed painted surfaces, and the paint coating tends to keep the moisture content high and thus favors decay. It would frequently help matters if some of the concealed surfaces subject to contact with rain water were painted during erection, but end-grain wood is difficult to paint, and the labor factor must always be taken into account. Repainting of such places is usually impossible. It would probably be found more practical to improve the methods of construction in such a way as to avoid crevices and pockets likely to retain rain water and, where they cannot be avoided altogether, to try to provide for quick re-evaporation.

In the program for the conservation of our timber supply, paint and varnish provide the most effective antidote for weathering. Unfortunately a great many people still fail to realize the true economy of keeping buildings well protected with paint and varnish; in fact, in certain sections of the country, a very large proportion of the less pretentious dwellings are not painted even when new, presumably from a mistaken idea of money saving. There is need for further educational work to encourage better practice.

On the other hand, someone is occasionally found trying to use paint to save a non-durable wood employed in a place where conditions make decay almost a certainty. This is unfortunate from the standpoint of both the paint manufacturer and the conservationist, because when disaster results the disappointed user is likely to discount the value of paint as a protection for wood, forgetting that when employed in its proper field as a protection against weathering it is remarkably effective and adds very materially to the service life of lumber.

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Yates - American Quality

2

How Protective Coatings Retard Moisture Changes in Wood

By F. L. Browne

"The structure of wood is largely fibrous. Free water or moisture in the wood is probably located between the fibers. This water forces the fibers apart. As the water dries out, the fibers come closer together, producing contraction (shrinking)."

SO WRITES a prominent chemist, giving concrete expression to a widespread popular misconception of the relation between change in moisture content and swelling or shrinking of wood. Persons holding that theory usually think of wood as a "porous" material, much like a sponge, with the water moving in and out through the cavities. If the "pores" of dry wood are filled with some such substance as paraffin or linseed oil, they believe that moisture movement and consequently swelling or shrinking can be completely prevented.

So deeply rooted is this ancient craftsman's tradition that a mere technical man criticises it with a good deal of diffidence. Yet it is clearly in contradiction to easily demonstrable facts of everyday experience, and it proves misleading when practical means for minimizing the swelling and shrinking of wood are being sought. For the truth is that the moisture responsible for the "working" of wood is not at all the *free water* held in cavities visible under the microscope and that mere plugging of such openings with oils or waxes does not suffice to prevent either moisture absorption or swelling of dry wood.

Water is held in green wood in two different ways. As an illustration, let us suppose that we have a board weighing two pounds of which one pound is "bone dry" wood and one pound is water. Of that one pound of water something like 73 per cent exists as *free water* partly filling cavities in the wood which can be made visible by putting the wood under a powerful microscope. During the proper kiln drying or air seasoning of the board, the free moisture is removed without change in its dimensions. At a certain stage of the drying known as the fiber saturation point, the wood cavities are empty of free water, but the board still contains perhaps .27 pound of *hygroscopic moisture* held, not in "pores," but in intimate association with the wood substance itself—dissolved in the lignin and cellulose, if you please.

There is nothing mysterious about the hygroscopic moisture of wood. Other common substances behave quite similarly. Take bread, for example. Fresh bread contains hygroscopic moisture so necessary that we use waxed wrapping paper to conserve it in the loaf. Stale bread or hard toast is more nearly bone dry, is shrunken, and has different physical properties. But it is readily observable that the moisture in a slice of fresh bread is not free water in the cavities. Fill the cavities by dipping the bread in water and soggy bread is obtained.

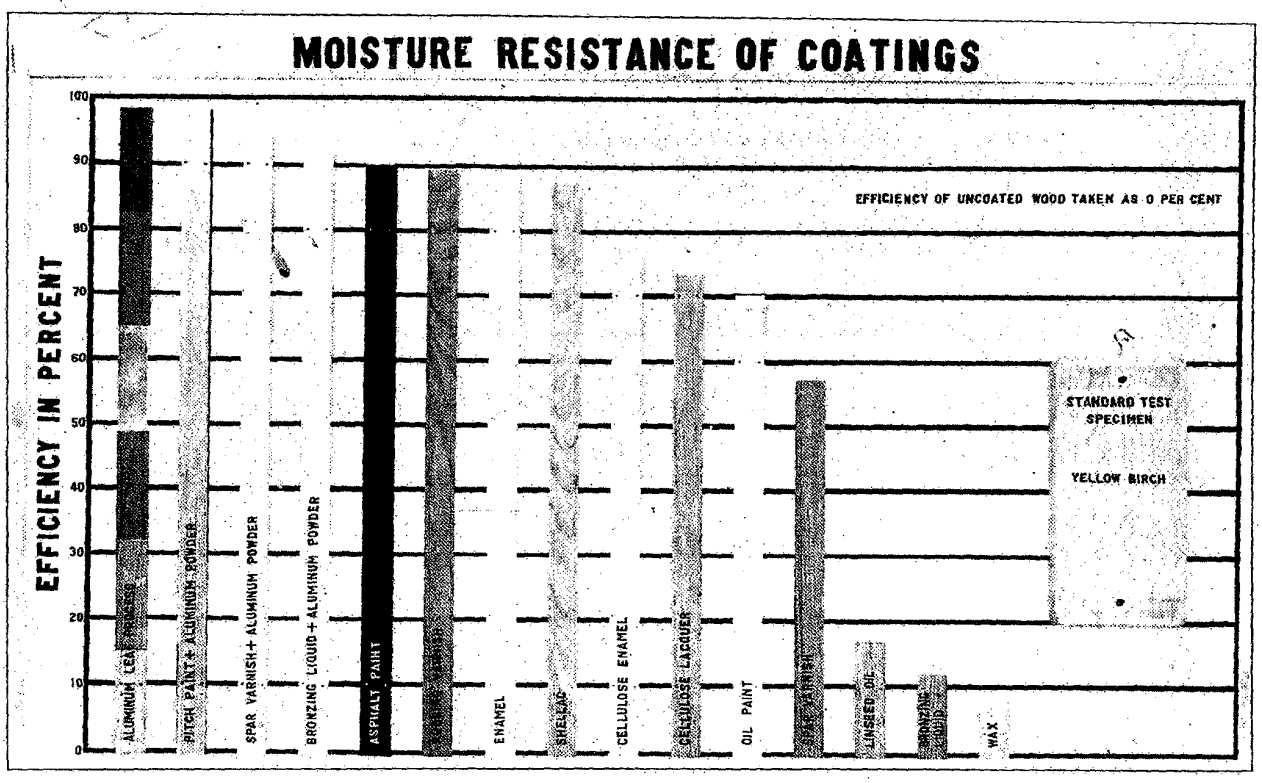
As our board passes the fiber saturation point during drying, it begins to shrink, and shrinkage continues as long as hygroscopic moisture is being removed. In commercial practice it is not usually desirable to remove all the moisture, so that "dry" wood still contains a considerable and a variable amount of hygroscopic moisture. Such necessarily must be the case, because interchange of moisture takes place between wood and the air with which it is in contact unless the wood happens to have that particular moisture content which is in equilibrium with the prevailing humidity and temperature of the air. In general the humidity and air temperature constantly are changing, however, and the moisture content of the wood tries to keep in step. For that reason wood in service is usually subject to a certain amount of variation in moisture content from time to time and hence "works." Fortunately the "working" is small enough so that it proves troublesome only in special uses of wood where the dimensions must be held constant to a high degree of precision.

The way to stop the shrinking and swelling of wood is to interpose between the wood and the air a continuous film of impermeable substance. Filling the wood cavities with oil or wax will not suffice if the wood substance itself is still in contact with air, because hygroscopic moisture can move through the wood substance and does not need to enter through "pores." Protective coatings rather than impregnation treatments should therefore prove the best means of retarding moisture changes.

Practice in fact confirms that conclusion. Wood which has been thoroughly impregnated with paraffin, but with the surfaces wiped clean after treatment, still absorbs moisture from damp air only slightly less rapidly than does the untreated wood. But if, instead of impregnating, a substantial coating of paraffin is applied to all surfaces of the wood, moisture is taken up only slowly. Similar results are obtained with oils. Treatments with non-drying oils or mere impregnation with linseed oil are comparatively ineffective, but as soon as a substantial coating of drying oil is obtained, the rate of absorption of moisture is materially retarded.

The U. S. Forest Products Laboratory for a number of years has been studying the effectiveness of protective coatings in retarding the absorption of hygroscopic moisture by wood. Their method of testing is as follows: Birch test panels are prepared and seasoned in a room at 60 per cent relative humidity and 80 degrees Fahrenheit. Some of the panels then are coated *on all surfaces* with the paints or varnishes being studied. Others are left uncoated. The panels are next weighed and placed in a chamber at 95 to 100 per cent relative humidity and 80 degrees Fahrenheit for two weeks, after which they are weighed again. The coated panels absorb less moisture than the uncoated ones, the difference being the amount of moisture excluded by presence of the coating. This difference, divided by the absorption by the uncoated panels, with the quotient expressed in percentage, is a measure of the effectiveness of the coating and is defined as its "efficiency."

The accompanying illustration gives the efficiencies of several types of protective coatings. The results are at



variance with some other time-honored traditions of the paint trade. Linseed oil, for example, is much less resistant to the passage of moisture than is commonly supposed. A long-oil spar varnish is much more effective, and a short-oil rubbing varnish is very efficient. To be sure, rubbing varnish is suitable only for indoor use because it does not last long out of doors. (It should be noted that the data refer to the moisture excluding efficiency of the coatings only and tell nothing whatever about their durability.) Evidently the resin component of the varnish rather than the oil is the effective constituent in excluding moisture. In line with that conclusion we find that shellac, the film of which consists entirely of resin and wax, is very efficient. So are asphalt and pitch paints. It is noteworthy also that the gums present in cellulose lacquers are more important in preventing moisture movement than is the nitrocellulose, because bronzing liquid, which is nitrocellulose solution alone, is somewhat less efficient than linseed oil.

The addition of mineral pigments to clear vehicles adds greatly to the moisture-excluding efficiency of the coatings. Compare oil paint with linseed oil, enamel with spar varnish, and cellulose enamel with cellulose lacquer. Aluminum powder used as a paint pigment is especially remarkable and gives coatings in several types of vehicle which are more effective than any of the more common paints and varnishes. The reason probably lies in the peculiar property aluminum powder has in the "leafing out" of paint liquids, so that it forms a more or less continuous metallic coating over the wood, much like the scales on a fish. When aluminum leaf is glued over the wood, using varnish for the glue, the nearest approach to complete exclusion of moisture so far discovered is attained.

Government Reports Now Available Gives The Advantages and Uses of End-Matched Soft Wood

The Subcommittee of the National Committee on Wood Utilization has prepared a report on the uses and advantages of End-Matched Soft Wood Lumber. Readers of this magazine will no doubt be interested to know that this report is now available in pamphlet form to anyone requesting it.

The need for conservation in the preparing of wood products for market is being impressed, more and more every day, upon the general public and especially manufacturers. End-matching of soft wood lumber is a great forward step in this direction and the government, in an effort to further this practice, is making exhausting researches. These researches cover every possible phase of the practice from the manufacture to the nailing of the end-matched lumber in the home or office. Upon the committee making these investigations are some of the most prominent men in woodworking manufacture, in architecture and in building associations.

Their report, now ready for distribution, covers a description of the end-matched process, the strength factor of the end-matched joints, the many uses for end-matched lumber, its advantages to the consumer, the distributor and the manufacturer and end-matched lumber as a potential export item.

This report should be interesting and particularly valuable to every one engaged in lumber manufacture. It may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. The price is five cents per copy.

Factory The Magazine of Management May 1926 (3)

BUILDINGS
Construction *and* Maintenance
For the manager who looks ahead to "that ideal plant" and the manager on the alert for improvements in present facilities

How to Prevent Decay When Building of Wood

By F. L. BROWNE
U. S. FOREST PRODUCTS LABORATORY, MADISON, WISCONSIN

WEATHERING, in itself, is enough to ruin a structure. It is the inevitable result of denying wooden structures adequate protection by paint.

It is not sufficient to apply a coat of bright paint when the structure is first erected. In time the paint wears away until it no longer shields the surface of the wood from the rapid fluctuations in moisture content caused by atmospheric changes. After that, general dilapidation is not long in coming. First the wood roughens. Then it checks and cracks, while warping and cupping set in, and boards begin to pull away from their nail fastenings.

The wind takes a strong hand in the work of destruction, and a way is opened in the once weather-tight structure for rain-water to obtain access to recesses from which it cannot easily evaporate. Eventually the accumulation of moisture in such a manner may supply the dampness necessary to start a fungus colony, thus exposing the building to its second enemy, rot. This whole cycle can be forestalled by the prevention of weathering – that is, by the simple expedient of applying paint to the exposed and readily accessible surfaces and renewing the coatings as they wear out.

END-GRAIN EXPOSURE

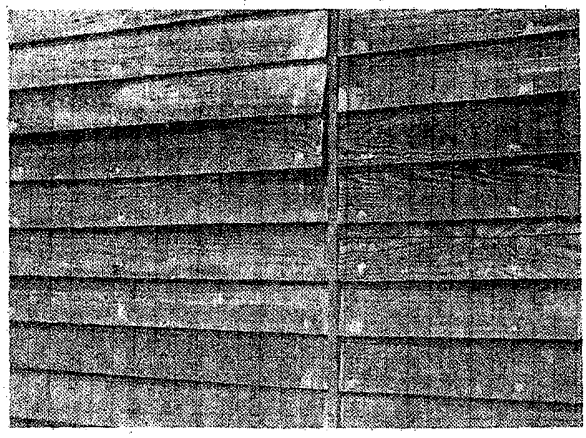
Though kept painted, this post decayed because moisture had easy access through the end-grain.

Decay, or rot, except in cases of long-continued neglect, is usually the result of unsuitable design of the structure. When discovered in wood in service, it may be difficult, if not impossible, to arrest without making serious alterations. It lurks in dark corners, at low, damp levels, and in concealed spaces. The most effective steps against decay must be taken during or even before the erection of the building. Wood rots only if it is kept at a moisture content favorable to fungus growth for relatively long periods. When subjected merely to alternate wetting and drying by direct exposure to weather conditions in the United States, wood does not usually become moist enough or remain so long enough to harbor wood-rotting fungi.

When rot is found in frame construction, some such factors as the following can be found responsible for keeping the wood in contact with moisture for abnormally long periods:

IDEAL CONDITIONS FOR DECAY

Moisture from the downspout is causing the decay of this wooden sill, which rests on the damp ground. The decay is spreading into the painted woodwork above.



DILAPIDATION THROUGH WEATHERING

On this siding, where the paint has worn away, checking, splitting, and warping are at work, and boards are beginning to pull away from their nail fastenings.

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1. Stringers or sills are laid directly upon the ground.

2. Although the stringers or sills may be raised a certain distance above the ground, the space between the floor and the ground is enclosed by brick or masonry, without allowing enough opening to provide thorough ventilation.

3. Although raised above the ground, with ample ventilation provided underneath, the sills and joists are supported on wooden piles or posts in contact with the ground. Under these conditions dry-rot fungi may start in the piles and may proceed through the sills and joists into the rest of the structure. Dry-rot fungi possess their own method of conducting the water necessary for their activities.

4. Leaky plumbing or downspouts or sweating water pipes keep the wood in contact with water for long periods. This is especially disastrous if the water reaches the wood through concealed surfaces and, to escape, must pass through the board to evaporate from painted surfaces.

5. Construction is such as to afford crevices into which rain-water can work its way and be retained in portions of the wood far from surfaces from which evaporation can take place. Window sills and bottom rails of sash, when made of sap-wood, occasionally rot. Posts or columns of non-durable woods or containing much sap-wood are quite likely to decay because the water working its way underneath is drawn up very readily from end-grain surfaces.

6. The building is used for manufacturing purposes of such a nature that the air within is saturated with moisture all or most of the time. Near the roof and outside walls, where condensation may result through cooling by outside temperatures, decay is especially likely to be encountered.

Protective measures against decay in wooden structures, in the order of their desirability, include:

1. Avoiding the use of wood as far as possible in places where it may be exposed to moisture continuously or for fairly long periods.

2. Providing ample ventilation in air spaces enclosed by wooden walls in which the air would otherwise be damp and stagnant.

3. Designing all joints and junctions between wooden pieces in such a way that there will be no possibility of rain-water working into crevices and being "pocketed," especially where water will come into contact with end-grain wood.

4. Selecting only the heart-wood of durable species for use in cases where provisions 1, 2, and 3 cannot be met.

5. Preserving the wood against decay by treatment, preferably by impregnation, with a material poisonous to fungi, such as coal-tar creosote, zinc chloride, or sodium fluoride.

From the practical point of view, paint and varnish cannot be considered preservatives for wood against decay.* In the first place, it is not customary and would generally be impracticable to keep paint on the hidden surfaces of wood likely to be continuously in contact with ground moisture or seepage. In the second place, such coatings merely retard the absorption of moisture and do not prevent it; so that wood, even though painted, if exposed constantly to dampness, will become moist enough to decay. In the third place, assuming that a coat of paint is an absolute safeguard against fungus infection (which experiments seem to show is not the case), wood during its long journey from forest to sawmill, to lumber-yard, and finally into construction, has been exposed to infection so constantly that spores are bound to be present on all surfaces, and decay is a certainty once conditions become favorable to fungus development.

*What About "Save the Surface and You Save All"?

So general has been the acceptance of the role of paint and varnish in preventing the deterioration of wood, as well as of other surfaces, that Dr. Browne's distinction between weathering and decay and his statement as to the limitations of paint in preventing the latter, may come as a surprise to many readers of FACTORY.

Dr. H. A. Gardner, Director of the Institute of Paint and Varnish Research, takes the position that "to the average reader the word decay connotes the passing of a material from a sound or perfect state to weakness or dissolution—the roughening and the raising of the grain, the checking of the surface, the splintering, and other obvious signs of decay in lumber; the corrosion of metal; the disintegration of the surface of cement; and similar defects. It is generally admitted that paint will prevent these defects and therefore it is called a preservative agent or an agent against decay. Therefore the slogan 'Save the Surface and You Save All.'"

In that phase of "decay" which Dr. Browne terms "weathering," he gives paint full credit. His article does not by any means belittle the supreme importance of paint as a protective agent in its rightful place.

It does point out that with wooden structures, the correct form of construction and protection against moisture should accompany any sound program of preservation by paint.

THE EDITORS

Mechanical Engineering Vol. 48 No. 11a Mid-November 1926
also Railway Mechanical Engineer May 1927
(4)

Wood Finishing—A Glance Ahead

Wood Finishing as an Art, a Science, and a Branch of Engineering—Technical Knowledge of Wood the Foundation of Wood-Finishing Engineering—Need for Methods of Measuring Service Value of Finishes

By F. L. Browne,[1] Madison, Wis.

From time immemorial the prophet has been granted a certain license in speculation, a certain freedom from the constraint of hard-and-fast detail, in order that the essential accuracy of his general forecast may not be too greatly obscured by petty discrepancies in particulars. Sufficient if the seer can predict the victor in the battle without setting forth in full the ebb and flow of the action; or, to change the simile, if he can foretell the direction of movement of the market during the next month without specifying, say, for the top quotation on Steel Common. In assuming the robe of soothsayer with respect to the future of wood finishing, then, the author bespeaks the traditional indulgence with regard to specific details in the hope that a consideration of general principles will be of interest and value at this time when wood-finishing practices are being subjected to critical scrutiny.

That wood-finishing methods are undergoing something of a revolution at the present time is obvious enough. The spray gun displaced the brush only a few years ago, and nitrocellulose lacquers challenged the supremacy of oleoresinous varnishes still more recently. Other new materials are being developed and still more radical changes in methods of application are likely to appear. But even more significant of the movement now under way is the fact that the A.S.M.E., in giving a special place on the program to the subject of wood finishing, recognizes that the time has come when certain phases of it, at least, must be placed under the charge of men having the specialized technical training of the engineer rather than be entrusted entirely to the craftsman.

However, in our enthusiasm to apply our technical knowledge to the solution of the wood-finishing problem we may make the serious blunder of thinking it a technical problem exclusively. It will be well to keep in mind that the technical aspect, though undoubtedly of primary importance, may prove in the long run to be more easily dealt with than other features. In fact, there are a goodly number of executives in the woodworking industries who would maintain that the problem is wholly one of foreman training, and that if one could find a satisfactory substitute for the old apprenticeship system, capable of providing craftsmen as competent as the good-old-timers are reputed to have been, there would be no need of calling in the aid of the technical man at all. So, before going to the other extreme, we should consider carefully how much of the burden of his finishing difficulties we dare promise to take from the executive's shoulders.

Wood Finishing as an Art

Wood finishing is at once an art, a craft, and a branch of engineering. It will always require skilled workmanship, esthetic appreciation, and technical knowledge. In the easy-going times when small manufacturing establishments were the order of the day, it was possible for the craftsman to assume the entire responsibility; but as the woodworking industries became more complex and more highly specialized the traditional policy of leaving it all to the finisher has been productive of more and more worry for the executive, until at the present time in many lines the finishing room probably gives rise to more exasperating difficulties than any other division of the operations. In looking for ways of improving the situation it is important to keep in mind that the problem has three sides, and that new developments on the technical side have an important bearing on the other two.

This is neither the place nor is the author the one to discuss the lines of future progress in wood finishing as an art. It is desirable, however, to emphasize the fact that the artistic consideration is a vital part of the wood-finishing problem, and that while it is likely to be affected by changes in technology, the engineer as such is not competent to advise upon it. The special talents of the artist, not always combined with those of the engineer or chemist, are required.

There are those who feel that the *art* of wood finishing has been even more seriously neglected than its technology, and that the tendency in recent years has been away from rather than in the direction of a better balance between these two aspects of the subject. At least two factors probably have tended to discourage artistic originality in wood finishing—the dominance of manufacturing considerations over esthetic values, and the craftsman's monopoly of finishing knowledge.

The first factor is well illustrated by the prevalence of very dark shades in walnut and mahogany furniture, dictated in all probability by the circumstance that it is easier to disguise birch and gum in combination with the more expensive woods when such finishes are employed than when using the more attractive lighter shades. When fashion swung to the other extreme during the recent vogue of French walnut, the attempt to use the darker-colored wood by bleaching led to a good deal of trouble and produced some finishes that left a good deal to be desired from the point of view of beauty.

The importance of the second factor tending to discourage artistic originality in wood finishing is manifest. Since the craftsman is concerned primarily with the routine of production, he naturally tends toward standardizing his work with as few materials and operations as possible, and opposing the introduction of new effects and new technic. For obvious reasons he is likely to take sides with the engineer against the designer in the conflict between convenient production and artistic expression. When he alone possesses the knowledge of what can be done in the way of finishing and how to do it, as has been the case all too frequently in the woodworking industries, the designer's efforts are very narrowly circumscribed. It is much like asking an artist to paint with three or four prepared paints of unknown composition which he is forbidden to mix or alter in any way. A talented artist no doubt could produce an excellent picture, but he will probably turn to a more flexible vehicle for expression. Similarly, higher standards of beauty in wood finishing are not likely to be achieved until the designer is freed from thraldom to the craftsman. To produce that result the technical man will have to devise adequate means of measuring the adaptability of the available materials and describing the results with different procedures. The choosing of proper finishing operations and the selection of necessary materials is then properly as much a part of design as the specifications for the woods and dimensions of the various parts.

There are, as a matter of fact, signs of a rebellion against mediocrity in wood finishes. As the lumber associations improve their merchandising methods they are emphasizing the finishing possibilities of their woods. The mahogany and walnut interests urge shades that bring out the beauty of their woods more clearly, the groups interested in maple are centering their advertising upon the new light brown and gray finishes for it, the gum producers would like to popularize distinctive finishes, and even some of the softwood interests are devoting much attention to the development of appropriate finishes. Now that the radio is competing with the automobile for the attention of the public, it seems reasonable to suppose that people will again be at home enough to heed the broadcast clamor of the lumbermen and demand beauty in the finish of their furniture and woodwork even as they do in their cars!

[1] Chemist, U. S. Forest Products Laboratory.

Contributed by the Wood Industries Division for presentation at the Annual Meeting, New York, December 6 to 9, 1926, of The American Society of Mechanical Engineers. All papers are subject to revision.

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There will always be a large scattered fuel demand, which can be met best by solid fuel.

It would not be advisable to attempt to carbonize 500,000,000 tons of soft coal until the country was prepared to absorb the by-products. This question seems bound up with the problem of automotive-fuel supply, and the two may be worked out together to a happy solution.

One of the best features about carbonized fuel is that it would automatically solve the part of our smoke problem that is most difficult of control—the human element. Providing a foolproof fuel that could be shoveled helter-skelter into any kind of a fire pot without any precaution, would remove the last barrier to a realization of our dream of smokeless cities.

None of these things are going to come overnight. At the proper time, depending on economic conditions, the fuel interests and technologists will meet the situation. In the meantime we should not relax our efforts along present lines, as it is by these efforts that the field will be prepared for more radical measures.

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Wood Finishing as a Craft

The wood-finishing craftsman has been traditionally jealous of the intrusion of the uninitiated, especially the engineer and chemist, into his secrets, and the technical man in return has continually increased the complexity of the subject by perforce introducing new materials, new methods of application, and even new woods, each departure from the good old-fashioned way bringing with it a whole new set of special precautions to be learned if disaster is to be avoided. Unfortunately, that rivalry has resulted in placing altogether too much emphasis upon cook-book formulas of magic concoctions. Both craftsman and chemist have wasted too much time in the vain search for a philosopher's stone of wood finishing. As a matter of fact, to obtain a given effect there are usually a dozen different methods, any one of which will give excellent results if skilfully applied, but no one of which will produce a really first-class job unless handled with skill and good judgment.

The craftsman's place in wood finishing is assured not by the secret formulas which he thinks he possesses but by his mastery of the materials with which he works. Technical progress has a way of making more rather than less demand upon his ability. It is more difficult to apply smooth, uniform coats by means of the spray gun than with the brush, and the care and operation of the new tool are more intricate. Nitrocellulose lacquers are even more capricious than varnish, and require closer attention to avoid getting into trouble. Not only are the newer materials and methods increasingly complex, but their very multitude in itself adds to the craftsman's burden by making it necessary for him to familiarize himself with the peculiarities of many different products. A generation ago the finisher needed to understand the use of a few dozen materials, whereas today he must be able to handle several score.

While the demands upon the craftsman have been growing more exacting, social forces too familiar to need mention here have combined to make it more difficult for industry to obtain skilful wood finishers in sufficient numbers. Much attention has been paid to the problem of finding a satisfactory substitute for the obsolete apprenticeship system, but thus far without much success. There seems to be a tendency for the woodworking industries to look for help from outside—from the schools or even from governmental bureaus—but it seems to the author that the problem is such a vital one to industry that its solution must be sought from within. Even with the excellent training in engineering subjects now furnished by the universities, some industries find it worth while to provide their own special schools for graduates entering their employ. But whatever the answer to this question may be, it is sufficient for present purposes to recognize that the training of craftsmen is a major portion of the wood-finishing problem which is not likely to be solved by developments of a purely technical nature but on the contrary may be rendered more acute.

Wood Finishing as a Branch of Engineering

Although the engineer is not the only expert whose special talents will be required to solve the wood-finishing problem, there can be no question that he must be called upon for an exceedingly important contribution.

It so happens that the technical man whose attention is drawn to wood finishing is very likely to approach the subject from the direction of the paint and varnish industries rather than from the side of the woodworker, and therefore to look upon wood finishing as a branch of paint science. The reason is not far to seek. Wood-finishing materials are commonly regarded as "chemicals" requiring the special knowledge of the chemist to understand them; the chemist, although sometimes thus enlisted in the paint and varnish industries, is practically unknown in woodworking. As there are plenty of unsolved problems in the chemistry of paint and varnish to keep the technical men of that industry too busy to learn about wood, the development of such technical knowledge of wood finishing as now exists has been decidedly one-sided.

As a matter of fact, wood-finishing engineering should have its foundation in wood science rather than in paint science. Complicated and imperfectly understood as our finishing materials are, the wood is still more complex and even less understood. Troubles in wood finishing probably arise far more often as a result of the peculiarities of wood than of those of the finishing materials. The characteristics of wood can be controlled only within very narrow limits, and as timber supplies become less abundant it is more difficult to choose woods for their ease of finishing alone. The finishing materials, on the other hand, are nearly all manufactured products or could be replaced by manufactured products, and therefore can be altered more nearly at will to suit conditions imposed by the wood. The ideal in wood finishing, therefore, is most likely to be achieved when we start with a thorough knowledge of wood properties and select materials and methods in conformity with them rather than by trying to modify wood properties to suit finishing methods.

If wood science is the foundation of wood-finishing engineering, then the latter is surely in its infancy, for our technical knowledge of wood is woefully inadequate. Long accustomed to dealing with wood, the average man does not realize how little is really known about it. Incorrect explanations of common observations and even statements of "facts" that are "not so" are accepted without question by engineers and chemists as well as by laymen. Hawley[2] has exposed a group of such fallacies. His list is representative, not exhaustive. Even such an apparently simple question as "how does moisture escape from a piece of wood during drying?" cannot be answered satisfactorily at the present time.[3] The obviously incorrect statement that the shrinkage of wood during drying is due to the removal of free water from the "pores" of the wood appears in print with discouraging regularity. Until we are in a frame of mind to answer such questions less glibly and more thoughtfully, it will be inopportune to try to explain such interesting facts of wood finishing as:

1 The effectiveness of shellac as an undercoat in comparison with other spirit varnishes, oil varnishes, and lacquers.

2 The difference in the amount of dyestuff required to stain wood a given color with a water or alcohol stain and with an oil stain.

3 The lighter color given to the summerwood of a softwood as compared with the springwood when using an oil stain, despite the apparently deeper penetration into the summerwood.

4 The property of a wood which the finisher calls "suction" and the paint technologist calls "absorption," and which seems to bear no relation to the ease with which the wood can be impregnated with chemicals.

5 The ease with which some oils and resins in woods work their way through paint and varnish coatings, apparently without rupturing them.

6 The development of such exasperating finishing-room troubles as varnish "shrinkage," "pinholing," and "blooming."

7 The apparent development of a third dimension or "depth" in a wood surface when shellacked, varnished, or lacquered.

Spectacular developments such as the widespread adoption of lacquer during the last few years are likely to mislead us into thinking that the important technical advances in wood finishing are to be sought in radically new materials and new methods. Undoubtedly many valuable new inventions will be made as the subject of wood finishing receives more adequate technical study, but it is the author's belief that even more profitable results can be expected from the better utilization of existing methods and materials which will result from a painstaking study of the fundamentals. Already there is a vast accumulation of empirical knowledge, much of it rendered mysterious by an overgrowth of fanciful theory. If the information is subjected to the cold scrutiny of systematic research and every theory examined with a vigorous skepticism, it should be possible to separate facts from fancies and to organize a body of knowledge that will form the real basis of a wood-finishing engineering.

One of the first problems for the future in wood-finishing engineering is the development of tests for *measuring* results. This is practically a virgin field, because heretofore very little has been accomplished except to finish sample panels and pass judgment upon them by visual inspection. For example, such a property of a varnished surface as "depth" should be susceptible of measurement by a suitable instrument. The trained eye of the ex-

[2] Seventeen Fallacies about Wood, News Edition of *Industrial and Engineering Chemistry*, vol. 3, no. 15, Aug. 10, 1925, p. 5.

[3] See The Movement of Moisture with Reference to Timber Seasoning, (British) Forest Products Research Technical Paper No. 1.

FLB 000787

perienced finisher seems to be very sensitive to it, but a mechanical "eye" of some kind is essential for a technical study of the property. With proper tools at his command for measuring this and every other significant factor, the engineer would be in a position to determine precisely how much each step and each variation contributes to or detracts from the finishing process as a whole.

The need of adequate tests for evaluating finishes will probably be felt most keenly in its relation to the selection of finishing materials. Every purchaser of such products has realized the difficulty in choosing intelligently among the many brands offered to him. Usually price and the reputation of the manufacturer are taken as the only available index of quality, and the most common method of testing is the hazardous one of using a trial shipment. Attempts to adopt other test methods as the basis of selection have been made often enough but have usually proved abortive.

Trying to borrow the test methods of the chemists of the paint and varnish industries is the most common reason for the failure of the woodworker's efforts to test materials. The varnish chemist, for example, finds a viscosity test very useful as a routine method of control of the uniformity of successive batches of the same varnish; but it does not follow that the viscosity test alone will tell the purchaser which one of several varnishes is most suitable for his use. Again, there is a natural tendency toward the assumption that a chemical analysis of a material gives all necessary information about it. But when the consumer tries to purchase finishing materials on the basis of a chemical analysis he finds himself at once at loggerheads with the makers on the ground that he is attempting an unwarranted intrusion into their trade secrets. Whether the varnish-makers' argument is valid or not, the woodworker will usually find that knowing the formula of a material will not help him much in determining what it will do.

Manufacturers of wood-finishing materials in the past have not found it necessary to devise methods of measuring the service value of their products, and they are not likely to spend much time in that direction unless the woodworkers themselves lead the way. The author recalls the experience of one large factory which was greatly troubled with varnish printing during shipment of their furniture. The problem was turned over to an engineer who soon devised a test requiring no more elaborate apparatus than some wood panels, some kraft paper, a few weights, and a corner of the factory cellar where temperature and humidity remained constant. When purchases of varnish were made in accordance with the findings of this test the printing troubles were eliminated. It is true that much more time and ingenuity will be required to work out practicable testing systems covering all the requirements of many finishing materials, but where a serious effort is made to do so it is likely to be generously rewarded.

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Factory, the Magazine of Management Oct 1927

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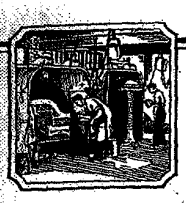


PAINTING *and* FINISHING

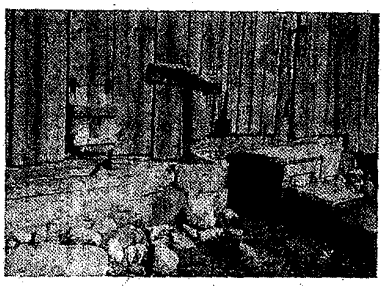
To protect from the weather, to please the eye, to give better light reflection—whatever the use, paints and finishes for both product and plant must be wisely selected and properly applied

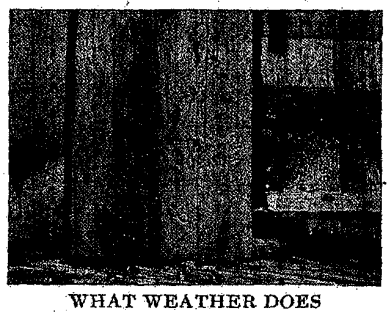
Why Wooden Buildings Need Paint Protection

By F. L. BROWN, Ph. D.
FOREST PRODUCTS LABORATORY, MADISON, WISCONSIN

"GOOD paint costs nothing," says an old Dutch proverb, expressing epigrammatically the wide-spread belief that savings result from painting which exceed in value the expense of applying it. It is not the present purpose to examine that statement from the accountant's point of view as it applies to wooden buildings. It will be worth while, however, to call attention to some of the ways in which paint maintenance is indispensable to the really satisfactory service of exposed woodwork.

The first manifestation of weathering in wood exposed without paint protection is "grain-raising." The smoothly planed surface, essential to the architectural effect for which wood house-siding, trim, and window-frames are usually employed, becomes rough and corrugated. In the softwoods such as the pines, cedars, firs, hemlocks, and spruces, the summerwood (the darker-colored part of the wood which delineates the "grain") becomes raised up in relief above the surrounding springwood. In the hardwoods like poplar, basswood, gum, and cottonwood the relief pattern is not so systematic—instead, individual wood fibers thrust out from the surface, making it "fuzzy."



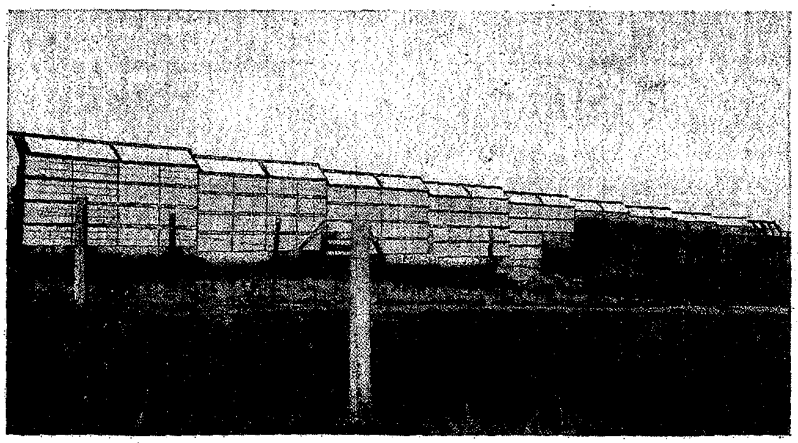


WHAT WEATHER DOES

Bran siding that has seen nearly 70 years of service. Most of the damage is done in the first few years.

The cause of grain-raising can be demonstrated very easily. It is merely necessary to wet the surface of a board and let it dry out again, simulating the action of rain and sun. One such treatment roughens the surface sensibly and repetition intensifies the effect. The probable explanation is that some parts of a piece of wood swell more than others when wet. The summerwood, of the conifers especially, which may be much more dense than the springwood, probably swells more. Internal stresses are therefore set up in the wood as it takes up moisture, and distortion of the wood structure takes place. On drying back to the original moisture content the former shape is not resumed exactly because of a permanent "set." This characteristic of

(See overleaf, Dept 20 Column)



AN OUTDOOR LABORATORY FOR TESTING DURABILITY

Various kinds of wood, painted and unpainted, are exposed to the weather under similar conditions on this test fence of the Government Forest Products Laboratory at Madison. The effects of weathering can be accurately determined.

ONE COAT IS NOT ENOUGH

One coat of black paint produced the desired appearance, but did not prevent cupping of the board.

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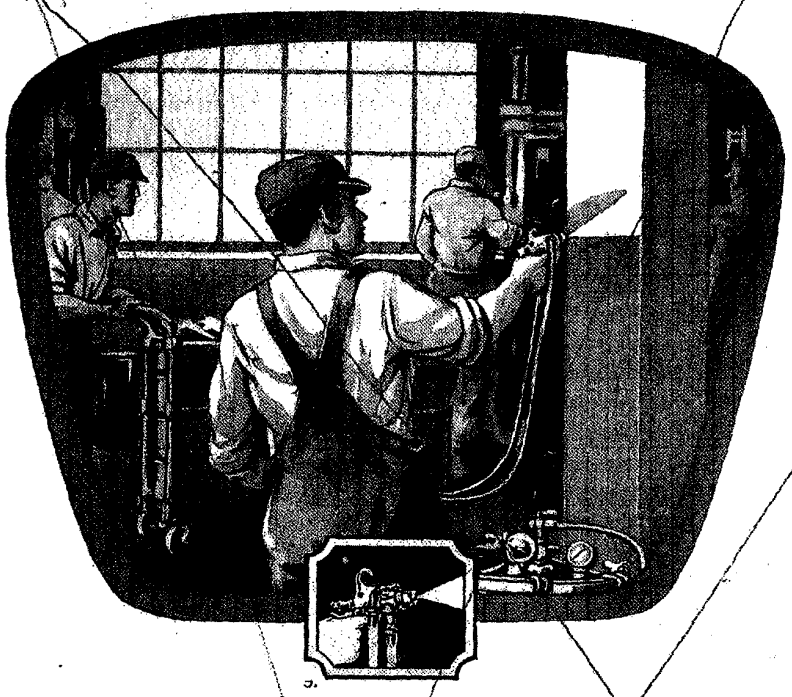

Paint Without Holding Up Production

Painting the plant interior has meant a time of delays and inconvenience. Often whole departments were held up—production at a standstill—until painters were through. Now the DeVilbiss Spray-painting System enables you to paint without any of this.

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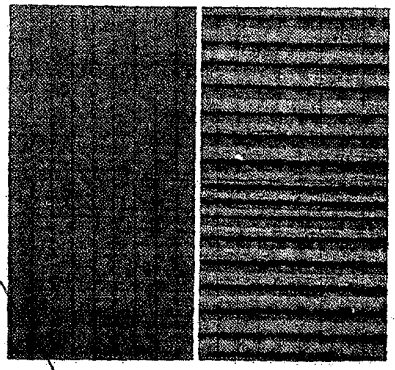
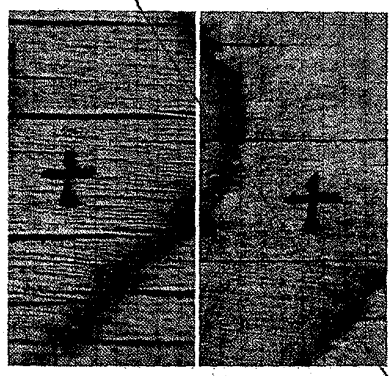
Some softwoods may develop "loose grain" as well as raised grain. One edge of the summerwood band comes loose from the neighboring springwood and curls up, leaving a projecting knife-edge of thin wood to splinter and present a jagged surface, dangerous to handle. The edge of the summerwood band which comes loose is always the one marking the end of one year's growth of the tree from which the board came. The difficulty is much more serious on "flat-grain" (plain sawed) than on "edge-grain" (quarter sawed) boards. Practical lumbermen say that the development of loose grain on weathering is prevented by turning the board so that the side exposed is the one that was nearest the bark of the log from which it was cut. A few experiments at the Forest Products Laboratory are inclined to confirm that statement.

The next stage in the weathering of most woods is surface checking. Us-



HOW PAINT PROTECTS

One year's weathering raised the grain and corrugated the unpainted board (right). The same wood painted shows only brush marks.



WEATHER CHECKS

Left, a test panel after a few weeks' exposure. Right, the same spot (identified by cross) after one year. The cracks run deep.

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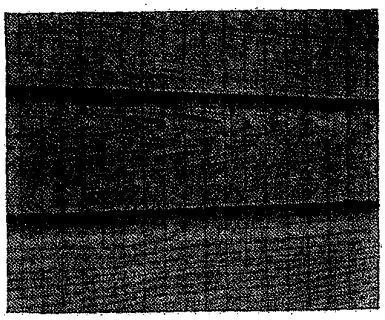
ually the checks are so small at first that it requires careful searching to find them, but as time goes on they become conspicuous fissures. They may eventually become large cracks running all the way through the boards. As would be expected, checks are likely to be most serious near the ends of boards, and, where boards are rather short—as may sometimes be true of siding between two adjacent windows—such end checks may split an occasional board in two.

Checking results from the continued operation of the same forces responsible for grain-raising. It can be pro-



LOOSE GRAIN

A short exposure of unprotected wood raises the grain beyond repair. Flat grain (center) suffers more than end grain (below).

duced artificially by repeatedly wetting the surface of a board and drying it out again rapidly. When it is considered that superficially wood absorbs water rather easily, while moisture moves very slowly through the deeper layers, it is evident that such alternate wetting and drying of the surface causes an outer layer of the board to "work" against the relatively constant interior. The internal stresses introduce a cumulative "compression set" in the surface layer of the wood—that is, the outer layer of the board tends to shrink continuously in the direction of the width of the board. Such stresses are usually relieved, in part at least, by checking.

Woods differ greatly in the extent of checking when exposed to weather. Some woods develop few checks even on prolonged weathering. Others check quickly. Flat-grain boards of any wood, which suffer more severely from loose grain, also weather-check more seriously than edge-grain boards. The greater swelling and shrinking of wood in the tangential than in the radial direction would lead us to predict as much.

As weathering continues and a thicker layer of wood becomes affected, cupping or warping of the board begins. The internal stresses in the weathered outer portion have finally become great enough to bend or twist the whole board. Of course thin boards cup sooner than thick boards of the same kind of wood, and there is much variation between woods in the tendency toward cupping.

The "working" of the wood with fluctuating weather conditions tends to pull nails loose. They may actually be withdrawn much as though the board were operating as the claw of a hammer. Fastenings may also come loose because nail holes tend to become centers for the development of deep cracks, especially when the nails are near the ends of the board.

Prolonged weathering results in the slow wearing away of the wood at the surface. For example, old signs with painted letters on an unpainted background are occasionally found with the wood under the letters in relief through the wearing away of the background.

Does Wood Ever Last without Paint Protection?

The weathering of unprotected wood proceeds rapidly in its early stages. Within a few weeks the grain raises and checking begins. By the end of a year the surface may be badly roughened and checked, and cupping may have started. The original yellow or brown color of the wood changes to gray, which with some woods may be drab but with others may have a pleasing silvery sheen. The further progress of weathering, however, is very slow, at least if the lumber is of substantial thickness, say 5/8-inch or more.

Even granting that well-built wooden structures might be maintained without the use of paint until they become obsolete, there are serious practical objections to leaving them unpainted. Moreover, once a building has become badly weathered it can be properly painted only at comparatively great expense, if at all. Again, the shaggy, splintery surface of weathered wood is undesirable on those parts of a structure likely to be touched with the hands.

In the second place, weathering, by cupping the siding and tearing it away from fastenings, loosens the structure until it affords less satisfactory shelter against the elements.

Then again, new or painted wood, in pieces of substantial size or in tight walls, does not take fire readily. It burns slowly, and usually will not continue to burn unless the fire has obtained some headway in the building. Weathering of (Continued on page 796)

Why Wooden Buildings Need Paint Protection

(Continued from page 660)

the roofs and walls of frame buildings breaks down their fire resistance and increases the fire hazard.

The rough surface offers a lodgment for firebrands and gives the fire a chance to take hold. Cupped and warped boards offer two sides instead of one to the combined attack of heat and advancing flames, and the loosened wall surface, instead of deflecting the hot draft rising from the fire, permits it in a measure to use the space between siding and sheathing as a flue to encourage combustion.

Decay due to the attacks of fungi is not a normal hazard of the wooden building, as has been pointed out in FACTORY for May, 1926 (page 882). However, weathering and neglect may occasionally open the way to decay by permitting access of rain-water through loosened siding to interior parts of the structure whence it cannot readily escape.

The whole series of events taking place in exposed woodwork and its serious consequences can be prevented completely by adequate paint maintenance if the building has been properly designed and constructed. Coated wood absorbs moisture or dries out so much more slowly than bare wood that inequalities of moisture content do not develop within the boards, and in consequence the wood near the surface does not struggle against that in the interior until it tears itself to pieces. By means of paint, siding can be kept smooth, flat, and snugly fastened, giving a tight wall effective against wind and rain, resistant to the spread of fire, and amenable to decorative treatment.

It Is Dangerous to Neglect Painting

The early stages of weathering, grain-raising, checking, and cupping, can be inhibited only by the use of paint or other protective coating. Once the paint is seriously neglected, an important part of the original value of the lumber is permanently lost.

Furthermore, the attempt to maintain without painting is also dangerous because of the related temptation to keep putting off necessary repairs. The act of painting involves a minute survey of the structure, periodically repeated, at a time when the owner is prepared to take action. Paint therefore has an "inspection value" which should not be overlooked.

FLB 000791

Hardware Dealers Magazine

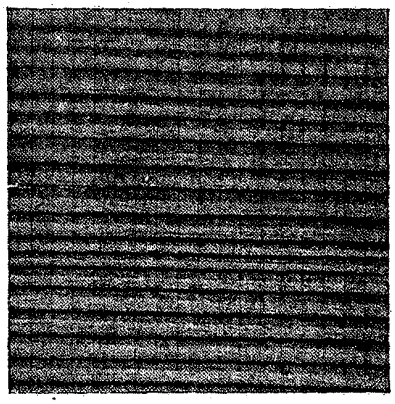
Hardware Dealers Magazine
November 1927

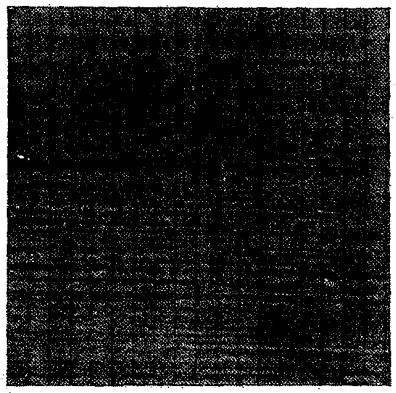
(6)

Principles for Testing Paint on Wood As Protection Against Weathering

IN spite of the fact that protection of the wood is universally considered as one of the primary reasons for painting exterior woodwork, no serious effort has heretofore been made to determine experimentally how long coatings of paint continue to protect wood against deterioration, according to F. L. Browne, chemist in the Forest Service, United States Department of Agriculture.

The tests included exposure of wood panels coated similarly on all surfaces to (1) 60 per cent. relative humidity for 2 weeks; (2) 95 to 100 per cent. relative humidity for 2 weeks; (3) 60 per cent. relative humidity again for 2 weeks; (4) outdoor exposure facing south for 6 weeks. The last step secures the actual weathering, while the second step provides the means for measuring the absorption of water as a result. Steps 1 and 3 merely return the specimens to a standard moisture content before their reexposure to the conditions of the other two parts of the cycle. By weighing the panels before and after exposure to the 95 to 100 per cent. humidity, the amount of moisture absorbed could be determined.





Unpainted softwood, exposed for one year, shows a "washboard" effect from swelling and shrinkage. The smoother surface (the irregularities are brush marks), on a similar board, was given three coats of paint and the same exposure.

Mr. Browne recently analyzed the results of a series of tests on the durability of paint coatings, some of which have been under way as long as six years. A more convenient and rapid technic embodying the principles determined in these tests is now being developed in the laboratory.

Paint coatings protect wood against weathering by retarding the exchange of moisture between the wood and air. Their durability as protective coatings can be measured by observing their effectiveness in retarding the absorption of moisture from saturated air by painted wood panels. The time when a paint coating first begins to chalk, or to expose the wood through cracking, is not always an indication that the paint is no longer effective.

Previous tests, says Mr. Browne, have been prone to ignore such evidence of wood weathering as wood checks, loose grain, cupping, warping, and loosening of nail fastenings, on the ground that they are "wood defects" rather than "paint defects." As a matter of fact, defective paint may often be responsible for bringing about, in some measure, what are thought to be defects in the wood.

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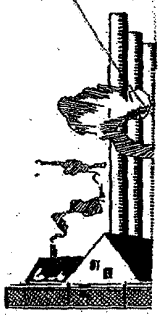

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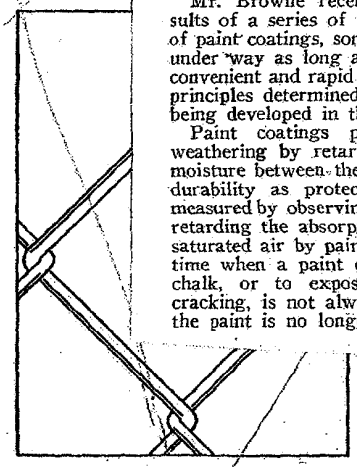

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SOME CAUSES OF BLISTERING AND PEELING OF PAINT ON HOUSE SIDING

Revised, March 1933

No. R6

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison, Wisconsin
In Cooperation with the University of Wisconsin

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SOME CAUSES OF BLISTERING AND PEELING OF PAINT ON HOUSE SIDING

By F. L. BROWNE
Senior Chemist

Introduction

Whenever paint coatings on wooden walls of houses fail unreasonably soon, say in less than two years after they have been applied, the failure is almost always due to certain circumstances called, for convenience, "abnormal conditions of exposure." Failure under such conditions is not a question of the kind of wood upon which the coating is applied, the quality of the paint, or the craftsmanship of the painter. The staff of the Forest Products Laboratory has observed the troubles in question on all of the kinds of wood commonly used for house siding, with paints of all the varieties generally accepted as of first quality as well as with cheap paints, and rarely has there been any possibility that poor workmanship on the part of the painter was responsible. The fault lies in the abnormal conditions of exposure, and the only certain cure is to search out the abnormal conditions and change them into normal ones. Attempts to overcome difficulties of this kind by using special priming paints, special paints, special liquids, or unusual amounts of liquids for thinning ordinary paint are, in the writer's opinion, of very doubtful merit. No sound structure can be reared on a faulty foundation.

The most common form of paint failure under abnormal conditions of exposure is that known as blistering and peeling. The failure, however, sometimes appears in other forms that at first glance do not seem at all related to paint blistering, such as paint scaling, some kinds of discoloration of coatings, and blue stain in the wood beneath the coating. Sometimes blistering and peeling occur along with the other defects. All such troubles with painted wood may well be discussed together because of their common origin.

Present information about the effects of abnormal conditions of exposure upon paint coatings is based chiefly upon

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examinations of occupied buildings which have given trouble. The staff of the Forest Products Laboratory has been called as consultants in such cases for many years. In addition a limited amount of laboratory experimentation has been done with miniature "houses" warmed and humidified inside and set out of doors during cold weather. Many characteristic paint defects have thus been reproduced under partially controlled conditions. Much more study will be needed before the mechanism of paint blistering and the allied defects are really understood, but the general nature of the practical conditions that commonly give rise to abnormal conditions of exposure is now reasonably well established.[1]

Most cases of paint trouble due to abnormal conditions that have been brought to the attention of the Forest Products Laboratory have been on widely scattered houses whose neighbors experienced no such difficulties. Many of them have been cheaply built houses, but on the other hand many have been relatively expensive houses on which every effort seems to have been expended to build properly. Occasionally, however, early paint failure caused by abnormal conditions occurs on a large majority of the houses built in some one community under the supervision of a single organization, either as a speculative building enterprise or as an employee housing plan. Losses incurred because of abnormal conditions in one large development of this kind are estimated by the construction company at more than a million dollars in 8 years. It is evident, therefore, that our present general knowledge of abnormally early paint failure does not suffice to prevent very large losses because of it and that much more specific information about the building of houses with certainty that such trouble will not be experienced is badly needed.

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[1]This mimeograph, emphasizing the necessity of avoiding the abnormal conditions if trouble from blistering and related defects is to be avoided, was issued first in May 1927, and later summarized in Circular 317 of the Scientific Section, American Paint & Varnish Manufacturers' Association, October 1927. Since then Otto R. Hartwig of the West Coast Lumbermen's Association has studied more than 1,500 houses on which such difficulties have arisen and has materially extended the knowledge of the details of construction in which the fault often lies. His observations, well illustrated by photographs, were published in 1929 in Circular No. 355 of the Scientific Section, American Paint & Varnish Manufacturers' Association, 2201 New York Ave., N. W., Washington, D. C.

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Circumstances that Have Been Observed to Cause Abnormal Conditions of Exposure

In practice, abnormal conditions of exposure almost always involve, as an essential factor, the access of large amounts of moisture to the unpainted sides of the boards. The conditions are greatly aggravated when the temperature on the unpainted side is materially higher than that on the painted side, as is the case on the outside walls of heated buildings during cold weather. Causes of abnormal exposure conditions that have been observed repeatedly may be classed as follows:

Type A.--Rain water seeping through leaky joints left by poor carpenter work or faulty design.

1. Poor fitting between siding and corner boards, between siding and casings of doors or windows, and between siding and drip caps over window and door headers or sills beneath such openings.

2. Joints in window frames forced open to permit swollen sash to move freely. When the sill and head of the window frame are housed into the jamb, this is an easy way to make the sash move freely, but it leaves an opening to admit water. If the jamb is housed into the sill and head, the joint cannot be forced open in this way.

3. Omission of metal flashing or its incorrect installation over doors and windows or at the junction between porch or dormer roof and side wall or chimney.

4. Incorrect junction between shingle side wall and water table where the upper part of the side wall is shingled and the lower part sided. This junction should either be protected by metal flashing or the shingles lapped over the water table carefully to see that no openings are left through which rain water can gain entrance.

5. Seepage into the joint between porch column and plinth block or porch floor.

6. Leaking roofs, eave troughs, or down spouts when so located that the water gains access to the interior of the side walls.

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7. Frozen gutters failing to carry off the water from snow melting on the roof and letting it back up beneath the shingles to gain access to the interior of the side walls.

Abnormal exposure conditions of Type A may occur on either heated or unheated buildings and, with the exception of No. 7, in any climate. However, heating the interior of the building during cold weather tends to aggravate the resulting difficulties with paint coatings. The only sure remedy is to locate the leaky joints and repair them until they are water tight.

Type B.--Moisture originating within the building and carried by air circulating within the hollow outside walls. When moisture laden air comes in contact with surfaces at sufficiently lower temperature, water condenses.

1. Attempting to hasten the drying of wet plaster or other building moisture by heating the interior of a building under construction without adequate circulation to carry off the moisture laden air. New buildings should be dried by circulating fresh air through windows and doors. Marked difference in temperature between interior and exterior permits water to distil from plaster to sheathing and siding through the hollow side walls. By leaving temporary openings at the top and bottom of the air spaces between studding, enough circulation through the side walls can be insured to prevent such action while the building dries.

2. Designing parts of buildings in such a way that stagnant air spaces are enclosed by wood walls within which the air may become moist and warmer than the outside air. Porches built beyond the foundation with skirting extending down to the ground and no provision for ventilating the enclosed air space are common causes of trouble. Hollow ornamental walls extending beyond the foundation and hollow columns with leaky joints admitting rain water at the bottom require ventilation.

3. Lack of ventilation in unused attics. During cold weather water may condense beneath the cold roof and drain down toward the cornice. If the top course of siding is placed below the frieze board the water is directed between siding and sheathing, coming directly in contact with the backs of the painted clapboards.

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4. Failure to secure a water-tight basement. Building in soil that is not adequately drained and using basement walls and floors that are not waterproofed may result in a damp basement and a circulation of the moist air through the hollow side walls of the building to condense behind the siding. Plumbing leaks left uncorrected may also produce this result.

5. Activities within the building that humidify the air. The bathrooms and kitchens of dwellings tend to show blistering and peeling of paint from their outside walls sooner than other rooms. Frame buildings, originally designed as dwellings, when used for purposes like laundering often give rise to severe blistering and peeling of paint. Horse stables at country clubs when built with hollow frame walls like those of dwellings instead of the more usual barn construction, are sources of trouble unless the walls are provided with louvers for ventilation.

The channels of circulation for air within the hollow exterior walls of frame buildings are controlling factors in abnormal exposure conditions. The subject has not yet been studied carefully and much remains to be learned about it. In general the direction of movement of air enclosed in the space between lath and plaster on one side and sheathing and siding on the other is upward along the warmer side and downward along the colder one. When the building is being heated during cold weather, the warmer side is the lath and plaster so that the upward air current moves along that side until it meets an obstruction, which may be a plate or a fire stop, where the air current is deflected and starts downward along the colder sheathing and siding side. This downward current of air is likely to circulate through the joists in the sheathing and building paper (even though waterproof building paper is used) and to pass out between boards of siding. The escape of air between clapboards may be helped or hindered by wind blowing on the outside wall according to the angle at which the wind strikes the wall.

In cold weather the temperature at the back of the siding where air is escaping may easily be below the dew point even though the air may have had a low relative humidity when it first entered the hollow side wall from the interior of the building. Thus air chilled from 70° F. begins to deposit its moisture as water or ice at 32° if the initial relative humidity was 25 percent, at 15° if the initial relative humidity was 11 percent, and at 1° if the initial relative humidity was 5 percent. Since the coldest surfaces in the side wall with which the circulating air may come in contact

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are offered by the back of the siding and the front of the building paper, these are often the points at which condensation sets in. The amount of the condensation will depend upon the amount of circulation and will naturally be greatest near the points in the side wall where the upward current of air is deflected by a window frame, plate, or fire stop so that the air starts its downward course along the sheathing and siding side of the wall. The effects on paint coatings of condensation of moisture behind the siding are commonly found most marked on the parts of the walls corresponding to the points of deflection of the air currents.

The fact that the effects of moisture condensation are often most marked near fire stops should not be regarded as an argument against the inclusion of fire stops in frame buildings. Fire stops are desirable, often necessary. Their omission in a building in which trouble from moisture condensation was experienced would not necessarily overcome the difficulty, though it might shift the location of its most marked development.

Forms of Paint Failure Under Abnormal Conditions

Failure under abnormal conditions may appear as blistering, peeling, or scaling, in which the coating is removed bodily from the wood, or as a discoloration, which mars the appearance of the coating. The discoloration may be due to substances leached from the wood by water, substances carried by water from other places within the structure, or blue-stain fungi growing in sapwood beneath the paint coating.

Blistering, Peeling, and Scaling

The characteristic form in which paint coatings fail under abnormal conditions is blistering and peeling or scaling. Blistering always precedes peeling, though the trouble often escapes notice or fails to arouse anxiety until the peeling is well under way. From their shape it is obvious that blisters are due to a fluid pressure beneath the coating forcing it away from the surface. When observed soon after their formation, blisters are sometimes found to be hollow, sometimes filled with water, but if the blistering conditions continue they always become filled with water. If the wood is of a kind that contains colored substances soluble in water the water in paint blisters is colored with them.

Sometimes water soluble extracts from the wood do not become highly colored until they break through the coating and come freely in contact with air. Deposits of such substances over paint blisters often look like resin exuding from the wood.

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The mechanism of the movement of water through wood and the development of pressure behind paint coatings is still obscure, but the following considerations are helpful in gaining an understanding of the sort of forces that are at work: From half to more than three-fourths of the volume of a piece of dry wood is air that is enclosed in the cavities of the wood. Ordinarily this air remains at atmospheric pressure because the cavities communicate with each other and with the surface through the openings in the pit membranes, but as soon as the wood becomes wet and there is free water in the cavities, the minute openings in the pit membranes become covered with films of water which can be dislodged only by high pressures. It has been shown that pressures of approximately 20 to 40 kilograms per square centimeter are required to force air through wet wood. Once wood begins to hold free water, therefore, its enclosed air is effectively trapped and the pressure acting on the air may rise above that of the atmosphere. Increase in pressure in the trapped air may be occasioned by rise in temperature, by evaporation of some of the free water, or by displacement of air by further amounts of free water.

While still turgid or filled with water, paint blisters can be broken easily and the coating peeled off though it does not necessarily peel of its own accord. As the abnormal conditions give way to normal conditions and the wood dries, the blisters often shrink back into place so completely that the coating may seem to be as sound as ever. The good appearance is deceiving, however, for a few months exposure under normal conditions may lead to scaling. Since the coating is now thoroughly dry and somewhat aged it is no longer tough and pliable, but is hard and fragile, so that the failure is of a sort easily confused with paint scaling under normal exposure. If often happens that scaling is the first sign of failure that comes to the houseowner's notice because the stage of blistering occurred during cold weather when he did not inspect the painted surfaces very carefully.

In scaling, the pieces of paint coating that become detached may include the entire thickness of the coating so that the wood beneath is left quite bare, or the separation may take place between coats of paint, leaving the oldest coats still in place. In general, intercoat scaling is most likely to be encountered on repainted surfaces, the newer coats scaling from the older ones, though it is occasionally seen on surfaces painted for the first time, especially if the first coat of paint differs markedly in composition from the others or if the first coat was allowed an exceptionally long time to dry before applying the others.

The susceptibility of paint coatings to blistering and the size of the blisters formed vary materially with a number of factors of which one of the most important is the age of the coating. Coatings blister most easily soon after they have been applied and

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hardened. At that age the coatings are very pliable and the blisters formed are likely to be numerous but small in size and sharply rounded. If the coating has time to age and become less pliable before abnormal moisture conditions arise it does not blister as quickly and the blisters are less numerous but larger in size and less sharply rounded. Blisters have been observed that were many inches across and the coatings could be peeled off in strips several yards in length. Coatings that reach an advanced age before abnormal moisture conditions arise become too hard and unyielding to bulge out into rounded shapes recognizable as blisters, but their grip upon the wood may nevertheless be broken so that failure promptly takes place by cracking and scaling. Very old coatings that are chalking or checking deeply or cracking badly do not seem to fail in the manner characteristic of abnormal moisture conditions; it may be that they are too readily permeable to vapors for pressure to develop beneath them, or perhaps they do so fail, but the failure is indistinguishable from paint flaking or scaling under normal conditions of exposure.

Paint mixed with a high ratio of pigment to linseed oil, which is accomplished practically by substituting turpentine for part of the linseed oil (not by merely adding turpentine), is more resistant to blistering and finally forms fewer, though larger blisters than similar paint mixed rich in linseed oil. It is good practice to mix paint rich in pigment because it improves the appearance of the coating and makes it last longer. Substitution of bodied linseed oil or of some kinds of varnish for part of the linseed oil in paint also increases the resistance of coatings to blistering. The addition of varnish to paint by paint users, however, is not to be recommended without competent technical advice in the selection of the varnish because most varnishes are unsuited for such use. The most resistant paint to blistering so far tested at the Forest Products Laboratory is linseed oil paint made with pure basic carbonate white lead, mixed with a high ratio of pigment to linseed oil, and allowed to age several months before subjecting it to abnormal moisture conditions. Moreover on houses painted with white lead paint that have been brought to the Laboratory's attention because of abnormal moisture conditions the complaint has been about discoloration more often than about blistering or peeling.

It must be emphasized that, although the composition of the paint does affect the ease and form of blistering, all good paints are subject to failure under abnormal moisture conditions so that the only certain remedy for such troubles is removal of the faulty conditions.

The kind of wood painted is ~~likewise~~ of little practical significance as far as paint blistering is concerned. The Laboratory has seen badly blistered paint on all kinds of wood commonly

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used in building and has made paint blister experimentally on all woods that it has tested. No differences have been found between wood species in the case of blistering or in the form of the blisters. Within any species, however, some boards or parts of boards seem notably less subject to blistering than others. In general paint blisters more readily over heartwood than it does over sapwood under the conditions that usually prevail on houses, but under other conditions that have been realized in laboratory experiments blistering occurs more readily over sapwood. On houses it seems probable that the boards most resistant to blistering are the ones through which air and liquids can move most easily so that there is least likelihood of building up pressure behind paint coatings.

Discoloration of Paint with Extractives from the Wood

Some woods widely used for house construction contain water-soluble materials that are strongly colored. Abnormal conditions may bring these substances to the painted surface to stain the coating. Discoloration commonly accompanies blistering and peeling on such woods, but discoloration may occur without blistering or blistering without discoloration, depending upon the sort of abnormal conditions prevailing and the resistance of the coating to blistering. Thus when water from a leaking roof or condensation in the attic drains down back of the siding to find its way out between clapboards, discoloration without blistering often results. If the paint is of a kind that resists blistering or has reached an age at which it does not blister easily there may be discoloration without blistering. Again, the trouble may not be noticed until the blisters have shrunk back into place and only the discoloration remains. On the other hand, if the abnormal conditions do not continue long enough for much water to pass through the boards to the painted surface, blisters may result that contain little or no water and there may be no staining. Long continued or severe abnormal conditions generally produce both discoloration and blistering.

The kind of paint and the painting methods have no bearing upon discoloration as far as is now known. The stain is a deposition of foreign material upon or within the paint coating, not a product of reaction with substances in the paint. It has been found in practice with paints of all kinds. There is no evidence that the danger of discoloration is increased by following such practices as two-coat painting on new wood, adding more than the customary amount of paint drier, reducing the time of drying between coats to a minimum, or using so-called "sealers" or "reinforcing oils," although these practices are open to serious objection for other reasons. The recommendation has sometimes been made that more than the usual proportion of thinner be used in the priming coat for the woods containing water-soluble, colored substances, or that special thinners like benzol

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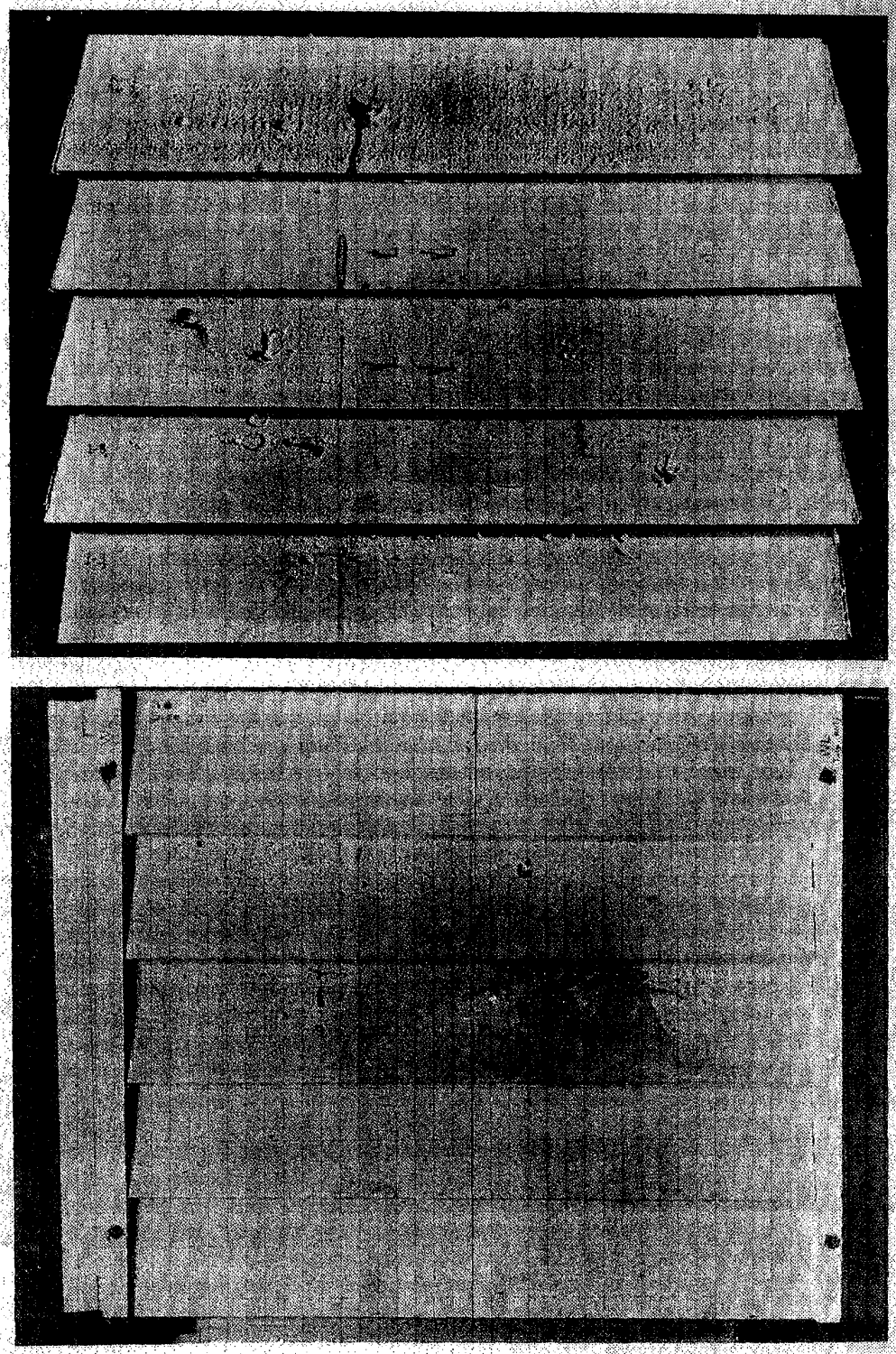
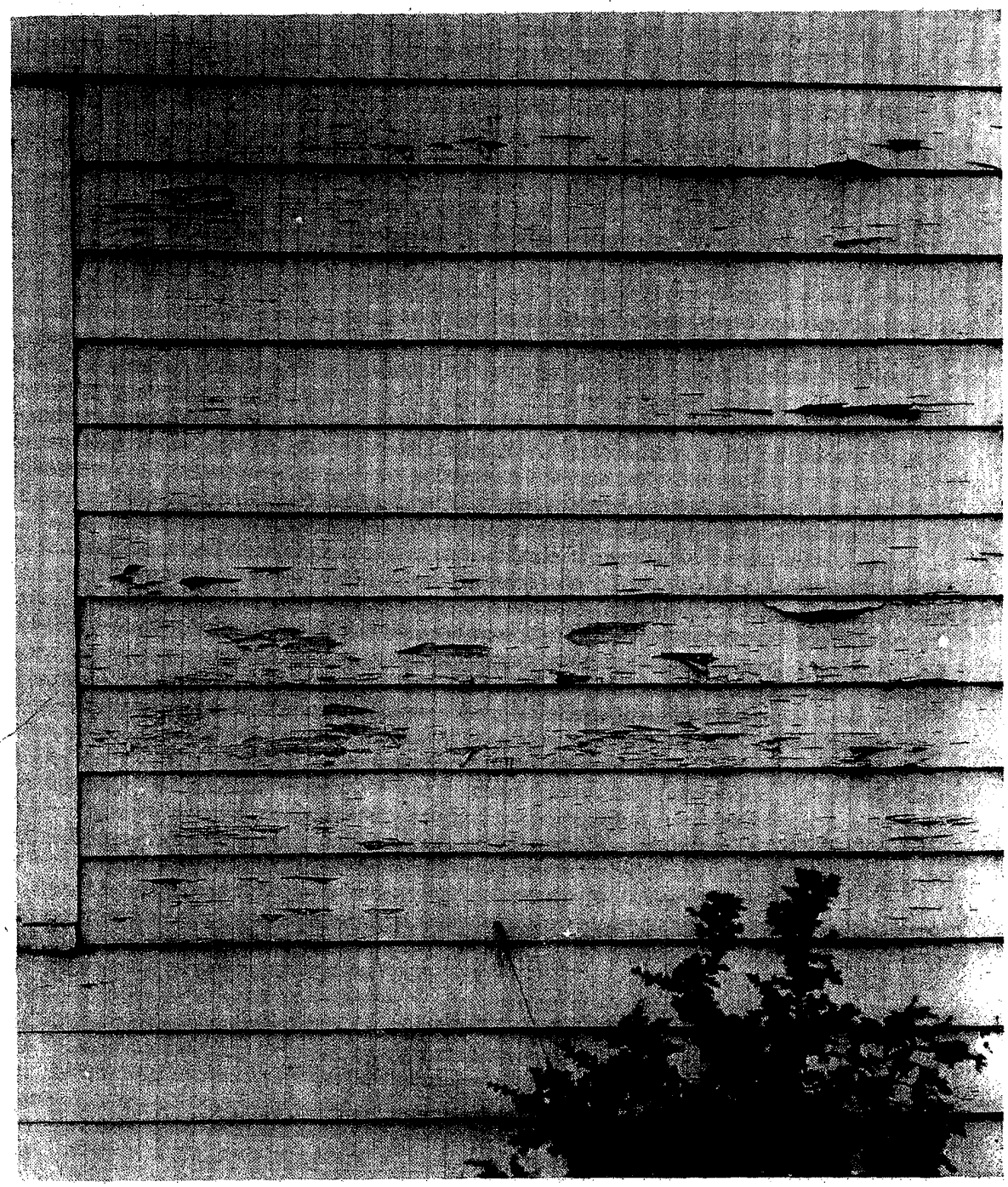


Blistering and discoloration of white lead paint (lower panel) and of a high-grade prepared paint (upper panel) produced in Laboratory experiments on "miniature houses." 2M23916F



Paint scaling within a year after painting, caused by condensation of moisture behind the siding during the winter season when the interior of the house was kept warm.

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or toluol be used in place of turpentine, but such suggestions are not well founded because the offending materials are not resins and are soluble in water rather than in paint thinners. Furthermore, the excessive use of thinners on the woods in question is bad practice because they belong to the class for which any departure from the standard proportions for the priming coat should be in the direction of more oil rather than of more thinner.

Only woods containing generous amounts of colored extractives soluble in water are subject to discoloration by extracted materials. Of the woods widely used for the exterior of buildings, redwood and western red cedar are of this class. That fact should not be regarded as a disadvantage for the two woods under consideration because abnormal conditions will give trouble of one kind or another on any wood. Moreover, the water-soluble extractives of redwood and western red cedar give them desirable properties, for the durability of their heartwoods against decay is known to reside in the extractives present. Under normal conditions of exposure both woods hold paint coatings especially well and there is good evidence that the extractives exert a favorable influence on the life of the coatings.

Discoloration of paint with extractives from redwood and western red cedar is usually more marked on some boards than on others. In part this may be due to differences in the amount of extractives in the boards or to their concentration near the surfaces of the boards during drying, but it probably is due still more largely to details in the construction of the house that make the abnormal conditions more pronounced in some spots than in others. For example, both blistering and discoloration tend to occur near windows or doors or just outside of plates or fire stops in the house walls.

Discoloration with Substances Carried by Water from other Parts of the Building

Abnormal conditions of a kind that permit water to seep out between clapboards and run over the painted surface are likely to produce discoloration even on woods other than redwood or western red cedar because the water may leach colored substances from building paper or composition shingles, or may carry dirt and deposit it upon the painted surface in irregular patches.

Discoloration by Blue-Stain Fungi Growing in Sapwood

Certain fungi grow in moist sapwood of practically all species of wood and stain it dark blue or black. The defect is known

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as blue stain. Like all other fungi, blue stain organisms can grow only in moist wood. When infected wood dries the fungi stop growing and remain dormant, though the discoloration persists. Sapwood that has become blue stained during seasoning may be painted without danger of the stain coming through the paint, provided that the wood subsequently remains dry. But if abnormal conditions arise so that the wood again becomes wet the organisms begin to grow once more and will penetrate through the coating, bringing the stain into view. The fact that a piece of sapwood is bright before painting does not prove that it will not blue stain if the wood later becomes wet because it may be infected even though the fungi have not developed far enough to reveal the color.

There is no evidence that the composition of the paint has any influence on the facility with which blue stain penetrates the coating under conditions permitting the fungi to grow.

Blue stain may occur in the sapwood of any species. A few species with naturally durable heartwood contain no sapwood in the highest grade in which the lumber is sold in commerce. In all but the highest grade of these species and in all grades of other woods, there may be some sapwood. The proportion of the boards of comparable grade in different species in which sapwood may be present varies widely because some kinds of trees contain more sapwood than others in the parts of the logs from which the select grades of lumber are cut.

Blue stain coming through paint may be distinguished from mold and lichen growing on the coating itself by the fact that blue stain is confined to the areas immediately over sapwood and the color is revealed deeply imbedded in the wood when the coating is scratched away with a penknife.

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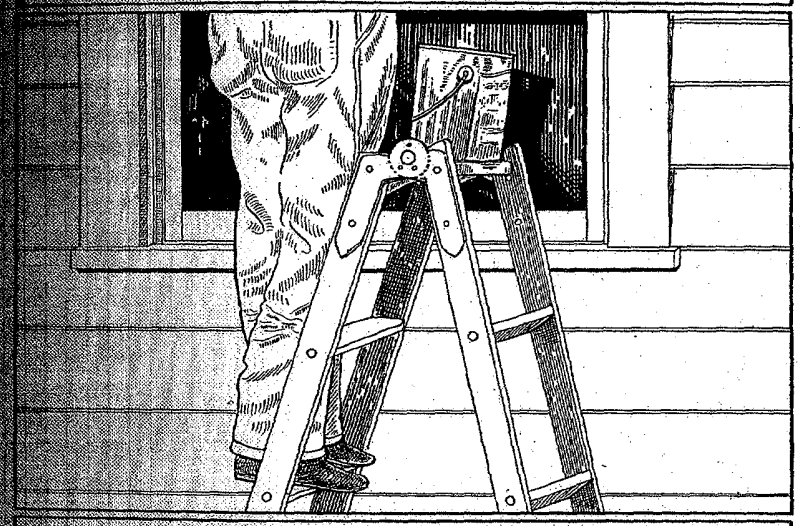
1930 (8)

Why some WOOD SURFACES HOLD PAINT *longer than others*



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WHY SOME WOOD SURFACES HOLD PAINT LONGER THAN OTHERS

By F. L. Browne, *Senior Chemist, Forest Products Laboratory,*[1] *Forest Service*

The impression has long prevailed that outside house paints must be mixed according to the kind of wood to be coated. Experimental study with the normal exterior exposure of painted softwoods—that is, wood cut from evergreen or coniferous trees—proves these traditional recommendations to be unnecessarily complicated. The painter need not change the composition of his priming-coat mixture for different softwoods; on the contrary, he may as well adopt a single formula for mixing the priming coat. To be sure, the paint when so applied will not last equally long on all woods, but the differences are not reduced materially by any practicable adjustment of the proportions of paint, oil, and thinner or of the kind of thinner in the priming coat.

Where abnormal conditions arise under which moisture in large amounts gains access to the backs of painted boards, paint coatings may fail by blistering and peeling or may be discolored with water-soluble materials leached from the wood. Paint trouble resulting from these abnormal conditions is not confined to any species of wood. Such trouble can be prevented only by discovering the source of the unusual amounts of moisture and removing it.

Painting Characteristics Depend on Wood Texture and Density

The painting characteristics of a board depend primarily upon the amount and distribution of summer wood in it. Summer wood is the dense, horny, dark-colored portion of the annual-growth ring, formed in the tree late in the growing season. It is made up of wood cells with very thick walls and small cavities and is in this sense much less porous than the spring wood, which is composed of cells with thin walls and correspondingly large cavities. Although liquids move more readily through the dense summer wood and paint oils are found to penetrate more deeply there, paint coatings do not seem to secure so firm an anchorage on summer wood as they do on spring wood; as a result, coatings exposed to normal conditions of weathering fail by flaking from the summer wood, leaving it bare while the spring wood remains apparently well covered. All native softwoods contain both summer wood and spring wood, but the proportions vary in different woods and in different boards of the same wood. There is, in fact, a greater variation in painting characteristics between the spring wood and summer wood in a single board than there is between average boards of different woods.

The density, or weight per unit volume, of a softwood board measures roughly its ability to hold paint coatings because boards are heavy or light according as they contain much or little summer wood. However, if a board has many annual-growth rings per inch it may have the summer wood confined to narrow bands and yet be moderately heavy. (Fig. 1.) Such boards hold paint far better than boards of equal weight cut from more rapidly grown trees, in which the summer wood is present necessarily in wide bands.

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Selecting Wood for Painting Characteristics

The following methods help in selecting the kind of wood that holds paint coatings most satisfactorily.

By Species

Since woods are marketed by species, this method is easier to follow but less effective and less economical than the other methods. In the Forest Products Laboratory's tests, the cedars, cypress, and redwood held paint best, and northern white pine, western white pine, and sugar pine did almost as well. With southern yellow pine and Douglas fir, which are abundantly available woods whose high strength makes them especially suitable for building construction, together with western larch, serious flaking of the coatings from the summer wood occurred sooner than with the other species tested. Western yellow pine, white fir, the hemlocks, and the spruces fell between the white pine group and the southern yellow pine-Douglas fir group.

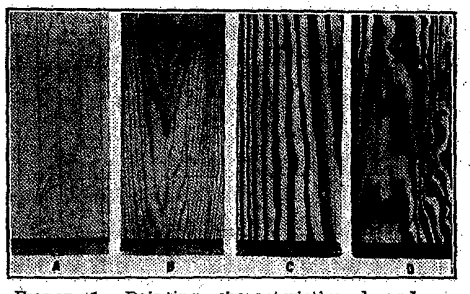

FIGURE 1.—Painting characteristics depend on wood texture and density. Boards A and B hold paint well, boards C and D poorly. Beneath each board is placed a small piece cut from the end and turned so that the annual growth rings can be seen on the end-grained surface. Board A had 36 annual rings per inch of radius of the log and at 6 per cent moisture content weighed 25 pounds per cubic foot; B had 27 rings and weighed 30 pounds; C had 6 rings and weighed 30 pounds; D had 15 rings and weighed 46 pounds

By Density and Texture

The wood of many species varies greatly in density and texture and therefore in painting characteristics. Thus, for example, when light, narrow-ringed boards are found in southern yellow pine or Douglas fir, they hold paint about as well as the wide-ringed boards of cypress, and light, narrow-ringed boards of western yellow pine behave like the white pines. Density and texture therefore afford the most satisfactory basis for selecting the best wood to paint, wherever it proves practicable to apply them.

By Grade

Knots and pitch play a large part in the grading of lumber. Since they give trouble in painting, the select grades of lumber, which permit few defects, are more satisfactory to paint than the common grades. Knots in the pines, both white and yellow pines, seem to be more objectionable from the point of view of painting than sound knots in woods like the cedars, the hemlocks, white fir, and larch.

By Kind of Grain

Edge-grained boards hold paint far better than flat-grained boards. (Fig. 2.) This is because the bands of summer wood in the edge-grained boards are cut in such a manner that they are as narrow as possible. Among flat-grained boards, those surfaced and painted on the bark side (the side nearer the bark of the log) are more satisfactory to paint than those turned pith side out because there is less danger of the "grain shelling out." (Fig. 3.) Even some woods that hold paint best may give difficulty with grain shelling under these circumstances. Like method 2, selection by the kind

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of grain is difficult to apply to the purchase of many kinds of lumber because only lumber cut from very large trees can be economically segregated according to such classifications.

Southern Exposure Is Hardest on Paint

Although the buyer of lumber in small quantities can seldom confine his purchases to the kinds of material that give best paint service, nevertheless he can sometimes distribute his lumber to best advantage among the various parts of his building. Some parts are more conspicuous or more severely exposed to the weather than others and the best lumber may be placed there. Paint wears out most rapidly where it is most directly exposed to sunlight, and the time for repainting the entire building is determined by the part on which the paint fails first. As a rule this is the south side, though local conditions, such as the shading by trees and neighboring buildings, may alter conditions greatly.

FIGURE 2.—Edge grain holds paint better than flat grain: A, Flat-grained panel showing failure of paint over summer-wood bands; B, edge-grained panel in a better condition than the flat-grained panel, but disintegration of paint over summer-wood bands is shown. This panel is of the same species of wood, paint, and age of paint coating as A

When to Repaint

Repainting should not be put off until the old coating has flaked badly and much bare wood is exposed. The old coating serves as the foundation for the new one, and if it is badly chipped and broken, customary methods of repainting do not secure a first-class appearance and a durable repaint job. Very often coatings fail to give adequate protection against weathering long before they flake noticeably. This is especially true of flat-grained boards of some species that hold paint well because of their low content of summer wood. Conspicuous wood checks or cracks show clearly that the wood is no longer receiving sufficient protection even though the coating is apparently intact. Repainting neither heals nor entirely conceals weathering damage that has become conspicuous, but if the wood is repainted promptly when minute wood checks begin to appear, it can be protected from weathering indefinitely.

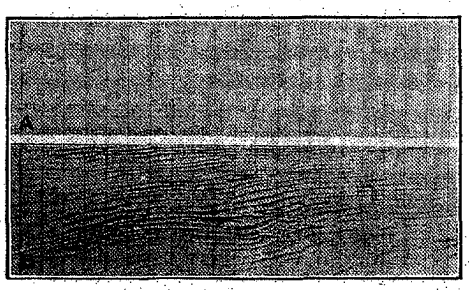

FIGURE 3.—Flat-grained boards surfaced and painted on the side nearer the bark of the log are more satisfactory to paint than those turned with the pith side out: A, Flat-grained board painted on the bark side showing a satisfactory coating; B, flat-grained board painted on the pith side showing paint failure as a result of the grain shelling out. This panel is of the same species of wood, paint, and age of paint coating as A

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How Properties of Wood Determine the Service Given by Exterior Paint Coatings

By F. L. Browne
Senior Chemist, Forest Products Laboratory, Madison, Wis.

PAINT makers have long recognized that exterior house paints made in accordance with the best technical standards of the industry vary widely in the service they will give on wood surfaces of different kinds, even though the painter applies them skillfully. However, there has been much uncertainty about the kinds of wood surfaces on which paint fails soonest and what can be done about it. Study of the painting characteristics of woods at the Forest Products Laboratory for more than six years has revealed the properties of wood that have most influence on paint behavior. The study indicates the direction in which improvement should be sought. The findings can be presented here to best advantage by first describing certain characteristics of wood and then discussing their bearing on paint service.

Classifications of Lumber by Species

Lumber is cut from trees of many different species and the grouping by species or closely related species is retained in merchandising because in general each species has more or less characteristic average properties and finds uses accordingly. A sharp distinction is made in practice between hardwood lumber, which comes from deciduous trees, and the softwood lumber from evergreen trees. Only softwoods need be considered here because the lumber used for the exterior of buildings is almost entirely of that kind.

In choosing lumber for a particular purpose, let us say house siding, paintability is only one of a number of factors to be considered, and not necessarily the most important one. Ability to stay in place, ease of working and of nailing, durability, cheapness and availability in the desired pattern must be given consideration varying with circumstances. No wood excels in all respects and none in common use is deficient in all of them.

Within each species there is a considerable range in properties, not only in lumber cut in different forest regions, but also in that from neighboring trees or even from different parts of the same tree. Consequently there is much overlapping in properties between species; for instance, dry western yellow pine is usually heavier than redwood and lighter than Douglas fir, but the lightest boards of pine weigh less than the heaviest ones of redwood and the heaviest boards of pine outweigh the lightest ones of fir. The painting characteristics depend largely upon such properties as density and therefore vary widely within species. From the technical point of view it is far more convenient in discussing painting characteristics to classify the woods according to their properties rather than by species, but the classification by species must be considered also as long as wood is bought and sold that way.

Classifications by Grade

In commerce, lumber of each species is subdivided into grades on the basis of the number and size of defects appearing on the surface of the boards. The highest grade admits only boards of clear lumber practically free from defects. Several of the higher grades are known collectively as the select grades; they contain only "lumber of good appearance and finishing qualities" and are the ones most likely to be used where painting is important. The common grades permit more defects and usually go into concealed parts of structures or are remanufactured, the defects being largely cut out.

The defects that have most influence on painting characteristics are knots, pitch pockets, pitch streaks, pitch, and loose grain.

Classifications by Grain

Wood has an oriented fibrous structure, that is, it has grain. Most of the fibers in a board are arranged parallel to the long axis of the tree or log from which the board is cut. Surfaces cut at right angles to the axis of the log cut through most of the fibers transversely and are known as end-grain surfaces. Only the ends of boards present end-grain surfaces.

A series of rough, concentric rings can be seen on the end of a log. They are the annual growth rings, one of which marks each year of the tree's life. Each annual ring in a softwood, or coniferous tree, consists of a soft, light-colored part termed the springwood, and a horny, dark-colored part termed the summerwood. If the principal surfaces of a board lie in planes that run approximately radially to the annual rings they are edge-grain surfaces and the board is an edge-grain board. Both surfaces of an edge-grain board are practically alike. If the principal surfaces of the board lie in planes approximately tangent to the annual rings they are flat-grain surfaces and the board is a flat-grain board. The two surfaces of a flat-grain board differ in important characteristics that will be pointed out later; the side that was nearer the bark of the log is the bark side, the other the pith side.

Lumber cut mostly from relatively small trees consists predominantly of flat-grain boards. In cutting lumber from large trees that yield a high proportion of clear lumber it is possible to turn out a predominance of edge-grain boards and to sell edge-grain lumber separately from mixed edge and flat-grain.

Heartwood and Sapwood

In many species the older wood nearer the center of the tree differs in color and in content of certain chemicals from the wood nearer the bark of the tree. The former is the heartwood, the latter the sapwood. Heartwood is usually less readily permeable to liquids than sapwood, often much more durable against decay, and is immune from blue stain fungi.

Select grades of lumber come from the outer parts of the log and therefore include much of the sapwood. Some species contain so little sapwood that there is little of it in clear commercial lumber, but other species contain much sapwood. In general there is more sapwood in lumber from small trees than from older and larger trees of the same species.

Microscopic Structure of Wood

The painting characteristics of wood are profoundly influenced by its porosity; from one-half to more than three-fourths of the volume of dry wood is air

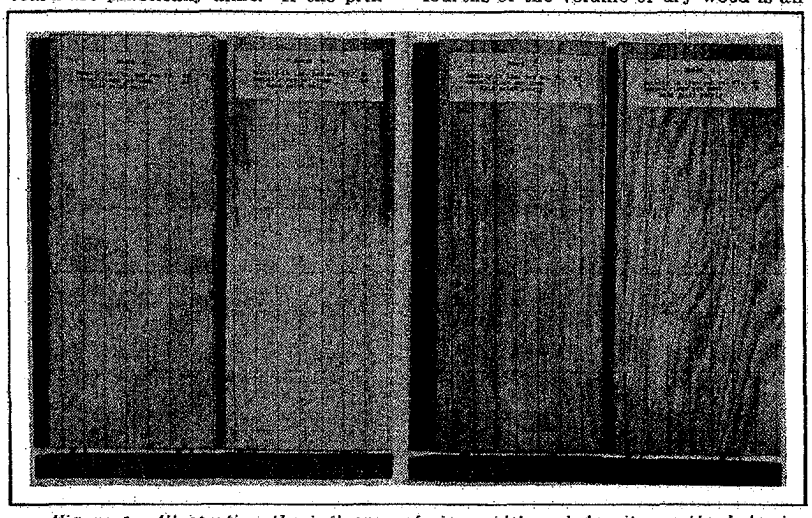

Figure 1.—Illustrating the influence of ring width and density on the behavior of paint coatings. The boards are all of the same species of wood, but Board A is both light in weight and narrow-ringed; Board D is heavy and wide-ringed; Boards B and C are equal in density, but Board B is narrow-ringed while Board C is wide-ringed.

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space. Wood structure is cellular, not labyrinthine, so that the porosity is more nearly like that of the honeycomb, in which there is no communication between cells, than like that of a heap of marbles or a bundle of rods, in which there is unobstructed, though much involuted passageway throughout the entire volume of enclosed air space.

The cellular elements of softwood structure consist very largely of tracheids, which are long, narrow tubes running vertically in the tree. They are roughly from 2 to 4 mm. long by less than 0.03 mm. wide. There are also shorter elements, termed the ray cells, which run along radii of the tree trunk and at right angles to the tracheids. Tracheids and ray cells are not merely bundled together; they are firmly embedded in a continuous matrix, the middle lamella, so that there are no spaces between elements through which liquids may move. The air enclosed in wood is mostly enclosed within the tracheids and wood cells. These cavities are not completely isolated from each other as in a honeycomb, however, because their walls are penetrated by small pits, covered by membranes, in which there are ultramicroscopic openings about 0.00002 mm. in diameter, large enough to permit liquids to pass slowly, but far too small to admit paint pigments.

In the pines, spruces, larches, and Douglas fir, there are scattered through the structure certain long channels, called resin ducts, running both vertically and radially. These afford long, relatively large passageways provided that they are not obstructed with resin. The true firs, hemlocks, cedars, cypress and redwood do not normally have such resin ducts.

Springwood and Summerwood

The reason why the annual growth rings are readily distinguishable in wood is clearly revealed in the microstructure because the tracheids of the springwood and summerwood differ strikingly from each other. In springwood the tracheids are roughly square in cross section, with thin walls and large voids; in summerwood the tracheids are flattened and have thick walls with small, thin voids. The enclosed air space in springwood occupies roughly 80 per cent of the total volume while in summerwood it amounts to somewhere near 40 per cent. Although summerwood has only half the capacity for holding liquids that springwood has, nevertheless liquids move through it much more readily than they do through springwood.

Pieces of wood differ widely in the width of their annual rings, usually expressed as number of rings per radial inch, and in the proportion of springwood and summerwood in each annual ring. If the tree grew rapidly, the annual rings are wide. A high ratio of summerwood to springwood makes wood heavy and strong. Ring width and proportion of summerwood are the most important determining factors in paintability.

Chemical Composition of Wood

The principal substances out of which the cellular structure of wood is built are probably identical in chemical composition in all woods and the proportions in which they occur vary only slightly between species, between springwood and summerwood, and between sapwood and heartwood. These chemicals will be spoken of collectively as wood substance.

Wood substance consists principally of cellulose and lignin. Cellulose is a very complex carbohydrate, essentially a polymer of sugar, into which it can be resoved by hydrolysis. Lignin is a very complex organic material, possibly aromatic in character, whose molecular structure is still a matter of speculation and which is very likely to prove a mixture of compounds rather than a pure substance.

The walls of the wood cells are made of the cellulose, which is present in thread-like fibrils woven together in spirals inclined more or less to the long axis of the cell. Part of the lignin is interspersed in this cellulosic fabric where it fills in the chinks between threads more or less completely. The rest of the lignin forms the middle lamella which is the matrix in which the wood cells are embedded.

Swelling of Wood Substance

Wood substance is a typical elastic jelly. It is not soluble in ordinary solvents and is inert toward linseed oil, turpentine, petroleum oils, and benzene. Many liquids are imbibed by wood substance which cause it to swell, and diffuse through it. Water is the most important of these liquids; others include methanol, ethanol, acetone, and some of the esters used as solvents or plasticizers for nitrocellulose lacquers. Wood substance imbibes and is swollen by these substances not only on contact with the liquids themselves but from contact with the vapors. The amount imbibed and the extent of the resulting swelling vary with the nature of the liquid or vapor and with the partial pressure of the vapor in the surroundings. Thus there is a definite equilibrium moisture content for wood substance at each relative humidity and temperature. Probably there is also a corresponding swelling equilibrium for wood substance also, but in practice what we observe is the change in dimensions of a piece of wood, not the swelling of the wood substance itself. Only a fraction of the total swelling expresses itself in a change in dimensions of the piece as a whole because much of it is absorbed in plastic deformation within the wood structure. As a result, both the magnitude of the gross change in volume and the amount of radial and tangential swelling (longitudinal swelling is small) vary markedly with the manner in which the change in moisture content is brought about as well as with the difference between initial and final moisture content. Still more important is the fact that such behavior as warping, cupping, checking, and weathering of wood depend more upon the manner in which changes in moisture content and in swelling take place than they do upon the amount of the changes concerned. Paint coatings, therefore, exercise a marked influence upon such behavior of wood even though they may not prevent change in moisture content from taking place.

Extractives in Wood

Besides wood substance, wood contains extraneous constituents which can be removed fairly easily by extraction with suitable solvents. These extractives are variable in nature and in amount, differing not only between species, but between different parts of the same tree. The extractives are conveniently classified into those soluble in organic liquids like ether and those soluble in water.

The ether-soluble extractive of longleaf and slash pines is a resin containing the volatile oil turpentine, which consists mostly of terpene hydrocarbons, and the non-volatile substance rosin, which consists largely of abietic acid. The other pines and Douglas fir contain resins of similar composition. Other softwoods contain such resins only in small amounts if at all, except when they occur in local deposits in the tree like pitch pockets. Western red cedar, redwood, the true firs, hemlocks, spruces, and larches ordinarily contain only small amounts of ether-soluble extractives. Port Orford cedar, eastern red cedar, Alaska cedar, and cypress contain characteristic oils soluble in ether but quite different in chemical nature, lacking an acidic substance analogous to rosin.

It is known that heartwood and sapwood may differ materially in the amount and particularly in the composition of the extractive present. It is not known whether there is more or less extractive present in summerwood as compared with springwood.

The water-soluble extractives include tannins and other complex organic substances of an aromatic nature, some of them highly colored; carbohydrates; organic acids like formic, acetic, and their homologs; traces of organic nitrogen compounds, and mineral constituents of wood ash. The amount and nature of these extractives vary widely between heartwood and sapwood and, in some species at least, in the heartwood from different parts of the same tree. During the drying of wood, under some circumstances, these extractives may tend to concentrate at the surfaces.

Object of Painting Wood

The painting characteristics of wood must be considered with due regard for the object for which wood is painted. Painting is done to secure and maintain a desired appearance on surfaces exposed to view. There are at least three factors in appearance, namely, color, texture, and line. Exterior wood surfaces must be kept painted wherever color with smooth texture and straight, snug lines are desired; they may be kept varnished where the natural wood color and grain together with smooth texture and snug lines are wanted; they may be kept stained or thinly painted where color with rough texture and broken lines are preferred; and they may be left without surface treatment where the neutral color, shaggy texture, and irregular lines of weather-beaten wood give the effect selected. In general, architectural considerations dictate that different patterns of lumber be used according to the effect desired. Thus siding nailed with the planed side out is almost always painted when any pretense of keeping up appearances is made, but if nailed sawed side out or if shingles are used, the surface is rarely painted and may either be stained or left to weather naturally.

In considering painting, therefore, we are striving to maintain a colored, opaque coating intact, presenting a smooth surface, with straight, snug lines. The effect is marred if the smooth wood surface is permitted to check badly or roughen by weathering, for ordinary painting does not restore a surface with smooth texture. Like-

wise warping, cupping, and loosening of the boards must be prevented if snug lines are to be retained. The paint coating must therefore protect the wood against weathering to keep up the desired appearance.

Influence of Wood Properties During Application of Paint

The first coat of paint applied to new wood is very largely consumed in filling the voids, leaving a level, nonabsorptive surface on which subsequent applications can build a coating. However, even though one-half to three-fourths of the volume of wood is void, a comparatively small amount of paint is required for priming it. A plaster wall takes two or three times as much paint as wood. The cellular structure of wood in contrast to the granular structure of plaster accounts for the difference, because in wood, penetration beyond the voids in those cells cut open in making the surface can take place only through the very fine openings in the pit membranes.

End-grain wood surfaces consume much more paint than edge or flat-grain surfaces because the long tracheids stand at right angles to them. However, not much end-grain wood need be painted. There is little if any difference in the consumption of paint between edge and flat-grain surfaces. Light wood, with its greater content of voids, consumes measurably more paint than heavy wood, though the difference is not much greater than the individual variation between painters in applying paint and it is largely compensated if the customary recommendation is followed of mixing the priming coat relatively richer in turpentine than in linseed oil for heavy woods than for light ones. Undoubtedly there would be a marked difference in spreading rate of paint between springwood and summerwood if we had the two kinds of surfaces to paint separately.

The liquids of paint penetrate more deeply into wood than do the pigments, as can be proved by adding an oil-soluble red dye to the paint before application and later examining the depth to which the red color penetrates. The ratio of solids to liquids in the paint remaining at the surface is thereby upset, so that a paint that dries with a glossy film on glass or metal, dries with a dull film on wood. Judged by the effect on gloss, more oil is thus filtered off in springwood than in summerwood, but penetration is found to be deeper in summerwood. The paradox is not mysterious, for the void capacity of summerwood is only half that of springwood.

Penetration of oil as deeply as possible has long been held desirable in painting wood. There seems to be no good reason for so believing, however, because paint fails soonest on the summerwood, into which oil penetrates deepest.

Extractives present in cypress and redwood tend to retard the drying of some paints on these woods, especially in the presence of much moisture or low temperatures. The fact is of no serious practical import, for experiment proves that coatings applied to these woods under conditions giving pronounced retardation of drying cannot be distinguished in later exposure from coatings applied under good drying conditions. From the point of view of theory, however, the fact is probably significant, for these woods are among those upon which paint coatings last longest even when they have rather wide bands of summerwood.

Normal and Abnormal Conditions of Exposure

In considering the behavior of paint coatings on wood, sharp distinction must be drawn between normal and abnormal conditions of exposure. Under normal conditions moisture in large

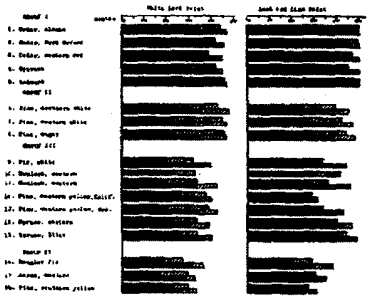

Chart 1.—Representing for the different woods the average time elapsed before repainting was needed to maintain (a) the integrity of the coating, (b) adequate protection against wood weathering. For each species the upper half of each bar represents flat-grain panels, the lower half edge-grain panels, except that for eastern hemlock only flat-grain panels were tested. The whole length of the bar, that is, the solid plus the cross-hatching, represents the time for repainting when coating integrity only is considered; the solid part alone represents the time for repainting when protection of the wood is considered also.

amounts gains access only to the painted surface for short times during wet weather. Under abnormal conditions much moisture gains access to the backs of the painted board, usually for fairly long intervals. The results of abnormal conditions will not be discussed here; it need only be said in passing that trouble from abnormal conditions may be experienced with any kind of paint, on any kind of wood, and may arise very early in the coating's history. The failure may take one or more of several forms. The coating may blister and peel, forms which are easily recognized, or it may scale, a form which is often hard to distinguish from scaling under normal conditions with some paints. The coating may become discolored with water-soluble extractives from the wood or with dirt and stains carried by the water from other sources within the structure. The coating may become discolored by blue stain fungi growing in sapwood, and finally, under prolonged or repeated exposure to abnormal conditions, the wood beneath the coating may rot.

Early Part of Normal Exposure Not Influenced by Wood

Under normal conditions of exposure the behavior of paint coatings during the early part of their service life is not materially influenced by the kind of wood surface upon which they are applied. The rate of loss in gloss, the collection of dirt, the development of chalking and fading, the time when paint checking begins, and the distinctive pattern of the checking depend upon the kind of paint, the climate, the local conditions of exposure, and perhaps to some extent upon the manner of application, but they are not influenced to any important extent by the wood.

By way of exception to this generalization it may be said that occasionally chalking and fading proceed more rapidly over springwood than over summerwood, so that the grain of the wood is revealed by the appearance of the coating over it. Such behavior is here regarded as due to inadequate priming and, therefore, to poor craftsmanship in painting, because well-painted surfaces do not so behave. Further exception may be made of loose grain appearing on flat-grain boards that are turned pith side out, which will be discussed later.

The nature of the wood surface begins to influence the behavior of coatings when they reach the point in their deterioration at which they no longer protect the wood adequately against weathering and when they begin to disintegrate by crumbling, flaking, or scaling, leaving parts of the wood surface bare. From this point on, under present painting practices, it may fairly be said that the kind of wood surface rather than the composition of the paint dominates the behavior of the coating and determines when repainting is in order.

Influence of Wood on Ultimate Failure of Coatings

Paints as we now use them fail ultimately either by (1) inadequately protecting the wood so that it begins to weather, check, cup, warp, or pull away from fastenings, or (2) crumbling, flaking or scaling, leaving parts of the

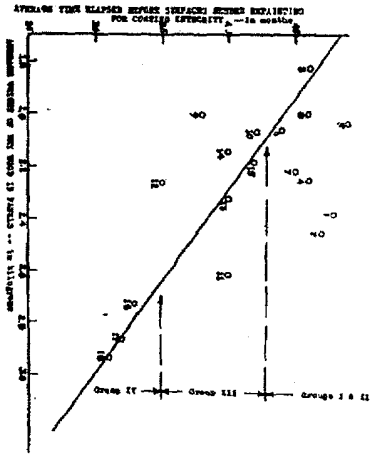

Chart 2.—The relation between repainting time and weight of dry wood in the panels tested for the different species. The key to the number is given in Chart 1.

wood bare. As would be expected, the wood surfaces on which failure by inadequacy of protection is first noticed are the surfaces having the greatest tendency to develop weathering defects. Failure of the coating to remain intact starts over the summerwood and a stage is usually reached, if the exposure continues long enough, when all the summerwood is bare while the springwood remains covered. The amount and dis-

tribution of summerwood is, therefore, the predominant influence in failure of the coating to remain intact.

Influence of Species

Chart 1 summarizes the results by species of an extensive series of field tests by the Forest Products Laboratory. Two kinds of paint were used, for each of which a separate tabulation is made. There is far more difference in the life of coatings of the same kind of paint on different woods than between the two paints on any wood.

The woods are divided into four groups on the basis of the results in this test: I, those woods on which paint protected and remained intact longest; II, those on which it remained intact but failed sooner in protection than was found for Group I woods; III, those on which paint failed in both protection and integrity sooner than on Group I woods; IV, those on which paint failed soonest, especially in integrity.

Density and Ring Width

Chart 2 shows that the classification by species follows fairly closely the average density of the species. A still closer parallel would be brought out if the chart could show ring width as well as density in their bearing on the results. The photograph, Figure 1, illustrates how ring width modifies density in determining coating integrity. The four boards shown are all flat grain and of the same species of wood. They were taken from paint test panels and planed to remove the remnants of the coatings and reveal the nature of the surface. Boards A and B held paint well, boards C and D poorly. Board A is both light in weight and narrow-ringed; Board D is heavy and wide-ringed. Boards B and C are equal in density, but B is narrow-ringed while C is wide-ringed.

As already pointed out, there is much variation within many species in density and ring width and it follows that there is a corresponding variation in painting characteristics. Density and ring width consequently are a far more precise guide to paintability than species, but woods are bought and sold by species and not by density and ring width.

Direction of Grain

Chart 1 shows that edge-grain boards are far superior to flat-grain boards, both because they require less protection against weathering and because they display their summerwood in narrow lines rather than in flaring areas and hence hold coatings intact longer.

The bark side of flat-grain boards is far superior to the pith side in many species because there is a tendency for the grain to shell out on the pith side. This is a form of wood weathering against which paint should, theoretically, afford protection. In practice, however, paint as we now use it proves inadequate. Flat-grain boards should therefore be turned bark side out.

Influence of Grade

Knots are objectionable in painted surfaces because they do not remain perfectly concealed, either because they do not remain level with the rest of the surface, because they sometimes cause the coating over them to turn yellow, because the wood of the knot may crack, or because the paint may scale over the knot. Pitch pockets and pitch streaks lead to objectionable exudation of pitch through coatings. For these reasons high-grade lumber of any species is better for painting than the lower grades.

Influence of Extractives

The position of cypress and redwood in Charts 1 and 2 seems to be more favorable than their density and ring width would predict. It has already been mentioned that these woods contain extractives that retard drying under certain circumstances and it is plausible to consider these substances as inhibitors of oxidation exercising a favorable influence on the maintenance of coating integrity.

A careful examination of Chart 1 shows that woods containing a resin

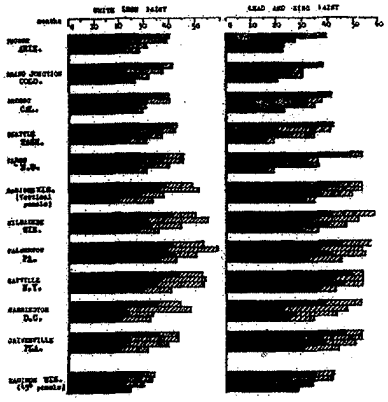

Chart 3.—Illustrating the influence of climate on the behavior of paint coatings. Each bar is divided into four parts representing respectively, beginning with the upper part, the behavior of coatings on woods of Group I, Group II, Group III, and Group IV. The whole length of the bar, that is the solid plus the cross-hatching, represents the average time elapsed before repainting was needed when coating integrity alone was considered; the solid part represents the time for repainting when protection of the wood was considered also.

with an oil-soluble acid like rosin compare with the other woods more favorably in maintenance of coating integrity for white lead paint than in integrity for lead and zinc paint. This is in line with the familiar evidence that paints containing zinc oxide are adversely affected by acids present in linseed oil.

Influence of Climate

Chart 3 shows that climate profoundly influences the durability of paint coatings, as has long been realized, but the differences between woods remain much the same. However, the amount of difference between woods of the four classes is less in the more humid climates than it is in the drier ones.

Influence of Paint Composition

The Forest Products Laboratory has tried various expedients in priming-coat procedure that have been recommended for obtaining better results on wood surfaces containing much summerwood. The proportions of turpentine and linseed oil in the priming coat have been altered greatly, thinners like benzol have been used in place of turpentine, and special priming-coat paints have been used. All but one of these expedients have either failed to alter the behavior of the coatings or have led to earlier loss of coating integrity. Aluminum paint used as a priming coat under white lead or lead and zinc paint materially prolongs the life of the coating both in protective power and integrity, but the ultimate failure takes place by flaking from the summerwood just as it does when the paints are applied in the customary fashion.

The Forest Products Laboratory has also tried a number of supposedly harmful painting practices, such as painting wood at high moisture content (not containing free water, however), painting in humid atmospheres and in the absence of sunlight and allowing short times for drying between coats. The results seem to indicate that the bad effects of such factors in paint application have been greatly exaggerated.

Problem for Future Research

The variability in behavior of paint coatings on wood surfaces of different kinds is the wood-painting problem that must be solved before consumers of paint and of lumber can be given better paint service. To some extent selection of lumber in accordance with its painting characteristics can be practiced but improvement in this direction is limited by the facts that in choosing wood for any purpose other factors must be considered besides paintability and that most of our available lumber supply is of the kinds that contain much summerwood. Furthermore, second-growth woods are likely to be less desirable in respect to painting than the virgin stands because the trees will usually be grown more rapidly and will be cut younger. It is conceivable that some means of treating lumber to improve its painting characteristics may be invented, but there is no reason for regarding that point of attack on the problem as particularly hopeful. Improved paint or painting technique seems much more likely to furnish the solution.

A coating that would endure indefinitely is probably a vain objective and perhaps not an altogether desirable one, for most people would like to change their scheme of decoration once in a while. The ideal coating for wood, however, ought to remain an adequate protective agent against wood weathering until its appearance is so changed that repainting is clearly necessary and it ought to wear down uniformly over summerwood and springwood alike, being firmly anchored to all parts of the wood when repainting is done. Flaking from summerwood should be unknown. With such a paint, all wood surfaces would give equally satisfactory paint service.

The attainment of an ideal paint of this kind is an ambitious but by no means unpromising objective. As we see it, the problem is one of securing firmer and more permanent adhesion between coatings and wood. Probably at present aged coatings cling to wood by mechanical embedding in the rough surface, much as plaster grips lath. Summerwood, with its low void volume and very small voids, offers an uncertain support for adhesion of that kind. A true adhesion between wood substance and the matrix of the paint coating is called for. Glue sticks to summerwood, why cannot paint be made to do so? The Forest Products Laboratory proposes to seek true adhesion between paint coatings and wood and invites the co-operation of the technical men of the paint industry in that quest.

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Developments in the Stabilization of Painting Practice for Wood

By F. L. Browne,[1] Madison, Wis.

Painting practice is changing from a craft to a part of engineering. The Forest Products Laboratory has tested the painting characteristics of softwoods. The tests included edge-grain and flat-grain boards, light woods consisting mostly of spring-wood and heavy woods with wide bands of summer-wood, white lead and prepared paint, various combinations of paint, linseed oil, thinner, and drier for the priming coat, and aluminum paint as a first coat. Conditions of dryness and of humidity entered into the tests. The basic factors responsible for the chief uncertainties of paint behavior were studied, and the way is pointed for a possible stabilization of painting practice for wood through further research.

Painting practice is in course of transition from a craft to a part of engineering. (1)[2] The breakdown of the apprenticeship system, the multiplication of new materials available for painting, the increasing variety of the surfaces to be painted, the accelerating tempo of building and manufacturing operations, and the rising standards of acceptable service have overwhelmed the old-fashioned painter. However, the engineer is not yet fully prepared for his new responsibilities because the background of technical data on painting practice is fragmentary and largely unreliable, and means of measuring the serviceableness of paint coatings is lacking. A specification for a durable exterior paint finish cannot be written with the same assurance of success that is possible in designing a structure to carry a given maximum load. Quality in a paint job is judged primarily by the costliness of the materials and the labor of applying them rather than by dependable yardsticks of performance.

Under the circumstances it is not surprising that painting practice is far from stabilized. Many kinds of paint are sold for similar uses, and opinions about their relative merits differ bewilderingly. Details of applying paint vary widely. New woodwork is sometimes painted with two coats, sometimes with three. Admixtures of oil, thinner, and drier are variously recommended. There is uncertainty about the limitations of weather, condition of the surface, and drying time between coats within which painting may be done safely. When paint jobs turn out unsatisfactorily, the cause of failure is frequently difficult to determine. All too frequently coatings give way soon after they have been applied, even though conscientious efforts were made to do first-class work. When reasonable length of service is attained, it is difficult to determine when a coating ceases to function properly and requires renewal. Opinions then differ about the way to prepare the surface for repainting and how to repaint it.

A major source of confusion about painting practice for exterior woodwork arises from the marked variation in durability of coatings on different kinds of wood. The fact has long been recognized, but statements about the kinds of wood that give good or bad service and what should be done about it have been strikingly contradictory. Some have thought that certain woods are inherently lacking in paintability and should not be used in places where painting is important. Others have held that each kind of wood requires an appropriate adjustment of the proportions of pigment, oil, and thinner in the priming coat, but the formulas for each kind of wood have never been stated definitely, that being left to the painter's judgment. Still others have maintained that for some woods the turpentine in the primer should be replaced by volatile liquids of greater solvent power. Many special priming paints have been proposed for use on woods upon which paints fail soonest.

Forest Products Laboratory Tests

To provide reliable information about such moot questions the Forest Products Laboratory in 1924 began an experimental study of the painting characteristics of softwoods. (2) Test fences were established at 11 places in the United States representing a great range in climates. On the fences, panels of 18 species of softwoods were exposed and painted. In general, at every station there were four panels of each species, two made with flat-grain boards and two with edge-grain boards. Of these one panel of flat-grain and one of edge-grain boards were painted with three coats of white-lead-paste paint and the other two panels with three coats of lead and zinc prepared paint.

In the 1924 tests no attempt was made to adjust the proportions of pigment, oil, and thinner in the priming coat according to the kind of wood painted. All woods were painted in exactly the same way. The mixtures of white-lead-paste paint were:

	First coat	Second coat	Third coat
Paste white lead (92 per cent pigment), lb	100	100	100
Raw linseed oil, gal	4	1½	3½
Turpentine, gal	2	1½	1
Paint drier, pt	1	1	1

The lead and zinc prepared paint consisted of:

Pigment, 64 per cent by weight, composed of:	Per cent by weight
Basic carbonate white lead	60
Zinc oxide	30
Asbestine	10

[1] Senior Chemist, Forest Products Laboratory, maintained at Madison, Wis., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Wisconsin. Dr. Browne joined the staff of the Forest Products Laboratory in 1918, when he engaged in developing water-resistant glues, particularly for use in aircraft. When investigations of wood finishing were begun in 1922, he was placed in direct charge of the experiments. He is a graduate of the course in chemistry at Cornell University and obtained the doctorate at the University of Wisconsin in colloid chemistry. He is a member of the American Chemical Society and of the Society of Sigma XI, a fellow of the American Association for the Advancement of Science, and an assistant editor of *Chemical Abstracts*.

[2] The numbers in parentheses throughout the paper refer to the List of References at the end.

For presentation at the Fifth National Wood Industries Meeting, New York, N. Y., Oct. 16 and 17, 1930, of The American Society of Mechanical Engineers. All papers are subject to revision.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

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Vehicle, 36 per cent by weight, composed of:	Per cent by weight
Raw linseed oil	90
Turpentine	5
Liquid drier	5

For the priming coat $1^1/_4$ pints of raw linseed oil and 2 pints of turpentine were added to a gallon of this paint. For the second coat $2^1/_2$ pints of turpentine were added to a gallon. For the third coat the paint was applied without any addition.

All test stations were visited at least once each year by the same inspector. During the first year or so the appearance of the paint coatings changed materially. (3) The gloss faded, the white surfaces became dirty, then the coatings began to disintegrate at the surface in the form of a fine powder and some of the dirt became dislodged, and finally the coatings began to check in fine, presumably superficial fissures. There were interesting differences in appearance between coatings of the two kinds of paint and between the different exposure stations, but the kind of wood beneath the coating had very little effect upon its appearance. However, as the tests continued, other changes set in that varied markedly with the kind of wood. These changes were of two sorts; namely, in the integrity of the coating, and in that of the wood itself. Sometimes deep slits developed in the coating at the edge of which the coating curled up and broke off in little pieces, laying the wood beneath bare. Sometimes paint checks finally became deep, interlacing cracks, and little areas of coating outlined by the cracks fell off bodily, leaving the wood bare. Such changes were recorded as deficiencies in the integrity of the coating. But sometimes checks opened in the wood where otherwise the coating seemed to be intact. Such changes were recorded as inadequate protection by the coating against wood weathering.

Results of the 1924 Tests

The most important facts revealed by the 1924 tests were the following: (4)

Summer-Wood and Spring-Wood. The variable behavior of paint coatings on the softwoods is due primarily to difference in behavior on summer-wood and spring-wood. Failure of aged coatings in integrity usually begins over summer-wood long before it sets in over the neighboring spring-wood, and therefore failure in coating integrity proceeds most rapidly on boards that contain the greatest amount of summer-wood.

Summer-wood is the harder, darker-colored part of the annual growth ring in the wood. Structurally it differs from spring-wood in that the wood cells are flattened and have thicker walls and smaller cavities than the wood cells in spring-wood. Summer-wood is roughly three times as heavy as spring-wood. Experience in impregnating wood with liquids proves that the heavy summer-wood is more easily and deeply penetrated by liquids than the light spring-wood. Experiment proves that the liquids in oil paint follow the same general rule and penetrate more deeply into summer-wood than they do into spring-wood, although there has long been a contrary impression among painters. The pigments of oil paint are too large to penetrate beyond the cavities of those wood cells that were cut open in forming the surface of the board. Like other liquids, resins exude more easily from summer-wood than they do from spring-wood, but there is no evidence that summer-wood actually contains more resin than spring-wood.

Aged coatings apparently do not adhere to wood substances as glue does, but cling to the wood by a mechanical embedding of the paint in the open cell cavities at the surface, much as plaster clings to lath. Summer-wood, with its small cavities, furnishes inadequate anchorage so that small pieces of aged coating easily become detached and fall off. However, if the band of summer-wood is very narrow, the little pieces of coating may retain sufficient grip in the spring-wood on either side to remain in place, arching over the summer-wood.

Some Woods Require More Effective Protection Than Others. A second factor causing variable behavior of coatings on softwoods is the fact that some woods require more adequate paint protection to prevent wood-checking, which is the first sign of wood weathering. (5) Test panels were often observed in which the wood had begun to check although the coating otherwise seemed to remain intact. The woods on which this happened were the kinds that quickly develop conspicuous checks and cracks when exposed to the weather without paint protection. Frequently the wood checks became centers from which failure of the coating in integrity progressed.

Edge-Grain and Flat-Grain Boards. Coatings remain intact longer on edge-grain boards than they do on flat-grain boards of otherwise similar wood. The difference in behavior is accounted for by the disposition of summer-wood at the surfaces of the two kinds of boards. Since the surface of an edge-grain board lies roughly in a plane along a radius of the tree, the bands of summer-wood are reduced to the narrowest width possible. The surface of a flat-grain board, on the other hand, is in a plane approximately tangent to some of the growth rings of the tree, so that the bands of summer-wood at the surface of the board may flare out into large areas.

Edge-grain boards weather-check less easily than flat-grain boards, doubtless because they swell and shrink less in width, and therefore coatings continue to furnish sufficient protection longer on the edge-grain boards.

Bark Side and Pith Side of Flat-Grain Boards. One side of a flat-grain board is always nearer the bark and the other nearer the pith of the tree from which it was cut. The bark side makes a better surface for painting than the pith side. On the pith side of some boards the summer-wood of one annual ring may separate from the spring-wood of the next ring and curl upward in a sharp, easily splintered edge. Paint coatings are often unable to prevent such grain shelling, and consequently the coating may be badly disrupted.

Density and Ring Width. Since summer-wood is much heavier than spring-wood, the density of a piece of softwood is a fairly good measure of the proportion of summer-wood in it and therefore of its painting characteristics. Paint fails sooner on heavy boards, because they contain more summer-wood than light ones. However, another factor must also be considered—namely, the width of the annual growth rings (usually recorded as the number of rings per radial inch of the log). When the growth rings are narrow (many rings per inch), there may be a fairly high proportion of summer-wood, and yet the bands may be narrow. Such wood holds paint better than wood of equal or slightly lower density in which the growth rings, and consequently the bands of summer-wood, are wide.

The lumber of many species varies widely in density and in ring width, and the painting characteristics vary correspondingly. Any classification of species with respect to painting characteristics is therefore a rough approximation at best and involves much overlapping; that is, light, narrow-ringed boards of a given species may be superior, from the point of view of painting, to heavy or wide-ringed boards of species assigned higher positions in the classification. In general, edge-grain boards of any species are as good or better for painting than flat-grain boards of the species assigned to the next higher class. Subject to these reservations, the softwoods were classified for painting characteristics on the basis of the 1924 tests as set forth in Table 1, which lists also the relative amounts of the species cut into lumber in 1927.

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Lumber Grade and Knots. The principal defects that form the basis for grading lumber are disadvantageous from the point of view of painting. Coatings over knots often discolor, crack, and fall off, and the wood of the knots checks conspicuously. Pitch often exudes through coatings over pitch pockets, pitch streaks, or pitchy wood. Low-grade lumber is therefore less desirable for painting than high-grade lumber of the same species unless the low-grade lumber is remanufactured in such a way that the defects are cut out. Even then the advantage may still lie with the high-grade lumber, because as a rule the high-grade lumber is cut from the outer portions of the log where the growth rings are usually narrower than they are nearer the center of the log.

TABLE 1 CLASSIFICATION OF WOODS FOR PAINTING CHARACTERISTICS AND THE ANNUAL PRODUCTION OF THESE WOODS AS LUMBER

Classification, Using U. S. Forest Service Common and Botanical Names	Percentage of all softwood lumber cut in 1927
Group 1—Woods on which coatings served longest, both in integrity and in protection:	
Cedar, Alaska; *Chamaecyparis nootkatensis*	1
Cedar, Port Orford; *Chamaecyparis lawsoniana*	
Cedar, Western red; *Thuja plicata*	
Cypress, Southern; *Taxodium distichum*	2
Redwood; *Sequoia sempervirens*	2
Group 2—Woods on which coatings failed in protection sooner than on woods of Group 1:	
Pine, Northern white; *Pinus strobus*	5
Pine, Western white; *Pinus monticola*	
Pine, sugar; *Pinus lambertiana*	1
Group 3—Woods on which coatings failed in both integrity and protection sooner than on woods of Group 1:	
Fir, white; *Abies concolor*	1
Hemlock, Eastern; *Tsuga canadensis*	7
Hemlock, Western; *Tsuga heterophylla*	
Pine, Western yellow; *Pinus ponderosa*	10
Spruce, Eastern; *Picea spp.*	2
Spruce, Sitka; *Picea sitchensis*	
Group 4—Woods on which coatings failed soonest, especially in integrity:	
Douglas fir; *Pseudotsuga taxifolia*	30
Larch, Western; *Larix occidentalis*	1
Pine, Southern yellow; *Pinus spp.*	38

Heartwood and Sapwood. Few differences in the behavior of coatings on heartwood and sapwood have been observed so far. In the few cases that have occurred, the advantage has sometimes been with the heartwood and at other times with the sapwood.

Extractive Substances Characteristic of Species. Although the primary cause of variation in the behavior of coatings on different species is found in the amount and distribution of summer-wood, a factor of secondary importance is the presence in certain woods of characteristic substances that can be separated from the woods by extraction with suitable solvents. Thus cypress and redwood each contain a substance peculiar to the species that affects the behavior of paint. When paint is applied to either of these woods while they are wet with water, the coatings will not harden until the moisture content has been reduced to a reasonable amount. On the other hand, coatings cling to the summer-wood of redwood and cypress somewhat longer than they do to the summer-wood of most other species. It seems likely that the extractives in redwood and cypress have a favorable effect on the durability of coatings.

All pines contain rosin or a similar oil-soluble acidic substance. Free organic acids in linseed oil are known to be harmful to paints containing zinc oxide, but not so harmful to straight white-lead paint. It was therefore to be expected that the lead and zinc paint would not prove quite so durable on the pines as it did on other woods of similar density and ring width, but that no such differences between pines and other woods should be observed in the case of the straight white-lead paint. The results of the tests confirmed this expectation.

Results in Different Climates. The same classification of the woods was found to apply in all climates, but the extent of variation differed materially. In climates where there are long periods of extreme dryness, failure of coatings by sloughing bodily from summer-wood takes place most rapidly and most characteristically. Such conditions accentuate the discrepancies in behavior on different woods. Where the humidity rarely falls very low, coatings cling longer to the summer-wood, the paint itself has more chance to disintegrate or wear away, and the difference between species is somewhat less marked.

Of the two paints used in the tests, one proved distinctly superior to the other on all woods in arid climates, but just as definitely inferior on all woods in the warm, humid climate of Florida. In the intermediate climates one paint often proved the more durable on the pines, while the other lasted longer on woods other than the pines.

The 1925 Primer Tests

A second series of tests was started in 1925 to determine how far the durability of coatings on woods containing much summer-wood can be improved by altering the proportions of pigment, oil, and thinner in the priming coat, by replacing turpentine with special solvents, or by using special priming paints. The test panels were divided into two halves, of which one was painted by the standard procedure followed previously in the 1924 tests, while the other half was painted by one of the special procedures to be studied. Thus comparison of new and old procedure could always be made on the same boards. The woods studied in 1925 were Southern yellow pine, Douglas fir, Western larch, Western yellow pine, Eastern hemlock, Western hemlock, and Southern cypress.

Results of the 1925 Tests

The following results were obtained in the 1925 tests: (6)

Proportions of Oil and Thinner in the Primer. In spite of the old and widely accepted tradition that the durability of paint coatings on woods containing much summer-wood can be improved by mixing the priming coat with more than the usual amount of turpentine (and correspondingly less oil and pigment), the tests proved that the priming-coat proportions have very little effect upon the serviceableness of the coatings. If the comparisons had not been made on the same boards, no differences at all would have been detected. As it was, the durability of the coatings with turpentine-rich primers was judged slightly inferior to that with the standard primer; clearly the comparisons between species made in the 1924 tests would not have been altered in any way by changing the proportions of the priming-coat ingredients.

The result of these experiments is reasonable. Thinning with turpentine is usually recommended in the belief that deeper penetration of the paint oils will secure firmer adhesion of the coating. However, penetration to begin with is deeper in summer-wood, from which coatings come loose first, than it is in spring-wood, to which coatings cling longer. The theory is therefore discredited at the outset.

Special Solvents as Paint Thinners. Replacement of turpentine with volatile liquids that are better solvents for the oils and resins in some woods has been recommended as a means of improving paint service. Three series of experiments have been made by the Forest Products Laboratory to test the theory. The volatile liquids included gum spirits turpentine, steam-distilled turpentine, destructively distilled turpentine, turpentine oxidized by bubbling air through it, petroleum distillates ranging in volatility from gasoline to kerosene, petroleum distillates from four types of crude oil, benzol, and coal tar naphtha.

Tests were made on Southern yellow pine, cypress, and Eastern hemlock.

The effects of varying the volatile liquid were in all cases so slight that they can be of interest only from the point of view of theory. None of the liquids gave better results than turpentine on any wood. There were indications that oxidized turpentine added slightly to the durability of the coatings. The beneficial effect of turpentine must therefore be attributed to the nonvolatile residue left when turpentine evaporates in the presence of oxygen or to a desirable alteration in the drying of linseed oil in the presence of the turpentine product.

Special Priming Paints. Five special priming paints were studied in the 1925 series of tests. Of these two had very little effect on the behavior of the coatings and two proved definitely harmful to the durability. The fifth primer, aluminum paint, materially retarded the loosening and detachment of coatings from summer-wood and thereby prolonged the life of coatings

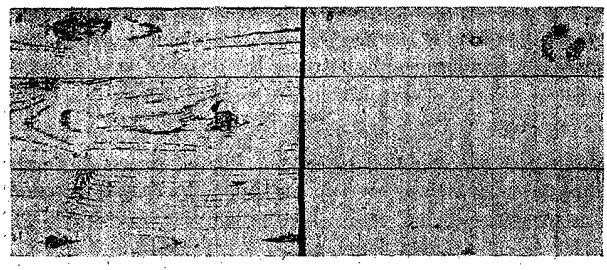

FIG. 1 CHARACTERISTIC FAILURE OF A PAINT COATING BY FALLING OFF THE SUMMER-WOOD AND THE BENEFICIAL EFFECT OF ALUMINUM PRIMER IN RETARDING SUCH BEHAVIOR

(The left-hand part of the panel, marked *A*, was painted according to the usual procedure of applying three coats of prepared paint, of which the first contained a little extra linseed oil and turpentine. The right-hand part of the panel, marked *B*, received first a priming coat of aluminum paint, followed by exactly the same second and third coats of paint that were applied on *A*.)

on woods containing much summer-wood. Fig. 1 illustrates the improvement in paint service brought about by priming with aluminum paint.

Aluminum priming paint (7) is made by adding polished aluminum bronze powder to a suitable liquid just before it is to be applied. From $1^1/_2$ to 2 lb. of the powder is stirred into the liquid; grinding in a paint mill is neither necessary nor desirable. The liquid should be either a kettle-bodied linseed oil thinned to suitable viscosity with paint thinner and drier or a long oil spar varnish (at least 80 gal. of oil per 100 lb. of resin). Ordinary spar varnish may be mixed with boiled oil, but the cost is likely to be greater. Aluminum priming paint must be thoroughly dry before the top coats of paint are applied over it.

Other priming paints or priming procedures have been suggested in recent years. Some of them are being tested by the Forest Products Laboratory or by paint manufacturers. (8)

ABNORMALLY EARLY PAINT FAILURES ON HOUSES

Much uncertainty about painting practice has arisen in the past because paints that give excellent service when exposed on test fences sometimes fail in an unreasonably short time, perhaps within a year, when applied on houses. Within the last few years observations by the Forest Products Laboratory (9) and by the West Coast Lumbermen's Association (10) have shown that such difficulties are due neither to faulty paint nor to defective lumber, but are caused by improper methods of drying the building moisture in new buildings, errors in designing the structure, faulty construction, or unusual conditions of occupation. The essential factor is water gaining access to the back of the painted boards either through leaking joints of one kind or another or by condensation from moist air coming in contact with the backs of the boards during cold weather. Many details that frequently prove sources of trouble have been described. The only sure cure for such ills lies in preventing access of water to the backs of the painted boards. No paints now on the market are proof against moisture failures of this kind, and no woods are immune to them.

CONCLUSION

Studies in recent years have contributed largely to the stabilization of painting practice for wood by removing much of the mystery and vague speculation that has beclouded the subject and also by setting forth clearly the basic factors responsible for the chief uncertainties of paint behavior.

The durability of coatings on different softwoods varies widely because aged coatings do not adhere satisfactorily to summer-wood and the amount and distribution of summer-wood in softwoods ranges between wide limits. To a limited extent paint service may be improved by selecting, for purposes where painting is important, woods that are light and have only narrow bands of summer-wood. However, painting is usually only one of many considerations in choosing a wood, and other requirements often dictate the selection of woods with wide bands of summer-wood. Furthermore, Table 1 indicates that by far the greater part of the available lumber supply is of kinds that contain prominent summer-wood.

The woods with wide summer-wood bands can be improved for painting purposes by cutting them as far as possible so that edge-grain surfaces are exposed for painting. The flat-grain boards should be surfaced so that the bark side rather than the pith side is exposed.

Further improvement in paint service on woods containing much summer-wood is not to be sought in special proportioning of the oil and thinner in the priming coat or in choosing unusual volatile liquids. The painter may remain free to employ these variables to facilitate application. Thus he may vary the proportion of thinner to control the consistency and spreading rate of the paint.

The durability of paint coatings on woods with wide bands of summer-wood can be increased by priming them with a properly made aluminum paint, given ample time to dry.

Abnormally early failures of coatings are not due to the paint nor to the wood, but rather to unhealthy moisture conditions which must be cured before acceptable service can be expected.

However, after full advantage has been taken of the foregoing means of improvement, painting practice for wood still falls short of the standards that engineers expect of the materials with which they work. Failure of coatings by bodily detachment from the wood, leaving the surface bare, is inherently unsatisfactory because it leaves a part of the wood temporarily unprotected, presents a difficult surface for repainting, and affords an insecure foundation for the new coating. The ideal coating would wear away evenly and remain continuous and firmly adherent until the need for repainting becomes clearly apparent in lack of opacity. A real stabilization of painting practice for wood cannot be reached until this ideal is achieved through research.

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The American Cypress, published by Southern Cypress Mfrs. Assn, 1931

(11)

X. PAINTING OF WOOD

EXTENSIVE experiments by the Government and by independent paint experts have shown conclusively that cypress lends itself excellently to painting with the types of linseed oil paints commonly used for painting houses. Paint should be applied to cypress in exactly the same way that it is commonly applied to other soft woods. No special kinds of paint, no unusual proportioning of paint ingredients, no special paint thinners, and no departures from customary painting practices are required.

Until within comparatively recent times, most investigations dealing with painting centered around the chemical composition of the paint and very little, if any, attention was paid to the characteristics of the wood surface to which the paint was to be applied. Within recent years, many investigations have been carried out, in which the character of the wood surface has been considered just as much as the paint applied to the surface. Notable among these investigations were those initiated in 1924 by the U. S. Forest Products Laboratory. A large number of test fences were erected in various parts of the United States consisting of several thousand test panels. All commercial softwoods were included in these tests. Comparatively few paints were used in these tests because the influence of the paint composition on the durability of the paint coating is reasonably well understood from other tests. On this account, most of the panels in these tests were tested with two paints, white lead paste paint and a typical prepared paint, containing white lead, zinc oxide and asbestine. From the results of the use of these two paints and the existing knowledge of paint composition the behavior of most house paints can be evaluated.

WOOD PROPERTIES THAT AFFECT PAINT DURABILITY

All wood should be in the air dry condition before it is painted. Paint applied to green wood may blister and peel or, if that does not happen, the coating may crack in an objectionable manner known as alligatoring, which is due to insufficient drying of the priming coat. Moisture retards the drying of paint, especially so on cypress and redwood, which contain characteristic chemicals that impede oxidation of linseed oil. On dry cypress paint dries normally and the chemicals exert a favorable influence on the durability of the coating by hindering the ultimate oxidation of the oil that causes final paint failure.

Ordinarily the nature of the wood painted does not affect the behavior of the paint coating for at least a year or two after the paint has been applied. Ultimately the coating fails, of course, and it does so at an earlier age on some kinds of woods than on others.

F. L. Browne, in the U. S. Dept. Agriculture Leaflet No. 62 of September, 1930, entitled "Why Some Wood Surfaces Hold Paint Longer Than Others," has summarized the most important facts upon which the successful paint surface depends:

"The painting characteristics of a board depend primarily upon the amount and distribution of summer wood in it. Summer wood is the dense, horny, dark-colored portion of the annual growth ring, formed in the tree late in the growing season. It is made up of wood cells with very thick walls and small cavities and is in this sense much less porous than the spring wood, which is composed of cells with thin walls and correspondingly large cavities. Although liquids move more readily through the dense summer wood and paint oils are found to penetrate more deeply there, paint coatings do not seem to secure so firm an anchorage on summer wood as they do on spring wood; as a result, coatings exposed to normal conditions of weathering fail by flaking from the summer wood, leaving it bare while the spring wood remains apparently well covered. All native softwoods contain both summer wood and spring wood, but the proportions vary in different woods and in different boards of the same wood. There is in fact a greater variation in painting characteristics between the spring wood and summer wood in a single board than there is between average boards of different woods.

"The density or weight per unit volume of a softwood board measures roughly its ability to hold paint coatings because boards are heavy or light according as they contain much or little summer wood. However, if a board has many annual growth rings per inch, it may have the summer wood confined to narrow bands and yet be moderately heavy. Such boards hold paint far better than boards of equal weight cut from more rapidly grown trees, in which the summer wood is present necessarily in wide bands."

PAINT CHARACTERISTICS OF DIFFERENT SPECIES OF WOOD

The experiments of the Forest Products Laboratory, which is maintained by the U. S. Government at Madison, Wis., resulted in the following classification of softwoods by species:

Group 1	Woods on which the paint remained intact and furnished adequate protection the longest. Cedar, Alaska. Cedar, Port Orford. Cedar, western red. Cypress, southern. Redwood.
Group 2	Woods that the paint coatings failed to protect against weathering as long as they did the woods of group 1 even though the paint coatings remained intact about as long. Pine, northern white. Pine, western white. Pine, sugar.

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cross-section of the pores and indirectly on the direction of grain of the wood. As an approximation, it may be assumed that the porosity of the wood is inversely proportional to the resistance. No standard of porosity has been established for the determination of quality of the separators.

The figures given in Table 7 are for separators of the type used in starting and lighting batteries. The separators had 16 ribs and 17 slots. The thickness of the backweb was 0.052 inch; the thickness over the ribs, 0.085 inch; and the mean thickness 0.063 inch. All of these separators had received the same treatment."

Those interested in a further study of this problem are also referred to a recent paper of the U. S. Bureau of Standards entitled "Measurement of Electrical Resistance and Mechanical Strength of Storage-Battery Separators," by C. L. Snyder, Technologic paper of the Bureau of Standards, No. 271.

TABLE 7

Resistance of Storage Battery Separators

Each figure is the mean of observations on four samples of each kind. The separators were allowed to stand for 23 days in sulphuric acid of 1,280 sp. gr. before being measured. The resistances are expressed as the resistance per square inch of surface in the electrolyte of specific gravity 1.280 at 22°C.

Wood	Cut	Resistance in Ohms	
		Per Sq. Inch	Per dm²
Poplar	Rotary	0.040	0.0026
Cherry	Rotary	0.042	0.0027
Basswood	Rotary	0.054	0.0035
Redwood	Rotary	0.084	0.0054
Redwood	Sawn	0.063	0.0041
Cedar	Rotary	0.084	0.0054
Cedar	Sawn	0.057	0.0037
Fir	Rotary	0.116	0.0075
Cypress	Rotary	0.124	0.0080

IX. HEAT INSULATING VALUE OF CYPRESS WOOD

Cypress is used for a good many purposes where the factor of heat conductivity is of significance. Cypress is particularly adapted on account of its decay resistance, ease of working, etc., to uses for fireless cookers, ice-cream tubs, vats, refrigerator rooms, incubators, etc. It is therefore of interest to know something of its heat conducting properties in comparison with other materials.

*"Wood conducts heat comparatively slowly. This is one of the principal properties that makes lumber desirable for building material, furniture, handles, refrigerators and fireless cookers. A wooden wall allows much less heat to pass through it than an iron, concrete, brick, or stone wall of the same thickness and under the same conditions.

"The rate at which heat passes through dry wood depends upon the direction of the fibers and upon the density. Wood conducts from two to three times as much heat along the fibers as across the fibers, other conditions being the same.

"Dense woods conduct heat more readily than light woods because in light woods a larger volume is occupied by air spaces, and air is a poorer conductor of heat than wood substance (cell walls). Therefore for fireless cookers, ice-cream containers, and other articles requiring good insulation, as light a wood as is practical should be used."*

Cypress is one of the lighter woods and its heat conductivity is correspondingly low, namely 0.00023. The following table* gives the heat conductivity of wood and various other materials at ordinary temperature.

Investigations are now in progress dealing with some of the details of heat conductivity by various species of wood. While these have not as yet progressed very far they already indicate the following:

First — Relation between moisture content and conductivity. It is of course recognized that the higher the moisture content of wood the greater its conductivity. Recent tests indicate that the amount of moisture present rather than the percentage present is the influential factor.

Second—Presence of knots. Indications are that the percentage of knots ordinarily present in lumber need hardly be given consideration in estimating its conductivity.

*The Properties and Uses of Wood, by Arthur Koehler, p. 67, 1924.

TABLE 8

*Heat Conductivity of Wood and Various Other Materials at Ordinary Temperatures**

Substance		Number of calories of heat which pass from one face to the opposite face of 1 cubic centimeter of the material within 1 second of time when the difference in the temperature of the two faces is 1 degree Centigrade
Air		0.00006
Air cell, ½ inch thick		0.000154
Asbestos paper		0.00017
Mill board		0.00029
Concrete, cinder		0.00081
Concrete, stone		0.0022
Corkboard, pure		0.000106
Cotton, firmly packed		0.00010
Flaxlinum, vegetable fibers firm and flexible		0.000113
Glass, window		0.0025
Granite		0.0053
Hair felt		0.000085
Insulite		0.000102
Iron, wrought		0.144
Limestone and marble		0.0047 to 0.0056
Linofelt, vegetable fibers between layers of paper, soft and flexible		0.000103
Pulp board, stiff pasteboard		0.00015
Sand, white dry		0.00093
Sandstone, dry		0.0055
Sawdust		0.00012
Water		0.00136
Wood:	Specific gravity	
Balsa	0.12	0.00012
Boxwood	0.90	0.00036
Cypress	0.46	0.00023
Fir, dry, across fiber		0.00009
Along fiber		0.00030
Greenheart	1.08	0.00112
Gum, red, across fiber (b)	0.50	0.00016
Along fiber (b)	0.50	0.00044
Lignum-vitae	1.16	0.00060
Mahogany	0.55	0.00031 to 0.00051
Maple, hard	0.71	0.00038
Pine, white	0.50	0.00027
Virginia	0.55	0.00033
Pine, across fiber (c)		0.00010
Along fiber (c)		0.00030
Oak	0.61	0.00035
Oak	0.65	0.00058
Poplar, yellow	0.58	0.00041
Wool, pure, loosely packed		0.00009

* From Smithsonian Physical Tables except (b) which are given as "satin walnut" by Barratt, T., "Thermal Conductivity," Proceedings Physical Society of London, vol. 27, 1914; and (c) which are taken from Duff's, A. W., "Textbook of Physics," 1910.

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Group 3	Woods from which the paint coatings flaked more rapidly than from the woods of groups 1 and 2 and which paint coatings failed to protect as long as they did the woods of group 1. Fir, white (and other *true* firs). Hemlock, eastern and western. Pine, western yellow. Spruce, eastern and sitka.
Group 4	Woods from which the paint coatings flaked most rapidly. Douglas fir. Larch, western. Pine, southern yellow.

The classification by species is somewhat of a rough approximation because there is a wide variation within most of the species in the painting characteristics of different types of boards. Thus the better types of boards sawn from woods in Group 4 paint as well as the poorer boards sawn from the woods in Group 3 and the better boards sawn from Group 3 woods are as satisfactory as the poorest one from Groups 1 or 2. The grouping by species gives the average results that may be expected from these species as they are customarily bought and used. If the better types of boards within a species are selected, the behavior of paint coatings on them may be more satisfactory than the average rating of the species.

Edge grain boards are decidedly better for painting than flat grain boards of the same species, particularly in the woods of Groups 3 and 4. Paint coatings remain intact longer on edge grain than on flat grain boards and edge grain boards require less adequate paint protection to keep them from weathering.

Flat grain boards paint better on the bark side than on the pith side. The bark and pith sides may be distinguished by the curve of the annual growth rings, seen on the end of the board. The rings are convex toward the bark side. If the grain of the wood becomes loose and shells up it almost always does this on the pith side and rarely on the bark side, which makes the pith side less desirable for painting than the bark side. This loosening of the grain on the pith side may cause early flaking of the paint coating. Raised grain is also more noticeable on the pith side than on the bark side.

Boards of high grade within any species, paint to better advantage than boards of low grade, for the reason that such defects as knots, pitch pockets, and pitch streaks prove difficult to handle. Over knots in the white and yellow pines, the paint coating often turns yellow and sloughs off leaving the knots exposed. Knots in cypress, the cedars, redwood, the true firs, the hemlocks, the spruces and larch, seldom cause the paint coating to turn yellow or slough off, but the knots are difficult to conceal and sometimes crack. Pitch pockets and pitch streaks often cause the paint coating to crack and mar its appearance by exuding resin. Pitch pockets should be chiseled out to remove all resinous substances and then be filled with putty.

When the factory or shop grades are used and the defects such as knots, pitch pockets, etc., are removed by remanufacture, it is natural that many paint troubles are also removed, but the fact remains that the clear wood remaining is often less desirable for painting than the wood contained in the select grades as these shop or factory grades come from that part of the log nearer the pith of the tree where the wood grew faster and where it is less uniform in texture.

The woods of Groups 1 and 2 are the softwoods of light weight, uniform texture or both. The woods of Group 4 are heavy and uneven in texture. The woods of Group 3 are either moderately heavy or uneven in texture. These two properties of wood, density and texture, afford an excellent means by which the painting characteristics may be judged. The reason for this is that early failure of the paint coating such as flaking, always begins over the bands of summer wood, particularly if they are wide, and the amount of summer wood determines the density of the wood.

SAPWOOD AND HEARTWOOD

Under ordinary circumstances, there is very little if any difference in the behavior of paint over sapwood and heartwood. If the unprotected surfaces of the boards come in contact with water for long periods, however, the paint may fail over the sapwood sooner than over the heartwood. In most types of construction such conditions can be avoided, but if water or continued moisture cannot be kept out, the heartwood of one of the durable species, such as cypress, should be used to prevent early decay of the wood.

CHARACTERISTICS OF DURABLE PAINT

Inasmuch as the authorities differ widely about the relative merits of the several kinds of house paints on the market, it is safe to say that each has its advantages and disadvantages as compared with the others and the choice between them must remain, to a large extent, a matter of personal opinion. Most experts will agree with the few general principals which follow.

The most durable paints are dark in color. Pure iron oxide red paint and black paint made with one of the carbon blacks are the most durable of all. The yellow, red and brown paints made with natural earth pigments in which the color is due chiefly to iron oxide, or paints made with artificial iron pigments are very durable, as are also paints made with chrome yellow, chrome green and prussian blue. Even the best white paints are much less durable than these deeply colored paints. Paints of light color made by tinting white paint with the deeply colored pigments are intermediate in durability.

White paints owe their whiteness and opacity to one or more of the following opaque pigments: basic carbonate white lead, basic sulphate white lead, zinc oxide, leaded zinc oxide, titanox, or lithopone.

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Besides these white and the colored pigments, many paints contain so-called inert pigments which lack opacity. Common inert pigments are: asbestine (magnesium silicate), silicia, barytes blanc fixe (barium sulfate), china clay (kaolin) and whiting. Moderate amounts of inert pigments often serve useful purposes in paints, but white or light colored paints containing large amounts of them are cheap paints and are either deficient in opacity or else limited in the amount of surface that a gallon of paint will cover. In paint, as in lumber, the price paid may be indicative of the service which will be rendered.

The liquid in a good house paint is at least four-fifths pure linseed oil. It contains at most only a trace of water and no varnish, except that black, dark blue, or dark green paint may contain some good varnish. The following rules will serve as a rough guide in choosing paints for quality, assuming that the paints compared are of the same color and reduced to proper consistency for application of a final coat.

1. Choose the paint containing the highest proportion of pigment to liquid, if possible determining the proportions by volume because the proportion by weight is somewhat less reliable.

2. If they are white or tinted paints choose the one containing the highest proportion of opaque white pigments. If a deeply colored paint, choose the one containing the highest proportion of iron oxide, carbon black, chrome yellow, chrome green or prussian blue.

White lead is the oldest of the opaque white pigments and is the only one commonly used without mixing with other opaque white pigments. Straight white lead paint chalks deeply and sloughs from summer wood in very small flakes. If repainting is deferred until much summer wood is left bare white lead paint leaves a surface more easily covered smoothly with new paint than other pigment mixtures. Paints containing zinc oxide and white lead usually do not chalk as deeply, fade less in color, and may not become as badly soiled with dirt. If repainted before there is much flaking from summer wood they offer a less absorptive surface on which a smooth glossy coating can be restored with a single coating instead of two coats, but if repainting is deferred until much summer wood is bare, such paints leave a rougher surface because the flakes of coating that fall off are larger. In extreme cases, the old coating may have to be removed before repainting. Paints containing titanox and zinc oxide in suitable proportions are very opaque, chalk superficially, hold their color well, and remain relatively free from dirt. Lithopone is cheaper than the other opaque pigments and, in combination with zinc oxide and inert pigments, can be made into very serviceable paint.

In localities where the climate is ordinarily very dry for at least a part of the year, straight white lead paint is more durable than mixtures of white lead and zinc oxide. In humid southern climates such as the south Atlantic and Gulf Coasts, mixtures of zinc oxide and white lead outlast straight white lead paint. In moderate climates like New England and the middle Atlantic states, all paints are more durable and there is little difference in durability between straight white lead and mixtures of white lead and zinc oxide, provided that the amount of zinc oxide is not more than half that of the white lead by weight.

Paints are sold in the form of paste, semi-paste or prepared paints. Prepared paints contain the proper amounts of liquids and drier for application as finish coats and are sold in white and many colors. Paste and semi-paste paints are usually white or one of the deep colors and must be reduced with linseed oil, volatile thinner and often some drier added before they are ready to apply. To make paint of light color, some of the deeply colored paints must be thinned and added to the white base paint in suitable amounts and colors. Paste and semi-paste paints have the important advantage over prepared paints in that the painter can alter the proportions of pigment, oil, and thinner over wider limits and is therefore able to mix priming coat and body coat paints that are not easily obtainable with prepared paint.

RECOMMENDED PRACTICES FOR PAINTING WOOD

Lumber for exterior construction should be in an air dry condition before it is delivered on the job. After receipt, it should be so handled that it will remain in that condition until used. Lumber piles should be raised above the ground, providing ventilation underneath and the piles should be kept covered as protection from rain. Exterior lumber should not be stored in a heated building where it may become too dry. After erection, dressed lumber should be painted promptly. The best moisture content of lumber for painting is roughly from 12 to 18 per cent. If the surface of the lumber becomes wet with rain or otherwise, it should be allowed to dry before painting.

Standard practice calls for three coats of paint on new wood surfaces.

Paint purchased in the form of semi-paste should be mixed according to the following formulas:

	First Coat	*Second Coat*	*Third Coat*
Semi-paste paint, gallons	1	1	1
Raw linseed oil, quarts.	4	1	2¾
Turpentine, quarts	2½	1⅚	⅙
Paint drier, pints.....	⅓	⅓	⅓

Boiled linseed oil may be used instead of raw linseed oil, in which case only half the indicated amount of drier should be added. If the semi-paste paint already contains the drier, use raw linseed oil and do not add any more drier. White lead paste paint is sold by weight instead of by volume and in the forms of soft paste (semi-paste) and of heavy paste, which contains less oil. One gallon of soft paste white lead weighs 30.8 pounds and should be mixed with the amounts of liquids given in the formulas. To mix heavy paste white lead, take 28.4 pounds, add 1¼ quarts of raw linseed oil, and then add the liquids given in the formulas.

To make tinted paints starting with white paste paints, mix white paint according to these formulas, then thin the necessary kinds of deeply colored pigment pastes (colors ground in oil) with a little turpentine and add them to the white paint in the required amounts to give the desired color. Ordinarily only a small amount of colored pigment is necessary.

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New woodwork is sometimes painted with two instead of three coats. When skilfully done, satisfactory results may be obtained, but the practice is not generally recommended. Thicker coats must be applied and therefore the mixtures should be made as follows:

	First Coat	*Second Coat*
Semi-paste paint, gallons	1	1
Raw linseed oil, quarts	2	2½
Turpentine, quarts	1¼	⅙
Paint drier, pints	⅓	⅓

If prepared paint is purchased, three coats should always be applied to new woodwork because prepared paint is designed for such use. For the priming coat, 2 pints of linseed oil and 1 pint of turpentine should be added to a gallon of prepared paint. For second coat add 1 pint of turpentine to a gallon of paint. The paint is already correctly mixed for third coat.

Repainting should be done before flaking of the old coating from summerwood goes very far and before wood checking due to insufficient protection has advanced to any great extent. When repainting is done at the proper time, one coat is often all that is necessary and, if the old paint contained zinc oxide, one coat is often all that is desirable. It should be mixed according to the instructions already given for third coat paint on new woodwork. When the old coating is very absorptive or when repainting has been deferred until there is much bare summerwood, two coats are needed which may be mixed as follows:

	First Coat	*Second Coat*
Semi-paste paint, gallons	1	1
Raw linseed oil, quarts	1½	2¾
Turpentine, quarts	2½	⅙
Paint drier, pints	⅓	⅓

The foregoing formulas are suitable for painting all softwoods. Recommendations are often made to use special thinners in place of turpentine or to change the proportions of oil and turpentine greatly in mixing the priming coat for some woods. Investigations at the Forest Products Laboratory prove that such alterations do not improve and, if carried too far, impair the durability of paint coatings.

SOME REASONS FOR SO-CALLED PAINT FAILURES

A choice of those species that take and hold paint better will overcome some of the difficulties of paint failure, but the conditions governing the use of lumber and paint are more responsible for unreasonably early failures of the paint to either protect or continuously beautify, than are the materials themselves. Probably the chief cause of early paint failure is moisture. More than any one thing and probably any combination of other causes excessive moisture either on or in the wood to be painted, or moisture coming from within the house, or from poorly drained surroundings, causes the greatest number of so-called paint failures.

Moisture within a house will seek an outlet when humidity of the outside air is lower than inside. This moisture, if allowed to find its way out through the side walls, will certainly cause trouble for the outside paint. The paint may peel, blister or in other ways destroy the continuity of the paint coating.

This moisture may be present in the house from natural continuous sources or may be caused by attempts to quickly dry out the plaster in newly constructed houses, thus driving the moisture through the outside walls.

The basement may contain moisture which comes in through poorly built walls or floors. It need not be visible to the eye, but if moisture stands in the soil around or under the walls or floor of a poorly constructed basement, this moisture will surely find its way upward and be absorbed by the various materials used in the house construction and later be given off through the walls causing trouble to the outside paint.

After a survey of some 1,500 houses of all types by a competent authority, a very substantial percentage of paint failures was traced to these sources and could have been prevented by proper caution. The various causes of paint troubles on the outside of house walls all deal with excessive moisture from one source or another, except where the paint itself is at fault and this latter condition is more rare than is usually considered.

It is only necessary to adopt such type of construction as will prevent moisture from getting into the basement and also provide proper ventilation of the side walls and attic to allow of the passage of this moisture to the outside air, by other means than through the walls. If during construction and the drying out of the plaster, sufficient time and ventilation is provided, very little trouble, if any, will develop on the outside painted walls.

Some of the modern types of house construction bring about tighter and tighter wall construction, thus blocking up all air passages through which moisture might find an outlet to the attic and escape through the wooden shingles, if the house is fortunate enough to have this time-proved roof covering.

The present emphasis on the value of insulating materials to prevent heat losses brings about a type of construction that leaves few, if any, channels through which moisture can easily find an outlet and it must therefore be absorbed by the walls and thus pass to the outside air, either through the paint or by pushing the paint off to form an opening.

Circular No. 317, October, 1927, of the American Paint and Varnish Manufacturers Association, by Henry A. Gardner, entitled "Painting Defects on Wood Surfaces, Their Cause and Cure," lists most causes of paint failures both from moisture and from improper application of the paint. A study of this pamphlet is recommended.

SUMMARY

The foregoing deals with fundamental facts relating to the painting of wood surfaces. All of it applies to the painting of cypress. Careful attention to the principles discussed will result in successful painting. Good construction, durable paint, and skilful craftsmanship in application are most economical in the long run. Nowhere will the original investment pay better than in the painting of wood surfaces.

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Wisconsin State Journal
Feb. 22, 1931

(12)

Congressional Cut May Block Paint Experiments Here

Committees Agree to Drop $33,700 Laboratory Request for Durability Test

Extensive research work of the Forest Products laboratory for improving the adhesive quality of paints to make them last from 15 to 20 years on dwelling houses, has been temporarily delayed because of $33,700 cut from the laboratory appropriations for next year which the joint congressional committee made Monday.

Appropriations of $526,000 for maintaining the regular work of the laboratory next year were the same as this year. The $33,700 added appropriations requested were intended to speed up three proposed researches of the laboratory. This amount had been recommended by the federal budget bureau and had been added to the agricultural department appropriations bill.

The budget bureau had approved $15,000 to continue the experiments to develop an antishrink treatment for wood, $10,000 to improve the use of wood in frame buildings and $8,700 for investigations to improve the lasting qualities of paints on wood.

Refuse Funds

The house of representatives refused to approve this fund at the joint hearing Monday but the senate amended the bill to include these items. The conferees for the house refused to accept the senate amendment and the senate conferees agreed to recede.

To make a paint job last from 15 to 20 years instead of the present length of from three to seven years is the purpose for which the laboratory asked $8,700 of the proposed additional appropriations.

Experiments of Dr. F. L. Browne, senior chemist, of the Forest Products laboratory, have shown that the irregular wearing of paint coats on the outside of dwellings is due primarily to the distribution of spring and summer wood in the lumber.

Make Jobs Last

By his experiments on paint-test fences, of the laboratory, Dr. Browne hopes to find a means of making the coats of paint adhere to the bands of summer wood over a longer period of time. When this is possible, paint manufacturers can carry out other steps now known which will make a paint job last from 12 to 20 years.

Home owners all over the country will save millions of dollars annually, it is believed, when a process is completed which will make the average grades of manufactured paints adhere as long to the summer wood of a board as they do to the spring wood.

Dr. Browne has specimen of old sign boards, lettered with ordinary lacq and opaque surfaced paints is believed to contain lamp black for coloring where the weather has worn away the wood and left the faded but distinctly visible painted letters in relief.

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Priming-Coat Reductions for Painting New Wood Surfaces

By Dr. F. L. Browne
For the Test Fence Committee*
Northwestern Paint and Varnish Production Club

THE exposure tests with which this report is concerned were described in detail in a first progress report published in the Proceedings of the Scientific Section, American Paint and Varnish Manufacturers' Association, Circular 404, page 596 (1931), and a second progress report describing conditions after 10 months' service was published in the Official Digest of the Federation of Paint and Varnish Production Clubs, No. 121, page 1068 (1932). The reader is assumed to be familiar with these prior reports.

The principal object of the study is to show how far the serviceableness of paint coatings depends upon the proportion of pigment, linseed oil, and turpentine in the priming-coat paint; to discover the optimum priming-coat reduction, and to determine whether the priming coat should be reduced differently according to the nature of the softwood painted, taking both two-coat and three-coat painting into consideration. The tests were made on Norway pine, white pine, western red cedar, and redwood. Three types of linseed oil paint were used, all in the form of semi-paste paints; they were white lead paint, a lead and zinc paint, and a titanox and zinc (lead-free) paint. Painting with an aluminum primer made with a Bakelite varnish vehicle was also included and to determine whether the effect of this primer is to be attributed to the aluminum or to the varnish three white primers made with this varnish were tried.

Since the second progress report the committee has met to inspect the fence twice, once in June and once in September, 1933. The coatings were 26 months old at the last inspection. Flaking of some of the coatings of all three types of white paint has begun on the south side of the fence and there is some failure in integrity of the lead and zinc paint on a few test areas on the north side.

Although it is of interest to report the present status of the tests at this time the committee cannot emphasize too strongly that the study is still far from complete and that great caution should be exercised in drawing conclusions from the present indications. Future developments might make it necessary to alter materially many generalizations that could be made now.

Order of Initial Failure on the Four Woods

On the south side of the fence flaking of the coatings of all three types of white paint has now progressed far enough to reveal distinct differences between the four woods in the rate at which failure of coatings by flaking from the bands of summerwood sets in. The order of the woods is the same for each of the three paints, namely, there is least failure on redwood, only slightly more failure on red cedar, distinctly more failure on white pine, and by far the greatest amount of failure on Norway pine. With white lead paint, white pine falls closer to red cedar and redwood than to Norway pine but with the two paints containing zinc oxide, and especially with the paint containing no white lead, white pine falls closer to Norway pine than to cedar and redwood.

These findings are strictly in accord with the results of tests by the Forest Products Laboratory (see for example Federation of Paint and Varnish Production Clubs, Official Digest, No. 95, page 106 [1930]). The data of Table I, which gives average values for certain physical properties of the boards with which the test panels were made, are significant in this connection.

These data in the light of the tests by the Forest Products Laboratory in-

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dicate that Norway pine shows most failure because it is the heaviest of the four woods and has the largest content of summerwood and because all of the boards have either flat grain or grain at 45° (half-way between flat and edge grain). White pine proves worse than redwood or cedar because of the predominance of flat grain boards and because of the deleterious effect on paints containing zinc oxide exerted by the resin in white pine and in Norway pine. Observation of the fence shows also that the high proportion of boards turned pith-side out in the white pine and Norway pine militates against these woods seriously. The superiority of redwood over red cedar must be attributed for the present at least to a beneficial effect of the extractives characteristic of redwood, although the relatively narrow annual growth rings may also exert a significant effect in favor of the redwood.

On the north side of the fence failure of coatings in integrity is confined so far to the lead and zinc paint on white pine and on Norway pine. This failure, however, is unexpected at this stage of the exposure and is not entirely normal in aspect. It may possibly be due to moisture getting in behind the boards through leaks in the fence construction. Although moisture-failure of paint coatings is very rare on test fences, well-authenticated cases of it have been observed.

Relative Behavior of the Three Linseed Oil Paints

It was reported previously that the white lead paint became soiled less rapidly than the other two paints during the first six months of exposure and that it held its gloss longer. By the time 10 months had passed the titanox and zinc paint was much cleaner and whiter than the other two paints, both on the north and the south sides of the fence. The superiority in appearance of the titanox and zinc paint has continued to the present time.

On the south side of the fence the white lead paint finally became slightly dirtier than the lead and zinc paint but both were sufficiently dirty to require ratings of "poor" in appearance. At the present time both of these paints are somewhat less dirty on the south side than they were at one time and the principal difference between them is that the white lead paint is slightly more spotted (less uniformly discolored) than the lead and zinc paint.

On the north side of the fence soiling of the white lead and lead and zinc paints continued for a longer time and reached a much darker aspect of grayness than it did on the south side. The present appearance of these two paints on the north side calls unquestionably for a rating of "bad" in appearance. The white lead paint is a darker gray than the lead and zinc paint, but is much more nearly uniformly so because the lead and zinc paint is now beginning to throw off the dirt as chalking progresses more freely. The titanox and zinc paint on the north side is almost as clean and white as it is on the south side. A house painted with the titanox and zinc paint would present practically the same appearance on all sides but houses painted with either of the other two paints would show marked differences in appearance on different sides and between shaded and unshaded areas on the same side.

All three paints are now chalking on both north and south sides, but the white lead paint on the north side has only just begun to chalk. On the south side reticulate checking of the white lead paint is easily visible, but on the north side it cannot be seen until the dirt is washed from the surface. In the lead and zinc paint on the south side checking is to be seen only with the aid of a microscope or magnifying glass and is in the "parallel" stage; checking is absent on the north side. The titanox and zinc paint does not show checking on either side.

It is difficult to say from direct observation how far the checking in white lead paint and lead and zinc paint extends through the coatings. Since the checking in the lead and zinc paint can be seen only with magnification it is presumably shallow. In the white lead paint, however, it probably penetrates completely through the coatings because on redwood and red cedar careful observation discloses small spots of brown discoloration where rainwater has leached colored extractive from the wood, access to the wood obviously being gained through the paint checks. The extent of such discoloration, however, is not sufficient to mar the appearance of the coatings.

Three kinds of fissures other than checking are now to be seen. Both of the paints containing zinc oxide exhibit the small parallel cracks that Browne calls "slits" (American Society for Testing Materials 3011, 852 [1930]). Flaking of these two paints over the bands of summerwood proceeds by a breaking off of the coating at the loosened edges of such slits. In white lead paint, on the other hand, flaking proceeds by detachment of small particles of coating marked off by reticulate checking. Besides slits there are occasional paint cracks of a longer type that seem much slower than slits in giving rise to flaking of the coating but, like slits, they are confined to the two paints that contain zinc oxide. Slits and cracks are very irregular in distribution, that is, they may be numerous on one board and completely absent on other boards in the same test area. Checking, on the other hand, is always uniformly distributed. The third kind of fissures corresponds exactly with weathering checks in the wood beneath the coating. Such fissures are not considered in rating the coatings for integrity but are considered evidence that the coating is no longer furnishing adequate protection against wood weathering. Wood checks of this kind are more numerous in Norway pine and in white pine than in the other woods and are more numerous under white lead paint than under either of the paints that contain zinc oxide.

Of the three paints the titanox and zinc paint on Norway pine and on white pine exhibits the most serious progress in flaking from the bands of summerwood. It should be pointed out, however, that the coating of titanox and zinc paint was thinner to begin with than the coatings of the other two paints (see Table 3 of the first progress report). Apparently one of the disadvantages of paints with unusually good hiding power is the temptation to apply them in thin coatings. Thus the painter applied the third coat of titanox and zinc paint in these experiments at 1225 square feet per gallon; the surfaces were hidden thoroughly and still remain hidden, but the durability of the coatings is undoubtedly less than it would have been if the third coat had been applied more generously. On redwood and red cedar, on the other hand, the titanox and zinc paint is perhaps in sounder condition at the present time than either of the other paints. With respect to integrity of the coatings the white lead and the lead and zinc paint seem to be relatively in the same condition on the average. In the white lead paint the flaking from the summerwood is of much finer grain and therefore less conspicuous than it is in either of the paints that contain zinc oxide, but careful inspection shows that fully as much wood has been left bare by flaking of the white lead paint as has been exposed by flaking of the lead and zinc paint.

It is of interest to point out that there is much more difference in the extent of failure in integrity of any one of the paints on the four woods than there is between the three paints on any one wood. Thus, for

Table 1.—Average Values for Certain Physical Properties of the Boards with Which the Test Panels Were Made.

Species	Density in lbs. per cu. ft.	Annual growth rings per inch	Percentage of boards that are Flat grain	Grain at 45°	Edge grain	Percentage of boards that are flat grain or grain at 45° and are known to be turned pith side out
Redwood	26.2	36	29	59	12	17
Red cedar	21.5	26	11	34	55	7
White pine	26.8	28	75	24	1	51
Norway pine	28.9	30	49	51	0	41

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example, there is much more difference in the condition of the coatings of titanox and zinc paint on Norway pine and on redwood than there is between the coatings of white lead paint and of titanox and zinc paint on Norway pine.

Two-Coat and Three-Coat Painting

Judging by the present extent of flaking of the coatings from summerwood the relative condition of the two-coat and three-coat jobs is as recorded in Table 2. With the lead and zinc paint the two-coat jobs seem to be proving slightly less durable than the three-coat jobs applied on neighboring areas of the same boards. With the other two paints, however, the two-coat jobs over primers 2-1 and 2-2 seem to be lasting as well as the three-coat job while the two-coat jobs over primer 2-3 are distinctly worse. Primer 2-1 was mixed without any turpentine, primer 2-2 with a moderate amount of turpentine, and primer 2-3 with much turpentine. Apparently the proportions of pigments, linseed oil, and turpentine are more significant than the number of coats applied, but it will be well to await further developments before drawing conclusions on that subject.

Priming-Coat Reduction

The preceding section reports that in two-coat painting the priming coat thinned generously with turpentine (and containing correspondingly less linseed oil) is proving distinctly inferior to priming-coat mixtures containing either no turpentine at all or only a moderate amount of turpentine. Exactly the same tendency is observable in the three-coat jobs. The primer thinned with the greatest proportion of turpentine is uniformly proving less satisfactory with all three paints and on all woods. On the other hand, the primer mixed without any turpentine is at present showing as good results as any of the priming mixtures, but further developments must be awaited before it will be possible to choose the best of the priming-coat mixtures tried. At present there is no indication that the optimum priming-coat reduction will prove different for different woods or that adjustment in priming-coat reduction will serve to offset differences in durability caused by variations in the nature of wood. In other words, the experience so far offers no evidence in support of the common custom of recommending that painters use different priming-coat mixtures on white pine, Norway pine, redwood, and red cedar.

Aluminum Priming Paint

No coatings are now in better condition than the corresponding ones applied over aluminum priming paint. There is as yet no flaking from summerwood over aluminum primer except on two boards that are obviously unusually difficult to keep well painted. On both of these boards there is only a small amount of flaking on the area primed with aluminum, but a great deal of flaking on neighboring areas primed with white paint. There are a number of panels on which the coating is entirely sound over aluminum primer, but is flaking distinctly from summerwood on neighboring areas painted with white primers.

It was pointed out previously that there was a tendency for the coatings to hold their gloss longer over the aluminum primer. As a result they also held dirt longer, and on the north side of the fence have not progressed quite as far in shedding this dirt. However, the discoloration by dirt tended to be somewhat more uniform and to be cast off again more uniformly over the aluminum primer than over white primers.

Checking of the white paints over aluminum primer follows exactly the same pattern and is no more conspicuous than it is over corresponding areas with white primers. On the south side of the fence the checking in the white lead paint can be seen with the microscope to extend down to the aluminum primer. Over white primers it probably extends down to the wood for reasons that have already been discussed.

Miscellaneous Tests on Units 7 and 8 of the Test Fence

Three primers made with the varnish vehicle used for the aluminum primer, but containing respectively white lead, zinc oxide, and titanox B as pigments, are proving less satisfactory under white lead paint than the aluminum primer or than the ordinary white lead primers made with linseed oil. Checking of the white lead paint over the white primers made with the varnish is coarser and more conspicuous than it is over aluminum primer or over white linseed oil primer. There is also some flaking of the coating of white lead paint over the primers made with white pigments in varnish; the flaking is most marked over the varnish primer made with zinc oxide. The flaking moreover is coarser and more conspicuous than the flaking of white lead paint when applied in the customary way.

At the present time the two white lead paints applied in accordance with recommendations of the National Lead Company and of the Eagle-Picher Lead Company, respectively, are behaving in much the same way as the corresponding coatings of white lead paint on Units 1 to 6 of the test fence.

The titanox, lead, and zinc paint and the cryptone paint, recommended respectively by the Titanium Pigment Co., Inc., and the New Jersey Zinc Company, are much cleaner and superior in appearance to the white lead or lead and zinc paint and are nearly as clean as the titanox and zinc paint. They both exhibit less flaking from summerwood on Norway pine and white pine than the lead-free titanox paint, though both are now cracking and slitting.

Table 2.—Relative Integrity of Coatings of Two-Coat Jobs as Compared with Coatings of Three-Coat Jobs on Neighboring Test Areas.

Wood	White lead paint over primer No.			Lead and zinc paint over primer No.			Titanox and zinc paint over primer No.		
	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3
Norway pine	better	same	worse	worse	worse	worse	better	better	worse
Red cedar	better	same	same	better	worse	worse	better	better	worse
Redwood	same	same	same	worse	worse	worse	better	same	worse
White pine	worse	same	worse	worse	worse	worse	worse	better	worse

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New England Paint & Varnish Production Club
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(14)

Painting Characteristics of Wood

Dr. F. L. Browne, Forest Products Laboratory, Madison, Wis.

THE Forest Products Laboratory has been studying the painting characteristics of soft woods since 1924. Experiments were conducted by exposing panels of 18 kinds of softwood lumber on test fences at 11 exposure stations in different parts of the country, and painting the surfaces of the panels with two representative kinds of white, exterior house paint. The panels were inspected at intervals to observe the course of disintegration of the coatings.

The study shows that paint coatings last much longer on some wood surfaces than on others and reveals the properties of wood that exert most influence on paint behavior. The study also indicates the direction in which improvement in paint service on wood should be sought. The findings can be presented here to best advantage by first describing certain characteristics of wood and then discussing their bearing on paint service.

Classification by Species

Lumber is cut from trees of many different species and the groupings by species or closely related species is retained in merchandising because in general each species has more or less characteristic average properties and finds uses accordingly. A sharp distinction is made in practice between hardwood lumber, which comes from deciduous trees, and the softwood lumber from evergreen trees. Only softwoods need be considered here because the lumber used for the exterior of buildings is almost entirely of that kind.

In choosing lumber for a particular purpose, let us say house siding, paintability is only one of a number of factors to be considered, and not necessarily the most important one. Ability to stay in place, ease of working and of nailing, durability, cheapness, and availability in the desired pattern must be given consideration varying with circumstances. No wood excels in all respects and none in common use is deficient in all of them.

Within each species there is a considerable range in properties, not only in lumber cut in different forest regions, but also in that from neighboring trees or even from different parts of the same tree. Consequently there is much overlapping in properties between species; for instance, dry western yellow pine is usually heavier than redwood and lighter than Douglas fir, but the lightest boards of pine weigh less than the heaviest ones of redwood and the heaviest boards of pine outweigh the lightest ones of fir. The painting characteristics depend largely upon such properties as density and therefore vary widely within species. From the technical point of view it is far more convenient in discussing painting characteristics to classify the woods according to their properties rather than by species, but the classification by species must be considered also as long as wood is bought and sold that way.

Classification by Grade

In commerce, lumber of each species is subdivided into grades on the basis of the number and size of defects appearing on the surface of the boards. The highest grade admits only boards of clear lumber practically free from defects. Several of the higher grades are known collectively as the select grades; they contain only "lumber of good appearance and finishing qualities" and are the ones most likely to be used where painting is important. The common grades permit more defects and usually go into concealed parts of structures or are remanufactured, the defects being largely cut out.

The defects that have most influence on painting characteristics are knots, pitch pockets, pitch streaks, pitch, and loose grain.

Classification by Grain

Wood has an oriented fibrous structure, that is, it has grain. Most of the fibers in a board are arranged parallel to the long axis of the tree or log from which the board is cut. Surfaces cut at right angles to the

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axis of the log cut through of the fibers transversely and are known as end-grain surfaces. Only the ends of boards present end-grain surfaces.

A series of rough, concentric rings can be seen on the end of a log. They are the annual growth rings, one of which marks each year of the tree's life. Each annual ring in a softwood, or coniferous tree, consists of a soft, light-colored part termed the springwood, and a horny, dark-colored part termed the summerwood. If the principal surfaces of a board lie in planes that run approximately radially to the annual rings they are edge-grain surfaces and the board is an edge-grain board. Both surfaces of an edge-grain board are practically alike. If the principal surfaces of the board lie in planes approximately tangent to the annual rings they are flat-grain surfaces and the board is a flat-grain board. The two surfaces of a flat-grain board differ in important characteristics that will be pointed out later; the side that was nearer the bark of the log is the bark side, the other the pith side.

Lumber cut mostly from relatively small trees consists predominantly of flat-grain boards. In cutting lumber from large trees that yield a high proportion of clear lumber it is possible to turn out a predominance of edge-grain boards and to sell edge-grain lumber separately from mixed edge and flat-grain.

Heartwood and Sapwood

In many species the older wood nearer the center of the tree differs in color and in content of certain chemicals from the wood nearer the bark of the tree. The former is the heartwood, the latter the sapwood. Heartwood is usually less readily permeable to liquids than sapwood, often much more durable against decay, and is immune from blue stain fungi.

Select grades of lumber come from the outer parts of the log and therefore include much of the sapwood. Some species contain so little sapwood that there is little of it in clear commercial lumber, but other species contain much sapwood. In general there is more sapwood in lumber from small trees than from older and larger trees of the same species.

Cellular Structure of Wood

The painting characteristics of wood are profoundly influenced by its porosity; from one-half to more than three-fourths of the volume of dry wood is air space. Wood structure is cellular, not labyrinthine, so that the porosity is more nearly like that of the honeycomb, in which there is no communication between cells, than like that of a heap of marbles or a bundle of rods, in which there is unobstructed, though much involuted passageway throughout the entire volume of enclosed air space.

The cellular elements of softwood structure consist very largely of tracheids, which are long, narrow tubes running vertically in the tree. They are roughly from 2 to 4 millimeters long by less than 0.03 millimeters wide. There are also shorter elements, termed the ray cells, which run along radii of the tree trunk and at right angles to the tracheids. Tracheids and ray cells are not merely bundled together; they are firmly embedded in a continuous matrix, the middle lamella, so that there are no spaces between elements through which liquids may move. The air enclosed in wood is mostly enclosed within the tracheids and wood cells. These cavities are not completely isolated from each other as in a honeycomb, however, because their walls are penetrated by small pits, covered by membranes, in which there are ultramicroscopic openings about 0.00002 millimeters in diameter, large enough to permit liquids to pass slowly, but far too small to admit paint pigments.

In the pines, spruces, larches, and Douglas fir, there are scattered through the structures certain long channels, called resin ducts, running both vertically and radially. These afford long, relatively large passageways provided that they are not obstructed with resin. The true firs, hemlocks, cedars, cypress and redwood do not normally have such resin ducts.

Springwood and Summerwood

The reason why the annual growth rings are readily distinguishable in wood is clearly revealed in the micro-structure because the tracheids of the springwood and summerwood differ strikingly from each other. In springwood the tracheids are roughly square in cross section, with thin walls and large voids; in summerwood the tracheids are flattened and have thick walls with small, thin voids. The enclosed air space in springwood occupies roughly 80 per cent of the total volume while in summerwood it amounts to somewhere near 40 per cent. Although summerwood has only half the capacity for holding liquids that springwood has, nevertheless liquids move through it much more readily than they do through springwood.

Pieces of wood differ widely in the width of their annual rings, usually expressed as number of rings per radial inch and in the proportion of springwood and summerwood in each annual ring. If the tree grew rapidly, the annual rings are wide. A high ratio of summerwood to springwood makes wood heavy and strong. Ring width and proportion of summerwood are the most important determining factors in paintability.

Chemical Composition of Wood

The principal substances out of which the cellular structure of wood is built are probably identical in chemical composition in all woods and the proportions in which they occur vary only slightly between species, between springwood and summerwood, and between sapwood and heartwood. These chemicals will be spoken of collectively as wood substance.

Wood substance consists principally of cellulose and lignin. Cellulose is a very complex carbohydrate, essentially a polymer of sugar, into which it can be resolved by hydrolysis. Lignin is a very complex organic material, possibly aromatic in character, whose molecular structure is still a matter of speculation and which is very likely to prove a mixture of compounds rather than a pure substance.

The walls of the wood cells are made of the cellulose, which is present in thread-like fibrils woven together in spirals inclined more or less to the long axis of the cell. Part of the lignin is interspersed in this cellulosic fabric where it fills in the chinks between threads more or less completely. The rest of the lignin forms the middle lamella which is the matrix in which the wood cells are embedded.

Swelling of Wood Substances

Wood substance is a typical elastic jelly. It is not soluble in ordinary solvents and is inert toward linseed oil, turpentine, petroleum oils, and benzine. Many liquids are imbibed by wood substance, cause it to swell, and diffuse through it. Water is the most important of these liquids; others include methanol, ethanol, acetone, and some of the esters used as solvents or plasticizers for nitrocellulose lacquers. Wood substance imbibes and is swollen by these substances not only on contact with the liquids themselves, but from contact with the vapors. The amount imbibed and the extent of the resulting swelling vary with the nature of the liquid or vapor and with the partial pressure of the vapor in the surroundings. Thus there is a definite equilibrium moisture content for wood substances at each relative humidity and temperature. Probably there is also a corresponding swelling equilibrium for wood substance also, but in practice what we observe is the change in dimensions of a piece of wood, not the swelling of the wood substance itself. Only a fraction of the total swelling expresses itself in a change in dimensions of the piece as a whole because much of it is absorbed in plastic deformation within the wood structure.

As a result, both the magnitude of the gross change in volume and the amount of radial and tangential swelling (longitudinal swelling is small) very markedly with the manner in which the change in moisture content is brought about as well as with the difference between initial and final moisture content. Still more important is the fact that such behavior as warping, cupping, checking, and weathering of wood depend more upon the manner in which changes in moisture content and in swelling take place than they do upon the amount of the changes concerned. Paint coatings therefore exercise a marked influence upon such behavior of wood even though they may not prevent change in moisture content from taking place.

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Extractives in Wood

Besides wood substance, wood contains extraneous constituents which can be removed fairly easily by extraction with suitable solvents. These extractives are variable in nature and in amount, differing not only between species, but between different parts of the same tree. The extractives are conveniently classified into those soluble in organic liquids like ether and those soluble in water.

The ether-soluble extractive of longleaf and slash pines is a resin containing the volatile oil turpentine, which consists mostly of terpene hydrocarbons, and the nonvolatile substance rosin, which consists largely of abietic acid. The other pines and Douglas fir contain resins of similar composition. Other softwoods contain such resins only in small amounts if at all, except when they occur in local deposits in the tree-like pitch pockets. Western red cedar, redwood, the true firs, hemlocks, spruces, and larches ordinarily contain only small amounts of ether-soluble extractives. Port Orford cedar, eastern red cedar, Alaska cedar, and cypress contain characteristic oils soluble in ether, but quite different in chemical nature, lacking an acidic substance analogous to rosin.

It is known that heartwood and sapwood may differ materially in the amount and particularly in the composition of the extractives present. It is not known whether there is more or less extractive present in summerwood as compared with springwood.

The water-soluble extractives include tannins and other complex organic substances of an aromatic nature, some of them highly colored, carbohydrates, organic acids like formic, acetic, and their homologs, traces of organic nitrogen compounds, and mineral constituents of wood ash. The amount and nature of these extractives vary widely between heartwood and sapwood and, in some species at least, in the heartwood from different parts of the same tree. During the drying of wood, under some circumstances, these extractives may tend to concentrate at the surfaces.

Object in Painting Wood

The painting characteristics of wood must be considered with due regard for the object for which wood is painted. Painting is done to secure and maintain a desired appearance on surfaces exposed to view. There are at least three factors in appearance, namely, color, texture, and line. Exterior wood surfaces must be kept painted wherever color with smooth texture and straight, snug lines are desired; they may be kept varnished where the natural wood color and grain together with smooth texture and snug lines are wanted; they may be kept stained or thinly painted where color with rough texture and broken lines are preferred; and they may be left without surface treatment where the neutral color, shaggy texture, and irregular lines of weather-beaten wood give the effect selected. In general, architectural considerations dictate that different patterns of lumber be used according to the effect desired. Thus siding nailed with the planed side out is almost always painted when any pretense of keeping up appearance is made, but if nailed sawed side out or if shingles are used, the surface is rarely painted and may either be stained or left to weather naturally.

In considering painting, therefore, we are striving to maintain a colored opaque coating intact, presenting a smooth surface, with straight, snug lines. The effect is marred if the smooth wood surface is permitted to check badly or roughen by weathering, for ordinary painting does not restore a surface with smooth texture. Likewise warping, cupping, and loosening of the boards must be prevented if snug lines are to be retained. The paint coating must therefore protect the wood against weathering to keep up the desired appearance.

Influence of Wood Properties During Application of Paint

The first coat of paint applied to new wood is very largely consumed in filling the voids, leaving a level, non-absorptive surface on which subsequent applications can build a coating. However, even though one-half to three-fourths of the volume of wood is void, a comparatively small amount of paint is required for priming it. A plaster wall takes two or three times as much paint as wood. The cellular structure of wood in contrast to the granular structure of plaster accounts for the difference, because in wood, penetration beyond the voids in those cells cut open in making the surface can take place only through the very fine openings in the pit membranes.

End-grain wood surfaces consume much more paint than edge or flat-grain surfaces because the long tracheids stand at right angles to them. However, not much end-grain wood need be painted. There is little, if any, difference in the consumption of paint between edge and flat-grain surfaces. Light wood, with its greater content of voids, consumes measurably more paint than heavy wood, though the difference is not much greater than the individual variation between painters in applying paint and it is largely compensated if the customary recommendation is followed of mixing the priming coat relatively richer in turpentine than in linseed oil for heavy woods than for light ones. Undoubtedly there would be a marked difference in spreading rate of paint between springwood and summerwood if we had the two kinds of surfaces to paint separately.

The liquids of paint penetrate more deeply into wood than do the pigments, as can be proved by adding an oil-soluble red dye to the paint before application and later examining the depth to which the red color penetrates. The ratio of solids to liquids in the paint remaining at the surface is thereby upset, so that a paint that dries with a glossy film on glass or metal, dries with a dull film on wood. Judged by the effect on gloss, more oil is thus filtered off in springwood than in summerwood, but penetration is found to be deeper in summerwood. The paradox is not mysterious, for the void capacity of summerwood is only half that of springwood.

Penetration of oil as deeply as possible has long been held desirable in painting wood. There seems to be no good reason for so believing, however, because paint fails soonest on the summerwood, into which oil penetrates deepest.

Extractives present in cypress and redwood tend to retard the drying of some paints on these woods, especially in the presence of much moisture or low temperatures. The fact is of no serious practical import, for experiment proves that coatings applied to these woods under conditions giving pronounced retardation of drying cannot be distinguished in later exposure from coatings applied under good drying conditions. From the point of view of theory, however, the fact is probably significant, for these woods are among those upon which paint coatings last longest even when they have rather wide bands of summerwood.

Normal and Abnormal Exposure

In considering the behavior of paint coatings on wood, sharp distinction must be drawn between normal and abnormal conditions of exposure. Under normal conditions moisture in large amounts gains access only to the painted surface for short times during wet weather. Under abnormal conditions much moisture gains access to the backs of the painted boards, usually for fairly long intervals. The results of abnormal conditions will not be discussed here; it need only be said in passing that trouble from abnormal conditions may be experienced with any kind of paint, on any kind of wood, and may arise very early in the coating's history. The failure may take one or more of several forms. The coating may blister and peel, which is easily recognized, or it may scale, which is often hard to distinguish from scaling under normal conditions with some paints. The coating may become discolored with water-soluble extractives from the wood or with dirt and stains carried by the water from other sources within the structure. The coating may become discolored by blue stain fungi growing in sapwood, and finally, under prolonged or repeated exposure to abnormal conditions, the wood beneath the coating may rot.

Early Part of Normal Exposure Not Influenced by Wood

Under normal conditions of ex-

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posure the behavior of paint coatings during the early part of their service life is not materially influenced by the kind of wood surface upon which they are applied. The rate of loss in gloss, the collection of dirt, the development of chalking and fading, the time when paint checking begins, and the distinctive pattern of the checking depend upon the kind of paint, the climate, the local conditions of exposure, and perhaps to some extent upon the manner of application, but they are not influenced to any important extent by the wood.

By way of conception to this generalization it may be said that occasionally chalking and fading proceed more rapidly over springwood than over summerwood, so that the grain of the wood is revealed by the appearance of the coating over it. Such behavior is here regarded as due to inadequate priming and therefore to poor craftsmanship in painting, because well-painted surfaces do not so behave. Further exception may be made of loose grain appearing on flat-grain boards that are turned pith side out, which will be discussed later.

The nature of the wood surface begins to influence the behavior of coatings when they reach the point in their deterioration at which they no longer protect the wood adequately against weathering and when they begin to disintegrate by crumbling, flaking, or scaling, leaving parts of the wood surface bare. From this point on, under present painting practices, it may fairly be said that the kind of wood surface rather than the composition of the paint dominates the behavior of the coating and determines when repainting is in order.

Influence of Wood on Ultimate Failure of Coatings

Paints as we now use them fail ultimately either by (1) inadequately protecting the wood so that it begins to weather check, cup, warp, or pull away from fastenings, or (2) crumbling, flaking, or scaling, leaving parts of the wood bare. As would be expected, the wood surfaces on which failure by inadequacy of protection is first noticed are the surfaces having the greatest tendency to develop weathering defects. Failure of the coating to remain intact starts over the summerwood and a stage is usually reached, if the exposure continues long enough, when all the summerwood is bare while the springwood remains covered. The amount and distribution of summer-

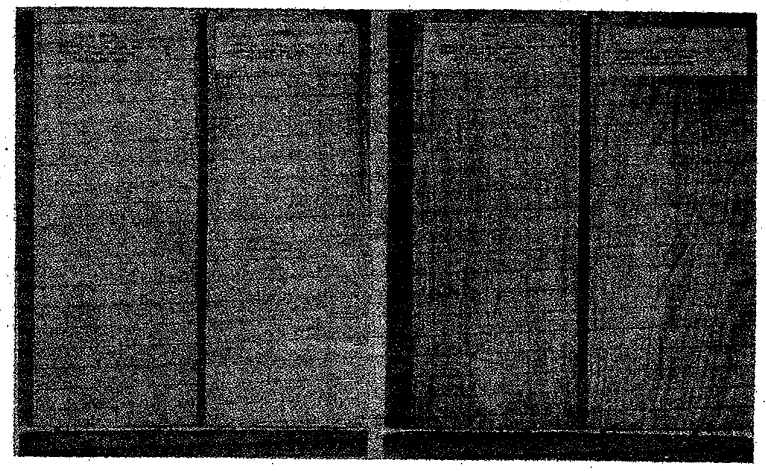

Figure 1.—Illustrating the influence of ring width and density on the behavior of paint coatings. The boards are all of the same species of wood.

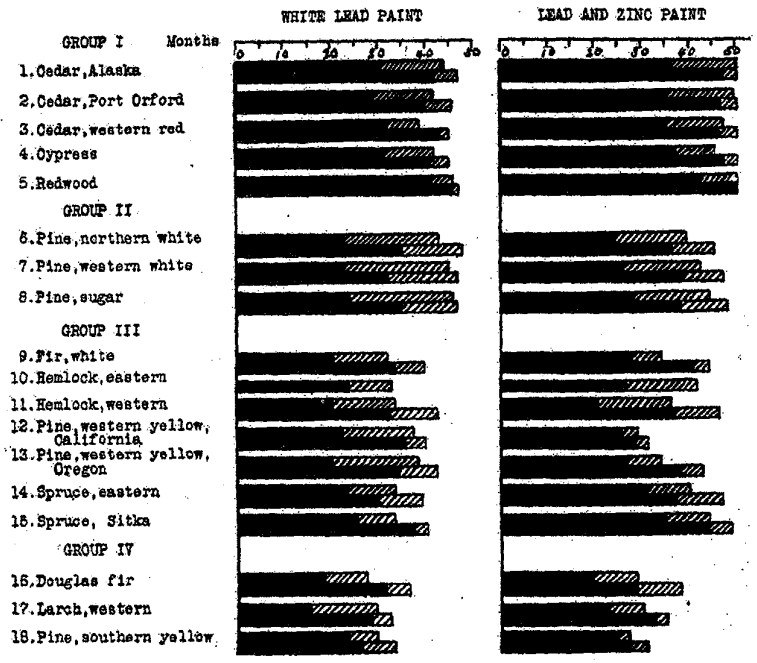

Chart 1.—Representing for the different woods the average time elapsed before repainting was needed to maintain (a) the integrity of the coating, (b) adequate protection against wood weathering. For each species the upper half of each bar represents flat-grain panels, the lower half edge-grain panels, except that for eastern hemlock only flat-grain panels were tested. The whole length of the bar, that is, the solid plus the crosshatching, represents the time for repainting when coating integrity only is considered; the solid part alone represents the time for repainting when protection of the wood is considered also.

wood is therefore the predominant influence in failure of the coating to remain intact.

Influence of Species

Chart 1 summarizes the results by species of an extensive series of field tests by the Forest Products Laboratory. Two kinds of paint were used, for each of which a separate tabulation is made. There is far more difference in the life of coatings of the same kind of paint on different woods than between the two paints on any wood.

The woods are divided into four groups on the basis of the results in this test; I, those woods on which paint protected and remained intact longest; II, those on which it remained intact but failed sooner in protection than was found for group I woods; III, those on which paint failed in both protection and integrity sooner than on group I woods; IV, those on which paint failed soonest, especially in integrity.

Influence of Density and Ring Width

Chart 2 shows that the classification by species follows fairly closely the average density of the species. A still closer parallel would be brought out if the chart could show ring width as well as density in their bearing on the results. The photograph, Figure 1, illustrates how ring width modifies density in determining coating integrity. The four boards shown are all flat grain and of the same species of wood. They were taken from paint test panels

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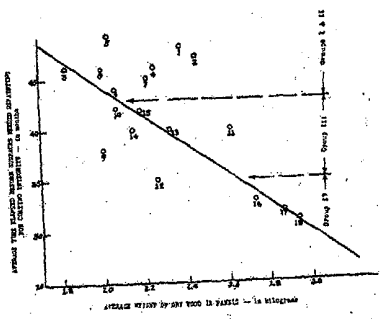

Chart 2.—The relation between repainting time and weight of dry wood in the panels tested for the different species. The key to the numbers is given in Chart 1.

and planed to remove the remnants of the coatings and reveal the nature of the surface. Boards *A* and *B* held paint well, boards *C* and *D* poorly. Board *A* is both light in weight and narrow-ringed, board *D* is heavy and wide-ringed. Boards *B* and *C* are equal in density but *B* is narrow-ringed while *C* is wide-ringed.

As already pointed out, there is much variation within many species in density and ring width and it follows that there is a corresponding variation in painting characteristics. Density and ring width consequently are a far more precise guide to paintability than species, but woods are bought and sold by species and not by density and ring width.

Influence of Direction of Grain

Chart 1 shows that edge-grain boards are far superior to flat-grain boards, both because they require less protection against weathering and because they display their summerwood in narrow lines rather than in flaring areas and hence hold coatings intact longer.

The bark side of flat-grain boards is far superior to the pith side in many species because there is a tendency for the grain to shell out on the pith side. This is a form of wood weathering against which paint should, theoretically, afford protection. In practice, however, paint as we now use it proves inadequate. Flat-grain boards should therefore be turned bark side out.

Influence of Grade

Knots are objectionable in painted surfaces because they do not remain perfectly concealed, either because they do not remain level with the rest of the surface, because they sometimes cause the coating over them to turn yellow, because the wood of the knot may crack, or because the paint may scale over the knot. Pitch pockets and pitch streaks lead to objectionable exudation of pitch through coatings. For these reasons high-grade lumber of any species is better for painting than the lower grades.

Influence of Extractives

The position of cypress and redwood in Charts 1 and 2 seems to be more favorable than their density and ring width would predict. It has already been mentioned that these woods contain extractives that retard drying under certain circumstances and it is plausible to consider these substances as inhibitors of oxidation exercising a favorable influence on the maintenance of coating integrity.

A careful examination of Chart 1 shows that woods containing a resin with an oil-soluble acid like rosin compare with the other woods more favorably in maintenance of coating integrity for white lead paint than in integrity for lead and zinc paint. This is in line with the familiar evidence that paints containing zinc oxide are adversely affected by acids present in linseed oil.

Influence of Climate

Chart 3 shows that climate profoundly influences the durability of paint coatings, as has long been realized, but the differences between woods remain much the same. However, the amount of difference between woods of the four classes is less in the more humid climates than it is in the drier ones.

Influence of Paint Composition

The Forest Products Laboratory has tried various expedients in priming-coat procedure that have been recommended for obtaining better results on wood surfaces containing much summerwood. The proportions of turpentine and linseed oil in the priming coat have been altered

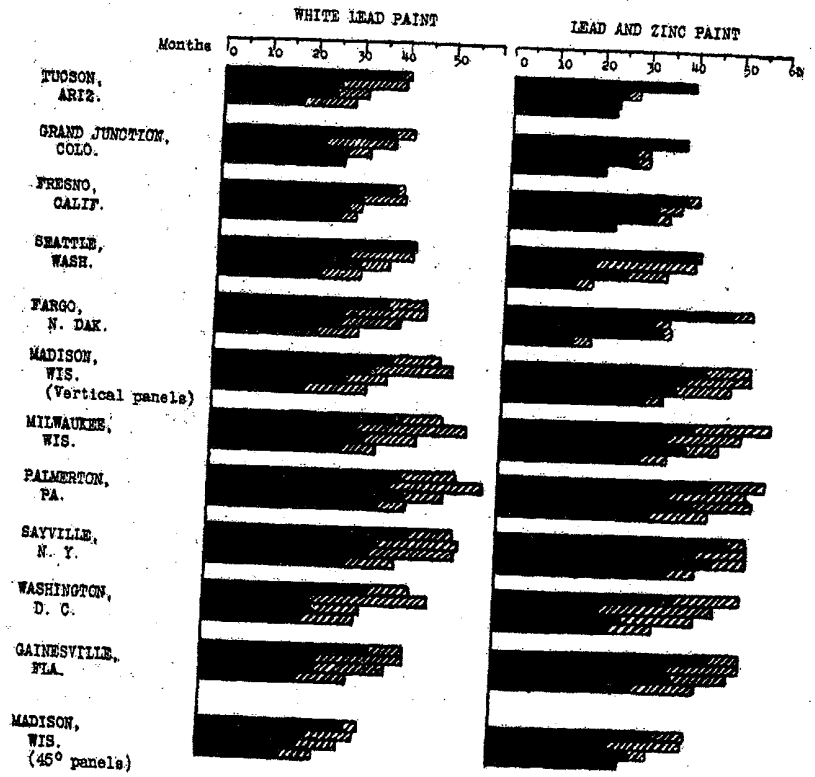

Chart 3.—Illustrating the influence of climate on the behavior of paint coatings. Each bar is divided into four parts representing, respectively, beginning with the upper part, the behavior of coatings on woods of Group I, Group II, Group III, and Group IV. The whole length of the bar, that is, the solid plus the crosshatching, represents the average time elapsed before repainting was needed when coating integrity alone was considered; the solid part represents the time for repainting when protection of the wood was considered also.

greatly, thinners like benzol have been used in place of turpentine, and special priming-coat paints have been used. All but one of these expedients have either failed to alter the behavior of the coatings or have led to earlier loss of coating integrity. Aluminum paint used as a priming coat under white lead or lead and zinc paint materially prolongs the life of the coating both in protective power and in integrity, but the ultimate failure takes place by flaking from the summerwood just as it does when the paints are applied in the customary fashion.

The Forest Products Laboratory has also tried a number of supposedly harmful painting practices, such as painting wood at high moisture content (not containing free water, however), painting in humid atmospheres and in the absence of sunlight and allowing short times for drying between coats. The results seem to indicate that the bad effects of such factors in paint application have been greatly exaggerated.

Problem for Future Research

The variability in behavior of paint coatings on wood surfaces of different kinds is the wood-painting problem that must be solved before

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consumers of paint and of lumber can be given better paint service. To some extent selection of lumber in accordance with its painting characteristics can be practiced, but improvement in this direction is limited by the facts that in choosing wood for any purpose other factors must be considered besides paintability and that most of our available lumber supply is of the kinds that contain much summerwood. Furthermore, second-growth woods are likely to be less desirable in respect to painting than the virgin stands because the trees will usually be grown more rapidly and will be cut younger. It is conceivable that some means of treating lumber to improve its painting characteristics may be invented, but there is no reason for regarding that point of attack on the problem as particularly hopeful. Improved paint or painting technique seems much more likely to furnish the solution.

A coating that would endure indefinitely is probably a vain objective and perhaps not an altogether desirable one, for most people would like to change their scheme of decoration from time to time. The ideal coating for wood, however, ought to remain an adequate protective agent against wood weathering until its appearance is so changed that repainting is clearly necessary, and it ought to wear down uniformly over summerwood and springwood alike, being firmly anchored to all parts of the wood when repainting is done. Flaking from summerwood should be unknown. With such a paint, all wood surfaces would give equally satisfactory paint service.

The attainment of an ideal paint of this kind is an ambitious but by no means unpromising objective. As we see it, the problem is one of securing firmer and more permanent adhesion between coatings and wood. Probably at present aged coatings cling to wood by mechanical embedding in the rough surface, much as plaster grips lath. Summerwood, with its low void volume and very small voids, offers an uncertain support for adhesion of that kind. A true adhesion between wood substance and the matrix of the paint coating is called for. Glue sticks to summerwood; why can not paint be made to do so? The Forest Products Laboratory proposes to seek true adhesion between paint coatings and wood and invites the cooperation of the technical men of the paint industry in that quest.

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TESTING HOUSE PAINTS *for* DURABILITY

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Paint making is still an art rather than an applied science. The approach to a scientific knowledge of paints and paint durability must be made by the empirical route. The present article outlines some of the variables which must be taken into account in paint testing and describes a technic for the conducting and recording of durability tests.

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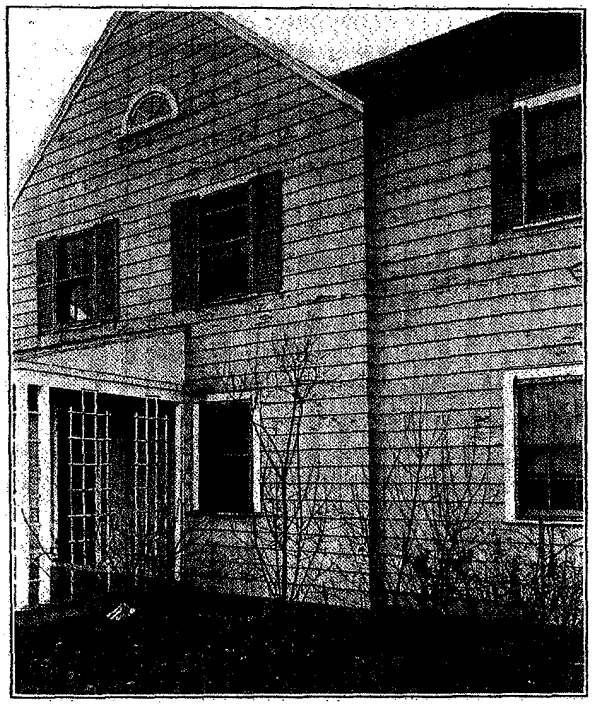
HOUSE paints have been developed empirically out of ancient craftsmanship; they are not yet to be regarded as products of science applied to industry. Many facts have been learned about paints through experience and practical testing but it has not yet been possible to establish general laws of paint behavior to correlate the facts. To be sure, the literature of the subject is replete with theories that are glibly accepted without verification by crucial experimentation and possess a remarkable ability to live on, long after they have been proved grossly inconsistent with the facts. Not only is there competition between rival theories but the facts themselves must be sought among a mass of utterly contradictory assertions often unsupported by citation of evidence. Moreover, there is as yet neither a generally accepted technic of measuring the durability of house paint nor agreement upon a definition of durability. The transformation of paint making from an art to a science is much to be desired but is not likely to be achieved for some time to come even though progress in that direction is proceeding more rapidly than it has in the past. Meantime current problems must continue to be met through frankly empirical experimentation and observation.

The young graduate in chemistry confronted with the problem of paint evaluation often finds it difficult to adjust himself to the empirical method of procedure. His college training usually has taught him very little about it and, still worse, may have led him to hold it in light regard. As a result he tends to shirk the direct attack upon the immediate objective in order to pursue some minor aspect of the problem by methods that are more to his taste. A well-grounded fear that empiricism in papers offered for publication in the chemical journals may be received with little enthusiasm by the evangels of the profession proves an additional discouragement. The young chemist's early years in such industries as paint making would be both happier and more fruitful if his college training taught him that empiricism must blaze the trail for science and that industry must solve its problems empirically when it cannot wait for the more adequate answer ultimately possible through the scientific method.



PAINT FAILURE OF THIS KIND IS NEVER OBSERVED ON PAINT TEST FENCES BUT ALL TOO FREQUENTLY ENCOUNTERED ON HOUSES

It is caused by moisture gaining access to the back of the painted woodwork. The possibility of such developments makes paint tests on houses uncertain; it also makes it necessary to study the behavior of paints when subject to such conditions before their merits for general house painting can be fully understood.

Empirical experimentation to be effective must usually be conducted on a much larger scale than scientific experimentation. This is particularly true of paint testing. Failure to appreciate it has led to great waste of effort and the disappointing results have done much to throw durability tests into disrepute. The durability of a paint depends on many factors besides its composition. Not all of the factors are known. It is, therefore, essential that the testing procedure duplicate practical conditions of service as closely as possible and take account of the probable variations in conditions of service. Many exposure tests are required to accomplish useful comparison of even a small number of paints, and the tests must extend over a period of several

* Maintained at Madison, Wisconsin, in coöperation with The University of Wisconsin.

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years before conclusions may be drawn. Great care must be taken to plan the tests adequately and to provide satisfactory methods of inspection, record, and evaluation. An adequate program of exposure testing is necessarily expensive, time-consuming, and exacting in its demands for trained technical supervision. In the writer's opinion durability tests of paint should never be attempted when these requirements cannot be met.

ARTIFICIAL WEATHERING TESTS

Strenuous efforts have been made to devise artificial weathering tests for house paints in which results may be obtained in much less time than is required in natural weathering (*1*). Such tests serve usefully as a subordinate part of the research program in large laboratories. They are useful, for example, in rejecting from a large number of previously untried paint compositions those mixtures so seriously faulty that they merit no further consideration, so that the smaller number remaining can be tested adequately by natural weathering. Artificial weathering tests probably will increase in usefulness as the nature of the changes that take place when paints age becomes better understood and study of the disintegrating influences, one by one, becomes desirable.

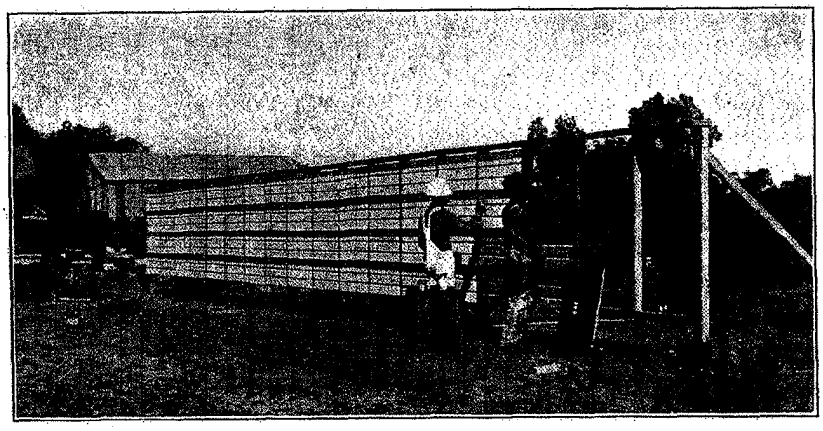
Artificial weathering tests are not at present acceptable as the sole basis for determining the relative durabilities of practical house paints because accelerated deterioration is achieved by deliberate aggravation of some factors in weathering, a procedure that is out of harmony with the requirement that the tests be made under conditions duplicating those of practical service as closely as possible. Results of accelerated tests are not always in satisfactory accord with results obtained by natural weathering.

TEST FENCES

The principal means of measuring the relative durability of house paints is the test fence. For reasons that will be detailed later, houses are less practicable than test fences because complicating factors not yet fully understood sometimes affect the behavior of paint on houses to such an extent that there is often uncertainty whether the deterioration of paint on a house may be attributed purely to normal weathering of the paint. These complicating factors on houses must be studied separately by means of a special technic.

The first paint test fence in the United States is said to have been erected by the U. S. Gutta Percha Paint Company some time prior to 1907 but its existence remained practically unknown outside of the company until recently (*2a*). Many paint manufacturers and paint technologists now conduct such tests (*3*) but one of the most experienced paint chemists (*4*) said not long ago that he finds "too few paint companies who have comprehensive and adequate exposure programs. . . . Our future progress in paint development will continue to be based on the evaluations of our exposure tests and not on theoretical considerations." Comparatively little of the data acquired from manufacturers' test fences becomes public through technical publications. The first fence tests to gain public interest were those started in 1907 by the late Senator Ladd while professor of chemistry at North Dakota Agricultural College (*2b*). They were an outgrowth of the famous North Dakota paint law that required all house paints sold in the state to bear a statement of composition unless they contained only white lead, zinc oxide, linseed oil, turpentine, and paint drier. Subsequent test fences to be made public are cited in the list of references (*2c*).

The earlier test fences failed to provide the expected basis for decision between different types of paint. Some of the worst compositions were clearly demonstrated but for the most part opinions about paint formulas remained as divergent after the tests as they were before. The difficulty lay in inadequate understanding of the essential conditions for conducting such tests properly and in the attempt to test too many paint formulas at one time with the means available. Modern knowledge of testing technic, however, has thrown new light on many of the older tests as a result of which a re-examination of the old records often proves very fruitful (*5*).



THIS RELATIVELY INEXPENSIVE TEST FENCE AT FRESNO, CALIFORNIA, MAINTAINED BY THE W. P. FULLER CO., HAS BEEN USED FOR TESTS BY THE FOREST PRODUCTS LABORATORY SINCE 1924

No repairs have been required by the unpainted framework, which is made of heartwood Douglas fir and redwood. Exposures are made on the south side of the fence only. Note that the panels were painted immediately after erection. The amount of paint applied to each panel was determined by weighing on the balance on the upturned box to the left of the fence.

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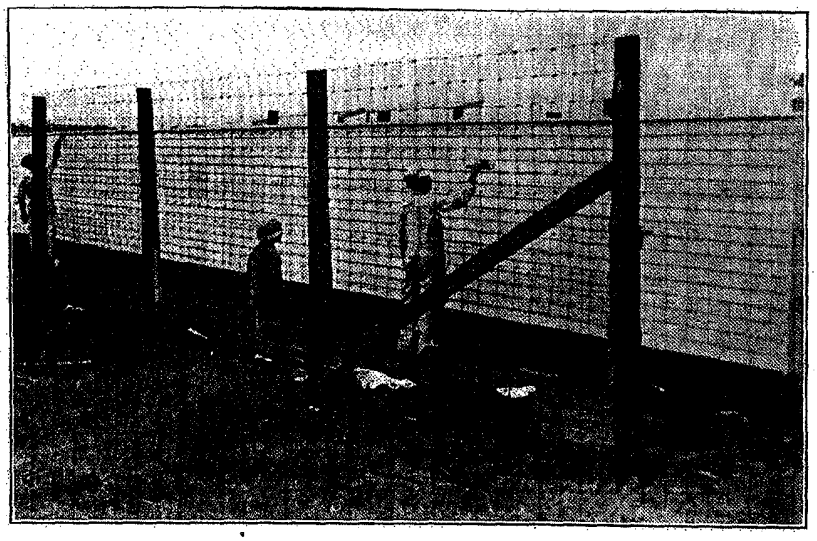


THE TEST FENCE OF THE NORTHWESTERN PAINT AND VARNISH PRODUCTION CLUB AT THE STATE FAIR GROUNDS, ST. PAUL, MINNESOTA, REQUIRES AN OPEN WIRE GUARD FENCE TO PROTECT IT FROM MOLESTATION

Siding lumber is nailed directly to the open framework on both north and south sides. The test areas were marked off by black stripes and numbered after the test paints had dried.

CONSTRUCTION OF TEST FENCES

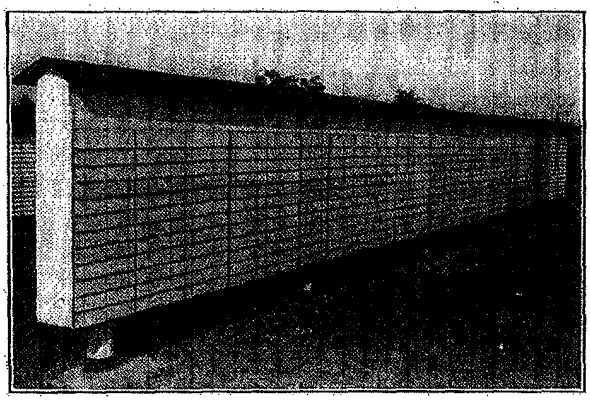
As a rule test fences should be erected in suburban or rural environments rather than in industrial centers. Tests made near factories are subject to serious uncertainties because of extreme accumulation of dirt and soot and possible abnormal chemical reactions with industrial gases. In such surroundings white paints that ordinarily maintain reasonably good appearance have been known to turn totally black and to last much longer than they can be expected to do on residences. Test fences in the country should not be located in unusually damp ground or too close to rivers or lakes to permit the air around the fence to follow the extremes of relative humidity characteristic of the climatic region.

Test fences consist of a simple framework for supporting painted panels. The framework should be durable and strong enough to remain upright during the most severe storms. A very satisfactory construction consists of 4 × 4-inch posts or 6-inch round posts set at least $2^1/_2$ feet into the ground, projecting 7 feet above ground, and set 6 feet apart from center to center. A concrete collar at the ground line serves to prevent working under wind pressure with consequent loosening of the anchorage in the ground. The posts are subject to decay, at least below the ground line, and must, therefore, be of durable wood. Heartwood of redwood or southern cypress is very durable and heartwood of southern pine or Douglas fir is satisfactory for square posts; cedar or chestnut makes good round posts. Sapwood of any species lacks durability and decays relatively soon. If posts containing much sapwood or non-durable species must be used they should be treated with creosote by impregnation under pressure or treated by the hot-and-cold bath method to a distance at least 18 inches above the ground. Failure to take proper precautions against decay has repeatedly resulted in the blowing down of test fences or in the necessity of replacing posts at frequent intervals. Surface application of creosote does not afford adequate protection for posts and paint is of no use whatever for that purpose. The Forest Products Laboratory fence at Madison, Wisconsin, built with creosoted posts, has stood for nearly eleven years without a single replacement or any sign of rot. A fence at Seattle, Washington, built with untreated posts of Douglas fir, has been in service for the same length of time.

The posts should be connected with a simple framework of 2 × 4-inch stringers and studs to which test panels can be attached and covered with a plate or roof projecting an inch or two beyond the face of the test panels to keep rain water from seeping in behind the panels. It is advisable to build this superstructure also with the heartwood of durable species, particularly so if the framework is to be painted, and to make all joints as tight as possible to keep out rain water. Trouble has been experienced on some test fences with decay setting in at such joints when the lumber contained sapwood. If non-durable lumber is used it is desirable to soak the ends of all pieces in creosote, especially if they expose end-grain sapwood, to brush all surfaces, or at least concealed surfaces, with creosote, and to leave the framework of the fence unpainted, although it may be stained if desired.

If desired the framework may be enclosed with lumber sheathing from the top down to the lowest stringer, which should be not less than 18 inches above the ground. Sheathing presents a supporting surface like that on the sidewalls of most houses but it adds materially to the cost of the fence and is not really necessary.

The most satisfactory test fences are erected vertically because that is the position in which most house paint is used. Most fences run east and west so that test panels face south, if but one side of the fence is utilized, and north and south if panels are attached to both sides. The fence should be far enough from buildings, trees, or other obstructions to expose all panels on the south side uniformly to full sunshine. Paint wears



AN EXCELLENT TYPE OF TEST FENCE MAINTAINED BY THE NATIONAL LEAD CO. AT SAYVILLE, NEW YORK

The framework is covered with sheathing lumber before the test panels are attached. Both north and south sides of the fence are used for tests. The tests shown are a series by the Forest Products Laboratory in which each test panel consists of four boards, six feet long, marked off by stripes into three test areas of which the center is painted with a "control" paint against which the other two are compared.

out most rapidly on the south side and least rapidly on the north side. Tests repeated on north and south sides reveal the range in durability normally to be expected in the region. On the southern exposure paints chalk and colors fade most rapidly, while on the northern exposure dirt collects for a longer time, yellowing of paint oils may be more marked, and there is more chance for mildew to develop. By considering both northern and southern sides the relative appearance of different portions of a house can be gaged more successfully than is possible with southern exposure only.

Some workers prefer test fences on which the panels slope back at an angle of 45 degrees from the vertical because the intensity of sunlight falling on the painted surface is thereby increased and failure of paint is accelerated (*6*). Like other forms of accelerated weathering tests, however, inclined exposure should be used only to supplement rather than to replace vertical exposure. Inclined panels apparently undergo greater extremes of temperature and moisture content than vertical panels and paint on inclined panels acts as it would on vertical panels in a drier and warmer climate. Observations of changes in the appearance of coatings on inclined panels are not entirely representative of the behavior of the paint on vertical panels.

A good wire guard fence around the test fence is often needed to protect it against vandalism. Many persons seem to have an uncontrollable impulse to write on fences. Fences on farms need a guard fence to keep cattle from licking fresh paint with consequent disaster both to the paint and to the cattle. The guard fence should be placed far enough from the test fence to leave plenty of room for photographing test panels.

EFFECT OF CLIMATE

The variations in climate in different parts of the United States materially affect not only the durability of paint in general but the comparative durability of different kinds of paint. There are two opposite extremes of unusually severe climate from the point of view of paint; most of the United States, especially the more populous parts, lies between the two extremes. One extreme is found along the southern Atlantic Seaboard and the coast of the Gulf of Mexico, conditions in Florida being typical. Here, for example, paints containing high proportions of zinc oxide are distinctly more durable than pure white lead paint. The other extreme is found in the southwest, the region of the Great Plains, and the interior valleys of southern California. There white lead paint is distinctly more durable than paints containing even moderate proportions of zinc oxide. In both of these regions all paints fail more rapidly than they do in most other parts of the United States. Common characteristics of the two extreme conditions are relatively high amounts of sunshine and high maximum temperatures. The significant difference between them is the high relative humidity prevailing almost constantly in the one and the exceptionally low relative humidity characteristic of the other during at least a part of the year.

In recent years there has been a tendency to regard tests in Florida as a form of accelerated exposure testing free from the shortcomings of artificial exposure tests. Florida exposure, however, cannot be accepted as a satisfactory test of paint for use in other parts of the country. Parallel exposures in Florida and in the southwest might be so accepted but it is wisest to test paints for national distribution in at least three characteristically different climates.

CHOICE OF WOOD FOR TEST PANELS

As a rule panels for testing house paints should be made of wood because that is the principal kind of surface upon which they will be used. Paints that endure well on metal often fail rapidly on wood.

One of the principal difficulties in interpreting the results of the earlier test fences arose with the discovery that the nature of the wood had as much effect on the durability of the coating as the composition of the paint, unless the paint is a very poor one indeed. A prominent paint executive dubbed the earlier tests a "lumber lottery" (*7*). Although recognized since 1912, the necessity for carefully considering the effect of the wood and practicable means of taking it into account have not been properly appreciated until recent years.

Lumber for exteriors of houses is predominantly softwood lumber. The following factors affect the durability of paint on softwood lumber (*8*):

1. The proportion of summerwood, which is the dense, hard, dark-colored portion of each annual growth ring in the tree. When paint coatings begin to break up and small pieces begin to fall off the wood, the disintegration sets in and progresses rapidly over the summerwood. The more summerwood there is, the sooner such disintegration becomes serious. The density of a board at some standard moisture content usually depends directly upon the proportion

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of summerwood. Other factors being equal, the less a board weighs the longer paint lasts upon it.

2. The width of the annual growth rings. Slowly grown wood has narrow growth rings and may, therefore, have narrow bands of summerwood even though the wood is fairly heavy. Slowly grown wood holds paint longer than otherwise similar wood that grew rapidly.
3. The direction at which the surface to be painted cuts the annual growth rings. Edge-grain boards are cut with the principal surfaces approximately parallel to a radius of the log and at right angles to the growth rings. The bands of summerwood are of minimum width in such boards and paint is, therefore, held to best advantage. Flat-grain boards are cut with the principal surfaces approximately tangent to the growth rings so that the bands of summerwood are wider and paint fails more rapidly than on edge-grain boards. Of the two principal surfaces of a flat-grain board the one nearer the bark of the tree often holds paint longer than the one nearer the pith of the tree.
4. The grade of lumber. Lumber is graded for sale according to the size and number of defects, of which the principal ones are usually knots. The high grades hold paint better than the low grades, both because knots often cause early paint failure and because the low grades as a rule come from the central parts of the tree where the growth rings are usually wider.
5. Resin and other extractives. The resins and other extractives in wood have less effect on paint than is commonly supposed (*9*). The resin characteristic of the white pines and the yellow pines, which contain rosin, exerts a slightly detrimental effect upon the durability of paints that contain zinc oxide. On the other hand the oily extractive in southern cypress and the aqueous extractive in redwood apparently tend to make most paints last longer.

Since lumber is sold primarily by species the following classification of softwoods for painting has been worked out, but it must be remembered that within each species there is wide variation in the above properties and consequent overlapping in painting characteristics:

Group I—Woods that are generally light in weight, of slow growth, hold paint well, and require little paint protection to prevent wood weathering:

Alaska cedar	Western red cedar
Port Orford cedar	Southern cypress
Redwood	

Group II—Woods that are generally light in weight but not always of slow growth, that contain resin slightly detrimental to paints containing zinc oxide, and that require more adequate paint protection than woods of Group I:

Northern white pine	Sugar pine
Western white pine	

Group III—Woods that are usually either more rapidly grown or heavier than those of Groups I and II and therefore hold paint less well and that require more adequate paint protection than woods of Group I:

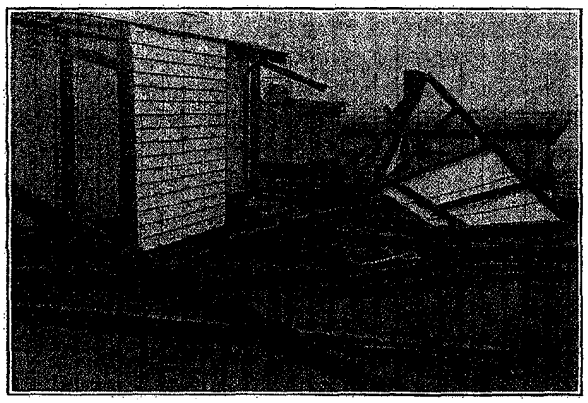
Commercial white fir	Ponderosa pine
Eastern hemlock	Eastern spruce
Western hemlock	Sitka spruce

Group IV—Characteristically heavy woods with wide bands of summerwood over which paint begins to fail comparatively early:

Douglas fir	Western larch
Southern yellow pine	

By choosing lumber for test panels with careful consideration for the properties that are known to affect paint behavior, the variability in results caused by the wood may be reduced materially. A relatively large supply of lumber may be sorted for boards of reasonably uniform properties. If such specially selected lumber for test purposes could be made available commercially there would undoubtedly be a demand for it in the paint industry even though it would necessarily be expensive. Variability due to the wood, however, cannot be entirely eliminated even by careful selection and other methods of allowing for it must be adopted.

There are two methods of minimizing uncertainty due to variability in the wood. The first is multiplication of the number of boards in each test panel and of the number of panels painted with each paint, and the second is the procedure of "matching specimens," that is, comparing paints by applying them to neighboring areas of the same boards. The most practicable procedure combines the two. The style of test panel preferred at the Forest Products Laboratory consists of four boards of 6-inch siding, each board 6 feet long. Record is kept of the density, width of growth rings, and direction of the growth rings in each board. The face of the panel is then subdivided into three test



THIS TEST FENCE WAS BUILT IN 1924 WITH LUMBER THAT CONTAINED MUCH SAPWOOD

Although decayed members were repeatedly replaced the fence collapsed early in 1933. The framework was kept painted. Durable lumber or lumber treated with wood preservatives safeguards the investment made in conducting paint tests.

areas each 2 feet long, one of which is painted with some paint chosen particularly as a suitable control against which experimental paints on the other two areas can be compared.

The best wood for testing the relative ability of paints to remain intact over bands of summerwood is southern yellow pine. When a paint formula has been worked out that lasts well on southern pine it may be assumed safely that it will give good service on any other softwood. Paint technologists working for paint manufacturers, however, are often expected to submit test panels to inspection by the sales department or by prospective customers and for that purpose they find southern yellow pine less desirable than a wood on which paint lasts longer and on which the ultimate areas of paint failure are not so conspicuous. For tests planned to disclose the range in behavior that will be exhibited by a paint offered for general use in house painting tests should be made on four kinds of wood, one from Group I, a second from Group II, and two from Group IV, of which one should be southern yellow pine. The writer recommends the following:

1. Western red cedar bevel siding, "clear" grade, $^1/_2 \times$ 6-inch size. This will be edge-grain lumber.
2. Northern white pine bevel siding, "B and better" grade, $^1/_2 \times$ 6-inch size. This will be mostly flat-grain lumber. Ponderosa pine should not be accepted for this purpose in place of northern white pine.
3. Douglas fir drop siding, "B and better" grade, $1 \times$ 6-inch size. This can be purchased entirely vertical grain (edge-grain) if desired but the flat-grain boards afford a more severe test of paints.
4. Southern yellow pine drop siding, "B and better" grade, $1 \times$ 6-inch size. This will be chiefly flat-grain lumber.

Lumber for test panels should not be stored in heated rooms or kept very long in heated carpenter shops or laboratories. It is best stored in unheated rooms or lumber sheds where the relative humidity never falls below that characteristic of outdoor air in the climate in which the test fence is located. For most climates the moisture content of the wood should not be allowed to fall below 10 per cent. of the weight of wood when oven-dry.

Test panels should be mounted on the fence with the boards running horizontally, as they do on most houses. At the Forest Products Laboratory the four boards making up each panel are fastened together by cleats on the back so that the panel can be handled as a unit before it is attached to the fence. It is fastened to the fence by driving zinc-coated nails or screws through the boards into the supporting framework. If panels are mounted against lumber sheathing or if both north and south sides of the fence are covered with test panels it is not necessary to paint the backs of the panels but if only the south side of an open fence is utilized the backs of the panels should be painted with two coats of exceptionally durable paint, such as aluminum paint.

LAY-OUT OF TESTS

Exposure tests are made to best advantage when a fairly large number of related tests are started at one time. By careful attention to the lay-out of such groups of tests it is often possible to weave together several problems in such a way that each one can be studied more adequately than would be possible if each problem were worked out separately at different times.

An excellent illustration of well-planned lay-out is afforded by a test fence at St. Paul, Minnesota, erected by the Northwestern Paint & Varnish Production Club, the Minnesota chapter of the Master Painters' Association, the Paint, Oil, & Varnish Club, and the Retail Lumbermen's Club of the Twin-Cities (*3d*). The principal object was to study the optimum proportions of pigments, linseed oil, and turpentine in priming-coat paints. Panels consist of four boards of 6-inch bevel siding each 12 feet long. On unit 1 of the fence, for example, there are two such panels of redwood. Each panel is marked off into 6 test areas, each 2 feet long. The third test area of each panel is the "control" area, which is painted with three coats of white lead paint following proportions considered most representative of good practice among painters. On the first panel test areas 1, 2, 4, and 5 are painted with three coats of the same kind of paint except that the priming coat was mixed with four different ratios of linseed oil to turpentine and on test area 6 the priming coat was an aluminum paint, the second and third coats being the white lead paint. On the second panel test areas 1, 2, and 4 were painted with two coats of paint only and the paint is, therefore, mixed with a relatively high proportion of pigment, the ratio of linseed oil to turpentine in the priming coat being different for each area; areas 5 and 6 were primed with pigment-rich mixtures but were painted with three coats of paint. By comparing the results on each test area with those on the "control" area of the same panel, comparisons can be drawn fairly throughout the series.

This group of tests, requiring 12 test areas, is repeated on north and south sides of the fence. It is then repeated, again on both sides of the fence, on panels of western red cedar, northern white pine, and Norway pine. Finally the entire procedure is repeated with a white paint containing zinc oxide and white lead and repeated once more with a white paint containing titanium pigment and zinc oxide. Thus there are in all 288 test areas assigned to this study. The large number of test areas, however, is abundantly justified by the assurance that definite conclusions about the primary objective will be reached at the end of the necessary exposure period. In addition, the adequate scale on which the work has been done will yield additional conclusions about (1) the relative merits of two-coat and three-coat painting, (2) the merits of aluminum priming paint, (3) the paint-holding qualities of four species of wood, and (4) the relative merits of three kinds of linseed oil paint. The three paints can be compared even though they are not applied to

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"matched specimens" of wood because each of them is applied to a sufficiently large number of test areas, they are applied in a variety of ways, and the lay-out is thoroughly symmetrical, that is, for each test area of any one paint there is an analogous area of each of the other paints.

APPLICATION OF PAINT TO TEST PANELS

It is best to paint test panels after they have been attached to the fence but it is often inconvenient to do so when the fence is located at a distance from the laboratory. If painted on the fence the priming coat should be applied within a day or so after the carpenter has attached the panels because even brief weathering of wood has been shown to impair the durability of paints.

Exterior paints applied and allowed to dry indoors before the panels are attached to the fence often develop a coarse form of paint checking that is not representative of the paint when applied under more practical working conditions. In its new building the Forest Products Laboratory has a large, flat roof with southern exposure in front of the painting laboratory. Test panels will be fastened temporarily to racks on this roof for painting and drying and will later be moved to the test fences for permanent exposure. If painting is interrupted by sudden rainstorms, trucks will be available for moving panels with wet paint into the laboratory until the storm passes.

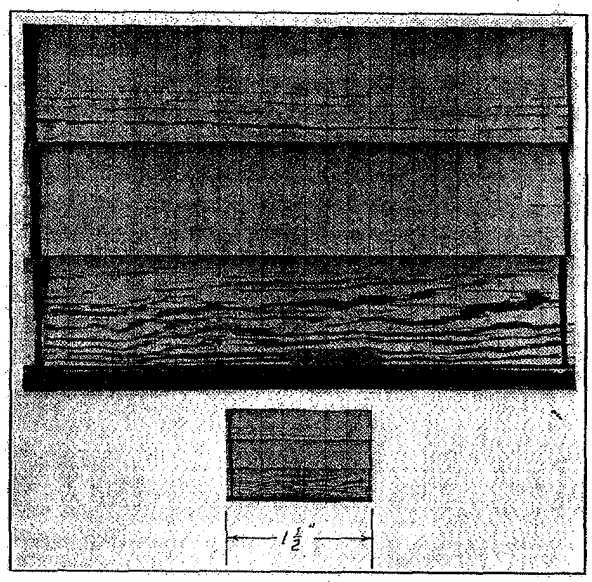
Test panels should be held in a vertical position while painting because mixtures that will cause trouble with running, sagging, and beads at the edges of boards will reveal their shortcomings in that position. Record should be kept of the amount of paint applied per area of surface and these spreading rates should fall within the range characteristic of practical painting. The tendency in many exposure tests has been to apply coatings much too thinly (*10*).

INSPECTIONS AND RECORDS

Carefully planned inspections and records made in the light of a definite scheme for evaluating paint service are necessary if exposure tests are to be fruitful, yet all too frequently investigators have seriously neglected this aspect of the work. There are as yet no generally accepted standards of procedure although some progress in that direction is being made.

Paints fail through a gradual development of numerous defects, the mechanism and significance of which are not yet well understood (*11a*), (*11d*). Since none of them can be measured strictly objectively and quantitatively the inspector must necessarily resort to personal judgments that are largely subjective in character (*11b*). Such methods of observation are usually foreign to the training of the graduate in chemistry and yet, if his work lies in the development of house paints, they are essential for determining the value of the products of his labor. Paint inspection, therefore, is a highly specialized art that should be undertaken only after present knowledge of the subject has been mastered and a definite plan of procedure has been adopted.

If possible, the responsibility for all inspections for any one organization should rest in one man. If the work must be shared all inspectors must first of all agree upon a satisfactory system of judging to which they must adhere conscientiously if their results are to agree. It is further necessary that they periodically check their judgments against each other. To do so a fairly large group of panels representing a wide range in paint deterioration should be inspected independently by each inspector. Their results should next be compared and finally discrepancies should be reconsidered by going over the questionable panels together. Groups of inspectors should never set out upon a fence inspection

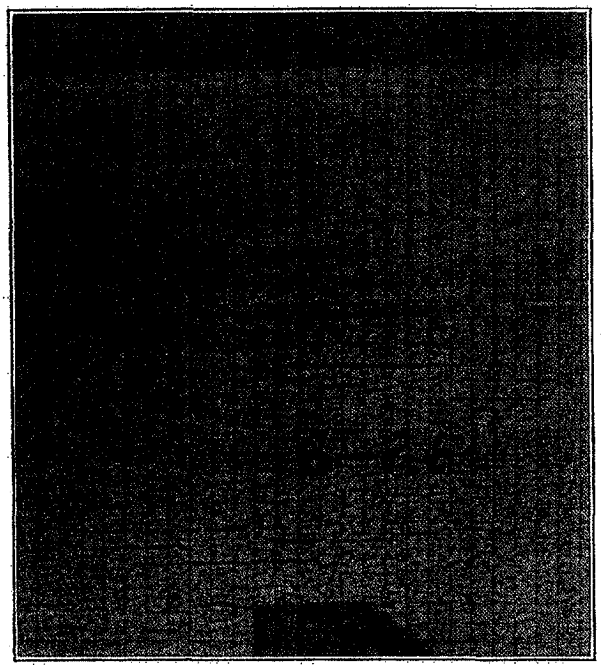


THE NATURE OF THE WOOD IS AS IMPORTANT AS THE NATURE OF THE PAINT IN DETERMINING THE LIFE OF A PAINT COATING

This illustration shows a test area made up of three boards of the same species of wood painted with the same kind of paint. The bottom board is the heaviest and has the widest bands of summerwood; the middle board is the lightest. The illustration shows also the very small photographs used by the Forest Products Laboratory for making records of inspections and the enlargement obtained from it.

together, especially if they have not been schooled in a common system of judgment. The discussions that arise make it almost impossible for any one of them to adhere consistently to one plan throughout the inspection and the results of such group inspection are less useful than those made independently by any one of the group.

The Forest Products Laboratory makes three detailed inspections a year of its test fence at Madison and makes other observations between times to watch for significant developments that may call for additional record. More distant stations cannot be visited so frequently but are inspected at least once each year. The system of judging test panels and the plan for recording and evaluating data followed by that Laboratory have already been published in detail elsewhere (*11c*).



A PHOTOGRAPHIC RECORD OF A TEST AREA SHOULD ALWAYS BEGIN WITH A VIEW OF THE ENTIRE AREA BUT IT IS OFTEN DESIRABLE TO SUPPLEMENT IT WITH CLOSER VIEWS SHOWING DETAILS OF TYPICAL PAINT DEFECTS, SUCH AS THIS ONE WHICH SHOWS PAINT "CHECKING"

The area included in this view is about $2^2/_3$ by $2^1/_2$ inches.

A very generous use of photographic illustrations is a necessary part of the record of exposure tests. Good photographs of test panels are difficult to take and must always be regarded as supplements to written records rather than substitutes for them. A photograph that shows the entire area of a test panel or test area fails to reveal minute defects that are significant in the written record. On the other hand photographs or photomicrographs of limited portions of a test area may give a very misleading impression of the area as a whole. An excellent plan is to photograph the entire test area and to supplement this with photographs or photomicrographs of small portions of the area having typical defects.

It is usually necessary to take a very large number of photographs of which only a few will ultimately appear in final reports or publications. With a view to economy and compactness of records the Forest Products Laboratory has adopted a camera for photographic records in paint panel inspection that uses standard motion-picture film stored in cartridges for daylight loading. Each exposure occupies the space of two frames of the usual motion picture, making a contact print about 1 by $1^1/_2$ inches in size. From 35 to 40 exposures can be made with one loading of the camera. Test areas 16 by 24 inches in size fill the field when taken from a distance of about $3^1/_2$ feet. The camera has an accurate range finder for adjusting the focus rapidly without using a measuring tape. The F 3.5 lens permits snapshots even on very cloudy days so that it is rarely necessary to use a tripod. An auxiliary lens that can be quickly slipped in place adjusts the camera for taking photographs at a distance of $9^5/_8$ inches, which is easily measured off with a foot rule; the area photographed at this distance is about $2^2/_3$ by 4 inches; that is, it is about $^3/_8$ actual size in the contact print and may easily be enlarged to full size or to twice actual size. With this equipment, which can be carried in an overcoat pocket or in a corner of a brief case, the writer often takes less than half an hour to photograph a test fence requiring 100 exposures. The contact prints are about the size of two common postage stamps so that a complete photographic record for a test area can be mounted on one 8-by-10 inch sheet which, together with the standard form of inspection record (*11c*), provides the entire history of the area on two sheets of paper. Although the contact prints are so small they show a surprising amount of detail, especially when viewed through a good reading glass, and those exposures chosen for closer examination or publication can be enlarged to at least 4 by 6 inches very satisfactorily.

EVALUATION OF RESULTS

An exposure test should lead to a decision about the durability or at least the relative durability of the paint tested. Few experimenters in the past have attempted to bring their work to such conclusion. As a rule they have been content to describe what happened and to leave it to others to draw their own conclusions. Evaluation of the results of exposure tests is admittedly a very difficult and complex problem but those most familiar with the facts should accept most responsibility for dealing with it.

If durability is conceived as the period of time that will elapse before users of the paint will renew the coating it becomes evident that the behavior of the paint itself is only the beginning of the story. The patience of the paint user with paint defects or his ability to meet the cost of repainting is the center of interest. Perhaps the chemist needs help from the psychologist and the economist to complete his study, but with or without such aid he should reach definite conclusions about the relative serviceableness of the products he tests.

The writer's opinions about evaluating the serviceableness of house paints have already been published (*11c*). For the present purpose it is sufficient to point out the following classes of paint users whose needs must be considered: (1) those who may become sufficiently dissatisfied with a paint because of changes in appearance, such as soiling and fading, to renew the coating before it shows signs of failing to remain intact; (2) those who do not repaint until the coating begins to disintegrate but repaint before the disintegration goes very far; (3) those who may not repaint until the old coating has failed very badly and the house has needed repainting for several years; and (4) those who never bother to repaint at all. For the first group a paint endures only as long as its appearance satisfies them. For the second group it endures as long as the coating holds together. For the third group it is less important

that the coating endure than it is that the coating fail thoroughly, leaving a reasonably smooth surface free from patches of partly loosened old coating whose jagged edges will show through the new coating. The fourth group probably is little concerned about paint durability. Paints considered durable by the first group are often unsatisfactory to the second and third; a few good paints are acceptable to the first two groups but not to the third; no paint of the present day is entirely satisfactory to all groups.

In considering the requirements of different users of paint nothing has been said about protection afforded the wood by the coating. Much nonsense has been said and written about the subject. In the first place paint is impracticable as a preservative of wood against decay by attack of wood-destroying fungi (*12*). Houses are protected against decay by building them so that none of the wood becomes wet unless it be temporarily. If paint-neglected houses were seriously subject to decay paint users of groups 3 and 4 would soon come to grief and would be far less numerous. There are difficulties with decay in some houses but they occur as often where paint is well maintained as they do where it is neglected and the remedy lies either in improved construction of the house or in the use of naturally durable kinds of wood or of wood treated with toxic preservatives.

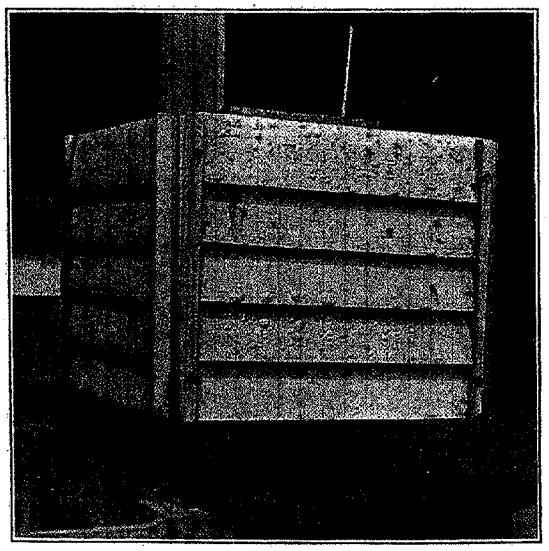
Unpainted wood or paint-neglected wood is subject to a form of deterioration known as wood weathering, against which paint affords adequate protection (*12*). The degree of protection afforded by different paints can be measured quantitatively and entirely objectively by technic that has been published and has been used in several laboratories (*13*). The practical significance of paint protection is somewhat uncertain, however. On the one hand, it is true that changes in moisture content with consequent swelling and shrinking cause a great deal of trouble in using wood but, on the other hand, many houseowners, especially farmers and wage-earners, do not seem to object very much to more or less weathered wood. Paint users of group 1 probably demand adequate paint protection but their painting habits insure adequacy of protection without worrying about it. For paint users of group 3, which is probably much more numerous if not so conspicuous, protection appears to be of minor importance.

EXCEPTIONAL BEHAVIOR OF PAINT ON SOME HOUSES

As a rule paint lasts somewhat longer on houses than it does on the south side of a test fence because few houses are as fully exposed to sunshine as a properly located test fence. Some houses will be found in nearly every community, however, on which paint not only fails more rapidly but fails in a very different manner than it does on test fences (*14*). Such failure may become noticeable within a few months after painting and become pronounced within a year. In typical cases the first abnormal development is blistering but the houseowner rarely makes complaint at that stage and may never notice that it has occurred. Later on the paint cracks and comes off in conspicuous scales whose size and shape bear no relation to the bands of summerwood beneath. Houseowners' complaints are usually made after this stage has been reached, when the surface not only presents a disreputable appearance but is very difficult to repaint properly. Abnormal paint failure of this kind is caused by moisture collecting behind the painted boards during the season when the interior of the house is kept at a materially higher temperature than prevails out of doors. The source of the moisture may be leaking joints of one kind or another (*15*) or condensation from air within the hollow sidewalls when the air is chilled below its dew point.

Although the extreme examples of abnormal paint failure caused by moisture are easily recognized the less well-defined cases are not. The writer has seen houses on which the type of paint failure was identical with that of similar paint on test fences but the comparatively early development of failure suggested that a few boards of siding be removed, whereupon the moisture in the sidewalls was revealed. Abnormal paint failures caused by moisture are so widely prevalent that the houseowners of the country are suffering a serious economic loss through unsatisfactory paint service and unduly frequent and expensive repainting. Even when the cause of the trouble has been discovered, it is still impossible to tell many of these houseowners what they can do, within their economic means, to prevent recurrence of such difficulties.

The uncertainties about abnormal moisture failure make paint testing on occupied houses difficult as well as inconvenient. Normal paint failure is best studied by means of test fences. On the other hand, paints should also be studied under controlled abnormal con-



"BLISTERING BOX"

For studying the failure of paint caused by the action of moisture behind painted woodwork the Forest Products Laboratory uses small "blistering boxes" placed out of doors in cold weather; the interior of the box is kept warm and moist.

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ditions because some kinds of paint are more seriously damaged by moisture than others. The only really satisfactory remedy for such conditions lies in research that will make it possible to build houses with certainty that moisture will not collect in the sidewalls, but meantime houses subject to moisture conditions will have to be painted for many years. A technic for studying moisture failures is gradually being developed. The writer builds test panels of 4-inch bevel siding 15 by 17 inches in area which are painted and exposed to the weather on a test rack for varying intervals of time, after which they are subjected to abnormal moisture conditions by attaching them in position as the sidewalls of a "blistering box," within which the air is kept warm and humid by means of a pan of water heated electrically. The box is operated out of doors during cold weather. When the paints have blistered thoroughly the supply of moisture within the box is cut off and the panels allowed to dry out again while the temperature gradient through them is maintained. The panels are then returned to the exposure rack until the coatings fail by scaling. In the writer's opinion it is essential that the ultimate scaling of the coating be taken as the endpoint of the test rather than the preliminary blistering while the panels are on the "blistering box."

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Readers who desire to pursue the subject of paint testing farther will find an interesting study by the same author on "Effectiveness of Paints in Retarding Moisture Absorption by Wood," beginning on page 835 of the August *Industrial and Engineering Chemistry*. Do mill-priming and back-priming afford real protection against moisture? This question is answered for several typical priming formulas.

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Dr. W. T. Read, Dean of the School of Chemistry of Rutgers University, will direct the program of student courses at the Fourteenth Exposition of Chemical Industries to be held at the Grand Central Palace in New York, December 4th to 9th. More detailed information, which came to hand too late to be included in this issue, will be presented in the October number.

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Southern Lumberman Feb. 1933

Durability of Paint on Longleaf and Shortleaf Pine

(16)

By F. L. Browne

Senior Chemist, Forest Products Laboratory, Forest Service

In general, the density and the width of the annual growth rings are the principal properties of a softwood that governs its painting characteristics(1)*; resin content, except when localized in pitch pockets or pitch streaks, is not ordinarily a significant factor in durability of paint coatings on well seasoned wood(2). On the average, longleaf pine tends to be denser than shortleaf pine; but, on the other hand, the longleaf pine also tends to slower growth, making the annual rings narrower. The two woods might therefore be expected to prove very similar in painting characteristics on the average. Individual boards of either species, however, vary widely in density and ring width, the ranges in these properties for the two species overlapping greatly. For that reason the variations in paint durability between different boards of either species are undoubtedly more important practically than any difference there may be between average values for the two species.

In the earlier tests of the painting characteristics of wood by the Forest Products Laboratory(3, 4) Southern pine was represented by a single shipment of commercial Southern pine, which may have been a mixture of species. The tests described in this article were therefore made to determine whether there is any observable difference in behavior of paint on longleaf as compared with commercial shortleaf Southern pine.

Lumber Used in the Tests

The lumber for these tests was provided by the Southern Pine Association. The boards were commercial 1 by 6 inch by 12 feet, surfaced on four sides, in the air-dry conditions. Before use they were stored in an open air lumber shed at Madison, Wis., and protected from the weather. They were taken indoors only long enough to cut and make the test panels and to paint them, but since this work was done during the winter the moisture content undoubtedly fell somewhat below that normal for wood kept out of doors in Wisconsin.

Six boards of each species were used for these tests. Measurements of the range in number of annual rings per inch radially and of the density were made at four points along each board; the results appear in Table 1. The boards of shortleaf pine on the whole were slightly lighter in weight and had fewer rings per inch than the boards of longleaf pine, although the light boards of longleaf pine were lighter than the heaviest boards of shortleaf pine.

Of the six boards of each species three were definitely flat-grain and three were as nearly edge-grain as could be found among the boards supplied. None of them, however, could be considered truly-edge-grain; as a rule they ranged from nearly flat-grain at one edge to approximately edge-grain at the other edge.

The Test Panels

Matched test panels were made as follows: The three flat-grain shortleaf boards, for example, were each cut into two pieces 3 feet long and four pieces 1½ feet long. One 3-foot piece from each of the three boards made up one test panel for vertical exposure facing south and one 1½-foot piece from each board made up one test panel for exposure in a position inclined at 45 degrees from the vertical and facing south. Thus a set consisting of two matched panels for vertical exposure and four matched panels for inclined exposure was made from the three flat-grain shortleaf pine boards. Similar sets of panels were made from the three edge-grain shortleaf boards and from the flat-grain and edge-grain longleaf boards, making four sets of matched panels or a total of 8 vertical and 16 inclined test panels.

*The numbers in parentheses indicate references given at the end of the article.

The Paints

Tests were made with straight white lead paint and with a mixed-pigment paint the pigment of which consisted of 60 per cent basic carbonate white lead, 30 per cent zinc oxide, and 10 per cent asbestine. Each paint was applied in three coats, but two different priming coat mixtures were tried with each paint, one of which is a general priming-coat mixture widely recommended for use on all kinds of wood and used in the earlier tests of the Forest Products Laboratory(3, 4) and the other a pigment-rich primer that was tested in experiments previously reported(2, 5).

The white lead paint mixtures were as follows:

Ingredients	Priming Coat: General Mixture	Priming Coat: Pigment-rich	2nd Coat	3rd Coat
Heavy paste white lead (92 per cent pigment), pounds	100	100	100	100
Raw linseed oil, gallons	4	1½	1½	3½
Turpentine, gallons	2	2	1½	½
Liquid paint drier, pints	1	1	1	1

The mixed-pigment paint mixtures were as follows:

Ingredients	Priming Coat: General Mixture	Priming Coat: Pigment-rich	2nd Coat	3rd Coat
Paste paint (82 per cent pigment), pounds	100	100	100	100
Raw linseed oil, gallons	3½	1 1-3	2⅔	2⅔
Turpentine, gallons	2	2	1⅓	⅓
Liquid paint drier, pints	2	2	2	2

Painting and Exposing the Panels

Each set of matched panels was painted as follows: One of the two panels for vertical exposure was painted with white lead paint, using the general priming-coat mixture on one-half its area and the pigment-rich mixture on the other half. The other vertical panel was similarly painted with the mixed-pigment paint. Two of the four panels for inclined exposure were painted with white lead paint one with each primer, and the other two panels were similarly painted with the mixed-pigment paint.

The painting was done indoors in a heated laboratory. Two days were allowed for drying of the priming-coat paints before applying the second coat and three days for drying of the second coat before applying the third. One week after the painting was completed the panels were placed on the test fence at Madison, Wis. This was in February, 1928.

How the Paint Wore

The panels were inspected at intervals and the serviceableness of the coatings judged by the standard procedure of the Forest Products Laboratory(6).

During the first half of the useful life of the coatings no differences in behavior of the paints on longleaf and on shortleaf pine were observed. The coatings gradually became soiled, the white lead paint somewhat more so than the mixed-pigment paint, the gloss faded and the coatings began to chalk. By the end of the first year the white lead paint coatings were checking in the manner characteristic of white lead paint, while checking of the mixed-pigment paint was barely beginning. After 18 months in the vertical position the white lead coatings began to shed the accumulated dirt and to improve in appearance, but the mixed-pigment paints continued to gather dirt until they were two years old.

No exudation of resin was observed on any of the boards, either of longleaf or of shortleaf pine.

Failure of the coatings in integrity, that is by crumbling or flaking leaving patches of wood bare, began earlier and proceeded more rapidly on the inclined panels than on the vertical panels, as was expected. The inclined panels received materially more sunshine than the vertical panels and rainwater probably drained less rapidly from the inclined panels. As soon as crumbling and flaking of the coatings began, differences in behavior over different boards became observable because such failures

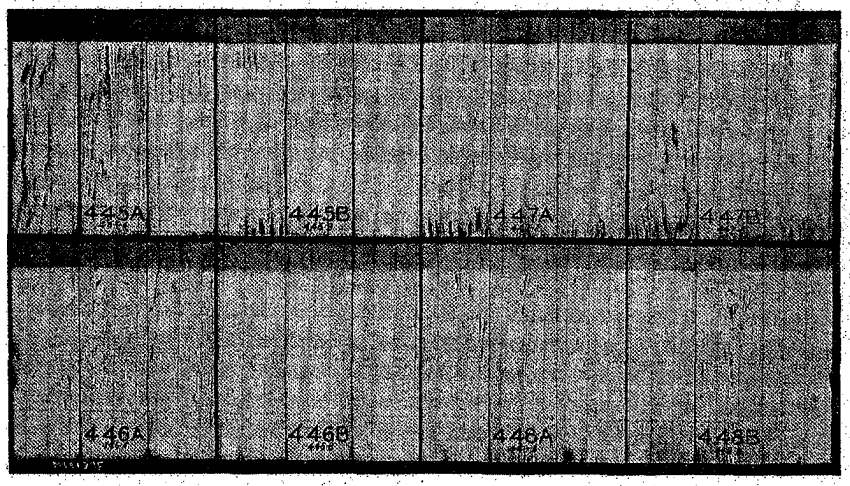

Figure 1.—Result of tests on shortleaf pine. Panels 445 and 447 were made with pieces from boards 1, 2, and 3 of Table 1 (left to right), panels 446 and 448 with pieces from boards 4, 5, and 6. Panels 445 and 446 were painted with white lead paint and panels 447 and 448 with mixed pigment paint. Panels A received the general priming coat mixtures and panels B the pigment-rich mixtures.

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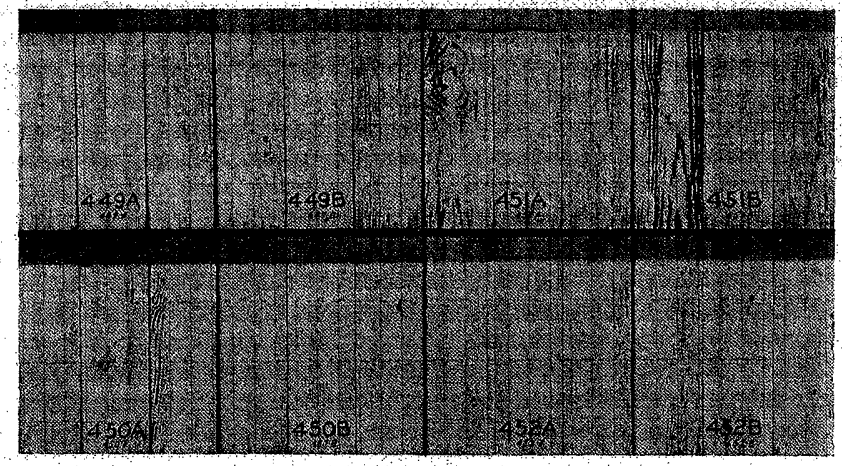

Figure 2.—Result of tests on longleaf pine. Panels 449 and 451 were made with pieces from boards 7, 8, and 9 of Table 1 (left to right), panels 450 and 452 with pieces from boards 10, 11, and 12. Panels 449 and 450 were painted with white lead paint and panels 451 and 452 with mixed pigment paint. Panels A received the general priming coat mixtures and panels B the pigment-rich mixtures.

appeared earlier and developed more rapidly on some boards than on others. Crumbling or flaking of the coatings was confined almost entirely to the areas of summerwood even when failure had progressed to the point where most of the summerwood was laid bare. This, of course, is the customary behavior of coatings of paint of good quality on softwoods exposed to normal conditions of weathering.

Results on Longleaf and Shortleaf Pine

Table 1 records the durability, in months, of the coatings on shortleaf and on longleaf pine. For this purpose the durability of the coating is defined as the age at which crumbling or flaking from summerwood had progressed far enough to require repainting to restore satisfactory integrity of the coating. Figure 1 is a photograph of the inclined panels of shortleaf pine at age of 28 months and Figure 2 is a photograph of the corresponding panels of longleaf pine at the same age.

On the average the coatings lasted a trifle longer on shortleaf than on longleaf pine. The differences between the two species on the average, however, are much too small to be of any practical significance, especially in view of the fact that much larger differences in coating durability were found on different boards of either shortleaf or of longleaf pine.

The number of boards involved in these tests is too small to permit tracing a satisfactory relation between durability of the coating and density and rings per inch in the wood. The physical properties of many boards can be expressed in simple figures only imperfectly at best because the wood varies widely in different parts of the same board. The illustrations show clearly, however, that paint flaking developed most conspicuously over the parts of the boards where the bands of summerwood were widest. The boards classed as edge-grain likewise fail to demonstrate the superiority of edge over flat-grain very convincingly, but again an examination of the illustrations shows that the edge-grain boards in reality had areas that were really flat-grain and that paint flaking was most marked over these flat-grain portions.

The pigment-rich priming-coat mixture in general proved inferior to the general priming-coat mixture in these experiments. The pigment-rich priming-coat, however, contained a much higher ratio of turpentine to linseed oil than the general priming-coat, which later experimentation indicates is the reason for the observed difference. At the time these tests were started the prevailing opinions of painters and paint technologists was that priming-coats for Southern Pine should contain more turpentine than priming-coats for most other softwoods. Experiments have proved, however, that priming-coats rich in turpentine decrease rather than increase the durability of paint coatings on Southern pine [4].

TABLE 1.—*Durability, in Months, of Coatings of Paint on Shortleaf and on Longleaf Pine.*

Board Number	Grain	Growth rings per inch	Density pounds per cubic foot	Durability of White Lead Paint in Months: Vertical Exposure General primer	Vertical Exposure Pigment-rich primer	Inclined Exposure General primer	Inclined Exposure Pigment-rich primer	Durability of Mixed Pigment Paints in Months: Vertical Exposure General primer	Vertical Exposure Pigment-rich primer	Inclined Exposure General primer	Inclined Exposure Pigment-rich primer
				SHORTLEAF PINE							
1	Flat	7 to 11	34 to 37	35	35	19	25	35	35	25	19
2	Flat	13 to 20	40 to 41	33	35	19	25	35	35	25	19
3	Flat	9 to 11	35 to 37	35	35	22	35	35	35	25	19
4	Edge	12 to 14	32 to 39	48	22	22	35	48	45	10	19
5	Edge	14 to 22	37 to 44	48	35	22	35	48	45	19	19
6	Edge	7 to 11	30 to 31	48	48	22	35	48	45	19	19
	Average	10 to 15	35 to 38	42	35	21	32	42	40	22	19
				LONGLEAF PINE							
7	Flat	17 to 32	29 to 37	45	35	25	19	16	16	16	16
8	Flat	32 to 40	29 to 33	45	35	25	19	48	25	16	16
9	Flat	16 to 21	44 to 52	45	25	25	19	48	35	16	16
10	Edge	20 to 50	42 to 57	35	25	21	25	35	33	35	22
11	Edge	32 to 35	38 to 55	35	25	21	25	45	42	25	25
12	Edge	15 to 30	40 to 48	35	35	21	25	45	42	25	25
	Average	22 to 33	37 to 47	40	30	23	22	40	32	21	20

Subsequent tests have indicated that the pigment-rich primer would have proved superior if it had been mixed with about 2 1-2 gallons of linseed oil and 1 gallon of turpentine for 100 pounds of paste paint instead of the proportions that were actually used.

Aluminum Primer for Southern Pine

Aluminum priming-coat paint offers the best means discovered so far for increasing the life of paint coatings on Southern pine and minimizing the variations in durability on different boards. The beneficial effect of priming Southern pine with aluminum paint before applying ordinary house paints has been pointed out in previous publications by the Forest Products Laboratory [7] and by others [8, 9]. Figure 3 shows some typical results of more recent tests by the Forest Products Laboratory; application of aluminum priming paint materially retarded flaking of ordinary paint, used for the top coats, from the bands of summerwood and not only prolonged the life of the coatings, but resulted in more uniform behavior on different boards.

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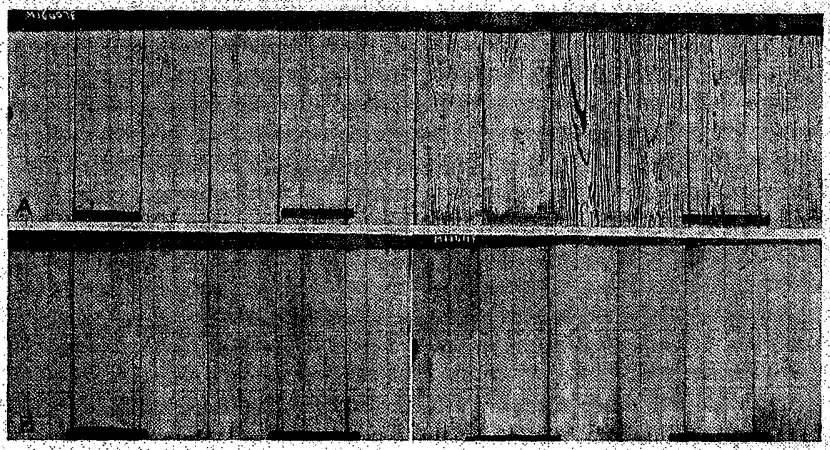

Figure 3.—Results of priming with aluminum paint. The boards of the upper row (A) were painted with two coats white lead paint while those of the lower row (B) were primed with a priming coat of aluminum paint followed by one top coat of white lead paint. The coatings, which were exposed in the inclined position, were 28 months old when photographed.

Why Mill Prime?

By ROBERT I. WRAY*

Because of the growing importance of mill priming in the lumber industry and because of the effect this practice promises to have on the marketing of yellow pine lumber, great interest has been shown in the technical facts which underlie this development. The store of both practical and technical knowledge concerning this practice is being augmented rapidly by additional information gathered from research and the experience of lumbermen in all parts of the country. Commercial use of mill primed lumber has confirmed the many merits of the product established by careful laboratory tests. This discussion is concerned primarily with the technical aspects of aluminum paint as they pertain to the problem of lumber protection.

Within the past ten years many of the fundamental ideas pertaining to wood painting have undergone radical changes. For example, it has been found that the use of a penetrating priming coat considered essential a decade ago is by no means as efficient as painters once believed. Also, the use of synthetic resins and varnish vehicles which yesterday were considered daring innovations are today rapidly gaining favor with the modern painter. The introduction of varnish-base primers has been largely a result of the advent of aluminum paint as a priming coat for wood.

The advantage of the varnish type of paint vehicle for wood priming purposes, as compared with a vehicle composed of drying oil and thinners is apparent when one considers the structure of wood and the action which moisture has on it. When moisture enters wood through a paint film it passes immediately to the cell walls, causing marked expansion of the wood across the grain. However, drying oils on absorption by the wood do not saturate the wood fibers but pass into the cell cavities through the border pits. Obviously then, deep penetration of an oil vehicle into wood can have little value in the prevention of moisture absorption by the cell walls. To be effective, it must prevent moisture from reaching the wood surface by forming an impervious relatively thick continuous film. The result of deep oil penetration is to remove a considerable portion of the vehicle from the surface, leaving in many instances an insufficient amount to properly bind the pigment. Varnish vehicles, because of their more viscous nature, do not penetrate so deeply and consequently a heavier film remains at the wood surface, resulting in better resistance to moisture passage and improved adherence and protection.

The justification for using aluminum paint as a wood primer lies principally in its ability to retain its excellent moisture-proofing efficiency over unusually long periods of exposure, thus protecting the underlying surface and adding life to the top coats. Its uniform adherence to both summer-wood and spring-wood makes it particularly suitable for priming flat-grained lumber. The first indication of paint failure on wood usually occurs over the bands of summer-wood. Here the cell walls are thicker and more dense whereas the cell cavities are smaller. Summer-wood can, therefore, show much greater dimensional changes with varying moisture content and paint adherence becomes increasingly difficult. Wood, such as yellow pine, which is cut with a predominately flat-grained surface shows wider bands of this hard horny summer-wood and it is therefore more important to use a paint as a primer which will show the maximum adherence to both spring and summer-wood.

The effectiveness of aluminum bronze powder in combination with a special varnish vehicle, as a primer for many species of wood, has been demonstrated in numerous tests carried on in various parts of the country. Of particular interest is a comprehensive test involving a series of long and shortleaf yellow pine panels which was undertaken for the purpose of comparing the effectiveness of aluminum primers with white primers on this widely used wood. The panels were made in duplicate, one set being sent to New Orleans and the other placed on test at New Kensington, Pa. The sets consisted of panels of both long and shortleaf yellow pine. Selected boards were cut into four 2-foot length panels, two of each being primed with aluminum paint made with a long oil varnish, while the remaining two were primed with a typical white pigmented oil base primer. Two top coats of high grade white house paint were then applied to all panels. The panels were exposed at an angle of 45 degrees to the vertical facing south, an exposure which is almost twice as severe as that normally encountered on the vertical side of a house.

An inspection after 18 months' exposure disclosed the fact that the paint film on the aluminum painted panels was still in good condition and adhesion was excellent although there was top coat checking which stopped at the aluminum primer. In the case of the panels primed with the standard white primer it was found that the top coats had checked through to the wood, and the paint had flaked in most cases from the summer-wood bands. It was obvious that the failure was worse on the sections of the white primed panels which were flat grained in character, while the paint had adhered much better to the edge grain with its narrower bands of summer-wood. Any differences in behavior of the paint on longleaf and shortleaf pine were

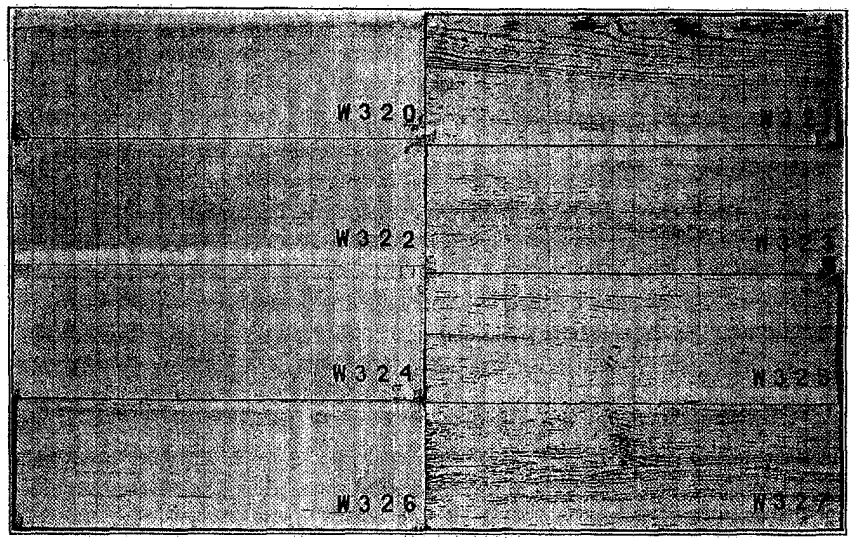

Figure 1

Panels of shortleaf Southern yellow pine after 18 months' 45 degrees' exposure facing south at New Kensington, Pa. Panels W320, W322, W324, and W326 primed with aluminum paint; panels W321, W323, W325, and W327 (from corresponding boards), primed with white paint. Two top coats of white paint applied to all panels.

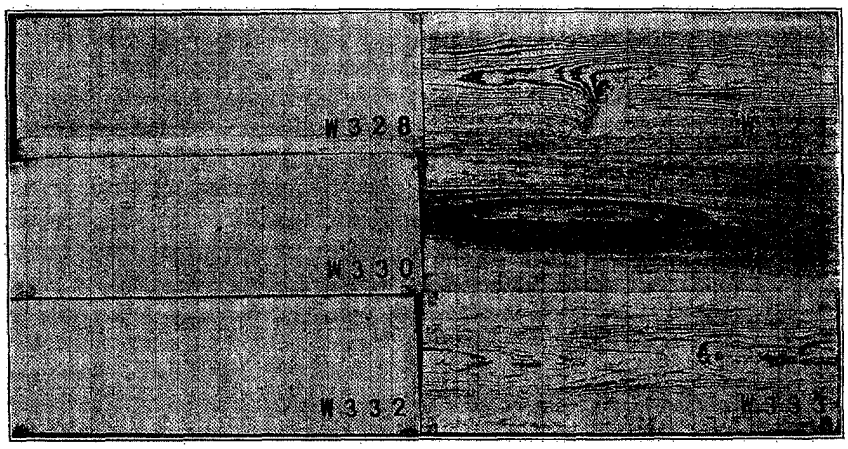

Figure 2

Panels of longleaf Southern yellow pine after 18 months' 45 degrees' exposure facing south at New Kensington, Pa. Panels W328, W330, and W332 primed with aluminum paint; panels W329, W331, and W333 (from corresponding boards) primed with white paint. Two top coats of white paint applied to all panels.

*Aluminum Company of America, New Kensington, Pa.

minor in character although in general the shortleaf panels appeared to be in slightly better condition.

The panels exposed at New Kensington are shown in Figs. 1 and 2. The panels in Fig. 1 are of shortleaf Southern yellow pine, while those in Fig. 2 are of longleaf. The panels are arranged in pairs, the even number panels on the left being primed with aluminum paint and the odd numbered panels on the right being primed with white paint. Each pair of panels was taken originally from the same board; thus, panels W320 and W321 represent one pair, W322 and W323 another pair, etc. The panels speak for themselves.

In another test sections of siding simulating house construction were built and exposed in a manner to reproduce the exposure that would be experienced in actual service. The sections were built with pattern No. 106 drop siding nailed to 2 by 4's spaced 16 inches on center. On one section was applied yellow pine siding mill primed with aluminum paint and on the other, the unpainted siding. After erection the bare section of yellow pine was immediately primed on the face in the usual manner with a good grade of white paint properly reduced. Two coats of the same white paint were then applied to both sections.

These sections have been weathering for 18 months and already some differences are apparent. Slight paint flaking and paint cracking has occurred on the section primed with white paint particularly on the sharp edges of the drop siding pattern. Some shrinking of the white primed boards has also been observed across the grain and bare wood is exposed at the joints—as much as 1-8 inch in some cases. The aluminum primed section, on the other hand, is still intact both with regard to the paint coating itself and the joint between the boards.

The latter test brings out the evident advantages of mill priming of yellow pine lumber and the merits of aluminum paint as a mill priming material. Dimensional changes and wood checking and warping during storage are greatly reduced by this procedure. Also because all sides of the lumber are coated, a maximum amount of protection against absorption of moisture after erection is effected. Furthermore, the mechanical application of aluminum primers of this type at the mill insures a better paint job that will hold subsequent paint coatings longer without their failing prematurely by scaling and peeling from the summer-wood bands. This should help remove the growing prejudice against yellow pine that arises out of its painting characteristics.

Mill Priming and Trade Promotion

By J. F. CARTER, *Southern Pine Association*

More than eighteen months ago a cooperative study of the paintability of longleaf and shortleaf Southern pine was decided upon by the Aluminum Company of America and the Southern Pine Association. The tests were to ascertain something slightly different from what had been previously reported by the Forest Products Laboratory.

From Forest Products Laboratory reports it was evident that the best primer was one composed of aluminum as the pigment, with a good oil vehicle. Proofs were established that the primer's integrity measured the integrity of the covering paint coats.

However, from the data, we were not certain at that time whether longleaf or shortleaf would bear up better under tests. Moreover, it was our desire to make the tests so that edge-grain of both species could be compared with flat grain of the same two species.

Eight-inch boards were collected from longleaf and shortleaf producers. There was a slight difference in density, though not noticeable if the boards were paired rightly. The plan was to expose the boards at New Kensington, Pennsylvania, and at New Orleans at the same time, under like conditions—with the panels placed forty-five degrees to horizontal, facing south, that they might suffer the worst conditions of exposure.

These boards were painted in sets, so that duplicate sets of longleaf and shortleaf could be exposed at these distant points, each showing flat and edge grain.

There is little point in discussing results at New Orleans. The photographs are almost exactly the same as those produced at New Kensington. Hence, one set of illustrations tells the story for both tests.

As we see it, from the standpoint of trade promotion for Southern pine, there is every reason why manufacturers of siding, drop or bevel, should prime with aluminum at the mill. Southern pine loses markets because its siding is largely flat grain and the broad bands of summerwood cast off the paint if the correct primer is not used. If Southern pine siding be primed with aluminum paint at the sawmill before shipment, that part of the painting is done at not as much cost as painting on the residence job, and the market will be regained so soon as the buying public, including the retailers, realize that the paintability is good. Quite naturally, the idea must not be kept a secret. The manufacturers will needs tell the world what are the values of mill-priming.

Some have suggested that retailers be told to paint ordinary Southern pine siding with aluminum primer. This means that the story must be impressed upon every painter, contractor, builder, carpenter, realtor and architect. It would be an expensive proposition to get the story to all those who have to do with completing a house.

It seems a much simpler proposition to put on the insurance policy at the mill—make the siding paintable before it goes to the retailer.

It might be well to state that, harking back to tests, there is little difference in the paintability of longleaf and shortleaf when properly viewed. It really does not matter which one failed the more—the fact that failure set in is sufficient. When the paint coat over ordinary lead or zinc primer is quickly flaked off the summerwood of either longleaf or shortleaf, that piece has poor paintability. If either or both species are introduced to the consumer with a coating of aluminum as a primer, that siding will gain and hold its market. It does not require much use on the part of any painter, contractor or builder of a home to realize the difference, and also the saving which is effected.

The selling points are all in favor of siding primed at the mill with aluminum. There may be other primers which work as well, but thus far they have not been put through the necessary paces to learn the value.

Manufacturers have discussed the inadequacy of returns on such additional service. That is a subject controlled by the sagacity of the sales managers. They have added a definite cost for the service. Knowing the value of that service they will handle it in a business-like manner. From what has been ascertained up to this moment by the activities of two Southern mills, the retailers will be only too glad to seize upon something which they can sell with more enthusiasm than ordinary lumber.

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Interesting Studies at Forest Products Laboratory

By F.
Senior Chemist, Forest Products Laboratory,[1]

Good paint is, of course, a necessary element in good paint maintenance, but it is far from being the whole story. For many years technical study and writings have dealt with paint composition almost to the exclusion of other factors in paint service some of which are even more important. As a result there is a tendency to believe that satisfactory paint service can always be expected provided only that a sufficiently good paint is purchased and that, when paint fails prematurely, there is necessarily something wrong with the paint purchased. A better understanding on the part of purchasing agents and maintenance men of the other important elements upon which the serviceableness of paint depends should help materially in securing more satisfactory painting and in avoiding unnecessary disputes.

The Forest Products Laboratory has been studying the painting of exterior wood surfaces for more than 10 years. Two principal sources of information are utilized, namely, (1) observation of the behavior of paint on buildings in service that are brought to the attention of the Laboratory, usually because of unsatisfactory experience with paint, and (2) practical exposure tests in which paints of known composition and methods of application are observed carefully throughout their life on different kinds of wood. Such exposure tests are made throughout the United States at stations representing various climatic conditions.

The major objective of painting studies at the Forest Laboratory is to learn how to get the most satisfactory service from wood when painting is involved and how to do so with a maximum assurance of results and a minimum expense. This point of view is unique in paint testing and has led to significant improvements in methods of evaluating paint service and to a better understanding of the various factors upon which satisfactory paint service depend. The competitive claims made for different paint ingredients, for example, have not been allowed to overshadow the importance of proper proportioning of ingredients, variation in behavior on different kinds of wood, application of paint in sufficient quantity, repainting before the old coating has worn too badly, and avoidance of certain abnormal conditions of service that rapidly ruin the best of paints.

[1]Maintained at Madison, Wisconsin, in co-operation with the University of Wisconsin.

EARLY FAILURE CAUSED BY MOISTURE IN SIDEWALLS
This house was painted twice in two years and failed in this way within a few months after each painting. Many other houses in this community failed in the same way.

Experiments by the Forest Products Laboratory are confined almost entirely to paints of known composition, usually manufactured at the Laboratory. Such paints can be described fully and can be formulated to bring out general principles of paint composition to best advantage. The Laboratory has not been concerned directly with the special problems of paint purchasing, such as specifications for paint and the relative merits of proprietary paints, but knowledge of the more general problems that it has been studying should prove helpful in the purchasing of paint as well as in the maintenance of painted buildings.

Moisture Failures of Paint

Probably the most frequent and costly cause of premature failure of paint on buildings is moisture getting behind painted woodwork, especially when the temperature behind the painted surface is higher than it is in front. Under such conditions good paint may fail within a few months after application and the failure may leave a surface that is unusually expensive to repaint properly. In pronounced cases failure begins with blistering and sometimes peeling; the blisters may subsequently disappear but in any case scaling or flaking of the coating sets in long before breakdown of the coating should be expected. In less characteristic cases the first form of failure observed is flaking of the coating from the harder parts of the wood surfaces, just as is ultimately to be expected, but the failure sets in much too soon. Failure of the latter type is especially likely to be attributed falsely to inferior paint because the form in which failure takes place lacks the distinguishing characteristics of typical moisture failures.

All linseed oil paints, good, bad, and indifferent, are subject to moisture failures if the causative conditions arise. To be sure pure white-lead paint escapes relatively unscathed under moderately severe conditions that prove disastrous to all other paints but if the conditions are bad enough white lead fails also. The only certain cure for moisture failures is to eliminate the moisture. In new buildings the moisture may get into the sidewalls when improper methods are followed in drying the plaster. A second source of moisture is open joints or inadequate flashing around windows, chimneys, dormers, eaves troughs, or other junctions in the construction. A third source of moisture, often the most difficult to remedy, is sweating or condensation within the sidewalls during cold weather.

Durability On Different Woods

Paints last much longer on some kinds of wood than on others. The variation results from the fact that linseed oil paints become brittle after they have been exposed to the weather for some time and when brittle they no longer hold firmly to the dense, hard, horny bands of summerwood present in softwood lumber. For that reason aged coatings flake from the summerwood, leaving it bare. The larger the areas of summerwood the sooner flaking becomes serious. The heavier the wood and the wider its annual growth rings the larger are the bands of summerwood and the less desirable it is for durable painting. Of the western softwoods the best for painting are western red cedar, Port Orford cedar, Alaska cedar, and redwood followed closely by western white pine and sugar pine; somewhat less desirable for painting are ponderosa pine, Sitka spruce, and western hemlock; paint fails soonest on Douglas fir and western larch.

There is, of course, much variation between boards of the same species. In general the lightest boards and those with narrowest growth rings are best for painting. Edge grain boards are always superior for painting to flat grain boards of similar wood.

Priming Paints For Wood

Two paints are outstandingly superior for priming new wood surfaces, namely, pure white-lead paint and aluminum paint. White-lead paint has the advantage of being white or easily tinted to a variety of colors so that it lends itself readily to two-coat

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ng Studies at Forest Products Laboratory

Browne
orest Service, U. S. Department of Agriculture.

painting. Priming-coat white-lead paint should be mixed with plenty of pigment; it should contain only slightly more liquid than a finishing-coat paint and the liquid should be mostly linseed oil with only a small proportion of turpentine. So-called "reinforcing oils" and varnish should not be used in white-lead paint.

Aluminum paint should be made by adding 2 pounds of aluminum bronze powder or paste aluminum to 1 gallon of long-oil spar varnish made specifically for mixing exterior aluminum paint. Aluminum priming paint has the advantage of markedly retarding the flaking of paint from the bands of summerwood. It is therefore the best priming paint for woods like ponderosa pine and Douglas fir. It has the disadvantage of requiring two coats of white or of light colored finishing paint to hide its color adequately.

Finishing Paints For Wood

On buildings for which there is no systematic plan of paint maintenance and on which the paint may be neglected for considerable periods pure white-lead paint often proves the most satisfactory finishing-coat paint. Such paint is not more durable than paints that contain proper mixtures of zinc oxide with other white pigments, but when it becomes brittle it changes from a sound coating into a loosely adherent mass of chalk that continues to hide and color the surface fairly well provided the wood is one containing only narrow bands of summerwood. Such a surface is easily repainted. Paints that contain zinc oxide, on the other hand, flake in a more conspicuous fashion after they have become brittle and if repainting is put off the surface may prove difficult to repaint satisfactorily.

For buildings that are repainted promptly when old coatings become brittle, paints that contain reasonable proportions of zinc oxide and white lead with or without some of the newer opaque white pigments, such as the titanium and zinc-sulfide pigments, are superior to pure white-lead paint in that they protect the wood adequately against moisture for a longer time and if tinted they hold colors better. For white paint the presence of titanium or zinc-sulfide pigments is particularly desirable because such paints are less seriously discolored with dirt.

Finishing coat paints should not be mixed with too much linseed oil. After the volatile thinner has evaporated at least 28 per cent of the coating *by volume* should be pigment and of this pigment at least 80 per cent *by volume* should be made up of opaque white pigments (unless the paint is one of dark color in which there is little or no white pigment).

Purchasing agents who wish to know the real value of the paints they buy should provide themselves with tables of the bulking values (volume per unit weight) of the important paint pigments and liquids and learn to compute the proportions of paint ingredients by volume from formulas or analyses expressed in percentages by weight.

Importance of Spreading Rate

Next to the use of too much linseed oil the most common mistake in painting is probably the stingy application of paint. Purchasing agents will do well to regard with suspicion paints whose markers claim that they will cover more area per gallon than other paints. On smooth wood surfaces priming coat paint should not cover more than 575 square feet per gallon and second-coat or third-coat paint should not cover more than 600 square feet per gallon. Rough surfaces, such as sawed surfaces or badly weather-beaten surfaces consume still larger quantities of paint.

Stingy application of paint leads first to early loss of gloss and particularly to uneven or spotty loss of gloss. If the paint is tinted loss of gloss is followed quickly by fading of the color. The ultimate durability of coatings is often seriously impaired if they are applied too thin.

Publications

More detailed discussions of the topics summarized in this paper are given in the following publications. Single copies of these publications may be obtained free upon application to the Forest Products Laboratory, Madison, Wisconsin:

List of Publications on Wood Finishing Subjects, mimeograph R454.

Some Causes of Blistering and Peeling of Paint on House Siding, mimeograph R6.

Testing House Paints for Durability, mimeograph R1011.

Properties of Wood that Determine the Service Given by Exterior Paint Coatings, mimeograph R895.

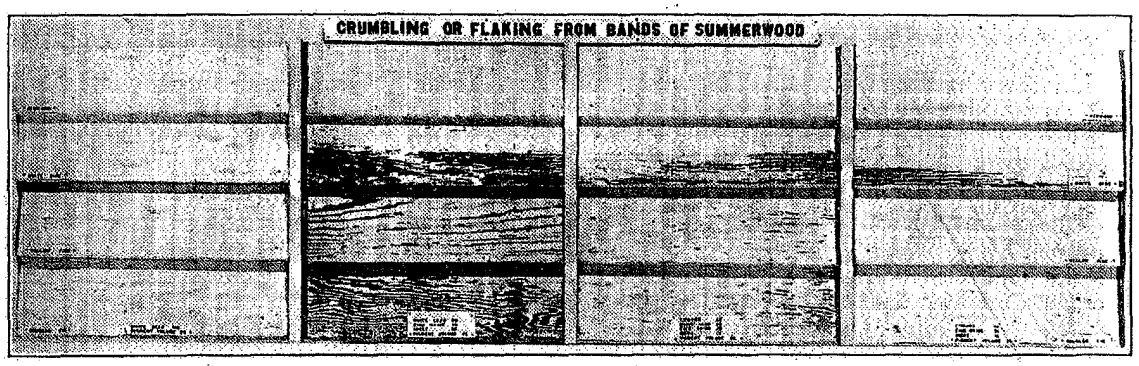
Why Some Wood Surfaces Hold Paint Better than Others, Leaflet No. 62.

When and How to Paint Farm Buildings, mimeograph R962.

Effect of Aluminum Priming Paint on the Durability of House Paints on Wood, mimeograph R1015.

Weathering and Decay, Technical Note No. 221.

Will we see you at the Joint Luncheon of the Paint Club and the Purchasing Agents, Palace Hotel, Friday, February 2?



VARIATION IN PAINT BEHAVIOR ON DIFFERENT WOODS

The top board of each panel is redwood, the second board white pine, the third board southern yellow pine, the bottom board Douglas fir. The left-hand panel is painted with pure white lead paint, the next one with a paint containing zinc oxide and white lead, the next with a paint containing zinc oxide, white lead, and titanium pigment, and the right-hand panel with a paint containing zinc oxide, titanium pigment, and no white lead. Normal failure of this kind should not set in until the paint is at least three or four years old.

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Priming-Coat Reductions for Painted New Wood Surfaces

By F. L. Browne

For Test Fence Committee of Northwestern Paint and Varnish Production Club

HE principal object of this study is to discover the optimum priming at reduction in applying common use paints to softwoods and to determine whether the priming coat ould be reduced differently according the nature of the softwood painted. e experiments have been described detail in three previous progress rts presented at the conventions in 31, 1932 and 1933, and published in rculars of the Scientific Section (404 445), the Official Digest (121), and the trade press.

Four woods and three paints were ed in the experiments on priming-at reduction. The woods were Nor-y pine, northern white pine, western l cedar, and redwood. The paints re white linseed oil house paints that fered only in the nature of the pig-nts; in one the pigment was entirely ic carbonate white lead, in the sec-l the pigment contained 60 per cent weight basic carbonate white lead, per cent lead-free zinc oxide, and 10 cent magnesium silicate, and the ment of the third contained 60 per t titanox B, 30 per cent lead-free c oxide, and 10 per cent magnesium cate. All three paints were made in form of semi-pastes, one gallon of ich consisted of 0.435 gallon of pig-nt and 0.565 gallon of linseed oil. the various priming coats these te paints were thinned with linseed turpentine, and paint drier as in-ated in Table No. 1. Some of the nting was done in two-coat work and some in three-coat work. For the final coat in two-coat painting the paste paints were thinned with 0.655 gallon of linseed oil, 0.036 gallon of turpentine, and 0.036 gallon of drier per gallon of paste paint, making paint of 26.4 per cent pigment volume. For three-coat work the second coat was made by mixing one gallon of paste paint, 0.218 gallon of linseed oil, 0.437 gallon of turpentine, and 0.036 gallon of drier, making paint of 35.9 per cent pigment volume; for the third coat the mixtures were one gallon of paste paint, 0.946 gallon of linseed oil, 0.036 gallon of turpentine, and 0.036 gallon of drier, making paint of 22.4 per cent pigment volume.

Panels were attached to both sides of test fences, providing both northern and southern exposures. The panels were made of boards of bevel siding 12 feet long so that groups of six matched test areas each two feet long were provided on which six variations in priming coat reduction were tested on the same boards. In Table No. 1 the six priming procedures tested on subdivisions of the same boards are grouped together. Priming reduction 1-3 was repeated on each set of boards in order to reveal differences due to characteristics of the boards in different panels of the same wood and to furnish a basis for comparing priming procedures tested on different panels.

Since the third progress report was written there have been two formal inspections of the fence, one in June and the other in October, 1934. At the last inspection the coatings were 38 months old. The writer also inspected the fence in August, 1934, in company with a group of visiting paint technologists but records were not made at that time. At 38 months the coatings on the south side of the fence were failing in integrity sufficiently to reveal distinct differences caused by the variations in priming coat reduction.

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aper presented at the annual meet-of the Federation of Paint and Var-Production Clubs, in Washington, 28-30. The Test Fence commit-of the Northwestern Paint and Var-Production Club consists of W. J. ippbar, chairman; L. P. Warren, T. MacMahon, S. O. Sorenson, J. M. en, Peter Gydesen, M. H. Sime and L. Browne.—Editor.)

On the north side of the fence, however, the coatings remained intact except for certain local cases of moisture failure mentioned in the third progress report. The present report is concerned chiefly with the trends in durability of the coatings on the south side of the fence.

Effect of Priming Coat Reduction

Table No. 1 records the ratings of the coatings in integrity at age 38 months, the durability in months of those coatings that had become unserviceable and were in the period of paint neglect, and an arbitrary estimate of the durability of those coatings that still remained serviceable. The estimated durabilities are based on the assumption that coatings rated Poor plus at the last inspection will remain serviceable three months longer, those rated Fair minus six months longer, and those rated Fair nine months longer. The estimated durabilities calculated in this way greatly facilitate discussion of the results but they are far from accurate predictions of future behavior. Less than one-third of the durabilities recorded in Table No. 1, however, are estimated in this way and for that reason the relative merits of the various priming procedures are as clearly revealed as they will be when the tests have continued until all of the coatings are unserviceable.

In Table No. 1 the priming coat reductions numbered 1-1, 1-2, 1-3, 1-4, and 1-5 were mixtures in which the concentration of pigment is suitable for three-coat painting, ranging from 17.2 to 23.2 per cent by volume of the mixture (including volatile). Reductions numbered 2-1, 2-2, and 2-3 had a higher concentration of pigment, 24.1 to 26.3 per cent, suitable for two-coat painting. Among the reductions of series one the best results were obtained with 1-1, in which no turpentine was used, and the tendency was for the durability to decrease as the turpentine was increased and the linseed oil decreased in the priming coat. The difference in results with primers 1-1, 1-2, and 1-3, however, was so small that they may well be considered equally serviceable. Reductions 1-4 and 1-5 were on the whole distinctly inferior, although on redwood 1-4 was still proving nearly as good as 1-3. The reductions of series two when used in two-coat work revealed a definite superiority of the reduction 2-1, made with linseed oil and no turpentine, over those in which there was linseed oil and turpentine. Of the two reductions of series two used for three-coat work, the one containing more oil and less turpentine proved somewhat superior.

It should be noted that, in three-coat work, reduction 2-2 was slightly superior to 1-3 in the cases of white lead and titanox and zinc paint and slightly inferior in the case of lead and zinc paint. In other words, reductions 2-2 and 1-3 on the whole proved about equally serviceable. The pigment volume in 1-3 was 22.3 per cent (of the non-volatile) and the ratio of linseed oil to turpentine by volume was about 2.6. In 2-2 the pigment volume was 30.2 per cent and the ratio of oil to turpentine 3.4. Reduction 1-4, which was inferior to 1-3 with all paints, had a pigment volume of 29.4 but a ratio of oil to turpentine of only 1.4. It seems, therefore, that the ratio of oil to turpentine is more significant, at least within the range of desirable reductions, than is the pigment volume. Apparently a good primer should have at least 2½ times as much linseed oil as turpentine and it is questionable whether there need be any turpentine in the primer at all. The pigment volume in a good primer for three-coat painting presumably may be anywhere in the range of 20 to 30 per cent but for two-coat painting practical considerations require that the pigment volume be in the upper portion of this range.

Reductions for Different Woods

The notion has long prevailed that the optimum priming coat reduction differs according to the kind of wood painted. There is no published evidence in support of such a belief and its soundness may well be doubted in view of the contradictory recommendations often made when writers try to give specific priming coat formulas for different woods. The data of Table No. 1 suggest the same optimum priming coat reduction for all woods, namely, reduction with linseed oil and little or no turpentine. The results are not at all consistent with the view that the reduction for red cedar or redwood should differ from the reduction for white pine or Norway pine. It should be recognized, however, that the present experiments were concerned principally with the proportions of linseed oil and turpentine in the priming coat and did not cover possible variations in pigment concentration as adequately as could be desired. Further research may show that for woods like redwood and red cedar, which absorb paint oils quickly, a slightly lower pigment concentration may be advisable in order to avoid unduly low spreading rates and difficulty with painters' laps than is appropriate for such woods as Norway pine, southern yellow pine, and Douglas fir. Nevertheless the present indications are that a single recommendation for reducing priming coats for all kinds of woods is entirely practical and prob-

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ably advisable. The "easily paintable" woods probably differ from the "difficultly paintable" one chiefly in degree of sensitiveness to departure from the optimum reduction, that is, less damage to the serviceableness of the coating may be expected if the painter fails to

(Continued on page 48)

Table 1.—Results Obtained With Different Priming Coat Reductions and With Aluminum Primer After 38 Months Exposure Facing South.

Figures for durability enclosed in parentheses are estimated on the assumption that the additional life of coatings still serviceable at the last inspection will be 9 months if last rated Fair, 6 months if last rated Fair minus, and 3 months if last rated Poor plus.

Reference number	Priming-coat reduction: 1 gallon of paste paint mixed with— Linseed oil (Gal.)	Turpentine (Gal.)	Paint drier (Gal.)	Pigment volume (Percent)	Number of coats of paint applied	Rating in integrity at 38 months and durability on — Norway pine: Integrity	Norway pine: Durability (Months)	White pine: Integrity	White pine: Durability (Months)	Red cedar: Integrity	Red cedar: Durability (Months)	Redwood: Integrity	Redwood: Durability (Months)	Average durability on all woods (Months)
White lead paint:														
1-1	1.168	0	0.045	20.0	3	Poor	38	Poor	38	Poor+	(41)	Poor+	(41)	39.5
1-2	1.06	.292	.041	21.1	3	Poor	38	Poor-	36	Poor+	(41)	Poor+	(41)	39.0
1-3	.946	.583	.036	22.3	3	Poor	38	Poor-	36	Poor+	(41)	Poor+	(41)	39.0
1-4	.475	.728	.027	29.4	3	Poor-	34	Bad+	34	Poor	38	Poor+	(41)	36.8
1-5	0	.875	.014	43.4	3	Bad	28	Bad-	26	Bad+	34	Poor-	36	31.0
---	aluminum primer				3	Fair-	(44)	Poor+	(41)	Fair-	(44)	Fair-	(44)	43.3
2-1	.655	0	.036	26.2	2	Bad	28	Poor	38	Poor+	(41)	Poor-	36	35.8
2-2	.437	.292	.026	30.2	2	Bad-	26	Poor-	36	Poor	38	Poor-	36	34.0
1-3	.946	.583	.036	22.3	3	Bad	26	Poor	38	Poor	38	Poor	38	35.0
2-3	.219	.583	.023	35.6	2	Bad-	24	Bad+	34	Poor-	36	Bad+	36	32.5
2-2	.437	.292	.026	30.2	3	Bad	26	Poor	38	Poor+	(41)	Poor	38	35.8
2-3	.219	.583	.023	35.6	3	Bad-	24	Poor-	36	Poor	38	Poor	38	34.0
Lead and zinc paint:														
1-1	1.168	0	0.045	20.0	3	Poor	38	Poor	38	Poor+	(41)	Fair-	(44)	40.3
1-2	1.06	.292	.041	21.1	3	Poor	38	Poor-	34	Poor+	(41)	Fair-	(44)	39.3
1-3	.946	.583	.036	22.3	3	Poor	38	Poor-	34	Poor+	(41)	Fair-	(44)	39.3
1-4	.475	.728	.027	29.4	3	Poor	38	Bad	30	Poor+	(41)	Poor+	(41)	37.5
1-5	0	.875	.014	43.4	3	Poor	38	Bad-	26	Poor	38	Poor	38	35.0
---	aluminum primer				3	Fair-	(44)	Poor-	33	Fair-	(44)	Fair	(47)	42.0
2-1	.655	0	.036	26.2	2	Poor-	34	Poor-	30	Poor+	(41)	Poor	38	35.8
2-2	.437	.292	.026	30.2	2	Bad	30	Bad+	29	Poor	38	Poor-	34	32.8
1-3	.946	.583	.036	22.3	3	Poor+	(41)	Poor-	32	Poor	38	Poor+	(41)	38.0
2-3	.219	.583	.023	35.6	2	Bad	31	Bad	26	Bad+	26	Bad+	32	28.8
2-2	.437	.292	.026	30.2	3	Poor	38	Poor-	29	Poor	34	Poor	38	34.8
2-3	.219	.583	.023	35.6	3	Poor	38	Poor-	29	Poor-	32	Poor	38	34.3
Titanox and zinc paint:														
1-1	1.168	0	0.045	20.0	3	Poor-	26	Bad+	26	Fair-	(44)	Poor+	(41)	34.3
1-2	1.06	.292	.041	21.1	3	Bad+	22	Bad+	34	Poor+	(41)	Poor+	(41)	34.5
1-3	.946	.583	.036	22.3	3	Bad	21	Bad+	34	Poor+	(41)	Poor+	(41)	34.3
1-4	.475	.728	.027	29.4	3	Bad	21	Bad	22	Poor	38	Poor+	(41)	30.5
1-5	0.	.875	.014	43.4	3	Bad-	22	Bad-	22	Poor-	34	Poor-	36	28.5
---	aluminum primer				3	Fair-	(44)	Poor	38	Fair-	(44)	Fair-	(44)	42.5
2-1	.655	0	.036	26.2	2	Poor	38	Poor	34	Fair-	(44)	Poor+	(41)	39.3
2-2	.437	.292	.026	30.2	2	Bad+	26	Poor	34	Fair-	(44)	Poor	38	35.5
1-3	.946	.583	.036	22.3	3	Bad	22	Poor	34	Poor+	(41)	Poor	38	33.8
2-3	.219	.583	.023	35.6	2	Bad	21	Bad+	27	Poor	38	Poor-	36	30.5
2-2	.437	.292	.026	30.2	3	Bad+	26	Poor	34	Poor+	(41)	Poor	38	34.8
2-3	.219	.583	.023	35.6	3	Bad	22	Poor	34	Poor+	(41)	Poor-	36	33.3

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at the last inspection is recorded in Table No. 4.

Of the special primers made with white pigments in Bakelite varnish the one made with zinc oxide gave distinctly inferior results. The ones made with white lead and titanox were better but by no means so good as the aluminum primer reported in Table No. 1. The type of failure of the white lead paint over these primers was not the same as that of white lead paint over white lead primer or over aluminum primer but took the form of flaking as distinguished from crumbling over the bands of summerwood.

Table No. 4—Results After 38 Months' Exposure Facing South for Miscellaneous Tests on Units 7 and 8 of the Fence.

Description of Coating	Rating in Integrity on Norway Pine	White Pine	Red Cedar	Redwood
Two coats of white lead paint over priming coat of:				
White lead in Bakelite varnish	Poor—	Poor	Poor+	Poor
Zinc oxide in Bakelite varnish	Bad	Bad+	Poor—	Bad—
Titanox B in Bakelite varnish	Poor	Poor	Poor+	Poor—
Three coats of linseed oil paints having the following white pigments:				
White lead paint, as recommended by National Lead Company	Poor	Poor+	Poor+	Poor+
White lead paint, as recommended by Eagle-Picher Lead Company	Poor	Poor+	Poor+	Poor+
Cryptone, leaded zinc oxide, inert, as recommended by New Jersey Zinc Company	Poor+	Poor+	Poor+	Fair—
Titanox, white lead, zinc oxide, inert, as recommended by Titanium Pigment Company	Fair—	Poor+	Fair—	Fair

French Naval Stores Trade in October

Washington, Dec. 3.—Vice Consul Frank Cassans, Bordeaux, reports to the Chemical Division, Bureau of Foreign and Domestic Commerce, that the most outstanding change which occurred in the market during the month was the curtailment of exports to Germany, brought about by an announcement by the French Minister of Commerce to shippers that if naval stores exports to Germany continue to increase the Franco-German office in Paris would be unable to pay the exporters in full for the shipments made.

The French naval stores market was considered to be in a better position as regards stock than it was at the end of October, 1933, due principally to the large quantities exported to Germany during recent months, and the estimated decrease in this year's crop from 15 to 20 per cent below last year's.

J. B. Keister, of the National Lead Co., recently returned to San Francisco after spending a month visiting in New York and other eastern cities following the Washington convention of the National Paint, Varnish and Lacquer Association.

Felton-Sibley Team Leads in Paint Bowling League

Philadelphia, Dec. 6.—As a result of the games played last evening, the Felton-Sibley ten pin shatterers leaped into the sunberth of the Philadelphia Save the Surface Bowling League. By applying the whitewash brush to the American Can team, the Felton-Sibley team earned 4 points and broke the deadlock for first place with the George D. Wetherill team, who lost 4 points to the E. I. du Point de Nemours & Co. team.

High average man in the league so far is Roman, of George D. Wetherill, whose average is 178; second place honors are shared by McGinley, of George D. Wetherill, and Joe Mack, of Felton-Sibley, with an average of 177. Thomas, of Felton-Sibley, holds the high single game score of 276.

W. H. Loughlin, of Pitts & Loughlin, San Francisco, spent the Thanksgiving week-end in Death Valley and at the Boulder Dam, and stopped en route home the first of last week in Los Angeles at the southern branch, presided over by S. Y. Pitts.

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that, by reason of the higher pigment concentrations and lower spreading rates followed in the two-coat painting, roughly similar total quantities of paint were applied in the two-coat and three-coat jobs. It is evident that two-coat painting when done in the manner followed in these experiments is thoroughly practicable and gives coatings that closely approach good three-coat work in durability and prove distinctly better than poor three-coat work.

Aluminum Priming Paint

Table No. 1 indicates that the best results were obtained with aluminum priming paint followed by two coats of white paint. On all woods except white pine the coatings of all three paints over aluminum primer were still rated Fair minus or better in intergrity at the last inspection and in all cases except that of lead and zinc paint on white pine the coating over aluminum primer was rated as high or higher in integrity than the best coating over a white primer on the same boards. On 10 out of 12 panels the coating over aluminum primer had the highest rating, on one panel its rating (Fair minus) was equalled only by white priming coat reduction 1-1, and on one panel it was distinctly superior to reductions 1-4 and 1-5 but inferior to reductions 1-1, 1-2, and 1-3. On the last panel, however, failure was confined to two of the four boards which developed loose grain toward the end on which the aluminum primer was applied but not on the end that received reductions 1-1, 1-2, and 1-3. This panel, therefore, was not an exception to the rule that the aluminum primer in these tests tended to hold the coatings intact longer than any of the priming coat reductions of the white paint.

Unusually Early Failure of the Paints

Failure of the coatings in integrity took place unusually rapidly on the St. Paul test fence. Coatings of the white paints used should be expected to remain serviceable in the Lake States region for at least four years on such woods as red cedar, redwood, and white pine, yet the failures took place in less than four years. The coatings of white lead paint and of lead and zinc paint applied with priming coat reduction 1-3 as recorded in Table No. 1 may reasonably be compared with certain tests by the Forest Products Laboratory in which the same paints were applied with very similar reductions and on some of the same kinds of wood at Fargo, N. D., and at Madison, Wis., in 1930. Table No. 3 records data suitable for comparing the results with those at St. Paul.

The reason for faster disintegration of the paints at St. Paul is unknown but the fact that there is unmistakable evidence of some moisture failure on the north side of the fence, as pointed out in the third progress report, suggests that moisture getting into the fence at some time may have hastened disintegration on the south side even though the moisture conditions were not severe enough to result in typical blistering or other developments clearly recognizable as moisture failures. It has been reported to the test fence committee that at one time during the winter of 1932-33 snow drifted against the fence to the extent of practically covering one side. This snow was not shoveled away and there is a possibility that entrance of moisture within the fence took place when it melted.

Miscellaneous Tests on Units 7 and 8 of the Fence

In addition to the main portion of the test fence there were two units added for the purpose of trying the effect of special primers made with white pigments in the Bakelite varnish used as a vehicle for the aluminum primer on units 1 to 6 and for trying the recommendations for thinning white lead paint made by the National Lead Co. and the Eagle-Picher Lead Co. and certain paints suggested by the New Jersey Zinc Co. and the Titanium Pigment Co. The condition of these paints with respect to integrity of the coatings

Table No. 3—Comparison in Durability Between White Lead Paint and Lead and Zinc Paint Applied with Priming Coat Reduction 1-3 at St. Paul and the Same Paints Applied Very Similarly in Tests at Fargo and Madison.
Figures in Parentheses Are Durabilities Estimated for Coatings Still Serviceable at 38 Months.

Station	Durability in Months with Respect to Integrity of Coating for White Lead Paint on				Lead and Zinc Paint on			
	Redwood	Red Cedar	White Pine	Norway Pine	Redwood	Red Cedar	White Pine	Norway Pine
St. Paul, Minn.1.....	(41)	(41)	36	38	(44)	(41)	34	38
St. Paul, Minn.1.....	38	38	38	26	(41)	38	32	(41)
Fargo, N. D.2.....	52	..	50	..	49	..	44	..
Madison, Wis.2	54	..	54	..	51	..	48	..

1 At St. Paul there were two test areas on each wood painted with each paint using priming coat reduction 1-3; each of these areas is reported separately.

2 Data for Fargo and Madison are average durabilities for 10 test areas of each wood painted with each paint.

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1934 (19)

AMERICAN WOOD-PRESERVERS' ASSOCIATION

This is an advance copy of a report to be presented at the Thirtieth annual meeting of the American Wood-Preservers' Association to be held at the Hotel Rice, Houston, Tex., on January 23, 24 and 25, 1934, and is not for publication until after the meeting.
Please bring this report with you to the meeting.

This Association, as a body, is not responsible for any statement made or opinion expressed in its publications.

DURABILITY OF PAINT ON WOOD TREATED WITH ZINC CHLORIDE

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Summary

The painting characteristics of wood treated with zinc chloride for preservation against decay were studied at the Forest Products Laboratory by observation of practical installations and by a carefully planned series of exposure tests in which matched specimens of wood were used with and without treatment. For interior surfaces the presence of as much as 1.5 lb. cu. ft. of zinc chloride in boards 1 in. thick does not affect the behavior of interior flat or gloss paint significantly. For exterior surfaces it is entirely practicable to maintain zinc-treated wood with ordinary linseed oil paints, but the paints do not last so long on wood containing zinc chloride as they do on untreated wood. When wood treated with zinc chloride is primed with aluminum paint before applying ordinary white paint, the durability of the coating is greatly improved. Wood treated with a mixture of 2 parts of zinc chloride and 1 part of sodium dichromate by weight holds paint fully as well as similar but untreated wood. Since at least half of the zinc chloride in such a mixture must remain in the wood as such and whatever zinc dichromate is formed by the rest of the mixture is toxic in laboratory tests, the mixture offers promise as a wood preservative, although service tests to determine that point are lacking. The mixture of zinc chloride and sodium dichromate may be given serious consideration for uses in which preservation is necessary and maximum economy in paint maintenance is desired and where service records proving satisfactory effectiveness as a preservative are not considered essential.

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

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DURABILITY OF PAINT ON WOOD TREATED WITH ZINK CHLORIDE

Paint is not a wood preservative, that is to say, it is not a practicable means of preserving wood against attack by wood-destroying fungi. Despite frequent assertions to the contrary in popular writing and advertising about paint, the common practice in the use of wood has been to rely for preservation against decay upon (a) design and construction that prevent the wood from becoming wet for long periods, (b) choice of the heartwood only of naturally durable species or (c) impregnation with chemicals that are poisonous to wood-destroying fungi. Painting is usually confined to exposed surfaces that are free to dry out promptly when temporarily wet by rain or other sources of water. On exterior surfaces the objects of painting are decoration and protection against the roughening, cupping, checking, and loosening of boards that result when wood is left unpainted. On interior surfaces the chief reasons for painting are decoration, improved illumination, and ease of keeping the surfaces clean.

Paints and wood preservatives are, therefore, not competitors. For the most part woodwork that is commonly painted is not subject to conditions under which there is much hazard of decay while, on the other hand, the uses to which most of the wood treated with preservatives is put do not require painting. There are, however, some important applications in which both preservative treatment and painting are necessary or desirable. One example is offered by roof timbers and ceiling boards in factories in which the operations release much moisture, such as paper mills, or in which humidification is necessary, such as textile mills. In these structures the interior surfaces must often be painted for appearance and to improve illumination. Another example is offered by highway posts, guard rails, and bridge timbers that must be kept easily visible with white paint.

At present there is no thoroughly reliable method of keeping creosoted wood painted with white paint. If the wood is so treated that the creosote does not bleed, creosoted wood can be painted successfully with aluminum paint but it has not yet been established that white paint can be applied safely over the aluminum. The difficulty with creosote lies, of course, in the fact that it is missible with drying oils and therefore discolors white paint. Water-soluble wood preservatives, on the other hand, are incapable of diffusion into drying oils and under ordinary circumstances do not discolor paint. Since zinc chloride is the most important non-proprietary water-soluble preservative at present, reliable information about its effect on the painting characteristics of wood is highly desirable.

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Review of Earlier Tests

In 1914, panels of white pine were treated at the Forest Products Laboratory with (1) 1.5 to 1.75 lb. per cu. ft. of zinc chloride, (2) 0.8 lb. per cu. ft. of sodium fluoride, and (3) 2.0 lb. per cu. ft. of a mixture of ammonium phosphate and ammonium chloride (*6*). The panels were air-dried "for several weeks" and it was noted that those treated with zinc chloride dried very slowly. It is now believed that they were not thoroughly dry when painted. There were also untreated panels for comparison. The panels were painted with lead and zinc house paints by Dr. H. A. Gardner, and sets of panels were exposed at Atlantic City, N. J., Washington, D. C., and St. Louis, Mo. On the panels treated with zinc chloride, the paints lasted longer than they did on the panels treated with ammonium salts, but not so long as they did on untreated panels or panels treated with sodium fluoride.

In 1926, the Service Bureau of the American Wood Preservers' Association arranged for a new series of tests (*7, 8*). A set of 60 specimens of southern pine was prepared at the Forest Products Laboratory; 20 specimens were untreated, 20 treated with 0.25 to 0.68 lb. per cu. ft. of zinc chloride, and 20 with 4 to 8.5 lb. per cu. ft. of creosote. The treated specimens were seasoned for about three weeks, but subsequent experience indicates that this was not enough time to dry the panels containing zinc chloride adequately. The panels were painted by Dr. H. A. Gardner and exposed at Washington, D. C. Two house paints were used, white lead paint and a lithopone, titanox, and zinc paint, each of which was applied with the white paint as the priming coat and over the following special priming paints, red lead, zinc dust and zinc oxide, aluminum, and a nitrocellulose paint. All of the specimens treated with creosote caused discoloration of the white paints. On the specimens treated with zinc chloride, white lead paint lasted nearly as long as it did on untreated specimens, but the treated wood checked distinctly more seriously than the untreated wood. The lithopone, titanox, and zinc paint failed more rapidly on the treated wood than it did on the untreated wood.

A third series of tests was started by Dr. H. A. Gardner in 1928 (*9*). Southern pine specimens were impregnated with about 0.75 lb. and about 1.5 lb. per cu. ft. of zinc chloride and matched specimens were left untreated. All treated specimens were seasoned until the moisture content was below 17 per cent; most of the specimens averaged about 12 per cent. A set of the specimens was then painted with a titanox and zinc paint and exposed to the weather at Washington, D. C. After five months the coatings were still in good condition; no later reports have been issued. Another set was painted with white-lead paint, a lithopone interior flat paint, and a lithopone and zinc interior gloss paint. The

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second set was suspended from a ceiling indoors over a vat of steaming aqueous solution to simulate a roof in a factory of wet occupancy. Although a relative humidity of 90 per cent was attained in the room, the test specimens lost in weight during the first 130 days exposure, indicating that there was a warm stratum of air of much lower humidity actually in contact with the specimens. When the specimens were later placed in a humidity cabinet they gained in weight significantly, those containing zinc chloride gaining materially more than the untreated specimens. The test over the steaming vat was then continued for a month and a half but apparently under somewhat different conditions because the specimens gained in weight by enough to raise the moisture content above the fiber-saturation point after which the coatings became blistered. Specimens containing zinc chloride absorbed more moisture and apparently became blistered sooner than untreated specimens.

In 1922, Dr. Hermann von Schrenk exposed a set of test panels at St. Louis in which there were cypress and southern pine specimens with and without zinc chloride, with planed and sawed surfaces, and coated with two different white paints and a red paint. After two years exposure the paints were still in excellent condition (*11*). Dr. H. A. Gardner later (*8*) published a photograph of the tests after six years exposure with the statement that the treated specimens held paint satisfactorily.

In 1926 the Minnesota Highway Commission exposed a few specimens of white pine and ponderosa pine treated with about 1.5 lb. per cu. ft. of zinc chloride and painted with two kinds of white paint, a chrome yellow paint and a black paint. The exposures were made in the inclined position facing south at St. Paul. The white paints failed completely in less than 16 months and the conclusion was drawn that the presence of zinc chloride accelerated the failure of the paint. There were no untreated control specimens and there is reason to doubt whether the treated specimens were thoroughly dry when painted.

The State of Illinois, Division of Highways, in 1927, began tests of paint on 10 southern pine fence posts treated at the Forest Products Laboratory. The posts, which were 6 in. by 8 in. by 8 ft., were treated with about 0.5 lb. per cu. ft. of zinc chloride. A lead and zinc paint was applied in 1, 2, and 3 coat work, both with and without special priming paints. After nearly two years of service the paints were all in reasonably good condition so that no conclusions were drawn, except to point out indications that the aluminum primer appeared to be exerting a beneficial effect, while the other special primers were not.

The California Termite Investigations Committee and the California Paint Superintendents' Club in 1930 made an extensive study of the painting of woods treated with various preservatives in-

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cluding zinc chloride (*10*). The woods were Douglas fir, redwood, and ponderosa pine. The specimens treated with zinc chloride contained about 0.5 lb. of salt per cu. ft. Untreated specimens were included, but they were not matched with the treated specimens. The conclusion was drawn that it is entirely practicable to paint wood treated with zinc chloride, but that the paint does not last quite so long as it does on untreated wood. The durability of white paint was improved when it was applied over aluminum priming coat paint.

The first painting studies of treated wood at the Forest Products Laboratory were reported by M. E. Dunlap (*5*). The impregnants were sugar, 0.55 lb. per cu. ft.; borax, 1.26 lb.; zinc chloride, 0.64 lb.; sodium fluoride, 0.53 lb.; mercuric chloride, 0.13 lb.; and two proprietary preservatives. The boards were seasoned to constant weight in a room at 60 per cent relative humidity before the panels were made and painted with white lead paint. On the panels treated with sodium fluoride and with mercuric chloride the paint lasted somewhat longer than it did on the untreated panel. On the panels treated with sugar and with zinc chloride the paint failed slightly more rapidly than it did on the untreated control and, in addition, the boards containing zinc chloride developed more weather checks than the untreated boards. The paint failed most rapidly on the panel treated with borax.

The writer has attempted to make a survey of practical experience in the painting of wood treated with zinc chloride. Through a producer of zinc chloride a list of installations was obtained of wood treated with zinc chloride and known to have been painted. Most of the installations were roof timbers and ceilings in paper or textile mills or factories in which much moisture is evolved; a few were exterior woodwork of some kind. Some of these installations were visited by the writer, while, for others, information was obtained through correspondence only. As a rule, information so obtained is subject to the serious limitation that there is no means of comparing the behavior of the paint on treated wood with that of similar paint subject to exactly the same conditions on untreated wood.

In all but one of the installations with which contact was made, those in charge of maintenance were satisfied that wood treated with zinc chloride can be kept properly painted as economically as untreated wood. The one exception was a state highway commission that has used both treated and untreated wood on signs and guard rails that are painted white. For a year or so no difference in paint behavior was observed, but after two or three years the paint was found to be flaking more rapidly from the wood containing zinc chloride.

A fair statement of experience and prior experimentation seems to be as follows: Interior woodwork treated with zinc chloride

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can be kept painted as easily and as economically as untreated wood. Exterior woodwork containing zinc chloride can be kept painted without unreasonable cost, even though the paint may not last quite so long as it does on similar but untreated wood.

Tests Started in 1928

The Forest Products Laboratory, in cooperation with the Grasselli Chemical Company, in 1928, started a series of tests of the painting characteristics of wood treated with zinc chloride, in which matched test specimens were used. The boards were thoroughly air-dry before painting, and the work was done on an adequate scale to justify the drawing of conclusions.

Lumber and Treatment

The lumber used was 1-in. by 6-in. by 16-ft., southern yellow pine boards, surfaced on 4 sides, of select grade suitable for finishing. Thirty-three boards were selected that contained as much sapwood as possible and were reasonably uniform in density and width of growth rings throughout the length of the board. They were all flat-grain boards and were well seasoned. A "board number" was assigned to each board for purposes of identification. Each board was then cut into 10 pieces, each piece 18 in. long, and each piece as it was cut off was marked with its board number and a "piece number" (from 1 to 10) indicating the order in which it was cut from the board. From the waste cuttings small specimens were taken for determining the moisture content of the boards, which varied from 9 to 15 per cent and averaged approximately 11 per cent.

Pieces numbered –1 from all boards were set aside as control specimens to remain untreated. They were stored in a room kept at 60 per cent relative humidity while the remaining pieces received treatments and were reseasoned subsequently.

Pieces numbered –2 from all boards were set aside as control specimens of another kind. They were treated to refusal with plain water under exactly the same conditions that were followed for the treatments with zinc chloride. The object of these controls was to determine whether the increased susceptibility to weather checking observed in previous tests of wood containing zinc chloride is caused by the conditions prevailing during impregnation, or is a property imparted to the wood by the presence of the zinc chloride.

Pieces numbered –3, –4, and –5 from all boards were treated with a 3.66 per cent solution of zinc chloride. Vacuum of 28 in. was drawn for 30 min., the solution was then admitted and pressure of 140 to 150 lb. per sq. in. at 176 to 194 deg. F. was applied for 5 hr. Each piece was weighed before and after treat-

ment to furnish data for calc
retained, which was roughly 1

Pieces numbered –6, –7, and
treated with a 1.74 per cent s
retention of roughly 0.75 lb. pe

Pieces numbered –9 and –1
treated with a solution containi
1.2 per cent of sodium dichrom
1 lb. per cu. ft. of mixed salts.

After treatment, all specime
grain surfaces with gloss oil a
drying from the ends and were
relative humidity to season. A
bring the moisture content of th
down to approximately 13 per
treated with water came to a
cent in that time.

Pieces numbered –4, –7, and
to remove the layer of wood n
there is some movement of wa
toward the surface, making the
ical higher near the surface tha
was thought that the removal
fore, tend to improve the pain
Pieces numbered –3, –6, and –
all respects to pieces –4, –7, an
the sap side without planing off

Pieces numbered –5 and –8 w
side with a saturated solution
fore painting. Borax reacts w
compounds of zinc. It was hop
near the surface into insoluble
tention of paint by the wood.

Grouping of Pie

Each test panel consisted of
taken from each of three board
pieces among panels is indicate
for example, were assigned to
lead paint. The three pieces nu
made up panel number 505, whi
for the group. The three pieces
made panel 506, the water-treat
made panel 507, which containe
chloride, and was neither plane
painting. The –4, –5, –6, –7, –

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ment to furnish data for calculating the amount of zinc chloride retained, which was roughly 1.5 lb. per cu. ft.

Pieces numbered –6, –7, and –8 from all boards were similarly treated with a 1.74 per cent solution of zinc chloride, yielding a retention of roughly 0.75 lb. per cu. ft. of zinc chloride.

Pieces numbered –9 and –10 from all boards were similarly treated with a solution containing 2.4 per cent of zinc chloride and 1.2 per cent of sodium dichromate, yielding a retention of roughly 1 lb. per cu. ft. of mixed salts.

After treatment, all specimens were coated thickly on the end grain surfaces with gloss oil and coating to prevent unduly rapid drying from the ends and were then piled in a room at 60 per cent relative humidity to season. About two months were required to bring the moisture content of the specimens containing zinc chloride down to approximately 13 per cent. The specimens that had been treated with water came to a moisture content of roughly 10 per cent in that time.

Pieces numbered –4, –7, and –10 were planed on the sap side to remove the layer of wood nearest the surface. During drying there is some movement of water-soluble ingredients in the wood toward the surface, making the concentration of impregnated chemical higher near the surface than it is in the rest of the board. It was thought that the removal of this surface layer might, therefore, tend to improve the paint retention on the treated lumber. Pieces numbered –3, –6, and –9, which otherwise were similar in all respects to pieces –4, –7, and –10, respectively, were painted on the sap side without planing off the surface layer.

Pieces numbered –5 and –8 were sponged thoroughly on the sap side with a saturated solution of borax in water and redried before painting. Borax reacts with zinc chloride to form insoluble compounds of zinc. It was hoped that changing the zinc chloride near the surface into insoluble compounds might improve the retention of paint by the wood.

Grouping of Pieces into Test Panels

Each test panel consisted of three similarly treated pieces, one taken from each of three boards. The method of distributing the pieces among panels is indicated in Table 1. Boards 7, 8, and 9, for example, were assigned to panels to be painted with white lead paint. The three pieces numbered –1 from these three boards made up panel number 505, which was the untreated control panel for the group. The three pieces numbered –2 from the same boards made panel 506, the water-treated control. Similarly the –3 pieces made panel 507, which contained roughly 1.5 lb. per cu. ft. of zinc chloride, and was neither planed nor sponged with borax before painting. The –4, –5, –6, –7, –8, –9, and –10 pieces from these

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boards made panels 508 to 514, respectively. Panels 505 to 514, inclusive, were all painted with two coats of white-lead paint.

Boards 10, 11, and 12 were assigned to panels for painting with lead and zinc paint and the arrangement of the pieces was exactly analogous to that described for the 10 panels painted with white lead paint. The remaining boards were set aside in groups of 3 and the pieces distributed into sets of 10 panels each in the same

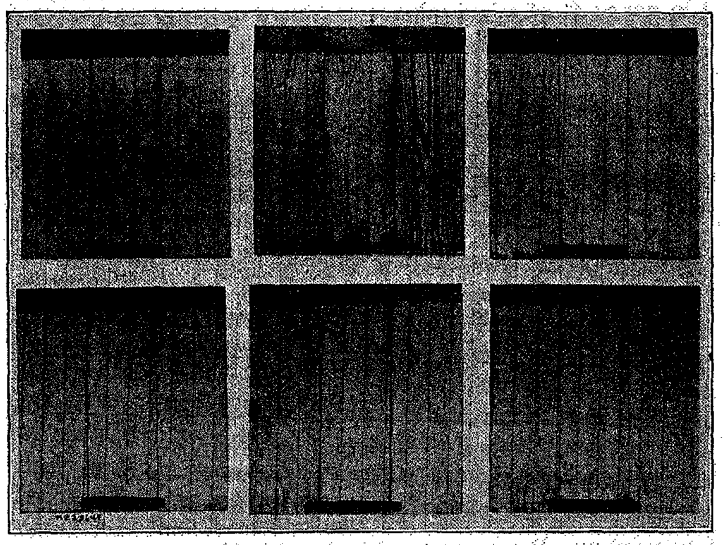

Fig. 1.—Treated and Untreated Wood Painted with White-Lead Paint.

The panels in the upper row were painted with two coats of white-lead paint, those in the lower row with one coat of aluminum paint and one coat of white-lead paint. In each row the left-hand panel was made of untreated wood, the middle panel of wood treated with 1.5 lb. per cu. ft. of zinc chloride, and the right-hand panel with a mixture of 1 lb. of zinc chloride and 0.5 lb. of sodium dichromate per cu. ft. The coatings were 26 months old when photographed.

way. Thus, in all, there were 11 sets of 10 panels each, one set for each of 11 paints or painting procedures to be tested. Of the 11 paints or painting procedures, 9 were exterior coatings and 2 were interior coatings.

The exterior coatings only are tabulated in Table 1. Three common types of house paint were tested, pure white lead paint, a paint containing zinc oxide and white lead, and a paint containing titanium pigment and zinc oxide without any white lead. Each of these paints was applied in two-coat work, each was applied as a finishing coat over aluminum priming paint, and each was applied

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in two-coat work using for the first coat a mixture of the paint with spar varnish.

Both interior paints were lithopone paints made with a bodied linseed oil vehicle; one of them was a gloss paint and the other a flat paint. The two sets of panels painted with these paints, numbers 485 to 494 and 495 to 594, respectively, are not listed in Table 1 because there are no acceptable methods of evaluating

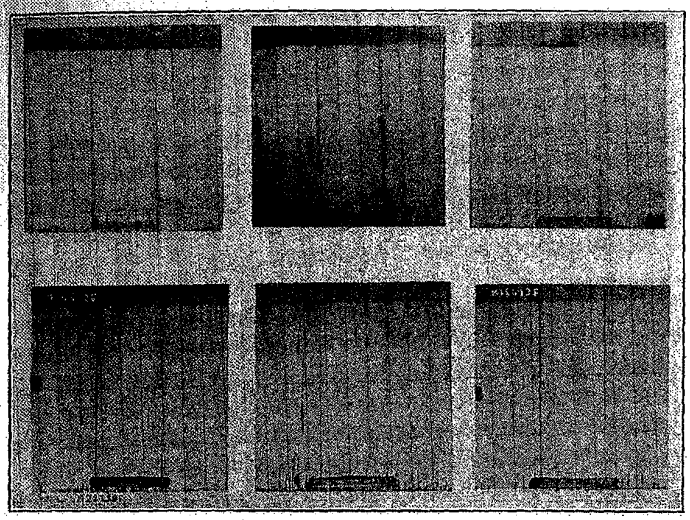

Fig. 2.—Treated and Untreated Wood Painted with Lead and Zinc Paint.

The panels in the upper row were painted with two coats of lead and zinc paint, those in the lower row with one coat of aluminum paint and one coat of white-lead paint. In each row, the left-hand panel was made of untreated wood, the middle panel of wood treated with 1.5 lb. per cu. ft. of zinc chloride, and the right-hand panel with a mixture of 1 lb. of zinc chloride and 0.5 lb. of sodium dichromate per cu. ft. The coatings were 26 months old when photographed.

the serviceableness of interior paints and determining their durability.

Composition of Paints

The linseed oil used in the exterior paints was a raw linseed oil of "premium grade" intended for paint making; a typical shipment was found to have an acid number of 5.5 mg. KOH per g. and an iodine number (Wijs) of 178.0.

The bodied linseed oil for interior paints was made by heating varnish makers' linseed oil at 300 deg. C. for 3 hr.

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The spar varnish for aluminum paint and for addition to some of the priming-coat paints was a commercial vehicle for aluminum paint of 80-gal. length in oil and presumably made chiefly of ester gum, tung oil, and thinners. It contained 52 per cent non-volatile by weight.

The liquid paint drier was a commercial brand of lead and manganese linoleate paint drier.

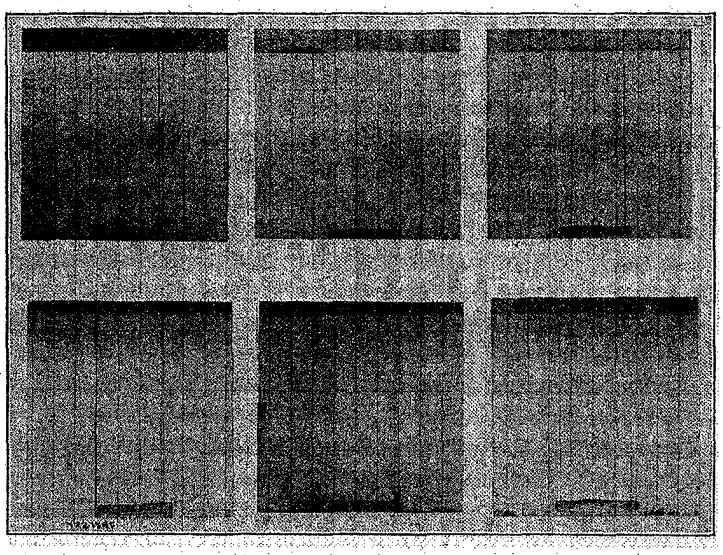

Fig. 3.—Treated and Untreated Wood Painted with Titanox and Zinc Paint.

The panels in the upper row were painted with two coats of titanox and zinc paint, those in the lower row with one coat of aluminum paint and one coat of titanox and zinc paint. In each row, the left-hand panel was made of untreated wood, the middle panel of wood treated with 1.5 lb. per cu. ft. of zinc chloride, and the right-hand panel with a mixture of 1 lb. of zinc chloride and 0.5 lb. of sodium dichromate per cu. ft. The coatings were 26 months old when photographed.

The paints and their various mixes are listed below with a system of symbols that will represent them in the subsequent discussion.

Paints

White paints are designated by the letters L for pure white lead paints, LZ for paints containing white lead and zinc oxide, TZ for paints containing titanium pigment and zinc oxide, and P for interior paints made with lithopone; aluminum paint is designated by A:

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	Pounds
L_1 Paste paint	
Basic carbonate white lead	92
Linseed oil	8
Unit weight for mixing	100
L_2 Paste paint	
Basic carbonate white lead	85
Linseed oil	15
Unit weight for mixing	100
LZ_1 Paste paint	
Basic carbonate white lead	42.6
Zinc oxide, lead-free	21.3
Magnesium silicate	7.1
Linseed oil	15.0
Unit weight for mixing	86.0
TZ_1 Paste paint	
Titanox B	33.0
Zinc oxide, lead-free	16.5
Magnesium silicate	5.5
Linseed oil	15.0
Unit weight for mixing	70.0
P_1 Paste paint	
Lithopone	53.6
Bodied linseed oil	11.4
Mineral spirits	9.9
Unit weight for mixing	74.9

		Per cent by weight
LZ_2 Prepared paint		
Basic carbonate white lead		55
Zinc oxide, lead-free		35
Magnesium silicate		10
Total pigments	66	
Linseed oil		90
Mineral spirits		5
Liquid paint drier		5
Total Liquids	34	
TZ_2 Prepared paint		
Titanox B		55
Zinc oxide, lead-free		35
Magnesium silicate		10
Total pigments	66	
Linseed oil		90
Mineral spirits		5
Liquid paint drier		5
Total liquids	34	

A Mixed immediately before use

Aluminum, powder standard varnish grade	1.5 lb.
Spar varnish	1.0 gal.

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Mixes of white paints for application

Mixes for priming coat are designated by letters a, ar (for repainting), and av (containing varnish), and mixes for final coat by c. In the mixing formulas below, the quantities of liquids in gallons are added to the unit weight of paste paint stated in the paint formulas or to one gallon of prepared paint:

a_1 2 linseed oil, 2 mineral spirits, 0.125 paint drier.
a_2 0.31 mineral spirits.
a_3 0.96 mineral spirits, 0.076 paint drier.
av_1 1.5 linseed oil, 0.5 spar varnish, 2 mineral spirits, 0.125 paint drier.
av_2 0.16 spar varnish, 0.15 mineral spirits.
ar 1.25 linseed oil, 2 turpentine, 0.125 paint drier.
c_1 3 linseed oil, 0.125 mineral spirits, 0.125 paint drier.
c_2 Prepared paint without any addition.
c_3 2.25 linseed oil, 0.125 turpentine, 0.125 paint drier.
c_4 0.96 mineral spirits, 0.076 paint drier.
c_5 1.12 bodied oil, 0.472 mineral spirits, 0.148 paint drier.

Exposure, Inspection, and Evaluation

All panels painted with exterior paints were exposed on the Forest Products Laboratory test fence at Madison, Wis., on October 29, 1928. They were placed on the fence facing south and sloping back at an angle of 45 deg. In this position the painted surfaces receive very nearly the maximum possible exposure to sunshine and paint coatings fail in two-thirds to three-fourths of the time required for failure when the panels are exposed in the vertical position facing south. Allowance should be made for this fact in considering the data in Table 1. In practice most exterior painted woodwork is in the vertical position.

The 20 panels painted with interior paints were exposed alternately in rooms kept respectively at 90 per cent and at 60 per cent relative humidity for periods of one month. The rooms were interior rooms with artificial illumination only.

The test panels were inspected at suitable intervals by members of the staff of the Forest Products Laboratory. The methods of inspection, records, and evaluation for exterior panels are described in detail elsewhere (*2, 3*). Coatings were judged for appearance, integrity, and protection.

Appearance is affected by such developments as soiling, loss of gloss, and chalking when the dirt is thereby dislodged; during the early part of the life of a coating changes are usually confined to appearance, but toward the end of the life interest shifts to integrity and portection. In these tests the appearance of the coatings was similar at all times on all 10 panels of any one group, in other words, the presence or absence of impregnated chemical had no effect upon the appearance of the coatings. There were, of course, differences in appearance between groups of panels painted

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TABLE 1.—DATA FOR TREATMENTS AND DURABILITY OF COATINGS ON PANELS PAINTED WITH EXTERIOR PAINTS

Panel number	Boards numbers	Piece number	Quantity of salt injected: zinc chloride	Quantity of salt injected: sodium dichromate	Subsequent treatment	Initial coating: Durability considering Integrity only	Initial coating: Durability considering Protection and integrity	Initial coating: Rating for integrity at age of 26 months	Repainted coating: Durability considering integrity only	Repainted coating: Rating for integrity at age of 58 months
1	2	3	4	5	6	7	8	9	10	11
			Lb. per cu. ft.	Lb. per cu. ft.		Months	Months		Months	
Panels painted with white lead paint										
Initially painted with paints L_1a_1 and L_1c_1; repainted with paints L_2ar and L_2c_3										
505	7, 8, 9	— 1	none	none	none	23	20	Bad	32+	Poor+
506	7, 8, 9	— 2	treated with water		none	23	19	Bad		
507	7, 8, 9	— 3	1.49	none	none	14	10	Bad—	19	Bad—
508	7, 8, 9	— 4	1.46	none	resurfaced	16	11	Bad—		
509	7, 8, 9	— 5	1.41	none	borax	20	17	Bad		
510	7, 8, 9	— 6	.69	none	none	23	19	Bad—	12	Bad—
511	7, 8, 9	— 7	.69	none	resurfaced	23	14	Bad—		
512	7, 8, 9	— 8	.69	none	borax	14	11	Bad—		
513	7, 8, 9	— 9	1.02	0.51	none	25	24	Poor	32+	Poor+
514	7, 8, 9	—10	1.00	.50	resurfaced	23	20	Bad		
Panels painted with lead and zinc paint										
Initially painted with paints LZ_2a_2 and LZ_2c_2; repainted with paints LZ_1ar and LZ_1c_3										
515	10, 11, 12	— 1	none	none	none	26	23	Poor	32	Poor
516	10, 11, 12	— 2	treated with water		none	26	23	Poor		
517	10, 11, 12	— 3	1.51	none	none	23	23	Bad		
518	10, 11, 12	— 4	1.46	none	resurfaced	23	21	Bad	16	Bad—
519	10, 11, 12	— 5	1.46	none	borax	21	20	Bad—		
520	10, 11, 12	— 6	.70	none	none	22	22	Bad—		
521	10, 11, 12	— 7	.71	none	resurfaced	26	23	Poor	18	Bad—
522	10, 11, 12	— 8	.71	none	borax	26	23	Poor		
523	10, 11, 12	— 9	.98	0.49	none	26+	26+	Fair		
524	10, 11, 12	—10	.95	.48	resurfaced	26+	26	Fair—	32+	Poor+
Panels painted with titanox and zinc paint										
Initially painted with paints TZ_2a_2 and TZ_2c_2; repainted with paints TZ_1ar and TZ_1c_3										
525	13, 14, 15	— 1	none	none	none	26+	26+	Good	32+	Poor+
526	13, 14, 15	— 2	treated with water		none	46	46	Good		
527	13, 14, 15	— 3	1.51	none	none	26+	26+	Fair	30	Poor
528	13, 14, 15	— 4	1.50	none	resurfaced	44	44	Fair		
529	13, 14, 15	— 5	1.50	none	borax	26+	26+	Fair		
530	13, 14, 15	— 6	.74	none	none	42	42	Fair		
531	13, 14, 15	— 7	.74	none	resurfaced	26+	26+	Good	28	Poor
532	13, 14, 15	— 8	.74	none	borax	26+	26+	Fair—		
533	13, 14, 15	— 9	1.05	0.53	none	56+	53	Good		
534	13, 14, 15	—10	1.04	.52	resurfaced	26+	26+	Good	32+	Poor+

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TABLE 1.—DATA FOR TREATMENTS AND DURABILITY OF COATINGS ON PANELS PAINTED WITH EXTERIOR PAINTS—Continued

Panel number	Boards numbers	Piece number	Quantity of salt injected: zinc chloride	Quantity of salt injected: sodium dichromate	Subsequent treatment	Initial coating[1]: Durability considering integrity only	Initial coating[1]: Durability considering protection and integrity	Initial coating[1]: Rating for integrity at age of 26 months	Repainted coating[2]: Durability considering integrity only	Repainted coating[2]: Rating for integrity at age of 58 months
1	2	3	4	5	6	7	8	9	10	11
			Lb. per cu. ft.	Lb. per cu. ft.		Months	Months		Months	
Panels painted with aluminum priming paint followed by white lead paint										
Initially painted with paints A and L_1c_1; repainted with paints L_2ar and L_2c_3										
535	16, 17, 18	— 1	none	none	none	26+	26+	Good	32+	Fair—
536	16, 17, 18	— 2	treated with water		none	42	26	Good		
537	16, 17, 18	— 3	1.52	none	none	26+	26+	Good	27	Poor
538	16, 17, 18	— 4	1.52	none	resurfaced	35	35	Fair		
539	16, 17, 18	— 5	1.58	none	borax	26	23	Poor		
540	16, 17, 18	— 6	.74	none	none	26+	26+	Fair	31	Poor
541	16, 17, 18	— 7	.75	none	resurfaced	33	26	Fair		
542	16, 17, 18	— 8	.76	none	borax	26	33	Poor		
543	16, 17, 18	— 9	1.08	0.54	none	26+	26+	Good	32+	Fair—
544	16, 17, 18	—10	1.10	.55	resurfaced	39	26	Good		
Panels painted with aluminum priming paint followed by lead and zinc paint										
Initially painted with paints A and LZ_2c_2; repainted with paints LZ_1ar and LZ_1c_3										
545	19, 20, 21	— 1	none	none	none	26+	26+	Fair	32+	Poor+
546	19, 20, 21	— 2	treated with water		none	35	30	Fair		
547	19, 20, 21	— 3	1.46	none	none	23	17	Bad	18	Bad+
548	19, 20, 21	— 4	1.46	none	resurfaced	32	27	Fair—		
549	19, 20, 21	— 5	1.47	none	borax	20	20	Bad		
550	19, 20, 21	— 6	.71	none	none	26	28	Poor	20	Bad+
551	19, 20, 21	— 7	.71	none	resurfaced	33	24	Fair—		
552	19, 20, 21	— 8	.72	none	borax	25	28	Poor—		
553	19, 20, 21	— 9	1.02	0.51	none	26+	20	Fair	31	Poor
554	19, 20, 21	—10	1.02	.51	resurfaced	42	30	Fair		
Panels painted with aluminum priming paint followed by titanox and zinc paint										
Initially painted with paints A and TZ_2a_2; repainted with paints TZ_1ar and TZ_1c_3										
555	22, 23, 24	— 1	none	none	none	26+	26+	Fair	32+	Poor+
556	22, 23, 24	— 2	treated with water		none	46	46	Fair		
557	22, 23, 24	— 3	1.55	none	none	46	46	Fair		
558	22, 23, 24	— 4	1.54	none	resurfaced	26+	26+	Fair	31	Poor
559	22, 23, 24	— 5	1.55	none	borax	26+	26+	Fair		
560	22, 23, 24	— 6	.71	none	none	26+	26+	Fair	31	Poor
561	22, 23, 24	— 7	.72	none	resurfaced	35	35	Fair		
562	22, 23, 24	— 8	.70	none	borax	26+	26+	Fair		
563	22, 23, 24	— 9	1.03	0.52	none	26+	26+	Fair	32+	Fair—
564	22, 23, 24	—10	1.04	.52	resurfaced	46	35	Fair		

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					resurfaced	35	35	Fair	31	Poor
		— 8	.70	none	borax	26+	26+	Fair		
		— 9	1.03	0.52	none	26+	26+	Fair	32+	Fair—
563	22, 23, 24	—10	1.04	.52	resurfaced	46	35	Fair		
564	22, 23, 24									

TABLE 1.—DATA FOR TREATMENTS AND DURABILITY OF COATINGS ON PANELS PAINTED WITH EXTERIOR PAINTS—Continued

Panel number	Boards numbers	Piece number	Quantity of salt injected: zinc chloride	Quantity of salt injected: sodium dichromate	Subsequent treatment	Initial coating[1]: Durability considering Integrity only	Initial coating[1]: Durability considering Protection and integrity	Initial coating[1]: Rating for integrity at age of 26 months	Repainted coating[2]: Durability considering integrity only	Repainted coating[2]: Rating for integrity at age of 58 months
1	2	3	4	5	6	7	8	9	10	11
			Lb. per cu. ft.	Lb. per cu. ft.		Months	Months		Months	
Panels painted with white lead paint having varnish in the priming coat										
Initially painted with paints L_1av_1 and L_1c_1; repainted with paints L_2ar and L_2c_3										
565	25, 26, 27	— 1	none	none	none	26	23	Poor	27	Poor
566	25, 26, 27	— 2	treated with water		none	23	14	Bad		
567	25, 26, 27	— 3	1.58	none	none	20	17	Bad	12	Bad—
568	25, 26, 27	— 4	1.56	none	resurfaced	14	11	Bad—		
569	25, 26, 27	— 5	1.54	none	borax	14	14	Bad		
570	25, 26, 27	— 6	.69	none	none	17	13	Bad		
571	25, 26, 27	— 7	.70	none	resurfaced	16	13	Bad		
572	25, 26, 27	— 8	.69	none	borax	14	11	Bad		
573	25, 26, 27	— 9	1.02	0.51	none	26	24	Poor	32+	Fair—
574	25, 26, 27	—10	1.02	.51	resurfaced	25	17	Bad+		
Panels painted with lead and zinc paint having varnish in the priming coat										
Initially painted with paints LZ_2av_2 and LZ_2c_2; repainted with paints LZ_1ar and LZ_1c_3										
575	28, 29, 30	— 1	none	none	none	23	17	Bad	20	Bad+
576	28, 29, 30	— 2	treated with water		none	23	19	Bad		
577	28, 29, 30	— 3	1.42	none	none	23	19	Bad	16	Bad—
578	28, 29, 30	— 4	1.44	none	resurfaced	17	14	Bad		
579	28, 29, 30	— 5	1.44	none	borax	17	14	Bad		
580	28, 29, 30	— 6	.69	none	none	19	17	Bad		
581	28, 29, 30	— 7	.70	none	resurfaced	19	19	Bad		
582	28, 29, 30	— 8	.70	none	borax	17	17	Bad		
583	28, 29, 30	— 9	1.01	0.51	none	26	26	Poor	32+	Poor+
584	28, 29, 30	—10	.97	.49	resurfaced	26	26	Poor		
Panels painted with titanox and zinc paint having varnish in the priming coat										
Initially painted with paints TZ_2av_2 and TZ_2c_2; repainted with paints TZ_1ar and TZ_1c_3										
585	31, 32, 33	— 1	none	none	none	26+	26+	Good	32+	Poor+
586	31, 32, 33	— 2	treated with water		none	26+	26+	Good		
587	31, 32, 33	— 3	1.54	none	none	26+	26+	Fair—	27	Poor—
588	31, 32, 33	— 4	1.53	none	resurfaced	26+	26+	Fair—		
589	31, 32, 33	— 5	1.52	none	borax	26	26	Poor		
590	31, 32, 33	— 6	.70	none	none	26+	26+	Fair		
591	31, 32, 33	— 7	.69	none	resurfaced	26+	26+	Fair		
592	31, 32, 33	— 8	.68	none	borax	26+	26+	Fair		
593	31, 32, 33	— 9	.99	0.50	none	26+	26+	Good		
594	31, 32, 33	—10	.98	.49	resurfaced	26+	26+	Good		

[1]The sign + following a rating in durability means that the coating was still serviceable when the panel was either repainted or removed from test at the age indicated. The scale of ratings is Good+, Good, Good—, Fair+, Fair, Fair—, Poor+, Poor, Poor—, Bad+, Bad, Bad—. The rating Poor marks the end of the serviceableness of the coating and the durability is the age when first rated Poor. There are two ratings for durability, one considers the integrity of the coating only and the other takes into account also the degree of protection afforded the wood against weathering. Inadequacy of protection is revealed by checking and cupping of the boards and by a tendency to pull away from fastenings. Some coatings failed in protection more rapidly than in integrity.

[2]Only those panels for which data are given were repainted at the age of 26 months. It is impracticable to attempt to judge repainted coatings for adequacy of protection against wood weathering because of difficulty in distinguishing between weathering damage done before and after the repainting.

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with different paints but since the present concern is not with comparisons of paints the data on appearance of the coatings are omitted in the tabulation of results.

Integrity of the coating is affected by such developments as checking, cracking, and particularly by flaking from the bands of summerwood, leaving patches of wood bare as shown in the illustrations. Ratings of "good". "fair", "poor", and "bad" have been defined in a reproducible manner. When the integrity first reaches the rating "poor" it is considered time to repaint and the time elapsed is taken as the "durability of the coating considering integrity only." These are the figures reported in the seventh and tenth columns of Table 1. Note that a rating of "poor+" is a little short of the typical "poor" while "poor—" is a little beyond it.

It is customary to regard exterior paints as protective coatings intended to protect wood against wood weathering but it is debatable whether users of paint actually consider protection very seriously. Sometimes painted boards develop wood checks, cup, or pull loose from fastenings when the integrity of the coating must still be rated "good" or "fair." In such cases the coating is rated lower in protection than it is in integrity; in the absence of such signs of wood weathering the coating is assigned the same rating in protection as in integrity. When the rating in protection first reaches "poor" the time elapsed is taken as the "durability of the coating considering protection and integrity." These are the figures reported in the eighth and eleventh columns of Table 1.

Satisfactory methods of evaluating interior finishes have not yet been worked out. The panels were weighed after each period of exposure in either the 90 per cent or the 60 per cent relative humidity room and notes were made concerning any observable changes in the coatings.

Repainting

After the exterior panels had been exposed for 26 months the majority of the coatings had reached or passed the point at which repainting was in order, but some of the more durable ones were still serviceable. It was also apparent that some of the variations tested, such as resurfacing boards after treatment and treating with water only, were without significant effect. It was decided, therefore, to repaint a representative portion of the panels, to continue the exposure of representative panels with the more durable initial coatings, and to reject the remainder. The disposition of each panel at this time can be seen in Table 1. Thus panel 505, on which the coating was rated "bad" in integrity, was repainted, while panel 506 in similar condition was rejected at 26 months, as indicated by the fact that no further data are reported in columns 10 and 11 of the table. Panel 525, on which the in-

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tegrity of the coating was still good at 26 months, was repainted, while panel 526 in similar condition was left on the fence to determine the durability of the initial coating, which eventually was found to be 46 months. Panels that were either rejected or repainted at 26 months although the coating was still rated better than "poor", are rated 26+ in durability in column 7 of the table; panels for which the durability recorded in column 7 is greater than 26 months were left on the fence without repainting, while panels rated 26 or less in column 7, and for which no subsequent data appear in columns 10 and 11, were rejected.

RESULTS

Exterior Painting

With all of the paints or painting procedures tested, the coatings proved measurably less durable on panels impregnated with zinc chloride (without addition of sodium dichromate) than on the control panels that had no treatment or treatment with water only. The impairment in durability of the coatings caused by presence of zinc chloride was greater when protection as well as integrity of the coatings was considered than was true when judgment was based on integrity alone. The boards containing zinc chloride were evidently more sensitive to checking, cupping, and loosening of fastenings than matched, untreated boards; when the protection furnished by the coating became inadequate, the fact was revealed more promptly by the boards containing zinc chloride. Similar observations were made in the earlier test at the Forest Products Laboratory and in Dr. H. A. Gardner's studies (*5*, *8*). The panels that had been treated with water held their coatings just about as long as the corresponding untreated panels and were not significantly more prone to weathering. It is the zinc chloride, therefore, rather than the conditions under which impregnation is effected that makes zinc chloride treated wood more sensitive to weathering.

There was no consistent difference in the durability of coatings between the panels containing approximately 1.5 lb. and those containing approximately 0.75 lb. per cu. ft. of zinc chloride. Resurfacing the treated boards by planing off the surface layer of wood after drying failed to improve the durability of the coatings and sponging the treated boards with borax proved slightly harmful on the whole. Earlier tests at the Forest Products Laboratory indicated that borax alone impairs the durability of coatings (*5*).

The impairment of the durability of coatings caused by the presence of zinc chloride was by no means great enough to render it impracticable to keep such wood painted. When it is remem-

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bered that these panels were exposed in the inclined position, facing south, which materially hastens paint failure, and that the standard of serviceableness adopted by the Forest Products Laboratory is higher than that of many property owners, the durability of paint on the panels containing zinc chloride must be considered reasonably satisfactory. The claim sometimes advanced by sellers of proprietary, water-soluble preservatives to the effect that wood treated with zinc chloride is unpaintable should be dismissed as unjustified.

On the panels treated with a mixture of zinc chloride and sodium dichromate, the coatings usually lasted fully as long as they did on the corresponding untreated panels and often longer. This statement applies whether durability is judged on the basis of integrity alone or on protection as well as integrity. The mixture of zinc chloride and sodium dichromate is economical and practicable for use in wood preserving plants that now use zinc chloride. As far as laboratory tests can determine, the mixture should be effective in preserving wood from decay because chromates are toxic toward wood destroying fungi and the proportions of zinc chloride and sodium dichromate suggested are such as to provide a large excess of zinc chloride after reaction with the dichromate. When injected in the proportions used in these tests the wood retained fully 0.5 lb. per cu. ft. of free zinc chloride, in addition to the zinc chromate presumably formed in the treating solution. It is reasonable, therefore, to expect that the treatment provided a satisfactory degree of preservation for applications in which zinc chloride alone would be suitable. There are, however, no records of performance in actual service upon which a final evaluation of the effectiveness of the mixture of zinc chloride and sodium dichromate can be based. In view of the excellent retention of paint by the panels containing this mixture it may well be given serious consideration for uses in which both preservation and paint maintenance are necessary.

Of the three white paints tested, the titanox and zinc paint proved decidedly more durable than white lead paint or lead and zinc paint. The titanox and zinc paint also proved distinctly superior to the other two paints in appearance during most of the life of the coatings. The difference in durability, however, should not be attributed to pigment composition, either wholly or in major part. The pigment volume (ratio by volume of pigments to linseed oil) in the final coat of titanox and zinc paint was 31 per cent while that in the white lead and lead and zinc paints was 28 per cent. Developments in paint technology since these tests were started emphasize the importance of pigment volume in the durability of paints and suggest that 29 or 30 per cent is a critical point below which durability falls off. In the writer's opinion the white lead paint and lead and zinc paint would have proved more

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durable if they had been made with 31 per cent pigment volume. Few commercial white paints at the present time are made with as much as 28 per cent pigment volume (except cheap paints containing large amounts of inert pigments and volatile thinners) and painters mixing paste paints are accustomed to adding generous amounts of linseed oil.

Addition of varnish in mixing the priming-coat paint proved distinctly harmful from the point of view of durability of the coatings. It also had a tendency to cause the coatings to flake in larger patches, so that a less satisfactory surface was presented for repainting.

Application of the white lead paint and the lead and zinc paint over aluminum priming paint materially improved the durability and the improvement continued when the surfaces were later repainted with the white paints only. The titanox and zinc paint proved so durable when applied with the white paint itself as the primer that little room was left for improvement when aluminum paint replaced the white paint as the primer. In general, aluminum priming paint has been found by far the best foundation thus far available for the painting of woods like southern pine, which have pronounced bands of hard summer-wood (4). When such wood has been treated with zinc chloride it is particularly advisable to prime it with aluminum paint. It should be pointed out, however, that two additional coats of white paint will usually be required instead of one only as was done in these experiments, because it is very difficult for painters to hide aluminum paint satisfactorily with only one coat of white or light-colored paint.

Interior Painting

The alternate exposure to 90 and 60 per cent relative humidity to which the interior panels were subjected was continued for about two years after which they were kept for about two years longer in 60 per cent relative humidity. It was supported that each cycle of this test would represent the extremes of moisture conditions to which many interior surfaces would be subject in the course of a year and that completion of six cycles a year would greatly accelerate final failure of the coatings in integrity. There were, however, no failures in integrity on any of the panels when the tests were discontinued. These experiments, together with the survey of practical experience in industrial buildings, lead to the conclusion that, in general, treatment of wood with zinc chloride does not materially affect its painting characteristics for interior exposures. In general, it is believed that interior coatings will usually be repainted primarily because the old coatings have become soiled rather than because of failure of the coatings to remain intact.

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During the exposures in 90 per cent relative humidity, the interior paints were attacked by a white mold that destroyed the gloss of the gloss paint and modified the sheen of the flat paint. On the untreated and water-treated panels, the growth of mold was uniform over all parts of the painted surfaces, but on the panels treated with zinc chloride or zinc chloride and sodium dichromate the mold grew less luxuriantly and some patches of the painted surfaces remained unaffected. Since these tests were started it has been learned that paints in which lithopone is the only pigment are very sensitive to attack by mold and that the incorporation of a substantial proportion of zinc oxide in place of part of the lithopone makes paint that is much more resistant to attack by mold.

Paint Blistering

These experiments were intended to study the behavior of paint under the normal conditions that lead to reasonably good paint service. Painted woodwork in buildings, whether the wood is treated with chemicals or not, is often subject to abnormal service conditions under which good paints often fail badly in a very short time (*1*). When the backs of painted boards become thoroughly wet while the temperature behind the painted surface is materially higher than it is in front, paint coatings are prone to blistering. Once blistered, coatings usually scale badly within a few months. No attempt has been made to determine whether the presence of zinc chloride in the wood aggravates failure of this kind but it seems hardly necessary to do so in view of the fact that painting is an uncertain procedure at best under such circumstances. It should be pointed out, however, that wherever there is enough hazard of decay to justify the expense of treatment with a wood preservative there is also likely to be enough moisture to expose the coating to the danger of failure by blistering. When early failures of paint are observed on treated woodwork care should be taken to make sure that they are not caused by blistering before attributing them to the chemical with which the wood has been treated.

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Paint Oil & Chemical Review Oct. 17, 1935

(20)

A Trouble-Shooter's View of the Gamble in House Paint

By F. L. Browne

• Anyone who has had much experience as a "trouble-shooter" in paint complaints knows that a disturbingly large proportion of paint jobs fails to give satisfactory service. There is as yet no reliable estimate of the unsatisfactory fraction of the total number of paint jobs because no systematic survey to determine it has ever been made. That it is alarmingly large, however, is attested by the fact that at least one prominent paint manufacturer for some time gave much valuable advertising space to an appeal to "end painting mistakes" by following directions closely. Still more significant is the advertising of certain building materials that do not require paint in which the principal sales argument is "end painting expense." A typical advertisement of the latter kind is reproduced in Figure 2. That such advertising is effective with house owners who have experienced repeated paint failures was illustrated by a photograph on page 14 of the August 8 issue of PAINT, OIL AND CHEMICAL REVIEW.

Paint Not Always to Blame

Poor paint is commonly held responsible for early paint failures by nearly everyone except the experienced trouble-shooter. That assumption comes naturally because nearly everything written or said to the public about paint for many years has strongly emphasized the composition of the paint, particularly its pigment composition, and has fostered the idea that there are great differences in durability between competitive brands of paint. The paint manufacturer for obvious reasons likes to identify "poor paint" with "cheap paint," as illustrated by the advertisements reproduced in Figures 1 and 3. The experienced trouble-shooter, however, knows that early paint failures are not particularly characteristic of cheap paints and that they are encountered by a considerable number of users of any one of the well known brands of high grade paint.

Trouble-shooting has formed an important part of the writer's work for more than ten years. The cases of early paint failure come to his attention from various sources including house owners, painters, paint dealers or manufacturers, and lumbermen; sometimes he takes the initiative himself by inquiring about interesting paint behavior on houses that he happens to pass. The houses observed include residences of all price classes and farm and business buildings in many parts of the country. Most of the paints used have been high grade paints and among them can be found nearly all of the nationally advertised brands as well as good paints made by smaller manufacturers. The writer's experience, however, includes very few trouble jobs in which

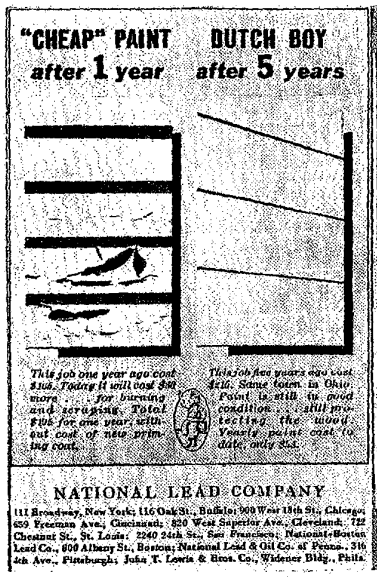

Figure 1, left: Paint manufacturers may attribute early failures like this to "cheap" paint but trouble-shooters know that they are not related to the quality or grade of the paint and that the conditions under which they arise affect first grade paints as seriously as second grade paints. Figure 2, center: A newspaper advertisement showing how manufacturers of building materials that take no paint play upon the disappointment of house owners who have experienced early paint failures. Figure 3, right: another illustration of the opinion that the gamble in paint lies in "cheap" paint.

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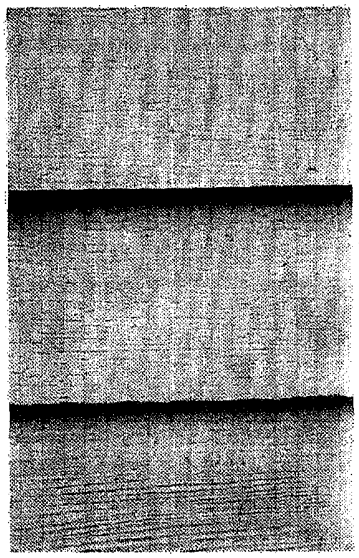

Figure 4. A paint dealer's gamble with good paint on his own house. Five paint jobs were applied within ten years on this house which is owned by a retail dealer in lumber and paint. Three different brands of first grade paint were used, two of them unusually high priced paints. The last paint job was put on only three or four months before the photograph was taken.

the paint used was of a kind commonly classed as a "cheap paint."

In line with this experience manufacturers with both a first grade and a second grade paint often report that most complaints come from users of their first grade paint. It may also be significant that manufacturers who have changed the formula of their first grade paint frequently in recent years are continuing to put out a second grade paint that they have been making for twenty years or more. The relative absence of cheap paints among the jobs about which complaints are made does not prove, of course, that cheap paints give less trouble than good paints but it does show very clearly that cheap paint is not the dominant cause of unsatisfactory paint service at the present time.

Very cheap paints of the kind described as "Skins in Paint" in Scientific Section Circular 427, selling at $1.50 a gallon or less, are apparently made and sold to a certain extent. That such paints may be so inferior in quality as to fail badly within a year or two is easily understood but the sale and use of such paints on houses of any value must be far too small a factor in the paint market to lead firmly established paint manufacturers to expensive advertising of the kind shown in Figures 1 and 3. It may be safely assumed that the "cheap paints" against which the advertising is directed are of a much more respectable variety. The very cheap paints would have little chance of gaining a market if good paint could always be counted upon to give better service.

Three Reasons for Failure

The conditions leading to early failure of good paints may be classified for convenience under three headings, moisture collecting behind painted woodwork, incompatible combinations of paints, and faulty technic of application and maintenance. The nature of the wood painted is not listed among the causes of early failure of paint. By early failure is meant failure within one or two years after application and of sufficient consequence to lead many house owners to complain. Dr. Gardner, quoting the writer's data, points out in Scientific Section Circular 489 that the life of good paint varies materially on different woods and in different climates. According to the data quoted, however, the average durability of good paints with respect to integrity of the coating exceeds two years except in the case of paints of hard type on woods of group IV exposed fully to the weather in regions characterized by periods of extreme dryness. The experienced trouble-shooter knows that only a negligible number of paint complaints can honestly be attributed to peculiarities of the wood painted. As an alibi for unsolved early paint failures the alleged "refractory" nature of wood lost its usefulness to the trouble-shooter when it was shown that common practice in house construction succeeded long ago in selecting for exterior surfaces those woods that normally hold paint best.

Moisture failures remain one of the most frequent causes of complaints about good paints. During the past ten years much has been learned about recognizing moisture failures after they have occurred but there is still no way of telling in advance whether the sidewalls of a house will sweat or how sweating can be stopped after it has been discovered. In spite of these serious limitations, however, much more is now known about moisture failures than about either of the other two classes of early paint failure.

Failures from incompatible combinations of paints have probably increased in number as proprietary mixed-pigment paints won a greater proportion of the market from white lead paint and as the different kinds of proprietary paints became more numerous. Under present conditions it may well be questioned whether the "progress" in production of new pigments and new vehicles for paint, about which so much has been said in recent years, should be considered an asset or a liability of the paint industry.

Every new paint that differs significantly from previous paints multiplies the possible number of incompatible combinations with which the painter and the house owner must contend. As yet only a few of the many possible combinations of paints that prove antagonistic in one way or another have been recognized and even these few have not yet been established to everyone's satisfaction. It seems to be generally agreed that ochre priming paint is not compatible with any of the ordinary white or tinted paints but that is perhaps the only common incompatibility about which technologists are in substantial agreement. In PAINT, OIL AND CHEMICAL REVIEW, issue of August 8, 1935, the writer described several other incompatible combinations that seem to occur frequently. Figure 4 is an excellent illustration of incompatible white paints. The house, which is less than 10 years old, belongs to a retail dealer in lumber and paint who tries to maintain unusually good appearance. It has been painted five times at intervals of two or three years, but three different types of white paint have been used, all of them high grade paints and two of them unusually expensive paints.

Many early failures of paint arise from faulty technic of application or from lack of a properly planned program of maintenance. Paints are mixed with too much liquid, incorrect ratios of volatile to non-volatile liquid are used, the coatings are applied too thin, loose old paint is not properly removed before repainting, primers and body coats are allowed to weather too long before applying the finish coat, two coats are applied where only one is desirable or one where two are needed, houses on which a good paint has failed too soon are repainted without attempting to discover the cause of the previous difficulty, paints are selected

Figure 5. The first paint job on this house failed within a year or two although a high grade paint was used. The paint manufacturer made good by having the house repainted with the same paint but it failed again within two years. Who can tell the owner how he can get a satisfactory coating of paint on this house?

without considering the nature of the paints used previously or the suitability of the paint for the painting habits of the house owner, and little or no effort is made to help the house owner to follow a rational program of paint maintenance.

The Trouble-Shooter's Task

The trouble-shooter's task as a rule is to determine the cause of early paint failure, fix responsibility for it, and recommend suitable procedures for avoiding difficulty in future. He deals primarily with specific cases rather than with average performance. In the first part of his task, determination of cause, a moderate degree of proficiency is gradually becoming possible. Many of the paint failures whose cause was mysterious or uncertain ten years ago can now be diagnosed fairly easily although there is still need for much more progress along this line. In determining responsibility and future procedure, however, little improvement has been made and the trouble-shooter remains notably unsuccessful.

Figure 5 is a good example of the discouraging situation in which the trouble-shooter so frequently finds himself. This farm house was completed in the fall of 1928 and the white pine siding and trim primed with white lead paint put on with a spray gun. In the spring of 1929 two coats of high grade prepared paint were applied by brush. Peeling began in 1930 and in 1931 the paint manufacturer repainted the house with two coats of the same paint. Peeling began again in 1932 and the photographs were taken in 1935. A summer kitchen, not attached to the house, was painted in 1929 with the same paint and the coating gave good service, being in good condition for repainting in 1935. The primary cause of trouble on the house is probably sweating in the sidewalls, which does not happen in the summer kitchen; secondary causes may be the lapse of six months between priming and finishing the original paint job and undue thinning of the priming-coat paint with volatile thinner for application by spray gun.

Who is responsible for the paint failure? The house is thoroughly conventional in construction with no indication of violation of any accepted principle of good building and no reason apparent for more sweating in its sidewalls than in those of other similar houses on which the same paint has been used with success. The paint manufacturer has assumed the costs of one repainting although his paint proved satisfactory on the summer kitchen. Obviously the owner must pay for the next job but who can tell him how to get a reasonably satisfactory job for his money? No one knows how to prevent sweating of the sidewalls, no one can wisely advise repainting without the heavy expense of complete removal of the old coating, no responsible painter wants to take the job, and no paint manufacturer can afford to offer his paint with any assurance that it will stand up. The farmer has the choice of letting the house go shabby or of taking another gamble with paint. The gamble with paint offering him the best odds is undoubtedly to burn off and repaint with pure white lead paint but who can blame him if he decides to reduce his ante as much as possible by gambling with cheap paint and cheap painters or if he prefers not to gamble with any paint by leaving the house unpainted or by covering the siding with unpainted materials to "end painting expense"?

The Problem of Responsibility

Specific cases of early failure from incompatible paints or faulty technic commonly lead to a similar impasse in the attempt to fix responsibility and to recommend future procedure. Neither paint maker, painter, builder, or owner has consciously violated any principle of sound practice generally understood and accepted in the trade. The paint manufacturer feels that he has fulfilled his obligations by supplying paint capable of giving good service under many ordinary conditions of use. The painter rarely has enough technical training to understand the problems of incompatibility even if the paints he uses carry adequate formula labels; he assumes, however, that his own experience is the best guide for thinning and application and he assumes that any good house paint can be handled according to his customary methods regardless of the directions supplied by the manufacturer. The builder and owner find no authoritative body of information to guide them in approving paint and painting methods and have to make shift with such information as they may obtain. Under such circumstances no party to the transaction can justly be held responsible for early paint failure. Unless one of them voluntarily assumes the burden of repairing the damage the owner finds that he has gambled with good paint and lost.

Many paint technologists regard the gamble in good paint as an inevitable consequence of the deterioration in craftsmanship and the pressure to reduce costs of building and feel that nothing can be done about it even if the ultimate result is to destroy the market for painted exterior woodwork. The writer does not share that pessimistic attitude. It is undoubtedly true that no single paint manufacturer can solve the problems of early paint failures by his own efforts alone but that does not absolve the industry as a whole from responsibility in the matter. The intricate technical problems involved are of concern to the industry collectively and offer no great prospect of competitive advantages to individual manufacturers within the industry. For that reason progress toward their solution is not to be expected from the technical research of laboratories dealing primarily with the competitive interests of individual concerns. Broader attack from the point of view of the basic common interests of the industry in relation to other industries such as the lumber industry and to the public is urgently needed. The fundamental nature of the problems of early paint failures puts them logically in the field of research activity of the paint industry as a whole through its national association.

Taking the Gamble Out of Paint

The following suggestions are offered by way of more specific illustration of types of study that are badly needed to remove the present gamble from good house paints:

1. There is need of a national survey of present experience with house paint that would reveal the relative proportions of successful and unsuccessful paint jobs and lead to a significant classification of the unsuccessful ones in the order of their importance. At the present time our information comes too largely from cases of paint failure about which someone has complained. Much more attention should be paid to successful experience. Demonstration of procedures that can be relied upon is even more important than discovery of those that involve too much gamble.

2. Until the problem of sweating sidewalls has been solved it remains important to learn the relative sensitiveness of different paints and combinations of paints to moisture failures. Laboratory "blistering boxes" as now used often give misleading results. Our most reliable information should come from analysis of the results of the survey suggested in (1). Elimination of the sweating itself is, of course, the proper final solution of problems of moisture failure but it goes beyond the field of the paint industry alone.

3. Vigorous study of paint compatibilities is urgently needed. If new products are to be placed on the market and proprietary brands of paint are to change in formula as frequently as they have in the past few years some means of guiding paint users to successful use of such paints must be devised. If adequate means of discrimination is not provided the paint user's only recourse to avoid gambling with his paint jobs will be to return to the simple, staple paint products of long established usage and to avoid proprietary paints regardless of price or quality.

4. Facts should be developed about proper technic of application and maintenance of paint coatings. The impatience with painters and the public because of faulty technic frequently expressed by technologists is not justified because the technologists themselves are not in agreement about such matters, as a survey of manufacturers' directions for application of paint will show. Claims made for the spreading rate and durability of paints for purposes of sale all too often fail to agree with the trouble-shooter's idea of proper application and maintenance after complaint has been made. Application and maintenance should be fully as important in paint technology as paint formulation but they are essentially problems of the industry as a whole rather than of individual manufacturers. Until technologists have established and accepted sound principles of application and maintenance they cannot justly feel aggrieved because painters and the public in their confusion so frequently make mistakes.

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Don't Let Faulty Painting Jobs Steal Public Confidence!

(21)

What Paint Salesmen, Painters and Dealers Can Do to Prevent Paint Complaints

By Dr. F. L. Browne
Senior Chemist, Forest Products Laboratory, Madison, Wis.

EDITOR'S NOTE.—By special arrangement with Dr. Browne we are able to present to readers of Canadian Paint and Varnish Magazine important information regarding the success or failure attendant upon different painting practices. Providing customers with satisfactory enduring painting jobs is of vital importance to manufacturer, salesman, painter and retailer alike. Painting complaints mean loss of confidence, more difficult repeat business, loss of profits to the painting industry. In the accompanying article, Dr. Browne reveals the facts behind some paint failures and the means of avoiding them.

NO SECRET is divulged in pointing out that some house paint jobs, even with the best of house paints, fail to give satisfactory service. If the failure takes place within a year or two the houseowner often complains to the paint dealer or paint manufacturer.

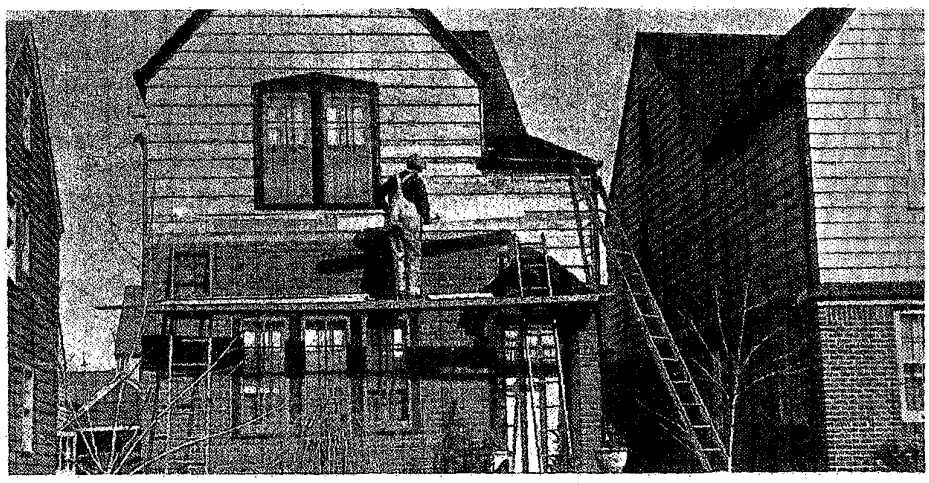
As a rule, the difficulty is not due to the quality of the paint but to some blunder in its use or unusual condition of service, but it is not always easy to convince the houseowner that the paint was not at fault after the difficulty has arisen. Just settlement of such cases is of much more than passing importance because in the aggregate these failures affect a very large number of consumers and the uncertainties because of them constitute a serious menace to the continued market for paint and wood for the exterior covering of buildings.

Some of the conditions that give rise to short-lived paint jobs are now known and paint salesmen, working in co-operation with their dealers and painters, can prevent many of the mistakes that would otherwise lead to complaints by seeing that customers are properly advised before the mistakes are made. A complaint prevented is far more profitable to everyone concerned than any possible adjustment that can be made after a paint job has gone bad.

Moisture Failures

One of the most common causes of premature paint failure is moisture collecting in the sidewalls of buildings during the time of year when buildings are heated. The latter part of winter and early spring are the times of year when the damage is most often done but the scaling of paint and consequent complaint may not come to the dealer's attention until the following summer, when the walls have dried out again. Unfortunately there is much that is not yet known about moisture conditions in houses; for example, why one house develops the trouble while neighboring houses do not and what steps can be taken to keep moisture out of the sidewalls of houses in which it collects.

Salesmen, painters, and paint dealers can do much to prevent future complaints by asking about the behavior of the previous paint used on the houses of their customers. If the last paint applied failed unreasonably soon it is not wise to promise that the new one will give good service until the house has been examined for the cause



Paint troubles lead to loss of market for paint. This house is being covered with composition material imitating brick because several paint jobs on wood siding each failed within a year or two. The neighboring houses were likewise covered over with composition material or with stained shingles for the same reason.

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of the previous difficulty. If the former coating shows evidence of moisture failure and nothing has been done to alter the conditions, the new paint will probably fail also.

Under such circumstances a sale of paint without warning the customer about its probable failure amounts to an invitation for him to file a complaint a year or so later. A complaint represents loss even if no adjustment is made and it makes future sales more difficult.

Soft and Hard Types of Paint

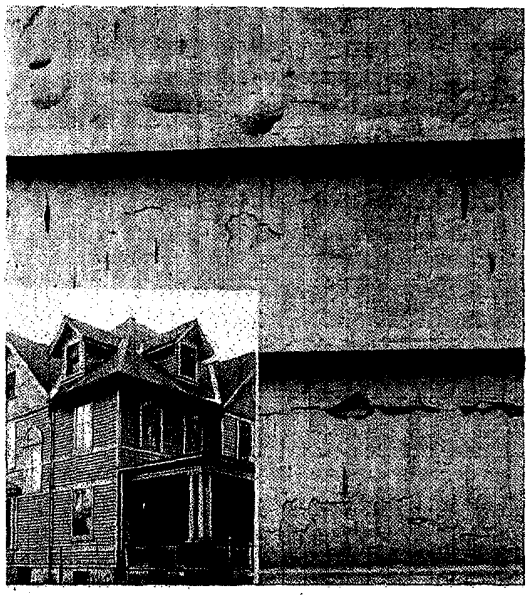
No one paint is superior in all respects. Experience proves that soft types of paint, such as pure white lead paint, are less prone to rapid failure on houses whose sidewalls become wet than are harder paints, such as the majority of mixed-pigment paints. If a soft paint is applied over a hard paint, however, the coating retains the characteristics of the hard paint so far as resistance to abnormal moisture conditions is concerned.

When a house is found on which hard types of paint have failed because of moisture, and no practicable means are discovered for making sure that the sidewalls will remain dry in the future, the safest procedure to recommend for repainting is to remove all of the old coating and to repaint with a soft paint. Most house owners under these circumstances prefer to forego the advantages of the harder paints for the greater assurance of having the coating remain intact for a reasonable length of time. The salesman's problem in advising a customer in such a predicament is to keep him from becoming discouraged with the use of any paint on wood rather than to sell him the salesman's brand of paint for that particular job.

Incompatible Paints

Much has been said about the effect of different woods on the durability of paint but it is not always appreciated that different kinds of old paint may exert even more effect on the durability of a new paint of different composition. This may be the case even though the old paint is still in very good condition as far as integrity of the coating is concerned. Some of the incompatible combinations of paints are known, and painters and dealers can often warn their customers about them beforehand provided they make an effort to learn as much as possible about the customer's particular problem.

The easiest incompatibility to recognize is a white or tinted paint applied over a full-color paint such as brown, green, or red. The incompatibility arises not merely from the difference in the nature of the pigments in white and



A chronic case of moisture blistering. Not only has the last paint applied developed blisters, but places where the previous paint job blistered and peeled are clearly evident.

in full-color paints but from the difference in total amount of pigments. As a rule full-color paints contain much less pigment by volume than white or tinted paints. The well-known case of yellow ochre priming under white paints is perhaps the most clearly recognized case of incompatibility.

Should Examine Coatings Where Cracking Shown

Sometimes the harmful effects of an incompatible combination show up promptly the first time white paint is applied over a full-color paint; frequently, however, the white paint jobs merely prove slightly less durable for a time, but after two or three repaintings, each less durable than the previous one, the surface develops such a bad case of deep cracking and curling that the whole coating must be removed before a satisfactory repaint job can be applied. For that reason painters should

(Continued on page 14)

NEXT ISSUE

What part does the incorrect use of thinners in the priming coat play in premature failure of painting jobs?

Too much paint and too frequent application are sometimes causes of difficulty in maintaining a satisfactory paint job. How thick should a coat be applied and how often renewed for varying types of surface and paint used?

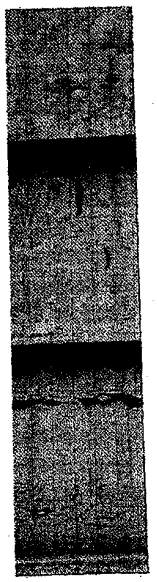
Why does paint fail frequently in protected portions of buildings?

Should successive paint coats be "spread" over a period of time before the entire job is completed? What effect has this spreading on the quality of the final job?

Why should quality paint jobs be given special care to see that they are properly maintained?

When should "soft" types of paint be used in preference to "hard" types and when not?

In the October issue, Dr. Browne will conclude his interesting article on preventing paint complaints by providing answers to these and other questions of importance to painters and paint salesmen. Don't miss this issue!



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Don't Let Faulty Painting Jobs Steal Public Confidence

(Continued from page 7)

be advised to examine coatings on older houses that show bad cracking and report the uncertainties that may arise if strikingly different colors are found underneath.

There are likewise cases of incompatibility between different brands of white or tinted paints and sometimes between the tinted paints and the white paint of the same brand. In general it is not safe practice to apply paint of high pigment volume over paint of low pigment volume. A salesman whose company offers more than one type of house paint may well advise that customers who have started out with one type continue to use it rather than to apply another type over it.

Bad Painting Practices

Paint salesmen and paint dealers can well afford to devote some time to getting acquainted with contracting painters who use their paints and helping them to avoid bad practices in paint application. Mistakes in thinning paint and in the amount of paint applied give rise to some of the common complaints about unsatisfactory service.

Stingy application of paint and too much thinning of priming coats often cause difficulty in paint jobs on new wood surfaces, leading to inadequate hiding and spotted gloss, chalking, and fading. Three-coat jobs, of course, are less subject to such troubles than two-coat jobs but at the present time a large proportion of our painting of new wood is two-coat work.

For good painting a sufficient quantity of paint must be applied whether it is done in two or in three coats. From experience it is known that the amount of paint should be enough to leave a coating about 1/200 inch thick even though a somewhat thinner coating of modern paints will hide the surface satisfactorily.

Table 1 shows the thickness and some characteristics of the coating produced by two paint jobs of which Job No. 1 is a two-coat job with the paint applied generously and Job No. 2 is a three-coat job with typically stingy application. Both jobs are done with the same prepared paint. Job No. 2 is by no means an uncommon one in practice and does not depart much, if any, from recommendations made by some paint manufacturers.

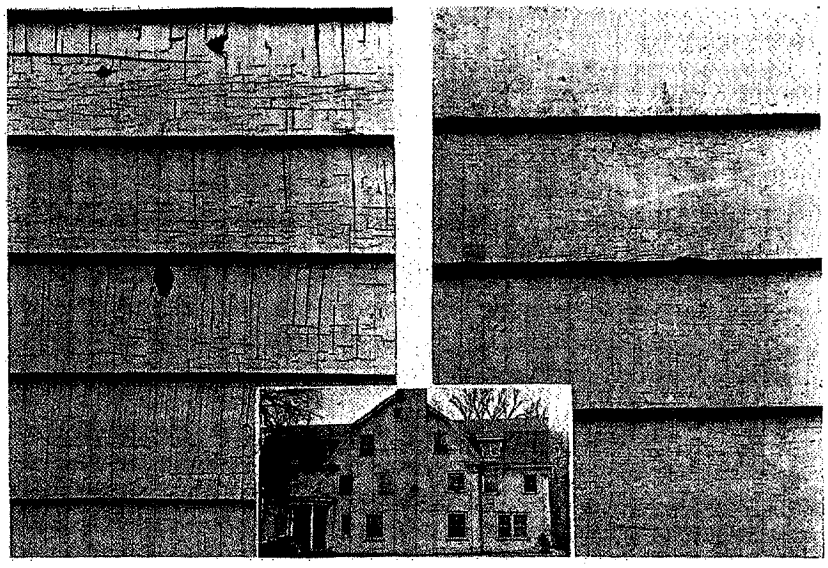
Job No. 1, the two-coat job, gives a coating 0.0045 inch thick, which is close enough to 1/200 inch. The priming coat supplies enough linseed oil to "satisfy" the wood and leave plenty of oil to bind its pigments. On such a foundation the finish coat retains all of its oil, dries with uniform gloss and color, and when it begins to chalk and fade it does so uniformly.

Job No. 2, the three-coat job, makes a coating only 0.0032 inch thick and the priming coat fails to supply enough oil to "satisfy" the wood and leave enough to bind the pigments. As a result the second coat is robbed of oil to make up for the deficiency of the primer. When

(Continued on page 26)

A Paint Salesman's Viewpoint

"You are to be congratulated upon your August issue of Canadian Paint and Varnish Magazine. Without a doubt the articles in this issue are splendid! I do not see how any salesman who wishes to give the best possible service to his customers can afford to be without any issue of this magazine!" — Joseph Seville, Kitchener, Ont.



An example of incompatible paints. On three sides of this house the paint has cracked and scaled badly as shown at the left. On the fourth side, which is more fully exposed to the weather than the others, the paint gives good service as shown at the right. On the bad sides the wood carries successive coatings of dark brown paint, deep yellow paint, dark grey paint and at least three jobs of white paint. The good side was rebuilt after a fire some years ago and has only the last three jobs of white paint.

Table I—Importance of Spreading Rate in Paint Application

Step in calculation:	Job No. 1			Job. No. 2			
	First coat	Second coat	Total coating	First coat	Second coat	Third coat	Total coating
Thinning formula:							
*Prepared paint ... gal.	1	1	.....	1	1	1	.....
Linseed oil ... gal.	0.25	0	.....	0.25	0	0	.....
Turpentine ... gal.	0	0	.....	0.25	0.25	0	.....
Spreading rate ... sq. ft. per gal.	475	350	.....	800	900	900	.....
Paint applied: gal. per 1,000 sq. ft.							
Pigments ...	0.421	0.455	.....	0.208	0.222	0.278	.....
Linseed oil ...	1.520	1.180	.....	0.750	0.578	0.722	.....
Volatile thinner ...	0.168	0.182	.....	0.292	0.311	0.111	.....
Oil taken from first coat by the wood ... gal. per 1,000 sq. ft.	0.750	0	.....	0.750	0	0	.....
Paint remaining on surface: gal. per 1,000 sq. ft.							
Pigments ...	0.421	0.455	0.876	0.208	0.222	0.278	0.708
Linseed oil ...	0.770	1.180	1.950	0	0.578	0.722	1.300
Total paint ...	1.191	1.635	2.826	0.208	0.800	1.000	2.008
Volume of pigment in coating ... per cent	35	28	31	100	28	28	35
Thickness of coating ... inch	0.0019	0.0026	0.0045	0.0003	0.0013	0.0016	0.0032

*Prepared paint assumed to have the following composition by volume: Total pigments, 25 per cent; linseed oil, 65 per cent; volatile and drier, 10 per cent.

Don't Let Faulty Painting Jobs

(Continued from page 14)

such a priming coat is used for a two-coat job, spotted chalking and fading soon develop and another complaint is often made against the paint.

To change Job No. 2 into a good paint job the painter need only reduce the spreading rates to 600, 700, and 700 square feet per gallon for the first, second and third coats, respectively. The thickness of coating is then 0.0046 inch and the percentage of pigment by volume in successive coats is 53, 28, and 28. Such a coating is thick enough but the fact that second and third coats contain the same percentage of pigment is open to some objection. If a paste paint instead of a prepared paint were used according to accepted practice the percentage of pigment in successive coats would be more nearly 50, 37, and 28. The principal advantage of paste paint over prepared paint lies in the fact that the body coat can be made richer in pigment than the finish coat. The disadvantage of paste paint is that unskilled or unscrupulous painters can "dope" it with inferior materials more easily.

(To be concluded)

Imperial Varnish & Color Co. Gives Bonus to Employees

Toronto, Ont.—The Imperial Varnish & Color Company, Ltd. has given to its employees tangible expression of its appreciation of their "loyal and faithful service."

The directors have distributed among 160 employees of the company a cash bonus equivalent approximately to a month's salary. Length of service was considered in the allocation of the bonus. Every member of the staff with over six months service participated, from the office boy up.

The Lid's Off—Maybe!

"Canadian Paint and Varnish Magazine makes the following significant comment — 'Just the other day a woman told the editor she bought a small-sized can of paint to do some touching up in her apartment. Even before touching a brush to the paint, she discovered that the problems of painting are many, not the least of which is the problem of getting the lid off the can.'

"The editor comments that it must be borne in mind that many purchasers may not be supplied with equipment necessary to open some cans and that unless paint cans are accompanied by the proper gadget or directions for opening, the result may be discouraging to the cause of painting, especially as a large proportion of goods sold over the counter are for small jobs and touching-up work." — "The Open Door," publication of the National Paint, Varnish & Lacquer Association, Washington, D.C.

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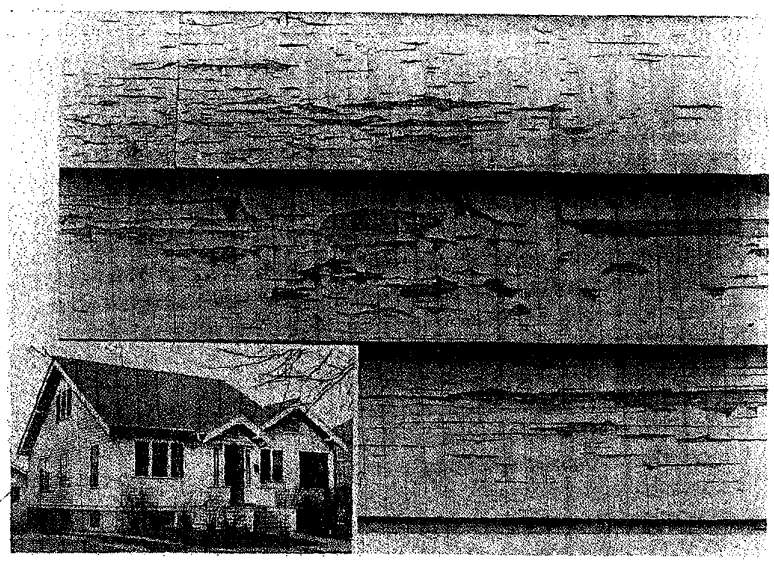
Don't Let Faulty Painting Jobs Steal Public Confidence!

PART 2 — Conclusion

What Paint Salesmen, Painters and Dealers Can Do to Prevent Paint Complaints

By Dr. F. L. Browne
Senior Chemist, Forest Products Laboratory, Madison, Wis.



Incompatibility of some white paints. This house was originally painted with a lead and zinc paint and subsequently repainted with a titanium, lead and zinc type of paint. The last paint was a very good one but it is failing in an unsatisfactory manner.

TOO generous use of volatile thinners in priming coats is a common cause of unnecessarily early failure of paint. The mistaken notion that thinners are needed to increase the penetration and secure firmer anchorage of the paint fosters this blunder in paint. As a matter of fact linseed oil penetrates all woods more freely than is desirable and the object of good priming is to restrain, not to stimulate it. Special primers for wood now being offered by several manufacturers are designed with this object in view.

In a good priming mixture with ordinary linseed oil paint there should be at least three times as much linseed oil as volatile thinner. It is entirely practicable to omit thinners entirely in the priming coat mixture. Resinous woods such as southern yellow pine offer no exception to this rule; in fact, too much volatile thinner is particularly harmful in priming coats for such woods.

Duration of Time Between Painting

While too little paint is a common blunder in painting new wood, too much paint and too frequent application of paint are likewise common causes of difficulty in maintaining paint over a period of years. As far as practicable the coating on wood should be kept in the neighborhood of 1/200 inch in thickness. That can be done only if the old coating is given time enough to chalk and erode materially before new paint is put on. Hard types of paint usually wear away less rapidly than soft types of paint and when repainted hard types of paint usually "hold out" the new paint better than soft types, that is, the hard paints absorb less oil from the new paint.

As a rule, if repainting is done within three years only one coat of new paint should be put on. After four years, soft types of paint may wear away enough to take two repaint coats but hard paints may often be repainted to best advantage with one coat only, possibly with preliminary spot coating of patches where loose paint has been scraped off. As already pointed out, the amount of paint applied rather than the number of coats is the important consideration.

The failure of paint on protected parts of buildings, such as overhanging eaves, when the paint on the exposed parts is in good condition often comes from the fact that too thick a coating has been built up on the protected areas where the weather has little chance to wear away the paint. Such areas should receive less paint than the exposed areas when repainted.

Bad Practice to "Spread" Painting Jobs

It is not good practice to apply two finishing coats in succession. Sometimes this occurs when a paint job is completed and the owner decides that he does not like the color. Architects sometimes have it done deliberately in the belief that they can select colors to best advantage after the house has been erected and painted. Paint salesmen and dealers should try to get customers to select

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Examine Every New Product

(Continued from page 18)

and Pittsburgh showed that the paint on the former was all gone while that in Pittsburgh was blackened by smoke but otherwise in good shape. The failure on the Atlantic City fence was probably hastened by the salt air."

Says Zinc Adds to Appearance of Film

C. Ross Elliot, The Lowe Brothers Co.—"Do you place most importance on zinc or lead for outside paint?"

Mr. MacGregor—"I do not advocate zinc for outside paint as far as wear is concerned. I have never seen an instance where the actual wearing qualities of a film were increased by the use of zinc. Zinc is valuable from the appearance point of view; it gives a nice film. When you add zinc to a paint you face the danger that this will in turn cause the addition of too much oil and thinner and the result will be to produce a hard film with greater cohesion than adhesion to surface, which is an undesirable condition."

Don't Let Faulty Painting Jobs Steal Public Confidence

(Continued from page 7)

under such conditions when aluminum paint has been used tend to undermine confidence in its recommendation for its proper purpose.

Modern mixed-pigment paints are made to give improved appearance during the useful life of the coating, to maintain their resistance to the passage of moisture longer, and to leave a surface that "holds out" new paint better than softer paint when repainting comes due. These improvements are gained by careful control of physical properties of the coating that may be called "hardness" for want of a better term.

Quality paints of this kind, however, call for greater care on the part of the house owner to see that they are properly maintained because the hardness on which the improvements are based makes a coating that cracks and curls badly if repainting is neglected long after it has come due. The surface should be repainted before it begins to disintegrate seriously. Once disintegration has been allowed to go on through a period of paint neglect it may become difficult to repaint the surface smoothly and the new job may not last as long as it should.

Those property owners who are accustomed to leave their paint in a shabby condition of neglect for several years before they repaint should be advised to use only a soft type of paint until they are willing to raise their standards of paint maintenance to a point justifying the use of mixed-pigment paints of a harder type. Selling a hard type of paint to a man expecting to repaint every 10 years is merely adding one more name to the company's complaint file and possibly a red ink entry in its ledger.

The Value of Special Training Classes

(Continued from page 12)

to such surfaces. Flat paints, sealers, enamels, varnishes, gloss paints, kalsomines and water paints will all receive attention during the progress of the lessons.

The art of the paperhanger will not by any means be forgotten, as the hanging of wallpaper as well as the ordinary fabrics, such as wall cloth, grass cloth, sanitas, etc., will all have their place in the course of study.

The care of brushes and instruction in the choice of correct tools for each purpose will be thoroughly explained, so that it is very evident that any young man attending the class and applying himself, cannot fail to be materially benefitted and will without question become a more capable journeyman.

The success of those who attended the classes under Mr. Gordon in former years and the fact that they, because of the instruction which they had received, were better men in their chosen field of endeavor, is a practical demonstration of the desirability, as well as the actual necessity for such education.

These classes were primarily organized for the benefit of the indentured apprentice, but for this year at least, they have been thrown open to the young journeyman, and to the journeyman who is not so young, who is sufficiently ambitious to acquire a knowledge of methods and materials that he would have little or no opportunity to acquire in his everyday routine of high pressure production.

Employer Can Devote Little Time to Instruction

The employer of today, because of keen and sometimes none-too-honest competition, is compelled to concentrate on the job of getting the work, financing his business and general supervising, so that he cannot afford to devote any time to the personal instruction of either apprentice or journeyman; the man in charge of the job, because of the low prices obtainable by the employer on account of the competition mentioned, is interested almost exclusively in getting the job done and producing a profit for the employer so that he cannot devote any time to individual instruction of the apprentice.

Then, too, because of changing materials, and this change has been particularly noticeable during the past decade, neither master nor man is in a position to give any authentic information relative to the materials in daily use. Generally speaking, they are satisfied to accept the manufacturers say-so as to the composition of materials, and the results obtained through their use.

Therefore to obtain reliable information on the composition of materials and their various uses, as well as the theory of the painting trade, the Toronto apprentice, or young mechanic, depends entirely upon such a class as is available at the Central Technical School. The small sum of a $2.00 registration fee will undoubtedly prove to be a sound investment, in skill and knowledge from which will accrue daily the greatest dividend of all—security of employment.

Employers would be well advised to lend every encouragement to these classes by urging, not only their apprentices, to attend but also journeymen who desire to attain further knowledge in the more advanced and artistic branch of their trade, the better to qualify them to be really designated as "Craftsmen."

New Goods

Reardon's Water Putty Claimed Shrink-proof Crack Filler

The introduction of Reardon's Water Putty makes available another indispensable product for filling cracks in floors, holes in concrete, flaws in furniture, woodwork, and many other everyday uses. The manufacturers state that tests by actual performance have proved this water putty to be shrinkproof. It comes in dry powder form and has simply to be mixed with water to a paste of the required thickness for use. Upon hardening it can be tooled or finished exactly like wood. Nails or screws may be driven into it without danger, it is claimed. Full information from The Reardon Company, 23 Hammersmith Ave., Toronto.

THE MACLEAN PUBLISHING COMPANY, LIMITED
481 UNIVERSITY AVE., TORONTO, CANADA
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H. V. TYRRELL, Vice-President and General Manager
Publishers of Canadian Paint and Varnish Magazine, Sanitary Engineer, Hardware and Metal, Canadian Grocer, Drug Merchandising, Dry Goods and Stylewear Review, Bookseller and Stationer, Men's Wear Merchandising, Hardware and Metal's Data Service. The General Merchant of Canada, Canadian Meat and Provision Buyer, Canadian Hotel Review and Restaurant, The Sheet Metal and Warm Air Heating Review, The Financial Post, The Financial Post Survey of Corporate Securities, The Financial Post Survey of Mines, The Financial Post Business Year Book, The Financial Post Record of Prospectuses, The Financial Post Directory of Canadian Directors and Officials, The Financial Post Corporation Service, Maclean's Magazine, Chatelaine, Mayfair, Canadian Homes and Gardens, Canadian Machinery and Manufacturing News, Canadian Printer and Publisher, Canadian Advertising, Canadian Trade Abroad, Modern Power and Engineering, Canadian Automotive Trade, Bus and Truck Transport in Canada.

FLB 000886

Kermath Heads Hamilton Painters' Board

Hamilton, Ont.—Charles Kermath was elected chairman of the board of the newly-formed Painters' Board for Hamilton district under the Industrial Standards Act, and George Thornewell was elected secretary. Other members of the board are: George Henry, A. MacArthur and Charles Yorston. The members have been given power to act as inspectors.

The new Act provides that anyone having entered into a contract prior to September 22 may, by application to the board, receive consideration on such contracts which may have been made at a lower rate, Mr. Thornewell said.

There is also a provision that persons physically incapacitated may receive consideration by the board if they make application to be permitted to work at a lower rate.

The Act went into effect officially on September 24. It prescribes an eight-hour day and five days a week. The work hours are to be between the hours of 8 o'clock in the morning and 5 o'clock in the afternoon.

Quebec Province Moves to Prevent Lead Poisoning

Canadian Paint & Varnish Magazine understands that members of the Canadian paint and varnish industry are being advised by inspectors of the Quebec Association for the Prevention of Industrial Accidents of a change in the law requiring the use of counter-poison agents in paint containing white lead as a preventive measure against lead poisoning The change was recently approved by the provincial government and requires that a counteracting agent be used in all paints containing white lead, salts of lead, salts of copper, ceruse or mimium. Under the law, the Department of Labor may upon advice of a doctor in hygiene and a chemist accept the use of any product deemed efficient.

W. GEO. HELLIAR
Of Sturgeons Ltd., Toronto, who was elected vice-president of the Paint, Oil and Varnish Club of Toronto.

E. A. McPhee Opens Branch in Peterborough

Lindsay, Ont.—E. A. McPhee, progressive painter and decorator, of Lindsay, has established an office in Peterborough which will be located at 355 McDonnel Street. This, however, does not mean that Mr. McPhee will be leaving Lindsay, as he has secured the services of Mr. Reg. L. Collins, who is experienced in painting and artistic work, who will be associated with Mr. McPhee.

Two Hamilton Industries Under Code

Hamilton, Ont.—Copies of orders-in-council confirming the setting up of codes under the Industrial Standards Act for the plumbing and painting industries were contained in a recent issue of the Ontario Gazette. In both instances, the order became effective on September 21.

Ordinary hours of labor are eight hours a day, not including Saturdays and Sundays. For plumbers, the minimum rate of wages shall be 85 cents an hour and for journeymen painters 60 cents per hour, work to be confined in each case between the hours of 8 a.m. and 5. p.m. Time and a half applies to all overtime employment.

In the case of the painters, provision has been made for work that cannot be performed during regular working hours. The code arrangement applies to those in the paperhanging and glazing trades as well as painters.

THE BUYERS' DIRECTORY

These firms solicit your business through their advertisements in Canadian Paint and Varnish Magazine. If what you want is not advertised or listed here, write us and we will be glad to give you the information you desire.

ALCOHOLS
Gooderham & Worts, Ltd., Toronto.

ALUMINUM PASTE
Aluminum Company of Canada Ltd., Toronto, Ont.

ANILINE COLORS
J. A. Taylor Limited, Montreal, Que.

BONE DROP AND IVORY BLACKS
Reichard-Coulston, Inc., New York, N.Y.
Sherwin-Williams Co. of Canada, Limited, Montreal, Que.

BRUSHES
Hamilton & Co. (London), Limited, London, England.
Simms & Co., Limited, T. S., Saint John, N.B.

CANS AND CONTAINERS
American Can Co., Hamilton, Vancouver, Montreal.
Macdonald Mfg. Co., Toronto.

COLOR LAKES
Sherwin-Williams Co. of Canada, Limited, Montreal, Que.

CRACK FILLER
Savogran Co. of Canada, Toronto.

DRY COLORS
Imperial Varnish & Color Co., Limited, Toronto, Ont.
McNulty, Jos. A., New York, N.Y.
Reichard-Coulston, Inc., New York, N.Y.
Sherwin-Williams Co. of Canada, Limited, Montreal, Que.
Taylor Limited, J. A., Montreal, Que.

DRY EARTH COLORS
McNulty, Jos. A., New York, N.Y.
Reichard-Coulston, Inc., New York, N.Y.
Sherwin-Williams Co. of Canada, Limited, Montreal, Que.
Taylor Limited, J. A., Montreal, Que.

DYESTUFFS
Taylor Limited, J. A., Montreal, Que.

GUMS, ESTER, VARNISH & LACQUER
Beck, Koller & Company, Detroit, Mich.
Boehm Limited, Fredk., London, Eng.
Paramet Chemical Corp., Long Island City, N.Y.

LAMPBLACK
Binney & Smith Co., New York, U.S.A.
Imperial Oil & Gas Products Co., Pittsburgh, Pa.
L. Martin Co., The, New York, N.Y.
Reichard-Coulston, Inc., New York, N.Y.
Taylor Limited, J. A., Montreal, Que.
Wilckes, Martin, Wilckes Co., New York.

LINSEED OIL
Brandram-Henderson Ltd., Montreal.
The Sherwin-Williams Co. of Canada, Montreal.

OXIDES
Harrisons & Crosfield Ltd., Montreal.
McNulty, Joseph A., New York, N.Y.
Northern Pigment Co. Ltd., New Toronto, Ontario.
Reichard-Coulston, Inc., New York, N.Y.
Ross Limited, Bruce, Toronto.
Sherwin-Williams Co. of Canada, Limited, Montreal, Que.
Taylor Limited, J. A., Montreal, Que.

PAINTS, VARNISHES, ENAMELS, LACQUERS, WALL FINISHES, ETC.
Aulcraft Paints Ltd., Toronto, Ont.
Brandram-Henderson, Limited, Montreal.
Canada Paint Co., Limited, Montreal.
Imperial Varnish & Color Co., Limited, Toronto, Ont.
Lowe Bros. Co. Ltd., The, Toronto.
Moore & Co., Ltd., Benjamin, Toronto.
Pilkington Bros. (Canada) Ltd., Toronto.
Reardon Company, The, Chicago, Ill.
Sherwin-Williams Co. of Canada, Limited, Montreal, Que.
Sinclair Co. Ltd., Malcolm, Oakville, Ont.

PAINT MACHINERY AND EQUIPMENT
Consolidated Products Inc., New York.
Greey Ltd., Wm & J. G., Toronto.
Taylor Instrument Companies, Toronto, Ont.

PAINT SPRAYING EQUIPMENT
De Vilbiss Mfg. Co., Ltd., Windsor, Ont.

PASTE
Meredith-Simmons Co., Ltd., Toronto.
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Reichard-Coulston, Inc., New York, N.Y.

WALLPAPER
Boxer Co., Ltd., The Reg. N., New Toronto, Ont.
Stauntons Limited, Toronto, Ont.
Watson, Foster Co., Ltd., The, Montreal.

WAXES, FLOOR
Sherwin-Williams Co. of Canada, Limited, Montreal, Que.

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Canada Paint Co. Ltd., Montreal, Que.

WHITING
Taylor Limited, J. A., Montreal, Que.

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(22)

Stingy Paint Application Often A Danger

By F. L. BROWNE

Senior Chemist, Forest Products Laboratory, Forest Service, Department of Agriculture, maintained at Madison, Wis., in cooperation with the University of Wisconsin.

MISTAKES in thinning paint and in the amount of paint applied give rise to some of the common complaints about unsatisfactory service.

Stingy application of paint and too much thinning of priming coats often cause difficulty in paint jobs on new wood surfaces, leading to inadequate hiding and spotted gloss, chalking, and fading. Three-coat jobs, of course, are less subject to such troubles than two-coat jobs, but at the present time a large proportion of our painting of new wood is two-coat work. For good painting a sufficient quantity of paint must be applied whether it is done in two or in three coats.

From experience it is known that the amount of paint should be enough to leave a coating about 1/200-inch thick even though a somewhat thinner coating of modern paints will hide the surface satisfactorily. Table 1 shows the thickness and some characteristics of the coating produced by two paint jobs of which Job No. 1 is a two-coat job with the paint applied generously and Job No. 2 is a three-coat job with typically stingy application. Both jobs are done with the same prepared paint. Job No. 2 is by no means an uncommon one in practice and does not depart much, if any, from recommendations made by some paint manufacturers.

Job No. 1, the two-coat job, gives a coating 0.0045 inch thick, which is close enough to 1/200 inch. The priming coat supplies enough linseed oil to "satisfy" the wood and leave plenty of oil to bind its pigments. On such a foundation the finish coat retains all of its oil, dries with uniform gloss and color, and when it begins to chalk and fade, it does so uniformly. Job No. 2, the three-coat job, makes a coating only 0.0032 inch thick, and the priming coat fails to supply enough oil to "satisfy" the wood and leave enough to bind the pigments. As a result the second coat is robbed of oil to make up for the deficiency of the primer. When such a priming coat is used for a two-coat job, spotted

TABLE I.---IMPORTANCE OF SPREADING RATE IN PAINT APPLICATION

Step in calculation	Job No. 1			Job No. 2			
	First coat	Second coat	Total coating	First coat	Second coat	Third coat	Total coating
Thinning formula:							
*Prepared paint---------- gal.	1	1	---	1	1	1	---
Linseed oil---------- gal.	0.25	0	---	0.25	0	0	---
Turpentine---------- gal.	0	0	---	0.25	0.25	0	---
Spreading rate----sq.ft. per gal.	475	550	---	800	900	900	---
Paint applied-gal.per 1000 sq.ft.							
Pigments	0.421	0.455	---	0.208	0.222	0.278	---
Linseed oil	1.520	1.180	---	0.750	0.578	0.722	---
Volatile thinner	0.168	0.182	---	0.292	0.311	0.111	---
Oil taken from first coat by the wood--------gal.per 1000 sq.ft.	0.750	0	---	0.750	0	0	---
Paint remaining on surface gal.per 1000 sq.ft.							
Pigments	0.421	0.455	0.876	0.208	0.222	0.278	0.708
Linseed oil	0.770	1.180	1.950	0	0.578	0.722	1.300
Total paint	1.191	1.635	2.826	0.208	0.800	1.000	2.008
Volume of pigment in coating-percent	35	28	31	100	28	28	35
Thickness of coating-------inch	0.0019	0.0026	0.0045	0.0003	0.0013	0.0016	0.0032

*Prepared paint assumed to have the following composition by volume : Total pigments, 25 percent; linseed oil, 65 percent; volatile and drier 10 percent.

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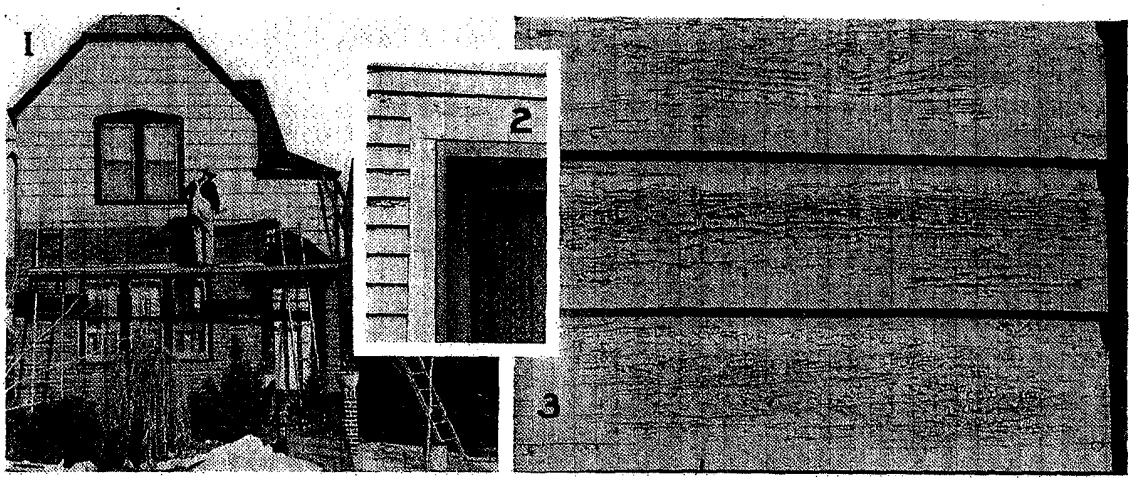

LEFT:. Paint Troubles lead to loss of market for paint. This house is being covered with composition material imitating brick, because several paint jobs on wood siding failed within a year or two. Other neighborhood houses were similarly treated for the same reason. CENTER: Photograph taken in June, 1935, showing scaling and moisture blisters. Painted in 1931 with pure white lead paint which proved satisfactory, it was repainted in 1934 with a hard type of paint made with a quick-drying vehicle. RIGHT: Result of repeated neglect of paints of hard type. This building has been painted repeatedly with hard types of paint over a long period of years, but each time the owner waited until the old coating was disintegrating badly before putting on new paint. The surface can no longer be painted smoothly or durably unless the old coating is removed completely.

chalking and fading soon develop, and another complaint is often made against the paint.

To Make a Good Job

To change Job No. 2 into a good paint job the painter need only reduce the spreading rates to 600, 700, and 700 square feet per gallon for the first, second and third coat, respectively. The thickness of coating is then 0.0046 inch, and the percentage of pigment by volume in successive coats is 53, 38, and 28. Such a coating is thick enough, but the fact that second and third coats contain the same percentage of pigment is open to some objection. If a paste paint instead of a prepared paint were used according to accepted practice, the percentage of pigment in successive coats would be more nearly 50, 37, and 28. The principal advantage of paste paint over prepared paint lies in the fact that the body coat can be made richer in pigment than the finish coat. The disadvantage of paste paint is that unskilled or unscrupulous painters can "dope" it with inferior materials more easily.

This material is extracted from a paper entitled "What Paint Salesmen Can Do to Prevent Paint Complaints," prepared at the request of a paint manufacturer for distribution to his salesmen. It is available at the Forest Products Laboratory, Madison, Wis., in mimeograph form, with illustrations. While the supply lasts single copies may be had free on request, and 20 or more copies at 5 cents each. . . . The first section of the paper deals with moisture failures, previous behavior of paints and incompatibility of paints (which subjects were dealt with in detail in Dr. Browne's articles in National Painters Magazine in April, May and June) and there is additional material touching briefly on aluminum priming and the care needed in maintenance of quality paints.

Too generous use of volatile thinners in priming coats is a common cause of unnecessarily early failure of paint. The mistaken notion that thinners are needed to increase the penetration and secure firmer anchorage of the paint fosters this blunder in paint. As a matter of fact, linseed oil penetrates all woods more freely than is desirable, and the object of good priming is to restrain, not to stimulate it. Special primers for wood now being offered by several manufacturers are designed with this object in view. In a good priming mixture with ordinary linseed oil paint there should be at least three times as much linseed oil as volatile thinner. It is entirely practicable to omit thinners entirely in the priming coat mixture. Resinous woods, such as southern yellow pine, offer no exception to this rule; in fact, too much volatile thinner is particularly harmful in priming coats for such woods.

Too Much Paint

While too little paint is a common blunder in painting new wood, too much paint and too frequent application of paint are likewise common causes of difficulty in maintaining paint over a period of years. As far as practicable the coating on wood should be kept in the neighborhood of 1/200 inch in thickness. That can be done only if the old coating is given time enough to chalk and erode materially before new paint is put on. Hard types of paint usually wear away less rapidly than soft types of paint and, when repainted, hard types of paint usually "hold out" the new paint better than soft types; that is, the hard paints absorb less oil from the new paint. As a rule, if repainting is done within three years only one coat of new paint should be put on. After four years soft types of paint may wear away enough to take two repaint coats, but hard paints may often be repainted to best advantage with

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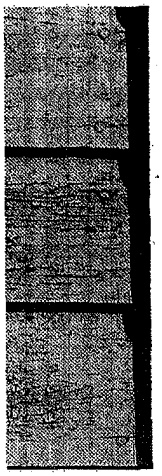

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Stingy Paint Jobs a Danger

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The failure of paint on protected parts of buildings, such as overhanging eaves, when the paint on the exposed parts is in good condition often comes from the fact that too thick a coating has been built up on the protected areas where the weather has little chance to wear away the paint. Such areas should receive less paint than the exposed areas when repainted.

It is not good practice to apply two finishing coats in succession. Sometimes this occurs when a paint job is completed and the owner decides that he does not like the color. Architects some time have it done deliberately, in the belief that they can select colors to best advantage after the house has been erected and painted. Paint salsmen and dealers should try to get customers to select color schemes carefully before starting the paint job, so that the paint job can be properly designed to give good service.

It is likewise bad practice to spread a painting job out over six months or a year. Only the finish coat is designed to stand weather exposure; primers and body coats are not. Many houses that have come back as complaints in recent years have been painted with intervals of several months between coats. Houses completed late in the winter, for example, are often primed perhaps in December, second coated in March, and finished during the summer. As a rule it probably would be better in such cases to take great precautions in drying the plaster to avoid forcing moisture into the sidewalls and to complete the paint job in December by taking advantage of the warmer days of the month and confining paint applications to the hours between 10 a. m. and 2 p. m.

Mr. Keys on Convention Tour

Charles B. Keys, director of the "Better Painted America" Campaign of the International Society and author of the brilliant series of articles which have been appearing in National Painters Magazine on business problems of painters, gave his address on "Building Better Business" before the annual conventions of the Michigan, New Jersey and New York State Councils in July, and after attending the International Board meeting in Cleveland left for Texas and Kansas to speak at association meetings. After a brief vacation Mr. Keys will resume his tour of conventions and specially arranged meetings. In his address, as in his articles, Mr. Keys cites the enormous possibilities for painters that lie in a co-operative movement toward one common objective—that of creating more profitable business. His articles will be resumed in the September issue of National Painters Magazine.

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NATIONAL PAINTERS MAGAZINE

12 Gold Street : : New York, N. Y.

FLB 000890

State Council Conventions

Continued from Page 23

intire and others. (See details of International Society Board action, page 17, this issue.)

Resolutions:

Favoring voluntary agreements for regulation of industry and endorsing in principle state registration acts for the building industry. (See page 17.) Also, designating Schenectady for an experimental "Better Painted City" campaign.

Reports:

By President Vyverberg and Guy R. Hunter, Secretary-Treasurer, on condition of the Council and methods of building it.

NEW JERSEY CONVENTION

New Officers:

E. J. McCoy, Atlantic City, succeeding A. B. Henderson; First Vice-President, Thomas Drayton, Montclair; Second Vice-President, V. G. Aschenback, Morristown; Secretary-Treasurer, Eli W. Jelsma, Paterson (re-elected); International Board Member, Eli W. Jelsma.

Features:

"Building Better Business," by Charles B. Keys, Eagle-Picher Lead Company. "Is There No Help for the Painting Industry?" by George S. Stuart. "A Demonstration of Simplified Bookkeeping," by H. W. Fisher, National Lead Company (see New York program). "Cracks," by George Whigelt. "Safety in the Painting Industry," by J. N. Dorsey, State Director of Safety, E. R. A. "Co-operation," by Charles R. Welti, President of the Travellers Association.

Resolutions:

Endorsing Eli W. Jelsma for International presidency and asking accounting from former National Code Authority.

Reports:

President Henderson gave in detail his year's hard effort to build "a greater, bigger, finer New Jersey Council." Mr. Jelsma gave further details of the progress of the association in the year and of the financial condition. George Schlenker, Chairman of the Legislative Committee, reported on efforts to obtain a license bill and a bill to reduce present excessive compensation insurance rates.

MICHIGAN

New Officers:

President, L. S. Hazen, Saginaw (re-elected); Vice-Presidents, George Elliott, Muskegon, and James A. Moynes, Detroit; Secretary-Treasurer, E. C. Betzing, Detroit (re-elected); International Board Member, W. C. Conrad, Ypsilanti.

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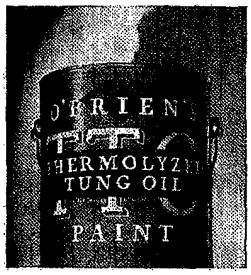

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Paint Oil & Chemical Review May 16, 1935

(23)

Repainting Old, Paint-Thirsty Surfaces

By Dr. F. L. Browne, Senior Chemist,

Forest Products Laboratory, Madison, Wis.

• Much of the painting that will be done this year will be on buildings that should have been painted a year or more ago and on which the old coating is chalking so freely that it will absorb much of the oil from the first coat of new paint. It is rarely safe to attempt repainting such paint-thirsty surfaces with one coat because the new coating may be too thin to prove durable and may be uneven in gloss and color or become so after a very short time. Even if two coats of new paint are applied there may still be difficulty with spotty chalking and fading if the first coat is not thinned properly and is not applied generously enough. For that reason some authorities recommend that three coats of new paint be applied. Few property owners, however, will be willing to go to the expense of three coats and as a matter of fact too much paint may prove as disadvantageous as too little.

Obviously the first coat of new paint should supply enough linseed oil to "satisfy" the old thirsty surface and still leave enough oil to bind its own pigments so that they will not in turn rob the finish coat of oil. Many paint technologists advise thinning the first repaint coat generously with linseed oil in order to accomplish this objective. At first thought it seems reasonable that the more oil there is in the paint the more oil will be applied to the surface. In practice, however, the writer has repeatedly observed that the extra oil added to the paint leads the painter to spread it out enough farther to actually *reduce* the amount of oil applied to unit area of the surface.

Neither Too Thick Nor Too Thin

The Forest Products Laboratory's painting exhibit at the Cypress Log Cabin at A Century of Progress in Chicago last summer included paint-out tests showing the harmful effect of undue thinning of priming-coat paint in two-coat painting of new wood. When the priming-coat paint was mixed rich in pigment enough paint was applied to prime the wood adequately and the second-coat paint dried with uniform gloss and color but when the priming-coat paint was mixed either too rich in linseed oil or too rich in turpentine the second-coat paint dried with spotted gloss and color. Exactly the same principle applies in the repainting of "paint thirsty" surfaces.

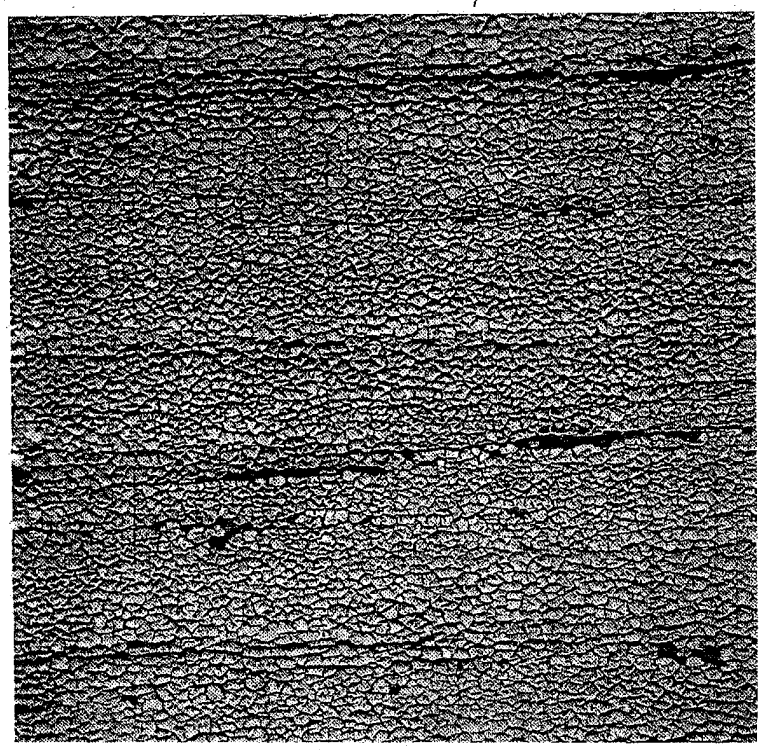
The nature of the relations involved can be set forth explicitly by making certain simple calculations. In order to provide a specific problem for consideration we shall assume that a painter is about to repaint a house that was erected and painted for the first time in 1930. The exterior surfaces are all of woods that hold paint very well, such as slowly grown redwood, red cedar, cypress, and white pine. The original painting was three coats of a paint that stands neglect well and after five years the coating where fully exposed to sunshine is now chalking very deeply and checking deeply in a fine reticulated pattern as shown in figure 1. Such a surface may well be described as paint thirsty. For simplicity it is assumed that there is very little crumbling of the coating and no curling, flaking, or scaling. The initial painting was done with a soft paste paint of the following composition:

Pigments	0.523 gallon
Linseed oil	0.387 gallon
Turpentine and drier	0.090 gallon
Total	1.000 gallon

(Presence of the drier in the paste paint is assumed to simplify the further considerations.) Details of the thinning, application, and the thickness and composition of the resulting coating are recorded in Table 1, from which it appears that the initial coating was 0.0051 inch thick, contained on the average 35 percent by volume of pigment and 64 percent of linseed oil, and its content of linseed oil was highest at the surface, diminishing progressively toward the wood.

During the five years since the house was painted some parts of the coating have been fully exposed to the weather and have become badly worn while other parts have been protected by the shading cornices and porch roofs and by position on the north side where there is little direct sunshine. On the fully exposed parts much of the initial coating has worn away and the remainder has developed deep checking and its content of oil has decreased from shrinkage of the linoxyn with age and probable loss of volatile products of photochemical decomposition. Assume, therefore, that on the fully exposed surfaces the old coating remaining is 0.0025 inch thick, that is, erosion has taken off all of the initial third coat and 0.00035 inch of the second coat. Assume further that 20 percent of the volume

A typical paint-thirsty surface. The area shown is 2 inches by 2 inches upside down



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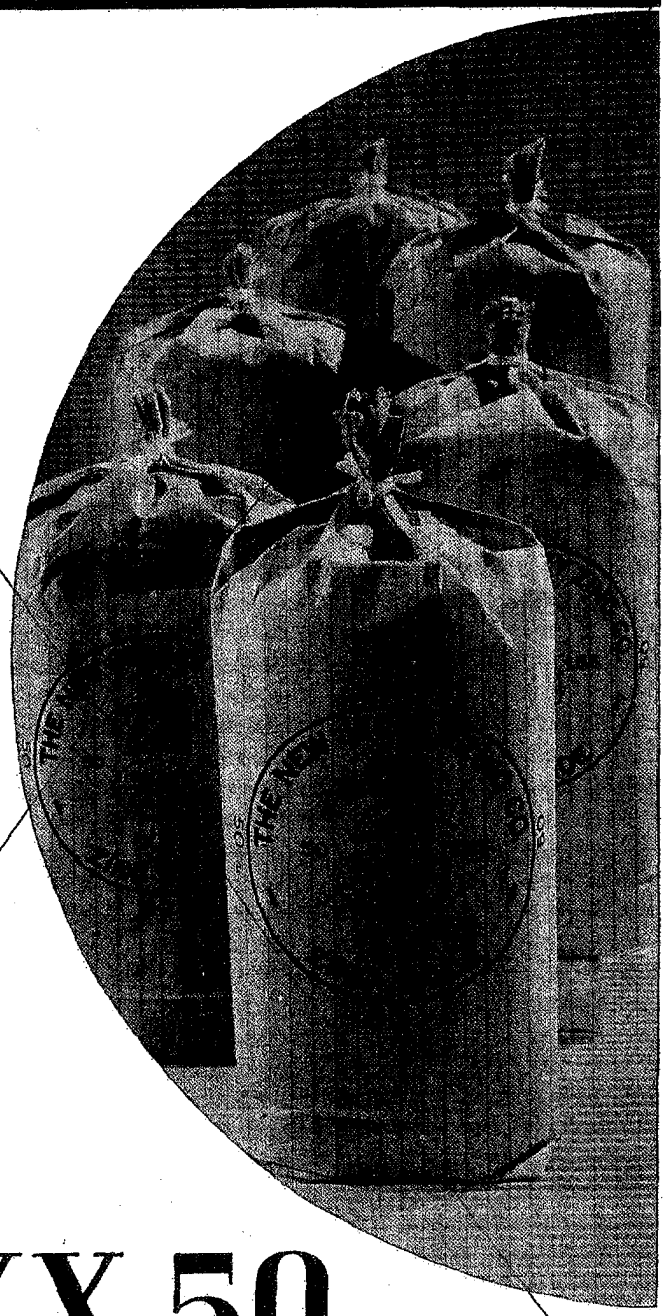

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Horse Head XX-50 Zinc Oxide was designed primarily to give improved durability in outside house paints. It is one of the newer pigments with this durability property produced by controlling the particle characteristics.

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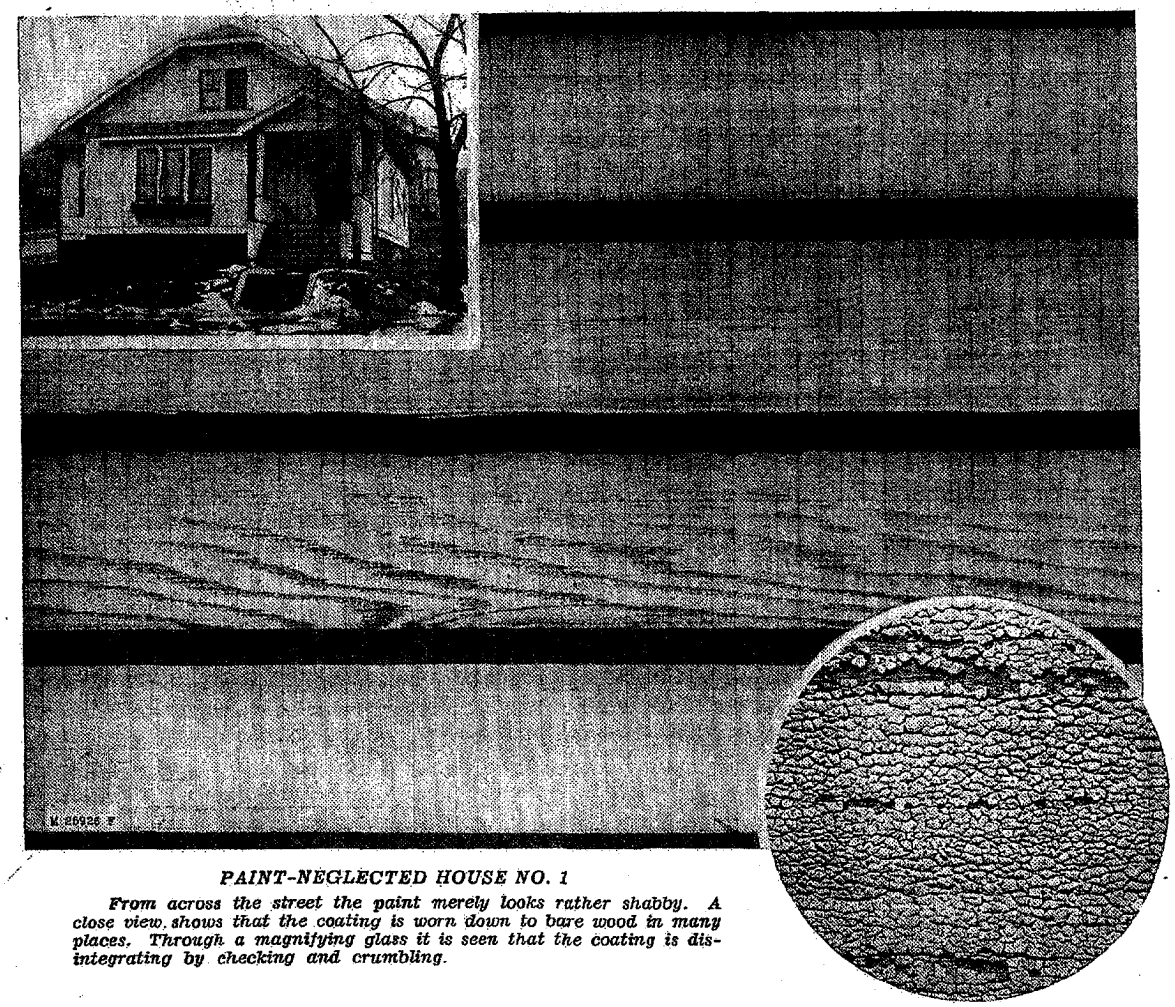

PAINT-NEGLECTED HOUSE NO. 1

From across the street the paint merely looks rather shabby. A close view shows that the coating is worn down to bare wood in many places. Through a magnifying glass it is seen that the coating is disintegrating by checking and crumbling.

Repainting Paint-Neglected Frame Houses

By F. L. BROWNE

Senior Chemist, Forest Products Laboratory, maintained at Madison, Wis., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Wisconsin.

PAINTING contractors during the next year or two should find a greatly increased demand for their services in the exterior repainting of houses. Everywhere house owners during the years of depression have been putting off repainting until in many communities the majority of the buildings are badly in need of new paint. While this increase in his market should be encouraging to the painting contractor, there are certain complicating circumstances that he must be prepared to deal with if the new business is to prove permanently profitable to him.

On many of the houses that the painter will be asked to repaint, the old coating wore out three or four years ago, and since that time has been in a state of paint neglect. If the old paint was one that stands neglect well, the surface can be prepared for the new job fairly easily. Many paints, however, do not stand neglect well; if the old paint was one of them, the painter may have a difficult problem on his hands. He knows that the safe course is to remove the old coating entirely, but if he bids on that basis he may lose the job to a less scrupulous competitor who plans merely to slap on some new paint and trust to luck that it will hang for a time. On the other hand, if he follows his competi-

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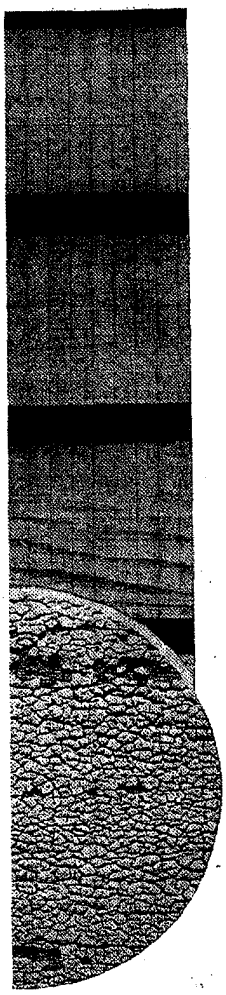

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Painting contractors must carefully examine surfaces and apply knowledge of paint behavior to determine their procedure in repainting. . . Long neglect makes problems difficult. . . Safe course in bad cases is complete removal. . . What to do when owners will not permit removal. . . Recent survey reveals variety of difficulties that will confront painters.

tor's methods and the job goes bad, he may seriously damage a fine reputation that he has taken years to build up. The painter who is going to get the business this year, and get it again four or five years from now, must learn to distinguish between the surfaces that can be trusted to hold new paint properly and those that it will be good business to concede to his competitors when the owner cannot be convinced of the need for proper preparation before repainting.

How to Know What to Do

No previous business depression has left painters with such a difficult problem in determining what to do with neglected surfaces. In former times most residential painting was done with a paint of a relatively soft type whose outstanding merit is the ability to stand neglect well. During the prosperous period following the World War there was a shift toward harder types that have certain important advantages during the useful life of the coating, but, unfortunately, do not stand neglect well. These paints were designed for an age in which better performance during four or five years of useful life could be demanded at the sacrifice of good behavior during a period of neglect, because it was believed that nearly everyone would be able to repaint before the coatings disintegrated.

Like other enthusiasms of easy times, this optimism has led us into serious difficulties when hard times arrived. Many of these paints have not been renewed at the proper time, and their badly neglected surfaces leave the painter uncertain about the outcome if he merely scrapes off the loose edges and repaints without removing all of the old coating.

A recent survey of one of the residential sections of a city in the Middle West provided the photographs with which this article is illustrated, and shows the variety of paint neglected surfaces with which the painters of that city must contend this year. The houses shown were selected at random in a community in which as a rule the occupant is the owner and the painting is done by local contractors. Past experience has taught the writer that under such conditions it is rarely possible to obtain accurate information about the painting history of a house. Even the owner's or the painter's statement of the date and kind of paint used at the last painting often proves incorrect.

That, however, is exactly the situation that the painter meets when he bids on a new job. He must rely primarily upon his own examination of the surface and knowledge of paint behavior to determine those facts about the past painting necessary for guiding his procedure in repainting. We can, therefore, examine these photographs much as a painter should examine a house that he is going to repaint.

House No. 1

House No. 1 always has been painted with the soft type of paint, but no new paint has been applied for seven or eight years, and the surface has become neglected. The coating has thoroughly disintegrated. From a distance it merely looks shabby, but close inspection proves that it has crumbled badly and has left considerable areas of wood entirely bare. Still closer observation with a magnifying glass demonstrates that disintegration of the coating developed from checking, which is characteristic of the soft type paint. When the paint "checks" finally penetrated the coating to the wood, some of the little "islands" of coating thus cut off became dislodged one by one, leaving the wood bare underneath. Many painters call this kind of disintegration "chalking," but, although the paint has been chalking for a long time, the failure really develops from checking and crumbling.

The painter who gets the job of repainting House No. 1 is lucky, because he has very little to worry about. After any necessary carpenter's repairs have been attended to the painter need merely dust off loose chalk and dirt, perhaps clean a few places where soot or grease from oil-burning furnaces have collected on shaded parts of the building, and he is ready to brush on new paint. Two coats of new paint are necessary, of course, because part of the wood surface has been left bare, and what is left of the old coating is little more than a mass of porous pigment that will absorb much oil from the first coat of new paint.

As a rule the new paint should be of the same soft type previously used on House No. 1, because the chances are that the job will again pass through a long period of neglect before it is repainted. If, however, the owner feels that in future he will repaint before the coating disintegrates badly and wishes to employ harder types of paint, it is practicable to apply them over this surface. The first coat of new paint should be thinned with linseed oil and relatively little turpentine or other volatile thinner, using not more than 1¼ gallons of total liquid to 1 gallon of soft paste paint. At least a gallon of the mixture should be applied for each 600 square feet of surface. For the finish coat a gallon of soft paste paint should be thinned with not more than one gallon of liquid, mostly linseed oil, and a gallon of the mixture applied for each 600 or 700 square feet of surface.

House No. 2

House No. 2 has been painted and two or three times repainted with paints of a fairly hard type, but the owner waits just a little too long each time before he calls in the painter. As a result, the painter each time has a difficult surface to deal with, and, as time passes, successive repaintings are proving less durable. The paint is in a more advanced stage of disintegration than that on House No. 1, yet the last painting of House No. 2 was two or three years more recent than that on No. 1. The break-up of the coating on House No. 2 is easily observable from the opposite side of the street.

Closer inspection shows that it is disintegrating by

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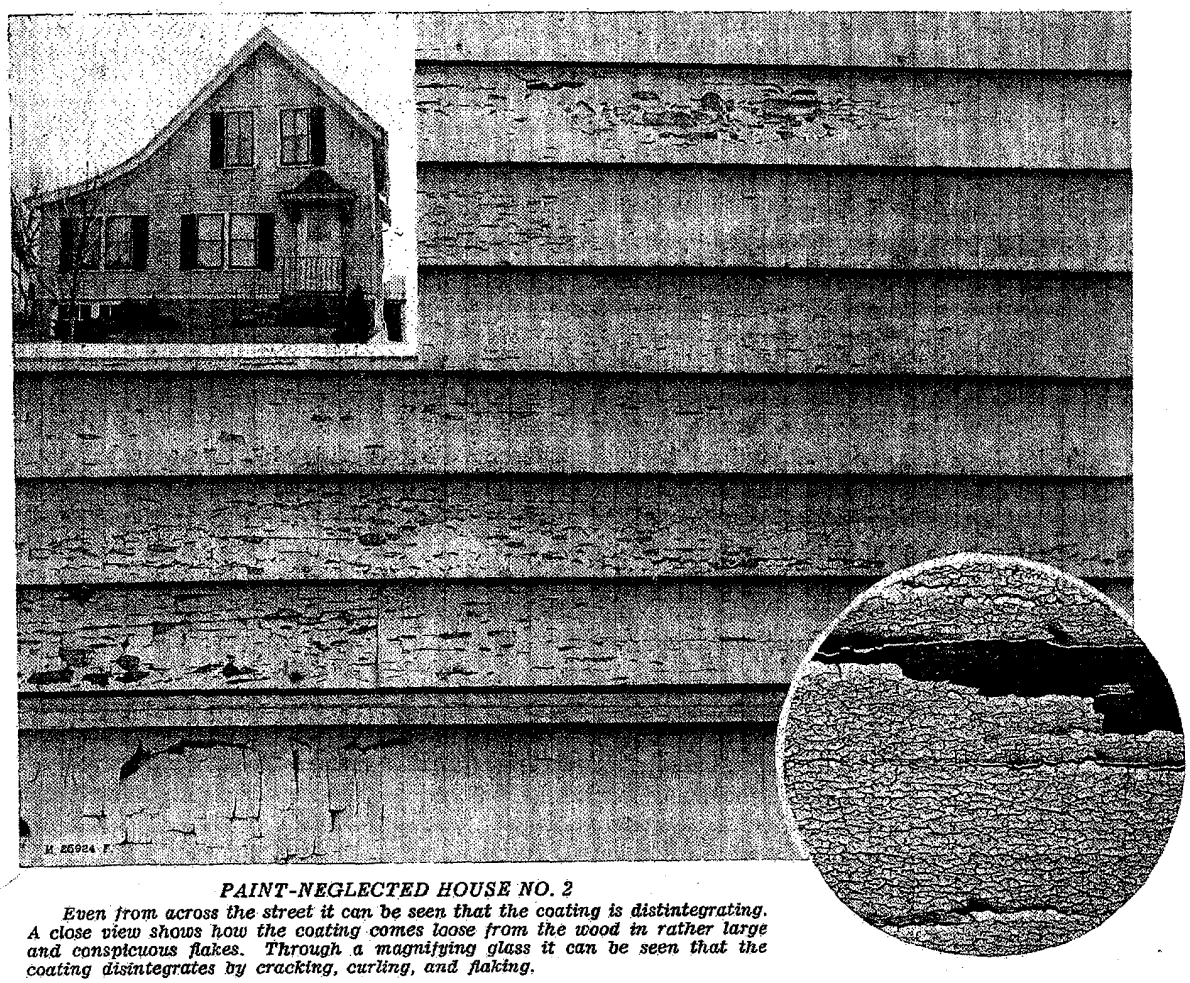

PAINT-NEGLECTED HOUSE NO. 2

Even from across the street it can be seen that the coating is distintegrating. A close view shows how the coating comes loose from the wood in rather large and conspicuous flakes. Through a magnifying glass it can be seen that the coating disintegrates by cracking, curling, and flaking.

flaking and scaling rather than by crumbling. The view through a magnifying glass shows how such behavior differs from the crumbling on House No. 1. Note that flaking does not develop from checking, but from an entirely different kind of fissure in the coating, cracking, which is a much larger and more conspicuous sort of break-up. At the edges of the cracks the coating curls upward and eventually falls off, leaving a patch of bare wood, and the coating still clinging to the wood has jagged and insecurely adhering edges.

For a really first-class job the old paint on House No. 2 should be removed completely. However, if the owner will not agree to pay for it this year, all loosened edges of old paint should be carefully removed with putty knife, wire brush, and sandpaper, and a fairly good job of repainting can be done with reasonable assurance that it will stand up for about three years, but probably no longer. The owner should be warned, however, that the new paint will not form a perfectly smooth coating, because the places where the old coating has flaked off will show as hollows in the new one. He should also be warned that continuance of his practice of allowing the coating to get into this condition before repainting will eventually make a complete removal necessary before repainting can be done at all satisfactorily.

In repainting over this old coating the painter should use a hard type of paint, preferably the same paint that was used previously. If a soft type of paint is applied, there is danger of conspicuous alligatoring developing within a year or two. The paint should be a real oil paint; it should contain no heat-treated oils or varnishes that tend to give enamel-like consistency to a paint. A real oil paint properly mixed will show brush marks, but it will fill the flaked patches better and more nearly conceal them than a paint containing oils treated to give quick drying or freedom from brush marks.

Two coats of new paint should be applied. The reduction of the first coat is necessarily a compromise between the needs of the patches of bare wood and those of the remnants of old coating, which are much less absorptive than the old coating on House No. 1.

Without knowing the composition of the paint to be used, it is not possible to make specific suggestions for thinning, but in general the paint should be mixed so that it will contain more pigment and the liquid portion a higher proportion of turpentine than was recommended for House No. 1. In applying the first coat

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of new paint a good plan is to lay off a stretch of paint and then, after the oil has had just time enough to sink into the wood of the bare patches, go back over the stretch without dipping the brush in the paint bucket. In that way much of the paint will be transferred from the poorly absorptive coated patches to the much more absorptive bare patches, and the final result will be a more nearly level coating, with the old flaked places showing less conspicuously.

Part Two

Failures Caused by Moisture

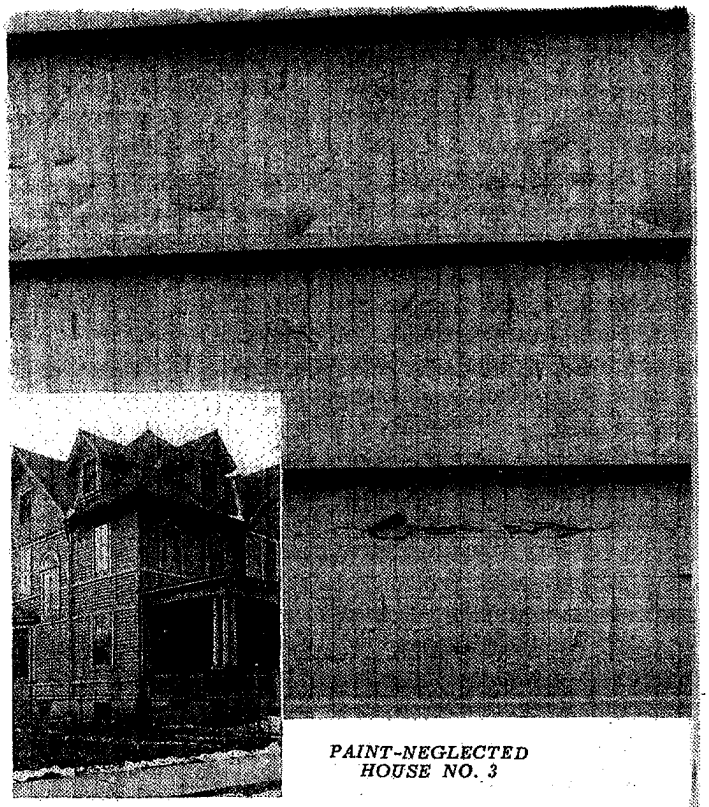
IN examining houses before bidding for their repainting the painter should look constantly for signs of failure of the old coating caused by moisture behind the painted boards. On houses afflicted with this faulty condition the best of paints may fail conspicuously in a very short time, often in less than a year. The wise painter will call the owner's attention to moisture failures before undertaking the job of repainting. If he waits until his own repaint job has failed, as it probably will, he will usually find it very difficult to convince the owner that the failure came from conditions beyond the painter's control.

The various ways in which moisture gets into the side walls of houses and ruins fine paint jobs are discussed in a mimeograph obtainable free from the Forest Products Laboratory, Madison, Wisconsin. Houses that are chronically subject to such conditions cannot be repainted with assurance of success even if the old coating is removed entirely. The source of moisture must be discovered and means taken to keep the side walls dry before paint can be expected to give good service on such houses. For his own protection the painter before agreeing to repaint the house should warn the owner that moisture collects at times behind some of the painted woodwork and may cause difficulty with the new paint job if means are not found to keep the wood dry.

Some of the forms of paint failure that should lead the painter to question whether the woodwork always remains dry can be described by considering specific examples from the writer's experience.

House No. 3

The condition of blistering observable on House No. 3 is an unmistakable sign of moisture in the side walls. If a board of siding is removed while such blisters are swollen the back of the board will be found thoroughly wet. A carpenter can easily remove a board of siding for such examination and replace it without damage if it is necessary to convince the owner that there is moisture behind the boards. As a rule that condition is found most often in late winter or early spring (House No. 3 was examined in March). Later in the season the side walls may dry out again and the blistered parts of the coating become flabby or even sink back almost to their original position so that the blisters may become hard to detect. While in the turgid state a pen-knife thrust into the blister may show it to be full of water, but that is not always the case. When the blister is peeled off it may reveal the bare wood beneath or it may reveal a prior coat of paint still clinging to the wood.



PAINT-NEGLECTED HOUSE NO. 3

Blistering caused by moisture in the side walls during the winter months. It is obvious that the previous paint job had likewise blistered because the places where the loose paint had been scraped off show under the last paint coating.

Effect of Blisters Drying

Blisters may break and peel soon after they are formed, but very often they merely dry out and shrink back until the coating becomes more brittle as a result of weathering for a few months longer, after which the blistered areas crack open and scale off. House No. 3 shows places where the previous paint job had blistered and subsequently scaled. The present coating was put on only a year or so ago and is still soft and flexible, yet it is already cracking and coming loose. The painter should recognize this house at once as a "chronic peeler" and should not undertake to repaint it even if he removes the old coating entirely unless the owner understands that the paint cannot be expected to give good service until proper steps have been taken to keep moisture from getting behind the painted boards.

The Forest Products Laboratory has equipment for reproducing typical moisture failures of paint for the purpose of studying the effects of different woods and paints. The panel shown in the illustration was made of 4-inch red cedar siding of the kind used on houses. It was painted in October, 1934, with three coats of a

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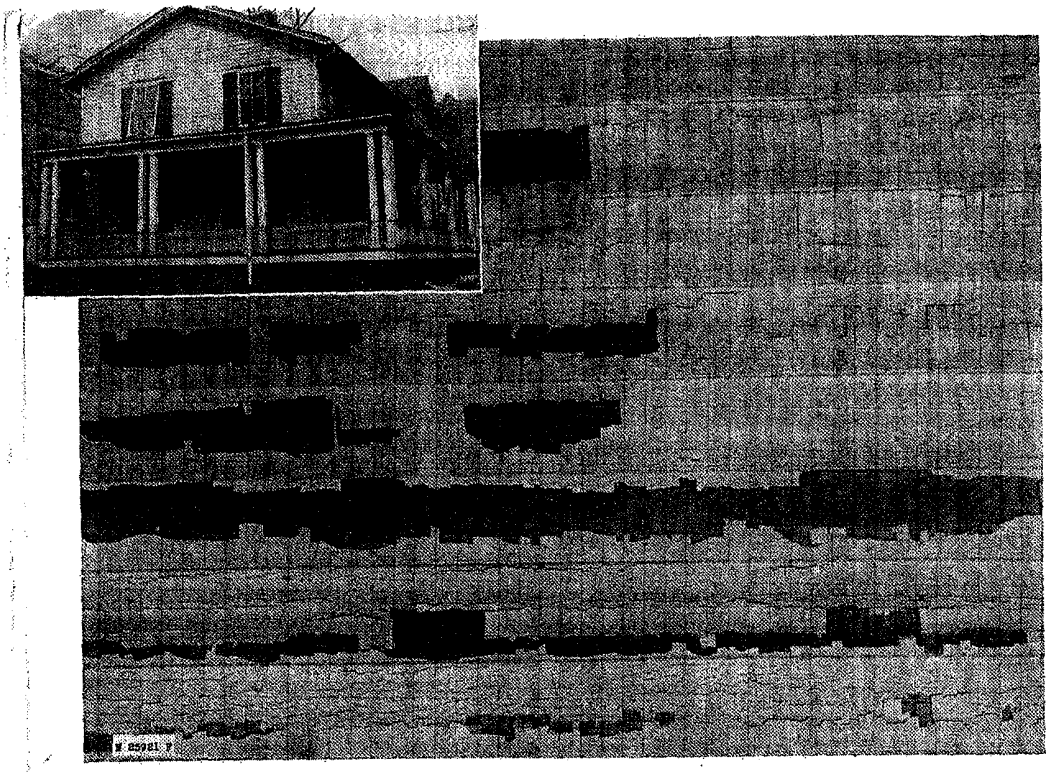


PAINT-NEGLECTED HOUSE NO. 5

The paint on all parts of the house was cracked as shown in upper right-hand corner of the photograph. The boards shown contained 30 to 40 percent moisture when the photograph was taken.

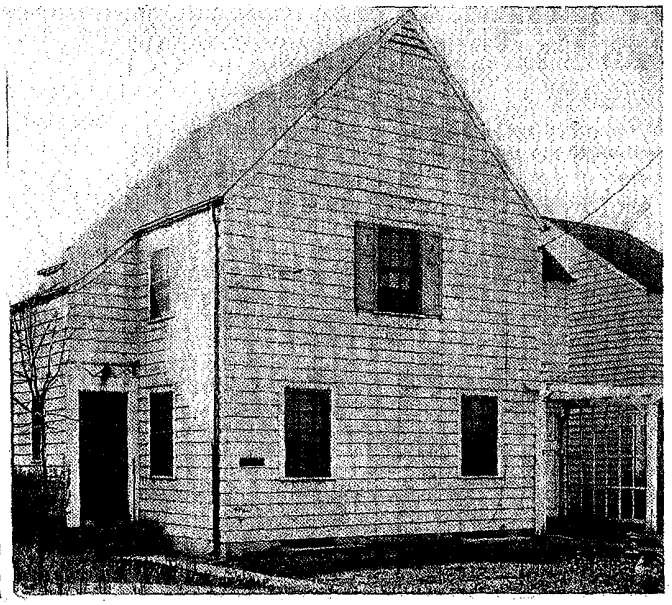
representative house paint of the titanox, lead and zinc type. On the left-hand half of the panel the paint liquid contained pure linseed oil, but on the right-hand half a mixture of linseed oil and heat-treated tung oil was used.

The panel was exposed to the weather facing south at 45° for 2½ months, after which it was tested on the blistering apparatus. The apparatus consists of a wooden framework to which panels are attached as though they were the side walls of a house. The miniature "house" has a roof and a floor, and inside there is a large pan of water that is heated electrically to provide heat and humidification. The "house" is placed in a large cold-room kept at 40° F. The temperature within the house was approximately 80° F. Under such conditions moisture condensed on the backs of the boards of siding, making them thoroughly wet.

Blisters began to appear on the top board of the panel shown after the "house" was in operation for one day. After two days blisters appeared on the second and third boards also, and after three days they appeared on the fourth board. The photograph was taken after 11 days, when the panel was removed from the "house" and replaced on the test fence out of doors. At the present time, six months after painting, the smaller blisters have apparently disappeared, the larger ones have sunk back and left a few ridges near their lower margins, and the coating is beginning to crack and scale where the largest blisters were.

Below: House No. 4. Scaling caused by moisture in the side walls during the winter months.

PAINT-NEGLECTED HOUSE NO. 4



House No. 4

The sort of scaling of the old coating to be seen on House No. 4 is commonly the result of wet side walls, but it must not be confused with some of the results of painting with incompatible paints that will be discussed subsequently. House No. 4 is one of nearly 200 houses in a single community that have been "chronic peelers" ever since development of the plat began some seven years ago. This house had been painted three times within two years when the photograph was taken, each job failing in much the same way. Some houses were burned off and repainted and still failed promptly in the same way. Examination of the houses showed that the backs of the boards of siding and the building paper behind them had become thor-

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oughly wet every winter. The writer knows of no way in which these houses can be kept properly painted at reasonable cost until construction practices in the community are altered in such a way as to keep the side walls dry at all times.

House No. 5

House No. 5 is an old house to which additions have been made from time to time. There apparently had been no great trouble with the paint until the last alteration was made some eight or nine years ago. Since then it has been necessary to repaint at yearly or bi-yearly intervals, and a very thick coating has been built up except on patches here and there where scaling took place before the last repainting. In 1934 the side walls were filled with insulation which, in this case, seems to have increased the condensation of moisture behind the siding. All over the house the thick paint is cracking badly as shown in the photograph, and under the porch on the south side the coating is now scaling very badly. At the time the photograph was taken the moisture content of the boards was 30 to 40 percent—that is, they were thoroughly wet.

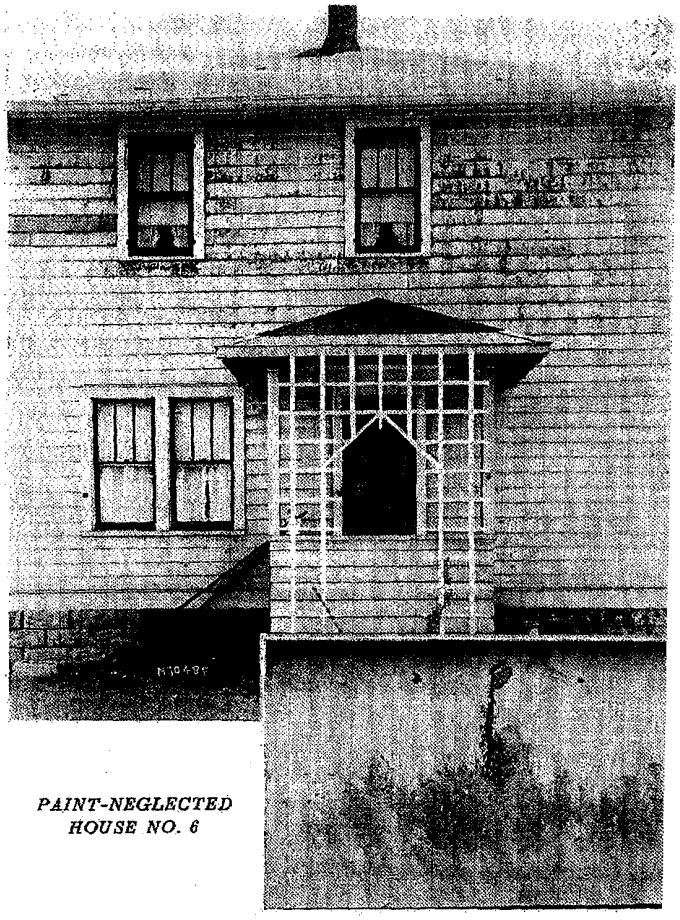
House No. 6

House No. 6 was erected in 1919 and painted with pure white lead paint, which gave entirely satisfactory service. In 1926 it was repainted with white lead paint. During the following winter the outlet to the sewer became clogged and caused water to run back through the cellar floor drain, partly flooding the cellar floor. The difficulty was not properly repaired until the ground thawed in the spring, when it was less difficult to uncover the connection to the sewer. The photograph was taken in May, 1927, nine months after painting.

Proof of Wet Wood

In this case there was comparatively little blistering because pure white lead paint is distinctly more resistant to blistering than most other kinds of paint. The siding, however, was redwood, a wood that holds paint excellently, but one that contains colored substances soluble in water that turn dark reddish-brown in color when exposed to air. When the boards became wet the water carrying the soluble matter exuded through the paint, smeared over the surface, and developed the dark stains as shown. Under similar circumstances somewhat similar stains may appear over western red cedar, and on at least one house the writer has seen them on white pine. Such discoloration of paint with water soluble material from the wood is unmistakable proof that the wood became thoroughly wet after the house was built. The fact that some woods discolor paint under such conditions should be no objection to their use in exterior construction because no wood will hold paint properly unless the faulty moisture conditions are removed. The discoloration gives warning of the need of corrective measures.

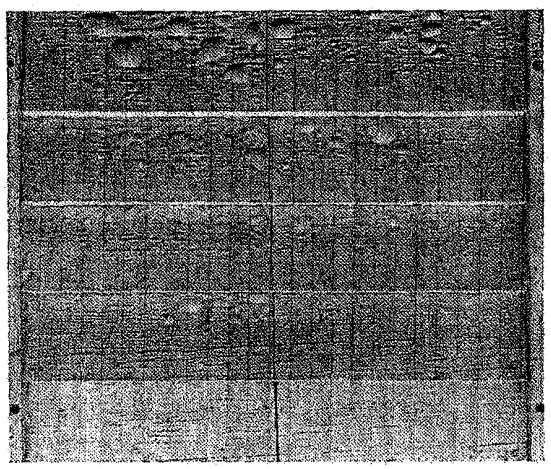
House No. 6 was washed and repainted in 1927 after the plumbing had been repaired. No subsequent difficulty with the paint has been reported.



PAINT-NEGLECTED HOUSE NO. 6

***Above:** House No. 6. Discoloration of white lead paint with water soluble substances in redwood siding caused by moisture in the side walls during winter months.*

The panel illustrated below shows blistering reproduced in tests in the Forest Products Laboratory. See accompanying article for explanation.



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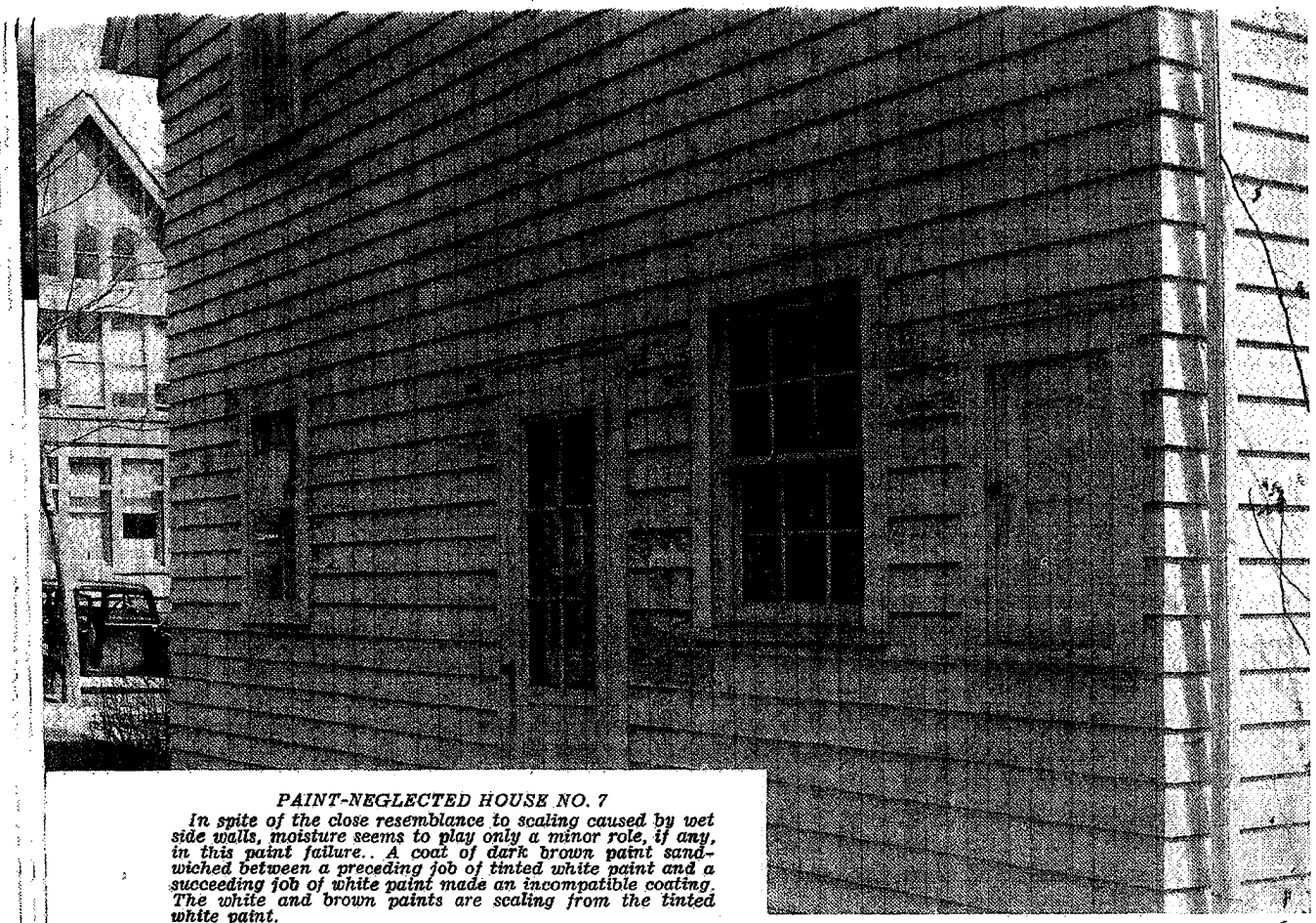

PAINT-NEGLECTED HOUSE NO. 7
In spite of the close resemblance to scaling caused by wet side walls, moisture seems to play only a minor role, if any, in this paint failure.. A coat of dark brown paint sandwiched between a preceding job of tinted white paint and a succeeding job of white paint made an incompatible coating. The white and brown paints are scaling from the tinted white paint.

Part Three

Failures Through Incompatibility of Paints

PAINTERS today have more good paints from which to choose than they have ever had before. While this variety of products helps the painter who understands them all to suit the needs of clients with different service conditions, different habits of paint maintenance, and different standards of satisfactory paint service, it likewise adds to his difficulties by increasing the chances of premature failure of his repaint jobs because of incompatibility of the new paint with the old one. There is no one kind of paint that can be applied over all other kinds of paint with assurance that it will perform properly. Certain combinations of paints, all of which may be good paints, result in early and conspicuous failures that can be set right only by burning off all of the paint and starting over again from the bare wood.

The typical dwelling may be painted ten or fifteen times in the course of its life in service. Unfortunately, many property owners think that these ten or fifteen paint jobs can be considered quite independently of each other, each one to be decided upon when it comes due without regard for the others. Such a course often leads to a succession of unsatisfactory paint jobs ending with an expensive burn off and serious damage to the reputation of the last two or three painters. Knowledge of incompatible paint combinations is essential for the painter who counts good will among the assets of his business.

The remaining houses in our survey of a middle western city illustrate common cases of failure due to incompatibility of paints. The first two of them, houses Nos. 7 and 8, should be compared particularly with houses Nos. 4 and 5 of the second article in this series because there is such a close resemblance between failures from incompatibility and failures from wet side walls that the two are frequently confused. It is bad enough to have an honest job fail, but when it does the painter gains nothing by attributing the failure to moisture only to have his client discover that the side walls were never wet.

House No. 7

House No. 7 was painted when erected, in 1928, with two coats of a dark gray paint, probably of a lead and zinc type, and a finish coat of a dark brown paint. The house was sold to a purchaser who disliked the dark color. In 1932 there was some scaling of paint on parts of the house and a few typical moisture

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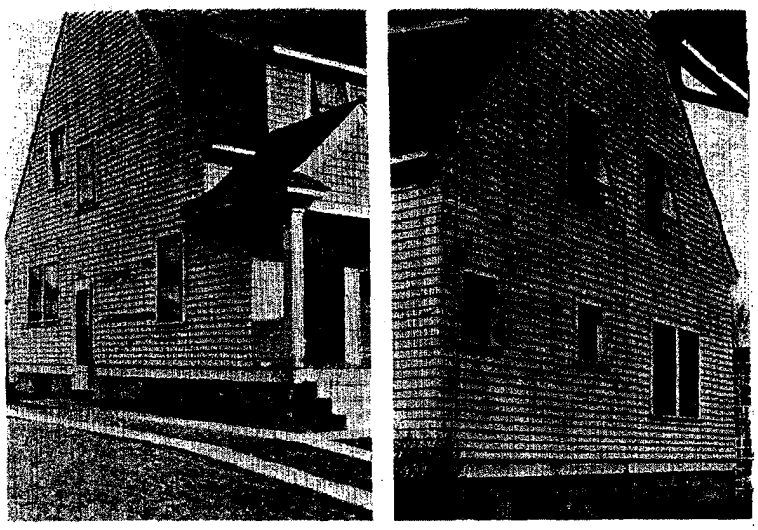
With many fine paints to choose from, painters must study the compatibility of one product with another if they are to achieve successful results in repainting paint-neglected frame houses . . . Survey of houses in a middle west city illustrates common cases of failure due to this incompatibility of paints.



PAINT-NEGLECTED HOUSE NO. 8

Careful examination, including removal of boards of siding, shows that the side walls have always been dry. A quick-drying type of paint was used over ordinary linseed oil paint on the north side (left), but the painter had so much trouble picking up laps that he added white lead paint to the quick-drying paint for the other three sides. The south side (right) shows little scaling.

blisters, such as those on house No. 3, were observed. The scaling was therefore attributed to moisture in the side walls, but the source of moisture and means of excluding it were not discovered. The house was repainted with white paint of the titanium, lead and zinc type. The photograph was taken in March, 1935. The moisture content of the boards from which the paint is scaling was found to be 11 percent, which is perfectly normal, and indicates that the boards were not wet during the past winter. On the opposite side of the house where blisters were observed before and after the application of the white paint a few boards were found with 20 percent of moisture, but there was very little scaling of paint on any of the moist boards. On those patches where the brown paint had scaled before the white paint was applied the coating is now in excellent condition. Where the scaling occurs the white and brown paints come off together, but the gray paint of the initial paint job remains intact.

Although some doubt may be admitted as to a possible part played by moisture in the paint failure on house No. 7 the sandwiching of a dark brown paint between a tinted white paint and a white paint makes an incompatible combination that is certainly the primary cause of difficulty in this case. To repaint without burning off all of the old paint is to invite further disappointment.

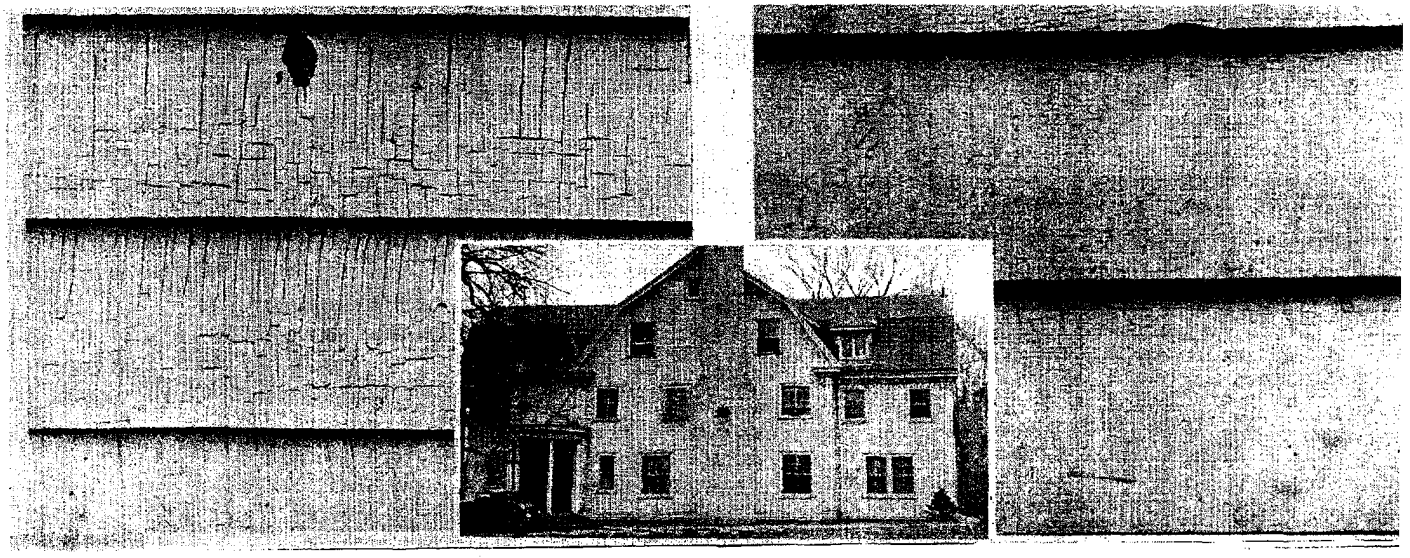
House No. 8

The failure on house No. 8 bears a striking resemblance to moisture failure like that on house No. 3, but the house was examined carefully for moisture in March and the boards found to contain slightly less than 11 percent. Four boards were removed and observed to detect signs of water on the backs of the boards, rust at the nail holes, or rumpling of the building paper behind them. Apparently the side walls have never been wet.

House No. 8 was completed late in 1929 and a primer coat of paint applied. In June, 1930, the painting was completed with what the owner understood to be lead and oil, but on examination proved to be a mixed pig-

PAINT-NEGLECTED HOUSE NO. 9

Three sides are in the condition shown at the left. Here there was successively a dark, reddish-brown paint, a yellow paint, a dark gray paint, and at least three jobs of white paint. On the east side, shown at the right, there were only the last two or three jobs of white paint, because that side had to be rebuilt after a fire some years ago.



ment paint, probably of the lead and zinc type. In July, 1933, the owner contracted to have the house repainted with one coat of lead and oil, but the painter purchased one of the quick-drying house paints in which the liquid contains a mixture of linseed oil and a re-inforcing oil and the pigment contains titanium, white lead, and zinc oxide. The painter began on the north side, but had so much trouble picking up his laps that he reduced 100 pounds of soft paste white lead and mixed it with five gallons of the quick-drying paint to complete the job.

Paint scaling began within a year. The photograph was taken in March, 1935. There is scaling on all sides of the house, but it is distinctly worse on the north side than elsewhere. The quick-drying paint is a well-made product put out by a responsible manufacturer and will give excellent service over a proper foundation, but it differs so markedly from the paint used previously that the combination failed very early. The failure should not be considered a fault of either the old or the new paint, but a mistake in using the one over the other. The painter, however, is badly compromised in any case because he used a paint other than the one specified in the contract.

House No. 8 must be burned off before it can be repainted with reasonable assurance of a durable coating.

House No. 9

House No. 9 is an old one that has been painted at least six times. On three sides the paint is failing very badly, but on the east side, which is as fully exposed to the weather as any of the others, the paint is in such excellent condition that one repaint coat should prove sufficient. About ten years ago a fire in the house made it necessary to rebuild the east wall, but left the other three walls undamaged.

Examination of the old coating shows that the house was painted initially with a dark reddish-brown paint, then successively with a paint of the color of yellow ochre, a dark gray paint, and at least three times with white paint. The east side has only the three jobs of white paint. The yellow paint may have been compatible with the brown paint, but the gray paint and the white paints were not. Painters have repeatedly struggled to repaint these three sides of the house smoothly with less success and less durable jobs each time. The east side, however, has never presented any difficulty. Now the three sides with the incompatible coatings must be burned off before they can be painted at all smoothly.

House No. 10

House No. 10 was painted initially with a white paint of the lead and zinc type and then repainted some years later with white paint of the titanium, lead and zinc type. The second paint probably was mixed with a materially higher proportion of pigment than the first, as is commonly the case in manufacturing paints of these two types. The failure takes place by scaling of the second paint, leaving the first paint still firmly adhering to the wood. Successive coats of paint should, as a rule, contain decreasing proportions of pigment. Violation of this principle probably accounts for the unsatisfactory form of failure on house No. 10.

House No. 11

House No. 11 is another example of white paint applied over paint of dark color with which it is incompatible. The incompatibility, however, is more pronounced, appeared after fewer repaintings, and presents a more characteristic form of failure than house No. 9, where the yellow and gray paints perhaps effected a more gradual transition from the dark brown to the white paints. Paint failures of the kind seen on house No. 11 have been common in recent years on the freight stations and other wooden buildings of many railroads. They were formerly painted with red "freight-car" paint for economy in maintenance, but were repainted with a more cheerful color chosen to represent the railroad for advertising purposes. The brighter paint often proved incompatible with the red.

House No. 12

House No. 12 was painted about seven years ago with a white paint of the lead and zinc type, and again three years ago with pure white lead paint. The conspicuous alligatoring that has now developed is very objectionable to the owner. The writer has repeatedly observed it on houses where white lead has been applied over other kinds of white paint and has reproduced it by painting panels in that way on test fences.

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PAINT-NEGLECTED HOUSE NO. 10
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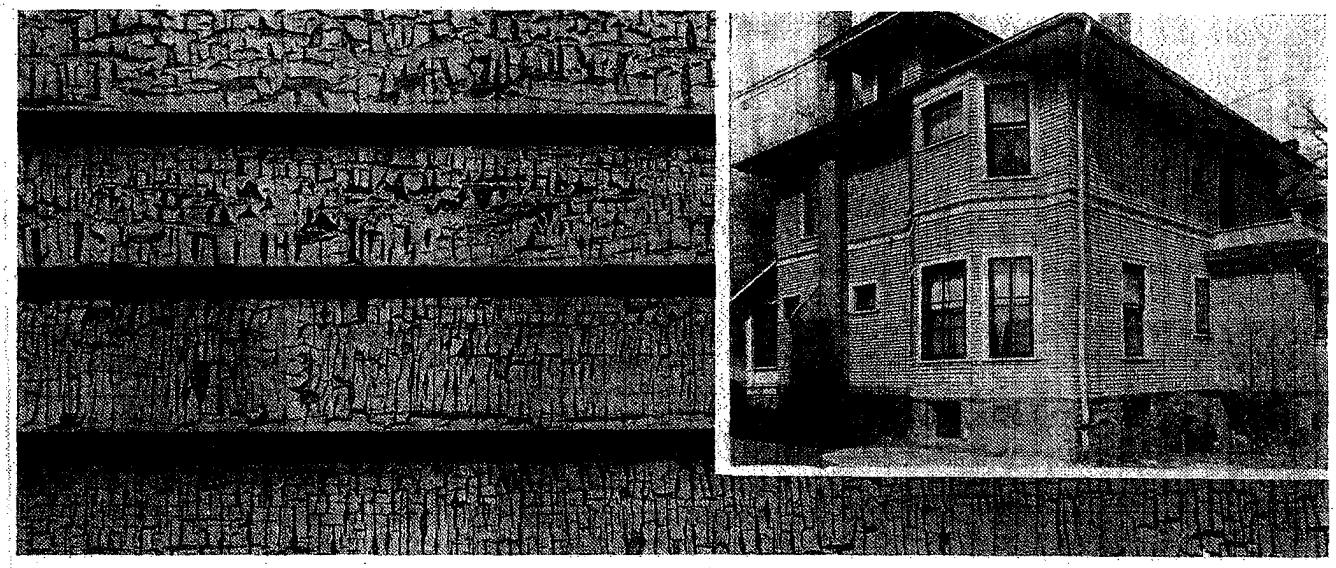
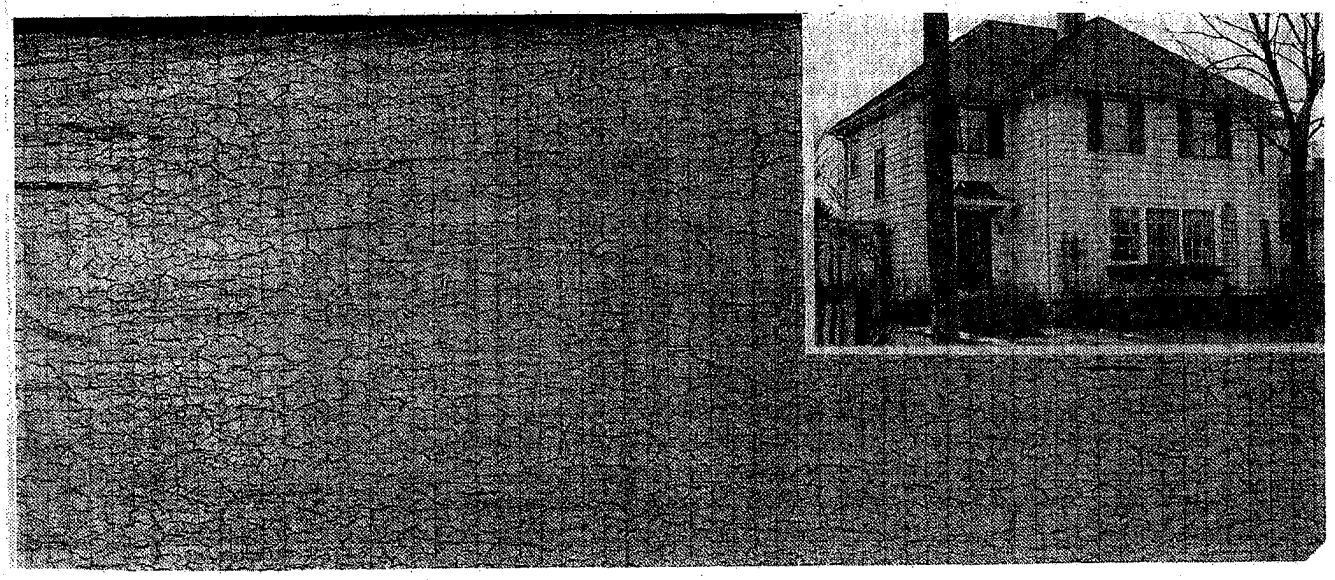


PAINT-NEGLECTED HOUSE NO. 11
A very typical form of failure of white paint applied over paint of dark color.

PAINT-NEGLECTED HOUSE NO. 12
Coarse alligatoring of pure white lead paint applied over old paint of the lead and zinc type.



The articles included in this brochure have been referred to by paint authorities as the most important contribution to the subject of painting wood exteriors yet published. Additional single copies will be furnished without charge. Copies in lots of 100, 500 and 1,000 may be obtained for a nominal sum.

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The Preservative Treatment and Staining of Shingles

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By F. L. BROWNE, Chemist,
Forest Products Laboratory

Most of the wood shingles used at the present time for roofs and side walls of buildings are of Western redcedar. Redwood, baldcypress, and Eastern white-cedar find use to a small extent. The heartwood of these species is resistant to decay. Experience proves that good quality, all-heartwood shingles of these woods give good service without preservative treatment under the ordinary methods of using Shingles in building construction. It is important, however, that the shingles be entirely of heartwood because sapwood is not resistant to decay. Edge-grain shingles are much better than flat-grain shingles because they warp much less and withstand weathering better. Commercial Western redcedar, cypress, and redwood shingles of the No. 1 grade promulgated by the United States Department of Commerce are all heartwood and all edge-grain. For lasting service the shingles should be properly laid and nailed with corrosion-resistant nails. The thickest standardgrade shingles (4/2 have butts 1/2 inch thick and will last longer and give better service than those with butts 0.4 inch (5/2) or 0.45 inch (5/2-¼) thick

Roofs are more severely exposed to weathering and decay than are walls. Only the No. 1 grade shingles are ordinarily recommended for roofs of permanent buildings. Shingles of lower grade may be suitable for side walls if it is more important to minimize cost than to obtain the best appearance. On side walls, however, shingles may be laid with as much as 7½ inches instead of a maximum of 5 inches exposed to the weather and wider shingles may be used on side walls than on roofs. These practices increase the tendency for shingles to curl as a result of weathering. Moreover, a moderate amount of curling that might be unobjectionable on a roof is unacceptable on side walls when the best appearance is desired. For best appearance. therefore, shingles of No. 1 grade should be used for side walls as well as for roofs. Shingles of lower grade may be used for temporary buildings, for the lower layers when shingles are laid in double courses, and for side walls when it is not necessary to maintain the best appearance.

Roofs should have sufficient pitch to make rain water drain off rapidly and to prevent water from melting snow from backing up under the shingles. Roof sheathing may be laid tight or with open joints. Tight sheathing affords better insulation against heat and cold. Open sheathing provides better opportunity for the escape of air-borne moisture entering through leaks. No actual evidence is available to show that the method of laying the sheathing has a noticable effect on the durability of the roof.

Where desired, it is entirely practicable to let shingles of the species named weather naturally without any surface treatment. In a few months the original color of the wood changes to a pleasing gray that blends harmoniously with many color schemes. For shingled side walls as a rule, and very often for shingled roofs, surface treatment to provide color is desired. Good shingle stains generally offer the most satisfactory and economical means of providing color. Stains provide color without gloss and without entirely concealing the grain and texture of the wood, a combination of conditions usually very appropriate for the rough, sawed surfaces of wood shingles. The most satisfactory shingle stains are highly colored, such as brown, green, red or yellow. It is not possible to make a white stain because stains do not entirely hide the color of the underlying surface. There are light gray stains but they are not so durable as paints. For that reason it is common practice, when white or a pale color is desired, to paint shingle side walls. Ordinary house paint may be used for the purpose; two coats of it are required for the first painting, one coat for repainting unless the previous coating has very largely worn away. The finish coat should usually be so mixed as to dry with as little gloss as is possible. Highly glossy paint is inappropriate for rough surfaces. Paste white lead, for example, may be mixed with its own volume of a mixture consisting of one-third linseed oil and two-thirds mineral spirits or turpentine, or the paste may be thinned with its own volume of "lead mixing oil."

When shingles are to be painted, the first coat of paint is best applied before the shingles are laid, so that the backs and butts as well as the faces are well coated. The paint may be applied by dipping the shingles to at least two-thirds of their length in the paint and then standing them vertically until the paint has dried. If the backs are not so painted,

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rain water seeping under the shingles may cause more curling than would otherwise take place and the paint near the butts and edges of cedar or redwood shingles may be discolored by water-soluble dyes extracted from the wood. The finish coat may be applied by brushing or spraying after the shingles have been laid, but care should be taken to see that the exposed butt ends are well coated with the finish paint. Good paint coatings on shingle walls usually should last about 5 years, after which the paint should be renewed, again seeing that butt ends of shingles are well painted.

Painting is not recommended for shingle roofs. Because of the sloping position of shingles on a roof, more water penetrates beneath shingles and it stays there longer than is the case on side walls. Moreover, painting or repainting after the shingles have been erected tends to build little dams of paint across the bottom of the gaps between shingles, which on roofs adds to the amount of water backed up under the shingles while the paint coating on the exposed wood surfaces retards the rate of subsequent drying out of the moisture. Painting shingle roofs, therefore, tends to increase cupping and the chances for decay to set in. Stains are not subject to these disadvantages and may properly be used on shingle roofs.

Commercial wood shingles can be purchased already stained, or they can be bought unstained and stained on the job. The commercially stained shingles have the advantage of convenience and may prove to be more uniformly and durably stained, but at times requirements of availability, grade of shingles, special color, or price may make it desirable to buy unstained shingles and stain them on the job. Staining on the job is done to best advantage by dipping the shingles one by one to at least two-thirds of their length in the shingle stain and standing them up nearly vertically to drain and dry. It is also practicable, as far as decorative effect is concerned, to apply stains by brush or spray gun after the shingles are laid. Stains, even though they contain preservatives, applied to a completed roof can have little effect on decay resistance for they do not reach the hidden surfaces between the shingles where decay is most likely to develop.

Shingle stains can be purchased in ready-mixed form or they can be mixed on the job from the necessary ingredients. Some commercial shingle stains contain coal-tar creosote in addition to other ingredients, for the purpose of imparting protection against decay. If the shingles are entirely heartwood of cedar, cypress, or redwood there is little need of toxic chemicals in the stain. On the other hand, shingles containing sapwood or of species not resistant to decay require more effective treatment than superficial application of creosote stains, if good durability is to be assured, at least when they are used for roofs. There is, however, no objection to the use of coal-tar creosote in stains for durable woods provided that it does not displace more necessary ingredients, such as linseed oil, and provided further that there is no thought of painting the shingles at some subsequent date with white or light-colored paint. Coal-tar creosote remaining in shingles may discolor paint even several years after the creosote stain was applied.

The most important ingredients of shingle stains are linseed oil and pigments of suitable color. For stains to be mixed on the job the pigments should be bought in the form of colors ground in linseed oil, which are obtainable from nearly all retail paint dealers. Pure colors of highest quality only should be used. They should contain no "inert" or "extending" pigments, such as china clay, barium sulfate, silica, or magnesium silicate. The higher cost per pound of the pure colors is more than offset by the smaller amount that need be used and the greater durability of the stain. For good durability the liquid part of the stain should be at least one-third and may well be two-thirds linseed oil. The remainder of the liquid may be volatile thinner such as turpentine or mineral spirits, coal-tar creosote, or a mixture of volatile thinner and creosote. Ordinary coal-tar creosote as used for wood preserving has a brown color that makes it unsuitable for stains of bright colors. For that reason makers of "creosote shingle stains" often use a light-colored, relatively volatile fraction of creosote that makes stains of bright color; but it is doubtful whether such "creosote" stains retain effectiveness against decay very long. Used automobile crank-case oil, sometimes suggested for use in home-mixed stains, has none of the toxic properties of creosote, but usually shares with creosote the disadvantage of dark color. Crank-case oil can be used to replace some of the volatile thinner in shingle stains of dark color, but no advantage other than a trifling saving in cost can be obtained thereby. Crank-case oil must not be used as a substitute for any of the linseed oil.

The amount of color-in-oil to be mixed with the liquid varies with the nature and quality of the colors and must be determined by trial. The following formulas for guidance, which are from the *Handbook on Painting* by the National Lead Company, give the amount of colors in oil required for each gallon of the liquid mixture to produce some of the more common colors:

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Gray—12½ pounds white lead and touch of lampblack.
Deep red brown — 1 pint Indian red.
Bright red — 1 pint Venetian red.
Permanent green — ¾ pint chromium exide.
Fairly permanent green — 1½ pints medium chrome green.
Golden brown — ¼ pint raw Italian sienna and ¾ pint burnt Turkey umber.
Seal brown — 1 pint raw Turkey umber.
Deep brown — 1 pint burnt Turkey umber.

Shingle stains are sometimes used on bevel siding. For the most attractive results it is best to attach siding that is to be stained with the sawed side rather than the planed side exposed to the weather.

Stains, particularly those of the deeper colors, last even longer than good house paints, especially when applied on rough surfaces such as the split or sawed surfaces of shingles. Good stains should last at least 5 years on shingle roofs and at least 8 years on shingle walls or the sawed side of bevel siding. The stains, however, will eventually wear and and must then be renewed if the original color is to be restored. Fresh stain can be applied by brushing or spraying; it should again last at least as long as the first staining did.

After stain has worn out on shingle walls it is often practicable to paint them if paint is desired instead of fresh stain. If the original stain, however, contained creosote there may be question whether it will discolor white or light-colored paint. The tendency for creosote to discolor paint gradually diminishes during exposure to the weather, especially if the creosote was applied superficially by dipping, brushing, or spraying. After 4 or 5 years, such creosote-stained shingles can often be painted satisfactorily but there is a problem of determining whether that stage has been reached. The best way to tell is to try painting a few shingles, preferably on an inconspicuous part of the house and on the area that receives least sunshine. If the paint remains free from discoloration for as much as two weeks, it is safe to paint all of the shingles. An additional test on a few shingles may be made by applying one coat of aluminum house paint followed by two coats of white or light-colored paint. Sometimes aluminum paint will prevent discoloration where ordinary house paint will be discolored.

Exposure to the weather tends to make shingles curl, although with commercial shingles of best quality the amount of curling should be unimportant. Cedar, cypress, and redwood usually curl less than most other woods. With any wood, there is less curling of edge-grain than of flat-grain shingles and less curling the thicker and narrower the shingles and the shorter the length exposed to the weather. Curling is especially marked in dry climates or in spells of very dry weather. Ordinary staining of shingles probably has little effect on their curling, though the thorough treatment of sapwood shingles with creosote or with water-repellent preservative, discussed farther on in this report, probably reduces curling appreciably. On walls, painted shingles, if well primed on the backs before laying and if the paint coating is well maintained, curl less than similar unpainted shingles.

In some parts of the United States it is believed that superficial application of creosote, of linseed oil, or even of spent crank-case oil will keep shingles from curling. Thorough treatment of sapwood shingles with any of the oils mentioned probably would delay curling for a long time, especially if further applications of the oil were made every few years for maintenance. At the Forest Products Laboratory it is doubted, however, that superficial application of any of these oils to heartwood shingles of cedar, cypress, or redwood materially reduces curling.

Once serious curling has taken place, no material is known that can be applied to straighten the shingles out again. Some improvement can be effected by face nailing the badly curled shingles, allowing the shingles to split as the wider ones will, but the large nail heads will be left showing.

Treatments for Shingles of Less Desirable Woods

Where building materials are purchased from the customary retail channels, it is rarely advisable to consider anything but the heartwood of durable species for shingles to be used on roofs. For walls, shingles of cheaper grade may be used because there is little chance of decay, though the cheaper shingles cannot be expected to lie so flat and maintain so good an appearance as the better ones will do. In rural communities, however, it sometimes proves desirable to build with locally grown woods, none of which may provide naturally durable shingles. Shingles of the less desirable woods may be expected to curl more and present somewhat less satisfactory appearance than shingles of the best woods; for that reason, shingles of the inferior woods probably should not be more than 6 inches wide and should not be made less than ½ inch thick at the butts. It is usually sufficient to dip such shingles for walls in suitable wood preservative or in stains that contain coal-tar creosote, but for roofs more adequate preservative treatment is necessary. Impregnation of the shingles by pressure treatment is not practicable unless there is a treating plant within reach,

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but many woods can be given a reasonably thorough treatment by the hot-and-cold-bath method, with equipment that can be easily improvised. For such treatment sapwood shingles are preferable to heartwood because sapwood takes treatment more readily. The shingles should be in an air-dry condition before treatment, because green or wet shingles will not absorb enough preservative in the hot-and-cold-bath method.

The effectiveness of coal-tar creosote as a preservative for wood shingles has been well established by practical experience. Because of the difficulty of making bright-colored stains with creosote of dark color, the time may be ripe to consider preservatives for shingles based on more recently developed fungicides that impose less limitation on the color of stains made with them. Although they have had little use in the treatment of shingles, oil solutions containing, for example, either 5 per cent pentachlorophenol or copper naphthenate equivalent to not less than 0.5 per cent copper metal are promising preservatives and can probably be used effectively for that purpose. The oil solvents or carriers used in these treating solutions must be carefully selected to meet special requirements such as compatibility with shingle-staining materials, freedom from bleeding, and suitability for heating to the temperatures required in hot-and-cold-bath process. For the present, however, the only procedures that can be recommended are those involving creosote; preservative staining treatments using the newer fungicides can be suggested only on an experimental basis to be verified by practical experience.

The hot-and-cold-bath method of treatment requires two tanks for creosote or stain, one of which is equipped for heating the liquid to 212° F. The best method of heating is with steam coils, because there is then little danger of setting the oil afire and the temperature can be maintained more uniformly. Fairly light galvanized iron tanks with joints riveted and soldered will do if the heating is done with steam coils. If the heating must be done by direct fire underneath, the tank for the hot bath must be heavy enough to withstand the flame, say 3/16 inch black iron, with the joints welded or riveted and caulked. Unless the tank for the hot bath is to be used for treatment of fence posts or other timbers also, it need be only large enough for the immersion of a single bundle of shingles. If more than a few bundles of shingles are to be treated at one time, the old bath should have capacity for at least four bundles, because they may have to remain in the cold bath as much as four times as long as they do in the hot bath. There must be some arrangement for submerging the shingles and separating them from each other so that the stain can gain uniform contact with the surfaces and color them evenly. The best way to accomplish this is to open the bundles and put the shingles in screen-wire baskets of suitable design. It is best to have the shingles stand on the butt ends in the treating baths, particularly in baths containing pigments. Such baths must also be stirred frequently to keep the pigments in suspension.

In commercial shingle-staining operations special staining machines are in use in which the shingles can be stained with suitable stains without opening the bundles. It is doubtful whether these machines could be used with some of the stains to be described, but in any event they would hardly be available at places where the use of shingles that require preservative treatment can be recommended.

Experiments at the Forest Products Laboratory by the procedures described in the following paragraphs resulted in reasonably satisfactory penetration and retention of coal-tar creosote and good staining of sapwood shingles of ponderosa pine. The stained shingles were exposed to the weather on a test fence at Madison, Wis., from February 1935 to September 1938. The stained shingles retained their colors well during the test period, but the appearance was somewhat marred by a certain amount of exudation of creosote during hot weather in July and August of 1935. Although the performance in that respect was inferior to that of commercially stained cedar shingles, it was considered reasonably acceptable. The sapwood shingles did retain an over-all bright appearance of the chosen color and at the same time they contained enough preservative to ensure reasonably long life. The mottled effect caused by exuded creosote was not considered seriously unattractive for shingle roofs. When sapwood shingles must be used, the procedure makes a variety of colors available without sacrificing durability to gain color.

In these treatments the hot bath consisted of coal-tar creosote of the kind generally used for commercial impregnation treatments of railway crossties and telegraph poles. The shingles were submerged in the hot bath at 212° F. for ½ hour, after which they were quickly submerged in stain at room temperature for 2 hours. They were then stood on the butt ends to drain and to permit the stain to dry.

The stains were made from colors-in-oil, boiled linseed oil, and mineral spirits. The colors-in-oil had the following composition:

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shingles were sub-
F. for ½ hour, after
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colors-in-oil, boiled
The colors-in-oil

		linseed oil by weight
Iron oxide red	72.5%	27.5%
Iron oxide yellow	56.2%	43.8%
Ferrite yellow	60.5%	39.5%
Vandyke brown	66.0%	33.4%
Chrome green	80.0%	20.0%

The iron oxide red, iron oxide yellow, and ferrite yellow were all pure, manufactured iron oxide pigments containing more than 95 per cent iron oxide by weight. The chrome green was a so-called C. P. green consisting entirely of chrome yellow and Prussian blue with no extending pigments. The Vandyke brown was a natural earth pigment.

The five stains used in the experiments had the following compositions:

1. Chrome green in oil ..... 1.5 pounds
   Boiled linseed oil ..... .67 gallon
   Mineral spirits ..... .33 gallon
2. Iron oxide red in oil ..... 1.5 pounds
   Boiled linseed oil ..... .67 gallon
   Mineral spirits ..... .33 gallon
3. Vandyke brown in oil ..... 1.5 pounds
   Boiled linseed oil ..... .67 gallon
   Mineral spirits ..... .33 gallon
4. Ferrite yellow in oil ..... 1.5 pounds
   Boiled linseed oil ..... .67 gallon
   Mineral spirits ..... .33 gallon
5. Iron oxide yellow in oil ..... 1.0 pound
   Boiled linseed oil ..... .67 gallon
   Mineral spirits ..... .33 gallon

These stains do not dry rapidly, but inasmuch as a stain is more or less absorbed by the wood, rather than a coating over the wood, rapid drying is not usually necessary. The shingles can be handled and laid without undue inconvenience before the linseed oil is thoroughly dry. Drying probably can be hastened somewhat by adding one-half pint of liquid paint drier to the above formulas.

For dark brown stains it is practicable to substitute creosote for the mineral spirits in the above formulas and thereby increase the amount of creosote retained by the shingles. On the other hand, if a browm color is desired it is possible to omit pigments altogether, in which event the cold bath consists of exactly the same creosote used for the hot bath. Such treatment with creosote alone is safer than any of the stains suggested where maximum preservation against decay is more important than bright colored shingles.

Detailed description of hot and cold bath treatment and other nonpressure treatments will be found in Farmers' Bulletin 744, "The Preservative Treatment of Farm Timbers," which may be obtained from the Forest Products Laboratory, Madison 5, Wis., on request.

The traveling man's eyes bulged when he entered a small general store in a distant community and saw a dog, seated in a chair, pushing discs about on a board with his front paws.

"You mean to tell me," he inquired incredulously, "that your dog is playing checkers?"

"Sure," replied the proprietor, "I learned him."

"Why, man, do you know what you've got there?" asked the salesman. "You could go into vaudeville and clean up a fortune with a dog as smart as that."

"Oh, I don't know," sniffed the storekeeper. "He isn't so smart. I beat him the last three games."

Stranger: "I noticed your advertisement in the paper this morning for a man to retail imported canaries."

Proprietor of Bird Store: "Yes sir. Are you looking for a job?"

Stranger: "Oh, no; I merely had a curiosity to know how the canaries lost their tails."

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Campbell - Lowrie - Lautermilch Corporation

400 West Madison Street
Daily News Building

Telephone Randolph 1606

BUILDERS

CHICAGO, ILLINOIS

Murphy Products Company

FEEDS THAT BALANCE
HOME GROWN RATION

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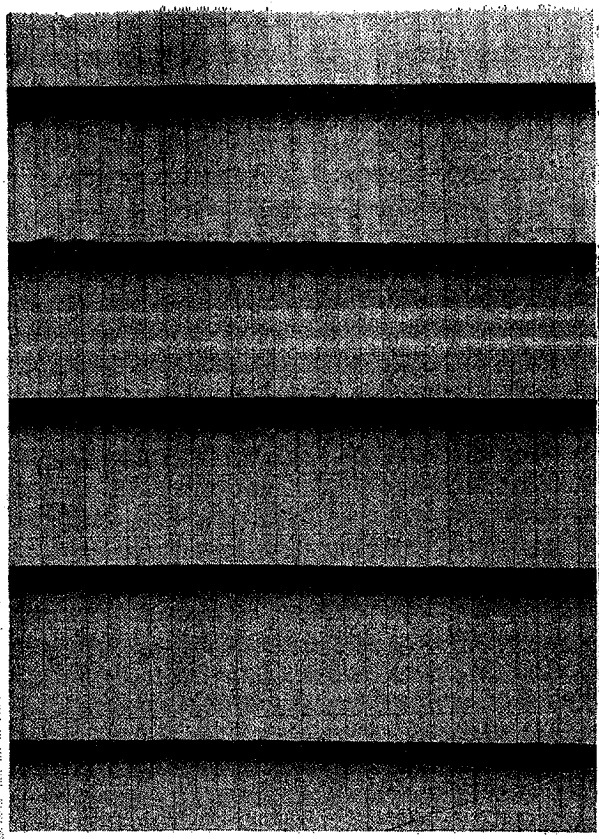

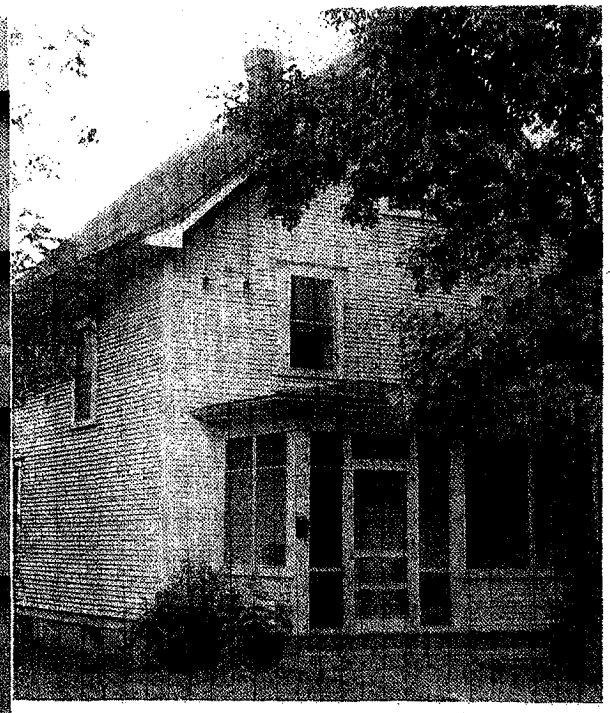

SUCCESSFUL MAINTENANCE WITH WHITE LEAD PAINT: House 27 years old. Painted only four times, last time five years ago. Only a soft type of paint is suitable for such long intervals between paintings. (House No. 18 in Dr. Browne's experimental series.)

National Painters Magazine
March 1936
April 1936
May 1936
June 1936

How Painters Can Prevent Painting Complaints --- No 1

Examining Condition of the Old Paint

By F. L. BROWNE

First article in a new series by Dr. Browne, Senior Chemist of the Forest Products Laboratory, maintained at Madison, Wisconsin, by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Wisconsin.

FAR too many jobs of house painting fail to give reasonably durable service, even though good paint has been applied by honest painters. When failure takes place within a year or two after application, as it often does, the house owner generally makes a complaint and asks for redress. An argument usually follows, in which painter, paint dealer and paint manufacture each try to pass the responsibility to one of the others or to some other interest, such as the lumber dealer, carpenter or general contractor. In many cases a settlement is made, in which the painter is put to some loss, perhaps for the labor of applying new paint furnished by the manufacturer. While just settlement of such complaints is important, no settlement completely restores the house owner's confidence in the painter's craftsmanship. It is much more important for the painter to learn how to prevent such complaints from occurring at all.

In addition to these early failures about which complaints are made, there are many jobs that last long enough to keep the house owner from complaining, but not long enough to keep him from feeling dissatisfied. In the aggregate, the proportion of unsatisfactory paint jobs is large enough to seriously undermine public confidence in paint and painters and to lead many house builders to use unpainted materials merely to avoid the uncertainties of painting exterior woodwork. Painters, therefore, are vitally concerned with the problem of reducing the number of unsatisfactory paint jobs in order to safeguard the future of the painting business.

If the painter is to take any steps at all toward protecting himself and his customer against early paint failures he must take them before the new paint is applied. For that reason the preliminary examination of a house for estimating should consider much more than the matters of how much paint and labor will be required for the job. The painter should use this opportunity to learn as much as he can about the previous history of the house with respect to paint and

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National
PAINTERS MAGAZINE
PAINTING AND DECORATING
12 Gold Street • New York
MARCH, 1936

Gordon P. M

What Painting Industry Wants: An End to Federal Competition and Recognition of Responsible Contractors

WHAT the painting industry wants, as indicated by action taken at the fifty-second annual convention of the International Society of Masters Painters and Decorators, Inc.:

1: An end to Federal competition with various units of the Construction Industry—of which painting is one of the largest—because it is a menace to private enterprise...and that steps be taken by the government to restore confidence by utilization of normal, private channels of construction.

2: An end to "the threat of pending legislation which would further undermine the Construction Industry..."

3: A continuation of Title I of the Federal Housing Act for one year, because "it has been of such benefit to the painting and decorating industry."

4: A continuation of intensive publicity and advertising, so that home and property owners may be made aware of the dangers of paint neglect...and of the economic wisdom of using competent and reliable contractors, skilled mechanics and quality materials...and so that they may be informed of the payment out of income plans now available for painting and decorating jobs.

5: A restoration of "the painting business into the hands of the painting contractor and profit into the painting job"...A stronger organization...A continuation of the study of the License Law question for the benefit of those states desiring such type of legislation...Cooperation with allied trade groups . . . Cooperation with labor.

6: Development of the League of Master Decorators "to provide for its sponsors the benefits of a well-rounded decorative service."

Gordon Marshall Named President

CONVENING in the Palmer House, Chicago, on February 18, with President John B. Dewar, of Pittsburgh, in the chair, all phases of business, technical and artistic problems were handled in the four-day convention, which elected Gordon P. Marshall, of Boston, to succeed Mr. Dewar. Mr. Marshall is head of the H. Newton Marshall Company, nationally known painting contractors, formerly was a member of the code authorities of both the painting and the construction industries and has been representative of the International on the Construction League of the United States. His study and work in behalf of the industry have won him recognition throughout the country.

Three Vice-Presidents were chosen—Henry Afman of

Continued on Page 36

Mr. Marshall's First Message

TO ALL PAINTING CONTRACTORS:

DO YOU know that every hour of the day a great organization is working to protect your individual interests and to advance the business of painting and decorating through which you earn your living?

Do you know of its efforts to show the public, through advertising and publicity, that the maximum economy and value in preserving and beautifying property comes by employing expert painting contractors.

Do you know of its fight to end government competition with your business, of its battle to stop painting on public works by the day labor method, and of its success in having millions of dollars of painting shifted to the contract method, with open bidding?

Continued on Page 34

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Gordon P. M

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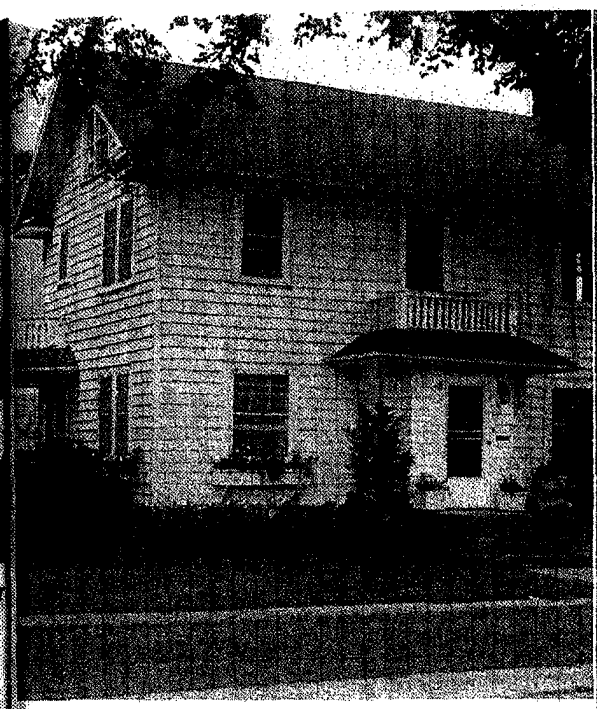

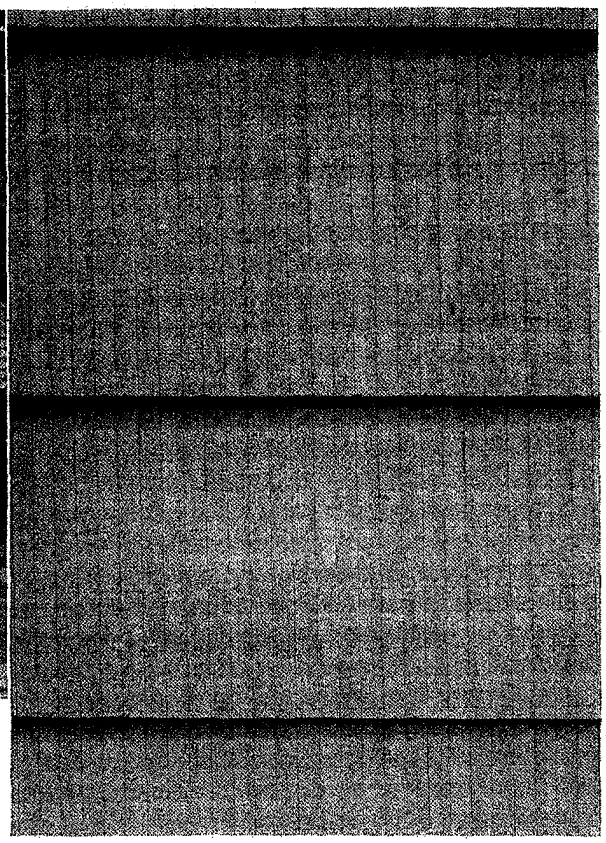

SUCCESSFUL MAINTENANCE WITH HARD PAINTS: House built in 1924. Painted with two coats of white lead Paint. Repainted with one coat of titanium and zinc paint in 1927, again in 1931. Photos taken in 1935 just before repainting again. Hard paints can be maintained well for long periods if repainting is done before old coating breaks up and if only necessary amount is applied. (House No. 19.)

to search carefully for conditions that might lead to unsatisfactory service of the new job or guide him in choosing the proper type of paint. It is also well worth while for him to keep a written record of his observations because a record made beforehand may place the painter in a very advantageous position if difficulty develops later.

It should constantly be borne in mind that the practice of painting suffers from a division of responsibility that leaves no one in a position to control all of the factors upon which successful results depend. The paint manufacturer cannot as yet make any one paint that may be used safely on all surfaces and for all maintenance programs. The painter can ruin any paint by faulty application and can often obtain good results with poor paint by skillful application, but he cannot determine when the surface is to be repainted; often is not permitted to prepare the surface as he knows it should be or to apply the necessary number of coats, and is often asked to apply paints whose composition and properties he does not know thoroughly.

The customer usually decides the very important question of when the surface shall be repainted, and often sets cost limitations that determine how much preparatory work can be done. Since there is rarely an adequate meeting of minds on the part of the three principal interests in a specific paint job, it is not surprising that the cooperation upon which success depends is often lacking, and the outcome is therefore something of a gamble. Of the three interests, the painter is in the best position to reduce or even eliminate the gamble, but the most difficult and important part of his work to that end comes before a brushful of paint is applied to the job.

In his first survey of a paint job the painter should gather as much information as possible about these three subjects:

First, the past history of the house with respect to painting.

Second, the owner's ideas of good paint service.

Third, the present condition of the surfaces to be painted.

Knowledge about these three subjects is essential for proper planning of the new job.

Past History of the Job

From the past history of the job the painter needs to learn the kinds of paint used previously, how long they lasted, and how they failed or wore out. This information is needed to determine whether the house is one on which paint behaves normally or abnormally, how long the owner expects to wait between paint jobs, and what sort of paint may be used safely for the new job. If there are signs of abnormal paint behavior, the cause of it must be investigated before a conscientious painter can afford to accept the job.

Very often the owner does not know what kind of paint was used previously or, still worse, he may report it incorrectly either from mistaken memory or because the previous painter misinformed him. A very common cause of misunderstanding arises from the loose use of the term "white lead paint" or "lead and oil paint." These terms should mean only linseed oil paint, in which the pigment consists entirely of basic carbonate or basic sulfate white lead, except for such added tinting colors as may be necessary to provide the desired color. They should not be used when there is zinc oxide, whether added by the paint manufacturer or by the painter.

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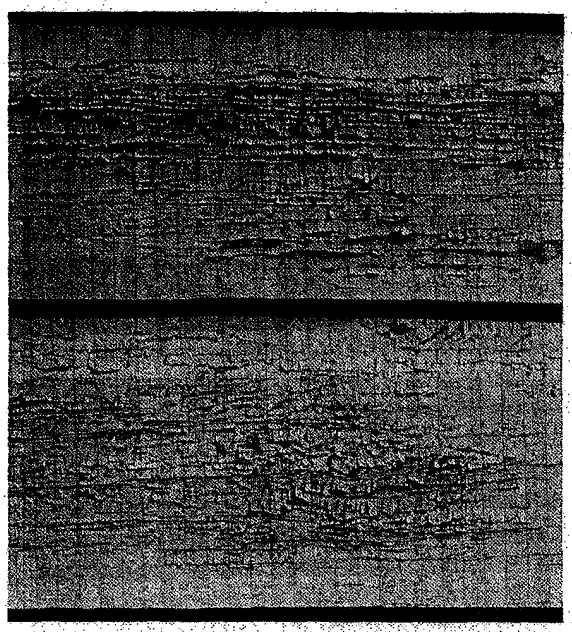


RESULTS OF REPEATED NEGLECT OF HARD PAINTS: Old farm building painted many times, always with paints of fairly hard type, but each time the old coating was allowed to flake badly before new paint was applied. Good paints have always been used by good painters, but for this type of maintenance program only a soft paint like white lead paint is suitable. (House No. 15.)

Unfortunately, some persons use the term "lead and oil" to describe any paste paint that is reduced for application by the painter, and others apply the term "white lead paint" to any paint that contains an appreciable amount of white lead. For these reasons the painter should accept the owner's statement of the composition of the previous paints, only subject to confirmation by his own inspection of the job.

Owner's Ideas of Paint Service

Too often the painter forgets that it is the owner who must be satisfied by the paint job, and the paint therefore should be the kind the owner likes, rather than the kind the painter likes. What the owner really wants is best determined by what it was that led him to have the house repainted and what qualities of the old paint he recalls with favor or disfavor. Very often the owner thinks that there is somewhere a magic paint that has all the merits he wishes and none of the disadvantages to which he objects. The painter knows that no such paint exists.

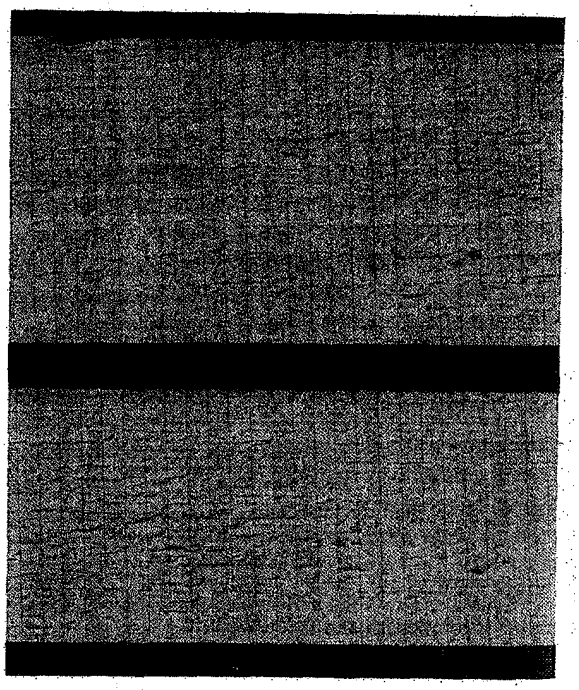
If paint is to be selected for the best possible appearance during its early life, it must usually be a paint that requires repainting before it begins to break up badly. If the owner wishes to be free to repaint when it is convenient, even though the surface may remain neglected for some time, he may have to be content with less satisfactory appearance during the early life of the job. The paints used previously may set limitations on the kinds of paint suitable for the new job. A clear understanding of the extent to which the owner must be responsible for important decisions should be reached before the job is undertaken.

It is not possible to analyze an old paint merely by looking at it, of course, but enough can usually be learned by careful inspection to tell the general class of paints to which it belongs, to check the owner's statement of its composition or brand and, if its age can be established approximately, to determine whether paint behaves normally or abnormally on the house. To do so the painter must learn to recognize the characteristic normal behavior of the different types of paint on the market.

Whenever a paint fails to follow its normal course of behavior or passes through it too quickly there are abnormal conditions to be discovered and rectified before new paint of any kind can be expected to give its customary service. The nature of the abnormal paint behavior often suggests the cause of the difficulty. In some cases the necessary corrective measures can be taken. In others correction may be difficult or impracticable or the owner may be unwilling to make it, but in any case the painter who knows how to make the old paint tell its own story, and takes the owner fully into his confidence in the matter before he accepts the job, will rarely find his good name jeopardized by complaint about unsatisfactory service of his jobs.

In a subsequent article the writer will discuss more specifically the sort of information the painter should collect during his preliminary survey of a prospective job and how to use it in planning his work. The discussion will make use of the illustrations of houses involving paint difficulties that appear in this issue and in the issues of April, May and June, 1935.

WHY HARD PAINTS MUST BE REPAINTED BEFORE THEY FLAKE BADLY: This house was repainted less than a year ago but the previous paint, of a hard type, had been allowed to flake badly before repainting. Surface was thoroughly wire-brushed, but new coating is not smooth and is already beginning to crack. It will flake again much too soon. (House No. 14.)



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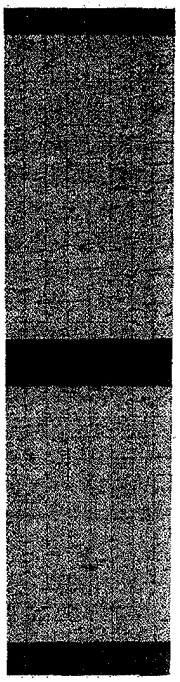

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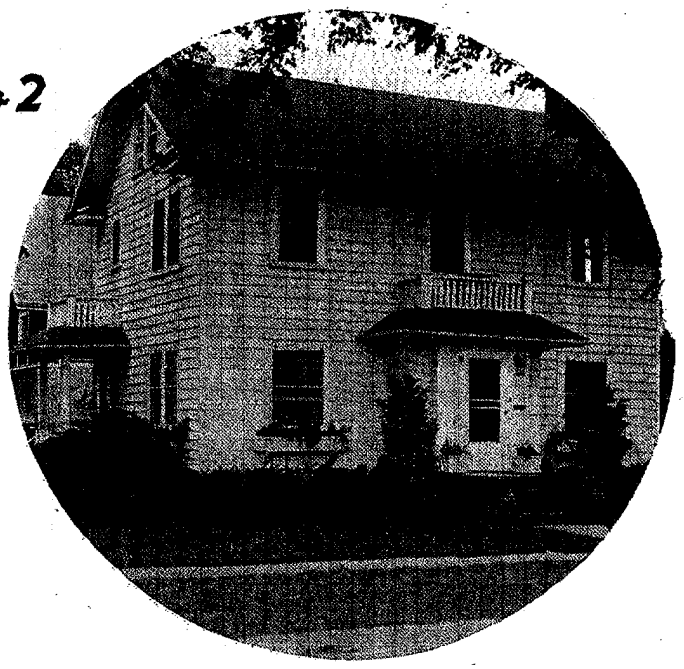
How Painters Can Prevent Painting Complaints --- No 2



Keeping A Written Record of All Painting Jobs

By F. L. BROWNE

Second article in a new series by Dr. Browne, Senior Chemist of the Forest Products Laboratory, maintained at Madison, Wisconsin, by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Wisconsin.

A FILE containing an adequate written record of the painting history of all jobs on which he bids can be of great help to a painter in several aspects of his business. The following are some of the uses that can be made of it once it has been in operation long enough to serve its purposes:

1. It is an ideal prospect list for future contracts for repainting. The painter knows beforehand when the surfaces should be due for more paint and when it will be worth while for him to remind the owner of that fact. Those jobs that he won in the first place should be easy to win again and those that he lost the first time are still worth another attempt.

2. The painter's successful jobs make a convenient list from which to select examples of his work to which prospective customers can be referred. Paint manufacturers are using houses painted with their paints to promote their sales and painters can well afford to copy their example.

3. Even jobs on which the painters' bid is unsuccessful may prove useful at times. When, for example, a customer whose house is due for repainting feels that the work can be put off a year or two longer the painter's advice will be far more effective if he can point out two or three houses, like Nos. 14 and 15 in the March, 1936, issue of National Painters Magazine, on which paint of the kind in question has been neglected too long. Moreover the painter will soon find that the practice of studying the history of paint jobs wherever possible will greatly increase his own knowledge of paint and explain many things that previously seemed unaccountable.

4. If subsequent difficulty arises with a paint job for which the painter made an adequate record the record may establish the sincerity of the painter's explanation by showing that his opinion is not a mere excuse invented after the difficulty arose. Very often the owner has forgotten that the previous paint blistered and scaled, for example, but the painter's record made before he took the job may well settle that part of the dispute.

The items to be included in recording the painting history of a house can be explained to best advantage by considering some of the houses already illustrated in this series of articles. As a rule the record should be made while going over the job to prepare cost estimates but we are not concerned here with the problems of estimating. Let us suppose that the painter is preparing to bid for repainting House No. 19, on page 11 of the March, 1936, issue. This is an unusually simple example because the owner is able to furnish all the necessary details accurately. Ficti-

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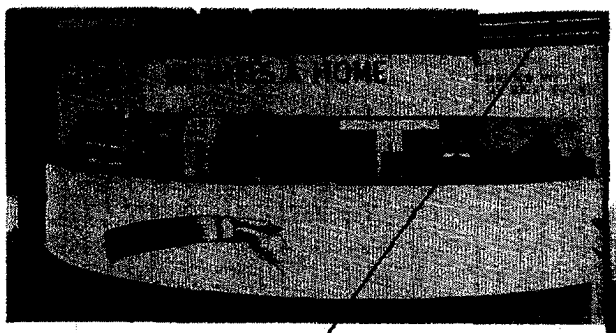
12 Gold Street • New York
APRIL, 1936



Typical paint exhibit in one of the FHA National Hom Shows which are being held throughout the land and whic are developing much business under provisions of Title of the Housing Act.

FHA Title I, Aid to Painting, Is Extended

EXTENSION for another year of the Federal Housing Administration's program of financing painting, repairing and remodeling of homes and business properties was approved by Congress in an eleventh-hour action.

This program, Title I of the Federal Housing Act, would have expired April 1, but a bill extending it for another full year was agreed upon by both Senate and House March 31 and rushed to President Roosevelt for his signature. The FHA immediately announced that its rules and regulations under this title will continue in effect except for the necessary changes.

Loans for Flood Victims

Extension of Title I will be good news for home owners in the areas which were devastated by recent floods, and for painting contractors as well, inasmuch as loans under its terms will be available to victims of the flooded rivers. The houses were damaged, not destroyed, and therefore are eligible risks. Paint, new foundations, new roofs, replacements, practically all major destruction wrought by the floods can be repaired under the terms of Title I.

(Congress is now considering measures to permit banks and other lending agencies to make insured loans in the flooded areas on special terms, but final action has not yet been taken.)

An interesting national broadcast on Title I as amended and extended was given on April 7 over the NBC network by L. R. Gignilliat, deputy administrator of the FHA, and Ernest T. Trigg, president of the National Paint, Varnish and Lacquer Association. The broadcast was in the form of questions and answers and among the highlights brought out by Mr. Trigg and Mr. Gignilliat, are the following:

1. FHA has insured almost a million different loans under title one, amounting to $327,000,000.
2. It has been estimated that the total value of construction work stimulated by FHA, activated under title one, is about $1,500,000,000.
3. The changes made in the law are based on the experiences of the FHA during the year and a half of operation.

Basically the Same Law

4. The most important conditions of the law remain the same. Eligible borrowers can still borrow up to $2,000 to improve homes and farms and other types of property and up to $50,000 for improvements to special types of property, such as manufacturing and industrial plants, stores and shops and so forth. Borrowers still have as long as five years to pay and the charges for these loans still cannot exceed a set maximum established by our regulations.
5. One new thing is that loans can be made only for improvements on property on which there is a completed structure. You cannot build a new home as you could under the original Title I. New construction is provided for in the Insured Single Mortgage System of the Federal Housing Administration, which is a long term program and which was not affected by the new legislation.
6. To be eligible for a modernization credit loan, you must either own the property, or you must hold a lease on it running for at least six months longer than does the loan itself. A person with a short term lease is not eligible for modernization credit.'

Continued on Page 52

Join Fight on "Jerry Builders" and "Paint Pot Jobbers"

Help the Federal Housing Administration, the construction industry—and yourself—by joining in the fight against "Jerry Builders," those racketeers who use poor materials and unscrupulous methods. Warnings are being posted all through the country. The FHA, aroused by reports of the activities of "Jerry Builders" now that there is an upturn in residential building, urges all persons using the Modernization Credit Plan or the Mutual Mortgage Insurance Plan to "give careful scrutiny to all bids for work submitted to them by contractors and builders"....To that official warning should be added a denunciation of the "Paint Pot Jobber," the man who poses as a painting contractor and who uses the same chiseling tactics to defraud the American home owner and to cheat legitimate contractors out of their business. Responsible painting and decorating contractors can be of great service to their country, their communities and themselves by helping in the fight against this type of racketeering.

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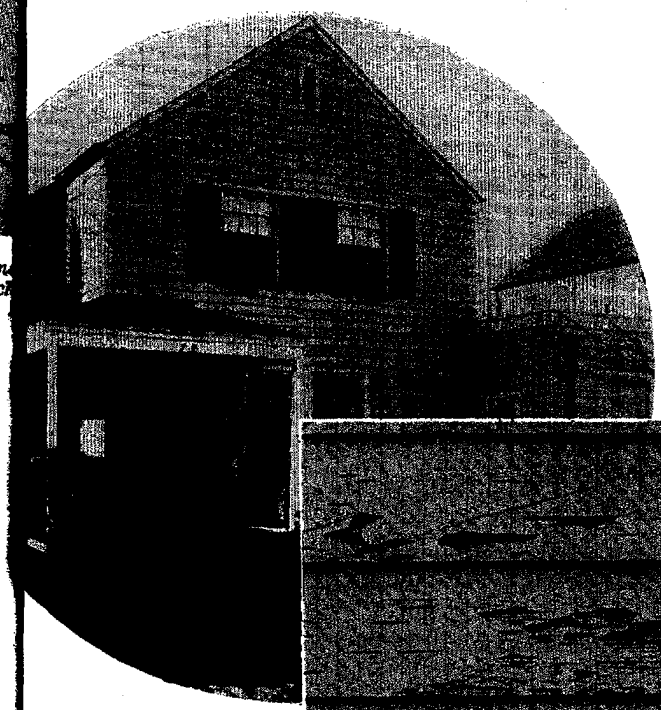
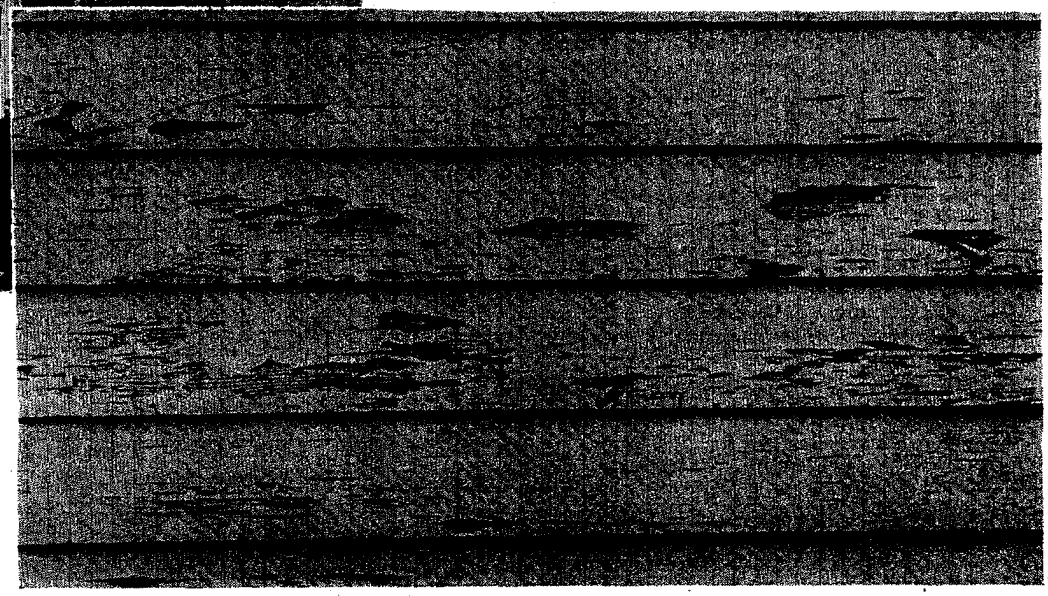


ON OPPOSITE PAGE: House No. 19 in Dr. Browne's series of tests, discussed in his articles in this and last month's issue.

ON THIS PAGE: House No. 16—A Typical Moisture Failure. This house was erected and the painting completed in February, 1929. Repainted in the summer of 1930 following failure of the first job. Photograph taken in the summer of 1931.



tious names and addresses are used in the discussion for obvious reasons.

A Typical Painting History

Owner:

James R. Black.

Address:

123 E. Belmont St.

City:

Mytown.

INFORMATION SUPPLIED BY OWNER:

House Erected:

Fall of 1923 to spring of 1924.

Materials Painted:

Cypress siding, redwood and ponderosa pine trim, ponderosa pine doors and windows, southern pine stair treads and porch floor at kitchen entrance, galvanized iron gutters and downspouts, sheet metal porch roofs and flashing, iron screen wire.

Initial Painting:

Two coats of lead and oil on siding, trim, doors and windows except screen door leading to roof over sun parlor, which had two coats of spar varnish. Stair treads and porch floor at kitchen entrance, two coats of lead and spar varnish tinted gray. Gutters and downspouts, two coats lead and oil. Metal roofs and flashing, two coats of iron oxide paint with spar varnish. Screen wire painted with black enamel by manufacturer.

Repainting:

In September, 1927. Siding, trim, windows, doors, gutters and downspouts painted with one coat of Brand A semi-paste paint thinned with one quart of linseed oil and one quart of turpentine per gallon and applied at 550 square feet per gallon. Brand A contained 70 percent pigment, composed of 70 percent titanium, 20 percent zinc oxide, 10 percent asbestine, and the liquid consisted of 90 percent linseed oil and 10 percent thinner and drier. Stair treads and porch floor at kitchen entrance painted

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with Brand B long-oil enamel with iron oxide red pigment. Metal roofs and flashing painted with Brand C iron oxide red linseed oil paint. Screen wire painted with zinc dust and zinc oxide paint.

In June, 1931. Siding, trim, windows, doors, gutters and downspouts painted with one coat of Brand D prepared paint applied at 600 square feet per gallon. This paint contained 60.9 percent pigment, composed of 60 percent titanium, 30 percent zinc oxide, and 10 percent asbestine and the liquid consisted of 81 percent linseed oil and 19 percent turpentine and drier. Stair treads and porch floor at kitchen entrance, metal roofs and flashing, and screen wire painted with the same paints used in 1927.

OWNER'S OPINION OF PREVIOUS JOBS:

The initial job became too gray with dirt and the change to titanium-type paint was made to get maximum whiteness. The 1927 job was satisfactory everywhere except on the screen door leading to the porch roof, which was previously varnished. Here the paint crackled and scaled rather badly and is doing so again. He plans definitely to have one coat of paint applied every four years.

PAINTER'S INSPECTION:

August 1, 1935.

The appearance of the paint on the major surfaces is entirely consistent with the owner's report of the painting history. The white paint is chalking freely on all surfaces except the under side of the overhanging eaves, where it is still glossy on north, east and west sides. The chalk has the appearance characteristic of titanium pigments and when wiped off reveals a smooth, glossy film of paint. The paint on north, east and west sides is entirely free from checking or cracking except under overhanging eaves noted below. On the most exposed parts of the south side cracking is just beginning. Paint on galvanized iron gutters and downspouts cracking and scaling fairly badly. On all important surfaces the paint behaves normally for paint of this type, giving no indication of abnormal moisture conditions, incompatible paints, or poor workmanshp.

Abnormal Paint Conditions:

Screen door leading to porch roof shows results of incompatibility in painting, evidently due to painting over spar varnish in 1927. Balluster members of rails around porch roofs show cracking and scaling at the junctions with the lower stringers of the rails; this is due to moisture seeping into these joints. In a few cases the nails have corroded and left the member loose. One stringer of steps at kitchen entrance has decayed where it rests on the ground although the paint is still intact on it. There is some cracking and scaling of the last coat only on the under side of overhanging eaves on north and west sides, apparently due to the fact that the previous paint was still glossy when repainted in 1931.

PAINTER'S RECOMMENDATIONS:

Preliminary Carpenter Work:

Have rotten stringer in back steps replaced and renail loose balluster members of rails around porch roofs, using corrosion-resistant nails.

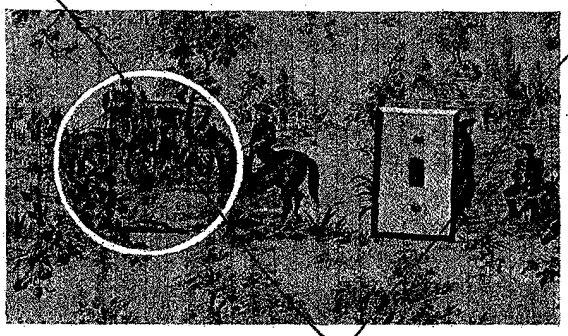
Preparation of Surfaces:

Remove entire coating from screen door to porch roof. Scrape off all loose paint from gutters and downspouts, clear to metal wherever possible. Wire brush loose paint from overhanging eaves on north and west sides and wash these surfaces with water containing trisodium phosphate to remove all dirt and reduce the gloss as much as possible. Scrape off all loose paint at junction of balluster members with lower stringers of porch rails.

Repainting:

Give gutters and downspouts a priming coat of red lead paint and two coats of white piant. Spot-prime the bare wood where loose paint has been removed on balluster members of porch rails, using the white paint without thinning with either oil or turpentine. Prime the door leading to sun parlor roof with lead and oil priming paint applied at 500 square feet per gallon. Then give all white woodwork one coat of white paint at 600 square feet per gallon except under overhanging eaves, where the least amount of paint that will hide properly should be applied. The white paint proposed is Brand E (the paint most similar to the previous paints that is available from the painter's usual source of supply). It is a prepared paint containing 65 percent pigment, composed of 40 percent titanium, 30 percent white lead, 22 percent zinc oxide, 8 percent asbestine, and the liquid consisting of 87 percent linseed oil and 13 percent thinner and drier. Give stair treads and porch floor at kitchen entrance one coat of Brand B iron oxide red long-oil enamel, metal roofs and flashing one coat of Brand C iron oxide red linseed oil paint and screen wire, one coat of zinc dust and zinc oxide paint.

Wallpaper Hides Ugly Switches



We are indebted to Frank Cross, of the E. J. Cross Company, Worcester, Mass., for this illustration showing the manner in which his company overcomes the ugliness of the common electric switch plate by the use of wallpaper. Even after the plate is papered it is removable and washable as the paper is glazed. It is important in using this method to make sure that all lacquer is removed from the switch plate before papering. The screw heads and switch button are stippled in colors to blend with the paper. Note that a masked plate is slightly discernible in the white circle to the left of the ordinarily exposed switch. This treatment made quite an impression in the exhibit at the annual convention of the Massachusetts Society, of which Mr. Cross is president.

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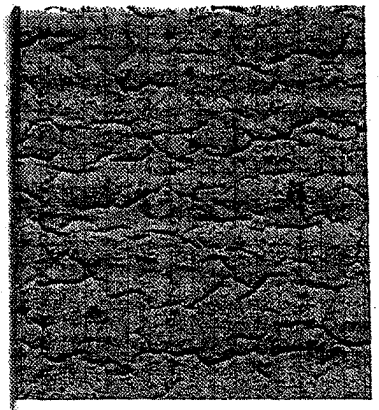
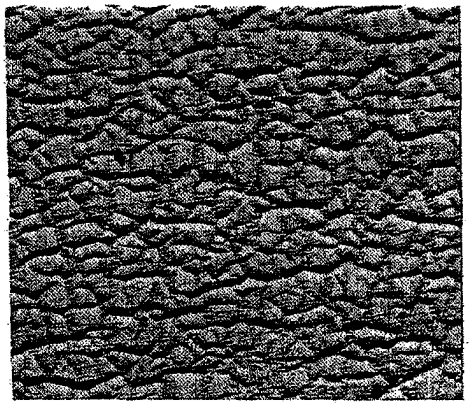
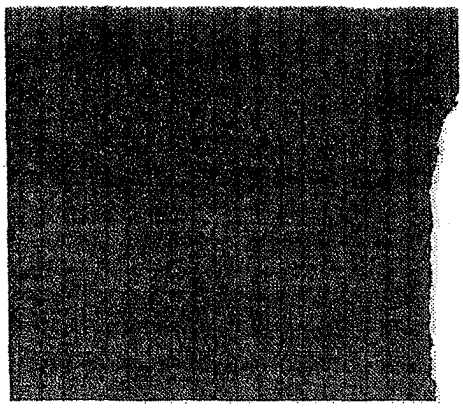


1A



1B



1C

Figure 1.—The checking characteristic of pure white lead paint under normal circumstances. The areas shown in 1A and 1B are ¼ by ¼ inch in size, the area shown in 1C is 3 inches by 3 inches in size. An early stage of checking is shown in 1A, a much later stage in 1B and 1C.

How Painters Can Prevent Painting Complaints --- No. 3

Judging the Nature of Previous Paint Coats By Inspection

By F. L. BROWNE

Third article in a new series by Dr. Browne, Senior Chemist of the Forest Products Laboratory, maintained at Madison, Wisconsin, by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Wisconsin

IT was a simple matter for the painter to collect the record of the painting history of House No. 19, as discussed in last month's issue of National Painters Magazine, because the owner knew exactly what had been done and what paints were used from the time the house was built. Unfortunately, most owners are unable to supply such reliable information. Very often the owner makes erroneous statements, because his memory is inaccurate or because he was misinformed. Some of the houses discussed in the June, 1935, issue of National Painters Magazine are typical of the need for critical consideration and independent judgment in recording painting histories.

When the writer first inspected House No. 8 (June, 1935, issue) the owner insisted that both the original paint job in 1929-1930 and the repainting in 1933 were done with pure white lead paint, because the contracts clearly so specified. He also said that he had personally seen the painter break down the paste white lead. The painter likewise maintained that he had used "lead and oil." The checking pattern of the 1933 paint and of the 1930 paint where it was revealed by scaling of the later paint showed at once that both paints were of harder types than white lead paint. When confronted with this evidence the painter told the true story as it has already been described. He had violated his contract in the sincere belief that the quick-drying paint he attempted to use, which was more expensive than lead and oil, would give a better job; but, unfortunately, it did not, and he was left in a legally indefensible position.

The owners of houses No. 10 and No. 12 (see June, 1935, issue) did not know the nature of the paints used when the writer made his first inspections. From the typical behavior of the paints, however, it was possible to determine the kinds of paint involved fairly closely. Subsequent inquiries through the painters and paint manufacturers fully confirmed the conclusions reached.

Studying Paint Behavior

In order to guard against misleading information and to supply information where it would otherwise be lacking, the painter must be able to tell as much as possible about paint composition from experience in watching paints of known composition as they pass through the various changes that take place during the useful life. The painter should remember, however, that experience is not measured by the number of years of work at the craft, but by the number of

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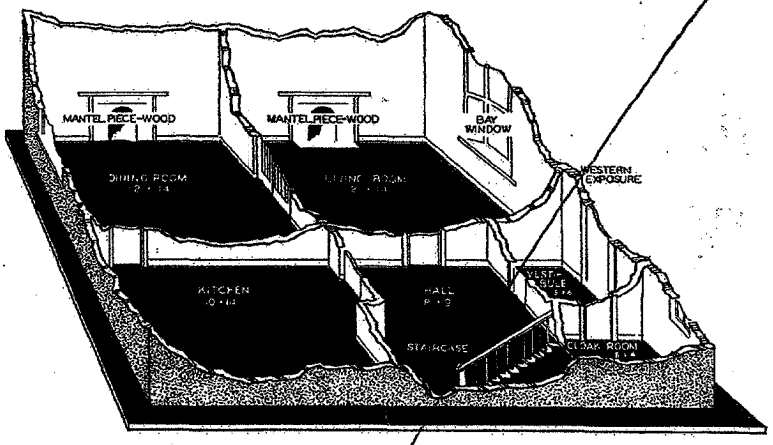
Harmonizing Color Plans With Old Furniture



One of our readers recently asked us to furnish him with a complete color scheme for the lower floor and one bedroom in a house a year and a half old, with plastered walls and ceilings which had never been decorated. The owners wanted a modern scheme and something a little different.

The reader supplied us with a diagram, which our artist has visualized in a sectional view, together with a statement of the colors of the furniture and woodwork which could not be changed. He wanted a scheme to harmonize with the following:

LIVING ROOM: Woodwork B. C. fir, stained light oak, highly polished. Oak floor, natural finish with one-inch dark wood border two feet from wall. Furniture upholstered blue and faun. Hearth rug blue and faun.

DINING ROOM: Woodwork and floor same as dining room, without border. Furniture dark oak. Hearth rug blue and faun. Carpet deep red and blue.

BEDROOM: Furniture dark oak. Ceiling has one-inch molding six inches from wall. (This molding also in living room, dining room and hall.)

This inquiry has been answered by Carl H. Dabelstein, one of our Associate Editors and a well-known New York decorator. Mr. Dabelstein's suggestions are given herewith:

By CARL H. DABELSTEIN

IN the living room, as we understand it, the woodwork is the color of light oak, the floor is the same color, and the predominating color of the furniture is blue. With natural finish wood contrasting colors are most suitable to set off the furniture and make the most pleasing background. The blue of the carpet and the blue of the furniture make it difficult to offer many suggestions, as the natural finish woodwork will lend itself to but one color that will not offend the blue, and that is an antique leather color, or a tobacco brown plain or mottled. Green would be ideal with the woodwork, but out of the question with the furniture and carpet. Blue of a dark shade would also go with the woodwork, but would not offer sufficient contrast as a background for the furniture. You say your client desires something modern. If that is the case, why not paint over the woodwork and make the entire room oyster white, which is very popular at present and makes an elegant background for your furniture.

The dining room, we understand, is the same as the living room, only that the carpet is of red and blue, probably an Oriental design, and the frames of the furniture, we believe, are dark oak. If you wish to paint this room, we can only suggest that you employ about the same effect as suggested for the living room, as the color effects of the furnishings are the same, with the exception of a little red in the carpet and the dark furniture frames. This will give you an additional opportunity to paint the walls red of deep color, like antique leather.

You state there is a molding around the room, which we take to mean a cornice between the wall and ceiling. This cornice could be painted and grained like the woodwork, and then a ceiling of an old yellow color will give a very stunning effect. If, however, you wish to use one of the modern scenic papers for the walls, you can avail yourself of an entirely different effect and have more latitude to carry out a scheme that will be lighter in color and more desirable, and in line with the modern type of dining room.

You do not mention the kitchen, but we wish to call to your attention that color here is just as necessary, and it should not be overlooked. In previous issues of National Painters Magazine the possibilities a kitchen offers have been discussed in detail.

You give no details regarding the hall except that it has a cornice at the ceiling. As there is so much blue in the furnishing of the first floor it might be well to do the hall in a light color, and we would suggest a paper of a foliage type on the wall in a gray or sepia color, and carry out the woodwork light like the ground of the paper, excepting the treads of the stairs and the handrail which should be natural wood. If, however, you wish to paint the hall, you can paint it in a yellow and white effect, which will go very well

Continued on Page 49

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useful things seen, understood, and effectively remembered. More than once the writer has had to show a painter who has worked with it for years that pure white lead paint under normal conditions of exposure develops checking comparatively early in its life.

Few men enjoy such excellent opportunities for learning how paints behave as does the painter, but he cannot learn without definitely setting out to do so. This article is not intended as a substitute for observations that the painter must make for himself among the paint jobs for which he has or can obtain the histories, but, rather, as a suggestion of the kinds of information that a paint gives about its own composition to those who learn by careful study how to interpret it.

When freshly applied there are very few features to distinguish different kinds of paint. Color, of course, serves to identify most of the paints made from colored pigments from the white or tinted white paints. From his experience in tinting paints and his knowledge of the colors in oil the painter should be able to recognize the paints made with little or no white pigment and to tell a good deal about the principal pigments from which they are made. Most of the white and tinted white paints, however, look pretty much alike at this early age. "Enamelized" paints—that is, paints made with much varnish or highly bodied oils—usually reveal their nature in a complete freedom from brush marks, a tightly drawn skin effect, a tendency to "curtains" at thick spots or formation of beads at the lower edge of boards, inability to fill cracks and other blemishes in the surface, exaggeration of planer marks or raised grain in the wood or checking or patches of flaked areas in the previous paint, and a brilliant gloss. House paints made with linseed or similar drying oils exhibit opposite properties.

Appearances of Grime

As time passes, all paints tend to collect a gray film of grime, but certain differences in the appearance of this grime, recognizable to the experienced eye but not readily described in words or shown by photographs, usually establish slight difference between the more important softer types of paint and the harder types of paint. With further ageing the next developments are usually loss of gloss, beginning of chalking, and fading of tints. Soft paints like pure white lead paint generally shed most of the gray grime rather promptly after chalking sets in, but paints hardened with zinc oxide or varnish are likely to retain the grime for a relatively long time, even after chalking starts. On the other hand, hard paints that chalk strongly on the surface, such as typical titanium pigment paints, may shed their grime quickly, and nearly completely leaving a bright matte appearance that is quite characteristic to one who has learned to recognize it.

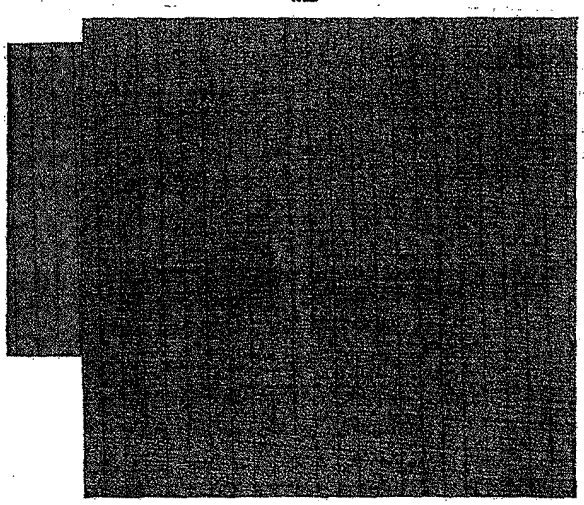
By far the most significant developments for distinguishing the different types of paint are the fissures and subsequent break-up of the coating that come at later age and are usually well developed before the owner is ready to consider repainting. With soft types of paint like pure white lead paint, checking begins rather early in life, usually well within two years on surfaces exposed to sunshine. It rapidly assumes a reticulate or interwoven pattern, as shown in Figure 1. Figure 1A shows an early stage of checking, 1B and 1C a late stage, when the surface may be considered by some owners to be ready for repainting; 1A and 1B are views as seen through a good magnifying glass, 1C as seen by the unaided eye. The meshes formed by the interweaving fissures are about as high as they are wide, and the pattern suggests polygons with more than four sides rather than square or rectangles. At the stage represented by Figure 1B the fissures are very deep, eventually extending through to the wood beneath, and the coating is so soft that most of it is removed by a few strokes of a wire brush or sandpaper. The edges of the fissures are rounded off and the fissures have a cross-section like a letter V with a wide spread at the top.

Identification of Fissures

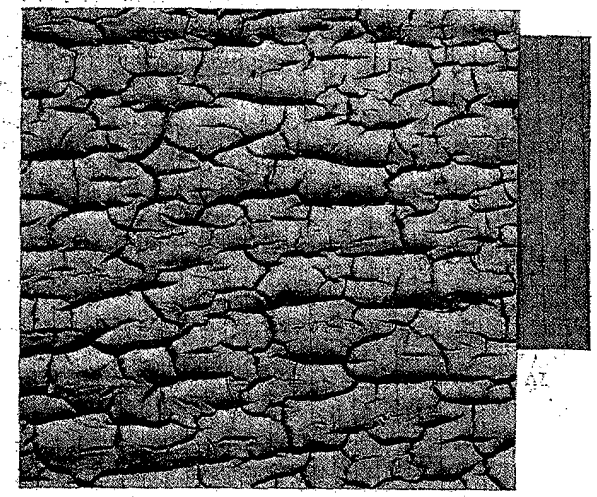
When paints are hardened by addition of zinc oxide the development of checking is profoundly modified. To begin with, the checking does not appear until a somewhat later age, and it takes much longer to progress from a few scattered fissures, mostly parallel to the last strokes of the paint brush, to a reticulate pattern in which the fissures become interwoven. Figure 2 (2A as seen by the unaided eye, 2B with a magnifying glass) represents the checking of a moderately hard paint at the same age as the checking of soft paint shown in Figure 1B and 1C. In Figure 2 the fissures roughly parallel to the brush strokes are

Figure 2.—The checking characteristic of a somewhat harder type of paint than pure white lead. The paint shown was made with lithopone and leaded zinc oxide in linseed oil. The area shown in 2A is 3 inches by 3 inches in size; the area shown in 2B is ¼ inch by ¼ inch in size.

2A



2B



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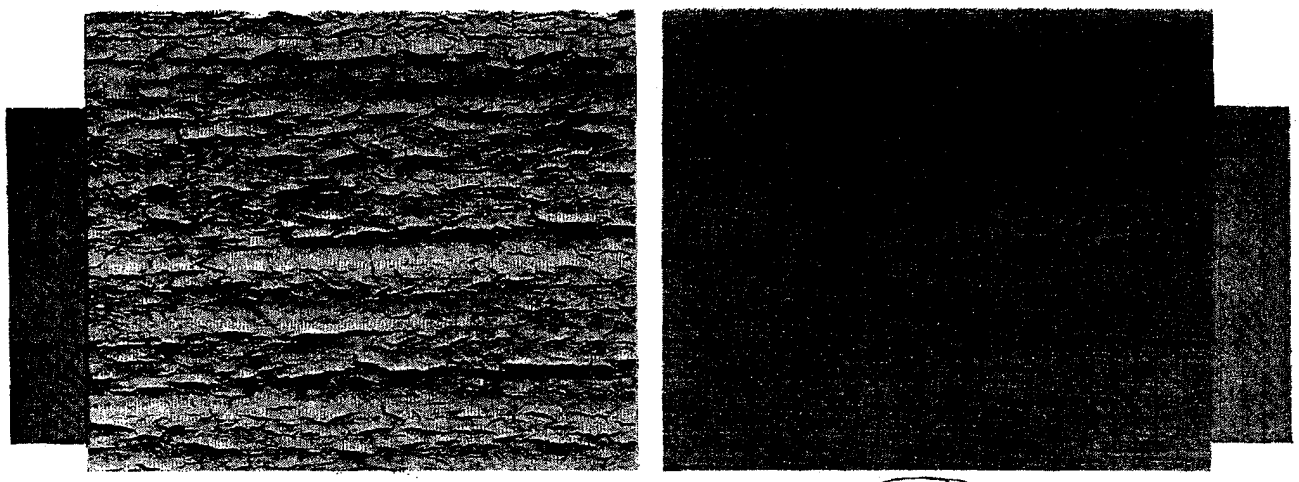

3A 3B

Figure 3.—The checking characteristic of paint slightly harder than the one shown in Figure 2. This paint was made with basic carbonate white lead, zinc oxide, and linseed oil. The area shown in 3A is 3 inches by 3 inches in size; the area shown in 3B is ¼ inch by ¼ inch in size.

deeper and more conspicuous than the connecting fissures that form the interwoven pattern, which developed later. All the fissures have sharper edges and are less V-shaped in cross-section than those of Figure 1B. The meshes formed by the interweaving fissures are usually wider than they are high, and suggest rectangles rather than polygons of more than four sides. The harder paint also resists the action of a wire brush or sandpaper much more effectively than the softer one.

A still greater degree of hardness attained by adding zinc oxide is represented by the paint shown in Figure 3, photographed at the same age as the paints of Figures 1B, 1C, and 2. In Figure 3 the checking developed less rapidly and is still in the "parallel" stage, but later it will become reticulate. At the stage shown in Figure 3 the fissures run predominantly in a direction roughly parallel to the last strokes of the paint brush, but they do not follow the brush marks exactly or form exclusively in the hollows.

Very hard types of paint, hardened either with zinc oxide or with varnish, may never develop checking, or, if they do, the checking is relatively unimportant and is greatly overshadowed by the appearance of an entirely different type of fissures; namely, cracking. In cracking, the fissures when first observed pass entirely through the coating, while in checking, the fissures are at first superficial and penetrate through the coating only after some further time has elapsed. Paints that do not develop checking at a fairly early age and are hard enough to have satisfactory durability eventually exhibit some form of cracking, although by wise formulation and careful application the cracking can be deferred as far as the fifth year of full southern exposure. House No. 19, for example, showed neither checking nor cracking of the paint at the end of the fourth year.

Sigmoid Cracking

There is a type of cracking known as sigmoid cracking, because the cracks, when first formed, generally have curving ends and suggest the letter S in shape. The longer cracks, which are the first ones formed, run parallel to the grain of the wood, but later they run at right angles to the grain of the wood.

In the examples of reticulate checking, Figures 1 and 2, the dimensions of the meshes of interwoven fissure remain fairly constant under all normal conditions of exposure. There is greater variation in this respect in the parallel checking of Figure 3, but the range is perhaps of the order of three or four fold, and the pattern is nearly always small enough to require rather close inspection to see it clearly. In the sigmoid cracking, however, there is an enormous variation in the size of the cracks and the dimensions of the meshes with different paints and even with the same paint under different circumstances. The longest cracks in some cases extend one-eighth or one-quarter inch; in other cases, three or four inches, and in extreme cases, three or four feet. For that reason in cracking the general shape and character of the fissures are the significant points to observe, while in reticulate checking the dimensions of the meshes are significant, also.

President Endorses Paint Up Campaign

President Franklin D. Roosevelt, in a letter to R. W. Emerson, Executive Secretary of the National Clean Up and Paint Up Campaign Bureau, which annually inspires thousands of community Clean Up—Paint Up campaigns throughout the United States and in Canada and overseas, from its headquarters in Washington, has extended his personal appreciation of the service which is being rendered by the millions of volunteer workers who at this season of the year are engaged in an organized movement to make their home cities and communities cleaner, safer and more attractive places to live in. The President wrote:

"I am glad to express my personal appreciation to all those throughout the nation who are devoting their time and energy to a National Clean Up and Paint Up Campaign.

"It is truly 'In the Public Service' when civic-minded men and women in all parts of the country, in cooperation with interested national business groups, unite for the accomplishment of greater health and beauty in our homes and communities. It is a further expression of what we in America can do through united effort to improve living conditions and solidify our fundamental institutions.

"After all, there is nothing that can replace that pride which comes from a clean and well-kept home and a well-developed and beautified community in which to live."

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How Painters Can Prevent Painting Complaints --- No 4

Judging Normal and Abnormal Conditions

By F. L. BROWNE

Fourth and concluding article in a new series by Dr. Browne, Senior Chemist of the Forest Products Laboratory, maintained at Madison, Wisconsin, by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Wisconsin.

THE checking of paints of the soft type illustrated in Figure 1 (published in last month's issue of National Painters Magazine) leads eventually to the crumbling shown in Figure 5 (published herewith). Such paints do not disintegrate by chalking, as is often stated, unless the painter made the serious blunder of mixing them with far too much linseed oil. It is true that paints can be made so soft that they disintegrate by chalking but such paints fail too quickly to be practicable house paints and are not represented among commercial house paints. In disintegration by crumbling the little "islands" cut off by the interwoven fissures of the checking pattern fall off one by one. They fall off sooner over the hard bands of summerwood than over the soft bands of springwood and for that reason disintegration sets in sooner and develops more rapidly on heavy woods like southern yellow pine and Douglas fir than on light woods like redwood, red cedar, cypress, and white pine. The most significant characteristic of the crumbling of soft paints is the absence of cracking and the absence of curling at the edges of the cracks. For that reason soft paints continue to offer suitable foundations for repainting even after crumbling has continued for a long time.

In harder paints disintegration proceeds by flaking, Figure 4, which differs from crumbling in that the paint curls upward at the edges of the fissures before it breaks off. Sometimes the flaking follows the pattern of checking fairly closely as shown in Figure 4 but more often cracking develops independently of checking and leads to curling and flaking in larger pieces as illustrated in the photomicrograph in the illustration of House No. 2 in the April, 1935, issue of this magazine. The magnification is not so great in this photomicrograph of House No. 2 and the area shown is about ½ inch in diameter. Curling and flaking developing from sigmoid cracking are shown in Figure 6B. (A description of sigmoid cracking appeared in last week's article.)

Figures 1 to 6 (Figures 1, 2 and 3 published last month) illustrate initial paint jobs on new wood under

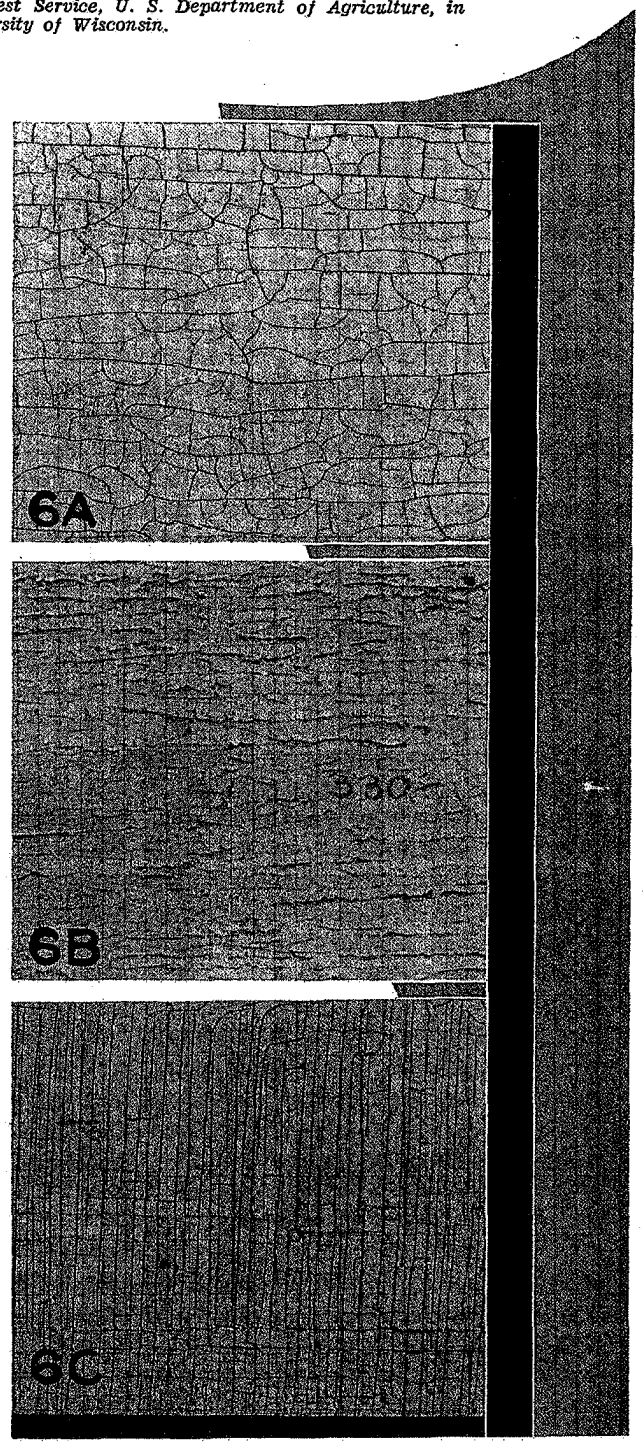

FIGURE 6

The sigmoid cracking and later curling and flaking characteristic of very hard types of paint. Each area shown is 3 inches wide. The two paints shown in 6-A and 6-B were made with titanium-barium pigment and zinc oxide in different proportions in linseed oil. The paint shown in 6-C was made with titanium pigment, white lead and zinc oxide in a synthetic drying oil of the alkyd type.

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An outdoor spot of rare charm. A white paint job on pillars and ceiling, the vari-colored chairs and cushions and flowers make this porch a thing of beauty as well as comfort. Photograph by George H. Van Anda.

Color Schemes For Out-Door Porches

SUMMERTIME is porch time, and the American people have become distinctly color-minded in the decorating and furnishing of their porches, whether they be fully outdoor covered affairs, terraces, glass-enclosed porches or built-in sun parlors. The painting contractor should have a variety of color schemes available and be familiar with current furniture styles and little decorative novelties if he is to do a pleasing job for his client, and accordingly we give herewith a few tips gleaned from data prepared by the Save the Surface Campaign.

In the first place, the new note in outdoor furniture this year is movability. Tables, chairs and sunbarrows are all on wheels. If your customer has furniture of an older type, suggest that you be allowed to put wheels on the chairs—and then paint them to match.

Various types of furniture, of course, call for various types of coatings. For furniture on covered porches, if it's of wood, wicker or rattan, flat paint or enamel will be suitable. If the old finish is in good condition, a single coat of either will be sufficient. Flat paint, incidentally, has the better hiding quality, but enamel makes the more durable and washable finish.

For metal porch furniture—if it's being painted for the first time—use a special metal primer to prevent corrosion. Over the primer use flat paint or enamel.

For the porch, natural wicker should be protected by a varnish such as is used for furniture or woodwork. However, if the wicker is to be in the garden, give it two coats of outside house paint so that it can successfully resist outdoor exposure.

Wooden furniture for the garden also requires two coats of house paint, while unpainted metal needs a coating of a special metal primer and then two coats of house paint.

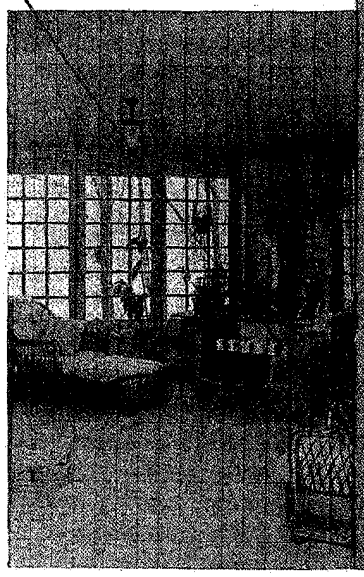
For a natural wood finish, use spar varnish for its highly protective qualities. Remember this especially for deck chairs which are apt to be left in the rain unintentionally.

Proper washing and rinsing, naturally, are necessary. If the old finish is in bad condition, brush it with a wire brush, scrape off the loose particles and then rub down with medium sandpaper.

If the surface is suffering from a bad case of cracking or scaling, use a paint or varnish remover and follow it with a priming coat thinned with turpentine. Where the old finish is glossy, wash with a solution of one pound sal soda to a gallon of water and rinse.

As for color schemes for an open outdoor porch, they should harmonize with the color scheme of the exterior of the house and contrast can be obtained not only in the furniture itself but in the cushions and pillows.

For the enclosed porch where you have walls to consider the room can be painted more "on its own." The walls can be in such soft coloring as putty, ivory, parchment, tan, nile green or hydrangea blue. We know of one enclosed porch where a delightful effect was secured through the combination of ivory woodwork and pale yellow walls. In another the woodwork is of quiet gray-green antiqued with sienna, all the painted walls are of light gray-green, stencilled all over with a small modernistic flower-and-bird design carried out in pastel gold, pink and rust. In enclosed porches where you want to emphasize the outdoor atmosphere, you can use some well-designed lattice work, painting it in blue-green, in Italian blue or Terra Cotta.



Here is a glass-enclosed porch, which nevertheless has an outdoor effect. White walls and trim again serve as a background for the colorful furnishings and plants. Photograph by George H. Van Anda.

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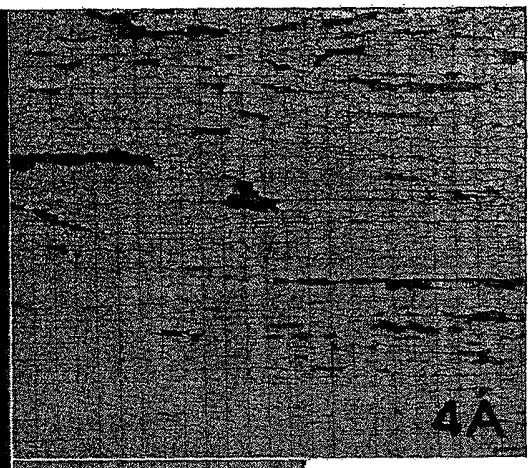
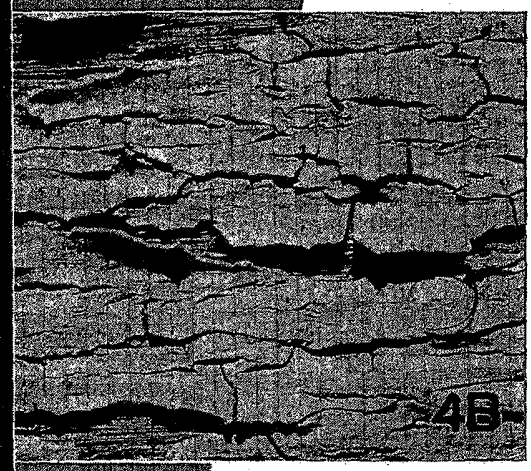
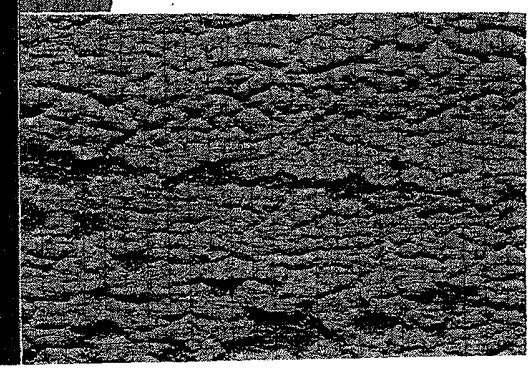






normal conditions of exposure, that is, on wood that remains dry at all times and with paint of the same kind used for all three coats. Succeeding paint jobs with white lead paint applied over the surfaces shown in Figures 1B, 1C, and 5 will behave almost exactly like the initial jobs. If the paints shown in Figures 2 and 3 are repainted properly with the same paints used the first time the behavior will again remain much the same except that the meshes of the checking patterns may become somewhat larger with each repainting, especially if two coats are applied each time instead of one.

If the surface shown in Figure 4 is repainted with the same type of paint two coats are necessary, the subsequent checking and flaking patterns become larger, cracking of the kind shown in Figure 6C is likely to occur, and if the practice is repeated through several paintings a condition like that shown in House No. 15 in the March, 1936, issue may be expected. If the surfaces shown in Figure 6 are repainted with the same kinds of paint cracking in a larger and still more conspicuous pattern will probably occur at each successive repainting. These surfaces should be repainted with one coat of paint long before cracking reaches the stage illustrated.

A painter who makes a practice of studying the behavior of paint jobs about which he knows the whole history will soon learn to recognize developments of the kinds described in this article and from these developments he will soon be able to tell rather closely the kinds of paint previously used on most houses on which he is asked to bid. It must be remembered, however, that paints go through their normal stages of behavior only when used under normal conditions of service. The three common types of abnormal conditions result in characteristic abnormalities in behavior that are usually either superimposed on the normal developments or proceed logically from them. For that reason an adequate understanding of the normal developments with different paints enables the painter not only to spot abnormal conditions promptly but often to determine the nature of the abnormalities.

The abnormalities in paint behavior caused by collection of moisture behind painted woodwork are illustrated by Houses Nos. 3 to 6 in the May, 1935, issue and House No. 16 in the April, 1936, issue. In these cases the forms of failure differ so strikingly from normal behavior of paints that the existence of abnormality of some kind is immediately obvious. Caution, however, must be exercised in assuming too freely that moisture is the real cause of difficulty because a comparison of Houses Nos. 4 and 16 with Nos. 7 and 8 proves that incompatible combinations of paints often result in forms of failure remarkably similar to those caused by moisture.

As a matter of fact there is a continuous gradation in early paint failures between typical moisture con-

FIGURE 4

The curling and flaking characteristic of moderately hard types of paint such as that shown in Figure 3 (last month). The area shown in 4-A is 3 inches in size; the area shown in 4-B is ¼-inch by ¼-inch in size.

FIGURE 5

The crumbling characteristic of soft paints that develop checking early, such as pure white lead paint shown in Figure 1 (last month). The area shown in 5-A is 3 inches by 3 inches in size; the area shown in 5-B is ¼-inch by ¼-inch in size.

ditions severe enough to ruin compatible paint jobs and mild moisture conditions that cause difficulty only when the paint job has been made unusually sensitive by an incompatible combination of paints. The latter condition is illustrated by House No. 17. On the other hand there are times when moisture causes early paint failure in a manner that looks like the perfectly normal developments illustrated by Figures 4 or 6 except that the failure occurs far sooner than it would do under normal conditions of service.

The second common class of abnormal conditions, which is probably far more numerous than the first, is that caused by incompatible combinations of paints such as those illustrated by Houses Nos. 7 to 12. The following additional information about these houses will help explain the methods of identifying types of paint from a knowledge of their behavior under normal conditions:

House No. 7

The original gray paint that shows where the subsequent brown and white paints are scaling exhibits the checking pattern of Figure 3, which probably indicates paints of lead and zinc types. The brown paint, before the white paint was applied, exhibited brush marks and a softness of texture showing that it was made with linseed oil with little or no varnish. The white paint was a titanium, lead, and zinc paint and was chalking but neither checking nor cracking except where the scaling took place at the time the photograph was taken.

House No. 8

The scaling goes clear to the wood in most places but in some spots it leaves the 1930 paint exposed to view, which exhibits a checking pattern similar to Figure 3 and is therefore not pure white lead paint but probably lead and zinc paint. The 1933 paint exhibits the surface appearance of titanium pigments but shows parallel checking rather representative of an earlier stage of the checking in Figure 3. Such behavior is reasonable for a mixture of white lead with the quick-drying paint finally reported by the painter.

House No. 9

The checking of the paint on the east side is similar to Figure 3 but somewhat coarser in pattern as would be expected after three paintings. By scraping off some of the coating with a penknife the absence of colored paints on the east side was easily established. On the other three sides the colored paints could be seen in the order of their application by removing a chip of paint and examining its edge under a good magnifying glass or pocket microscope. Note that the white paints over the colored paints developed sigmoid cracking like Figure 6C but on a much larger scale, which is completely absent under the normal conditions of the east side.

House No. 10

The original paint coating remains intact and exhibits the checking pattern of Figure 3, indicating probably a lead and zinc paint. The last paint job has the characteristic surface appearance and chalking of titanium pigment paints and shows the sigmoid cracking, curling, and flaking of Figure 6B but on a much coarser scale. Subsequent discovery of the manufacturer of the two paints made it possible to confirm these deductions.

House No. 11

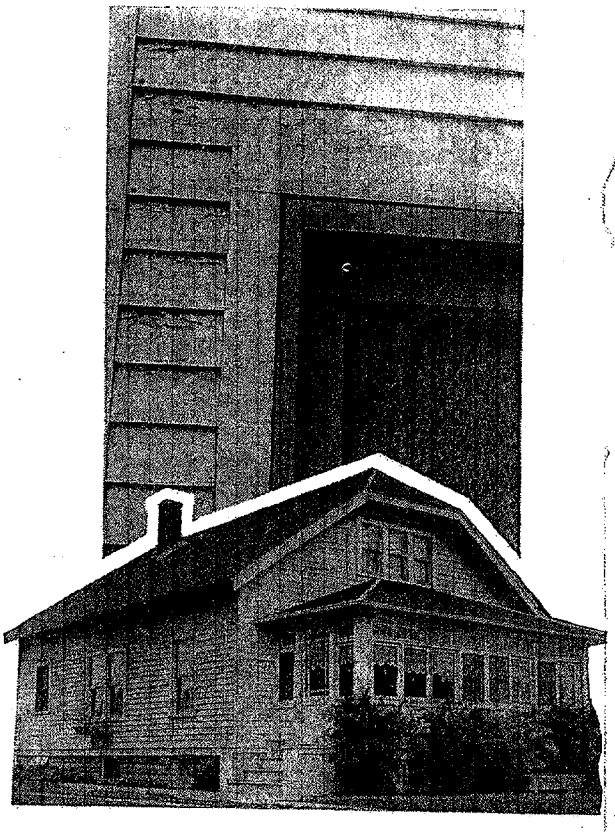
The colored pigment paint first used on this house is readily seen through the wide open gashes in the white paint last applied. The failure of the white paint is a development of the sigmoid cracking of Figure 6C due to a shrinking and "slipping" of the white paint over the very much softer colored paint beneath.

House No. 12

Alligatoring of pure white lead paint when applied over a harder paint containing zinc oxide is a modification of the normal checking shown in Figure 1 in which the meshes of the checking pattern are greatly enlarged and there is shrinking and slipping of the white lead paint over the underlying paint much like that exhibited on House No. 11. White lead paint may alligator in much the same way when applied over clear varnish or over colored pigment paints.

The third common class of abnormal conditions arises from faulty procedures in applying paints. Some of these were discussed by Glenn H. Pickard in the April, 1936, issue. Errors of application as a rule have less disastrous consequences than abnormal moisture conditions and incompatible combinations of paints. The common practice of thinning priming coats for new wood with too much turpentine and the

Continued on Page 33



House No. 17 in Dr. Browne's series of test houses, mentioned in accompanying article. The house was built in 1931 and painted with white lead paint. In 1934 it was repainted with a quick drying paint. The photos were taken early in 1935.

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Judging Normal Paint Conditions

Continued from Page 18

stingy application of paint impair durability appreciably but not enough as a rule to make the owner aware of that fact. The development of checking, cracking and disintegration usually follow the normal pattern for the paint in question. Unduly generous thinning of paint with linseed oil may cause some paints to fail by rapid chalking at an earlier age than their normal disintegration by cracking, curling and flaking.

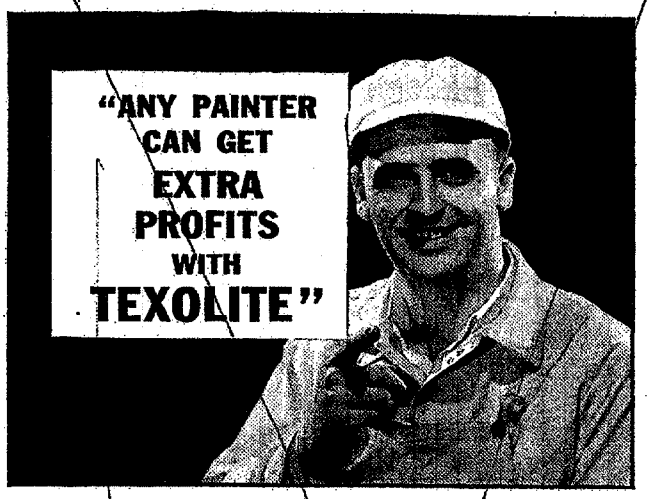
The painter who has become thoroughly familiar with the normal behavior of the various paints likely to be used in his community and with the abnormalities in behavior to which they are subject will generally find himself able to record painting histories accurately enough for practical purposes even when information about previous paints cannot be obtained otherwise or is reported incorrectly. He will likewise find himself able to avoid dangerous mistakes that may lead to early failures, expense of restitution for early failures, and damage to his reputation. He will also be able to give his customers service of far more value than the mere application of paint to their property.

The writer is well aware that the suggestions he makes involve more technical study than is commonly considered within the painter's province. Among the past presidents of the International Society, however, there have been men who felt that technical knowledge of this kind is essential. The writer is glad to acknowledge his own debt to the late John B. Dewar, father of the recent president, for much valuable advice about the technology of paint when the writer was begining his own investigations of the subject. Since Mr. Dewar's time the technical demands upon the painter's ability have been made increasingly difficult by the multiplication of different types of paint on the market with consequent increase in the number of faulty combinations that may easily be brought about. Under the present conditions of manufacture, sale and use of paints the painter is the man who must shoulder most of the responsibility for seeing that paints are chosen and used successfully. The house owner cannot be expected to master the intricacies of paint behavior and expects to pay others to do that for him.

The painter who is able to sell his customers paint and labor plus sound advice backed up by a file of records of satisfactory jobs is worth more money and in the long run will get more money than the painter who has nothing to offer but the mechanics of spreading paint.

Colors for Cottages

Three attractive color schemes for cottages are based on cream yellow, light gray and a pale green. With the cream yellow used for the body of the cottage, a deep brown roof is effective. White trim and green shutters complete the yellow-brown combination. With the pale green body, a deep green roof goes well. White for the trim and gray for the shutters will combine harmoniously with the greens. If gray is selected as a body color, ivory trim and shutters will go exceptionally well with a dark red roof.



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Learn about this genuinely new paint. Learn how it can get you more business — at an increased profit per job! Send coupon now for free quart of Texolite and tube of Deep Color. Texolite comes in white and ten standard colors. Texolite Deep Colors — made in nine deep colors — can be added to white to get any desired shade; or Deep Colors can be used as deep, brilliant paint for unusual and colorful decorative effects. Test Texolite yourself for quality, coverage, for economy. Prove to yourself you're losing money if you don't use Texolite.

TEXOLITE IS A 7-IN-1 PAINT
1 One coat covers
2 Dries in one hour
3 Goes 25% farther
4 It's washable
5 No paint odors
6 No brush marks
7 Simply add water and it's ready

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TO PAINTERS . . . *a new idea*

HYLITE CASEIN WASHABLE PAINT, our newest product, is entirely different from any other cold-water paint because it is manufactured from the same pigment that goes into high-grade oil paint. This pigment comes from our own mines.

HYLITE, a dry powder to which you merely add water, is positively permanent. Does not rub off. Can be washed. No brush marks; no lap marks. Shows no "hot spots" on green plaster. Forms a natural bond to surface to which it is applied. Has unusual one-coat covering properties. Odorless. Quick-drying. Costs consumer less than 75c per gallon, painters considerably less.

HYLITE forms a natural undercoat before oil paint on wood, plaster, etc., for both interior and exterior surfaces, saving cost of oil paint. Lacquer, varnish, enamel also can be painted over it. Solves old problem of decorating insulating board by covering completely with one coat.

Representatives, dealers and jobbers wanted.
TRY IT BEFORE YOU BUY IT.
Write for sample.

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BRONZITE
PERMANENT GREEN

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Sample sent on request. Have your dealer write us.

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Manufacturers of Adhesium Wallpaper Size

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Brooklyn, N. Y.

323 West Polk Street
Chicago, Ill.

Paint Jobs on Budget Plans

Continued from Page 9

This makes it easy for the customer. The painter gets the purchaser, the purchaser's wife, and other members of his family, if their incomes are included, to sign the credit statement, agreement, and note.

"Under most of the plans, the dealer from whom the painter expects to buy the brand of materials specified in the agreement, orders a credit report from a responsible credit bureau, which report must verify the information on the purchaser's credit statement, including a re-check on the property owner's statement of mortgage holder and the amount of annual payment. If there is no credit bureau in his town, the dealer writes the nearest branch of the finance company for detailed instructions as to how the credit investigation should be handled. After the first time, he works out a simple routine for handling this credit problem. The credit bureau's usual dollar fee is paid by the painter.

"Practically any wholesaler handling reputable merchandise has one of these finance plans available to the painters who deal with him. If he doesn't offer such a plan and isn't willing to help the painters in closing installment deals with their customers, then his painters, if they're wise, will change to some other wholesaler who is interested in pushing these installment contracts.

"For this idea of time payments by customers and cash payments for the painters, helps the painter in three ways. First, it gives a painter somet
canvass with. And there are three ways to us
payment plan in canvassing for jobs. A pain
use his time payment plan as his big sales po
direct mail campaign to a list of people he has
either from examination of his own records
observation, to believe need some painting wor
Next, he can use the plan as a good reason for
up both old customers and new prospects on t
phone to inform them how easy it now is to
having the work done that they've probably w
long time. Or the painter can use the plan as a
for calling personally on people he thinks n
services. And in this connection, I know fro
sonal experience, that it will pay any resp
painter to hire good specialty salesmen, cl
young fellows skilled in selling door-to-door, to
and canvass his whole territory at a ten per
mission on all sales he is able to close from
they give him.

Something to Talk About

"But a time payment plan, besides giving a
something interesting to talk about when canv
is also a help to him when he is trying to make
mind just what kind of a job to try to sell to a
tomer on whom he may happen to call. It ha
the experience of the painters I've interested
time payment plan that customers are willing
a better grade of job if they can pay for it in
ments. So in cases where these painters forme
three hundred dollar jobs, they now sell four h
dollar jobs, and where they formerly would
a job to cost seven hundred dollars, they now s
and close a job costing nine hundred dollars.

"But probably a time payment plan is most
to a painter when, after convincing a custome
his ideas about the job are right, he runs up
the objection that his price is too high.

"The time payment idea is the best way y
covered for overcoming a price objection and
the sale. I've helped my painter customers
dozens of time payment contracts. Just yeste
went out on a call with a painter who had a cu
that was threatening to get in a cheaper man
job for which my painter had quoted $460. Bu
I pointed out to the customer that the contract
fied a nationally advertised, standard brand of
and that he himself was to be the judge of the
manship, not being obligated to pay one cent
satisfied the job was done right, and that he
draw any money out of the bank to pay for
could pay the small monthly installment of $31
of his regular income, he agreed to let us fill
credit application for him and start work just a
as this application was approved.

"For the first time in years, we've all got a
both to give the public real value and make a
ourselves too. But the key man in the cycle
painting and decorating contractor. If he'll
out and push whatever time payment plan th
ticular manufacturer or jobber he deals with is
soring, he can offer his customers a better gr
work, land more jobs, make more money for h
and be the main factor in building up the wh
dustry to a greater degree of prosperity than
us has ever known before."

Wood Handbook
Forest Products Laboratory
Chapter by
F. L. Browne

(about 1936?)

(27)

PAINTING AND FINISHING WOOD

The principal reason for coating woodwork is usually improvement and maintenance of appearance. Immediate considerations in coating wood for appearance are:

(1) Paint or enamel is opaque and therefore conceals the grain and color of the wood, substituting a color, sheen, and texture of its own.

(2) Varnish, lacquer, oil, or wax is transparent, thus revealing the grain of a piece more fully by displacing the air at its surface with a medium of much higher refractive index. In conjunction with stain the color is also altered. The sheen and the texture of the coating are substituted for those of the wood.

(3) Stain without varnish or lacquer changes the color of wood without greatly altering its sheen or texture.

Ultimate considerations in coating wood for appearance are:

(1) Unless protected by moisture-retardant coatings, wood exposed to the weather becomes dull gray in color; smoothly planed surfaces become rough and cracked; boards tend to cup, twist, and pull loose from their fastenings; short boards may split in two; snug joints are loosened; and straight, parallel lines are disarranged. Durable coatings adequately maintained prevent such weathering (Browne, first and fourth references).[34]

(2) Uncoated interior wood surfaces are porous enough to absorb liquids quickly, to stain and spot readily, and to hold dirt tenaciously. Nonporous coatings or coatings that tend to shed liquids protect wood from discoloration and present a surface easily cleaned.

Those parts of buildings that are customarily kept painted are not, as a rule, subject to much hazard of decay by wood-destroying fungi (Browne, first reference) because they are well drained and dry rapidly. Decay and its prevention are discussed on pages 249 to 253 and the painting of wood treated for the prevention of decay on page 232. Ordinary paints and varnishes are not effective as preservatives against fungous decay.

Paint is chosen for exterior woodwork more often than any other coating; it is much more durable than varnish or other transparent coating and usually affords more effective protection against weathering of the wood (fig. 62). Exterior enamel may be used in place of paint where a smoother, harder, and more wear-resistant coating is needed, and the surface may be washed at intervals to keep it clean. It is best to use enamels only on surfaces that are accessible enough to be easily repainted somewhat more frequently than the major surfaces of the building. Porch railings, columns, and window sills, for example, can often be enameled to advantage.

PAINTING CHARACTERISTICS OF WOODS

The same painting procedure and kind of paint are suitable for painting all native softwoods (conifers) and the native hardwoods

[34] For further information, the references at the end of this section should be consulted.

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that have relatively small vessels (pores) (Browne, seventh and tenth references). Hardwoods with relatively large vessels require a wood filler before painting or varnishing.

SPREADING RATES ON SOFTWOODS (CONIFERS)

The spreading rate of paint is the area of surface covered by a unit volume of paint. On smoothly planed surfaces of softwoods the spreading rate varies with species only for the first or priming coat of paint applied on the new surface; the spreading rate of subsequent coats does not vary with species (Browne, third reference).

Even for priming-coat paint the species of wood has less effect on spreading rate than the individuality of the painter or the kind and proportion of ingredients in the paint. Some painters brush paint out farther than others; the best painters apply paint in

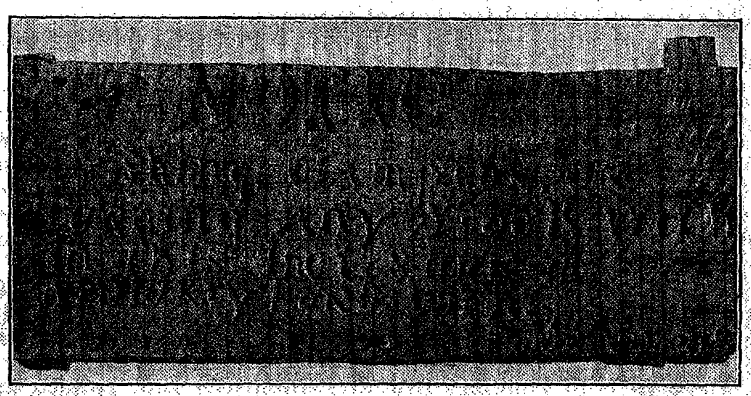

FIGURE 62.—A good example of protection against weathering afforded by paint. After many years of service only the painted letters on this sign resisted erosion.

fairly thick coats roughly 600 square feet per gallon, while unskilled painters very often apply coating too thin, covering as much as 1,000 or 1,200 square feet per gallon. A few of our native softwoods tend to take 10 or 12 percent more priming-coat paint than the average, and a few tend to take as much less. By the time second-coat and third-coat paints have been applied, however, the difference in paint consumed amounts to only 3 or 4 percent above or below the average, a value that is probably within the limits of uniformity with which a good workman will paint at different times. The woods that tend to take more than the average amount of paint are, in general, the lightweight ones and those that tend to take less paint are the heavy ones that have a high proportion of summer wood. Rough surfaces, such as shingles, the sawed side of bevel siding, weathered wood, or surfaces on which repainting has been neglected for a long time may consume twice the amount of priming-coat paint required for smoothly planed surfaces.

DRYING OF PAINT ON SOFTWOODS

The time required for a coating of paint to dry—that is, to harden—usually depends almost entirely on the composition of the

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paint, the intensity of sunlight, and the temperature and relative humidity of the atmosphere. The drying is retarded, however, if the wood is wet when painted; its moisture content should not exceed 20 percent. On wet redwood or southern cypress, priming-coat paint may remain liquid for days, especially when the paint is one containing little or no white lead or zinc sulphide pigment (Schmutz and Palmer). On air-dry redwood paint hardens as rapidly as on any other wood. On air-dry cypress in the absence of sufficient sunlight paint may take longer than usual to harden. Cypress boards that contain much more than the average amount of the oily extractive material characteristic of cypress may retard the hardening of paints lacking white lead or zinc sulphide even when the boards are reasonably dry unless the drying takes place in strong sunlight.

FILLING POROUS HARDWOODS BEFORE PAINTING

For painting purposes the hardwoods may be classified as follows:

Hardwoods with large pores:	Hardwoods with small pores:
Ash	Alder, red
Butternut	Aspen
Chestnut	Basswood
Elm	Beech
Hackberry	Cherry
Hickory	Cottonwood
Khaya (African mahogany)	Gum
Mahogany	Magnolia
Oak	Maple
Sugarberry	Poplar
Walnut	Sycamore

Birch has pores large enough to take wood filler effectively when desired but small enough, as a rule, to be painted satisfactorily without filling.

Hardwoods having small pores may be painted with ordinary house paints in exactly the same manner as softwoods. For hardwoods with large pores, however, the usual priming-coat paint should be replaced with a wood filler, which is a paste consisting of pigment, chiefly ground quartz, mixed with linseed oil and a paint drier.

Filler is necessary on woods having large pores because paint applied by brush or spray gun does not fill the pores properly. Without filler the pores not only appear as depressions after the painting has been finished but also act as centers from which disintegration of the coating sets in.

EFFECT OF NATURE OF WOOD ON WEARING OF PAINT

During the first year or two after an exterior wood surface has been painted or repainted properly the nature of the wood usually has very little effect on the behavior of the paint coating. Later on, when the coating has become embrittled with age, differences between woods become very important and very largely determine how rapidly the coating disintegrates. Under normal conditions of exposure—that is, when the moisture conditions discussed on page 240 do not pertain—paint coatings on wood (Browne, eighth, eleventh, and thirteenth references) deteriorate most rapidly where the greatest

amount of sunshine falls and deterioration proceeds in successi but overlapping stages as follows:

(1) The soiling stage. The coating gradually becomes dirty.

(2) The flatting stage. The coating loses its gloss.

(3) The chalking stage. Dirt may be thrown off more or le completely, but colors appear to fade.

(4) The fissure stage. Fissures are of two general types, depen ing upon the nature of the paint (pl. 4):

(*a*) Checking. The fissures are at first superficial but later m penetrate entirely through the coating.

(*b*) Cracking. The fissures pass entirely through the coating wh first observed. The coating at the edges of the cracks sooner or lat comes loose from the wood and curls outward. As a rule crackin comes at a more advanced stage of paint embrittlement than checkin

(5) The stage of disintegration. Behavior in the fissure stage d termines the form in which disintegration takes place:

(*a*) Crumbling, which develops from checking, consists in the fa ing away of tiny fragments of coating cut off when the fissures becor interwoven and penetrate entirely through the coating.

(*b*) Flaking, which develops from cracking and curling. T loosened edges of coating that curl outward finally fall off, after whi the newly formed edges curl outward and the process continu Flaking is usually a more rapid form of disintegration than crun ling.

From the time that cracking or disintegration begins the nature the wood painted dominates the further rate of progress of failu On softwoods cracking, crumbling, and flaking progress chiefly o the bands of summer wood. The wider the bands of summer wo intersected by the painted surface the more rapidly disintegrati proceeds and the more conspicuous the areas laid bare. Repaint coatings behave in much the same way as coatings applied to n wood except that the fragments of coating that fall off may be sor what larger and may not begin to come off quite so soon.

The following wood properties or characteristics (Browne, si reference) largely determine how long softwood boards retain pa satisfactorily: (1) Wood of light weight (low density) holds pa longer than heavy wood because light wood contains less sum wood; (2) narrow-ringed wood holds coatings longer than wi ringed wood because the bands of summer wood are narrower; edge-grain surfaces hold coatings longer than flat-grain surfa also because the bands of summer wood are narrower at the surfa (4) flat-grain boards may hold paint better on the bark side t on the pith side because on the pith side there is sometimes a te ency for the edges of the bands of summer wood to loosen and outward, thus dislodging the coating; and (5) high-grade lum holds coatings better than low-grade both because knots and o defects hold paint poorly and because the low grades usually c from the center of the tree where the wood is likely to be w ringed.

Coatings begin to fail to protect wood against weathering w deep fissures develop. The consequences of inadequate protec depend upon the characteristics of the wood. Edge-grain bo are less seriously affected than flat-grain boards of the same spe

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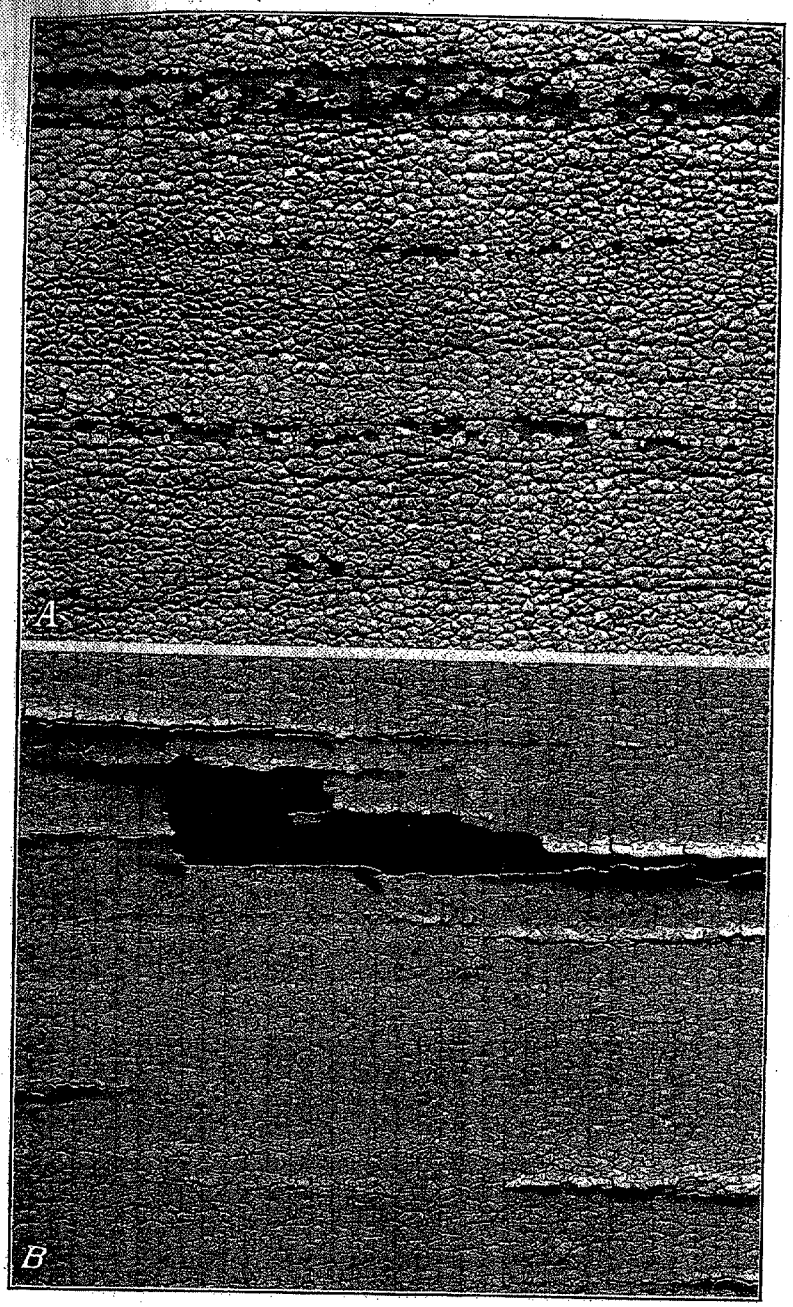

A, Disintegration of a paint coating by crumbling. The interweaving fissures, known as recitulate checking, were at first superficial but in the course of time they penetrated entirely through the coating. Now tiny fragments of coating cut off by the fissures are beginning to fall away from the bands of summer wood in the wood beneath. The area shown here is magnified × 4.4.

B, Disintegration of a paint coating by flaking. Checking was retarded in this paint by suitable choice of pigments and the checking is still superficial but cracking has started in the embrittled coating, the coating comes loose over the bands of summer wood in the wood beneath and curls upward at the edges of the cracks. Finally the curled edges of coating break off. The area shown here is only 1 by 1 inch in size. The coatings shown in *A* and *B* are similar in age and in all respects except the pigment composition of the paint.

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Woods that hold their shape well and do not develop conspicuous checks or cracks on weathering are less seriously affected by inadequacy of paint protection than are other woods.

CLASSIFICATION OF SOFTWOODS FOR PAINTING

Table 45 classifies native softwoods by species with respect to their painting characteristics for exterior use (Browne, sixth and ninth references). The classification is based upon the average behavior of commercial shipments of select grades of the different woods; that is, upon material of a quality that may be used for house siding or millwork. Boards of any one species may vary widely in paint retention so that, in general, boards selected for the physical properties that favor paint durability will serve much more satisfactorily than the average run of the species rated in table 45.

TABLE 45.—*Classification of softwoods for painting*

Group 1 [1]	Group 2 [2]	Group 3 [3]	Group 4 [4]
Alaska cedar. Incense cedar. Northern white cedar. Port Orford cedar. Southern white cedar. Western red cedar. Southern cypress. Redwood.	Northern white pine. Western white pine. Sugar pine.	Commercial white fir. Eastern hemlock. Western hemlock. Ponderosa pine. Lodgepole pine. Eastern spruce. Engelmann spruce. Sitka spruce.	Douglas fir. Western larch. Norway pine. Southern yellow pine. Tamarack.

[1] Woods that hold paint longest and suffer least when protection against weathering becomes inadequate.
[2] Woods that hold white-lead paint as long as those of group 1 but do not hold mixed-pigment paints quite so long and suffer more than those of group 1 if protection becomes inadequate.
[3] Woods that do not hold either white-lead paint of mixed-pigment paints so long as woods of group 1 and suffer more than woods of group 1 if protection becomes inadequate.
[4] Woods that do not hold paint coatings so long as woods of group 3.

EFFECT OF EXTRACTIVES IN WOOD ON PAINT BEHAVIOR

In general, the extractives in wood have much less effect on paint behavior than has been commonly supposed. They are far less important than the width of the bands of summer wood.

Distinction must be made between piny resins, which are characteristic of pines but occur also in other softwoods, and other extractives.

Piny resins consist of a solid rosin and a volatile liquid such as turpentine. They affect paint unfavorably by exuding through coatings, leaving unsightly encrustations. Exudation is minimized by thorough seasoning of the lumber to drive out the turpentine, rendering the resin less mobile. Much longer seasoning is necessary to remove turpentine than to remove moisture (Browne and Hrubesky). The piny resins may also be responsible for the fact that paints containing zinc oxide fail somewhat more rapidly on the pines than they do on other softwoods having bands of summer wood of similar width.

Other extractives in wood may have a favorable effect on the durability of paint (Browne, sixth reference). There is evidence that such is the fact with extractives in redwood and southern cypress, although colored extractives in redwood and red cedar that

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are soluble in water may exude through coatings if the wood beneath the coatings becomes very wet; under normally dry conditions these discolorations do not occur.

EFFECT OF IMPREGNATED PRESERVATIVES ON PAINTING

Wood treated with the water-soluble and other somewhat colorless preservatives in common use can be painted satisfactorily. The life of the coating may in some instances be slightly less than it would have been on untreated wood, but the loss in durability is not enough to offer any practical objection to the use of treated wood for purposes where preservation against decay is necessary and the appearance of painted wood and protection against weathering are desired (Browne, seventeenth reference). Coal-tar creosote or other dark oily preservatives tend to stain through paint and no entirely satisfactory method of painting over them is known (Dunlap), but fairly good results can be obtained with 1 or 2 coats of exterior aluminum paint.

CHOICE OF PAINTS FOR EXTERIOR WOODWORK

House paints of the best quality are recommended for nearly all needs for exterior painting. Inferior paints made to sell at materially lower prices must be applied in greater amount to accomplish the same result, may not last so long, and are less reliable generally. Even when low initial cost of painting is the chief consideration it usually proves cheaper to use high-grade paint in the minimum number of coats because the labor for a paint job usually costs several times as much as the paint. For both low initial cost and great durability, whenever the colors are acceptable, paints of good quality made with iron oxide pigments are more economical than most other good paints. Two coats of exterior aluminum paint make an exceedingly durable, highly protective coating when a metallic appearance is not considered undesirable. For very brief service or where very frequent repainting is desired for some reason and protection against weathering is not necessary, old-fashioned white-wash or modern types of exterior water or water-emulsion paints are safer to use than linseed oil paints of very inferior quality. The water paints give their best service on rough rather than on smoothly planed wood.

For residences or buildings of architectural pretension white or light-colored paints are most popular for the major painted surfaces, supplemented if desired by deeply colored paints on minor surfaces. When deep colors are appropriately dominant it is often better and more economical to use rough wood surfaces such as shingles or the sawed side of siding and apply exterior stains rather than gloss paints.

PASTE AND PREPARED PAINTS

Paste paints contain a greater proportion of pigment than prepared paints and must be thinned with more linseed oil and turpentine to make them ready for application. As a rule paste paints manipulated by a skillful painter in accordance with the particular conditions prevailing on the job permit closer adherence to the traditional technique of the paint craft than is possible with prepared paints. For example, in table 46 the second-coat mixture for three-

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coat painting and in table 47 the first-coat mixture for repainting contain less linseed oil in proportion to pigment than the manufacturer of prepared paint has already incorporated. For that reason these mixtures practically can be made only from paste paints. In congested urban locations or in parts of the South where mildew is troublesome, it is advantageous to mix even the finish-coat paint with less linseed oil than is already present in prepared paint.

On the other hand, unskilled or unscrupulous painters can make far more serious blunders in manipulating paste paint than they can make with prepared paint. The manufacturer of prepared paint can also make sure that a larger proportion of the linseed oil used in the paint is of the type most compatible with the particular kinds of pigments he has used. Further advantages of prepared paints lie in the fact that they are commonly sold in a much greater variety of colors than paste paints, so that tinting by the painter is often unnecessary and they are simpler for the ordinary home owner to use for general household painting purposes.

COMPOSITION OF PAINT

The quality of a house paint depends upon the quality of the liquids, the quality of the pigments, and the proportions of pigments and liquids of which it is made (Browne, eleventh reference).

Quality of the Liquids

Linseed oil is the most widely accepted liquid ingredient for exterior paints for wood. It is available in many degrees of refinement for different purposes. Proper choice of the kind of linseed oil most suitable for the pigments used is essential for making high-grade paint, but as a rule the purchaser must rely upon the manufacturer's judgment in selecting the kind of oil. Substitution of other drying oils for part of the linseed oil is not necessarily detrimental to the quality of the paint. In most high-grade paste or prepared paints from 80 to 100 percent by weight of the liquid consists of linseed oil or linseed oil and other drying oils. For the painter's needs in thinning paints for application, raw or boiled linseed oil of good quality should be used. The oil for thinning mixed-pigment paints should have an acid number not exceeding 4.

Varnish is rarely a desirable ingredient in the liquid of good house paint (except in aluminum paint, p. 239), but cheap varnish is often used in inferior paints because large proportions of volatile thinners, which are inexpensive, can then be incorporated. On the other hand, good exterior varnish or heat-treated linseed oil or tung oil is necessary to make exterior enamels or exterior floor paints, which must stand mechanical wear as well as weather. In such enamels or floor paints of good quality as much as 50 percent by weight of the liquid may be volatile thinner. Synthetic drying oils are now manufactured for paint oils; they make paints that dry faster than linseed-oil paints, but they have not been in use long enough for their merits to be well established.

The volatile thinner in most paints is mineral spirits, a petroleum product, but turpentine is commonly recommended for painters to use in thinning paint. There should be no more than 1 or 2 percent by weight of water in the liquid of any good paint.

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Quality of the Pigments

Differences in the behavior of linseed-oil paints during the successive stages in deterioration with age (p. 229) are determined largely by the nature of the pigments. No kind of paint now known is superior in all stages of deterioration; improvement in one stage is usually effected at some sacrifice in other stages. For that reason the user's judgment about the relative importance of the different stages, and particularly about the stage at which he expects to repaint, determines what kind of paint he can use to best advantage. For intelligent paint maintenance, therefore, the user should know the pigment composition of the paint and its bearing upon behavior during deterioration.

The opaque white pigments predominate in the pigment of good white paints. Tinted paints, which include the majority of colored house paints, are essentially white paints containing minor proportions of colored pigments. The good white paints and white base paints for tinting may be grouped for convenience into pure white-lead paint, lead and zinc mixed-pigment paints, and mixed-pigment paints containing modern, very opaque pigments.

In pure white-lead paint the pigment is entirely basic carbonate white lead. During the soiling and flatting stages of its life white-lead paint may become dirtier than mixed-pigment paints, especially in congested urban locations or when applied in the late fall, winter, or early spring, or in deeply shaded places. Chalking of white-lead paint and apparent fading, if it is tinted, usually set in fairly early, after which the dirt is thrown off promptly and evenly, leaving a clean surface which may, however, contrast strongly with deeply shaded parts of the building that are still dirty and not yet faded. Checking begins comparatively early, usually inconspicuously, and gradually works deeply into the coating, but probably for that reason cracking and flaking rarely occur (pl. 4). The outstanding merit of white-lead paint is the long interval between checking and beginning of crumbling and the slow progress of crumbling in the stage of disintegration, especially on woods of groups 1 and 2 in table 45. Even badly neglected white-lead-painted surfaces can usually be covered fairly smoothly and durably with new paint unless large weather checks have developed in the wood. Initial painting with white-lead paint provides a very satisfactory foundation for subsequent painting with mixed-pigment paints, but it is not advisable to apply pure white-lead paint over mixed-pigment paints because checking may then assume the conspicuous form known as "alligatoring."

In good mixed-pigment paints of the lead-and-zinc type, part of the basic carbonate white lead is replaced by zinc oxide, and another and smaller part may or may not be replaced by inexpensive transparent pigments such as magnesium silicate, silica, barium sulphate, clay, or calcium carbonate. In such paints basic carbonate and basic sulphate white lead are commonly considered interchangeable, either one or any mixture of the two may be used for the white-lead content of the pigment. Incorporation of the zinc oxide reduces the chances of excessive soiling of the coating and retards both chalking and checking. Appearance during the soiling, flatting, and chalking stages may therefore be somewhat better than that of pure white-

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lead paint, especially if the paint is tinted, but on the other hand the coating may remain dirty longer. Ultimate disintegration of lead and zinc paints usually takes place by cracking, curling, and flaking (pl. 4). Long neglect of repainting after flaking starts, especially if the content of zinc oxide is high, may leave a surface that cannot be smoothly and durably repainted without removing the old coating completely. Federal Government Specification TT–P–36 for lead-and-zinc paint requires that the content of white lead shall be not less than 60 percent by weight and the sum of the white lead and zinc oxide not less than 90 percent of the total pigment. Transparent and colored pigments together must therefore be limited to 10 percent of the total pigment. Some authorities who regard this as a satisfactory specification for white paint think that in tinted paints the minimum content of white lead should be 50 percent and the minimum sum of white lead and zinc oxide 85 percent of the total pigment. In parts of the South where the relative humidity is always high, chalking and fading of paint are stimulated while cracking and flaking are retarded and paints are subject to the growth of mildew. For such a climate it is advantageous to increase the content of zinc oxide to as much as 50 percent of the total pigment.

Mixed-pigment paints containing very opaque white pigments may be considered conveniently as lead-and-zinc paints in which part or all of the white lead is replaced by one of the titanium pigments, by one of the zinc sulphide pigments, or their mixtures. Good paints of this type are characterized by unusual freedom from dirt in the soiling stage and prompt shedding of dirt in the chalking stage. When white lead is replaced entirely by one of the titanium pigments development of fissures may be greatly retarded and checking entirely prevented; but if repainting is postponed long enough, cracking and flaking ultimately set in as they do in the mixed-pigment paints already discussed. The most popular titanium pigment for exterior paints is a mixture of 25 percent titanium dioxide and 75 percent barium sulphate by weight. Some paint manufacturers prefer to use pure titanium dioxide, in which case it is good practice to consider a mixture of 1 part by weight of titanium dioxide together with about 1¾ parts of magnesium silicate, silica, or calcium carbonate as the titanium pigment that can properly replace 2¾ parts of white lead in good lead-and-zinc paint. The most important zinc sulphide pigment is lithopone which contains about 30 percent zinc sulphide and 70 percent barium sulphate. Pure zinc sulphide is now used in a few brands of house paint.

Dull red, brown, and yellow pigment paints are made most economically with iron oxide pigments, either natural earths or manufactured pigments. For good retention of color and maximum durability the content of iron oxide in the pigment may well be 80 percent by weight or more and should certainly be not less than 30 percent. Bright reds require organic lake pigments that are more expensive and less durable than iron oxide reds. Bright yellows and oranges are made with chrome yellows (lead chromate and basic lead chromate) which are fully as expensive as white pigments but are more durable. Greens are made with chrome green, which is a mixture of chrome yellow and prussian or chinese blue (iron ferro-

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cyanide). Durable blacks are made with carbon pigments, such as lampblack; asphalt paints make cheaper but less durable blacks for exposure to the weather. When color permits, colored-pigment paints often retain color and protective power better if they contain some zinc oxide or white lead. If they do not, it is advisable to apply them over priming coats of white-lead or aluminum paint.

Proportions of Pigments and Liquids

Durability as well as color and capacity are imparted to paint by pigments. For that reason there is an optimum proportion of pigments and linseed oil in good paint. Although the optimum proportions have not been determined accurately to the satisfaction of all authorities, it is known to be good practice with the paints described herein to keep the pigment volume, which is the percentage by volume of total pigment to total nonvolatile ingredients, within the range of 25 to 32 percent in the finish-coat paint. At the lower end of this range or below it, paints may become unnecessarily dirty; while at the upper end of the range or above it, they may lose gloss rapidly and begin to chalk and fade early. Prepared paints, and paste paints when thinned for application as finish coats, should contain enough total pigment to fall within this range, preferably nearer the upper part of it. Inferior paints, unless they contain very large proportions of transparent pigments, are usually deficient in content of total pigment. The painter can readily add more linseed oil if it should be desirable, but it is seldom practicable to remove excess oil from prepared paint.

Once the correct ratio of pigment and linseed oil has been established, some volatile thinner is usually necessary to obtain good brushing consistency and convenient application at the proper spreading rate. Paints that require unusually large amounts of thinner to establish good consistency have "false body" and may justly be regarded as of questionable quality.

The pigment volume in paint is not customarily indicated in the manufacturer's statement of composition, which gives the proportions of ingredients by weight, but it can be easily calculated if the specific gravity of each of the ingredients is known. Tables of the specific gravities of the important ingredients of paint are available (Gardner).

Exterior Stains

Exterior wood stains are essentially paints greatly diluted with linseed oil, a volatile thinner, and sometimes creosote. Stains are cheaper than paints, but they do not protect wood against weathering and are therefore most suitable for rough surfaces, such as shingles or siding placed with the sawed side out. Good stains should contain only pure, finely divided, opaque pigments, free from transparent pigments. The pure iron oxide, chrome, and carbon pigments are very satisfactory; white pigments less so. The liquid part of the stain should be at least one-third linseed oil by volume, with two-thirds recommended by some authorities. Particular merits are claimed for stains made with pigments ground in very highly bodied linseed oil because the pigments are more highly dispersed in such

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liquids and become more deeply embedded in rough wood surfaces. Houses with shingles or siding with the sawed side out, stained with colored-pigment stains, and with smoothly planed and painted wood trim often have the trim painted twice for every time that the side walls are stained.

VARNISHES

Transparent finishes are rarely practicable on exterior surfaces fully exposed to the weather, except on small, easily accessible surfaces such as doors, because even the best varnishes are far less durable than paints. When transparent finishes are used, prompt renewal of the varnish when needed is essential to prevent the wood from turning permanently gray.

APPLICATION OF PAINT

Wood should not be painted when it is wet. As long as there is no free water present, however, the moisture content is of minor importance; wood painted at 16- to 20-percent moisture content holds paint slightly longer than wood painted at 10-percent moisture content. Paint dries very slowly at low temperatures; painting should therefore not be done at times when the temperature is likely to fall below 40° F. When there is danger of dew or frost at night application of paint should cease several hours before sunset. In clear, warm weather coatings of paint can be applied within 24 hours of each other if necessary, but it is better practice to allow at least 2 or 3 days. On the other hand, it generally is inadvisable to allow more than 1 or 2 weeks to elapse between successive coats.

On new houses faulty methods of drying the interior plastering that drive moisture into the sheathing and siding (Browne, fifth reference, and Hartwig) cause blistering and peeling of paint (p. 240). If there is doubt about the moisture content within the side wall, it is best to apply only the priming coat to the exterior woodwork and defer the remaining coats until the walls are thoroughly dry. The priming coat will not blister; but on the other hand it furnishes only partial protection against weathering, so that the painting should be completed as soon as it its safe to do so.

On new wood surfaces or on painted surfaces on which the old coating has not yet become deeply cracked, paint may be applied by brush or spray gun with equally serviceable results. Over old coatings that have passed well into the fissure or the flaking stage of paint deterioration, however, sprayed paint may not prove so durable as brushed paint.

The conventional procedure in painting new wood surfaces calls for the application of three coats of paint, a priming coat, second coat, and finish coat. Usually the three coats are made of the same kind of paint except for differences in proportions of pigments, linseed oil, and turpentine, but the current trend is toward the use of special paints for priming coats. Much painting of new wood is now done with only two coats, but this practice frequently leads to unsatisfactory results. When properly done 2-coat painting is practicable, but it requires much more skillful workmanship than 3-coat painting.

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MIXING OF PAINT

In three-coat painting of new wood surfaces it is well-established practice for the priming-coat paint to have a pigment volume between 20 and 25 percent, the second-coat paint 35 to 40 percent, and the finish-coat paint 25 to 32 percent. The high pigment volume in the second coat requires the use of paste paint. With prepared paint it is generally necessary to have the same pigment volume in the second and finish coats, but the second coat should never have a lower pigment volume than the finish coat. In two-coat painting of new wood both coats may have 25 to 32 percent of pigment volume, and they should be applied thicker than is customary in three-coat painting. Table 46 presents suitable directions for thinning paste paints in accordance with the foregoing practices, provided the approximate proporation of total pigment in the paste paint is known. When using prepared paint the painter has little control over the pigment volume. In general, not more than 1 quart of linseed oil and 1 pint of turpentine should be added to a gallon of prepared paint for the priming coat, and the second coat should be thinned with 1 pint of turpentine and no linseed oil. As a rule, no addition is made to prepared paint for finish coat.

TABLE 46.—*Approximate amounts of linseed oil and turpentine to be added to 1 gallon of paste paint for painting new wood surfaces*

Reduction and spreading rate	For 3-coat initial painting			For 2-coat initial painting	
	First coat	Second coat	Third coat	First coat	Second coat
For soft paste [1] white-lead paint and other paste paints containing more than 50 percent pigment by volume:					
Raw linseed oil [2] ..... quarts	6	2	4	4	4
Turpentine ..... do	1½	1½	0	1	0
Spreading rate [3] ..... square feet per gallon	575	600	600	450	500
For paste [1] paints containing 40 to 50 percent pigment by volume:					
Raw linseed oil [2] ..... quarts	5	1½	3	3	3
Turpentine ..... do	1	1	0	1	0
Spreading rate [3] ..... square feet per gallon	575	600	600	450	500
For paste [1] paints containing less than 40 percent pigment by volume:					
Raw linseed oil [2] ..... quarts	3½	1	2	------	------
Turpentine ..... do	1	1	½	------	------
Spreading rate [3] ..... square feet per gallon	550	575	575	------	------

[1] If the paste paint contains no drier about ½ pint of liquid paint drier should be added in each of the above mixtures.
[2] Boiled linseed oil should be used in place of raw linseed oil only if the manufacturer indicates that it is satisfactory to do so.
[3] If additional thinning is necessary to give good brushing consistency, thin further with turpentine, not with linseed oil, and apply the paint at correspondingly lower spreading rate. For congested urban districts where paint becomes very dirty or where mildew is troublesome, the amount of linseed oil added to finish coats may be reduced by about 1 pint and the amount of turpentine increased by about ¾ pint.

Changes in priming-coat reductions according to the nature of the wood painted are often recommended in the mistaken belief that the differences in painting characteristics of woods can be offset in that way. The priming-coat mixtures given in table 46 are suitable for all native softwoods. For resinous woods such as southern yellow pine the common suggestion to mix priming coats with

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more than the usual proportion of turpentine is very definitely bad practice.

The durability of paint on woods of groups 3 and 4 of table 45 can often be materially increased by using special priming paints. Pure white-lead paint when used as a priming paint over which mixed-pigment paints are applied, especially paints high in zinc oxide, may be considered a special priming paint for this purpose. The experience of the Forest Products Laboratory so far indicates that the most effective special priming paint on woods of groups 3 and 4 is exterior aluminum paint (Browne, seventh, fourteenth, fifteenth and sixteenth references, and Edwards and Wray). Aluminum priming paint is made usually with 2 pounds of dry aluminum powder, standard varnish grade, or 2 pounds of commercial paste aluminum in 1 gallon of long-oil spar varnish made specifically for that purpose. The right kind of varnish must be used. Neither ordinary spar varnish, which is both unsuitable and too expensive, nor cheap bronzing liquid for interior use is acceptable for exterior aluminum paint. When properly applied the aluminum primer hides the surface of the wood completely. Aluminum priming paint, in common with other colored primers, makes checking in those paints in which it occurs somewhat more prominent; but if the aluminum primer is a suitable one, it does not hasten the development of checking or alter the pattern in which it occurs.

REPAINTING

The fundamental factor in good paint maintenance is to repaint at the right time. Neglect of repainting results in damage that cannot be satisfactorily repaired by mere application of paint. Warped and checked boards are not restored by paint, and a badly broken old coating cannot be covered smoothly without first removing it entirely, which is an expensive operation (Browne, twelfth reference).

It sometimes happens that a relatively small number of boards on a house lose their paint much sooner and more conspicuously than the rest of the boards. In such cases the average life of subsequent coatings can often be increased by replacing these boards with new ones chosen for good painting characteristics in accordance with the principles stated on page 230.

Those who are willing to repaint often to maintain the best possible appearance may do their repainting at some time during the chalking stage of deterioration. They should either have two coats applied fairly thinly or else have the dirt washed off thoroughly and only one substantial coat of paint applied.

Those who wish to repaint as infrequently as is consistent with good maintenance usually wait for the stage of fissures or the very early part of the stage of disintegration before repainting. Two coats are then advisable and are usually necessary if crumbling or flaking has begun. Any loosened parts of the old coating should be removed with a putty knife, wire brush, or sandpaper. Conspicuous spots of bare wood should be touched up with priming-coat paint. Two full coats of paint should then be applied. Table 47 may be used as a guide for thinning paste paints for repainting according to the same principles on which table 46 for initial painting is based.

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TABLE 47.—*Approximate amounts of linseed oil and turpentine to be added to 1 gallon of paste paint for repainting during the fissure stage or the very early stage of disintegration of the old coating*

Reduction and spreading rate	First coat	Second coat
For soft paste [1] white-lead paint and paste paints containing more than 50 percent pigment by volume:		
Raw linseed oil [2] ..... quarts	2⅔	4
Turpentine ..... do	2⅓	0
Spreading rate [3] ..... square feet per gallon	600	600
For paste [1] paints containing 40 to 50 percent pigment by volume:		
Raw linseed oil [2] ..... quarts	1⅔	3
Turpentine ..... do	2	0
Spreading rate [3] ..... square feet per gallon	600	600
For paste [1] paints containing less than 40 percent pigment by volume:		
Raw linseed oil [2] ..... quarts	1	2
Turpentine ..... do	2	½
Spreading rate [3] ..... square feet per gallon	575	575

[1] If the paste paint contains no drier about ¼ pint of liquid paint drier should be added in each of the above mixtures.

[2] Boiled linseed oil should be used in place of raw linseed oil only if the manufacturer indicates that it is satisfactory to do so.

[3] If additional thinning is necessary to give good brushing consistency, thin further with turpentine, not with linseed oil, and apply the paint at correspondingly lower spreading rate. For congested urban districts where paint becomes very dirty or where mildew is troublesome, the amount of linseed oil added to finish coats may be reduced by about 1 pint and the amount of turpentine increased by about ¾ pint.

If repainting is neglected until long after flaking sets in, the surface may present a difficult and uncertain problem in repainting unless the old paint was one that stands neglect well. The safest procedure may be to burn off the old coating completely and repaint with three coats as for new wood.

In the maintenance of a paint over a long period it is advantageous to adhere to one type of paint, at least for all paintings after the first one. Changing the type of paint at each time of painting builds up a coating of varying composition with the danger that unpredictable vagaries in behavior may be encountered.

BLISTERING OF COATINGS

Conditions sometimes arise under which paint coatings on wood buildings do not undergo the normal course of deterioration already described but fail in an unreasonably short time by blistering followed by peeling or by scaling of the coating, generally in large patches, or else become discolored by exudation of water-soluble dyes contained in the wood or by blue stain fungi growing in sapwood (Browne, fifth reference, and Hartwig). Practically speaking, moisture gaining access to the backs of the painted boards is invariably the cause of such abnormal paint behavior (pl. 5). The quality of the paint, the workmanship during application, and the nature of the wood are not directly responsible for abnormal behavior because under such circumstances all paints fail and trouble may be expected on any kind of wood.

There is only one remedy for abnormal paint behavior of this type, namely, location of the source of the moisture and improvement of conditions to eliminate it.

Moisture may gain entrance to the side walls of buildings in several ways, among which the most important are (1) by seepage of

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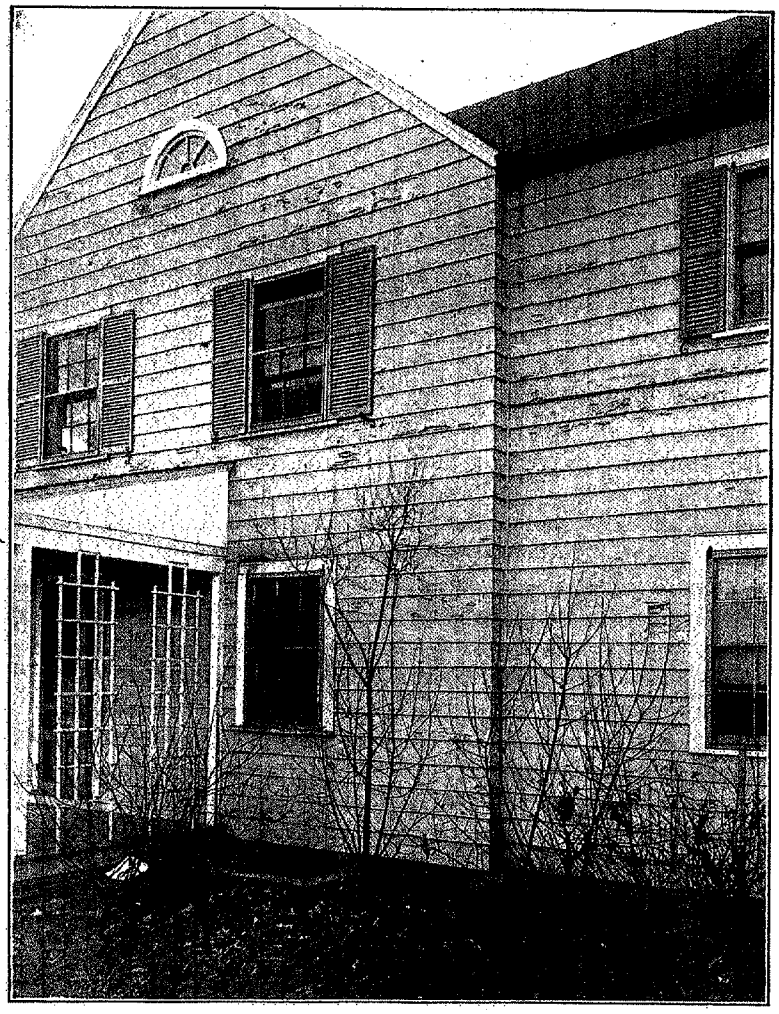

The side walls of this house become wet every winter and by spring the boards of siding are thoroughly wet and cause scaling of paint. The house was painted in March of one year, repainted in July the next year, and photographed the following year.

rain water or melting snow through joints and (2) by condensation from warm, moisture-laden air that originates within the building, circulates through hollow side walls, and is chilled when it meets the cold surfaces of sheathing or siding during cold weather. The following joints in frame buildings have frequently been found sources of seepage moisture: Junctions between the siding and corner boards, window and door casing, and chimney masonry; junctions between side walls and porch roofs; the junction between porch columns and plinth blocks; and leaking roofs, eave troughs, and down spouts. The following conditions have often caused condensation of moisture within painted side walls: Hastening the drying of plaster by heating without adequate ventilation; enclosing damp, stagnant air spaces under porches or parts of structures extending beyond the basement excavation; lack of ventilation in unused attics; failure to obtain a watertight basement; plumbing leaks; and artificial humidification or activities within the building that give off much moisture during cold weather.

BACK PRIMING AND MILL PRIMING

Concealed surfaces are sometimes painted to retard changes in the moisture content of the wood (Browne, fifteenth reference, and Edwards and Wray). More than one coat is rarely applied for such purposes, and using the same priming-coat paint that is applied to the exposed surfaces is often convenient. Siding, shingles, and millwork are the principal items of building lumber back primed in this way.

The practice of priming lumber and woodwork at the mill is increasing. One object of mill priming is to give protection against moisture during shipment, storage, and erection before final finishing is possible. Mill priming in general should include back priming where practicable because boards coated on one side are more likely to warp when the moisture content changes than uncoated boards or boards coated equally on all sides.

No coating that completely prevents changes in the moisture content of wood has been found; the best that can be done is to retard the rate of change (Hunt). Good coatings furnish adequate protection against rapidly changing atmospheric conditions or against alternate rain and sunshine, but they are relatively ineffective against prolonged exposure to extreme conditions and do not prevent seasonal fluctuations in the moisture content of interior woodwork.

Table 48 gives the comparative effectiveness of various common coatings in protecting wood at 11-percent moisture content against absorption of moisture during 2 weeks' exposure to nearly saturated air. Table 48 gives also the comparative effectiveness of 1, 2, and 3 coatings. These values are for the coatings when new. With age the effectiveness at first increases somewhat and then decreases as the coating deteriorates so that the coatings must be kept in good condition to maintain their effectiveness. A similar comparison of coatings for interior use only is given on page 246.

The degree of protection attainable with a priming coat alone is usually limited; at least 2 coats and often 3 are necessary to build up an adequate barrier against moisture (Browne, fifteenth ref-

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erence). Mill priming, therefore, affords only a very moderate degree of protection against change in moisture content before installation, and after woodwork has been installed the benefit derived from back priming is probably limited.

Oils, resins, or waxes absorbed by the wood or forced into it by impregnation are much less effective against movement of moisture than good coatings that form a layer of substantial thickness over the wood.

TABLE 48.—*Moisture-excluding effectiveness of coatings, suitable for both exterior and interior use, during 2 weeks' exposure of wood (initially at 11-percent moisture content) to nearly saturated air*

[For ordinary exterior house paints in their customary uses moisture-excluding effectiveness greater than about 60 percent is not necessary. The data in this table should not be construed as an index of the serviceableness of such paints in general]

Coating no.	Description	Effectiveness [1] found for—		
		1 coat	2 coats	3 coats
		Percent	*Percent*	*Percent*
1	Aluminum powder in asphalt or pitch paint vehicle	----	----	98
2	Aluminum powder in no. 16 vehicle	39	88	95
3	Extra fine aluminum powder in no. 16 vehicle	78	92	94
4	Aluminum powder in "alkyd" type synthetic vehicle	15	81	93
5	White lead in a vehicle similar to no. 16	62	86	91
6	One coat of no. 2 plus 2 coats of no. 17	39	86	91
7	White lead in no. 19 vehicle	24	85	91
8	Aluminum powder in no. 23 vehicle	9	61	90
9	Asphalt or pitch paint	----	----	90
10	Aluminum powder in bodied linseed-oil vehicle	26	84	89
11	One coat of no. 8 plus 2 coats of no. 17	9	62	86
12	White lead in no. 23 vehicle	7	62	83
13	Aluminum powder in linseed oil	14	57	77
14	Aluminum powder and red lead in linseed oil	7	65	75
15	Linseed-oil house paint containing zinc oxide and other white pigments with or without tinting colors	30	69	73
16	Phenol-aldehyde synthetic resin, 50-gallon varnish [2]	5	49	73
17	Linseed-oil house paint containing no zinc oxide, such as common lead-and-oil paint	20	57	70
18	Red lead in linseed oil	4	58	64
19	Ester gum resin, 33-gallon spar varnish [2]	6	37	65
20	Graphite in linseed oil	4	58	64
21	Red linseed-oil barn paint, pigment 98 percent pure iron oxide	25	53	56
22	Red linseed-oil barn paint, pigment venetian red containing 40 percent iron oxide	1	25	45
23	Ester gum resin, 75-gallon long-oil spar varnish	3	14	35
24	Linseed oil containing paint drier	3	5	21

[1] Perfect protection would be represented by 100-percent effectiveness; complete lack of protection, as with uncoated wood, by zero.
[2] A "50-gallon" varnish is made in the proportion of 50 gallons of drying oil to 100 pounds of resin; a "33 gallon" varnish is made with 33 gallons of drying oil to 100 pounds of resin.

UNCOATED EXTERIOR WOODWORK

Architectural design sometimes calls for the appearance of weather-beaten wood, and the best way to attain such appearance is to let wood weather naturally, especially since uncoated exterior woodwork is not necessarily lacking in durability. For weathered construction it is advisable to choose woods that weather with a minimum of cupping, twisting, and conspicuous checking, such as those of group 1 in table 45. Edge-grain boards weather better than flat-grain boards, and thick boards better than thin ones. It is also best to exclude boards containing pith and to place flat-grain boards with the bark side (the side nearer the bark of the log) out. Fastenings for wea-

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thered construction should be secured especially firmly with noncorrosive metals, and joints should be designed to prevent retention of moisture as far as that is possible.

INTERIOR FINISHING

Interior finishing differs from exterior chiefly in that interior woodwork usually requires much less adequate protection against moisture and that more exacting standards of appearance and a greater variety of effects are expected (Browne, second reference). Good interior finishes should last much longer than exterior paint coatings, but no interior finish should ever be used out of doors.

OPAQUE FINISHES

Interior surfaces may, if desired, be painted with the materials and by following the procedures recommended for exterior surfaces. As a rule, however, smoother surfaces, better color, and a more lasting sheen are demanded for interior woodwork, and therefore enamels rather than paints are employed. These finishes differ from paints in that linseed oil is replaced partly or entirely by bodied oils or by varnishes in order to make a coating that does not show brush marks and presents a harder surface with a desired degree of gloss. They may also be made of nitrocellulose lacquers or synthetic resins and drying oils that dry much more rapidly than oleo-resinous enamels. Unless made with expensive pigments of extraordinary opacity, such as titanium dioxide or zinc sulphide, enamels are less opaque than paints of the same color because they cannot be made with so large a proportion of pigment.

Before enameling, the wood surface must be made extremely smooth. Imperfections, such as planer marks, hammer marks, and raised grain, are accentuated by enamel finish. Raised grain is especially troublesome on flat-grain surfaces of the heavier softwoods because the hard bands of summer wood are sometimes crushed into the soft spring wood in planing and later are pushed up again when the wood changes in moisture content (Koehler). It is helpful to sponge softwoods with water, allow them to dry thoroughly, and then sandpaper them lightly with sharp sandpaper before enameling. In new buildings woodwork should be allowed adequate time to come to its equilibrium moisture content before finishing.

Hardwoods having large pores must be filled with wood filler before the priming coat. For all woods the priming coat may be white-lead paint mixed according to directions for exterior priming-coat paint, or special priming paints made for that purpose may be used. Knots in the white pines, ponderosa pine, or southern yellow pine should be shellacked after the priming coat is dry. A coat of shellac is sometimes necessary also over the white pines and ponderosa pine to prevent discoloration of light-colored enamels by colored matter apparently present in the resin of the heartwood of these species. One or two coats of enamel undercoat are next applied; this should completely hide the wood and should also present a surface that can easily be sandpapered smooth. For best results the surface should be sandpapered before applying the finishing enamel, but this operation is sometimes omitted. After the finishing enamel has been applied it may be left with its natural gloss or rubbed to a dull finish.

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TRANSPARENT FINISHES

There are many good ways of applying transparent finishes to either hardwoods or softwoods. Most finishing consists in some combination of the following fundamental operations: Staining, filling, sealing, surface coating, rubbing, and polishing. Before finishing, planer marks and other blemishes of the wood surface that would be accentuated by the finish must be removed.

Both softwoods and hardwoods are often finished without staining, especially if the wood is one with a pleasing and characteristic color. When used, however, stain often provides much more than color alone because it is absorbed unequally by different parts of the wood and therefore accentuates the natural variations in grain. With hardwoods such emphasis of the grain is usually desirable; the best stains for the purpose are dyes dissolved either in water or in oil. The water stains give the most pleasing results but raise the grain of the wood and require an extra sanding operation after the stain is dry. "Non-grain-raising" stains are now available that often approach the water stains in clearness and uniformity of color. With softwoods, stains color the spring wood more strongly than the summer wood, reversing the natural gradation in color in a manner that is often garish. Pigment-oil stains, which are essentially thin paints, are less subject to this objection than are other stains and are therefore more suitable for softwoods.

Hardwoods having large pores must be filled before a smooth varnish or lacquer coating can be applied. If a smooth coating is not desired, however, filling is optional. The filler may be transparent and without effect on the color of the finish or it may be colored to contrast with the surrounding wood. Usually colored filler is darker than the rest of the wood.

Sealer is used to prevent absorption of subsequent surface coatings and to prevent the bleeding of some stains and fillers into surface coatings, especially lacquer coatings. Shellac is the oldest type of sealer. Varnish can be used as a sealer but is not so effective as shellac.

Surface coatings may be of wax, shellac, varnish, or nitrocellulose lacquer. Wax provides a characteristic sheen without forming a coating of sensible thickness and without greatly enhancing the natural luster of the wood. Coatings of a more resinous nature, especially shellac and varnish, accentuate the natural luster of some hardwoods and seem to permit the observer to look down into the wood to a certain extent. Shellac applied by the laborious process of French polishing probably achieves this impression of depth most fully, but the coating is easily marred by water and is expensive. Rubbing varnishes made with resins of high refractive index for light are nearly as effective as shellac. Lacquers have the advantage of drying rapidly and forming a hard surface but require more applications than varnish to build a lustrous coating.

Varnish and lacquer usually dry with a highly glossy surface. To reduce the gloss the surfaces may be rubbed with pumice stone and water or polishing oil. Waterproof sandpaper and water may be used instead of pumice stone. The final sheen varies with the fineness of the powdered pumice stone, coarse powders making a dull surface and fine powders a bright sheen. For very smooth surfaces with high

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polish the final rubbing is done with rottenstone and oil. Varnish and lacquer can be made to dry dull in the first place, but the result is not quite the same as that produced by rubbing.

FINISHES FOR FLOORS

Finishes for wood floors are subject to severe mechanical wear and consequently deteriorate more rapidly than finishes on most other classes of woodwork. Floor finishes must, therefore, be renewed frequently. Discussions of floor finishes usually place undue emphasis upon the kind or quality of material used and pay far too little attention to the maintenance. Any of the common types of floor finishes will keep wood floors in excellent condition if properly maintained, but no finish will do so if it is neglected. The essential problem is to adapt a systematic program of maintenance to the requirements of the finishing material chosen and of the degree of wear to which the floor is subjected.

The opaque and transparent interior finishes already described are applicable to floor finishing, provided that the floor paints, floor varnishes, or lacquers are made with the careful balance between toughness and hardness necessary to make them resistant to mechanical wear. The essential point in maintaining any floor finish that includes a surface coating is to recoat before the old coating has actually worn down to the wood in conspicuous spots. Good floor paints or varnishes require less frequent renewal than wax finishes under similar conditions of wear, but each renewal is more expensive in material and labor and keeps the floor from being used for a longer time than finishes that do not include substantial surface coating. For floors subject to heavy wear, coatings of any kind often prove unduly expensive and inconvenient.

Floors subject to heavy wear are often finished with floor oils that are absorbed by the wood and do not form substantial coatings. They furnish less adequate protection against moisture and dirt than coatings, but are cheaper and can be applied with less labor and inconvenience. Most floor oils darken wood appreciably and do not present so fine an appearance as well-maintained coatings. A new method is coming into use that keeps oiled floors bright and clean by buffing them with steel wool after oiling, and at suitable intervals. Machines for buffing floors with steel wool are now available.

Floor waxes applied either directly to wood or over a sealer do not form substantial coatings. They are usually superior to floor oils in appearance although they must be renewed even more frequently. Floor waxes of the emulsion type are very quickly and easily applied and are relatively inexpensive.

EFFECTIVENESS OF MOISTURE-EXCLUDING COATINGS SUITABLE FOR INTERIOR USE

The comparative effectiveness of various common coatings in protecting wood at 11-percent moisture content against absorption of moisture during 2 weeks' exposure to nearly saturated air is given in the following tabulation in which perfect protection would be represented by 100-percent effectiveness; complete lack of protection, as with uncoated wood, by zero. A similar comparison of coatings for exterior use is given on page 242.

Description:	Percent effectiveness
3 coats of spar varnish coated with vaseline (for storage purposes only)	98
Aluminum-leaf process, cellulose-lacquer base	94
3 coats of aluminum powder in gloss oil (quick drying)	92
3 coats of aluminum powder in shellac	92
Heavy coating of paraffin	91
3 coats of rubbing varnish	89
3 coats of shellac	87
3 coats of enamel (cellulose-lacquer vehicle)	76
3 coats of cellulose lacquer	73
3 coats of gloss oil bronzing liquid	12
3 coats of furniture wax	8

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Pacific Retail Lumbermen

SOME INTERESTING FACTS ABOUT PAINT COMPLAINTS

(28)

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ALTHOUGH thousands of owners of frame buildings succeed in keeping them painted to their satisfaction there is another large group that experiences repeated and disastrous early failures of their paint coatings. The latter group is numerous enough to give rise to a growing public feeling that exterior paint and painting are not so reliable as they should be. Lumbermen and lumber dealers suffer from such public resentment against paint for two reasons: First, it becomes a factor in turning builders against wood in favor of competitive materials that may be used without paint, and second, the lumberman is sometimes drawn into specific complaints and asked to share in settlement for them.

Realization of the handicap of paint difficulties in the selling of their products has led various lumber groups to take active measures against bad painting practices. Ten years ago one of the regional lumber manufacturers' associations detailed Otto Hartwig to inspect houses on which complaint about paint had been called to the attention of the association. Within a few years Hartwig studied over 1500 houses. More recently the Lumber Products Better Paint campaign was organized under the sponsorship of lumber groups, the master painters, and the lead miners to encourage better practices and to study home owners' complaints about house paint. The regional lumber manufacturers' associations are now placing pamphlets containing painting instructions in bundles of siding lumber but find thmselves badly handicapped by the fact that pure white lead paint is the only kind of paint commonly sold in a sufficiently standardized form to permit making specific recommendations for its use. The National Retail Lumber Dealers' Association from time to time distributes circulars about paint prepared by the National Paint, Varnish and Lacquer Manufacturers' Association. The Secretaries' Conference of the lumber dealers has appointed a research committee to study the paint situation and the International Society of Master Painters has a committee considering a plan to examine and certify satisfactory paints to its members.

These various activities speak eloquently of the widespread dissatisfaction with painted woodwork. All of the movements

*Maintained at Madison, Wisconsin, in co-operation with the University of Wisconsin.

When paint failures lead to expensive jobs of removal with the blow torch the cost of paint maintenance becomes excessive and house owners become dissatisfied with painted exterior woodwork.

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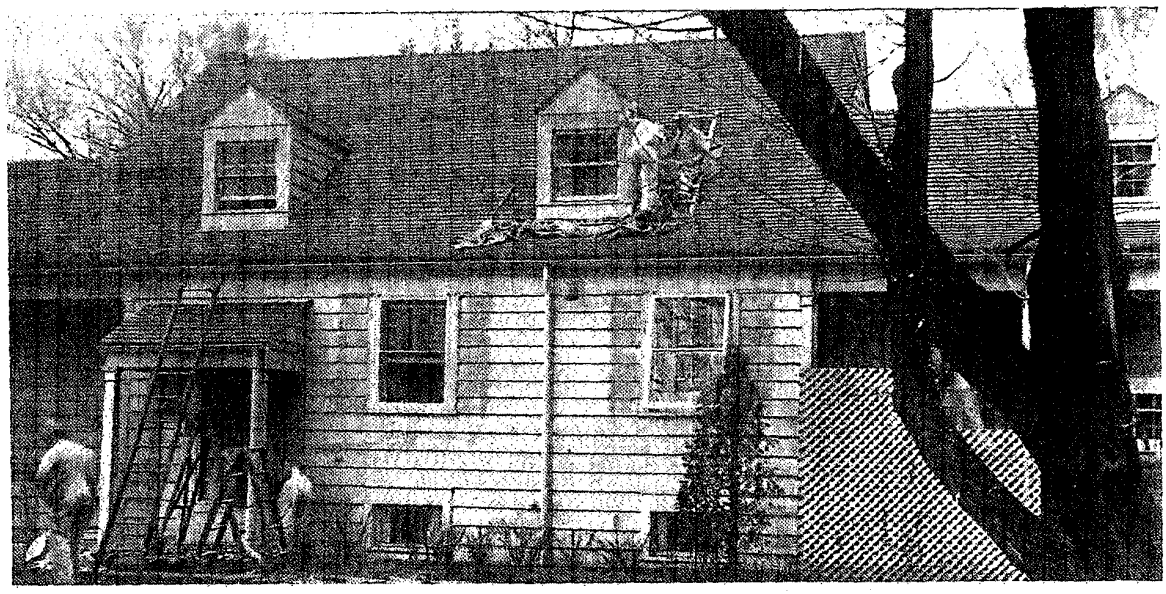

have the commendable objective of making paint maintenance more reliable and painted woodwork more attractive to house owners, and therefore should be given every encouragement. There is some danger, however, that the separate groups in their zeal to protect their own interests may tread on one another's toes sufficiently to embroil them all in minor bickering to the detriment of their common purpose. Each group fully appreciates the virtues and achievements of its own members but is less familiar with those of the others and consequently is prone to see the other fellow's faults but not its own.

Perhaps the temptation to mutual recrimination can be illustrated to best advantage by the following quotation from one of numerous similar letters received from lumber dealers by the Forest Products Laboratory:

> We furnished some Clear (name of species) siding on a job here about five years ago and have been receiving complaints at various times since on discoloration of the siding. We were convinced that this was due to the presence of moisture which in some manner got to the wood itself, but were unable to prove this to the satisfaction of the customer.
>
> We received the assistance of the.....Lumber Co. who shipped us the siding and the owner had an architect inspect the job. The consensus of opinion was strongly to the effect that the paint was inferior and did not protect the siding. However, the owner has always been loathe to believe this, preferring rather to strongly condemn the wood.

Undoubtedly the owner had heard also from the paint dealer and paint manufacturer and one of them may have written the laboratory telling how his fine paint had failed because it was applied to this inferior wood and asking whether we knew of any way of painting such wood satisfactorily.

Nothing is gained by blaming either the wood or the paint for failures of this and most of the other kinds that so often discourage house owners with painted woodwork. Both lumber and paint suffer from the resulting public dissatisfaction.

●

Removal of paint with modern house paint removers is less expensive and involves less hazard of fire than removal with the blow torch, but from the number of men working on this job it is evident that the cost still remains too high. In good paint maintenance removal of paint should be unnecessary.

Both industries, therefore, are vitally concerned with the causes of paint complaints and with the working out of methods of ensuring satisfactory service of house paints on wood. Self interest demands that the two industries recognize a common problem in which one is as much concerned as the other.

The basic cause of difficulty with paint is well expressed in the following quotation from a letter from a contracting painter:

> I have spent 30 years studying paint failures and successes, and the real truth is shocking and disgraceful. Not more than 20 per cent of all exterior painting done today can be regarded as above reproach and well over half of it is positively rotten and dishonest.
>
> As I see it, the chief causes are: No one is accountable to anyone and it is comparatively easy to pass the buck when failure comes; the great number of substitutes and adulterants available; the ease with which anyone can engage in the painting business, the prime requirement being that one is a fair brush-hand which can be acquired by painting two or three small cottages.

Divided responsibility for maintenance arises from the fact that the paint manufacturer turns out only a semi-fabricated product that must be further fabricated by another interest, the painter, before a useful coating is obtained and this coating in turn must be renewed at suitable intervals at the dictates of a third interest, the property owner, who usually has little technical knowledge and is untrained in the art of paint maintenance. Even there the division of responsibility does not cease because some woods hold paint longer than others and certain details of design, construction, and occupancy may admit water behind painted woodwork to the detriment of the paint. As a result nearly every interest connected with the design and construction of the house may share with the paint manufacturer, painter, and owner the responsibility for factors upon which the serviceableness of the paint coating depends. Is it any wonder that, when failure arises, everyone passes the buck to someone else and the owner is left holding the sack?

Some Statistics on Paint Complaints

There is a general tendency on the part of the public, lumbermen, architects, and painters to attribute paint failures hastily to cheap paint. The paint industry, on the other hand, equally hastily attributes them to bad lumber, wet lumber, or "defects in construction." These conclusions come largely from the human inability to see the forest for the trees. For many years the Forest Products Laboratory has been asked for advice by owners, architects, painters, lumbermen, or paint manufacturers about specific paint complaints and the writer has inspected the jobs whenever he could gain access to them or has had boards of siding or photographs submitted with the reports. During the past two years record of over 200 complaints has been made from which certain significant generalizations may be drawn. Most of the complaints deal only with a single house but in some cases one complaint involves several houses and in a few cases one complaint deals with several hundred houses in one group.

TABLE 1

Distribution of Species by Painting Group in Approximately 200 Paint Complaints

Species and painting group—	Per cent of total complaints
Group 1—Cedar, cypress and redwood	42.7
Group 2—The true white pines	15.1
Group 3—Ponderosa pine, spruces, and hemlocks	5.8
Group 3—Basswood and poplar	3.9
Group 4—Douglas fir and southern pine	3.8
Species not identified in the reports	28.7
	100.0

Table 1 records the relative occurrence of different species of wood in the paint complaints. The species are grouped according to their ability to retain paint coatings under normal conditions of service, group 1 holding coatings longest and group 4 requiring more frequent repainting.

As a rule only one species, that of the principal paint supporting surface, was recorded for each house. For houses with wood siding the species noted was the siding, unless the complaint was confined to exterior surfaces other than siding. For houses covered with materials other than wood, of course, the species recorded was that of the painted woodwork about which complaint was made.

Table 1 indicates that the order of occurrence of paint complaints on different species of wood is just the reverse of our expectation if the nature of the wood painted had very much to do with the troubles. The reason for this reversal of the true order of desirability for painting is easily understood. The Forest Products Laboratory's studies revealed a difference in paint retention between woods of group 1 and woods of group 4 at the ratio of roughly 4 : 3, that is, a coating lasting four years on wood of group 1 reaches a similar condition in three years on wood of group 4. Paint complaints, however, rarely arise unless the paint fails within half of its normal period of durability, say within two years. Early failures that cause complaints therefore arise from factors other than the nature of the wood. Lumbermen will promptly recognize that the species occur in Table 1 roughly in the order of most frequent use for painted exterior surfaces on buildings of value in the northeastern and middle western parts of the country, where nearly all the data were obtained. Bevel siding, for example, is made predominantly of woods of groups 1 and 2. Drop siding, which is often made of woods of groups 3 and 4, is used chiefly for cheaper construction which the owner is not so likely to expect to keep well painted. It appears, therefore, that most of our complaints about paint arise on structures on which the best woods from the point of view of painting have been selected.

TABLE 2

Distribution of Paints by "Grades" in Approximately 200 Paint Complaints

"Grade" of paint—	Per cent of total complaints
Manufacturers' first-grade paints	57.5
Manufacturers' second-grade paints	7.5
"Cheap" paints	2.1
Brand or grade of paint not determined	32.9
	100.0

Table 2 reveals a very similar situation with respect to the quality of paint that most frequently figures in paint complaints. The paint industry has no recognized grading system for house paints but it is common practice for a paint manufacturer to offer two or more brands of paint at different price levels in which case the brand sold at the highest price is first-grade paint and is the brand featured most prominently in the manufacturer's advertising. That first grade paints differ widely in quality must be admitted but until there is some accepted system of grading paints we have no other course than to consider all first-grade paints on an equal footing. In Table 2 the paints are classified according to this usage of the paint industry. The list of first-grade paints occurring among the 200 complaints is practically a roll call of the best known brands of paint in the United States together with a smaller number of paints made by local manufacturers. The second grade paints are not to be considered "cheap" paints because many of them compare favor-

ably in quality with some of the first-grade paints. Only paints of clearly very inferior quality and sold at very low prices can be publicly branded as "cheap" paints at the present time.

Most of the houses about which complaint was made had been painted more than once and more than one brand of paint had been used. If all paints were first grade the case was scored under first grade. If any one of the paints was second grade or "cheap" paint the case was scored under the paint of lowest grade. Very often on older houses the nature of the earlier paints had long since been forgotten and the scoring had to be done on the basis of those paints that were still recalled. About one-third of the cases are recorded as indeterminant because the writer did not accept statements when he felt it possible that he was being misinformed or that the owner or painter was merely guessing.

Table 2 shows clearly that "cheap" paints are not as a class responsible for a major part of our difficulties with paint. As in the case of the woods the order of occurrence of the paints is chiefly the order of frequency of their use for painting buildings of value. The complaints about paint responsible for the public's discouragement with painted woodwork for exterior surfaces come predominantly from those who have used the best paints the paint industry has to offer on the best woods for painting the lumber industry has to offer. Clearly there is some factor other than the quality of wood and paint and more important than either that as yet is not generally understood; because the dominant factor is not understood resort to the time-honored pastime of passing the buck when trouble arises is almost inevitable.

The forgotten factor in serviceableness of paint is the owner's program of maintenance. When paint is worn out it cannot easily be thrown away; we expect to renew it by putting new paint over what is left of the old. Some owners repaint at reasonable intervals, say every four years, some wait six, eight, or even ten years regardless of what happens meantime, some want to paint every year or two, some try to follow a definite plan of spacing paint jobs, while some have no plan at all. Rarely is any one kind of paint good paint for all of these programs. To make matters worse owners frequently try a different brand of paint every time they repaint. Unfortunately two paints, A and B, may each be good paint when used in consistent programs of maintenance, that is, when A is repainted with A and B with B, but it does not follow that A will give good service over B or B over A.

Tables 3 and 4 reveal significant facts about the maintenance programs of owners complaining about paint service. Table 3 discloses that only 13 per cent of the complaints were about houses painted for the first time. The 13 per cent may be subdivided into 10.2 per cent in which the trouble came from collection of moisture in sidewalls, 1.4 per cent in which the owner expected paint of a hard type to last more than four or five years, 0.7 per cent in which the painter failed to apply enough paint, and 0.7 per cent for which the cause of difficulty was not determined. In 30.8 per cent of the complaints the trouble arose after painting for at least the fifth time. Complaints about the second paint jobs were nearly twice as numerous as complaints about the first job in spite of the fact that owners are usually most concerned about their houses and most likely to complain about anything that goes wrong when the houses are new.

Table 4 clearly reveals the preponderance of inconsistent maintenance programs among paint complaints. Unfortunately the writer has no statistics to offer about the relative proportions of consistent and inconsistent programs among jobs that remain successful over a long period of years. Undoubtedly there are many satisfied owners who have changed paints at times during their paint maintenance but Table 4 very strongly suggests that such practice is dangerous unless the particular combination of paints has been tested and proved satisfactory.

TABLE 3

Distribution of Complaints According to the Number of Times the House Had Been Painted

Number of times painted—	Per cent of total complaints
1 (initial paint jobs)	13.0
2 (first repaint jobs)	24.0
3 or 4	22.6
5 or more	30.8
Number of jobs not reported	9.6
	100.0

TABLE 4

Distribution of Complaints According to Consistent or Inconsistent Programs of Maintenance

Character of maintenance program—	Per cent of total complaints
Consistent (same kind of paint each time)	9.0
Inconsistent (more than 1 type of paint used)	51.7
Houses with only the initial paint job or for which insufficient information was obtained	39.3
	100.0

That the experience of paint manufacturers may often bear out the findings of Table 4 although they have not realized it is indicated by the following quotation from a letter to the Forest Products Laboratory:

> Not very often, but every once in a while we hear of peeling complaints. In practically every instance it isn't the paint we sold that peels, but rather the first original coat that may have been applied five, 10 or 15 years ago. And sometimes we find it due to an original ochre primer, sometimes due to excessive moisture, etc.
>
> There is a question in our minds and possibly you can help us out with some information on the same as a result of considerable experimentations which we understand you have initiated on paint problems with respect to paint applied over wood surfaces. The question is this: How many coats of paint will an average house stand before a burn-off job is necessary?

The answer to the correspondent's question is that the necessity of a burn-off at any time should be regarded as proof that the program of maintenance was faulty. Probably the most common fault leading to the necessity of paint removal is changing the kind of paint used. Owners faced with the expense of a burn-off often prefer to cover the old siding with composition material that need not be painted.

Responsibility for Bad Maintenance Programs

The owner, of course, must necessarily be responsible for his maintenance program because he dictates when the house shall be painted and who shall do the work. Under the present circumstances, however, he cannot be blamed for the numerous mistakes that are made. He is rarely a technically trained man and still less often a paint expert. He must be guided by information furnished him in simple language principally by the industries whose products he purchases. At present they tell him next to nothing about the practical details of his maintenance program and how it affects his choice of paint. Consequently he is entirely justified in feeling that someone owes him redress when his paint coating fails badly after he has bought good wood, good paint, and hired a good painter.

The present difficulty in advising owners about paint maintenance lies largely in the fact that the 30 or 40 different

types of house paint now on the market are sold merely as house paint. They are differentiated only by manufacturer's brand and roughly by price level. Many of them bear a complicated statement of composition on the label, which is required by law in some states, but interpretation of formulas baffles many technical men. About all the layman can do with a formula is to use it later in selecting another paint having the same principal ingredients in much the same proportions. An effective approach to the problem of paint maintenance cannot be expected until the paint industry adopts some program of identifying paints by types, each type standardized within sufficient limits to ensure compatibility of all paints within the type, and reveals the types to purchasers in simple language. Along with type identification will logically go a system of grading paints within each type. Type identification and grading of paint are closely analogous to species identification and grading of lumber and should serve similar purposes.

Paint Failures Caused by Moisture

Many early failures of paint are caused by collection of moisture in the sidewalls of houses. A recent booklet circulated by the New Jersey Zinc Co., over Otto Hartwig's signature, asserts that "at least 80 per cent if not more of all paint failure complaints could be laid at the door of construction defects of various kinds." Since Hartwig made his studies we have learned that defects in construction cause collection of moisture in sidewalls much less often than condensation in houses where there are no recognizable defects in construction. How to prevent condensation in modern, tightly built and well insulated buildings, especially if air conditioning and winter humidification are to be introduced, is an as yet unsolved problem on which much work is now being done in many laboratories. Until it is solved and probably for a long time thereafter we shall have the problem of keeping paint on houses whose sidewalls at times condense moisture.

The Forest Products Laboratory's records of paint complaints reveal moisture as the cause of failure in 78.5 per cent of the cases where only the initial paint job had as yet been applied. These, however, numbered only 13.0 per cent of the total number of complaints recorded. In the total number of complaints moisture played a part in 47 per cent of the cases but among these many were also due in large measure to incompatible combinations of paints or other mistakes in paint maintenance. On the whole, therefore, moisture, serious though it is, is not the predominant cause of paint complaints. Moreover, studies of the Forest Products Laboratory made to test inferences drawn from the records of paint complaints have shown that some kinds of paint are much more sensitive to adverse moisture conditions than others and have shown particularly that incompatible combinations of paints are sometimes exceedingly sensitive to moisture. Paints A and B, for example, may each be reasonably resistant to adverse moisture conditions but if B is applied over A an extremely sensitive coating that fails quickly and badly in the presence of only minor amounts of moisture may result.

Friendly Co-operation Is Needed

Difficulties with paint maintenance at the present time cannot in general be attributed to deceitful practices on the part of any of the interests involved. As long as cheap paint, bad lumber, and bad painting are made scapegoats we can expect only continuation of buck passing and mounting indignation on the part of those who ultimately pay the bill and whose patronage is necessary if the various business interests are to remain alive. Paint difficulties come basically from divided responsibility for, and inadequate technical knowledge of, the most important factors in paint maintenance. Since a large share of responsibility must remain on the shoulders of the owner, those interests capable of employing competent technical men must for their own protection work out practicable means of placing paint and wood in the hands of the owner with adequate instructions in simple language for using them, together with reasonable assurance of success. The element of gambling must be eliminated.

Obviously the lumber industry and the paint industry are charged with the responsibility for technical leadership in the enterprise. Sympathetic understanding and friendly co-operation between them is certainly essential. There should be no time for mutual recrimination and acrimonious debate. In both industries time-honored policies that were good business in the expansive and somewhat irresponsible early decades of the century may have to be abandoned in these times of competition between rather than within industries when good business comes more and more to mean sincere adherence to the fundamental law of mutuality of contract. Changes in traditional policy are not readily accomplished by compulsion; they are most effectively achieved by earnest devotion to constructive solution of mutual difficulties.

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Pacific Purchaser Feb. 1937

(29)

PAINT
VALUABLE DATA FOR BUYERS

Buy House Paint for a Planned Maintenance Program

By F. L. Browne PR
Senior Chemist, Forest Products Laboratory, Madison, Wis.*

The paint industry in recent years has developed many new raw materials that have led to new and better kinds of exterior paints. The new paints, however, rarely displace older types of paint, but merely multiply the number of types in common use. The trade custom has always been to identify paints to purchasers only by manufacturer's brand, sometimes supplemented by a detailed formula too technical to be fully understood by anyone but a paint expert. Consequently the improvements in paint formulas have failed to effect an improvement in the average service given bv paint, have remained generally unappreciated by paint users, and have added seriously to the bewilderment of purchasing agents who have to buy paint.

There have always been paints made to sell at different price levels, of course, and it has been tacitly assumed that the purchasing agent's problem is merely one of getting his money's worth in paint quality. Presumably the more expensive paints are better paints; any good paint, supposedly, is good paint for anyone to use, which involves the assumption that one good paint can be applied safely over any other good paint. These assumptions caused trouble enough in the days when there were only a limited number of types of paint on the market, but with the multiplicity of paints now available they reduce most of our painting to sheer gambling. If the user is lucky, good paint will give him good service, but if he is unlucky there is always some factor other than the paint to which the difficulty may be attributed. In buying paint, getting his money's worth is only one of the purchasing agent's problems; getting the right kind of good paint for the specific purpose is much more important and often more difficult.

House paint should be purchased in accordance with the requirements of a definitely planned program of maintenance for the buildings on which it is to be used. In so doing the purchasing agent stands between the maintenance engineers of his company and the salesmen of the paint manufacturers, both of whose co-operation he needs. From the maintenance engineers he should have the assurance that there is a carefully considered plan of maintenance and that adequate records are kept of the painting histories of the buildings. With a plan and record of its execution it becomes possible to select paint intelligently and to guide the maintenance program along lines justified by past experience. The uncertainties of experimentation can be avoided.

Classification of Maintenance Programs

Maintenance programs for exterior woodwork may be classified according to the length of time between paintings. The approximate period of durability of good white or tinted white paints offers a convenient yardstick. In most parts of the country and on woods that hold paint reasonably well (see Pacific Purchasor for February, 1934, page 18) good white paints should not be expected to remain durable beyond 4 to 5 years. It is not always practicable to paint industrial buildings so often. For programs with more than the expectancy of white paints between paintings either unusually durable colored paints should be chosen or the white or tinted paints, which will break up seriously before the next painting, should be chosen for their ability to stand neglect well rather than for their durability. Soft paints, such as pure white lead paint and the very durable colored paints, can be relied

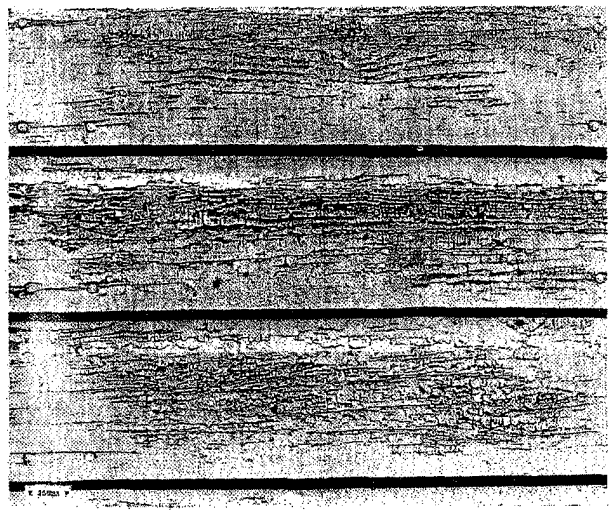

FIG. 1—The unsatisfactory result of using a paint of a hard type in a maintenance program with long intervals between paintings during which the paint passes through a period of neglect.

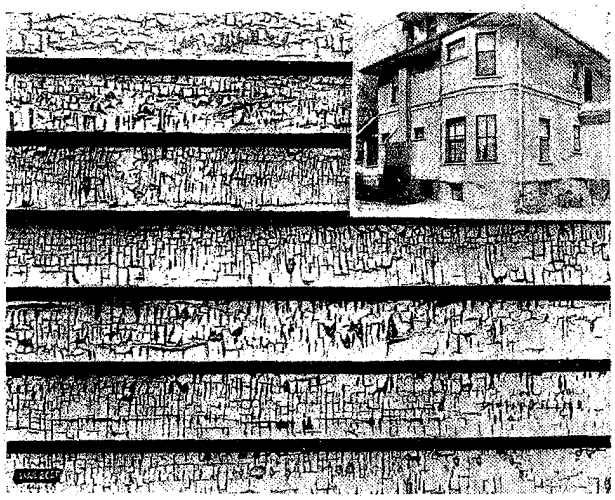

FIG. 2—The disastrous result of a marked change in type of paint. This house was maintained with colored pigment paints for many years and was finally painted with a tinted white paint of fairly hard type.

*Maintained by the Forest Service, U. S. Department of Agriculture, at Madison, Wis., in co-operation with the University of Wisconsin.

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upon to stand neglect well so that they can be repainted easily and durably without removing the old coatings.

Programs in which repainting can be assured at intervals that anticipate the break-up of white paints permit the choice of any one of the good paints on the market when the building is new or the old coating has been removed completely. Once the program has been started with a given paint, however, paint of the same type should be used for all subsequent painting unless the specific change in type that may be considered has been proved safe by much previous experience. When radical changes in type of paint are made there is no assurance that the new paint, no matter how good it may be, will give its normal period of durability. Paints of medium hardness are probably the logical choice for programs that make use of most of the expectancy of white paints although soft paints are also satisfactory and very hard paints may be used if sufficient care is taken to see that they do not begin to break up before repainting.

Perhaps the most difficult programs are those in which, for business reasons, unusually fresh and clean appearance must be maintained at all times. Painting is then done at short intervals. The old paint scarcely has time enough to reach a suitable condition for repainting and does not wear away much. Under such circumstances consistent use of exactly the same type of paint is very important. Just as little new paint as possible should be applied at each painting. Where practicable washing of the coating to remove dirt and restore gloss should be practiced in order to put off repainting as long as possible. If the washing is done with an alkaline solution strong enough to remove some of the old paint so much the better. Ultimately the coating may be expected to become too thick and break up badly so that a complete removal will be necessary. For programs of this kind very hard types of paint, often enamelized paints, have certain advantages such as long retention of gloss and ease of washing. They should be made with very opaque pigments and have unusually great hiding power.

Need for Type Identification and Grading

From the foregoing the difficulty of using strictly proprietary paints intelligently in a planned program of maintenance is obvious. If the purchasing agent is not fully informed about the composition of the paint and the paint manufacturer has no knowledge of the maintenance program there is no means of bringing the two into harmony. The purchasing agent's position is very similar to that in which the physician would find himself if there were no pharmacopoeia and the only drugs available were proprietary medicines whose composition the physician did not know. To meet this condition in painting some of the large paint manufacturers offer to make painting surveys of industrial plants so that they can specify what they believe to be appropriate paints of their own manufacture together with the maintenance programs that should be followed. This system, of course, takes the whole responsibility for maintenance out of the hands of those who pay for it.

A reasonable system of type identification and grading of paints adopted and enforced by the paint industry through its trade association would open the way for a sound program of education of purchasing agents, maintenance engineers, painters, and property owners in proper methods of guiding maintenance along lines justified by past experience and avoiding the numerous uncertainties that now ruin so many paint jobs. So far all efforts to furnish adequate instruction in the use of paint fall down on the stumbling-block of buying proprietary paints with reasonable knowledge of their characteristics. Although there are in fact many varieties of paint they appear on the market merely as house paint. Formula labeling solves the problem only for those able to make a thorough technical study of paint and to keep it up to date. What we need is a label that reads somewhat as shown in the next column.

Such a label based on adequate standards properly enforced would isolate the technical problems of paint and its maintenance in technical laboratories capable of dealing with them effectively. Type and quality of paints would be identified in simple, non-technical terms. Sound programs of maintenance could then be specified in language easily understood by everyone concerned. Clumsy formula labels and the cumbersome method of purchasing on formula specifications could both be dispensed with.

	—— Brand Exterior Paint Cream Color	
Manufacturer's Brand Symbol	Type TLZ, Medium Content of zinc oxide Grade A, N. P. V. & L. M. Assoc. standards Manufactured by_____	Paint Association Seal

Type Identification and Grading are Practicable

The details of a practicable plan for type identification and grading cannot be discussed within the scope of this article. For several years the Forest Products Laboratory has been following such a plan in classifying paints used in its studies and for advising correspondents about paint formulas. The conventional formulas in percentages by weight are recalculated to show the volume of each ingredient in 1 gallon of prepared paint. The calculations are similar to those followed in the paint industry in computing yields and costs. From these data the volume of opaque pigments, the volume of total pigments, and the volume of non-volatile material (pigments plus fixed oils) are computed and used as the basis for grading as follows:

Grade	Minimum content, of— Opaque pigments	Total pigments	Non-volatile
	in gallon per gallon of prepared paint		
A	.25	.25	.89
B	.21	.23	.82
C	.17	.21	.75
D	.13	.19	.67
E	.09	.17	.60
F	—	—	—

The opaque white pigments commonly used include the white leads, the zinc oxides and leaded zinc oxides, titanium-barium pigment, and regular lithopone. Titanium and zinc sulfide pigments in which the titanium dioxide or zinc sulfide exceeds the proportions by volume in titanium-barium pigment and regular lithopone are credited with a proportionately greater volume of transparent pigment in computing the content of total opaque pigments in the paint.

The paints are divided into types according to the nature of the opaque pigments present, the percentages of zinc oxide by volume in the total pigment, and the nature of the fixed vehicle. The white or tinted paints now on the market make it necessary to recognize at least the following types exclusive of the colored pigment paints:

True house paints (fixed vehicle wholly or chiefly unbodied drying oil):
- Zinc-less paints:
  1. Type L, pure white lead paint
  2. Type TL, white lead and titanium-barium pigment
- "100 per cent pure" paints made with lead and zinc pigments only
  3. Type LZ with high content of zinc oxide
  4. Type LZ with medium content of zinc oxide
  5. Type LZ with low content of zinc oxide
- Lead and zinc paints in which transparent pigments are used:
  6. Type LZ with high content of zinc oxide
  7. Type LZ with medium content of zinc oxide
  8. Type LZ with low content of zinc oxide

Titanium, lead and zinc paints:
  9. Type TLZ with medium content of zinc oxide
  10. Type TLZ with low content of zinc oxide

- Lithopone, lead and zinc paints:
  11. Type PLZ with medium content of zinc oxide
  12. Type PLZ with low content of zinc oxide
- Lead-less paints:
  13. Types TZ, PZ, and TPZ with medium content of zinc oxide
  14. Types TZ, PZ, and TPZ with low content of zinc oxide

Enamelized, quick-dry, and resin-fortified paints:
- All of the foregoing pigment types possible but so far usually LZ, TLZ, PLZ, or TZ with high, medium, or low content of zinc oxide.

Very cheap paints with no lead or zinc pigments and with varnish and water in the vehicle:
- Type P, T. or PT.

(Continued on page 28)

FLB 0009(

Many new standards adopted in 1936 cover various non-metallic materials, including the following:

High-Early-Strength Portland Cement.
Natural Building Stone.
Load-Bearing Concrete Masonry Units.
Structural Clay Tile.
Clay Fire Brick for Malleable Furnaces, Annealing Ovens, and Stationary Boiler Service.
Refractories for Incinerators.
Ground Fire Clay.
Sodium Silicate for Curing Concrete.
Titanium Dioxide.
Zinc Sulfide.
Normal Amyl Acetate.
Industrial 90 per cent Benzine (Benzol).
Rubber Belting.
Rubber Hose.
Asbestos Roving for Electrical Purposes.
Asbestos Yarns.
Woolen and Worsted Yarns.
Round-Hole Screens for Testing Purposes.

Copies of the book in blue cloth binding can be obtained from A. S. T. M. Headquarters, 260 S. Broad St., Philadelphia, Pa., at the following prices: Either part, $7.50; both parts, $14.00.

Buy House Paint for a Planned Maintenance Program

(Continued from page 16)

When it is remembered that most of the above types of paint may run the gamut of grades from A to E or F and that an industrial plant usually requires many kinds of paint besides house paint the complexity of the modern paint market can readily be appreciated. If the frequent misfits between type of paint and maintenance program are to become less numerous some such simplified method of reaching an understanding between buyer and seller as that suggested is essential.

Old Timers' Night

(Continued from page 5)

In closing let it be said that the "Old Timers" deeply appreciated the opportunity to present themselves to the members. Our interest in Association affairs is as keen as in the days when we were actively engaged in the promotion of its progress. The "Old Timers" are ready and willing at all times to be called upon for advice and counsel in the hope that their experience will prove to be of value.

Let's have an "Old Timers' Night" every few years!

* * *

A different seating arrangement than usual was utilized at this "Old Timers' Dinner," inasmuch as there was no head table. The charter members were all seated at one long oval table at which Ralph W. Myers presided. At an adjoining table were seated the past presidents who were not charter members and at the head of this table was Arthur H. Silverstone—"the oldest living past president who was not a charter member." At a third table of "Old Timers" was seated the past secretaries as well as the present secretary, Arthur R. Woodman.

The president's table was presided over by Ralph N. Jacobson, who called the meeting to order and handled it up to the time it was turned over to Ralph W. Myers for the "Old Timers" participation. A guest at the head table was C. P. Visel, Cavelier of Los Angeles, and now operating Asilomar-by-the-Sea, who enlarged upon the advantages of that wonderful resort and urged the members to attend the weekend party on January 30th and 31st.

Short reports were made by Ed Thatcher and Clyde Yerge of the Program Committee and Al Short presented our new member, Russell Mills of the E. D. Bullard Company.

A very interesting talk was given by Frank I. Doane, associate electrical engineer of the San Francisco-Oakland Bay Bridge, who spoke on the topic, "Electrification of the Bay Bridge." He showed a number of slides depicting the sodium lighting fixtures and the electrical connections and features for lighting and controlling fog horns, signal lights, etc. Mr. Doane afterwards touched briefly upon the plans for operation of the two railway systems over the bridge on which the work is now progressing. He stated that these trains would operate in units up to ten cars each and with a minimum headway of seventy seconds. The maximum speed will be 35 miles per hour; other speeds will be 25 miles, 18 miles and 8 miles. Special safety arrangements will be installed to eliminate any possibility of collision or delay in case of accident beyond the control of the operator.

After Ralph Myers turned the meeting back to President Jacobson at the close, Charles Wall, president of the X. P. A. Association and "Old Timer," who used to play harmonica duets with Dave Gray, was called upon and rendered in a very delightful and appropriate manner on his portable organ, "Aloha," out of special respect to Past President Hobart W. Mears of the Matson Line, who was unable to attend the meeting.

The total attendance at this meeting was 104.

New In Industry

A new control valve for vacuum brakes on trailers allows the operator of passenger car or tractor to apply the trailer brakes without removing his hands from the steering wheel.

A line of new type soft-face hammers for working on fine finished surfaces has tips of a tough amber-colored plastic that will not shatter, chip or break. When the tips become worn, new tips may be easily installed.

Hardwood floors of two-inch pieces in a basket-weave pattern are now made into grilled sections two by six feet that may be quickly and economically laid over old floors. The blocks composing the sections are 5/16 inch thick. Sections are laid with adhesive, not brads.

A recently developed metal finish is said to dry with a lustrous hard surface, yet have resiliency to prevent checking and marking. Insoluble in oils, it is resistant to alkalis, commercial acids, and atmospheric corrosion.

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which lime has been added, have been passed through filter presses at a temperature of 190° F. without affecting the Industracote finish or changing the original flavor of the juice.

Many other more common tests have proved the adaptability of Industracote Finish as a protective coating against unusual corrosive agents, according to the General Paint Corporation.

Reflection Values

Diffuse reflection values on gloss house paints—

Cream	57%	Blue (Pale)	49%
Ivory	63%	Blue (Bright)	19%
Buff (Pale)	55%	Mandarin Red	10.2%
Yellow (Lemon)	66%	Apple Green	44%
Tan	42%	Green (Pale)	32%
Brown Cafe-au-Lait	30%	Shutter Green	6.5%
Brown (Cocoa)	11.1%	Green (Dark)	3%
Blue (Flag)	7.3%	Red (Pompeian)	5.8%
Gray (Medium)	29%	Red (Crimson)	4.4%
Gray (Light)	38%	Brown (Dark)	4.4%
Gray (Dark)	16.4%	Orange (Deep)	18%
Gray (Pearl)	39%	Yellow (Bright)	39%

Diffuse reflection values on flat wall paints—

Ivory	59%	Peach or Salmon	53%
Cream	71%	Brown Cafe-au-Lait	25%
Apricot Beige	66%	Green (Light)	41%
Buff (Light)	56%	Aluminum	*55%
Apple Green (Pale)	51%	Blue Gray (Dark)	8.7%
Light Gray (Pearl)	53%	Medium Gray	43%
Pale Green (almost sky blue)	45%	Yellow (Lemon)	65%
Pale Blue	41%	Rose (Deep)	12.4%
Light Ivory	71%	Dark Green	7.9%

* Diffuse 35% or total of diffuse and specular 55%.

A. S. T. M. Book of Standards

The American Society for Testing Materials has recently issued its 1936 Book of A. S. T. M. Standards. This triennial publication contains all of the standard specifications, methods of test, recommended practices and definitions formally adopted by the Society. The 1936 issue is in two parts—Part I giving in their latest form all A.S.T.M. standards covering metallic materials; Part II, all standards relating to non-metallic materials. Both parts aggregate 2,400 pages.

In each Part, the specifications for a particular class of material are given first, followed directly by the test methods, definitions, etc. A complete subject index lists each standard under the principal subject covered, with the keywords in alphabetical sequence. This index, together with two tables of contents, one listing standards by the materials covered, the other in order of sequence of the serial designations, facilitates the use of the book.

Of the 181 standards in Part I, 109 cover the ferrous metals, steel, wrought iron, pig iron and iron castings and ferro-alloys, while 60 relate to non-ferrous metals, including aluminum and magnesium alloys, copper and copper alloys, lead, nickel, zinc, bearing metals, solder metal, deoxidizers, electrical-heating and electrical-resistance alloys. Twelve of the standards involve metallography and general testing methods.

During 1936 many new standards were adopted relating to widely used materials. In Part I, the following materials are covered by new specifications:

- Alloy-Steel Castings for Structural Purposes.
- Carbon-Steel and Alloy-Steel Castings for Railroads.
- Welded and Seamless Steel Pipe for Ordinary Uses.
- Electric-Fusion-Welded Steel Pipe.
- Lap-Welded, Seamless and Electric-Fusion-Welded Steel Pipe for High-Temperature and High Pressure Service.
- Alloy-Steel Pipe, Forgings and Castings for Service at Temperatures from 750 F. to 1100 F.
- Uncoated Wrought-Iron Sheets.
- Zinc-Coated (Galvanized) Wrought-Iron Sheets.
- Gray-Iron Castings.
- Copper-Base Alloys in Ingot Form for Sand Castings.
- Bronze Trolley Wire.
- Rockwell Hardness Testing.

Included in the 335 standards in Part II—Non-Metallic Materials—are specifications and test methods covering the general classes of materials.

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Railway Engineering and Maintenance Feb, 1937 (30)

PAINTING PROBLEMS — WHAT ARE THEY TODAY

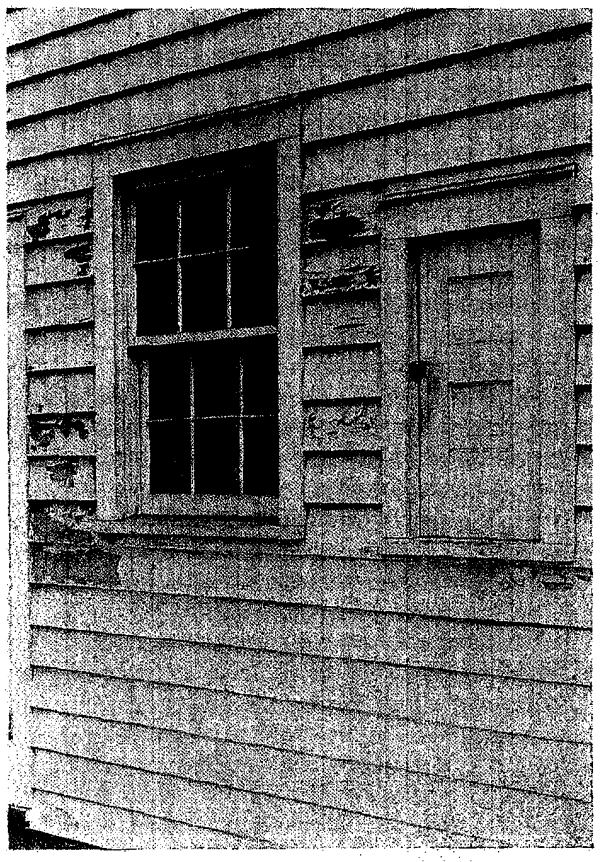
Painting

Painting Problems — What are they Today?

Developments in paint composition in recent years have tended to complicate problems involved in the painting of both old and new structures. Important among these problems is that presented by the "incompatibility" of different paints, which is dealt with at length in this discussion. Thickness of paint coats, frequency of painting and new developments in paint formulation are other matters that are given attention.

By F. L. BROWNE

Senior Chemist, U. S. Forest Products Laboratory, Madison, Wis.



Outcome of an Unplanned Paint Maintenance Program

First painting with two coats of white paint, second painting with dark brown paint, and third painting with two coats of white paint. Photographed 18 months after last painting. Definite result of incompatibility.

THE past decade or two marks a period of accelerating changes in paint formulation, the end of which is not yet in sight. Many of the changes in paints have been in the direction of furnishing distinctly improved products from the user's point of view. The same period of time, however, has marked also an increasing feeling of exasperation with the uncertainties of paint behavior and with the numerous cases of unreasonably early failures of paint jobs.

The dominant factor that has been so generally overlooked in the past is the fact that a good paint, if it is to give the good service of which it is capable, must be used in a program of paint maintenance for which it is suitable and for which it was designed. Most painting takes the form of renewing a coating applied some years previously; the composition of the new coating and the behavior to be expected of it depend upon the composition and age of the paint or paints used previously as well as upon the composition of the new paint.

What Is Good Paint?

If a building stands 50 years it receives one paint job when erected and, if well maintained, some 10 or 12 paint jobs at suitable intervals subsequently. Each repaint job is applied over what is left of the preceding jobs; if it becomes necessary at any time to remove the old coating the maintenance program has been unsatisfactory at least for that building. To the paint purchaser, therefore, the important point is not whether a given paint is capable of good service, but whether it can be relied upon to give good service on the particular building for which it is purchased. A good paint for one building may be bad paint for the one next door.

Failure to recognize that, after the initial paint job, a coating is com-

*Abstract of a paper presented before the convention of the American Railway Bridge and Building Association on October 21.

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joints between the stones and the heads clinched over the reinforcing bars. To prepare the spikes for this purpose, they are heated to a forging temperature and flattened somewhat to facilitate driving. To render them more malleable they are allowed to cool slowly.

An interesting innovation, involving the use of clamps of a special design, is employed in the repair of stone masonry piers in which the stones in the top course have shown a tendency to spread apart under the weight of the superstructure. The clamps used are formed of 1-in. by 4-in. steel bars about 28 in. long. A 5-in. right-angle bend is made at each end of each bar and the bent portions or legs are given an inward or concave curve. When the two legs of a bar are driven into holes drilled in adjacent stones in the top of the pier the springing action induced by the curvature tends to draw the stones together. The horizontal portions of the clamps are inserted in grooves cut in the masonry so that the upper edges are flush with the top surface of the pier.

Since the concrete repair program described in this article was inaugurated the patching of such structures on about 700 miles of line has been completed, and as the repair forces have gained experience and skill in the application of patches, the railroad has become even more fully convinced of the soundness of the policy of repairing concrete before deterioration has been allowed to progress beyond the initial stage.

The concrete repair program on the Burlington is being carried out under the general supervision of G. A. Haggander, engineer of bridges.

"Don't Let It Occur to You"

FROM 22.9 to 27.4 per cent of all railway employees killed while on duty during the last 15 years lost their lives as a result of being struck or run over by locomotives or cars. For this reason the Committee on Education of the Safety section of the Association of American Railroads has issued at least three circulars in each of the last five years dealing with this serious menace to railway men. The effectiveness of these appeals is indicated by the fact that deaths from this one cause were reduced from 1,578 in the five years ending with December 31, 1931, to 628 for the following five years, and by the fact that fatalities from this cause represented 22.9 per cent of the total fatalities for the last five years, compared with 27.9 per cent for the five years ending with December 31, 1931.

As a means of continuing its education work on this subject the committee has issued circular, No. S-517, that drives home the hazard of "walking, standing or sitting on the track" and is distributing the poster reproduced on this page. The bulletin reads as follows:

DON'T LET IT OCCUR TO YOU

Walking, standing or sitting on tracks except when necessary in the performance of duty is prohibited. This is a good rule to follow in our efforts to prevent men from being killed or permanently injured by being "STRUCK OR RUN OVER BY LOCOMOTIVES OR CARS."

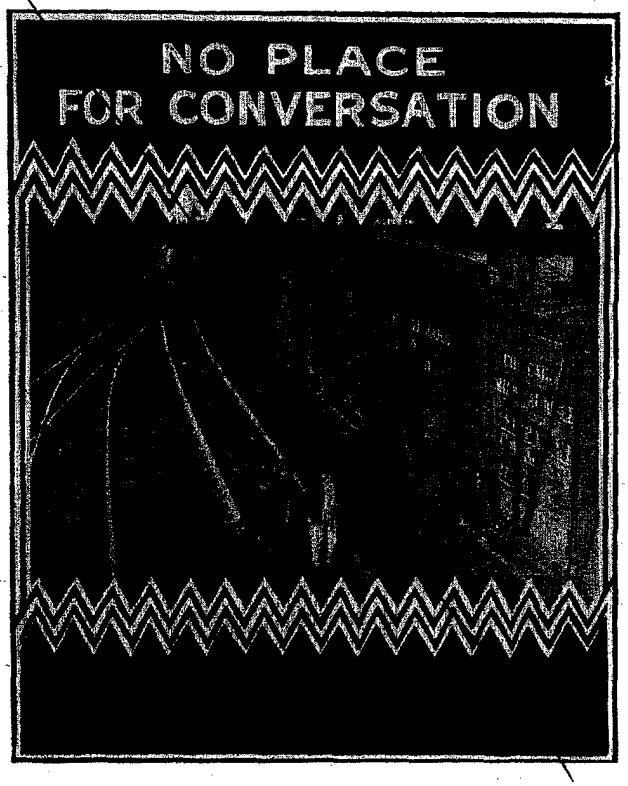
Some railroads enforce this as a definite safety rule, while others are seeking its application through education, warnings, reminders, etc. By whatever means the effort is made it is a long step in the right direction, for this class of accidents accounts for nearly one-fourth of all employee fatalities and at least 80 per cent of the cases of "Struck or Runover," result in death or permanent disability.

It is said that we must learn from the horrifying experiences of others, but it is better to learn that way than not at all, so, with the hope that many now living and unhurt may remain so, a few cases are here related in which the victims forgot their own safety.

A young track foreman was supervising work being performed by two laborers. It was snowing hard and a movement of time freight was soon to be made. The foreman became dissatisfied with the manner in which one of the laborers was doing his work, and taking the tool from him he undertook the job himself, squatting down between the rails. He was killed by a yard engine within five minutes. There is no quarrel with the foreman for demonstrating to a laborer the correct method of work. We might even overlook his having taken on a laborer's job temporarily, if the emergency warranted. We cannot condone his act in making a laborer of himself without delegating to a member of his force that part of a foreman's duty requiring him to safeguard his men.

A traveling inspector from the general offices was walking between the

(Continued on page 110)



The Safety Poster for February

roblems—

What Are They Today?*

posed of the old paint plus the new paint is largely responsible for the failure of recent developments in paint formulation to effect an improvement in the general serviceableness of paint. Each new paint formula brought out adds one more to the already super-abundant types of paint on the market, for the new products never succeed in displacing the old. With paint users generally making little effort to follow consistent programs of maintenance this means that with every new paint the chances of incompatible combinations of paint are increased and the number of abnormally early paint failures becomes greater. On the other hand some of the new paints offer distinct advantages for those who learn how to work them into their maintenance programs safely.

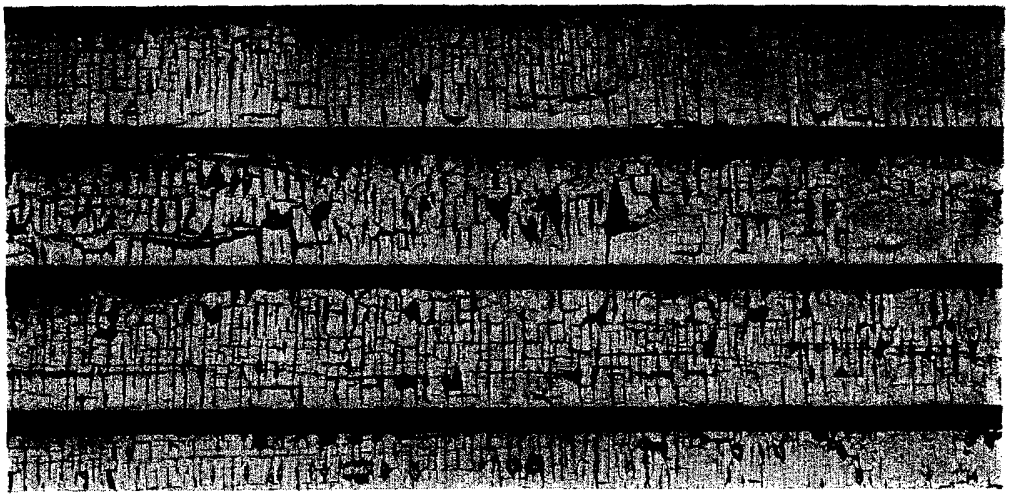
Haphazard programs of paint maintenance so often lead sooner or later to disaster even though high grade paints are always used because one or more of three principal blunders are made: (1) Incompatible combinations of paints are used either in the same paint job or in successive paint jobs; (2) either too much or too little paint is applied at a time, (3) either too much or too little time is allowed to elapse between paintings. To these three basic causes of difficulty with good paints must be added a fourth with which it is often very difficult to deal, namely, access of water to the backs of painted boards, causing blistering and subsequent scaling of the coating at an early age.

Incompatible Combinations

For a long time much emphasis has been placed on the fact that paints last longer on some woods than on others but very little has been said about the even greater variation in behavior when paint of any one kind is applied over paints of other kinds. We know certain combinations of paints that commonly lead to difficulties but we do not know yet just how far two paints may differ and still work reasonably well together. For the present, therefore, the paint user should take the conservative position of considering any serious change in type of paint in the make-up of a coating too dangerous unless there is good evidence in past experience that the particular combination under consideration can be expected to give good service.

A very common incompatibility results from the application of a white or tinted white paint over a colored paint made with little or no lead or zinc pigments. For example, during a 2,000-mile journey over a certain railroad a few years ago the cracking and slipping of a bright yellow paint over red iron oxide paint could be observed from the Pullman car at nearly every station. Early failures of white paints over greens, browns, and blacks are likewise to be seen frequently.

Incompatibilities likewise arise among white paints when they are made with very different combinations of white pigments. It has long been held that white lead and zinc oxide, unlike the remaining white and transparent pigments, are chemically active and profoundly modify the linoxyn formed from linseed oil. Zinc oxide particularly has a definite hardening action on paint, the effect being roughly proportional to the amount of zinc oxide in the total pigment. At any rate, variation in the zinc oxide content of paints causes very distinct changes in the physical properties of the paint. It seems to be advisable to keep the zinc oxide content of paints used successively as nearly constant as practicable. When pure white lead paint, for example, is applied over a previous coating of paint that



An Excellent Example of Incompatibility

Failure of a tinted white paint applied on a building that for years previously had been kept painted with paints of dark color in which there would be no lead or zinc pigments.

contains zinc oxide, especially if the previous paint has not weathered for a long time, early failure of the white lead paint by conspicuous alligatoring is often observed.

To what extent the proportions of white lead and of chemically inert pigments in successive paint coats affect the durability of paint jobs is not yet known. A number of cases have been observed, however, in which paints of the newer pigmentations involving titanium or zinc sulfide pigments, when applied over older paints of the lead and zinc type, have failed to give the service such paints have demonstrated in consistent programs of paint maintenance. Until more is known about the compatibilities of paints prudence suggests the practice of repainting always with much the same kind of paint used previously.

The proportion of total pigment to non-volatile liquids in paint is significant from the point of view of compatibility. In the formulation of the newer paints it is being generally recognized that in a finish coat of white paint the total pigments should amount to roughly 27 to 30 per cent by volume of the total non-volatile matter instead of the 20 to 25 per cent and even lower that was characteristic of the older formulations. The undercoat, however, should never have less pigment than the finish coat and best practice requires that it have more. For that reason a painter, by thinning the undercoat with too much oil can produce an incompatibility, even when working with the same paint.

Thickness of Paint Coats

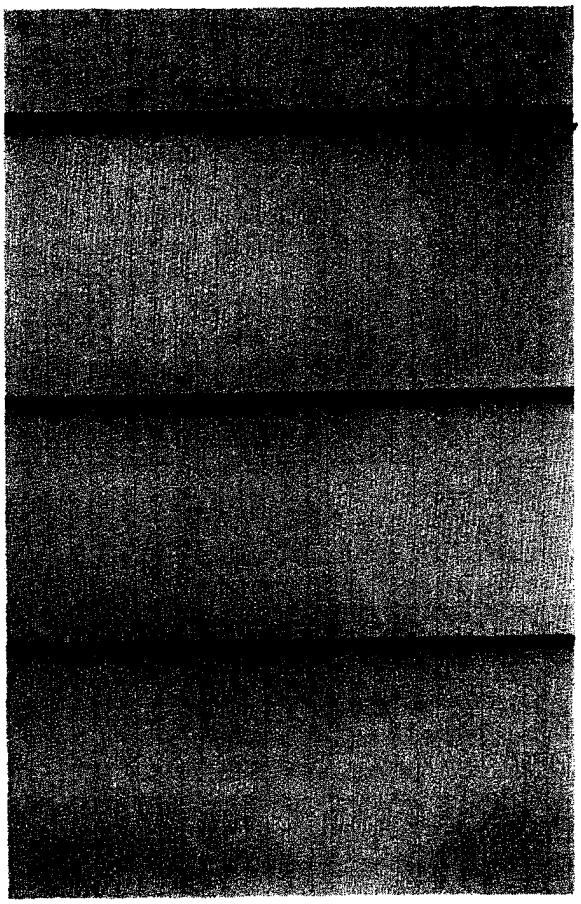
There seems to be an optimum range of thickness of paint coatings for optimum service. An initial coating of white lead paint applied to new wood according to customary recommendations is about 0.005 inch in thickness while initial jobs of harder paints are often nearer 0.004 inch. Thinner coatings of each type of paint, whether they hide the surface satisfactorily or not, are less durable and more liable to difficulty with spotted chalking and fading. On the other hand thicker coatings, especially with the harder paints, not only prove no more durable but are prone to more conspicuous cracking, curling and flaking.

In a good program of maintenance the amount of paint restored at each repainting does not greatly exceed the amount worn away since the previous painting so that the thickness of the coating can be kept within the region of optimum serviceableness. Where the coating is allowed to become very thick in the course of time objectionable forms of paint failure are observed that are never seen with thinner coatings of the same paints, and the surface becomes more and more difficult to repaint acceptably.

Frequency and Quantity

The more frequently a surface is painted the less paint should be put on at a time. For a given interval between paintings the harder the paint used the less should be put on at a time. Fortunately the harder paints, after weathering, are less absorptive and "hold out" new paint more easily than softer paints. Since different parts of a building usually receive different degrees of exposure to sunshine some parts need more paint than others at each repainting. For these reasons it is impracticable to make general statements about the amount of paint that should be applied in repainting.

It may be said, however, that there is a general tendency to use too much paint in repainting when paints of the harder types are used. This tendency is likely to be particularly pronounced in the maintenance of the property of large corporations where it is desired to impress the public favorably. Where good appearance in a necessarily sooty environment is desired it is often better to use hard paints of high opacity that wash satisfactorily, washing them once or twice between paintings, and washing and repainting them with one coat at reasonable intervals rather than repainting them at short intervals with two thick coats at a time. With moderately hard paints, one good coat of paint applied about every four years is ordinarily sufficient on woodwork.



An Example of a Well Planned Paint Program

First painting in 1924 with two coats of white lead paint. Repainted with one coat of a harder paint of the modern titanium pigment type in 1927, 1931, and 1935. Photograph taken just before last painting shows a surface that is chalking freely but is free from checking, cracking, curling, flaking, or scaling.

Much trouble with paint comes from failure to observe any systematic plan of repainting. Except with paints that stand neglect well, repainting should anticipate rather than follow break-up of the coating. Where repainting is done before the coating cracks, curls, and flakes in patches there is no problem of scraping off all loosened paint and a smooth, sound foundation for the new layer of paint is assured. The renewed coating, therefore, may be expected to have normal durability. The economical course in the long run is to adopt a planned program

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of maintenance when the building is erected, select a type of paint suitable for the program, and then adhere firmly to the program.

The old custom of using red iron oxide paints for the maintenance of buildings of strictly utilitarian purpose still has much to commend it. Good paint of that type is exceedingly durable and stands neglect well. For those reasons colored pigment paints like iron oxide paints are particularly appropriate for maintenance programs with long intervals between paintings or for buildings for which it proves impracticable to adopt a definite program. In times of financial depression maintenance painting is usually curtailed and it may be wise to recognize that some buildings at times will be neglected.

Aluminum Paint

Aluminum paint is beginning to find use as a complete coating for wood for programs with long intervals between paintings. From the point of view of maintaining protection for an unusually long time it is superior to iron oxide paints and its appearance, although metallic, is brighter and more cheerful than the dull red of iron oxide.

Among white paints and tinted paints based on white paints, only formulations that make very soft paints are capable of standing neglect well. Pure white lead paint is the best known very soft paint. It disintegrates by deep chalking, fine checking, and fine crumbling and it wears away by erosion fairly rapidly but, in consistent maintenance programs, it does not crack, curl, or flake. While not an outstandingly durable white paint it is one of the very few white paints that can safely be allowed to pass through periods of neglect and still leave a surface that can be repainted easily and with assurance of normal durability. For maintenance of railroad property, however, soft paints have the serious disadvantage of collecting dirt badly and being somewhat difficult to wash satisfactorily. Harder types of white and tinted paints are therefore preferred, but in using them it should be remembered that they cannot safely be neglected and should be maintained strictly in accordance with a conservatively planned program.

In the writer's opinion the outstanding development in exterior paints in recent years is the increasing diversity in types of paint on the market and the consequent necessity for greater technical knowledge of paint composition and its significance in paint maintenance programs on the part of the paint user. Inasmuch as it is rarely practicable to place the maintenance program completely in charge of a single paint manufacturer, the paint user must assume far more technical responsibility than he is often prepared to handle intelligently.

Combinations of Pigments

The dominant trend in the manufacture of first grade white paints in recent years has been in the direction of combinations of titanium pigments, white lead, and zinc oxide. The trend is less marked in tinted white paints because the very opaque chalk characteristic of titanium dioxide gives rise to marked fading. The disadvantage of fading, however, should be weighed against the advantage of greater freedom from dirt which is likewise characteristic of titanium formulations. In many tints a fairly clean surface even though somewhat faded, is superior in appearance to a dirty surface. With white paint, fading does not enter into the picture and greater cleanliness is a clear advantage.

Most of the titanium formulations are further characterized by a lower content of zinc oxide and a higher content of total pigment than was customary in lead and zinc formulations of similar grade. As a result these paints, when used in consistent programs of maintenance and properly applied, remain free from checking or cracking for a long time. On the whole the writer feels that the typical titanium formulations are somewhat less dangerous than the older lead and zinc formulations if for any reason repainting is deferred a trifle too long, but they cannot safely be allowed to go through long periods of neglect. Good titanium pigment paints have much greater opacity than older paints and are therefore especially useful in maintenance programs with relatively short intervals between repaintings, in which the least possible amount of paint should be applied at a time.

Lead titanate is a very new paint pigment that may become important in the future. It is not quite white, having a trace of yellow color, and for that reason the amount that can be used in a white paint is limited but a large proportion can be used in many tinted paints. The information available so far indicates that lead titanate has a remarkable tendency to retard the embrittlement of paint with age. If it proves possible to take adequate advantage of that property, white and tinted paints may be made more durable in the future.

Soy Bean Oil

In recent years many efforts have been made to replace the linseed oil in house paint wholly or in large part with other drying oils or resins. Soy bean oil is much discussed at the present time. While not so good a drying oil as linseed, very substantial proportions of soy bean oil can be incorporated in good paint, especially if fortified with superior drying oils like perilla or with a small amount of properly treated tung oil. The use of soy bean oil, however, is chiefly a question of utilization of domestic farm crops; there is no immediate prospect of obtaining definitely improved paints in that way.

Some consideration is being given to the possible use of moderate proportions of resin in the vehicle of paints in which there is no zinc oxide in the pigment, the resin being used to impart the desired degree of hardness instead of zinc oxide. Whether such a radical shift in traditional formulation offers any material advantage remains for the future to disclose.

A typcial stretch of track on the Western Lines of the Atchison, Topeka & Santa Fe.

FLB 000969

The Lake Pontchartrain Trestle

By W. B. GREGORY

Professor of Experimental Engineering,
Tulane University of Louisiana,
New Orleans, La.

Built in 1882 of creosoted yellow-pine timber, this structure is still carrying all trains of the Southern and the Gulf, Mobile & Northern railways into New Orleans. Although strengthened at various times to accommodate heavier loading, much of the original timber is still in use after 53 years service. The history and present status of this historic structure were presented at the thirty-third annual convention of the American Wood-Preservers Association at New Orleans on January 27.

THE Lake Pontchartrain trestle, 5.82 miles long, carries the Southern into New Orleans. Construction was started in February, 1882, and finished in September of that year. It was built of creosoted yellow-pine timber. Piles from 50 to 68 ft. long, below cut-off, were driven. The total penetration varied from 40 to 48 ft., according to the length of the piles and the depth of water, which is from 8 to 10 ft. The piles were cut off to support caps 12 in. by 44 in., laid flat; above the caps are the stringers on which the crossties and decking rest. When first built, the crossties were supported by six stringers, 6 in. by 16 in. in cross-section by 30 ft. long. Originally the bents were 15 ft. apart.

The deck of the trestle is protected by a covering of gravel, the use of which was commenced in 1885 after fire had seriously damaged or destroyed about 325 panels to the water line.

In 1928, after almost 45 years service, there remained intact 574 of the original pile bents out of a total of 2,010, or approximately 28.5 per cent. In 322 other bents, half the piles had been cut off just above the water line and half-framed bents erected. In 1,114 other bents the original four piles had been cut off just above the water line and four-post framed bents erected. All of the original ties had been renewed, almost entirely as a result of mechanical damage by reason of creeping rail and the thin tie plates used originally. Of the original stringers, only 194 had been renewed on this date. The renewal of piles above the water line had been made necessary almost entirely as a result of decay of heart timber, where they were cut off for the placing of the caps.

In connection with the Southern's bridge renewal program, 320 intermediate pile bents in this structure were replaced during 1927, requiring the driving of 1,920 piles, varying in length from 65 to 75 ft. To provide for heavier loading in the future, all new bents have six piles.

Since 1928 more work has been done driving intermediate bents, while decay of the tops of piles has required more attention and caused more expense. The road is now probably facing a much more extensive renewal of stringers.

Decay at Cutoffs

Decay at the tops or cutoffs of piles has been the largest factor limiting the life and strength of the Lake Pontchartrain trestle. The piles were of generous diameter, so that the area of bearing between the cap and the ring of creosoted lumber of the pile was sufficient for the load, even when the inner part of the pile started to decay from lack of adequate treatment prior to construction.

This decay of the tops of the piles did not cause much concern until about 1920 (37 years life). Then piles here and there in various locations became so poor that strengthening was required. By 1932, (49 years life) there were only 1,038 out of an orig-

The American Home April 1937 (31)

Have you a PAINT MAINTENANCE program?

ASSUMING that a frame house remains serviceable for fifty years before obsolescence leads to its replacement, a good program of paint maintenance for the exterior consists of one initial paint job when the house is erected and ten or twelve subsequent repaint jobs at suitable intervals. If the program is successful, the coating of paint remains substantially intact and of good appearance throughout the life of the house. Between paint jobs the coating wears appreciably thinner by chalking and erosion but it does not break up and fall off in patches. Each new repaint job is applied over what is left of the previous jobs without at any time having the expense and trouble of removing all of the old coating down to the bare wood.

Such a program of maintenance is thoroughly reasonable and has been achieved successfully by many property owners. With enough good luck it may be realized without any careful planning on the owner's part but luck, like the weather, is notoriously fickle and likely to prove adverse at embarrassing moments. The property owner who feels that he can dispense with a well-planned program merely by hiring a painter whenever he happens to notice that the dear old place could stand another coat runs a grave risk of an expensive disappointment. Those careless owners against whom lady luck has turned will testify that a badly maintained paint coating soon turns into a heartless gold digger who makes you pay and pay!

Since paint maintenance involves separate jobs at intervals over a long period of years, the small property owner is rarely able to hire anyone to take care of it for him. He can buy single paint jobs but not a maintenance program. Unacquainted with paint though he may be, the maintenance program is a responsibility that he cannot escape. As a rule, the owner determines when each painting shall be done; he selects the painter; he often selects the paint; and he may set limitations of cost that profoundly affect the technique of painting. The owner should also be able to give each painter an accurate history of previous paint jobs. Under these circumstances property owners need considerable technical knowledge about paint.

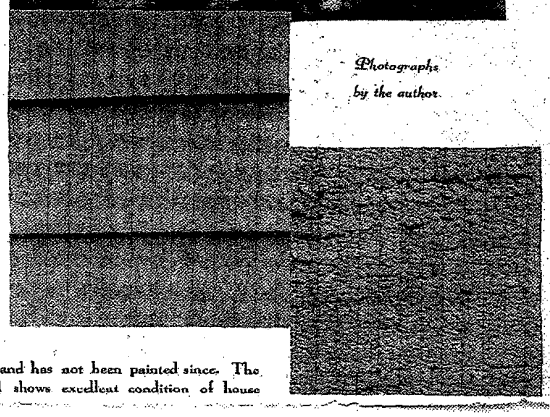
The property owner's responsibility for his program of maintenance is not properly emphasized in the literature on painting that is commonly brought to his attention. Paint composition is such a fascinatingly complex subject and there has been so much bitter controversy about the rival merits of different paint ingredients and different paint formulas that the importance of the owner's program of maintenance has usually been forgotten. In consequence, the layman commonly believes that the secret of successful paint maintenance lies almost wholly in choosing good paint. Good paints are presumed to give good service if properly applied, regardless of the nature and age of the paints used previously, and conversely unsatisfactory paint service is taken as proof that the paint last used was a poor one. As a matter of fact, a paint cannot properly be judged good or bad apart from the maintenance program in which it is to be used. It should never be forgotten that, in repainting, the composition and properties of the renewed coating are not determined solely by the composition of the new paint because the new paint is merely added to what remains of the paints used previously.

In such a planned program the frequency of repainting, the type of paint to be used, and the number of coats to be put on at a time are determined in advance, before the house is erected if practicable. Such planning offers the immediate advantage of a sound basis for budgeting the approximate costs among the expenses of upkeep and, of more importance, it makes it possible to guide the maintenance along lines established by past experience. Above all, a wisely planned program should keep the owner from unwilling experimentation with untried paints and dubious painting procedures with the unexpected expenses to which they may subject him if the job turns out to be a disappointing one.

Planned programs of maintenance may be classified according to the frequency at which repainting will be done: (1) programs in which more than four or five years may elapse between painting, (2) programs in which repainting can be assured at four- or five-year intervals, and (3) programs in which repainting may be done at intervals shorter than four years. The size of the owner's income and the painting habits of his neighbors, of course, may have much to do with his decision about this part of his program. In making the decision, it is wise to remember that the lifetime of a frame house usually spans one or two serious periods of financial depression during which paint continues to deteriorate with complete indifference to the state of the owner's bank account. Paint is no respecter of persons.

The interval of four or five years is taken as the line of division between maintenance programs because it marks approximately the maximum period during which good coatings of white or light-colored paints can be expected to remain substantially intact on the fully exposed parts of a house, assuming that a consistent program is followed and that no moisture collects behind the painted wood-

Photographs by the author



A successful maintenance program in which paint of soft type is used with long intervals between paintings. This house, which is next door to the one shown above, was erected in 1925, repainted in 1931, and has not been painted since. The photograph was taken in 1936 and shows excellent condition of house

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work. Within this period, which may be called the period of durability, inconspicuous fissures, known technically as checking, may appear in the coating; chalking and erosion should wear away a substantial portion of the coating, but the coating should not crack conspicuously or break up and become detached at places, revealing bare wood beneath. In such case, something is wrong.

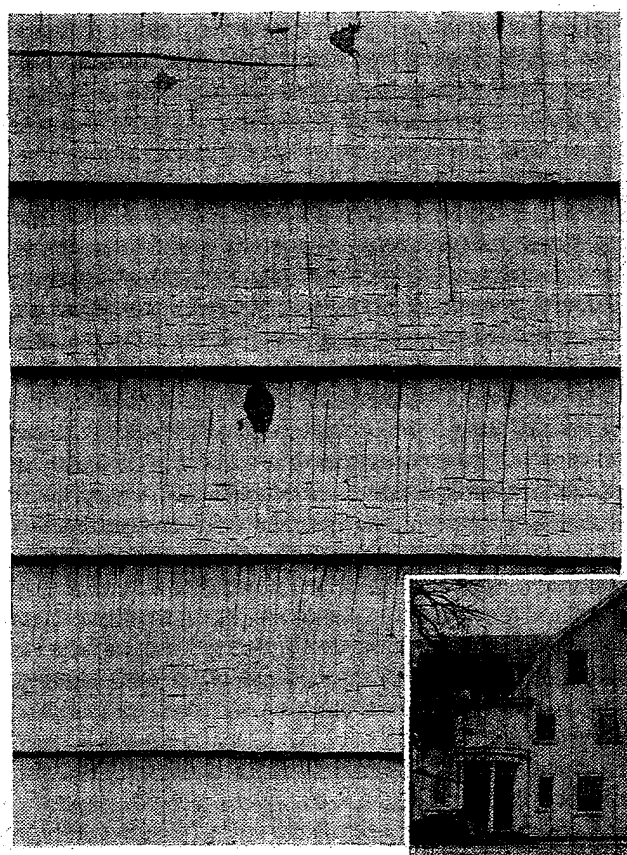
Strong sunshine is usually a major factor in deterioration of paint, hence those parts of the house, frequently the south side, that receive most direct sunshine determine the durability of paint jobs. The durability of white paint may be somewhat longer than four to five years on heavily shaded houses and somewhat shorter in climates that combine much strong sunshine with prolonged periods of either extremely high or extremely low humidity. The nature of the wood painted likewise has a bearing on durability. The cedars, redwood, cypress, and true white pines in the select grades practically free from knots can be expected to hold good paint coatings intact for four to five years under normal conditions. Edge-grain boards of slowly grown and fairly light weight in ponderosa pine, the spruces, and the hemlocks hold paint intact nearly as long, but the flat-grain boards of rapid growth or of high density lead to earlier break-up of paint coatings. The strong, heavy softwoods such as Douglas fir and southern yellow pine ordinarily cannot be relied upon to hold white paints intact beyond three or four years, but by priming them with exterior aluminum priming paint before the first job of white paint is applied, the durability of the coating can be raised more nearly to that on the woods of lighter weight.

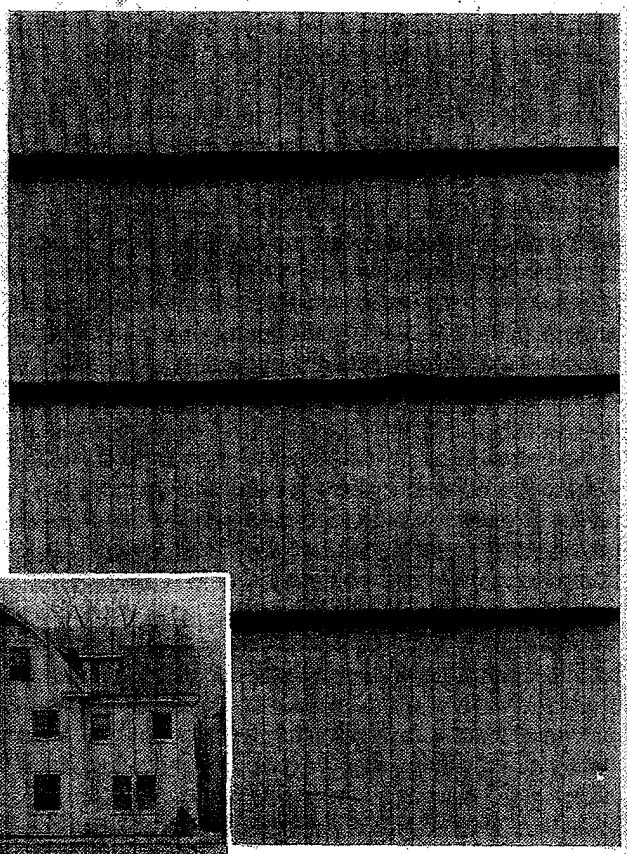
For programs in which more than four or five years may elapse between paintings, colored paints of great durability are particularly suitable. Of the very durable paints the reds, browns, and yellows made with iron oxide pigments are probably the most commonly used. In a good iron oxide paint the major part of the pigment should be iron oxide. Unfortunately many red barn paints have degenerated into cheap paints containing very little iron oxide. Other very durable paints are those in which a major part of the pigment is chrome yellow, chrome green, chromium oxide, lampblack, or carbon black. Aluminum paint, applied in two or three coats, is very durable. The very durable paints are limited to the deep colors or are metallic in appearance and are therefore unsuitable for the major surfaces of many residences.

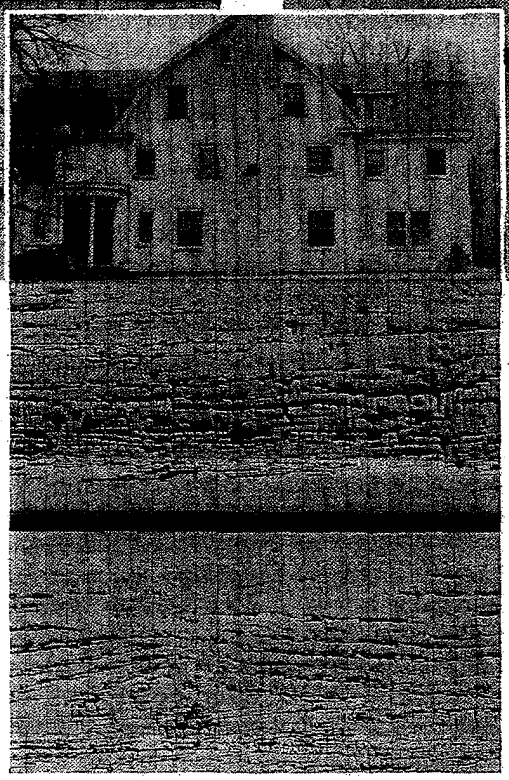
When white or light colored paints are used in programs with long intervals between paintings, each paint job goes

[Please turn to page 102]

An unsuccessful maintenance program in which repainting was done often enough but radical changes were made in the type of paint used. During the first 15 years after erection, this house was kept painted with iron oxide paints containing neither lead nor zinc pigments. Then a small fire made it necessary to rebuild the east side with new siding, after which the whole house was painted with white paint of fairly hard type. The house was subsequently repainted twice with white paint. A few years after the last job, the coating on the north, south, and west sides was in the condition shown in the photograph at the left and should be removed before any further painting is done. On the east side, shown at right, the white paint jobs have served well







The two strips at the bottom represent an unsuccessful maintenance program in which paints of hard types were allowed to go too long between repaintings. This farm building of a Middle Western university is repainted with paints of fairly hard type whenever the state legislature provides fairly generous appropriations for maintenance. Repeated periods of long neglect have left a surface that cannot be repainted acceptably without complete removal of the old coating

FLB 000972

ured up the time and money he could have saved if he had taken up the study of garden problems and methods as a leisure time hobby for even just one year before he moved to his country place. He never tells people what those figures totaled—he is going to forget *them*, he says, and remember only the pleasure he had in trying out his experiments and attaining at last his present, satisfying results.

Have you a paint maintenance program?

[*Continued from page 42*]

beyond its period of durability and passes through a period of neglect during which the coating breaks up in a manner characteristic of the type of paint. Some paints, even after long neglect, can be repainted with reasonable assurance that the new job will be just as durable as the last one. Other paints leave an uncertain surface on which a new paint job may break up much too soon. Of course, the old paint in the latter case can be removed but paint removal is too expensive to have any place in a program of extreme economy. For such programs white or light colored paint must be chosen rather for their ability to stand neglect well than for their qualities during their normal period of durability.

Pure white lead paint, in which white lead is the only pigment other than necessary tinting colors and linseed oil is the only liquid except thinners and driers, has long been used successfully in programs involving periods of neglect. Since white lead paint was the only high grade white paint available until comparatively modern times, painting traditions in this country are largely based upon its characteristics. Pure white lead paint develops chalking and checking fairly early in its life and it wears down with moderate rapidity. It is therefore called a soft paint in contrast to hard paints with opposite qualities. Soft paints stand neglect well because they disintegrate eventually by fine crumbling rather than by cracking, curling, and coarse flaking or scaling. When repainted after a period of neglect, soft paints are little more than a porous mass of pigment "chalks;" oil from the new paint thoroughly permeates the old coating and incorporates it with the new. The new job therefore behaves much as the previous one did and has about the same durability or wearing quality.

Programs with four or five years between paintings are best adapted to the needs of owners who wish to keep their property well maintained at all times without extravagance. For such programs any one of the many types of good house paints may be chosen at the outset but thereafter it is wise to repaint always with the same type of paint. Changing types of paint at successive repaintings opens the program to unnecessary possibility of failure because paints of different types are not always compatible with one another. Too much variation in composition between successive layers of paint apparently increases internal stresses within the coating as it ages and causes it to break up abnormally early or in an objectionable or unsightly manner.

In conservative programs of this kind the surface should be repainted before the coating begins to break up seriously. It is dangerous to wait until conspicuous cracking, curling, and flaking prove that the durability of the paint has been stretched to its limit. The temporary saving effected by postponing repainting for a few months may shorten the life of all subsequent paint jobs and eventually require expensive removal of the entire coating. When paints that do not stand neglect are used, repainting should anticipate rather than follow the breaking up of the coating.

Repainting should restore to the surface approximately the amount of paint worn away since the previous painting. If too much paint is put on at a time the coating eventually becomes too thick and may break up so badly that it must be removed. Hard paints wear away less between paintings than soft paints; the harder the paint the less of it should be applied at each repainting. The painter gauges the amount applied partly by the number of coats and partly by the extent to which he brushes each coat out. With soft paints two coats at each repainting may be necessary, while with hard paints it may be safer to apply only one coat. For much the same reason different parts of a house may require varying amounts of paint because less paint wears away from those parts which are more shielded from sunshine.

Programs in which repainting may be done at intervals of less than four years are sometimes necessary for commercial buildings but as a rule are inadvisable for residences. On the protected parts of the house particularly the paint does not get time to weather sufficiently to be in best condition for repainting and it wears away so little that the coating necessarily becomes thicker at each painting. Under these conditions it is especially important that the new paint be as nearly as possible like the previous paint in composition and that paints with great hiding power be chosen so that they may be applied as thinly as possible. If exceptionally good appearance is desired it is often safer to use paint of a hard type that can be washed easily once a year rather than to repaint at short intervals.

To follow a consistent program of maintenance the owner must learn how to identify the type of paint he has decided to use. House paints other than white lead paint are sold by manufacturer's brand, not by type, and the manufacturer reserves the right to change the formula at will. In recent years such changes in formula have been of frequent occurrence. In many brands the white paint and the tinted paints differ markedly in type; in any brand the deeply colored paints necessarily differ greatly from the white and tinted paints. For these reasons the manufacturer's brand does not identify paints by type. Many manufacturers, however, print the formula of the paint on the label. Although adequate interpretation of the formula requires much technical knowledge of paint composition, it is a comparatively simple matter to use the formula for selecting paint as similar as possible to that used the last time. Each paint used successively should contain the same principal ingredients in approximately the same proportions.

Attempts to improve upon old-fashioned white lead paint for the most part have aimed at retarding chalking, checking, and erosion, and improving opacity and whiteness. All of these objectives have been achieved, but the newer paints are necessarily harder in type and cannot be relied upon to stand neglect. Repeated neglect of hard paints ultimately leads to a condition demanding complete removal before new paint can be relied upon to give satisfactory durability. Such paints are not intended for use in accordance with the old painting traditions based on white lead paint because their manufacturers designed them for more exacting programs of maintenance. Their superior appearance during their period of durability can be utilized safely only if reasonable care is exercised to see that they are always repainted before they begin to break up.

White paints other than white lead paint always contain a mixture of pigments one of which nearly always is zinc oxide. Mixtures of white lead and zinc oxide have long been popular. Zinc oxide is the hardening agent in linseed oil paints; the greater the proportion of zinc oxide in the pigment the harder the paint. Zinc sulfide pigments, such as lithopone, and titanium pigments are more opaque than white lead or zinc oxide and make whiter paints with greater hiding power. The present trend in the industry is to use zinc sulfide pigments in cheaper paints and titanium pigments in high grade exterior paints. Such pigments as silica, magnesium silicate, barium sulfate, calcium carbonate, and calcium sulfate are transparent in linseed oil and are used primarily to reduce cost or to increase the total amount of pigment without increasing the cost. Until recently nearly all high grade house paints were made with linseed oil but attempts are now being made to introduce various resins in the form of oil varnishes or synthetic drying oils. Resins harden paint much like zinc oxide so that it is often necessary to reduce or eliminate the zinc oxide as resin is added. The resins likewise tend strongly to make the product an enamel rather than a paint, which makes it less amenable to the common technic of house painting. Enamel characteristics can also be imparted without resins by heat treatment of the linseed oil or a major part of it. Since tung oil must be heat treated for use in paint, substitution of it for a major part of the linseed oil results in an enamelized paint. In enamelized paints free from resins the content of zinc oxide in the pigment is often very high. Substitution of soy bean oil for part of the linseed oil in house paint tends to make a softer product whose use is favored primarily to gain a market for a relatively new domestic farm crop becoming more abundant.

The best way for a property owner to select a type of paint for a new house is to observe houses in his neighborhood that were painted with it one, two, three, and four years previously. Such observations are infinitely more revealing than any other source of information. It should be remembered that the appearance of a paint changes at intervals during its life so that coatings of various ages must be seen to learn the whole story. On the other hand the shaded parts of a house and the fully exposed parts show paint at different stages of deterioration at the same time. If some of the neighbors have coatings that are breaking up badly, do not attribute it hastily to the quality of the paint last used. First make sure that the past program of maintenance has been consistent and that the paint is giving its normal service. A survey of this kind will show very clearly that after all the particular type of paint chosen is usually much less important than insistence upon a program of paint maintenance to which the paint is properly adapted.

The maintenance programs discussed in this article are based on the assumption that the side-

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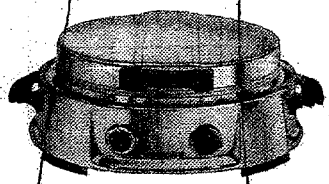

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walls of the house remain dry at all times and that water never gains access to the backs of the painted boards. Unfortunately there are some houses for which the assumption is unsound. In some of them rain gets behind the painted woodwork through leaks resulting from faulty construction such as omission of necessary flashing around windows, doors, dormers, roof angles, and back of gutters. The more common cause of such difficulty, however, is condensation during times when the interior of the house is heated while it is cold outside. Humidification of the interior at such times aggravates the difficulty. Water behind painted woodwork causes blistering and subsequent scaling of the paint. Such developments may destroy the integrity of the coating within a few months after it is applied. Soft paints resist abnormal moisture conditions more effectively than hard paints, while heterogeneous coatings consisting of paints of different types are often exceedingly sensitive to them. The only reliable way of assuring satisfactory paint service on houses subject to abnormal moisture conditions is to find means of keeping the backs of painted woodwork absolutely dry at all times.

The secret of successful paint maintenance over a long period of years lies in strict adherence to a program that has been proved satisfactory by actual experience in the past. The scientific principles that govern paint behavior still await discovery and until they are revealed our knowledge of the subject must remain essentially empirical. There is no magic paint formula that can be relied upon to behave satisfactorily over all other paints on the market. The property owner himself should see to it that his program, both with respect to the paints used and the intervals between painting, is so planned that there is past experience to give him reasonable assurance of success, unless he is willing to trust to luck and pay the penalty if it turns out badly.

The Swallows build a nest

[*Continued from page 28*]

a picket gate to broad, low steps, which invite one to enter through the simple doorway into the traditional tiny "entry" from which, as in all New England houses of this type, doors open to either side and a staircase leads straight upward to the bedrooms on the second floor.

But the door to the right, instead of opening into the box-like "best room" of the early homes, leads into a spacious living room extending across the width of the house and with windows on three sides—the sort of room where a number of people can engage in varied interests without getting in one another's way, and therefore ideal either for family life or the entertainment of friends.

The fireplace is nicely centered on one of the long walls and directly opposite is space for a long sofa, or perhaps a convertible daybed lounge to provide additional sleeping accommodations in an emergency. With comfortable chairs grouped on either side of the fireplace, lamps and small tables for books and smoking appointments, and a low coffee table placed before the sofa, the stage is set for the rallying ground which is the heart of the home. A baby grand piano might be located at one end of the long room for the music lovers, and a library arrangement with bookshelves and desk at the other.

At the rear, almost in line with the door leading into the dining room, is one opening upon a room-size open porch, which because of its accessibility to the kitchen can be conveniently utilized for an outdoor dining room, yet is not so closely related to it as to prevent its use also as a summer sitting room.

Another praiseworthy feature of this house is the little room to the left off the front hall, a room which opens as well into the dining room, from which it is but a step to the adjoining kitchen, and so to the garage and service entrance.

In the old days such a room would have served as a downstairs bedroom and might now be utilized for that purpose should any member of the family be temporarily invalided or find stair climbing difficult. But it suggests also a nursery, where the children can be looked after while mother is occupied with kitchen duties, and also makes a grand playroom where toys and things can be scattered about without disturbing the serenity of the rest of the house. A closet in which to put the toys when "pick-up" time comes around is an especially helpful feature.

Because of its location, it is also a grand study room for older children going to school, for here they can be shut off from the rest of the family and be undisturbed.

If there are no children to be considered in the household arrangements, this room will provide an ideal retreat for a person engaged in literary pursuits, since it is well lighted and has plenty of wall space for bookshelves and cabinets. It might also be converted into a game room, a sewing room, or a corner which the man of the house can call his own. All in all, it is a very usable room.

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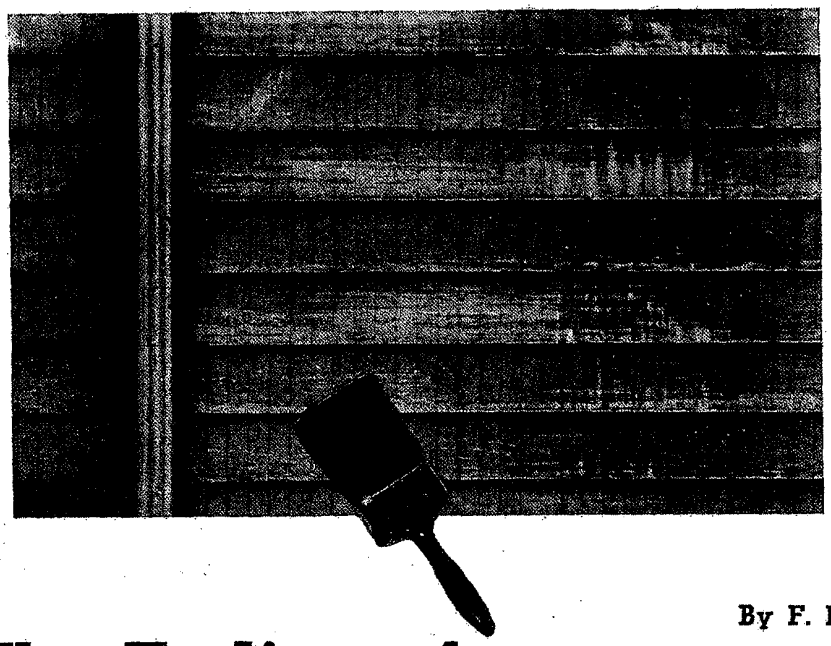

Uneven fading of paint of brick color applied in one coat over previous paint in good condition and uniform in absorptiveness. The photograph was taken about one year after repainting. The faded areas are the thinner portions of the last paint coating.

By F. L. BROWNE†

The Fading of Painted Surfaces*

IN MOST exterior paints for wood, the colored pigments are chemically stable inorganic substances that do not change materially in color from weathering. The fading of paints containing such pigments is not caused by any change in the pigments but by loss of organic vehicle, usually dried linseed oil, from the exposed surface of the paint coating, thus leaving the outermost part of the coating with insufficient vehicle to fill in all of the spaces between the particles of pigment. Under such circumstances we might expect to find the outer layers of pigment bound together inadequately, and to the remainder of the coating. In fact, we find that the loose pigment can be rubbed off easily with the fingers or a piece of cloth of a color contrasting with that of the paint. In other words, fading begins when the paint begins to chalk.

Why chalking causes fading may be demonstrated by mixing thoroughly enough dry iron oxide red, or other colored pigment, with dry white lead or zinc oxide to make a mixture very light pink in color. Save part of this mixture for comparison and rub up the remainder with linseed oil to the consistency of paint. The paint will have a far deeper red color than the mixture of dry pigments. Chalking and fading are the reverse of this experiment, in that oil is taken out of the exposed surface of the paint leaving the pigments dry. It should also be remembered that such pigments as silica, whiting and barium sulphate, which are transparent in linseed oil, are opaque and white in the form of dry powder and, therefore, help to cause fading when paint begins to chalk.

Fading Expected

Ordinarily, chalking is the preferred form of deterioration for exterior paints on wood. Fading is, therefore, a result that must be expected. Before choosing a tint in the first place, the faded appearance as well as the initial appearance should be considered. Some tints look well in both the initial and faded colors, while others that may be very attractive originally look shabby when faded. In any case, painting should be done so that all parts of a building that can be viewed from any one position will always be as nearly uniform in color as practicable, except where different colors are chosen deliberately to begin with.

There are several kinds of lack of uniformity in fading, some preventable and others not. Paint deteriorates most rapidly on those parts of a building most fully exposed to sunshine. As a rule, therefore, fading begins earlier on the south side than on the north, unless the south side happens to be in the shade of another building. Fortunately the south and north sides cannot be observed from any one position.

Even if the east and south sides, for example, are seen at one time a reasonable difference in color may merge in the viewer's impression with the difference in intensity of illumination of the two sides. This kind of lack of uniformity in fading, which is unavoidable, causes little trouble unless the extent of the fading is excessive or the color is one that looks very shabby when faded.

Some kinds of paint begin to

*This discussion was submitted for publication in What's the Answer department for the July issue, in answer to a question as to what causes parts of repainted wood surfaces to fade. Because of its scope, however, it was withheld for presentation here as an independent article. For further discussion of the subject, see page 489 of the July issue.

†Senior chemist, Forest Products Laboratory, Forest Service, Department of Agriculture, Madison, Wis.

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chalk and fade at an earlier age than others. With any one kind of paint and a given exposure, fading will begin earlier the greater the proportion of pigment and the smaller the proportion of organic vehicle in the exposed layer of the dried paint coating. If this outer layer of paint does not have a uniform content of organic vehicle, some parts of it will fade earlier than others.

Uneven fading of this kind is always objectionable, even though both the original and the faded colors are in themselves attractive. Except under a few rather unusual circumstances, uneven fading caused by uneven composition of the last coat of paint can be charged definitely to bad craftsmanship on the part of the painters or to unreasonable limitations of time and materials imposed on the painters by their supervisors.

On a non-absorptive surface, a coating of new paint dries with uniform composition, determined entirely by the proportions in which the paint was mixed. On an absorptive surface, however, part of the linseed oil is taken out of the coating to saturate the surface beneath. As a result, parts of the new coating dry with less oil than others, and these parts will fade sooner.

If the old paint is uniformly absorptive and takes the same amount of oil from the new paint over all parts of the surface, the composition of the new coating might still remain uniform, if the coating were applied with the same thickness everywhere. Few painters are capable of such meticulous craftsmanship, however. Almost always there are areas thicker and thinner than the average. If so, the thin areas lose proportionately more oil and fade sooner, while the thick areas fade later than the rest of the coating. Uneven fading of this kind is not uncommon. The writer has even seen cases in which the hollows of the brush marks faded earlier than the crests.

In general, an old paint is uniformly absorptive up to the age at which it begins to break up seriously by cracking, crumbling, flaking or scaling. A nice question of painter's judgment arises in determining whether one or two coats of new paint are needed over a substantially unbroken coating of old paint. From the viewpoint of assuring uniform fading, obviously, two coats are much safer. On the other hand, repeated repainting with two coats before a large part of the previous coating has worn away, builds up a very thick coating that may break up early and badly.

If two repaint coats are applied, the first should be thinned generously with a volatile thinner and brushed out to 800 or 900 sq. ft. to the gallon. In this case, the object of the first coat is to saturate the old paint while adding as little as possible to the thickness of the coating. The finish coat may then be brushed out to the point at which it just hides adequately and makes a satisfactory job.

If the surface is repainted with one coat only, very little volatile thinner should be used. The paint should be mixed stiff enough—with high content of pigment—to be brushed out properly at no more than 600 sq. ft. per gal., and the coating should be laid on with a thickness as uniform as possible.

Old Surfaces Misleading

An old surface that is cracking conspicuously, but has not yet begun to flake or scale often proves to be misleading. The paint itself is usually quite uniform in absorption, but the cracks, if deep, may take much oil from the new paint. After repainting there may be early fading over the old cracks.

This occurs most frequently with paints of hard type, that should be repainted with the minimum amount of paint at a time, seldom more than one coat. The paint should be mixed to a stiff consistency with much pigment, and should be brushed down into the cracks as thoroughly as possible before it is finally leveled off by the last strokes of the brush.

When the old coating has started to break up by crumbling, flaking, or scaling, exposing bare wood, the absorption of the surface is quite variable and two coats of new paint are necessary. All loose paint should first be scraped off and the jagged edges tapered off by sandpapering. Even with two coats of new paint there is danger of uneven fading, unless the first coat is thinned and applied properly.

A very common blunder is to thin the first coat with much linseed oil on the theory that the way to satisfy excessive suction is to put plenty of oil into the paint. This theory overlooks the important matter of spreading rate. The more oil there is in the paint the farther the painter brushes it out, and the less oil there is left per unit of area. Moreover, the thinner the coating the greater the change in its composition caused by withdrawal of a given amount of oil per unit of area. Consequently, the problem of excessive absorptiveness should be met with paint mixed with plenty of pigment, no added volatile thinner, and application in a coating of substantial thickness. Such a repaint coat will prime the surface adequately and hold out the finish coat so that fading will be uniform. It will also come far closer to leveling off the flaked patches with the rest of the coating.

There are many badly neglected surfaces that ought not to be repainted without first removing all of the old paint from them. When old paint is scaling from the wood in places but the portions remaining are thick, curling at the edges, yet resist dislodgement by the scraper, the behavior of a repaint job is uncertain at best. Again, on a surface on which various types of paint have been used and part of the coating is slipping over or curling away from previous coatings, it is wise to take off all of the old paint and start from the wood with a properly planned program for future maintenance of the surface.

One other factor affecting the uniformity of finish coats may be mentioned. Absorption of oil by the underlying surface goes on for some hours after fresh paint has been applied, but it can continue only so long as the oil in the new paint remains liquid. Reasonably rapid drying of the new paint will, therefore, assist in sealing the surface against further absorption.

Many painters are unduly cautious about adding drier to paint. While overloading paint with driers should be avoided, it is equally bad practice to restrict the drier to such an extent that the paint remains wet abnormally long. In good weather paint should dry to a firm film overnight. Slow drying is particularly likely to occur with dark-colored paints containing no lead or zinc pigments. When repainting with two coats of brown paint, for example, the first coat, even after it seems to be firm, sometimes has the property of absorbing oil from the second coat. The writer has seen this occur to such an extent that the finish coat dried without gloss.

To avoid such possibilities it is wise to repaint before it becomes necessary to use more than one coat of new paint. When two coats are necessary, it is sometimes advised to use for the first coat white-lead paint tinted toward the color of the finish coat and then to use the colored paint for the finish coat. The writer does not endorse this procedure, because the application of white or tinted white paints over colored paints containing no white pigments, has been known frequently to cause unsatisfactory paint service.

Reprinted from September, 1937 issue of Railway Engineering and Maintenance

Pacific Purchaser Feb. 1938

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PAINT
VALUABLE DATA FOR BUYERS

The Effect of Climatic Differences on the Behavior of House Paint

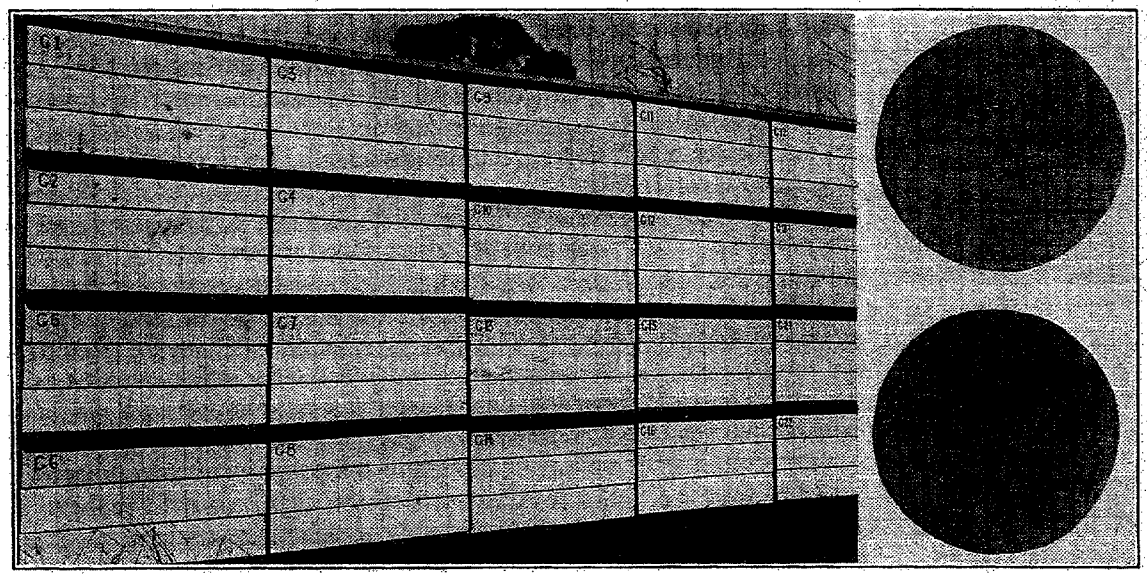
By F. L. Browne
*Senior Chemist, Forest Products Laboratory**

It has been recognized for many years that house paints behave differently in different climates. The subject is of particular interest on the Pacific Coast because of the unusually wide variation in climatic conditions within the borders of any one of the three states. In California alone there are practically all the variations in climate to be found anywhere in the United States. Technologists necessarily have to give careful attention to climatic variations in designing and testing paints because paints may be made that behave well in some climates but badly in others. Fortunately it is possible to make paints that serve well in all climates even though their behavior varies in certain details. Paint buyers may well give some attention to climatic peculiarities in selecting paints, particularly in considering advertising claims based on tests made under one extreme of climatic conditions, but in general the subject is of most interest to the paint user from the point of view of planning his program of paint maintenance correctly for the type of paint selected and the locality in which it is used.

As far back as 1910 the Lincoln Paint and Color Company attempted to build a merchandising program on the idea of "pre-acclimated" paint. George B. Heckel in his "Reminiscences of the Paint Industry" (American Paint Journal Company) tells the story and reproduces the famous "climate map" of the United States by means of which the purchaser was to learn which of the four types of paint made was pre-acclimated for his locality. Heckel considered the plan a "dud," which is probably true for the large manufacturer who wishes to advertise on a national scale. Small manufacturers doing business in a limited territory, however, can and often do design their formulas with special regard for climatic characteristics. Larger manufacturers whose advertising does not commit them to any precise formula sometimes supply paint of somewhat different formula in different parts of the country. One large Pacific Coast manufacturer makes a number of brands of paint and apparently has his local dealers handle the one best suited to the dealer's locality.

The dominant factors of climate affecting the behavior of house paints on wood are sunshine and relative humidity. For paints on metal extremes of temperature are also important. Salt in the air near the sea coasts adversely affects paint on iron and steel by stimulating corrosion of the metal but, in the writer's opinion, it does not impair the service of good house paints on wood. Contamination of the air by industrial fumes, which is a local rather than a climatic influence, may seriously affect paint on both wood and metal. Soot discolors paint and, if there is enough of it, may

*Maintained by the Forest Service, U. S. Department of Agriculture at Madison, Wis., in co-operation with the University of Wisconsin.



The behavior of paints at Gainesville, Florida, where the climate is damp and sunny. Panels 1, 2, 5, 6, 9, 10, 13 and 14 painted with a moderately soft type of paint, panels 3, 4, 7, 8, 11, 12, 15, and 16 with a moderately hard type of paint. Circular area shows details of behavior of the two paints. Panels 1, 2, 3, and 4 are southern yellow pine, 5, 6, 7, and 8 western white pine, 9, 10, 11, and 12 ponderosa pine, 13, 14, 15, and 16 northern white pine. Panels of odd number have flat-grain boards, even numbers edge-grain boards.

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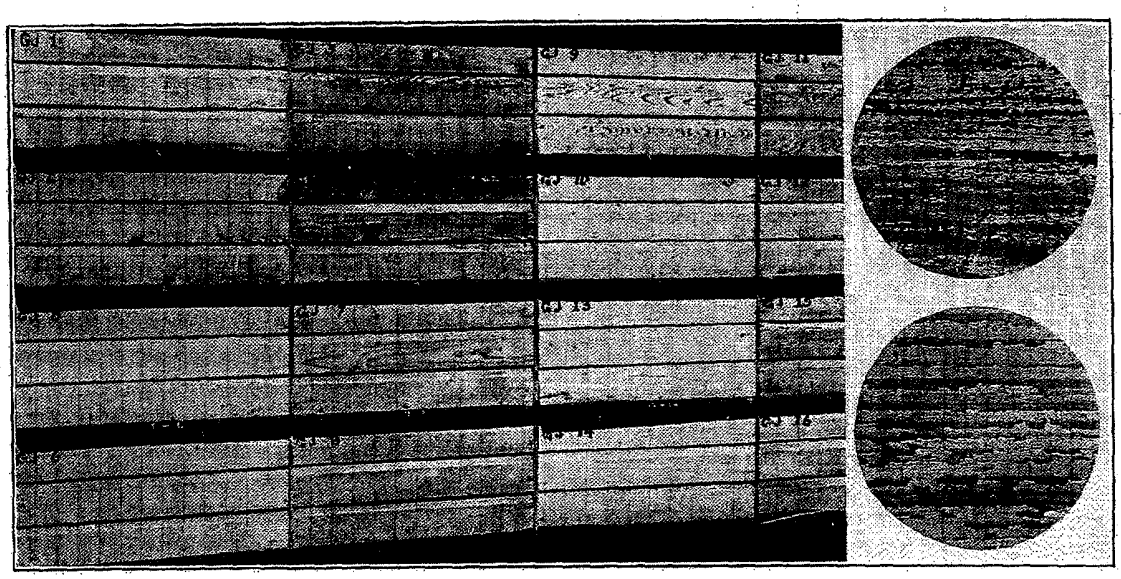


The behavior of paints at Grand Junction, Colorado, where the climate is sunny with very dry summers. Panels 1, 2, 5, 6, 9, 10, 13, and 14 painted with a moderately soft type of paint, panels 3, 4, 7, 8, 11, 12, 15, and 16 with a moderately hard type of paint. Circular areas show details of behavior of the two paints. Panels 1, 2, 3, and 4 are southern yellow pine, 5, 6, 7, and 8 western white pine, 9, 10, 11, and 12 ponderosa pine, 13, 14, 15, and 16 northern white pine. Panels of odd number have flat-grain boards, even numbers edge-grain boards.

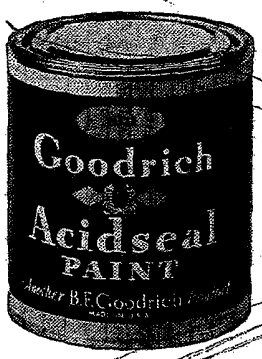
make the paint last longer by shielding it from sunlight. Hydrogen sulfide turns white lead pigments black while sulfur dioxide may render zinc oxide pigments soluble in water so that they are washed out of the coating by rain.

Sunshine shortens paint life by hastening the aging and disintegration of the drying oils that bind the pigments together in the coatings. The chemistry of the process is not yet known but it is known that the blue, violet and ultraviolet rays are more potent than the rest of the sunlight. Sunlight is less deleterious to paints indoors because the ultraviolet rays are largely filtered out by window glass. Regions that are characterized by a high proportion of sunny weather and by high content of ultraviolet in the sunshine are particularly severe on paint. As a rule the ultraviolet content of sunshine increases in southern latitudes and with altitude above sea level but is always low during cloudy weather. The action of sunshine may be especially severe where clear skies frequently follow swiftly after showers of rain.

Moisture is absorbed by paint coatings and makes them much more flexible than they are when dry. Young coatings of good paint have plenty of flexibility even when thoroughly dry but gradually become brittle as they age. When old and brittle they are much less likely to crack, curl, and flake off if they are always slightly moist, which is the case in climates in which the relative humidity is always reasonably high.

For the above reasons sunshine largely governs the rate at which coatings grow old and brittle while the minimum relative humidity to which they are exposed largely controls the form in which failure sets in after embrittlement has occurred. The desirable form of failure is the slow erosion known as chalking which is characteristic of moderately soft paints such as pure white lead paint. The undesirable form of failure is a breaking up of the coating by cracking and curling and the sloughing off of pieces of the coating by flaking or scaling. Incorporation of zinc oxide in house paints makes them harder and retards erosion by chalking but increases the chances of ultimate failure by flaking or scaling. Climates characterized by much sunshine and absence of periods of low relative humidity favor disintegration of paint by erosion and make paints of the harder types more practicable. Climates characterized by much sunshine and periods of low relative humidity accentuate failure by flaking and scaling and make it necessary to avoid paints of undue hardness.

(Continued on Page 28)



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A protective coating for concrete, steel, or wood may be sprayed on with a paint gun; protects against many acids, alkalis, oils and other corrosives; prevents electrolysis by its non-conductance. Naturally colorless, it may be given practically any color. It has a smooth semi-glazed surface.

A completely flexible system for storage in boxes is built from steel racks in which the boxes slide like drawers. The rack units lock together easily without tools and unlock as easily for quick rearrangement.

A specially treated titanium dioxide pigment has both high tinting strength and resistance to chalking. It can be mixed with chemically reactive pigments such as zinc oxide.

A novel thermometer for hot liquids is floating, all-metal, non-breakable. Spherical in shape, the temperature scale is engraved on the outside. When dropped in the liquid it floats with the number indicating the temperature uppermost.

A new time recorder is said to save time by its one-hand operation. It prints on the face of the card. Tardy or irregular registrations may be printed in red.

Black and colored lead for mechanical pencils is now packed in transparent containers so that the owner may check his stock at a glance.

Aluminum coated steel, the surface of which after drawn can be polished with a cotton cloth to a high mirror finish which will last indefinitely in ordinary atmospheres. The surface of the coated metal is free from pin-holes. Its resistance to oxidation at the high temperatures makes the sheet suitable as a resistor material in the place of resistor alloys now used.

A lighting fixture permits the reflector to be adjusted through a vertical arc of 37 degrees and can be rotated horizontally through 360 degrees. The reflector finish produces a soft even distribution of light.

The Effect of Climatic Differences on the Behavior of House Paint

(Continued from Page 14)

The accompanying illustrations show the behavior of a moderately soft paint (pure white lead paint) and a moderately hard paint (lead and zinc paint of medium content of zinc oxide) after four years of exposure facing south at two stations typical of the extremes of climatic effect on paint to be found in the United States. In the study there were 11 testing stations chosen for climatic variations at each of which these two paints were simultaneously exposed on flat-grain and edge-grain panels of 18 different woods. At all of the other stations the behavior of the paints fell between the two extremes shown. At Gainesville, Fla., where the climate may be described as damp and sunny, both paints wore away gradually by chalking with a minimum of crumbling, flaking or scaling. The moderately hard paint outlasted the moderately soft paint by a small margin and differences in durability on different woods were small. At Grand Junction, Colorado, where the climate may be described as sunny with very dry summers, both paints failed more rapidly and the failures took place by crumbling or by flaking rather than by chalking. The moderately soft paint outlasted the moderately hard paint by a rather wide margin, and durability on the different woods varied much more strikingly.

The effects of climate on paint, while great enough to deserve careful attention by paint users, are far less important in determining serviceableness than correct planning of programs of maintenance, correct choice of type of paint for the programs selected, correct technic of application, and the avoidance of coatings of heterogeneous composition whose behavior is unpredictable and often disastrously unsatisfactory.

X.P.A.s Elect New Officers

The X.P.A. Association of San Francisco, which is made up of a few choice spirits who formerly belonged to the Purchasing Agents' Association of Northern California, and which now has a real entity of its own with constitution and by-laws, regular

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plication will give an excellent job and will absolutely not crack, peel or blister.

There is a *Tnemec* coating for every application, such as structural steel, galvanized iron, tank cars, oil and water storage tanks, underground pipe lines, concrete, stucco, brick and wood surfaces.

Petroleum Equipment Company have been distributors for *Tnemec* for many years, and are supplying it to some of the largest industrial plants in California. They carry complete stocks in San Francisco and Los Angeles and welcome any inquiries regarding the application of *Tnemec* for rust and corrosion prevention. Ask them for Bulletin No. 4-36 on *Tnemec* No. 6 Red Primer and catalog covering other industrial coatings.

Turco Keeps Pace With Changing Industrial Requirements

The consistent and progressive growth of Turco Products, Inc., from a modest beginning some fifteen years ago to its position today as the largest manufacturer of industrial cleaning materials in the West, furnishes a fine example of the successful application of enterprise, service, ethical business practice and superior technical ability.

At the start "Turco" stood for not more than a half dozen products applicable to only a limited few of the countless cleaning operations in the industries. As time passed a constant succession of new, original and exclusive materials emerged from the Turco laboratory and were accorded rapid acceptance in the field by virtue of their sheer merit. There are now some two hundred standard Turco products in use in every conceivable line of industry throughout the eleven Western States.

Manufacturing and merchandising this vast line of Turco industrial cleaning materials is only a portion of the part played by this organization in serving the industries. New industrial practices, processes and methods are being adopted almost daily.

These give rise to an ever shifting demand for cleaning compounds specifically suited to new requirements. New and often complex cleaning problems are being constantly referred to the Turco Laboratory for prompt solution. Most of them involve serious and complicated original chemical research. This technical labor is cheerfully undertaken—regarded as a regular and essential part of the day's work, and carried through to a successful conclusion. In this way new, modern and highly specialized Turco materials are constantly in process of evolution and the usefulness of "Turco" to the industries is everlastingly increasing.

One of many concrete examples of Turco's contributions to industry is seen in referring back to the time when aluminum alloys first came into use in aircraft manufacture. These aluminum parts required cleaning, both in the course of the manufacture of the ship and as a maintenance measure after the ship entered service. Aluminum is a highly reactive metal and the general run of cleaning materials available were of such a nature as to cause varying degrees of damage to this chemically sensitive substance. The Turco Laboratory immediately undertook to evolve cleaning compounds sufficiently potent to remove the heaviest grime from aluminum surfaces without reacting in the slightest degree with the metal itself. How well the Laboratory succeeded is demonstrated by the fact that it was not long before every major aircraft manufacturer and maintenance plant in this and many foreign countries, as well as the United States Army and Navy at home and at distant posts, have adopted the use of these Turco Cleaning Compounds.

As an aggressive, rapidly growing and responsible southern California business enterprise, Turco Products, Inc., has won its place in the first rank, officered by M. J. (Jim) Dee, President; "Bill" Thornbury, Vice-President; S. G. (Syd) Thornbury, Secretary and Technical Director; Ray Sanders, General Manager, supported by its loyal and highly efficient plant and office staff together with its corps of fifty sales and service men covering the eleven Western States.

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FLB 000980

The Decorator March 1938

WOOD AND PAINT

Experiments carried out in America have shown that the durability and behaviour of a paint coating on wood may vary to a considerable extent according to the species and grading of the wood. Some of the conclusions of a well-known technologist on this subject are given in this extract.

34

In an abstract of an official paper by Dr. F. L. Browne, the well-known technologist, on the properties of wood which determine the behaviour of exterior paint coatings, a recent issue of our American contemporary, *Drugs, Oils and Paints*, publishes some comments of direct interest to painters.

Dr. Browne states that exposure tests, conducted by the U.S. Forest Products Laboratory over many years, on painted panels of various kinds of soft woods, showed that the same paint lasted much longer on certain species of woods than on others; these tests further indicated the properties of wood which exert most influence on the behaviour of the paint.

Penetration of First Coat

In dealing with the properties of wood during the application of the priming coat, he observes:

"The first coat of paint applied to new wood is very largely consumed in filling the voids, leaving a level, non-absorptive surface on which subsequent applications can built a coating. However, even though one-half to three-fourths of the volume of wood is void, a comparatively small amount of paint is required for priming it. A plaster wall takes two or three times as much paint as wood. The cellular structure of wood in contrast to the granular structure of plaster accounts for the difference, because in wood, penetration beyond the voids in those cells cut open in making the surface can take place only through the very fine openings in the pit membranes.

"The liquids of paint penetrate more deeply into wood than do the pigments, as can be proved by adding an oil-soluble red dye to the paint before application and later examining the depth to which the red color penetrates. The ratio of solids to liquids in the paint remaining at the surface is thereby upset, so that a paint that dries with a glossy film on glass or metal, dries with a dull film on wood. Judged by the effect on gloss, more oil is thus filtered off in springwood than in summerwood, but penetration is found to be deeper in summerwood. The paradox is not mysterious, for the void capacity of summerwood is only half that of springwood."

Influence of Exposure

The influence of exposure is summarised as follows:

"Under normal conditions of exposure the behaviour of paint coatings during the early part of their service life is not materially influenced by the kind of wood surface upon which they are applied. The rate of loss in gloss, the collection of dirt, the development of chalking and fading, the time when paint checking begins, and the distinctive pattern of the checking depend upon the kind of paint, the climate, the local conditions of exposure, and perhaps to some extent upon the manner of application, but they are not influenced to any important extent by the wood."

Nature of Wood and Ultimate Paint Failure

"The nature of the wood surface begins to influence the behaviour of coatings when they reach the point in their deterioration at which they no longer protect the wood adequately against weathering and when they begin to disintegrate by crumbling, flaking, or scaling, leaving parts of the wood surface bare. From this point on, under present painting practices, it may fairly be said that the kind of wood surface rather than the composition of the paint dominates the behaviour of the coating and determines when repainting is in order."

With regard to the nature of the wood and ultimate failure, Dr. Browne observes:

"There is much variation within many species in density and ring width and it follows that there is a corresponding variation in painting characteristics. Density and ring width consequently are a far more precise guide to paintability than species, but woods are bought and sold by species and not by density and ring width.

"The bark side of flat-grain boards is far superior to the pith side in many species because there is a tendency for the grain to shell out on the pith side. This is a form of wood weathering against which paint should, theoretically, afford protection. In practice, however, paint as we now use it proves inadequate. Flat-grain boards should, therefore, be turned bark side out."

Composition of the Paint Coating

The composition of the coating also exerts a decided influence upon durability.

"The Forest Products Laboratory has tried various expedients in priming-coat procedure that have been recommended for obtaining better results on wood surfaces containing much summerwood. The proportions of turpentine and linseed oil in the priming coat have been altered greatly, thinners like benzol have been used in place of turpentine, and special priming-coat paints have been used. All but one of these expedients have either failed to alter the behaviour of the coatings or have led to earlier loss of coating integrity. Aluminium paint used as a priming coat under white lead or lead and zinc paint materially prolongs the life of the coating both in protective power and in integrity, but the ultimate failure takes place by flaking from the summerwood just as it does when the paints are applied in the customary fashion."

Conclusion

In conclusion, Dr. Browne states:

"The variability in behaviour of paint coatings on wood surfaces of different kinds is the wood-painting problem that must be solved before consumers of paint and of timber can be given better paint service. To some extent selection of timber in accordance with its painting characteristics can be practiced but improvement in this direction is limited by the fact that in choosing wood for any purpose other factors must be considered besides paintability and that most of our available supply is of the kinds that contain much summerwood. Furthermore, second-growth woods are likely to be less desirable in respect to painting than the virgin stands because the

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Painting on Keene's Cement

THE views of the Information Bureau of the Building Research Station on the traditional practice of "following the trowel" with a sharp coat of paint in the painting of Keene's cement, are given in the February Notes issued by the Bureau in a reply to an enquiry on the subject.

The reply states that although the question of painting on Keene's cement is one which has interested the Building Research Station for some time, it must be stated at once that no definite conclusion has yet been reached.

"While it might appear at first sight a comparatively simple matter to decide whether or not a coat of paint should be applied to Keene's cement immediately following the trowel, the problem is actually somewhat complex. One of the chief difficulties lies in the fact that the material sold under the name of Keene's is not a standard product, and probably the difference between various brands accounts in part for the conflicting views, based on practical experience, which are often put forward concerning the best technique for decorating this type of material.

The problem is being actively investigated at the present time as part of a study of the problem of painting on calcium sulphate plasters as mentioned in the Report of the Building Research Board for 1936, pages 87-95. Special attention is being paid to the causes of failure of adhesion of paint, which is the type of defect most frequently experienced on plasters of the Keene's type.

It may be of interest to mention briefly certain observations which have already been made :—

Some plasters of the Keene's type combine with water somewhat slowly. With these it is desirable, therefore, to avoid unduly rapid drying in the early stages, since otherwise the plaster may be weakened and the paint fail to adhere. A thin coat of paint applied early is likely to reduce the rate of drying to some extent and may be of some value for this reason. If, however, this procedure is adopted with a plaster suited to treatment in this way, two essential conditions must be observed:

(a) Any paint applied must contain only a minimum of oil, for it has been shown that if an appreciable amount of oil penetrates into the partially set plaster it will interfere with the setting of the surface layer,

(b) no further coats of any kind must be applied until drying of the structure is well advanced.

Within these limits, therefore, the traditional procedure of applying a "sharp" coat of paint immediately following the trowel finds experimental justification, but this conclusion does not necessarily apply to all plasters of the Keene's type. There are other considerations to be taken into account besides the degree of hydration of the plaster, and with some plasters better results have been obtained by delaying the painting to a later stage.

It is sometimes stated that paint fails to "take" on Keene's cement which has been allowed to set and dry fully and it is suggested that the reason for this lies in the dense, polished nature of the surface. Experimental evidence does not support this view, for ordinary oil paint has been found to adhere well to even the most highly polished plaster surfaces.

The "suction" shown by wet and dry plasters, the ease with which they permit the formation of efflorescence and their behaviour on different types of backing may be mentioned as other factors affecting decoration which are being investigated. It is not expected that the final results of this work will accrue for some little time, but as soon as conclusions are reached they will be made known generally.

The present attitude of the Building Research Station towards the particular problem of Keene's cement is that the practice of painting following the trowel is unobjectionable, provided that the paint contains only a minimum of oil, and that no further coats of any kind are applied until drying of the structure is well advanced.

Wood and Paint

(*Continued from previous page*)

trees will usually be grown more rapidly and will be cut younger. It is conceivable that some means of treating timber to improve its painting characteristics may be invented, but there is no reason for regarding that point of attack on the problem as particularly hopeful. Improved paint or painting technique seems much more likely to furnish the solution.

"The attainment of an ideal paint is an ambitious but by no means unpromising objective. As we see it, the problem is one of securing firmer and more permanent adhesion between coatings and wood. Probably all present aged coatings cling to wood by mechanical embedding in the rough surface, much as plaster grips lath. Summerwood, with its low void volume and very small voids, offers an uncertain support for adhesion of that kind. A true adhesion between wood substance and the matrix of the paint coating is called for. Glue sticks to summerwood, why cannot paint be made to do so? The Forest Products Laboratory proposes to seek true adhesion between paint coatings and wood and invites the co-operation of the technical men of the paint industry in that quest."

Painting Case in the Courts

In a case heard before Judge Hildyard at the Nottingham County Court last month, Henry Unwin and Co., paint and varnish merchants of Nottingham, sued Tyson Bros., Ltd., painters and decorators of the same city, for £15 5s. 6d., in respect of paints supplied. The defendants made a counter-claim for £13 6s. 5d. for alleged damage done by the paint in the decoration of seven houses.

For the plaintiffs, Mr. T. S. N. Roose said that the issue in the case was whether or not six drums of ground colour supplied by the plaintiffs to the defendants were worthless as the latter alleged. On the 22nd August, these drums were supplied to Messrs. Tyson Bros., Ltd., for use on the decoration of houses on the Beeston Estate. About a fortnight later, a complaint was made that the ground colour used on doors on the estate had crept and was unsatisfactory. In September, a sample of the colour was accordingly returned to the plaintiffs who carried out tests by applying it to various wood, metal, and glass surfaces, on which they found that it dried satisfactorily. Mr. Roose added that defendants had informed the plaintiffs that, in mixing up the graining colour, a turpentine substitute had been used and not pure turpentine.

Mr. Henry Unwin gave evidence of supplying the paint; he denied, however, that he had agreed to take back the paint and make good the damage done to the doors. Mr. H. S. Unwin, who mixed the paint, denied that there was too much oil in the ground colour.

Mr. W. W. Taylor, public analyst, said that he had examined a sample of the paint and gave it as his opinion that it was unsatisfactory from a drying point of view.

In his judgment, Judge Hildyard said that, on the evidence, there seemed to have been something wrong with the paint, but that the subsequent damage ought not to have accrued when the results of the trouble first became evident. Judgment on the claim would, therefore, be given for £10 13s. 0d., and on the counter-claim, for £4 and costs.

FLB 00098

a pimply film due to aggregations of particles which can usually be detected with the microscope.

Grain Raising: The objectionable roughness of wood caused by the application and absorption of stains or other materials. The roughness is due to the short broken fibres of wood which more-or-less stand up, due to the swelling or raising action of the liquid coating. There are non-raising stains and varnishes now on the market which eliminate this disturbing condition.

Grapeseed Oil: The seeds of grapes (raisins) contain a desirable oil with an iodine number of 95 to 140, which makes the oil valuable for use in paints and enamels. However, only small quantities are available, since it is economical only to produce it as a by-product of the raisin and grape wine industries. The oil resembles soybean oil except that it is slightly faster drying, and is somewhat darker in color.

Graphic Red: A series of lithol red toners having a specific gravity ranging from 1.43 to 3.63, and oil adsorptions from 30 to 50. Made by Sherwin-Williams Co.

Graphite: A native or artificially made allotropic carbon which occurs in metallic, soft, amorphous masses or hexagonal lamellae. Sometimes called black lead or plumbago. It is occasionally used as a pigment. The specific gravity is 1.9 to 2.3.

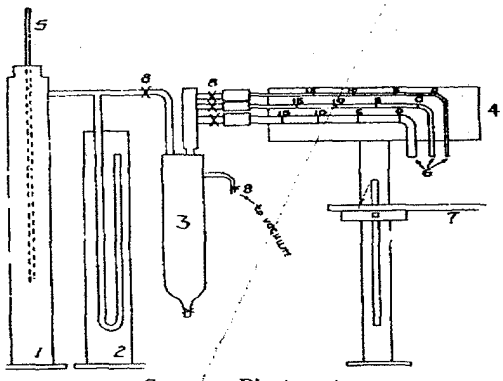
Gravimetry: The measurement of specific gravity or density of any material.

Green Method: A method of determining the particle size of pigments by the use of photomicrographs at a known magnification. For details, see J. Franklin Inst. 192, 637, (1921).

Greenockite: A rare and natural mineral cadmium sulphide (CdS), occuring in yellow, translucent, hexagonal crystals, and as an earthy incrustation.

Green Oxide: A pigment consisting mostly of chromic oxide, and having a specific gravity of 5.1 to 5.2, and an oil absorption of 9 to 11. Made by George S. Mepham Co.

Green Toner: A 100 per cent. precipitated organic pigment having a specific gravity of 2.77, and an oil absorption of 38. Made by Krebs Pigment and Color Corp.



Gregory Plastometer

Gregory Plastometer: A device for measuring the consistency of paints by the horizontal tube method combined with a vacuum in a plastometer. The instrument is not used extensively due to its high cost. However, it is fundamentally sound in its design and operation. See J. Rheology, 1, 30, (1929).

Grenoble Green: A 100 per cent. organic green pigment having a specific gravity of 2.43 to 2.48, and an oil absorption of 55.0. Made by Ansbacher-Siegle Corp.

Grinding Oil: A vegetable oil (usually linseed oil) used in the grinding of lead, particularly pulp lead. It has a high acid number (9 to 15) so as to impart the desirable wetting characteristics.

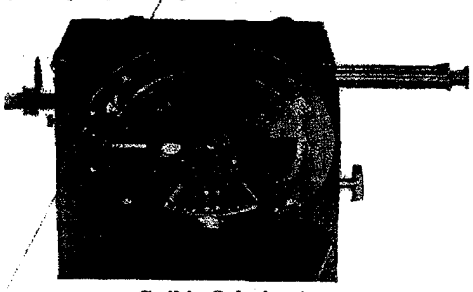
Grittiness: See "graininess."

Ground Coat: The coat of material applied before the graining colors or glazing coat to give the undercoat the desired background.

Guanine: $C_5H_5ON_5$. A leucomain found in scales of fish, in the excre- spider, in swine, in human decomposition product of nucleins. As derived from fish scales, the material is used in the production of "pearlescent" lacquers. The material in the pure state appears as colorless needles, insoluble in water, but soluble in alcohol, ether and alkalies.

Guiacol: $C_7H_8O_2$. A colorless liquid of peculiar odor consisting essentially of a phenol ether. Used extensively as an antiskinning agent in varnishes and enamels. Also known as methylpyrocatechin.

Guignet Green: A green pigment composed principally of hydrated chromium oxide.



Guild Colorimeter

Guild Colorimeter: A color analyzer of the trichromatic type which was developed at the National Physical Laboratory. It is not extensively used due to its high cost.

Gulf Solvent: A petroleum thinner having a distillation range of 154.4° to 192-202° C., and a flash point of 102-103° F. Made by the Gulf Oil Corp.

Gum: A natural, resinous or balsamic material derived from certain trees or fossil sources. In general, it may be stated that gums are natural products, whereas resins are synthetic materials.

Gum Arabic: The dried gummy exudation of *Acacia Senegal*, and which consists essentially of the salts of arabic acid. The white powdered resin is often used in cold water paints, and in show card colors.

Gum Elastic: Same as India rubber or caoutchouc.

Gun Cotton: $C_{12}H_{14}O_4(NO_3)_6$. A form of highly nitrated cellulose (cellulose hexanitrate) used in explosives. It is contrasted with pyroxylin in that it is sparingly soluble in the usual lacquer solvents.

Gurjum Balsam: A yellow, oily, viscous material which has been considered as a substitute for linseed oil. It comes from British Malaya, and has a specific gravity of 0.934, and a viscosity of A-2. For details, see Scientific Sect. Circ. No. 224.

Guttameter: A device for measuring surface tension by counting the number of drops.

Gutta Percha: $(C_{10}H_{16})_x$. A material of rubbery nature which constitutes a group of complex hydrocarbons. It consists of the purified and thick, milky exudate of certain trees. Used in protective coatings where good insulating properties are desired. Also used as a rubber substitute. In properties it resembles caoutchouc or rubber. Also known as *gummi plasticum*.

Gypsum: A native, hydrous, crystalline calcium sulphate. Also known as selenite, alabaster, satin spar, gypsite. It has a specific gravity of 2.32, and is used as an inert extending pigment in some paints.

(To be continued)

Past Presidents of the Paint and Oil Club of New England were honored at a meeting held on February 17th at the Parker House, Boston, at which President E. E. Morton presided. Of the club's forty-two presidents twenty are still living and active in business, according to President Morton. Those at the meeting included Albert E. Cole, 1909-1910; D. William Wade, 1912-1913; George A. Richardson, 1913-1914; March G. Bennett, 1918-1919; Frank H. Nutting, 1921-1923; Harry H. Hill, 1923-1924; Chas. S. Robbins, 1924-1925; William H. Kirkpatrick, 1925-1926; William D. Rockwood, 1926-1927; George J. Beake, 1927-1928; A. Irving McLauthlin, 1928-1929; Evert W. Hinckley, 1929-1930; Frank Bownes, 1930-1932, and C. K. Stodder, 1932-1934. At the meeting James F. McLaughlin was appointed executive secretary of the "Clean Up and Paint Up Campaign."

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The Men Behind the Guns

". . . it's savior of 'is country when the guns begin to shoot."—KIPLING.

Dr. Joseph Mattiello, M.Sc., Ph.D.

Dr. Mattiello, who handles the higher mathematics as skilfully as a juggler keeps six balls in the air at one time, tells us that he "was born of Italian parents, in the city of New York, on February 28th, 1900"; but he also gives us a glimpse at the quality of his Italian antecedents, when he tells us that father Celestino Mattiello was a sculptor—the direct descendant of a long line of sculptors—who died when Joseph was four years old, and that his mother was Elizabeth Bottigleri, who was the descendant of a family which for several generations served the church and the state in important positions. The family, in Italy, today is prominent in the sulphur industry. Joseph's mother died while her son was in his eleventh year.

He then passed into the care of an aunt who saw that he received a good primary education, first in the public schools and later in a private school.

During his sixteenth year (1916) he enlisted as a private in Company I, of the Fourteenth Infantry, New York National Guard, which, it may be recalled, was one of the units sent to the Mexican border, during that same year to settle that little matter of invasion with Senor "Pancho" Villa, who had evidenced his contempt for the "Gringos" by sacking the town of Columbus, New Mexico, and killing a number of its peaceful inhabitants. It will be recalled that Senor "Pancho" later settled that account, on his native soil, with Gen. "Jack" Pershing. And, on the other hand, it proved good practice for our American boys, in view of what was to follow—perhaps the higher-ups knew what was coming!

In any case it was only a few months after their return from the Mexican border that Uncle Sam decided to help "make the world safe for Democracy" and young Mattiello found himself a member of the American Expeditionary Forces, as Sergeant of Company H, 165th U. S. Infantry (the old 69th New York National Guards)—the "Fighting Irish," 42nd "Rainbow" Division.

During his sojourn in *"la belle France,"* Mattiello saw service in the defense sectors of Luneville (which the "Heinies" took and lost) and Baccarat, and played his part in the battles of Champagne-Marne, Aisne-Marne (Chateau-Thierry Sector), St. Mihiel and Meuse-Argonne, where, with the smashing of the Kriemhilda defense, victory was in sight. Unluckily for him it was here, on October 17, 1918, that he "got his" in both legs and in his right arm. It cost him his right leg, but earned for him a Regimental Citation and the Order of the Purple Heart.

He is still a member of the Father Duffy Chapter of Rainbow (42nd) Division Veterans and of the Purple Heart Association, and is active in American Legion affairs.

On his return he was sent to the Walter Reed Hospital, in Washington, whence, immediately after his discharge from the army, he returned to high school and after "cleaning up" there, in 1921, went on to the Brooklyn Polytechnic Institute, where, in 1925, he received his B.Sc. degree.

While there he participated in student activities, as President of the Student Council, President of the Athletic Association (1924-25), received the "Merit Key" for extra-curricular activities and was elected to the Honorary Delta Kappa Pi Fraternity, which he served as President during 1930. He is still a member of Alpha Phi Delta and was President of its Delta Chapter during 1925; and, for good measure, he is a member of the Board of Directors of the Polytechnic Alumni Association.

Shortly after acquiring his B.Sc. degree, in 1925, he found employment, as chemist, with the Hilo Varnish Co., and while holding down this job, continued his work at Polytechnic, which, in 1931, earned for him his degree of M.Sc., and more recently, still unsatiated, he attended the Department of Engineering at Columbia (still holding his job!) which, in 1936, conferred on him his ultimate degree of Ph.D.

ow Technical Director and a mem-
e Board of Directors of the Hilo
Corporation.

Dr. Mattiello is a "joiner" of the first rank, but is highly selective, as is evidenced by the following list: Phi Lambda Upsilon, National Honorary Chemical Society (President of its Alpha Zeta Chapter during 1931), Sigma Xi National Honorary Scientific Society, American Chemical Society, American Society for Testing Materials, American Society for Military Engineers, American Institute of Chemical Engineers, Chemists' Club of New York, and New York Paint and Varnish Production Club (formerly Secretary-Treasurer, now Vice-President).

As an author, both solo and ensemble, he has produced many important research papers on linseed, fish, tung and oiticica oil, chemistry, paint, varnish and lacquer. In 1936 he served as Chairman of the Committee of his Club which prepared the paper entitled "Properties of Linseed Oil, Heat-Bodied in Air and in Vacuum, and Its Behavior with Pigments, with and without Wetting Agents." It won the "American Paint Journal Award" all right, and if there had been a prize for Applied Higher Mathematics he would have garnered that also. Dr. Einstein would have enjoyed the lecture and Leibnitz, if he had heard it, would agree with every statement, but the average young production man had to take it on faith as did this writer. Furthermore, when better "high brow stuff" is produced Mattiello will be its producer.

Dr. Joseph Mattiello

Seriously, however, all this work is of fundamental importance and it is fortunate that we have available a competent man who likes it!

In 1922, Dr. Mattiello married Josephine Critelli and today the couple are the proud parents of the Misses Margaret, Elizabeth, Rosamond and Barbara Mattiello.

He lists his chief interest as his family, oil studies, stamp and book collecting, and friends who wish to learn the how and why of things. "Work," he maintains, "should be done for the sake of what the results obtained actually teach—only in this way can men serve mankind."

And there we have an entire code of practice boiled down to twenty-one words.

Postscript! He adds: "I volunteered to fight for 'Democracy,' but, to my surprise, on my return, I found that we had won only prohibition."

The Mandis Society, which is composed of of manufacturers and distributors who are associate members of the Painting and Decorating Contractors of America, at its annual meeting held at Boston on February 10th, elected the following officers: President John M. Sturges, John W. Masury & Son; vice-president, Joseph Kempf, Wilson-Imperial Co.; secretary-treasurer, George S. Merwin, Devoe & Raynolds Co. Directors: Elmer G. Ziercs, Clark Stek-O Corporation; A. G. Schumann, Hilo Varnish Corporation, and Milton K. Pine, Muralo Company.

The Official Glossa

By JEFFREY R. STEWART*
Paint Technologist

(Continued from February

Glyceryl: A group of compound from glycerol and aldehydes, acetyls. Frequently used as plas lacquers.

Glycerides: A group of ethers or rived from glycerol. Most fats are glycerides of fatty acids.

Glycerinum: Same as glycerol or g

Glycerol: A syrupy, oily liquid, usua white, having the formula (CH_2O It is used extensively as a basic ra in the manufacture of synthetic plasticizers. Occasionally used ticizer in artists' colors. Also glycerine, trihydroxypropane, trih hol, propenyl alcohol, glycyl al glycerinum.

Glyceryl Derivatives: This is the b used to indicate the numerous of glycerol which are often use ticizers.

Glycopon: A liquid and viscous resin having an acid number of soluble in toluol, mineral spirits acetate. Made by Glyco Products

Glyptal: A series of synthetic resi alkyd type. The specific gravit to 1.040, acid number 2 to 6. Th available as solid resins, but a solutions in which the solvents xylene, toluene or mineral spirits the General Electric Co.

Gnaedinger Sampler: A sampling signed to sample drying oils in For details, see Scientific Sect. 254.

Gneiss: A metamorphic mineral or ilar to granite, but containing su uents as mica, magnesium sili arranged in cleavable planes.

Gothite: Ruby mica. The hydrate iron having the formula FeO.OH, ite: Hackh).

Goggin System: A method of elim controlling the fumes in a varni stack. It is based on condensin the condensable fumes and burni remainder.

Gold Bond Silica: An amorphous, d quartz or 450 mesh size. Th gravity is 2.65 and the oil absor Made by Tamms Silica Co. It 99.0 per cent, silica, the bala alumina, magnesium oxide and

Goldsmith Test: A test used for th and determination of tung oil in oils. The principle of the tes the formation of a gel, and the tion of the amount of petrol soluble matter in the gel.

Gombrea: A resinous exudation of tree which is occasionally used stitute to replace gum arabic.

Goose Flesh: The appearance of a has small pimple-like elevations surface. It is similar in appeara peculiar roughness of the human is produced by exposure to cold, citement.

Gossypol: The poisonous substance in the seeds of cotton or in cotto

Gottsch Cone: A cone-shaped instr signed to determine the consist value and mobility of paints. is specified in the testing pro traffic paints for the City of Ne

Gouache: A method of painting w colors that have been ground in mixed with a preparation of any picture painted by this met pigment.

Graham-Linton Tester: An instr measuring the hardness of a film vice is designed on the principle ing the load in grams necessar a knife blade to cut throu

Graininess: The objectionab

* Editor, *National Paint Bulletin*

ing it into a paint formula, namely, its color, opacity, chemical activity, and effect on consistency. Some formulators may be accustomed to considering a longer list of properties, including such items as the effect on dirt collection, fading, chalking, checking, cracking, and ultimate durability. The latter properties, however, may be consequences of the former and are more appropriately considered characteristic of the paint formula as a whole than of the individual pigments. Titanium dioxide, for example, is white, opaque, and chemically inactive regardless of the other pigments present, the vehicle, or the concentration of pigment but the chalking, checking, etc., depend upon the other pigments, the vehicle, and the concentration of pigment. At any rate color, opacity, and chemical activity play important parts in the proposed classification of paints with respect to pigment composition while consistency imposes certain limitations on the selection of a particular variety of any one pigment, say a zinc oxide, that will be suitable for a given formula. When paints are classified in types and divisions it is believed that the paints within any one type and division, if properly manufactured, will prove very similar in such properties as fading, chalking, checking, and cracking so that these properties may be discussed as characteristics of the types and divisions.

It is commonly accepted that the white leads and zinc oxides confer distinctly useful properties on paint by reason of their chemical activity. The chemical activity no doubt arises from their chemically basic nature but the nature of the chemical reactions to which the effects of these pigments are due is not fully understood. To be sure it is often assumed that lead and zinc soaps formed by reaction with free fatty acids of the drying oils are responsible for the characteristic effects of these pigments but, while there is no doubt that soaps form under some conditions, it has not been proved that the soaps give paint the properties in question. Reactions at the double bonded carbon groups in the fatty acids of the drying oils are also possible. Moreover the basic compounds may exert their effect by neutralizing the various acids set free during the oxidation of oils, preventing them from exerting a peptizing effect in opposition to the desired gelation in the final stage of drying. Whatever may be the nature of their chemical reactions, however, there can be no doubt that the white leads and zinc oxides profoundly modify the linoxyn obtained when linseed oil paint dries.

The effects produced by the activity of the white leads and of the zinc oxides are dissimilar. The effects are well understood by paint technologists although we experience some difficulty in agreeing upon satisfactory language in which to describe them. The white leads seem to keep paint films tough and slightly flexible to an advanced age, though they do not restrain checking, and make comparatively soft films. The zinc oxides, on the other hand, harden paint to the point of brittleness, retard erosion and often delay checking. Many consider cracking a property imparted by zinc oxide but cracking may be regarded merely as a consequence of brittleness with delayed checking and erosion because cracking is not confined to paints that contain zinc oxide. Because of their profound effect on the chemistry of paint drying the white leads and zinc oxides should be expected to have much to do with the compatibility of successive paints and there is already substantial evidence that they do.

Although basic carbonate white lead is somewhat more readily reactive than basic sulphate white lead, the two are used more or less interchangeably in paint formulation and are so regarded for purposes of classification. About the zinc oxides there is less agreement. Some zinc oxides with high proportions of very fine particles are considered unfit for use in exterior house paints at all while among others there is said to be a wide variation in quality. From the evidence published so far the differences between the zinc oxides do not lie in the extent to which they harden paint but rather in the extent to which they delay checking. There seems to be no reason at present for believing that the particular kind of zinc oxide chosen affects the properties of the paint that govern application and maintenance except insofar as it governs consistency, which can be measured directly by physical methods. For purposes of classification, therefore, all of the zinc oxides are considered interchangeable and the leaded zinc oxides are treated as though they were mechanical mixtures of basic sulphate white lead and zinc oxide.

The titanium pigments and the zinc sulphide pigments are considered chemically inactive. Lead titanate, though said to be chemically inactive, is also said to keep paint films tough and flexible for a long time even more effectively than white lead. For the present it is grouped together with the white leads for purposes of classification but this procedure may have to be revised when more information becomes available. The transparent pigments with the possible exceptions of calcium and magnesium carbonates are chemically inactive. Calcium carbonate seems to have fallen into disrepute in recent years, presumably because it fails to restrain checking as the other transparent pigments do. The writer believes that checking is not an unmixed evil and that there were good reasons for the favor that calcium carbonate formerly enjoyed for use in paints in which a high content of transparent pigment was desired for one reason or another. Among the colored pigments the iron oxide pigments, the iron blues, ultramarine, and the carbon pigments are chemically inactive. Red lead and the basic lead chromates are chemically active and possibly should be counted among the active lead pigments in paint.

From the point of view of the effect of the pigment on the fundamental nature of the resulting paint film we can divide the pigment into three parts, the white lead, the zinc oxide, and the chemically inactive parts of the pigment. It is therefore convenient to chart the fields of pigment composition with the aid of triangular diagrams. Figure 1 is a diagram of that kind showing the variations in pigment composition of white and tinted paints in 68 paints belonging to 30 current brands of commercial prepared paints of the lead and zinc groups, LZ and (LZ)n. Each circle represents a paint of a brand indicated by the enclosed number. If there are two numbers two brands have a paint of the same pigment composition. The enclosed letters refer to the divisions into which the paints fall in the proposed system of classification. Pigment composition is expressed, of course, in terms of percentage by volume in the total pigment.

At one time the left-hand edge of Figure 1 represented the entire market for house paints. The pigment in white paint consisted entirely of white lead at one end of the line, addition of tinting colors or adulteration with transparent pigments moved the paint upward along the line, while the full color paints were at the top of the line, which is the apex of the triangle. When zinc oxide came into the industry the straight line was spread out into the triangle and the paint market became very much more complex. Both zinc oxide and transparent pigments were adopted primarily to reduce manufacturing costs, the zinc oxide doing so largely because its consistency made it possible to decrease the total pigment in the paint. Technical rationalization of these practices was not seriously attempted until the North Dakota paint law made it necessary to discuss composition with the industry's customers.

Since zinc oxide is an opaque pigment its presence in paint was more easily justified than that of the transparent pigments and some manufacturers saw a merchandizing advantage in excluding transparent pigments in order to advertise their paints as "100 per cent. pure" in the sense defined by the North Dakota law. White paints of that kind fall along the bottom edge of the triangle of Figure 1. When tinted, however, they move upward toward the apex, especially if the natural earths, which contain large proportions of transparent ingredients, are used as tinting colors. Brands 1 and 2, for example, are "100 per cent. pure" paints that can be traced through the triangle from the whites in the bottom edge through various tints clear to the apex. When the tint, are included, therefore, the LZ paints cover much the same range in composition as the (LZ)n paints. White paints in the interior of the triangle, of course, contain transparent pigments. A large number of them are strung along the level of approximately 20 per cent. inactive pigments. There were formerly many white paints in the upper third of the triangle but they have been largely replaced in recent years by formulas based on zinc sulphide pigments so that the upper portion of the triangle now represents predominantly deeply tinted paints with full color paints at the apex. The region of very high zinc oxide at the right-hand corner is dotted because no paints seem to be made in the region at the present time although there were such paints in times past. The heavy lines drawn through the triangle mark the borders of the various types of lead and zinc paints set up in the proposed classification.

Pure white lead makes an excellent paint that is still thoroughly satisfactory to large groups of paint users. Replacement of part of the lead with zinc oxide leaves the opacity unimpaired except insofar as advantage is taken of the higher consistency of zinc oxide to reduce the proportion of total pigment in the paint. Increasing proportion of zinc oxide hardens the paint, retards erosion and checking, and improves the retention of some tints but these otherwise desirable improvements are offset against the disadvantages of cracking and curling and ultimate disintegration by flaking instead of crumbling so that the paint becomes unreliable for maintenance programs involving the periods of neglect to which many paint users are accustomed. By diluting the chemically active pigments with inactive pigments and keeping the content of total pigment high, cracking, curling, and flaking can be retarded but if the inactive pigments are transparent there is serious loss of opacity unless the paint is deeply tinted. For whites and the lighter tints, dilution with inactive pigments is limited to roughly 20 per cent. if the paint is to compare at all favorably with the "100 per cent. pure" paints in both opacity and spreading rate. This still leaves us in a region in which checking is prominent during much of the life of the paint, and disintegration ultimately takes place by curling and flaking. Higher dilution with transparent pigments impairs opacity so seriously that the total pigment must be made high enough to force the application of a thicker coating with consequent reduction in spreading rate. At the same time the transparent pigments stimulate erosion more than the remaining limited amount of zinc retards it. In spite of these shortcomings, however, these low-grade lead and zinc paints often proved less disappointing than the high-grade lead and zinc paints in the hands of those following the old traditions of paint maintenance involving periods of neglect before repainting.

The zinc sulphide pigments were the first to offer a means of obtaining high dilution of the chemically active pigments without sacrifice of opacity in white and light tinted paints. Figure 2 shows the pigment composition of 36 brands of zinc sulphide pigment paints now on the market. Except for one brand they range over only a small part of the area of the triangle near the apex. Most of these paints, of course, are manufacturers' second-grade paints. Zinc sulphide pigments were originally proposed for the purpose of displacing white lead entirely. Unlike most of the inactive pigments, however, zinc sulphide has little tendency to restrain checking, and once the checking penetrates through the coating, zinc sulphide, in contrast to white lead, seems to stimulate rapid crumbling of the coating even over the soft bands of springwood in the lightest woods. If checking is restrained too much by the addition of zinc oxide, cracking is rapidly followed by curling and flaking. The leadless formulations with zinc sulphide therefore require a restricted content of zinc oxide and of zinc sulphide and leave no choice but the inclusion of much transparent pigment. Most manufacturers finally found it advisable to add some white lead, commonly in the form of leaded zinc oxide. A large proportion of white lead, however, usually defeats the business purposes of resorting to zinc sulphide in the first place. Undoubtedly, good paints can be made in the lower left-hand portion of the triangle but there would be little point in making them because of their close resemblance in cost and properties to the ordinary lead and zinc paints.

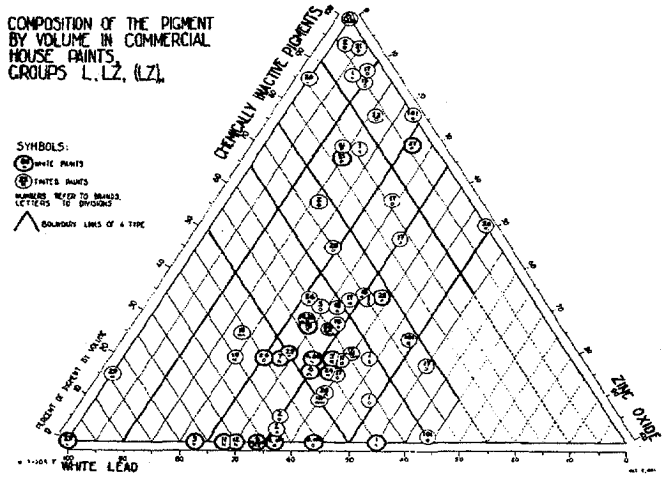

Fig. 1

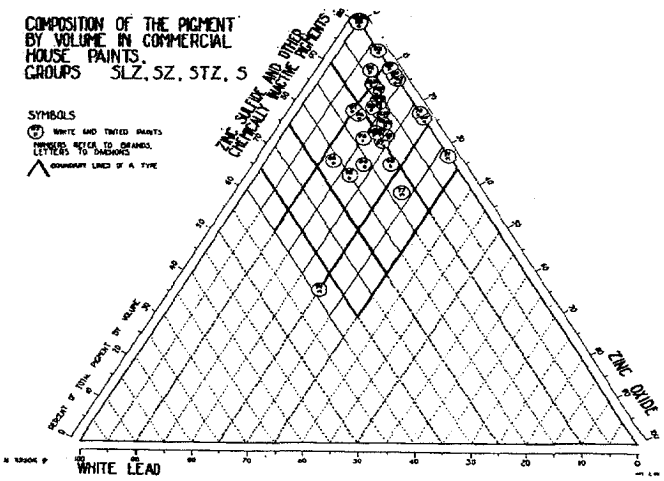

Fig. 2

The titanium pigments offered another way of diluting the chemically active pigments without loss in opacity and without some of the disadvantages of zinc sulphide. **Figure 3** shows the range in pigment composition of 64 paints belonging to 41 brands made with titanium pigments at the present time. Brands 63 and 64 are enamelized paints that cannot be considered representative of formulation for true house paints. With these exceptions it is evident that the industry holds the content of zinc oxide to lower limits in the titanium pigment paints than in lead and zinc paints but that the content of white lead varies nearly as widely as it does in lead and zinc paints. The TLZ paints fall predominantly in that area of the triangle representing greater proportions of inactive pigments than can be used in high grade (LZ)n paints but less than are commonly used in SLZ paints. In this area it becomes possible to retard erosion, practically eliminate checking, and greatly postpone cracking. Cracking occurs eventually and is usually of a rather conspicuous sigmoid type but its seriousness is mitigated by the fact that, under favorable circumstances, there is relatively little curling and flaking may lag behind cracking for a long time.

Vehicle Composition

Fortunately the vehicle in house paints, in contrast to the pigment, has been kept relatively simple and contributes very little to the problem of classification. For the most part the vehicle of white and tinted house paints remains essentially unbodied drying oil and thinner. There is, of course, much variation in the quality of linseed oil and there are developments in the way of substitution of other oils, such as soybean oil, for part of the linseed oil. As far as present evidence goes, however, such variations in the vehicle do not affect the nature of the paint with respect to its application, maintenance, and compatability with other paints, although they may affect the quality of the paint and make trouble for the manufacturer in controlling such properties as drying time and proper drying in cold weather. Questions that affect the quality of the individual paint but do not govern the characteristics of the class of paints to which it belongs are questions of specification and not of classification. In trade-branded paints the manufacturer's brand certifies to the quality of the individual product and he is responsible for seeing that it is capable of delivering the service to be expected from the class of paints to which it belongs.

It is becoming increasingly customary to incorporate a small proportion of moderately bodied drying oil in the vehicle of house paints for various purposes such as improvement in consistency or in drying qualities. As long as the amount and degree of body of the addition are too slight to compel reduction in total pigment or to change paint-like consistency to enamel-like consistency there seems to be no reason for altering the classification of the paint. When the amount and degree of body of the addition are enough to impart properties of enamel, however, the paint must be assigned to a new type to differentiate it from a true house paint of similar pigment composition because its methods of application, suitability for specific purposes, and probably its compatibility with other paints have been altered. As a matter of fact an enamelized paint is likely to differ seriously from true house paints in its pigment composition. The enamelized paints among the commercial brands charted in Figures 1 to 3 are Nos. 63, 64, and 74, which fall in regions of the triangles not occupied by other paints. The enamelized paints likewise differ from true paints in that the content of total pigment is necessarily lower and the content of volatile thinner higher. It is therefore difficult to make enamelized paints without using the very high opacity pigments, such as titanium dioxide and zinc sulphide.

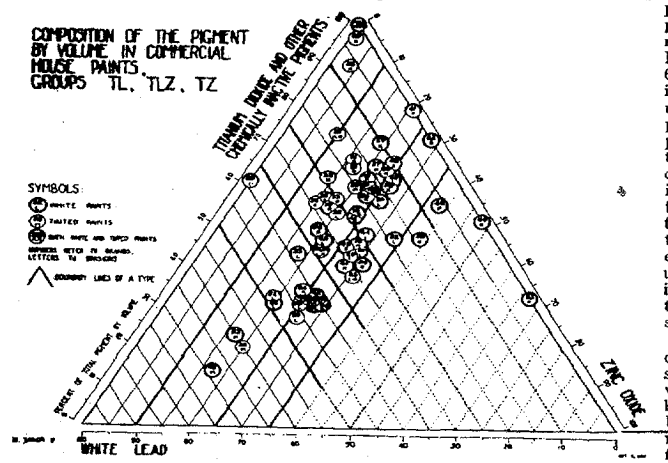

Fig. 3

Until recently the use of resins, other than the small amount in driers, was confined to cheap house paints, where a very high content of volatile ingredients without sacrifice of gloss was desired to meet a price level, and to moderate proportions in the vehicle c unduly soft, slow drying, full-color paint: During the last few years resins have bee introduced into some high-grade white an tinted paints for a variety of purposes. Resin may be used to produce enamel-like propei ties, to make quick-drying paints, or to harde zincless paints. Resin fortification does no appear to be particularly successful as ye and may not develop into a serious adde complexity in the paint market but if it doe we shall have to learn a great deal more tha we now know about the effects of resins o the behavior of paints. Since resins as rule must be added in the form of varnishe it is not possible to introduce very large pro portions without giving the paint the con sistency of enamel and without diminishin the content of nonvolatile well below th level commonly expected in high grade hous paints. For the present it seems sufficien for the purpose of classification to make dis tinction between the resin-fortified paints, th enamelized paints containing resins, the enam elized but resin-free paints, and the unbodie drying oil paints.

Pigment Concentration

Some technologists who recognize the im portance of correctly adjusting the concen tration of pigment in the nonvolatile part o paint seem to consider the concentration o pigment in the total paint unimportant. The add enough drying oil to make the concen tration of total pigment 29 per cent., let u say, of the total nonvolatile and then ad whatever proportion of volatile thinner tha may be required to produce paint of suitabl consistency. That view, however, overlook two vital considerations, raw materials cos per gallon and thickness of permanent coatin obtainable at customary spreading rates. Fo high-grade prepared paints of the unbodie drying oil types there is an informal conven tion that not much less than 90 per cent. o the vehicle by weight, which is usually roughl 90 per cent. of the paint by volume, shoul be nonvolatile matter and the consistenc should be such that application to smooth primed surfaces in the vertical position a 600 square feet per gallon is practicabl though the industry likes to claim at least 70 or 800 square feet per gallon "coverage." Fo these reasons the amount of volatile thinne incorporated in a formula is not a matter of indifference and it is necessary to pay strict attention both to the concentration of the pigment in the nonvolatile part of the paint and to the concentration in the total paint.

The writer feels that, in formulating a paint, the concentration of pigment in the paint should be decided first with due consideration for the degree of opacity of the pigment and the spreading rate at which the paint is intended to be applied, and then the ratio of nonvolatile to volatile ingredients in the vehicle should be adjusted to give the correct proportion of pigment in the nonvolatile. Consistency, however, cannot be overlooked, though it seems to be in many of our

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discussions of formulation. Observation of the tremendous variation in consistency of high-grade prepared paints on the market, without much observable relation to thinning directions or recommended spreading rates, confirms the feeling that the significance of consistency is not generally appreciated even though production men need scarcely be reminded that their painter customers are quick to detect any very material change in the consistency of a brand of paint they have been using for some time. Obviously consistency, thinning instructions, and spreading rates are necessarily interdependent and must be taken into account systematically in any sound technology of paint formulation.

With the composition of the pigment and vehicle and the proportions of pigment in the nonvolatile fixed within rather narrow limits by other considerations it might seem at first glance that the formulator could exercise very little control over consistency and would have to accept it pretty much as it happens to fall. Years ago that was probably the case and set very definite practical limits on formulation. At the present time, however, there are a number of ways of varying consistency with the formulation of the paint as recognized by the proposed system of classification already determined. Most of the important opaque white pigments are available in a range of consistencies from which the formulator may make his choice. This is particularly true of the zinc oxides, especially when it is remembered that, as far as classification is concerned, the leaded zinc oxides may be used interchangeably with mechanical mixtures of lead-free zinc oxides and white lead. That ingredient commonly described in label analyses as "silica and silicates" is likewise subject to wide range in consistency. The various types of unbodied linseed oils likewise afford means of controlling consistency which can be further extended through the use of small proportions of bodied or oxidized oils. The choice of volatile thinner permits a minor variation in consistency. Finally, though not without apology, it may be confessed that certain soaps embraced within the somewhat elastic term "driers" and even a slight touch of water that need not be admitted on the label have long been used as methods of controlling consistency.

The suggestion that choice may be made between the various zinc oxides and leaded zinc oxides and between the composite and mechanically mixed titanium and zinc sulphide pigments largely on the basis of consistency of the finished product will not be acceptable to all technologists. Some hold that pigments of certain particle size distribution or particle shape are so superior to other pigments of chemically-like kind that they profoundly modify the serviceableness of the paint and should therefore enter into the system of identifying paints by types. At present the subject is decidedly controversial and the evidence indecisive. There has not yet been enough experimentation on the part of those with no axe to grind and it is notable that similar controversies that have raged in the past have largely died out without attainment of a decision as soon as some change in business conditions eliminated the element of competition between producers of raw materials. The writer's present opinion, subject to change when the evidence justifies it, is that the physical differences between varieties of chemically similar pigments affect the behavior of paint with respect to application and serviceableness only to a slight extent except as they do so through their effect on consistency.

Examination of the high-grade paints on the market shows that the industry at present has no very definite idea of proper consistency for good house paint (H. A. Gardner, Scientific Sect., National Paint, Varnish and Lacquer Association, Circular 507) because consistencies vary exceedingly widely without recognizable relation on the one hand to the concentration of pigment in the paint or on the other to the instructions for thinning and recommended spreading rates. Apparently many manufacturers defer to painters' prejudices instead of attempting to educate them in correct practices. Paints may be made unduly thin to help the painter spread them over too much surface or unduly thick so that he can add oil or thinner and then spread them too far. In formulation studies at the Forest Products Laboratory certain tentative standards of consistency are being used at the present time. Unbodied drying oil paints of division L are made with consistency of 250 grams for 2 centimeters per second rate of fall of the Gardner mobilometer, using the 51-hole disc at 20°C. LZ paints of the "100 per cent. pure" variety, in which the content of total pigment necessarily decreases on going down in division, are made with consistency 250 regardless of division through suitable choice of pigments, oils, and, in the lowest divisions, addition of small amounts of soaps or water. Paints in which transparent pigments are used are usually made as far as practicable with higher content of total pigment and higher consistency the lower the division so that they facilitate application in thicker coatings to compensate for the diminished opacity. For such paints the consistencies are tentatively set at 250, 275, 325, 375, and 450 for divisions L, M, N, O, and P, respectively.

The above trend toward higher content of total pigment in paints of lower division is representative of much commercial practice in formulation of paint, especially in the region from division N down to division Q, but it cannot be followed in the LZ paints that contain no transparent pigment and is not always followed in the (LZ)n and other paints containing transparent pigments. It is for that reason that the minima for total pigments in the proposed definitions of paint divisions decrease in passing downward from division L to division Q.

If we start with a given paint so formulated that it falls in division L there are in general three ways in which it may be altered progressively to pass step by step through the various lower divisions. The first method is to reduce the content of total pigment in the paint without altering the composition of the pigment. By this method it is often possible to make paint through a range of four or five of the six proposed divisions without altering the composition of the pigment and without letting the consistency fall below 250. The second method is to decrease the content of opaque pigment by substitution of transparent pigment. In this procedure the total pigment may be held constant, may be increased, or may be decreased less rapidly than the opaque pigment as the formulator prefers. By this method, however, it is rarely possible to shift a white paint of (LZ)n class through more than two or three of the six divisions without likewise passing over a border line into a different type of paint because a material increase in the content of transparent pigment must be effected at the expense of white lead or zinc oxide or both. With paints of the classes containing much titanium dioxide or zinc sulphide pigments nearly any division can be realized within any type of paint because transparent pigment may be increased at the expense of chemically inert opaque pigment. The third method of shifting the division of a type of paint is by control of the content of total nonvolatile but with paints made with unbodied drying oils this method is severely limited by the difficulty of maintaining satisfactory consistency and by impracticably high content of total pigment in the nonvolatile part of the paint when the paint contains too much volatile thinner.

Discussion of Dr. Browne's Paper

By Dr. J. S. Long

I have been asked to discuss briefly the paper that Dr. Browne has just presented. The first question is whether we need a classification to replace the present label analysis. In my judgment, or as far as our experience goes, the average consumer does not get much from the label analysis. Its biggest value is directed to state chemists and others in official capacity who use it to see if the material sold is misbranded.

Our sales department has run into many funny stories arising from attempts of customers to judge paint from the analysis. Some time ago I stopped in a restaurant in South Carolina and noticed on the wall an official state placard which said, "This is an A grade restaurant," and was signed by a state inspector. My immediate reaction was that the food in that restaurant was safe to eat and represented the highest quality reasonably obtainable in commercial establishments.

If it is decided by the paint people that Browne's proposal of classification is logical, then the next question that presents itself is the matter of nomenclature and system of classification. Browne has presented a logical system using the symbols L, Z, S, etc., with subscripts. This can be considered by the paint industry and if anyone has a better or alternate system it can be presented for discussion, but Browne's suggestion has many things to commend it.

Paint technologists will probably agree on the importance of percentage by volume rather than percentage by weight as the basis for classification. It is of course true that it will take some time before various state chemists and officials would agree to such a classification or the symbolizing of the paint composition and until such replacement of the analysis by the latter classification had been accomplished, Browne's proposal would not have its full value. I suspect that even the approval of the Paint and Varnish Manufacturers Association would not of necessity move the various states to rescind their label laws and substitute new ones.

In connection with the final type and division of paint, the letters L, M, N, O, P, would not seem as logical as either A, B, C, D, E, or 1, 2, 3, 4, 5. In general there is some significance in the popular mind to the symbol A—in other words, an A grade paint would mean the highest quality. Browne had originally contemplated this but for the purposes of the paper changed it to the other letters while the system was in the tentative stage.

Coming now to the detail as to what is to be regarded as an A grade paint, there will naturally be considerable opposition on the part of some manufacturers who have been marketing a certain quality of paint and who do not want to change but who would find themselves in the classification of B or lower on even their top quality product if the present system was accepted as is.

I do not feel that I can speak for the industry on this. What little conversation I have had has indicated some lack of agreement on the part of various paint companies as to what constitutes an A grade paint, but I am inclined to think that these differences could be ironed out and a minimum standard of quality set up for each grade which would be acceptable to all of the sound technologists of the industry and on this basis the others would have to agree in common interest.

There is one point which Browne has carefully circumscribed which, however, deserves further consideration; that is the matter of the composition of the vehicle and also the relationships of pigment to vehicle in the resultant dry film. Browne is considering essentially raw linseed oil as the vehicle with modest additions of bodied oil or the like.

First of all, we all realize that the iodine number of the linseed oil is of considerable importance and affects the toughness of the film and the durability of the paint. At several times in recent years actual paint exposures involving series of oils having iodine number of broad range and in each case with which I am familiar, the oils of higher iodine number showed greater durability. This is just an obvious starting point.

The admixture of various oils such as China wood, perilla, fish, and others with the linseed affects the results seriously and the amount of heat bodied or blown, sulphur chloride treated, or otherwise processed oil present together with the extent of blowing, sulphur chloride treating, etc., have some influence. It therefore seems that considerable more attention must be given to the matter of the vehicle which, after all, is the life of the film. The matter is not simple and the information is rather carefully guarded. In certain types of paints involving say 30 per cent. of zinc oxide or more, the simple addition of perilla oil has been found in at least one series of experiments to throw definitely the paint over from a chalking type failure to a cracking type despite the fact that the average iodine

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number of the mixture is not as high as the iodine number of linseed oil that has been successfully used in the same formula.

In addition to this, it must be remembered that the final film architecture is not just the sum of the non-volatile constituents but that chemical reactions occur which are a prelude to final collodial processes involving all the features of each.

One obvious way to call attention to the differences that can result would be to refer to the influence of the percentage of driers and the ratios of these driers to one another. In certain cases very modest changes in composition will change the film from a smooth drying one to one that will wrinkle badly. This is of course well known to all of us but is only mentioned as a simple illustration to put emphasis on the fact that two paints which would pass anybody's A rating might give vastly different results in practice. It is quite conceivable therefore that a paint with a coveted A rating might consistently fail to give good results in performance; whereas another with a B rating but of very smart design might give wholly acceptable results to the consumer.

Finally, the tremendously important variables—the painter and the surface—must be considered. It is not just a matter of education of the painter. Even in these days of regimentation it is unlikely that painters as a class can be taught to follow the instructions on the can. Someone has aptly said that the painter does not think he is exercising his craftsmanship unless he adds something to the paint. This is undoubtedly a factor. However, there are others. Thus, different brands of paint, even with the same classification, will undoubtedly feel different under the painter's hand and if he is in general accustomed to using a certain brand and is asked to use a different one on a certain job, he will encounter a difference. Whether the difference is favorable or unfavorable doesn't matter, there is a difference and it at least tempts him to do something to get what he is accustomed to.

Furthermore, the surface varies and the conditions of painting vary—which again are factors.

Two years ago, in November I went out to watch a painter painting on Cape Cod, right at the edge of the water. He was using our material. He was wearing a heavy jacket on the ladder and, although the sun was shining, the temperature was quite cold, even during the day. By actual test, instead of getting 700 to 800 square feet to the gallon, he was getting 400. It might be argued that he should not paint in such cold weather. Nevertheless, that is beyond our control. As a matter of fact I was called onto the job to make an adjustment, due to the fact that one side of the house painted three days before had wrinkled terribly due to a cold night following the application of the paint.

In Chicago, last December, we had several other wrinkle jobs and the contractor involved finally became bitter and decided to switch back to white lead. The lead jobs wrinkled equally badly, so he thinned the paint tremendously beyond the Lead Company's thinning limits and then got to the point where the paint didn't cover in three coats of white. To overcome this, he tinted the paint buff and, although the house was supposed to be a white house, and all the other ones in the subdivision were white houses, this one is a buff house and the fellow that bought it on a Government loan could take it or leave it as he saw fit.

These various tales could be multiplied indefinitely when paint men get together. Each one has had annoying and interesting experiences. My only thought in raising the point is that what the painter does is beyond our control and probably will continue to be so. In some ways this is an argument in favor of a definite class label—A, B, C, etc. If the paint used is a certified A grade paint, no complaint or adjustment is thereafter possible. The painter takes the blame. You can imagine how he is going to love this. I can foresee some conflict, but in the broad general outlook I think it is a good thing.

Finally, the matter of paint compatibility will require a great deal of attention. Browne has had considerable experience in observing paint faults and complaints and on the basis of his experience has observed that bad results are inherent in certain succession of types of paint.

There are unquestionably some bad combinations. I think his most unfavorable experience has been obtained when a very soft paint, such as straight white lead, is put over a hard paint according to practice normally followed and thinning directions normally suggested. Many cases of failure have also been noticed when repainting has been done with hard types of paint over surfaces which contained somewhere down underneath a coat of yellow ochre in oil, or over a surface where there is an old coat or coats containing a lot of iron oxide. Our knowledge today is such as to lead us to expect such a result.

However, other factors are of at least equal importance. The excessive and uncontrolled and irregular penetration of a priming coat into an old surface has unquestionably led to bad results in many cases and is a factor of major magnitude. It is apparent from the way many companies are now proceeding that this is regarded as of prime importance and efforts being made to control this factor by the use of special primers containing thickened oils. The finish coat applied over these primers after they are dry is of substantially different composition, so that this would warrant the general statement that it is undesirable ever to paint the same kind of paint over itself.

There are restrictions to this in the case of people who paint one coat frequently to maintain a gloss, but this is undesirable practice and leads to the building up of an excessive quantity of paint on the surface. I mention this point; namely—that a system of painting is needed rather than always using the same type of paint over itself—because I think it is an important point, not yet incorporated in Browne's classification and compatibility ideas, and I feel that discussion of it and experience along these lines is needed before the story will be complete enough for final adoption. I know, however, that Browne is doing this and with proper co-operation all around we can finally arrive at a rational system or basis on which to advise the painter or home-owner what to do.

During the past few years we have painted several hundred thousand houses with our own particular Two Coat System. Inspection of a reasonable percentage of those houses by our field men has disclosed rather striking examples of failures and has pointed out the things that happen to paint after it leaves the factory—and I refer to paint that would receive an A grade label under any classification.

Nevertheless, the percentage of complaints has been ridiculously small. It is unquestionably fair to assume that this one type of system has been put over practically every kind of paint ever devised, including recently one of the highly enamelized paints. Despite this, as I previously mentioned, the percentage of failures is extremely small, so that we would have a very strong case against the necessity of considering compatibility, since sufficient time has elapsed to bring out any serious failures.

It is our feeling, however, that the results we have obtained have indicated at least certain extreme cases where the idea of compatibility is useful; namely, painting with hard system over ochre in oil, or painting with what might be classified as an extremely soft paint over a very hard one.

Proceeding from these specific cases it should be possible to anticipate the results on the basis of coefficient of expansion and contraction and other general principles and so gradually evolve a minimum of practical warning signals to the customer. I say "minimum" since I think that the instructions to the customer or the painter must be kept at a minimum and he must not be necessarily alarmed.

We are all familiar with the constant barrage of advertising dealing with "pink tooth brush," "B. O." and the like, and I think it would be advisable to avoid this kind of advertising in the paint industry; but it seems likely that we can proceed to some rational basis which will minimize the troubles encountered and protect the position of the paint manufacturer against the things that now happen to him. So, in this respect, I think that Browne's thesis is valuable to the paint industry and merits our serious consideration.

© A Simplified Chemistry of Paint Technology

By Francis William Brown, Ph.D.
Industrial Consultant, Phila., Pa.

[Note: In this series of articles, Dr. Brown will cover the entire field of inorganic paint chemistry in language the any paint man with an ordinary high school education can understand. The editor is confident that this will constitute a real service to every member of the industry, with the possible exception of the professional chemists thereof.]

(Continued from February)

SALTS (Continued)

Density

The heavier the metal present in a salt, the greater its density. The greater the percentage of the metal present, the greater the density. Compounds that occur in nature usually have a higher density than the same ones artificially made, although the latter approximate the natural form if calcined. As a general rule the soluble salts of a metal are less dense than the insoluble ones. The active metal salts usually are more dense than the metal, the lesser active ones being less dense than the metal.

Water Solubility

All the salts of sodium, potassium and ammonium (NH_4) are soluble in water. All nitrates, acetates and chlorates are water soluble. The following salts are water insoluble:

Chlorides—Silver AgCl, Mercury HgCl, Lead $PbCl_2$,
Sulphates—Lead $PbSO_4$, Barium $BaSO_4$, Strontium $SrSO_4$,
Carbonates—All except sodium, potassium ammonium,
Sulphides—All except sodium, potassium ammonium, barium, calcium, strontium magnesium,
Phosphates—All except sodium, potassium ammonium.

Natural compounds are usually more insoluble than the artificial ones unless the latter are calcined.

Electrical Conductivity

Dry salts are non-conductors, but in water solution are excellent conductors. Molten salts are fair conductors, while mixtures of molten salts are often better conductors than the separate components.

Freezing and Boiling Points

The presence of dissolved salts in water lowers the freezing point and raises the boiling point. The higher the concentration of the dissolved salt, the greater the change. The greater the number of component atoms in a salt, the greater the effect; i. e., aluminum chloride, $AlCl_3$, which contains four atoms, is more effective than sodium chloride, NaCl, having but two atoms to the molecule.

Chemical Properties of Salts

Thermal Stability

The naturally occurring compounds are usually very stable to moderate heat. As a general rule, the unstable compounds are more complex than the stable. For instance, chlorides, carbides, sulphides, selenides, and nitrides are very stable, whereas the chlorates, carbonates, and nitrates are decomposed by moderate heat. Sulphates, phosphates and silicates, however, are very stable to high heat, although they are comparatively complex.

It is evident that high temperatures favor the simpler compounds and low valence. Heat rarely liberates the free metal unless the metal present is very inactive, such as silver, gold, platinum, etc.

Metals

A metal will react with a salt of a lesser active metal, displacing the latter. Zinc reacts with iron sulphate to form zinc sulphate and free iron, zinc being more chemically reactive than iron.

A metal will react with a salt solution if the latter has an acid nature. Ammonium chloride, a salt of the weak ammonium hydroxide (NH_4OH) and the strong hydrochloric acid (HCl), in water solution gives an acid reaction due to hydrolysis. An active metal, such as zinc, dissolves in ammonium chloride solution just as it would in any acid solution.

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Paint Oil and Chemical Review Apr. 14, 1938 (36)

What Can Be Done to Make Paint Maintenance More Successful . . . . . .

By Dr. F. L. Browne

Senior Chemist, Forest Products Laboratory

Madison, Wisconsin

Address at the Recent Annual Convention of the Southwestern Lumbermen's Association at Kansas City

Reprinted from

American Paint Journal

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tion, but conform to no standards by means of which the various kinds and grades can be recognized by the users.

The Forest Products Laboratory has recently shown that it is perfectly practicable to define good paints of all kinds in such a way that they can be set apart from inferior paints. In fact, it is technically feasible to classify paints in a logical manner. The proposed "grading" rules, though technical in nature, are much simpler than the various grading rules for lumber. While some technologists of the paint industry recognize the desirability of classifying paints the paint industry as a whole is opposed to it. Since the idea is a new one originating outside of the industry, it is by no means surprising that it should be regarded with suspicion, especially since its primary purpose is to provide a clearer basis of mutual understanding of the composition of the product between manufacturer and user in so far as composition affects the correct use of the product in practice. If there is a better way of accomplishing the latter objective it is to be hoped that someone will soon propose it.

The Forest Products Laboratory's proposed system of classifying house paints was published in detail in the American Paint Journal, issues of October 11 and October 18, 1937. Briefly, paints are separated into types according to the nature of their opaque white pigments and the proportions of the two kinds of chemically active white pigments, namely, white lead and zinc oxide. Each type is then marked off into divisions according to the content of total pigments, opaque pigments, and nonvolatile matter (pigments plus drying oils). Where paints contain vehicles other than the customary unbodied drying oils, such as linseed oil, additional classification is provided. In the writer's opinion the proposed system of classification evaluates paints in essentially the same way that any well informed paint technologist would evaluate them but, inasmuch as the various types are merely recognized as differing from one another without inferring that any one is inherently better than another, it does not lend support to any one school of thought about house paints at the expense of contrary opinions. Each may choose whatever type of paint he prefers and reject those he dislikes.

The proposed classification assumes that the system would be administered by the appropriate trade association, just as lumber grading is administered by the regional lumber manufacturer's associations. A commercial paint would then be identified for sale *both* by the manufacturer's trade brand, which would remain his seal of responsibility for quality of the product, and by the association's symbols of type and division. These symbols would be simple enough to be explained to laymen, in contrast to the complicated formula label that now appears on many paints in conformity with the laws of some states. A typical symbol of type and division might read: "This paint is of TLZ (titanium, lead, zinc) type with medium content of white lead and medium content of zinc oxide, division M, as classified by the..... Association." With paints so classified there would be no great difficulty in telling the public the difference between good paints and inferior paints. The problem of cheap paint, therefore, can be dealt with effectively just as soon as we really wish to do so.

"Moisture" Failures and Their Cure

Access of moisture behind painted woodwork is the cause of one large class of early paint failures. The moisture may get in through carelessly designed or erected joints in the construction, or by condensation of moisture laden air from inside of the house when it comes in contact with the cold back surfaces of the exterior woodwork. Trouble from condensation has probably increased materially in recent years because of the greater use of thermal insulation, which makes the back surfaces of exterior woodwork colder by letting less heat escape from inside, and because of provision for air washing and humidification in modern heating plants. Condensation of this kind is more troublesome in the northern parts of

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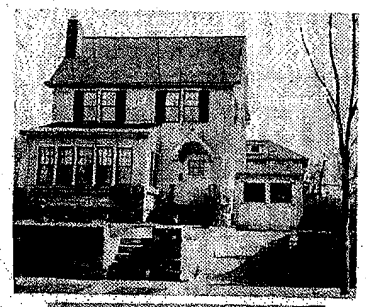
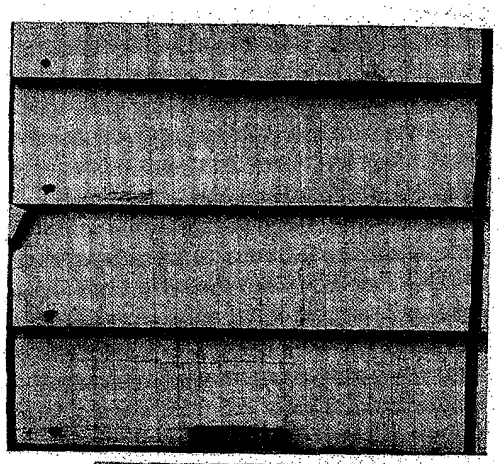
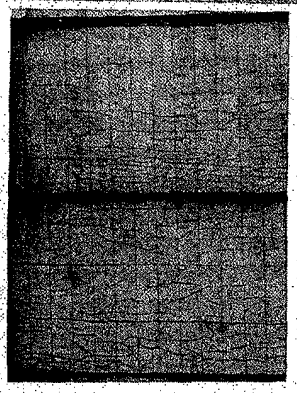
the country, but in more southern areas where studs are sometimes covered with drop siding without sheathing and heating is accomplished with inadequately vented open gas burners, condensation on or in the sidewalls or under the roof sometimes occurs as a result of the large amount of moisture formed in the combustion of gas.

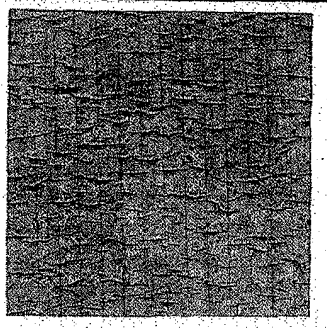
Condensation in sidewalls and attics can be prevented by keeping moisture from passing through the walls. This can be accomplished by the correct installation of vapor barriers on the *inside* of the studs and *underside* of attic floor joists. In houses already erected two coats of aluminum paint on the interior surfaces of sidewalls and ceilings under the attic makes an effective vapor barrier over which other wall decoration may be applied. Where moisture arises from open gas burners it should be carried off by means of adequate flues.

Much moisture is evaporated in houses during normal living operations such as cooking, bathing, laundry work, and the breathing of persons and plants. Families undoubtedly vary in their living habits that affect the amount of moisture evapor-









Paint capable of giving good service sometimes gives bad service in actual practice. The house shown at the left was painted with a high-priced paint about one year before the photographs were taken. The bad cracking that developed has been observed on other houses on which this paint was applied over previous coats of paints of other types. The views at the right show the excellent service given by the brand of paint in question in an exposure test by the Forest Products Laboratory. The test panel consists of one board each of redwood, white pine, Douglas fir, and Southern yellow pine, painted with three coats of the paint in question, and exposed at 45° facing south (a very severe condition) for 2¾ years. The square showing fine checking of the paint is an area only 1 inch by 1 inch in actual size.

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Table 1—Variation in Composition of Semipaste Paints on the Market, Manufacturers' Directions for Thinning Them for Finish Coat, and Characteristics of the Paints When So Thinned.

Identification No.	Composition of Semipaste Paint			Liquids to Be Added to 1 Gal. of Semipaste Paint			Characteristics of Resulting Paint		
	Total Pigment	Opaque Pigments	Non-volatile	Total	Linseed Oil	Volatile	Total Pigment	Opaque Pigment	Non-volatile
	Gals. per gal. of semipaste			Gals. per gal. of semipaste			Per cent	Per cent	Per cent
20	.58	.34	.97	1.0	1.0	0	29.0	17.0	98.5
31	.53	.27	.83	1.0	.87	.13	26.5	13.5	85.0
Lead & Oil	.52	.52	.91	1.05	1.00	.05	25.3	25.3	93.3
38	.51	.36	.93	1.03	1.00	.03	25.1	17.7	94.6
26	.50	.28	.87	1.0	1.00	0	25.0	14.0	93.5
19	.50	.25	.97	1.0	1.00	0	25.0	12.5	98.5
27	.45	.38	.69	1.0	1.00	0	22.5	19.0	84.5
18	.44	.34	.72	1.0	1.00	0	22.0	17.0	86.0
23	.44	.26	.86	1.0	1.00	0	22.0	13.0	93.0
3	.43	.43	.82	1.25	1.25	0	19.1	19.1	92.1
4	.42	.37	.91	1.25	1.20	.05	18.7	16.4	96.0
13	.42	.35	.84	1.07	1.07	0	20.3	16.9	97.0
24	.41	.18	.90	1.0	1.00	0	20.5	9.0	95.0
12	.41	.27	.91	1.1	1.10	0	19.5	12.9	95.8
39	.39	.36	.90	.75	.75	0	22.3	20.6	94.5
36	.37	.37	1.00	.87	.75	.12	19.8	19.8	93.6
30	.35	.31	.89	1.04	.87	.17	17.2	15.2	86.3
45[a]	.30	.26	.79	maker gives no directions			.....	.....	.....

[a] Note that semipaste No. 45 contains little more than half as much pigment as semipaste No. 20 and that No. 45 contains little more pigment than prepared paints Nos. 1A and 2A in Table 2.

Table 2—Variation in Composition of Prepared Paints on the Market and in Manufacturers' Directions for Application.

Identification No.[1]	Composition of Prepared Paint			Liquids to Be Added for 1st Coat[3]			Liquids to Be Added for 2nd Coat			Liquids to Be Added for 3rd Coat		
	Total Pigments	Opaque Pigments	Non-volatile	Total	Linseed Oil	Volatile	Total	Linseed Oil	Volatile	Total	Linseed Oil	Volatile
	Gals. per gal. prepared paint			Gals. per gal. prepared paint								
1A	.29	.18	.79	.31	.25	.06	.06	0	.06	.06	.06	0
2A	.29	.27	[illegible]	[illegible]	[illegible]	[illegible]						

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Table 2—Variation in Composition of Prepared Paints on the Market and in Manufacturers' Directions for Application.

Identification No.[1]	Composition of Prepared Paint			Liquids to Be Added for 1st Coat[3]			Liquids to Be Added for 2nd Coat			Liquids to Be Added for 3rd Coat		
	Total Pigments	Opaque Pigments	Non-volatile	Total	Linseed Oil	Volatile	Total	Linseed Oil	Volatile	Total	Linseed Oil	Volatile
	Gals. per gal. prepared paint			Gals. per gal. prepared paint								
1A	.29	.18	.79	.31	.25	.06	.06	0	.06	.06	.06	0
2A	.29	.27	.88	.5	.25	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0
3B[2]	.26	.32	.90	1.00	.75	.26	.125	0	.125	0	0	0
6At	.26	.21	.91	1.125	1.00	.125	.875	0	.875	.5	.5	0
7	.26	.25	.90	1.125	1.00	.125	.50	.25	.25	.25	.25	0
8Aw[2]	.26	.29	.91	1.00	.875	.125	.875	0	.875	.25	.25	0
5At[2]	.26	.28	.90	.25	.125	.125	.06	0	.06	.06	.06	0
8[2]	.26	.29	.90	1.00	1.00	0	.25	0	.25	0	0	0
9	.24	.19	.90	.625	.50	.125	.25	.125	.125	.125	.125	0
10	.24	.17	.86	.18	.10	.08	.18	.06	.12	0	0	0
11	.23	.23	.88	.625	.50	.125	.25	.06	.19	0	0	0
12	.22	.22	.90	.5	.25	.25	.25	.125	.125	0	0	0
13	.22	.22	.90	.5	.25	.25	.125	0	.125	.125	.125	0
14A	.21	.17	.93	.5	.375	.125	.125	0	.125	0	0	0
15	.21	.21	.94	.75	.625	.125	.375	.125	.250	.125	.125	0

[1] In the identification no. the numeral stands for a manufacturer and the capital letter to one brand out of two or more made by that manufacturer. Lower case letters t and w distinguish between white and tinted paints of the same brand.

[2] These paints contain very opaque pigments, titanium dioxide or lead titanate, without equivalent dilution with transparent pigments, consequently the opaque pigments calculated by the method described on page 32, American Paint Journal, October 18, 1937, exceed the total pigments.

[3] Where directions differ for different woods, those given for red cedar or white pine are reported.

ated and the amount that can subsequently escape when the house is ventilated by opening windows. House owners should be taught that condensation on windows is an indication that the relative humidity indoors is higher than the house can carry safely with the prevailing temperature out of doors and that reduction of relative humidity by opening windows and adjustment of the heating plant is desirable until the condensation is reevaporated. In northern climates storm windows are necessary, whether or not the windows are weatherstripped, both to save heating expense and to prevent condensation without limiting the house to unreasonably low relative humidity during cold weather.

Fortunately the problems of moisture leakage and condensation are becoming generally appreciated and at least for new houses and some of those already erected, we now have effective means of keeping the woodwork dry. To be sure there remains the serious undertaking of educating those concerned with the erection of houses and the house owners themselves, but there are reasonable grounds for believing that in time moisture as a large cause of unsuccessful paint maintenance can be eliminated.

The Cure for Mistakes in Applying Paint

Much unsuccessful painting comes from faulty technic in applying paint. The most common blunders arise from the painter's very human desire to do the work with the smallest amount of expensive material possible just as the paint manufacturer tries to make his paints with the smallest practicable proportions of the more expensive ingredients. In most cases in which the bounds of safety are overstepped the painter was not intentionally dishonest, he was merely mistaken in his judgment or unfamiliar with the limitations of the material with which he was working. It should be remembered that the painter's judgment is necessarily based on insufficient information because, except in the case of lead and oil, he does not have prac-

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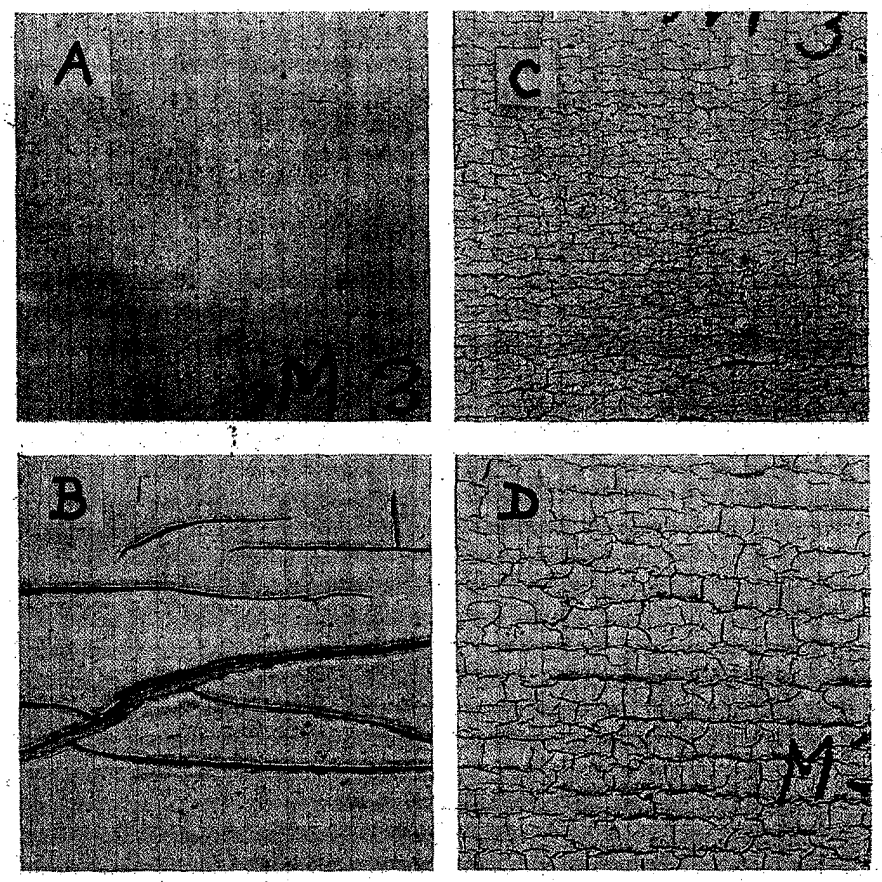
tical knowledge of the composition of the paint he is using and there are no generally accepted standards of correct application. Commercial paints differ in composition far too widely to conform to any general standards of application, and since they are not recognized by classes each paint presents a separate problem in application. Often the painter is asked to apply a paint that came on the market long after he learned his craft and differs seriously as respects application from anything he has been trained to use correctly.

To be sure directions for application are usually printed on the label on paint containers. The painter is often chided for paying little attention to such directions, but when manufacturers' directions are studied carefully in relation to the composition of their products it becomes clear at once that manufacturers' ideas of



The behavior of a finish coat depends upon what kind of paint is underneath. The four squares show areas each 1 inch by 1 inch representative of the behavior of the coating on four test areas on the Forest Products Laboratory test fence after two years of exposure at 15° facing south. Area A shows three coats of a commercial brand of titanium-lead-zinc paint. Area B shows two coats of that paint over a commercial zincless primer made by another manufacturer. Area C shows three coats of a high-priced quick drying paint made by the first manufacturer. Area D shows two coats of the paint used on A with a finish coat of the paint used on C.

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correct application are just as divergent and illogical as painters' practices. Since directions usually are most explicit about the extent to which the paint should be thinned the conflicting state of opinion about application can be illustrated by considering manufacturers' directions for thinning.

Table 1, which is condensed from a much larger table of data, shows the composition of 18 semipaste paints on the market in relation to the makers' instructions for thinning to make finish-coat paint and the composition of the paints when so thinned. The paints are arranged in the table in order of their content of total pigment by volume, which decreases from 0.58 to 0.30 gallon in 1 gallon of semipaste. The content of opaque pigments, calculated by the methods described in the Forest Products Laboratory's system of classification, ranges from 0.52 to 0.18 gallon per gallon of semipaste. Yet with negligible exceptions the thinning directions call for the addition of a gallon or more of liquid to a gallon of semipaste. This proportion is obviously determined less from consideration of the best way to mix these paints than from the fact that the accepted proportions for mixing lead and oil, namely 3 gallons of oil and ½ to 1 pint of drier per 100 pounds of paste lead, is very closely gallon for gallon. That the thinning directions are not guided by any logical relation to the composition of the semipastes is shown by the very wide variations in the composition of the resulting paints after thinning.

Table 2 shows that for prepared paints also there is a lack of logical relation between composition of the paint and directions for thinning. In Table 2 after the composition of the paint there are given the directions for thinning the first, second, and third coats in painting new exterior woodwork of the kinds of wood the paint manufacturer considers best for painting. Sometimes the directions call for variations in thinning the first coat for different woods, in which case it is seldom possible to recognize any reasonable connection between the properties of the woods and the variations in thinning specified. As a matter of fact the names by which the woods are designated often are not the names under which they are sold in commerce.

An old rule of painting held that the undercoat (the second coat in three-coat work) should always be mixed with more pigment in proportion to oil than the finish coat. This rule is still recognized in directions for thinning lead and oil and many semipaste paints. It does not fit in, however, with the conception of prepared paint as ready for application without further thinning. Consequently it was formerly customary to direct that the paint be thinned only with turpentine for second coat so that the undercoat would contain at least no less pigment when dry than the finish coat. Eight of the twenty paints of Table 2 break with this custom and depart still farther from the old rule of craftsmanship by directing that oil be added to the paint for second coat. Of these eight only three call for addition of oil to the finish coat also so that five of them definitely instruct the painter to violate a rule of craftsmanship to which the older painters were trained.

It is curious that the instructions for eight of the twenty paints of Table 2 direct that the paint be thinned for all three coats, one of them calling for addition of as much as half a gallon of oil per gallon of paint for finish coat. Such a paint ought not to be called a prepared paint, but rather a semiprepared paint. As put up in the can the paint in question is of very respectable quality, but when thinned as directed for finish coat its content of total pigment drops to 16.7 per cent, and its content of opaque pigment to 14.0 per cent, figures not at all in accord with modern conceptions of high quality in house paints.

Bad technic of application can be cured only by education in correct technic. We cannot teach painters to read and follow directions, however, until the directions are reasonable and are agreed upon by those to whom painters must look for instruction. Where the teachers contradict one an-

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other the pupils, being human, hold the teachers' opinions lightly and follow their own judgment, inevitably making many mistakes in so doing. It is the writer's opinion that the present irrationality in directions for applying paint arises less from lack of technical knowledge than from commercial considerations of price competition. Manufacturers' directions are written too much with a view to convincing the painter that the paint will "go farther" than competitive paints and too little with the idea in mind of making sure that the paint will give the best possible performance.

If paints were properly classified according to composition, paint technologists probably would find no great difficulty in agreeing upon sound instructions for applying each of the classes of paint provided that they were permitted to do so solely from the point of view of performance. With such agreement on standards of correct application a campaign of education for painters becomes practicable, but until there are such standards there is no way of giving painters adequate instruction.

The cure for bad technic of application, therefore, lies in classification of paints by some such method as that proposed by the Forest Products Laboratory, followed by agreement upon reasonable instructions for applying each class of paint, and then by united and vigorous insistence that painters learn and follow the accepted standards of application.

The Cure for Mistakes in Paint Maintenance

In the writer's experience more complaints about paint jobs are caused by incorrect programs of maintenance than by poor lumber, poor paint, bad application, or moisture. Neither the paint manufacturer nor the painter as a rule has much control over maintenance because the house owner generally decides when painting shall be done, how much work he is willing to pay for, and often what brand of paint shall be used. Efforts to attain more successful paint maintenance, therefore, must take into account the necessity of teaching house owners how to space jobs correctly and how to choose the right kinds of paints for their purposes.

Many house owners have no definite plan for spacing paint jobs and merely wait until the old coating goes to pieces before trying to renew it. In this group many have no intention of painting more often than every eight or ten years. Since we have no white paints that can be relied upon to remain durable for such long periods, those who follow such programs are more interested in the ability of the paint to stand neglect well than they are in its durability. They want a soft type of paint that breaks up slowly by crumbling so that it does not look too unkempt during the period of neglect and after neglect can be safely repainted without expensive removal of the old coating. Pure white lead paint, if used exclusively, will behave in this way, and is largely responsible for the fact that so many owners are accustomed to maintenance programs involving long periods of neglect.

Most of the newer paints, however, are made to provide greater durability and superior appearance, which can be provided only by making harder paints that break up finally by cracking, curling, and flaking, and therefore cannot be neglected safely. Of course, practically all paints are advertised as wearing away slowly by chalking, leaving a fine surface for repainting, and avoiding the defects of cracking and scaling, but such claims are made on the assumption that repainting will be done before the end of the period of durability and before neglect begins; they do not mean that the paint is suitable for those who expect to let their coatings go through periods of neglect.

There are two ways of successfully linking together the maintenance program and the kind of paint for those with unduly long intervals between painting. One way is to convince the house owner that it will be worth his while to change his program to permit him to use paints of harder type satisfactorily. The other way is to sell him the kind of paint that will serve satisfactorily in the program to

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which he is accustomed. To persuade him to buy a paint unsuited to the program he intends to follow, however, is simply to add one more to the number of those who are dissatisfied with painted woodwork.

A large proportion of paint complaints that come to the writer's attention occur on houses that have been painted at reasonable intervals with good paints well applied on woodwork that remains dry and yet the paint fails far too soon and often in a manner not characteristic of the normal behavior of the paint last used. In all these cases, however, two or more paints of distinctly different composition have been used for successive paint jobs or successive coats in the same paint job. Some of the combinations show up repeatedly in different complaints. Some well known combinations frequently occurring in complaints are white paints over yellow ochre primer or paint, almost any house paint over clear varnish, and white paints over full color paints like deep red, brown, green, or black. Unfortunately technical exposure tests in the past have been confined chiefly to initial paint jobs or repainting with the same kind of paint, but some past records of tests involving combinations of paints differing in type have been discovered, the outcome of which reveals the same abnormalities of behavior found when these combinations of paints are seen on houses.

The evidence that good paints are not all compatible with one another is now conclusive, but there is much difference of opinion about the seriousness of the problem. Some hold that incompatibility occurs only in a few extreme cases such as those named in the preceding paragraph. The writer believes, on the basis both of observations of houses and of technical exposure tests, that the principle of incompatibility is very much more far reaching. Combinations of white paints, differing materially in content of zinc oxide for example, have been observed to deteriorate more rapidly and in a less satisfactory manner than corresponding coatings made up entirely of either one of the paints separately. A great deal of research will be necessary to establish all of the ramifications of the principle of compatibility, but when it has been done many of the present mysteries of house paint maintenance will be cleared up. A large proportion of the Forest Products Laboratory's research on painting is now directed toward this problem.

Until future technical study discloses the extent to which paints may differ in composition and still remain compatible, the conservative practice in maintenance is to start out with a good paint when the woodwork is new and thereafter maintain it at proper intervals with paint of essentially the same composition. Switching from one kind of paint to another is doubtful practice unless the particular combination so produced has been tested or found satisfactory by previous experience. Certainly those combinations of paints that have frequently led to difficulty should be avoided. At the present time the only white paint that is used consistently by large numbers of house owners is pure white lead because it is the only paint recognized by type as well as by manufacturer's brand. In the writer's opinion the high regard in which white lead paint is held by so many good painters and paint users is due largely to this consistency in its use. When white lead is applied over paints of other kinds it often fails prematurely and in an abnormal manner, indicating that it is just as subject to the requirement of compatibility with previous paints as are paints of other kinds.

The cure for bad programs of paint maintenance, therefore, lies in a classification of paints that will make it possible to teach house owners how to buy the right kinds of good paint for their purposes and how to get out of the paints they buy the good service of which they are capable.

The Need for Classification of Paints

Consideration of the causes of unsuccessful paint maintenance and consequent loss of public confidence in painted exterior woodwork shows that our most serious troubles have come

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not so much from jerry building and inferior paint as from efforts to improve building methods and paints that have made the situation more complicated and unduly technical for craftsmen and laymen. Thermal insulation and modern heating plants are distinct improvements over past practices but, unless appropriate precautions are taken to control condensation on cold parts of the structure, they tend to increase the number of houses in which moisture leads to early paint failures and other difficulties. In a similar way modern developments in paint have given us better paints than we ever had before but there are now so many kinds of good paint on the market and they vary so much in composition, manner of correct application, and compatibility with one another that painters and house owners do not know how to use them all correctly. Merely offering the public good paints that are capable of giving successful service is not enough to reestablish confidence in painted woodwork unless we likewise make it possible for each good paint to be so applied and maintained that it will give the good service of which it is capable. To accomplish that purpose the technical complexities of application and maintenance must be simplified sufficiently to bring them within the comprehension of craftsmen and house owners. Such simplification can be effected by some such classification as the one proposed by the Forest Products Laboratory just as it was accomplished years ago for lumber through species identification and grading.

The working out of a classification of paints together with reliable instructions for application and maintenance is a strictly technical problem that must be handled by paint technologists, that is to say by the paint manufacurers. Moreover it is a problem of the industry as a whole through group action because there is obviously little or nothing that an individual manufacturer can do about it by himself. Meantime those who deal in paint must continue to sell paint pretty much as they have been doing unless they can give the time and effort to closer technical study of the situation and individual contact with their painter and owner customers to help them avoid the more serious mistakes about which there is now general agreement. There is, however, one suggestion that the writer would like to leave with paint dealers. That suggestion is to make a regular practice of keeping track of a fair sample of paint sales and observing the service obtained by the customers over a period of years. In the smaller cities at least this should not be a very heavy burden and it has the highly important advantage of letting the dealer know what sort of service his customers actually receive with the material he sells them. As a rule the dealer learns only about jobs that turn out badly and lead to complaints. No matter how good his paint there will be some complaints, the real causes of which could be determined to everyone's satisfaction much more successfully if the dealer could point specifically to other houses painted perhaps from the same shipment of paint on which satisfactory service was being obtained. Such comparisons, if made conscientiously, will almost invariably show that the paint was capable of giving good service but failed to do so for some one or more of the reasons discussed in this article. It will also restore the dealer's confidence in the paint he is selling and make him less inclined to experiment with some new brand that offers no greater prospect of avoiding complaints and may even increase them by bringing about more heterogeneous combinations of different kinds of paint on the houses of his customers.

Wisconsin Carpenter and Builder early 1948 (37)

When and How to Paint Homes and Farm Building

By F. L. BROWNE, Senior Chemist
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EDITOR'S NOTE: Volume I of the Proceedings of the Forest Products Research Society. This volume of 340 pages, 10½ by 7½ inches, which is substantially bound in green cloth with gold lettering, incorporates the papers (with discussion) presented at the First National meeting of the Society held in Chicago on October 31 and November 1, 1947. It also includes: record of attendance at that meeting; monthly bulletins of the Society, May, 1947, to October, 1947, inclusive; Articles of Association and Bylaws; style standards; alphabetical and geographical directories of membership; and other features. The volume is for sale at $6.00 per copy. Orders should be addressed to Thomas R. C. Wilson, Secretary-Treasurer, Forest Products Research Society, P. O. Box 2010, University Station, Madison 5, Wisconsin.

KEEPING A BUILDING satisfactorily painted depends on three things — good paint, good painting, and good maintenance. Before the paint is selected, however, and before any painting is done, the first thing to do is to decide what appearance is desired and how much trouble and expense the owner is willing to undergo to maintain that appearance.

Maintaining Buildings Without Paint

The least expensive procedure is to leave the building unpainted, and merely keep up the repairs as the building deteriorates with age and use. Paint does not prevent decay, and if decay is allowed to enter the structure, a painted building will rot just as quickly as an unpainted one. Decay is prevented by proper design and construction and the use of decay-resistant or treated wood where necessary, and not by painting. When the weathered appearance of old unpainted wood is not objectionable, therefore, painting may be omitted altogether. If so, the plan should call for patterns of exterior lumber of substantial thickness and of woods that weather well, in order to minimize checking, warping, and splitting of the wood and loosening of the fastenings.

Except for shingle roofs and timbering, however, weather-beaten wood is adaptable only to a limited number of architectural designs and to spaceous rustic settings. It is rarely appropriate for urban dwellings. Once it has become weather beaten, wood can seldom be painted satisfactorily, though it can be stained. On the other hand, properly maintained paint coatings protect wood against weathering and retain the original architectural effect indefinitely.

Using Stains Instead of Paint

When color is desired but painting is, for one reason or another, not considered practicable, a common procedure is to use an exterior stain. Exterior stains consist, in general, of linseed oil, turpentine, and only sufficient mineral pigment to give the desired color. They penetrate the wood surface without forming a substantial coating over it. Since they do not protect wood against weathering, they should be used where the appearance of a weather-beaten surface is not objectionable. Good stains are not expensive and they last longer than most paints. One coat only is the usual application, and a new coat is easy to apply.

Linseed oil is the essential constituent of the vehicle for wood stains; just as it is for paints. More volatile liquid and very much less pigment are used in stains than in paints, however, because a stain should be absorbed rapidly by the porous wood. At least one-third, some authorities say two-thirds, of the vehicle of a stain should be linseed oil. The remainder may be turpentine or mineral spirits and may also contain some creosote. Creosote is not necessary and must not be considered a satisfactory substitute for the linseed oil. If the creosote is of a kind that does not evaporate, it protects the surfaces with which it comes in contact from decay by fungus attack, but it does not penetrate deeply, hence the interior of the wood and the hidden surfaces are not protected. Exterior woodwork that is likely to be stained usually does not need protection against decay.

Compositions of some typical exterior stains that may be recommended are the following:

Vehicle, two parts linseed oil, one part turpentine. To one gallon of this mixture add —

For *gray stain*, 12½ pounds white lead, a touch of lampblack.
For *deep red-brown*, 1 pint indian red.
For *bright red*, 1 pint venetian red.
For *permanent green*, ¾ pint chromium oxide.
For *fairly permanent green*, 1½ pints medium chrome green.
For *golden brown*, ¼ pint raw italian sienna, ¾ pint burnt turkey umber.
For *seal brown*, 1 pint raw turkey umber.
For *deep brown*, 1 pint burnt turkey umber.

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The colors named should be pure colored pigments ground in linseed oil, which can be purchased at any paint store. The dry pigments should never be used for mixing stains. There are, of course, many other formulas that may be used.

Using Paints

The great majority of people consider that buildings usually look best when kept well painted and, if they can afford it, are willing to spend money for the purpose. Good paint maintenance not only keeps buildings looking well, keeps surfaces smooth, and retards warping and checking of the lumber, but it also gives the property a look of prosperity, encourages general tidiness of the premises, and gives the owner a well-deserved feeling of pride in his property.

When to Paint

Exterior woodwork should receive the first or priming coat of paint as soon after erection as practicable. Succeeding coats should be applied at intervals not greater than two weeks; in warm, dry weather the intervals may be as short as two days. It is very poor practice to let exterior woodwork stand for weeks with only a priming coat, or to postpone the application of the third coat of paint for six months or more.

Metal surfaces that are to be painted are often primed at the mill. Succeeding coats should be applied promptly after erection. If galvanized iron is to be painted, however, it is helpful to let it first weather for several weeks.

Interior surfaces other than mteal should not be painted until moisture from the plastoring, concrete work, or other operations of building have entirely disappeared. Wood work should then be painted or varnished, because further delay is likely to entail more labor in sandpapering and properly cleaning the surfaces. Plaster and concrete, on the contrary, become more receptive to paint on aging and painting may therefore be deferred as long as desired.

Exterior painting may be done in any season of the year during which the painter can work with reasonable comfort. Obviously, paint should not be applied when it is raining or foggy and the surface should be allowed to dry after rain, fog, or dew before continuing to paint. During cold, damp weather paints harden more slowly than they do in warm, dry weather. A sudden drop in temperature while the coating is hardening may make it wrinkle or it may cause dew to form on the fresh paint and damage it. Coatings applied during late fall or winter are likely to become more seriously soiled as time passes than coatings applied in the spring or summer. On the other hand, during the summer, insects and seeds sometimes become embedded in fresh paint and disfigure it.

What kind of paint to use, and the very important matters of when and how to repaint, can be discussed to best advantage after the composition and various kinds of house paints have been described.

Composition and Kinds of House Paints

Only good, durable paint (or stain) should be used on exteriors of permanent structures because the principal cost of painting is the labor. If a cheap coating is desired for temporary structures or surfaces that must be repainted frequently and do not require protection against weathering, either whitewash or an exterior water paint containing casein may be used.

Many commercial paints bear a label giving the name and address of the manufacturer and the composition of the paint. In the absence of previous experience with a paint, appraisal of its quality must be based upon the information given by the formula label. It is wise to buy only paints that give the formula on the label, and to keep a record of the formula so that paint of similar composition can be purchased when it comes time to repaint the building.

Paint composition, of course, is a highly technical question with which the house owner and painter are compelled to deal as best they can in spite of their lack of the necessary technical training. What is needed is a reasonably simple system of classifying house paints by kind and quality, much as lumber is classified by species and grade. It would then be possible for paint users to select the kinds of paint best suited to their individual requirements and to learn to apply and maintain them correctly. Such a system of classification has been described in technical detail in Industrial and Engineering Chemistry, volume 29, page 1018, September 1937, to which reference should be made for a more complete discussion of paint composition and classification than is practicable in this mimeograph. That discussion is very technical, however, and was written for the information of paint technologists rather than for the average home owner.

House paint consists of two parts, a solid part (the pigments) and a liquid part (the vehicle). The kind and quality of a paint are determined by the nature of its vehicle, the nature of its pigment, and the proportion of pigment in the vehicle.

The Nature of the Vehicle

The vehicle in house paints consists of two parts, a drying oil and a volatile thinner. The volatile thinner is usually mineral spirits (a petroleum prod-

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uct) or turpentine. Thinner is necessary to give paint correct consistency for brushing but after application it evaporates and therefore forms no permanent part of the coating. Mineral spirits of suitable quality is just as satisfactory as turpentine and cheaper but it is often wiser for the painter, buying at retail, to use turpentine for thinning paint because there is greater assurance of obtaining it in suitable quality. Some paints contain water as part of the volatile thinner. On the label water is often called "colloidal solution", "soap solution", "emulsifying agent", or "aqueous bodying agent." If it amounts to less than 1 per cent of the vehicle it may not be particularly objectionable but larger amounts betray a paint of inferior quality.

Linseed oil is the principal drying oil used in house paints. A small amount of paint drier or japan drier, the nature of which need not concern the ordinary paint buyer, is also necessary to make the paint harden promptly after application. It makes little difference whether raw linseed oil or boiled linseed oil is used, provided that there is the correct proportion of drier, because boiled linseed oil may be considered, for practical purposes, as raw linseed oil in which the drier has already been incorporated. Bodied linseed oil, however, is linseed oil that has been heated until its viscosity has been increased very greatly. In moderate proportions (up to roughly 10 per cent of the total drying oil), bodied oil may often be used to advantage in improving the consistency of house paint but, in greater proportions, it makes enamolized paints, which are discussed in the second paragraph following. In paint formulas, bodied linseed oil is often called "heat treated" or "specially processed" linseed oil and sometimes the proportions of bodied and unbodied oils are not stated.

In recent years soybean oil has been substituted for part of the linseed oil in house and barn paints. There is no objection to this practice, which comes primarily from a desire to extend the market for a domestic farm crop, provided that the resulting paint hardens promptly under all reasonable weather conditions during application. To insure prompt drying, a third drying oil of superior drying proportion, such as perilla oil or a small amount of tung oil, may be added to the mixture of drying oils. Fish oil may be used in much the same way as soybean oil provided that it does not impart objectionable odor to the paint. Raw tung oil cannot be used in material proportions, because it wrinkles badly during drying but, when properly bodied or heat treated, during which it becomes very viscous, it may be used in moderate proportions. When a mixture of drying oils has been used in a paint the formula often refers to "vegetable drying oils" or "vegetable oils" instead of naming the oils used specifically.

Large proportions of bodied drying oils or varnishes (heat treated mixtures of drying oils and resins) are not used in true house paints of good quality. Because of the high viscosity imparted by heat treatment, excessive proportions of volatile thinner must be added and, as a rule, the amount of pigment must likewise be reduced in order to obtain a brushable product. Moreover, the product takes on the flowing and leveling qualities of enamel, as distinguished from true house paint. Such products are sometimes called enamelized house paints. For special purposes, for example, where it may be the intention to wash the coating frequently, enamelized paints may be advantageous but, as a rule, they are inadvisable for ordinary house painting because they are difficult to apply and maintain correctly. Enamelized paints tend to "pull under the brush" unduly, they must be applied in rather thin coating to avoid running, sagging, and formation of beads at sharp horizontal edges on vertical surfaces, and they accentuate irregularities in the underlying surface, such as raised grain in wood or flaked patches of the previous paint.

Varnish or resin of any kind in house paint has a rather bad reputation because very cheap paints often use varnish together with large proportions of mineral spirits and water. Such paints are unreliable and make it necessary to regard any paint that contains varnish or resin with suspicion. Nevertheless there are a few paints of good quality on the market in which small proportions of resins of high quality are used. Such paints are called "resin-fortified" paints and sometimes they are "quick-drying" paints. They are also likely to be enamelized paints, unless the amount of varnish used is very small. For most house paint purposes, quick drying has more disadvantages than advantages. Fortification with small amounts of resin is sometimes used in order to dispense with zinc oxide as one of the pigments, resin having some of the action of zinc oxide as a hardening agent in paint. It is still questionable, however, whether there is any real benefit to be gained from the use of resin in white or light colored house paints. In deeply colored paints like dark green, dark brown, and black, paints in which little or no white lead or zinc oxide can be used, addition of some varnish or of a substantial amount of bodied drying oil is often adviseable to insure prompt hardening after application and to prevent unduly early fading of the color.

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The Nature of the Pigment

Durability, opacity (hiding power), color, and, to a large extent, brushing consistency are imparted to paint by the pigments. The opaque white and colored pigments (see next paragraph) provide all four of these qualities. Certain other less expensive pigments that are practically transparent in linseed oil are used in paint to improve brushing consistency, to reduce cost of manufacture, and to keep the pigments in prepared paint from settling into a hard cake at the bottom of the can. In the interest if economy, the transparent pigments are used as generously as is consistent with durability and opacity. Paints of inferior quality usually contain excessive amounts of transparent pigments.

The opaque white pigments commonly used in house and barn paints are: basic carbonate white lead, basic sulfate white lead, zinc oxide, the titanium pigments, the zinc sulfide pigments, and, in a few brands of paint, antimony oxide. Certain opaque white pigments, known as leaded zinc oxides, contain both basic sulfate white lead and zinc oxide but when they are used it is common practice to report the white lead and zinc oxide separately in the formula label.

The important opaque colored pigments are the manufactured iron oxide reds, browns, and yellows, the iron oxide earths such as "red oxide", indian red, umber, sienna, ochre, venetian red (iron oxide and calcium sulfate formed by calcining a mixture of ferrous sulfate and limestone), chrome yellow (lead chromate or lead chromate and lead sulfate), chrome orange (basic lead chromate), prussian blue or chinese blue (ferric ferrocyanide), chrome green (chrome yellow and prussian blue), ultramarine, zinc yellow (zinc chromate), red lead (lead oxide), aluminum powder, the carbon pigments (carbon black, lampblack, graphite, drop black, bone black), and mineral black (black oxide of iron).

The important transparent pigments are magnesium silicate, talc, barytes (barium sulfate mineral), blanc fixe (manufactured barium sulfate), silica, whiting or chalk (calcium carbonate), calcium sulfate, china clay (kaolin), and mica. On formula labels, mixtures of transparent pigments are sometimes ambiguously called "silicates", "inert pigments", or "extending pigments".

The white lead pigments and the zinc oxide pigments are called chemically active pigments because they are believed to react chemically with the drying oils during the hardening of paint. At any rate they impart desirable properties to paint that are obtainable with no other pigments except red lead and basic lead chromate. For that reason all good house paints should contain a substantial proportion of white lead, zinc oxide, or both, except in deep colors that do not admit opaque white pigments.

The titanium pigments include titanium dioxide, titanium-barium pigments (25 or 30 per cent titanium dioxide and 75 or 70 per cent barium sulfate), titanium-magnesium pigment (30 per cent titanium dioxide and 70 per cent magnesium silicate), titanium calcium pigment (30 per cent titanium dioxide and 70 per cent calcium sulfate), and lead titanate. (The term Titanox that occurs in some formula labels is a trade name for titanium pigments made by the Titanium Pigments Company). Titanium dioxide is so much more opaque than white lead or zinc oxide that the titanium-barium and titanium magnesium pigments, in spite of the large content of transparent pigment, may be considered opaque white pigments fully equal in opacity to white lead and zinc oxide. Lead titanate is also a very opaque pigment and, though said to be chemically inactive, imparts some of the properties of white lead pigments to the paints made with it. Titanium-calcium pigment is intended for use in interior paints only and should not be used in exterior paints of high quality.

The zinc sulfide pigments include zinc sulfide, which is very opaque, lithopone, "double-strength" or "high-strength" lithopone, and titenated lithopone (a mixture of titanium dioxide and lithopone). (Cryptone is a trade name for certain zinc sulfide pigments made by the New Jersey Zinc Company). The zinc sulfide pigments are very useful in interior paints but in exterior paints their use, with few exceptions, is confined to manufacturers' second-grade paints and to cheap paints. House and barn paints containing zinc sulfide pigments of any kind cannot be generally recommended.

For house and barn painting the most widely used paints are white paints or tinted white paints. Tinted white paints are paints in which most of the pigment is made up of white pigments with just enough colored pigments to produce the desired color. A manufacturer's brand of paint that is offered in 32 colors, for example, may consist of 24 tinted white paints and only 8 colors made chiefly with colored pigments (colored pigment paints). As a rule the principal areas of buildings are painted with the white or tinted paints and the colored pigment paints are used for trim and minor areas. Colored pigment paints made with iron oxide pigments, however, have long had a special field of usefulness because of the fact that, when properly made, they are less expensive and much more durable than the best white or tinted paints. They have long been used, therefore, for painting barns and other chiefly utilitarian buildings, where low cost of paint main-

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tenance is preferred to a wider choice of brighter colors.

In recent years aluminum paint has come into use for some of the purposes for which iron oxide paints are commonly used. Aluminum paint consists of aluminum powder in a vehicle made especially for the purpose. For exterior use on wood the vehicle may be either a bodied drying oil containing not more than 40 per cent thinner or a so-called very long oil spar varnish containing a small proportion of resin and not more than 50 per cent thinner. The aluminum and the vehicle are either bought separately or are put up in two-compartment containers so that they may be mixed just before use. From 1¾ to 2 pounds of dry aluminum powder of "standard varnish grade" or 1¾ to 2 pounds of commercial paste aluminum are added to 1 gallon of the vehicle. Aluminum paint is slightly more expensive than good white paint but is fully as durable as good iron oxide paint and is bright in appearance though metallic in luster.

The Various Kinds of House Paints

There are many types and grades of house paint on the market. Until they are classified and graded for sale by some such system as that proposed by the Forest Products Laboratory it is possible to discuss them and to indicate how they can be recognized from the formula labels only in a very rough way.

There are three broad groups of high-grade white or tinted house paints whose serviceableness is well established by adequate experience and whose general use can be recommended. In all of them the liquid consists of linseed or other drying oil containing not more than 10 per cent of bodied oil, no resin of any kind, and only moderate proportions of volatile thinner and drier. The groups differ in the nature of the pigments used and, in the Forest Products Laboratory system of classification, are designated groups L (lead), LZ (lead and zinc), TLZ (titanium, lead and zinc). Groups LZ and TLZ are available in a number of types, differing in proportions of white lead and zinc oxide, and each type in various divisions differing in content of opaque pigments, total pigments, and total nonvolatile (pigments plus nonvolatile vehicle) in the paint. Group L is represented by one type and division of paint only, namely pure white lead paint, which is sold in essentially the same composition by a number of different manufacturers.

Pure white lead paint is sold chiefly in the form of soft paste paint, in white only, to be thinned with more liquid and tinted, if tinted paint is desired, by the painter. The soft paste contains 89 per cent basic carbonate white lead, 9 per cent linseed oil, and 2 per cent turpentine by weight. If thinned correctly it makes paint of the highest quality. Because it is essentially a standard article of commerce it is the simplest paint to buy and use consistently in a program of paint maintenance extending over a long period involving repeated repaintings. Pure white lead paint is rarely sold in the prepared (ready-mixed) form.

Paints of groups LZ and TLZ are sold in both the prepared and semipaste forms. Many of the prepared paints are of high quality but most of the semipaste paints of the mixed-pigment groups are either of inferior quality or are so made that the painter is encouraged to thin than with too much liquid, thereby making inferior paint. It is therefore safer, as a rule, to buy mixed-pigment paints in the prepared form.

Lead and zinc paints, group LZ, contain a mixture of one or both of the white leads and zinc oxide or leaded zinc oxide. In addition many of them contain transparent pigments. There are at least 9 different types on the market of which the 3 most important are those with (1) very high content of white lead (over 50 per cent of the pigment by volume) and medium content of zinc oxide (25 to 35 per cent), (2) high content of white lead (35 to 50 per cent) and high content of zinc oxide (35 to 50 per cent), and (3) high content of white lead and medium content of zinc oxide in the pigment. In LZ paints of good quality the sum of the white lead and zinc oxide should be not less than 90 per cent of the pigment and the total pigment should be not less than 67 per cent of the paint by weight. At the present time, paints of group LZ are used chiefly for tinted paints, the white paint of most of the better known brands being of the TLZ group.

Titanium, lead, and zinc paints, group TLZ, contain one or more of the titanium pigments in addition to white lead and zinc oxide pigments. In addition, they contain very substantial proportions of transparent pigment either as ingredients of the titanium pigments or as additions by the paint manufacturer. There are at least 7 different types on the market, of which the 3 most important are those with (1) high content of white lead and medium content of zinc oxide, (2) medium content white lead and medium content of zinc oxide, and (3) low content of white lead (10 to 25 per cent) and medium content of zinc oxide. In TLZ paints of good quality the sum of the white lead and zinc oxide should be not less than 45 per cent of the pigment, the sum of white lead, zinc oxide, and titanium dioxide not less than 60 per cent of the pigment, and the total pigment should be not less than 65 per cent of the paint by weight. Paints

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of group TLZ are now the predominant mixed-pigment white paints and are also used widely for tinted paints.

In good iron oxide paints, not less than 30 per cent of the pigment by weight should be iron oxide and the pigment should be not less than 53 per cent of the paint. If the pigment contains more iron oxide, however, the content of total pigment in the paint should be higher, for example, if the pigment contains 75 per cent iron oxide there should be not less than 61 percent pigment in the paint.

What Kind of Paint to Use

The kind of paint to use should be determined when the new building is to be painted for the first time or after previous paint has been removed completely by painters' blow torch or house paint remover and the bare wood is again exposed. Once the building has been painted, future repainting should be done with the same kind of paint used the first time. Changing kinds of paint for successive paint jobs often leads to abnormally early failure and unsatisfactory forms of failure of the new job. The renewed coating consists of the new paint plus what is left of the old paint and, unless there is past experience with the combination to judge by, no one can tell what the result will be. Certain repainting combinations that have repeatedly been observed to cause abnormal and usually unsatisfactory developments are white paints over yellow ochre primer or paint, white paints over colored pigment paints such as red, brown, green or black, almost any house paint over clear varnish, pure white lead paint over mixed pigment paints that have not aged for a very long time, enamelized paints over softer house paints of the ordinary types, and ordinary house paints over enamelized paints.

In selecting the kind of paint for a new building, the first point to consider is the length of time that will elapse between paint jobs. In most parts of the United States coatings of white or tinted paint cannot be expected to remain durable for more than 4 or 5 years. If the intervals between paint jobs are to be longer than that, either an extremely durable paint, such as iron oxide paint or aluminum paint, should be chosen or, if white or a tint is demanded, the paint should be one that stands neglect well. Pure white lead paint has long been used satisfactorily by owners who paint only at long intervals. White lead paint is no more durable than good LZ or TLZ paints but the coating gradually wears thin by chalking and very fine crumbling; after it begins to disintegrate there is a long period during which the surface, if not examined too closely, still looks reasonably well, and after much neglect the surface can be repainted easily and with assurance that the new job will give the same service over again. When LZ or TLZ paints reach the end of their serviceable life they begin to crack and break up in a coarser and more conspicuous pattern than does white lead paint and, if further neglected, they commonly begin to curl up at the edges of the cracks and to flake or scale off in a manner that leaves an unsightly appearance and a surface that requires much careful preparation for repainting and, even then, forms an uncertain foundation for the new job.

If repainting is to be done at intervals of 4 or 5 years the owner may choose a good paint of any of the types described. For such programs, white lead paint has the advantage of being easily purchased at any time without bothering about careful study of complicated paint formulas and of being thoroughly understood by all good painters so that it is likely to be applied well. During the first year or so of its life it may become somewhat dirtier than other paints but, when it reaches the chalking stage, the dirt is usually sloughed off and good appearance restored. The LZ paints may take somewhat longer to pass through the dirty stage and begin to clean themselves by chalking. The TLZ paints, on the other hand, collect notably less dirt than either L or LZ paints and soon begin to chalk freely enough to become clean again. For white paints the TLZ paints have therefore become very popular.

The appearance of a tinted paint depends both on sailing with dirt and on retention of the color; when the chalking stage is reached the dirt may be sloughed off but the color begins to fade. For that reason the LZ paints are sometimes preferred for tints. The choice may well depend largely on the particular color chosen. Tints, such as cream or light yellow, are marred more seriously by dirt than by fading, provided the fading takes place uniformly. Tints, such as light green or light blue, however, are seriously marred both by fading and by dirt. In choosing a tint it is well to give consideration to its probable appearance after chalking begins.

Repainting at intervals of less than 3 years is rarely advisable because, on sheltered parts of the building particularly, the old paint has not aged long enough to become a reliable foundation for new paint and in the course of time the coating becomes unduly thick and of uncertain behavior. As a rule, where it is desired to keep the coating with a cleaner and fresher appearance than is generally customary, it is better to have the house washed every year or so rather than to repaint it too often. Where wash-

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ing is planned, paints containing higher proportions of zinc oxide have an advantage in that they are somewhat easier to wash. If the washing reduces the thickness of the coating somewhat, so much the better, because the harder types of paint do not wear away as much between paintings as is desirable.

While climate has some bearing on the choice of paints it is less important than consistent use of one type of paint, good application, and wise maintenance. In the warm, humid climate of the coastal plain of the Southeastern States the harder types of paint, containing the higher proportions of zinc oxide, are often more durable than are the soft paints, such as pure white lead paint. Such paints may also be somewhat less seriously affected by mildew, which is troublesome in warm, humid regions. On the other hand, in the dry climates of the Southwest, paints of the harder types are notably less durable than are soft paints and tend to break up very badly if they are allowed to go too long.

How to Use the Paint

Two blunders that are frequently made in using paint are excessive addition of liquids, especially of linseed oil, and stingy application of paints. Painters sometimes seek by these means to save paint and manufacturers often recommend maximum allowable additions to convince purchasers that their paints "go as far" as any other.

Good paint is much more durable than linseed oil, but linseed oil is necessary to bind the pigments together into paint. Obviously there is an optimum proportion of pigments to oil for maximum durability. The optimum proportion has not yet been satisfactorily established but the best modern evidence indicates that it is materially less oil than is generally used. Final coats of paint probably should contain little more than the minimum amount of oil necessary to make them harden with a glossy surface. Undercoats should contain even less oil and should not harden with a glossy surface. These modern ideas, however, are not applied strictly in the recommendations for thinning paints given in succeeding paragraphs. Instead, the formulas are based upon the present practice of good painters. For durable painting the stated amounts of linseed oil may be decreased somewhat but should not be exceeded. If more liquid is needed to make the paint flow properly, add turpentine rather than oil.

General Procedure in Mixing Paint

Prepared paint is not ready for application when the container is first opened. The pigments usually settle to the bottom, leaving clear liquid on top. Pour off most of the liquid into another and somewhat larger container and then begin to stir the rest of the contents into a smooth paste. Gradually pour back the clear liquid in small portions while continuing the stirring until all of the paint is mixed uniformly. Transfer the paint to the larger container and add any additional oil or turpentine that may be needed. Stir once more and finally pour the paint back and forth from one container to the other several times. If the paint is a colored one purchased in more than one container, it is desirable to pour and mix together all of the paint that will be needed for the job, to make sure that the color will be uniform.

To mix paste paint for application, transfer the paste to a container large enough to hold the amount of paint that is to be mixed. If the paint is to be tinted, enough paint to complete the job should be mixed at one time. Measure out the required amount of linseed oil and pour some of it into the original container to wash out any paste left clinging to its walls. Stir the paste in the larger container and add the linseed oil gradually until a smooth mixture results.

If the paint is to be tinted, it is best to thin the tinting colors with turpentine so that they will mix quickly with the white paint. Add the colors in successive small amounts, while stirring very thoroughly, until the chosen color is attained. Finally, add the required amounts of turpentine and drier and stir until the paint is uniformly mixed.

Do not adulterate your paint.— Substitutes for linseed oil, reinforcing oils, sealers, and waterproofing agents, or other concoctions sold for addition to paint should be avoided.

The volatile thinner in most paints is mineral spirits, a petroleum product, but turpentine is commonly recommended for painters to use in thinning paint. Both are satisfactory. No other liquid possesses any advantage over these two.

New exterior woodwork.— Good prepared paints have usually been made on the assumption that three coats will be applied to new woodwork. Do not try to make two coats of such paints suffice. For the first or priming coat paint 1 pint of linseed oil and 1 pint of turpentine may be added to a gallon of prepared paint. For the second coat 1 pint of turpentine may be added to a gallon of paint. No addition should be necessary for third-coat paint.

In recent years certain paint manufacturers have developed special primers and paints to be used in two-coat painting. The best of these should give very good results if correctly applied, but if they are brushed out too thin the results are likely to be poor. In two-coat work it is desirable, for best results, to have about the same thickness of paint

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left on the wood as in the three-coat method. If a two-coat painting system is used, both primer and finish coat should be made by the same manufacturer for use together.

Formulas for Mixing White Lead Paste Paint

For three-coat painting on new woodwork soft paste white lead paint should be mixed as follows:

	Soft paste white lead Pounds	Raw linseed oil Gallons	Turpentine Gallons	Paint dried Pints
For first coat	100	4	1¾	1
For second coat....	100	1½	1¼	1
For third coat	100	3	0	1

With soft paste white lead, a skillful workman can paint new woodwork acceptably with two coats. For this purpose the mixtures may be made as follows:

	Soft paste white lead Pounds	Raw linseed oil Gallons	Turpentine Gallons	Paint dried Pints
For first coat	100	2	1	1
For second coat ...	100	2½	¼	1

Paint coatings do not last so long on heavy woods that have wide bands of hard, dark-colored summerwood, such as southernpine and Douglasfir, as they do on light woods or more even texture. Such woods should be primed with one coat of aluminum paint of the kind previously described, and two coats of the paint of desired color applied over it.

Repainting exterior woodwork. — If the old coating is not too dirty or is first washed, if there are no areas of wood left bare by loss of coating, and if vigorous rubbing of a small area will remove the superficial chalk and restore a fair degree of gloss, a single coat of paint may be sufficient repainting. For this purpose, prepared paint should be applied without addition of any oil or turpentine. Soft paste white lead paint should be mixed with 2½ gallons of raw linseed oil, ¼ gallon of turpentine, and 1 pint drier per 100 pounds of paste.

If the old coating is chalking too deeply to restore any gloss by rubbing or if there are small patches of bare wood, two coats of paint are needed. With prepared paint the first coat may be mixed with 1 pint of turpentine per gallon and the second coat applied without addition. Soft paste white lead paint should be mixed as follows:

	Soft paste white lead Pounds	Raw linseed oil Gallons	Turpentine Gallons	Paint drier Pints
For first coat	100	2	1¾	1
For second coat....	100	3	0	1

If repainting of a mixed-pigment paint has been too long deferred so that the old coating is badly shattered and large areas of wood are bared, all loose paint must be removed with putty knife, wire brush, and sandpaper, and bare areas touched up with priming coat paint before proceeding with a two-coat painting job. Even when the surface is carefully prepared for repainting, the new job will suffer in appearance and durability from the neglect of the previous coating.

How Much Paint To Apply

Although paint coating should be brushed thoroughly they should not be brushed out too thin. Good painters apply coatings of substantial thicknesses. On the other hand, coatings that are too thick wrinkle as they harden. The proper thickness must be learned by experience but the experience can be acquired rapidly if the beginner will observe the amount of paint he applies to measured areas of surface.

The following figures for the spreading rate of paint may be used for estimating the amount of paint needed for a job and for gaging the proper thickness of paint coatings:

	Spreading rate in square feet of surface per gallon of paint for—		
	1st coat	2nd coat	3rd coat
Three-coat painting on new woodwork ..	600	700	700
Two-coat painting on new woodwork ...	500	600	...
Two-coat repainting on woodwork	650	700	...
One-coat repainting on woodwork	600	...	...

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Buildings and Building Management June 1939

(38)

Effective Floor Finishes

By F. L. Browne

Senior Chemist, Forest Products Laboratory

YEARS ago floors were commonly finished with repeated applications of hot linseed oil, each application buffed by hand; and when the surface was saturated with oil, it was waxed and maintained by waxing at suitable intervals. Because unbodied drying oils such as linseed penetrate into wood relatively deep, a good many applications were necessary, making the process rather laborious; but the finish was correspondingly durable, did not show scratches, and was readily patched at places of maximum wear without refinishing the entire floor. The pure linseed-oil finish dried hard enough to be free from any tackiness and made a floor that was very easily kept clean by dry mopping. In time the finish darkened, partly because of the change in color of the wood itself and partly because drying oils and varnishes become discolored with decomposition products as they age. Since the finish saturated a substantial layer of the wood, this darkening effect was more serious than it is with a superficial coating of varnish.

As time passed, the drying-oil finish was increasingly adulterated with nondrying mineral oils until at the present time floor oils have become cheap products often containing no drying oil at all. The mineral oils prevent proper hardening of linseed oil, thereby keeping the finish tacky, so that it clings to dirt and the finish ultimately becomes very dark in color or even black. Largely because of the adulteration of floor oils the old oil finish fell into disrepute and for a long time has been replaced by varnish, shellac, shellac and varnish, or shellac and wax finish. There is now, however, a growing trend back to the old oil finish, except that in place of linseed oil, specially designed products known as floor seals are being used because they are obtainable in satisfactory quality and are more economical in labor of application than unbodied linseed oil. According to a recent estimate, 70 per cent of the floors in large cities in the East are being finished with shellac, 20 per cent with floor seals, and 10 per cent with varnish, in spite of the fact that nearly all who give technical advice about floor finishing rate shellac as the least desirable of the three.

The varnish and shellac finishes form coatings of substantial thickness over the surface of the wood in contrast to oil and seal finishes, which penetrate into and are embedded in the surface of the wood without forming a definite coating over it. When a coating wears through in a traffic channel, it can rarely be patched without showing the edges of the worn place; and even if the whole floor is recoated there is usually a difference in color between the worn area and the areas where old coating discolored by age remains underneath. For fully satisfactory refinishing, the old coat must be removed completely either by sanding or scraping or by use of suitable liquid removers. The necessity of removal can be avoided by taking care to renew the coatings before traffic channels wear through, but with varnish finishes particularly the color gradually darkens as thicker layers of old varnish accumulate. Shellac has much less tendency to darken with age than varnish but, on the other hand, water causes it to turn white if the water stands on it very long before being wiped off thoroughly.

The modern floor seals may be regarded as thin varnishes or bodied drying oils prepared to penetrate less deeply into the wood than unbodied drying oils. Fewer applications are required, yet they penetrate more deeply than ordinary floor varnishes so that a surface layer of the wood can be saturated and the finish can be embedded in the wood rather than coated over it. Some of the seals contain emulsified water for the purpose of controlling the degree of penetration and the spreading rate at which the seal is applied. The seals are relatively new products on the market; composition and properties vary widely; and inadequate instructions for application are often given. Inasmuch as the seal finish differs fundamentally from the varnish finish in method of application, it is very important that those who use seals for the first time make sure that they learn exactly how the products should be used to obtain the excellent service of which the finishes are capable.

Selection of Finish

Wood floors can be maintained in good condition by any one of various types of finishing methods, if good materials are properly applied and if maintenance methods appropriate for each type of finish and for the degree of wear to which the floor is subjected are employed. No one type of finish can be said to be superior in all respects and none will long continue to give good service unless it is suitably maintained. The secret of good floors lies in thorough understanding of the nature and limitations of the particular kind of finish chosen and in careful following of the appropriate maintenance program.

Where the owner's chief requirement is a maximum interval of time between refinishing jobs, during which the floors will be merely kept clean by sweeping and dry mopping, or where the highly lustrous appearance obtainable only by using a substantial coating of resinous material is desired, coatings of varnish or shellac are

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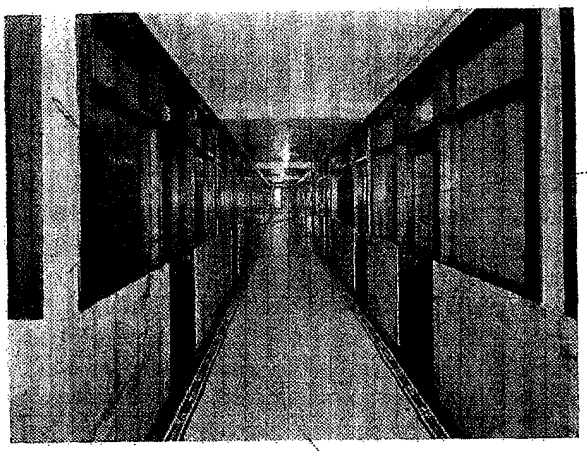
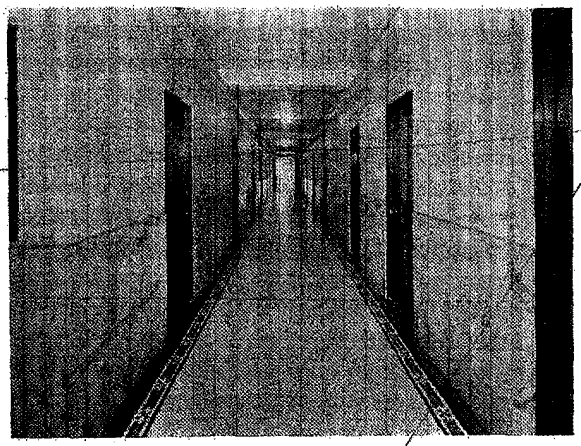
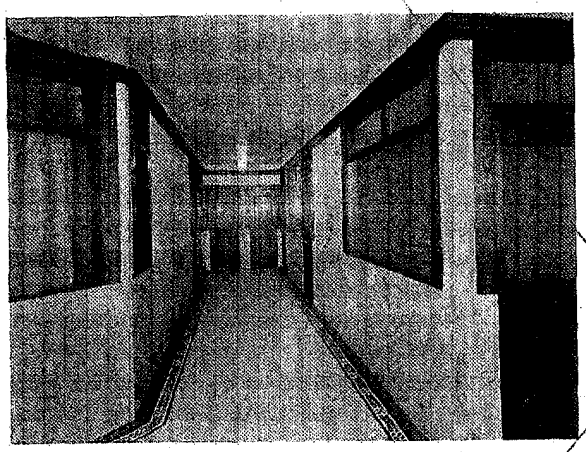


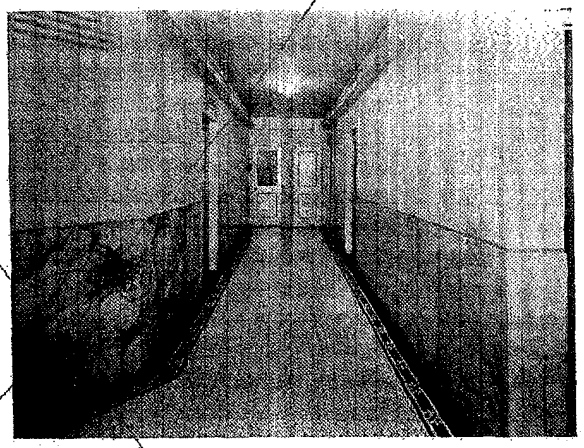
BEFORE: A typical upper floor corridor in the Brockman Building at Los Angeles, showing the old fashioned trim and the large areas of glass before modernization



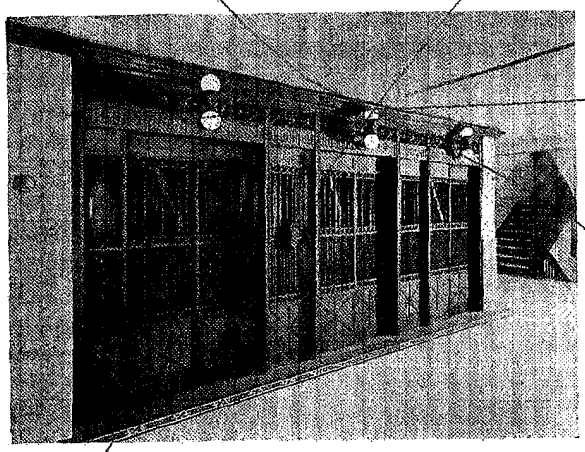
AFTER: The same corridor after remodeling. All of the alterations were made by the building's regular employees, on plans conceived and supervised by the manager



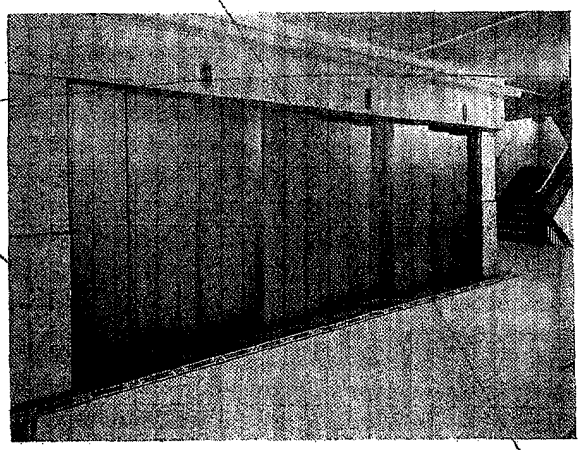
BEFORE: Another view of an old corridor in the Brockman Building. All of the work necessary to effect the transformation shown at right was done at night



AFTER: Throughout the alterations, all scaffolding and muss was removed before tenants arrived each morning, and the whole program was completed in this way



BEFORE: These old elevator entrances were solid, but antiquated. The old grille fronts were covered with sheet metal and this was finished exactly like the walls



AFTER: The modernized elevator fronts are simple and attractive. They completely change the appearance of the corridors, and are in keeping with the other work

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likely to prove most satisfactory. The coatings should be cleaned and renewed when they begin to become thin in the channels of maximum traffic but before they wear through to bare wood at these points. Dissatisfaction with such finishes arises most often where recoating has been too long postponed; and this is particularly likely to occur, because those who choose such programs do so largely to escape the burden of watching their floors carefully. After three or four renewals of the coating, when it has become dark in color, it should be removed completely by scraping, sanding, or with varnish remover and a new coating applied to the bare wood.

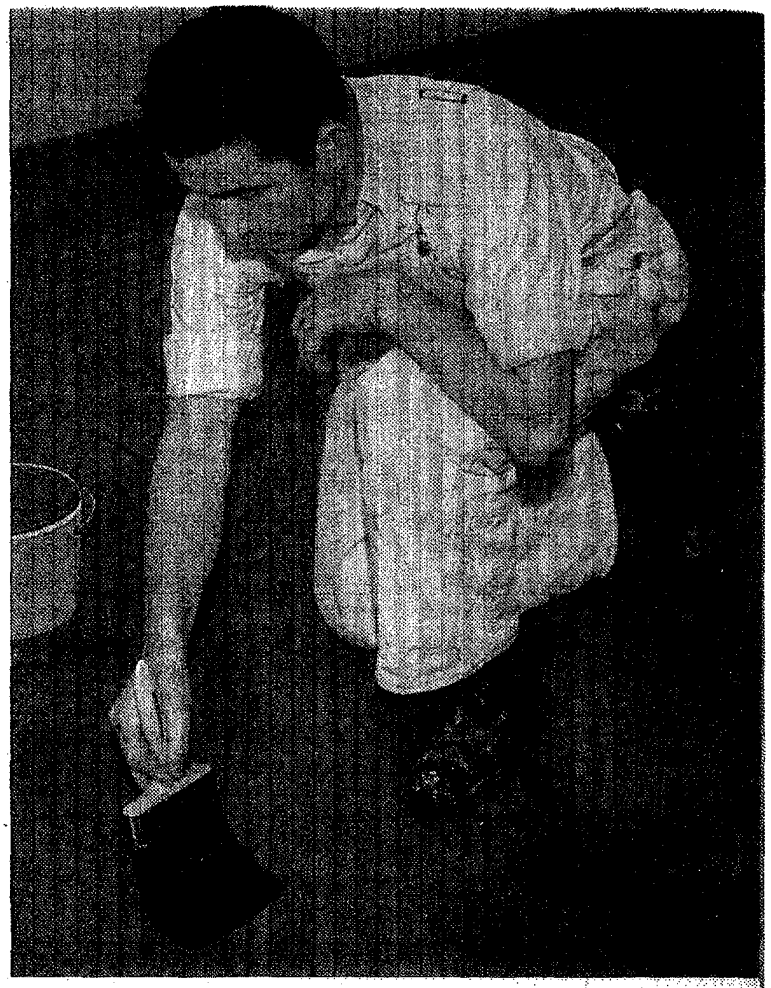
Shellac is used so widely for floors chiefly because it dries so rapidly that a floor may be finished or refinished and put back in service within 24 hours. Varnishes, even the quick-drying kinds, require longer intervals between coats and remain tender for some time so that the floor should be kept out of service for several days when varnishing is being done, although they are often used within 24 hours.

Where floors can be kept out of service long enough to apply varnish finishes properly, varnish is commonly chosen instead of shellac because of its better resistance to water that may be spilled upon it. Varnish finishes are also tougher and less easily scratched than shellac.

The shellac and varnish finish, in which shellac is used as the first coat on the bare wood and the varnish put on over it, is a compromise between the shellac and the varnish finish. Like so many compromises, it retains many of the disadvantages of both sides with some new shortcomings of its own. Water may still turn the shellac white under the varnish; the floor still needs to be kept out of service long enough to dry thoroughly; and the finish is usually very easily marred by scratches from shoe nails or scraping chair legs.

The durability of coatings can be improved by keeping them waxed, renewing the wax every 4 to 6 months according to the amount of wear on the floor. Well-waxed floors are also more easily kept clean by dry mopping. Wax over a substantial coating of shellac or varnish, however, tends to make a slippery floor unless the coating of wax is kept very thin. For that reason where wax is to be used, the shellac is often limited to one or two coats and sanded or buffed off so that it acts more as a seal to support the wax than as a coating. Some of the modern floor waxes are made with resinous ingredients in a further effort to make them less slippery. Those who choose coatings to relieve them of the necessity of paying fairly frequent attention to floor maintenance, however, are not generally inclined to renew wax often enough to gain much benefit from it in extension of the intervals between recoatings, and they might therefore do well to consider the newer floor-seal finishes with or without wax.

The modern floor-seal finishes are well suited to the needs of those who wish to keep their floors well waxed at all times, with minimum of slipperiness, and those who do not like the appearance of the very lustrous coating finishes, or who wish to pay a minimum of attention to floor maintenance except at an annual or semi-annual housecleaning time and then want to be able to clean and patch worn spots without the trouble of moving all the furniture out of the room and keeping the room out of service for a day or more.



Ewing Galloway

Finishing New Floors

In new construction, floor finishing should be the last operation performed after all other interior work has been completed. It is advisable to have the floors protected by a covering of heavy paper from the time they are laid until the finishing is to be done. The first and most important operation of finishing is scraping or sanding. Scraping by hand has been displaced almost entirely by sanding with electrically operated sanding machines. The sanding machine should be well designed, of rugged construction, with its bearings well aligned and kept in good condition. A machine with badly worn bearings may do more harm than good. It is usually advisable to have the sanding done by a man who specializes in floor sanding, not by a carpenter or painter. If part of the work is to be done by relatively unskilled labor, let it be the application of the finish rather than the sanding.

In sanding, the floor should be gone over several times, first across the grain and then in the direction of the grain. On the first traverse No. 2 sandpaper is usually used on the machine, graduating down to No. ½, No. 0, and No. 00 on succeeding traverses. On softwood floors, however, No. ½ sandpaper is often the finest grit practicable. After the last sanding, the floor may be buffed with No. 3 steel wool. For working close to walls or corners or in closets, where [Please Turn to Page 68]

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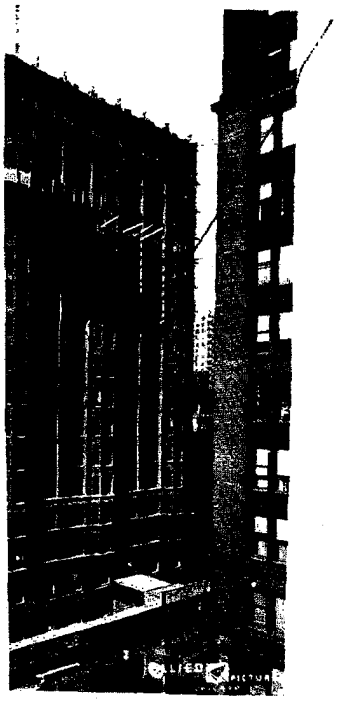
Effective Floor Finishes

(Continued from page 35)

Chicago's Capitol Building, once

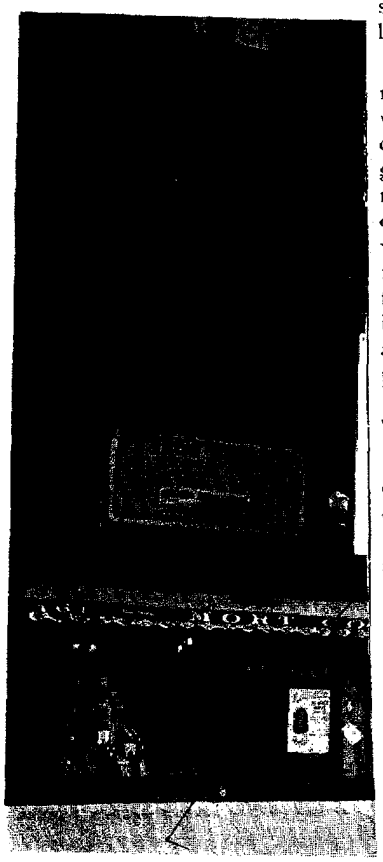


building ever torn down

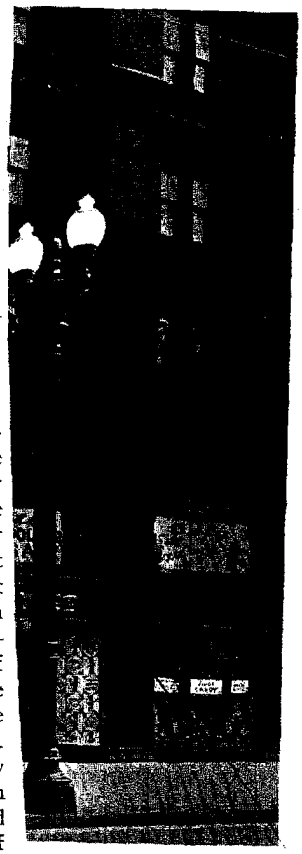
the large machine cannot be used, there are small, power-operated machines. After the floor has been sanded, it should be swept clean and carefully inspected, looking at it across the floor toward the light from a window and remembering that any scratches, undulations, or other blemishes will appear greatly accentuated when the finish is applied. The floor should not be walked on until the first coat of finish has been applied and finishing should be done as soon as possible after sanding.

If the floor is to be stained, this should be done with a penetrating oil stain at this time. Where floor seal is to be used, however, the stain may be incorporated in the first coat of seal. Some commercial floor seals are put out in colors as well as in the colorless form. Stained floors require particularly careful maintenance to avoid wearing traffic channels deeply into the wood. No stain penetrates very deeply with uniform color and if a patch becomes light in color through wear, it is very difficult to repair it to match in color the unworn areas of the floor. On the other hand, some stain may penetrate very deeply in the large pores of some hardwoods so that the owner, if he subsequently wishes to sand the floor down to get rid of the stain, may have to remove a considerable layer of the board. Stain incorporated in a first coat of floor seal is less likely to result in such deep penetration in local spots.

Floors of oak or other hardwood with large pores may require filling with paste wood filler before proceeding with the subsequent finishing. The filler may be colorless or it may contain pigment if it is desired to bring out the grain of the wood more contrastingly. Paste filler is almost always used on oak floors before applying shellac or varnish coatings, but with floor seals the practice varies. Some manufacturers of seals recommend that filler be used; others recommend its omission. When filler is used, care should be taken to see that the excess is wiped off very thoroughly to avoid an uneven, smeared appearance of the final finish. Any imperfections left by poor sanding make it difficult to do a clean job of filling.



Its successor will be a two-story



th the future subway

Varnish

Methods of applying floor varnish are commonly understood and are usually described on the labels of the containers. Only floor varnishes should be used for floor finishing. Varnishes made for other purposes and the so-called all-purpose varnishes are not so durable for floors as varnishes made specifically for the purpose. At least two coats are needed over paste filler or over a first coat of shellac and at least three coats where the varnish is applied directly to the bare wood. The chief precautions to observe are cleanliness and reasonable control of temperature and circulation of air. The floor should be clean when varnish is applied, and the brush must be clean to avoid leaving grains and lumps in the coating. The room should be kept at 70° F. or warmer and plenty of fresh air should be provided, since oxygen is taken from the air when varnish dries. Low temperature and high relative humidity greatly retard the drying of varnish.

FLB 001011

Shellac for floors should be purchased in the form of 5-pound cut shellac varnish and should be pure shellac unadulterated with cheaper resins. It should either be freshly manufactured or put up in glass containers. Shellac that has stood long in contact with metal may contain salts of iron that discolor oak and other woods containing tannin. The correct thinner for shellac is 188-proof No. 1 denatured alcohol. For application, 5-pound cut shellac should be thinned with 1 quart of thinner per gallon. It should be supplied with a wide brush that will cover three boards of strip flooring at one stroke and should be put on with long, even strokes, taking care to join the laps smoothly. The first coat on bare wood requires 15 to 20 minutes to dry. It should then be rubbed lightly with steel wool or sandpaper and the floor swept clean. A second coat should be applied, allowed to dry 2 or 3 hours, then gone over with steel wool or sandpaper, swept, and a third coat applied. The floor should not be put back in service until next morning if possible but may be walked upon in about 3 hours after finishing, if necessary. If wax is to be used, it should not be applied less than 8 hours after the last coat of shellac and should be a paste wax, not a water-emulsion wax, since water may turn the shellac white.

Floor Seals

Manufacturers' directions for applying floor seals vary widely and in some cases are very inadequate. In general, floor seals may be brushed on with a wide brush or mopped on with a squeegee or lamb's wool applicator, working first across the grain of the wood and then smoothing out in the direction of the grain. After an interval of 15 minutes to 2 hours, depending upon the characteristics of the seal, the excess is wiped off with clean rags or a rubber squeegee. For best results the floor should then be buffed with No. 2 steel wool although the buffing is omitted by those who are willing to sacrifice something in appearance and service to save the labor of buffing. If possible, the buffing should be done by a rugged power-driven machine designed specifically for buffing with steel wool. The next best procedure is buffing with steel wool pads attached to the bottom of a sanding machine. The buffing may be done by hand if a machine is not available. One application of seal may be sufficient, but a second application is generally recommended for new floors or floors that have just been sanded.

A correct interval of time between applications of the seal and buffing is exceedingly important. If the interval is too short, the appearance and durability suffer; while if it is too long, the excess seal "gums" the steel wool badly, is removed from the floor with difficulty, and where not removed becomes blackened with detritus from the steel wool. If the manufacturer of the seal does not specify the correct interval of time clearly, the user should determine it for himself by trial on samples of flooring or in some inconspicuous places where imperfect results will not prove too disappointing. Once the user has learned how to work successfully with one brand of seal he will do well to stick to it, since he might have to learn the technique all over again with another brand.

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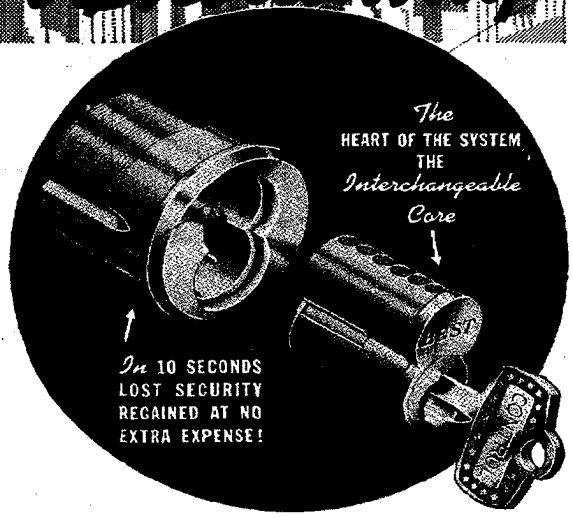

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facturers of floor-finishing materials and equipment, who are usually able to give precise and reliable instructions for the proper application and maintenance of their products. Seals are also sold by most of the larger paint and varnish manufacturers, although the preference of their dealers is usually for floor varnishes.

Waxing Floors

Waxing of floors is done to best advantage with paste floor wax and an electric polishing machine designed for the purpose. For best appearance and durability there is no satisfactory substitute for the polishing machine; polishing by hand is far too laborious for the modern household and too expensive for the business building. The paste wax is mopped on the floor, allowed to stand until the volatile thinner evaporates, which may take 15 to 30 minutes, and the floor is then polished with the machine. The most modern type of floor-waxing machine applies the wax and polishes in the same operation. For those who wish to get along without a polishing machine and are willing to accept a somewhat less attractive and less durable wax finish, there are water-emulsion floor waxes that are mopped on the floor and allowed to dry.

Refinishing Old Floors

Where floors have become badly discolored and worn by neglect or improper maintenance, the most practicable procedure and often the only one that will restore a fine finish is to have the old finish removed and the floor reconditioned by power sanding. Where the floors have been reasonably well maintained but the finish has become dingy with age, refinishing without power sanding may be practicable. The method of removal of the old finish depends upon the kind of finish that was used.

Old Oil Finish

An old oil finish, since it is embedded in the wood, may cause some difficulties. If a steel-wool buffing machine is available, an attempt should first be made to clean the floor sufficiently merely by buffing with No. 3 steel wool. If this is not feasible or proves ineffective, a chemical treatment will be necessary. Through the action of mild alkalies, the oil is changed to soap. The alkali used may be a water solution of trisodium phosphate, washing soda, or a commercial cleanser. If lye is used, care must be taken not to have the solution too strong because strong alkali swells and softens the wood. (If the oil contained mineral oil, however, there may be no practicable way of removing it, since alkalies do not saponify mineral oil.)

Application of Alkali

In applying the alkali, flush a small area of the floor at a time and allow to stand for a few minutes, then scrub with a stiff brush or No. 1 steel wool. Next flush with clean water and scrub to remove the soap that has been formed, and finally remove all the water possible by mopping and let the floor dry thoroughly. If the floor turns gray in color as a result of the action of the alkali and water, it may be necessary to bleach it with a saturated solution of oxalic acid in water (oxalic acid is poi-

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sonous and must be handled with great care). Rinse off the oxalic acid thoroughly with clean water, mop, and let the floor dry completely. Any raised grain or roughening of the surface of the boards as a result of the drastic treatments should be smoothed off with sandpaper or steel wool before new finish is applied.

Old Varnish

Old, discolored varnish finish is usually removed most easily by power sanding; but if desired it can be done with liquid varnish remover. Alkaline solutions in water and removers sold in powder form to be dissolved in water should not be used. The directions for using the liquid remover should be followed carefully. Since some old, discolored varnish remains embedded in the wood, complete restoration of the natural wood color should not be expected. Traffic channels where the old varnish has long been worn through and dirt ground into the wood should be cleaned by sanding.

Old Shellac

Old shellac and wax finishes that have merely become soiled by dirt clinging in the coating of wax may be cleaned by going over the floor with steel wool saturated with clean turpentine. Any white spots in the shellac caused by contact with water may be taken out by rubbing lightly with a soft cloth moistened with denatured alcohol diluted half and half with water, but the alcohol must be used with care to avoid cutting the shellac coating. On floors where the dirt is ground into the shellac itself or white spots penetrate all the way through the coating, more drastic treatment is necessary. First, wash the floor with neutral or mildly alkaline soap solution followed by clear water, using as little water as possible in each operation. Then scour the floor with No. 3 steel wool and denatured alcohol diluted half and half with water. If the floor boards are level and are not warped or cupped, the scouring can be done to advantage with a floor-polishing machine fitted with a wire brush to which a pad of the No. 3 steel wool is attached. After the scouring, the floor should be rinsed with a minimum amount of clean water and allowed to dry thoroughly before refinishing with shellac.

Floor Maintenance

Wood floors with fine finishes should never be scrubbed with water or unnecessarily brought in contact with water except in connection with refinishing old floors as already described. Sweeping or dry mopping should be all that is necessary for routine cleaning. A soft cotton floor mop kept barely dampened with a mixture of 3 parts of kerosene and 1 part of paraffin oil is excellent for dry mopping. When the mop becomes dirty it should be washed in hot soapy water, dried, and again dampened with the mixture of kerosene and paraffin oil. Exceptional patches of dirt that cannot be removed in this way may be removed by rubbing lightly with fine steel wool moistened with turpentine. Where the finish is a floor seal, badly soiled spots, such as gray spots where water has been allowed to stand on the floor for a time, can be sanded by hand, patched with seal, and buffed with a pad of steel wool. Varnish finish if kept in good condition offers better protection against water scars; but if it does become stained it is not so easily repaired.

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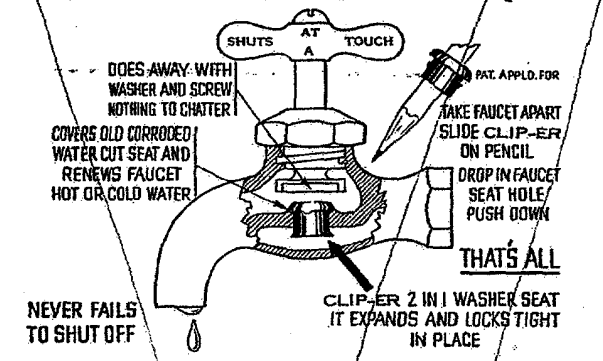

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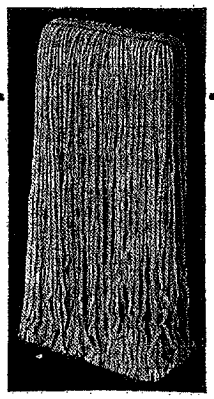

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Common Heating Problems

(Continued from page 41)

heating boiler being circulated in the shell around the coil to heat the water which circulates through the coil and to the tank. Installations of this kind are usually economical, but they must be kept clean. A type of indirect heater often attached to a steam boiler resembles a long cylinder which contains a steam chamber surrounding long water tubes or coils, the water being heated in the coils and conveyed to the tank for storage. All such attachments should be opened up at least once a year and thoroughly cleaned out, both in the steam chambers and in the water coils.

Still another form of indirect heating is the steam coil located inside the water tank, steam being supplied by the heating boiler. Perhaps the most recent type of heater is the coil directly within the boiler. This may be either the sort known as a submerged heater or the sort called an instantaneous heater. The former involves circulation of the water through the boiler coil and back to a storage tank. The so-called instantaneous or tankless heater likewise involves a coil located in the boiler water but not the use of a tank, the hot water being conveyed directly into the house circulating system. This is the most direct of all systems of hot water heating from the steam boiler and operates on the principle that the entire piping system of the building is a reservoir replacing the usual tank. It is obvious that good circulation throughout the hot water system is necessary if this type of heater is to be successful. Naturally the hot water cannot be heated from the steam boiler by any of the attachments or coils mentioned unless the capacity of the boiler is in excess of the load required to heat the building.

A hot water system which requires steam to be taken from the heating boiler and passed through a coil in the tank or to any of the attachments mentioned, will prove expensive in the summer when the boiler is not in use for heating the building, because such a system requires a head of steam on the boiler at all times. The amount of heat required to raise one pound of water from freezing point to boiling point as sea level is 180 Btu. The amount of heat required to push that same pound of water up from 32 degrees and turn it into steam is 970 Btu., or more than five times as much as was required to bring it from 32 degrees to 212 degrees. Therefore, with the use of the submerged or instantaneous type of coil, the boiler need be fired only enough in the summertime to raise the boiler water temperature to approximately 180 degrees, and the fuel required to do this is very much less than the amount required to make steam at the boiler.

A proper installation of the instantaneous coil system will include an automatic mixing valve which will introduce cold water into the line whenever the temperature of the water coming through the coil is higher than the temperature desired for the water in the water lines supplying bathrooms and kitchens. This, of course, requires aquastats on the boiler water, on the feed line, and on the lines supplying hot water to the building.

Air Supply

It is usually considered that a chimney causes a draft because the gases originating in the combustion chamber are lighter than air and therefore, rising up through the

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39

PAINTING YOUR HOUSE

By F. L. BROWNE
Forest Products Laboratory
Madison, Wisconsin

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PAINTING YOUR HOUSE

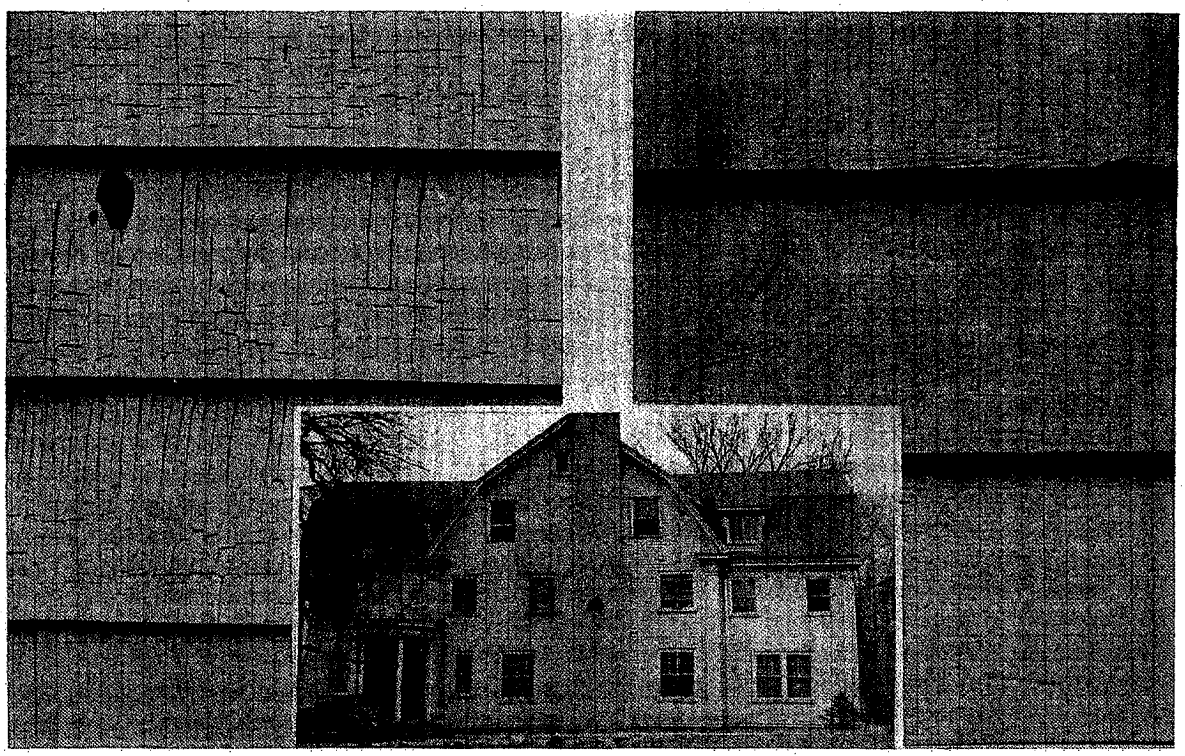
By F. L. BROWNE

The homes we live in form one of the greatest contributions of the forest to human comfort. In every house no matter what type its construction there is wood somewhere in large or small amount. With rare exceptions every home owner, therefore, is periodically confronted with the problem of painting and repainting the exterior wooden parts of his home, his garage or his barn. Beauty, serviceability and lasting qualities of the paint to be used are the owner's hoped for realization. Unfortunately most home owners are ignorant of how to achieve this combination of results. The author of this article has spent many years at the Forest Products Laboratory, Madison, Wisconsin, studying paint with special reference to its use on wood. In "Painting Your House," he deals with the subject from the home-owner point of view.—Editor.

DISCUSSION of house painting usually begins with a consideration of the different kinds of house paint. You can buy paint and you can hire a painter but what you want is paint maintenance and that you cannot buy. The job of putting paint and painting together to make a program of paint maintenance is all yours. Whether you like it or not you cannot dodge the responsibility if you are a home owner. Your ignorance of the technical problems involved does not let you out. You pay the damages anyway if paint, painter, and program fail to fit together.

The new house starts out with a coat of paint that is durable for no more than four or five years. The house may stand for a century or two but let us say that it has an expectancy of half a century as a building of prideful occupancy. Ten or twelve renewals of the paint coating within that time are to be anticipated if you wish to keep the coating always in good condition without unnecessary expense. Since a worn out coating is not easily discarded renewal rather than replacement is essential for economy.

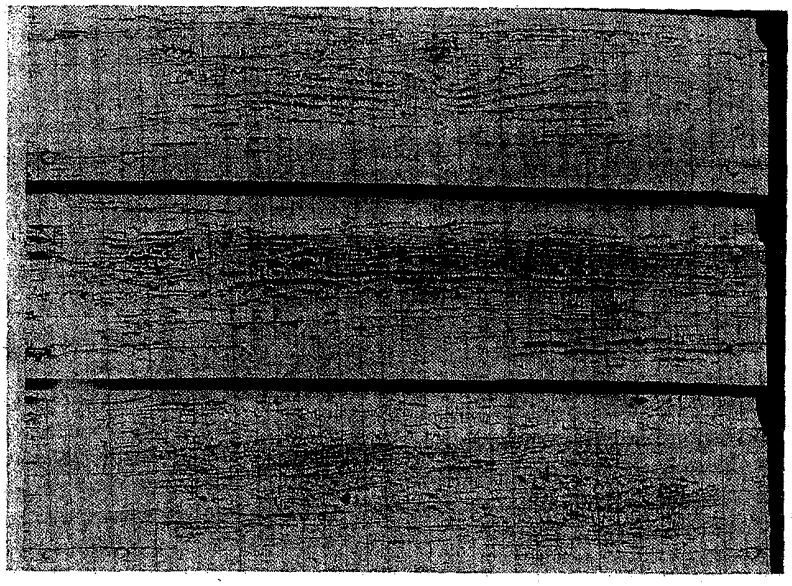
Renewal means that new paint is applied over what remains of the previous paint and that the composition of the renewed coating depends upon that of the old paints as well as that of the new paint. You therefore need good paint for *your* house, not just good paint in general. The latest marvel of the paint industry is no good to you unless you can be reasonably sure that it behaves properly when incorporated with the old coating already on your house. If repainting every four or five years seems reasonable to you and you hire good painters to do the work the annual cost of maintaining the exterior paint may well be less than a third of the annual real estate tax provided the maintenance program is properly guided. Two things should be watched carefully—stick to your pro-



For economy and good appearance your house should be painted every four or five years. Be sure that in repainting you always use the same kind of paint you start out with when the house is new. Above is shown an excellent reason why. This house was originally painted in color. Then a new sidewall was built on the right side, after which the whole structure was painted white. The detail at left shows the colored paint under the white—at right the section on which only white paint has been used

gram so that you always repaint a little before the coating begins to break up and stick to the same kind of paint with which you start out when the house is new. A systematic written record of the painting history helps materially in keeping the program on the right track. In noting the paint used, an accurate copy of the complete formula, or better yet one of the labels bearing the formula, should be preserved.

The time to consider the many kinds of house paint on the market is when choosing the paint for a new house or when failure of the program of maintenance has made it necessary to remove the old coating to start over again. The rival advertising claims and the confleting opinions of experts may then be pondered carefully. Each paint will be found better and more durable than any of the others but no paint maker will allow himself to be pinned down to a claim of more than four or five years for the durability of his paint. When the field of possible choice has been narrowed down somewhat according to your likes and dislikes among the makers and dealers it is a good plan to look at some houses painted with the paints in question three or four years previously.



If you wait too long between paint jobs and repeatedly use paint of a hard type—this is the result. So unless you repaint frequently it is best to use pure white lead paint for white and tinted white colors

A survey of neighbors' experience is likely to prove a liberal education in paint maintenance. In the first place unless the neighborhood is very exceptional it will show that few owners stick consistently to one type of paint, follow a systematic plan of maintenance, or keep a record of the dates of painting and kinds of paint used. That is often why they get into trouble eventually. In the second place your survey will show that any one kind of paint may give satisfactory service or very unsatisfactory service according to its suitability for the maintenance program and its compatibility with the paints used previously. When a hodge-podge of different kinds of paint occasionally stands up well for a long time the owner is merely lucky. The wise owner plays safe by making changes in kind of paint only when he knows that past experience justifies the specific changes in question.

After surveying the neighbors' experience you may still feel unable to decide what kind of paint is best but probably will conclude that, for the new house, it is much less important than you originally supposed. Almost any one of the good paints on the market should prove satisfactory if you use it consistently in the future and renew it at the proper intervals. Make sure, however, that the paint you select is labeled with a complete statement of composition so that another one like it can again be purchased, even if the manufacturer meantime changes the composition of the brand you are now choosing.

Once your house is erected and painted no further thought should be given to the rival claims of different kinds of paint. The decision has been made. Stick to the kind with which you began. If for any reason something goes wrong and you are dissatisfied find out what was wrong and what can be done to set it right. Do not blindly experiment with some other kind of paint for you will merely make a bad matter worse.

Many house owners feel that painting every four or five years is unreasonably expensive. As a rule, of course, they belong to groups of lower income level to whom the cost of a paint job is a real burden and who in times of financial depression find it hard enough to keep possession of the house at all. In justification of their expectations there is a long tradition of American practice in house painting according to which maintenance programs with ten years or even more between jobs were taken as a matter of course. Programs with painting every four or five years are a relatively modern innovation perfectly proper where the standard of living permits but we must recognize that large portions of our population have not yet been lifted above the urgency of immediate necessity. If a man must choose between paint for the house and shoes for the children by all means let the children have shoes. The house will suffer less from worn out paint than will the children from worn out shoes.

The choice of suitable paints for programs with more than four or five years between paintings is greatly restricted. The old red or brown iron oxide paints were durable for as much as ten years but in modern times "barn paints" have deteriorated very seriously in quality until it is now difficult to buy a really good one. Two or three coats of aluminum paint are durable for very long periods but the metallic appearance rarely proves agreeable for houses, though it is sometimes attractive for barns and other utilitarian structures.

For the most part programs with long intervals between paintings are based on the assumption that each paint job will pass through a considerable period of neglect following the break up of the coating before another paint job is put on. The paint for such programs,

therefore, must be chosen for its ability to retain a reasonably presentable appearance during the period of neglect and to leave a surface that can then be repainted without danger of impairing the serviceableness of the next paint job. Durability of the paint is not important, in fact the paint should not be too durable because the less of it left when repainting finally is done the better.

Of the so-called first grade white or tinted white paints on the market pure white lead paint is probably the only one that can properly be advised for maintenance programs that presuppose periods of neglect. The old tradition from which such programs come was based on the exclusive use of pure white lead paint because it was the only white paint available until comparatively modern times. All attempts so far to make white paints less subject to soiling and fading of tints and more durable have led to paints that are harder in nature than white lead paint.

Because the newer paints are harder they break up more objectionably when neglected and do not wear off as much by erosion with the result that, when the belated repainting is done, there are thick patches of uncertainly adhering old coating interspersed with patches of bare wood; the painter is unable to apply new paint smoothly, and the new job is less durable than the previous one. Ultimately, complete removal becomes necessary, the expense of which is inconsistent with a program of extreme economy. Those who wish to wait a long time between paint jobs will do well to insist on pure white lead paint for white and tinted white paints.

If you belong to the relatively small class of house owners who insist upon superfine appearance obtained by repainting every year or two you have selected the most difficult program of all and must expect to pay well for it. Complete removal of the coating at intervals, say every ten years, should be anticipated. Fortunately the painter's blow torch is no longer the only means of removing old paint. There are now house paint removers on the market that will do a better job with less hazard of fire and usually at somewhat less cost. At best, however, complete removal is too expensive to put up with any oftener than is necessary.

The first difficulty with frequent repainting lies in the fact that the coating does not have time to wear away much between jobs, hence it becomes materially thicker at each painting. No paint behaves well when the coating is too thick. Cracks appear at an unreasonably early age and take the form of huge gashes. Coarse scaling sets in at an age when a thinner coating would not have begun to break up at all. Each paint job becomes less durable than the one before it. For these reasons the least possible amount of paint should be applied at a time and the paint used should have unusually high hiding power. No more than one coat should be applied at each painting.

The second difficulty with frequent repainting is that incompatibilities between paints of different kinds are often more pronounced the less the earlier paint has weathered before it is repainted. Those parts of the house that are greatly sheltered from the weather are particularly prone to difficulty on this score. Meticulous adherence to the same type of paint for each painting is very necessary in programs calling for frequent repainting.

Those who paint so often may be deceiving themselves through a lack of understanding of the course of events in the aging of paint. Soiling of the coating progresses most rapidly during the first year or so, while the paint is still glossy. When gloss disappears and chalking sets in the dirt may begin to be dislodged and the cleanest and most pleasing period of the paint's life may continue until the coating finally begins to disintegrate. If white paint is repainted when at its dirtiest stage the period of best appearance may be sacrificed only to start in again with the dirt collecting stage. With white paints, a little patience while the coating sheds its dirt may be better than hastily repainting.

With tinted paints appearance is marred at first by dirt and later, as the dirt is dislodged, by fading of color. If the initial color must be maintained exactly frequent repainting may be necessary. A little more care in choosing color at first may make it less essential to retain the initial color exactly. Yellows and buffs can fade rather seriously and still look well but when light greens and light blues fade they look shabby. Too frequent repainting can often be avoided by considering the faded color as well as the initial color in selecting tints at the outset.

Those who are tempted to paint too frequently in order to keep particularly good appearance at all times might well consider washing as a substitute for some of the repaintings. Instead of painting every two years wash after a year and a half and repaint with one coat after three or four years. For such a program paint of rather hard type should be chosen because it lends itself readily to washing and since it chalks superficially rather than deeply washing restores practically the initial color. After washing it will be found that dirt collects less seriously than it did after the paint was first applied. Use of an alkaline solution of trisodium phosphate which removes some paint from the surface making the coating a trifle thinner is advised if washing is done.

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An Open Letter From Dr. Browne

Madison, Wisconsin.
April 22, 1939.

The Editor,

National Paint Bulletin,
Washington, D. C.

An item in your Bulletin, Vol. 3, No. 1, page 8 (January 1939), in which a paint manufacturer's advertising matter comparing formulas for certain well known brands of paint is reported, deserves further discussion because it illustrates very well some of the difficulties in explaining formulas in their present complicated form to laymen without confusing or misleading them. In continuing the discussion, however, a different set of paint formulas to illustrate the points raised will be chosen so that reference to brands of paint on the market or to specific manufacturers will be unnecessary.

Two common causes of misinterpretation of formula labels are exemplified in the item in the January Bulletin, (1) failure to appreciate the significance of the percentage of total pigment in the paint, and (2) the difficulty in telling from the conventional method of expressing paint formulas when "extending" pigments are used sincerely to control desirable paint properties and when they are adulterants. The second point is further confused by ambiguous nomenclature for paint ingredients and varying practice in dealing with the composite pigments. Both points can be illustrated to advantage by discussing the formulas of five paints now being subjected to exposure tests on the test fences of the Forest Products Laboratory. These formulas might appear on formula labels, following conventional practices, as shown in Table 1. All of the paints are thoroughly practical house paints the consistency and brushing qualities of which resemble closely commercial paints of the types represented.

Paints A and B represent a common comparison of manufacturers' first grade paints before the titanium pigments became so popular. The comparison is still reasonably applicable to tinted paints. The layman, overlooking the difference in percentage of total pigments in the two formulas, assumes that formula A contains more white lead and zinc oxide than formula B because the pigment in the latter contains 10 percent of "extender". The fact is that formula A contains 10.3 pounds of white lead and zinc oxide per gallon whereas formula B contains 10.6 pounds. If formula B is "adulterated" with magnesium silicate formula A is likewise adulterated with excess vehicle. That the excess vehicle in formula A is not demanded by requirements of consistency is shown by formula C, which has practically the same consistency as formula A but is made, of course, with a different type of zinc oxide and a different linseed oil and contains 12.7 pounds of white lead and zinc oxide per gallon. To the best of the writer's knowledge no LZ paint with so high a content of white lead and zinc oxide has ever been sold commercially. Its performance on exposure will prove surprising to those whose experience with LZ paints of high content of zinc oxide is limited to formulas such as A.

In Table 2 the five formulas of Table 1 are recalculated in terms of volume, expressing the composition of each ingredient in terms of gallons per gallon of paint. The sum of the white lead and zinc oxide in formulas A and B is exactly the same, 0.200. Formula A, which from Table 1 the layman assumes has less linseed oil than formula B, in Table 2 is found to contain more oil. Comparing formulas A and C, the layman, overlooking the difference in percentage of total pigment in the two paints, assumes that they contain the same amount of white lead and zinc oxide whereas formula C actually contains 25 percent more. On the other hand the difficulty in telling the layman how to take proper account of percentage of total pigment in formulas expressed by weight is apparent on comparing the five paints in Tables 1 and 2. Formulas A and E are both relatively low in percentage of pigment by weight but by volume the comparison is 0.200 with 0.268 gallon per gallon of paint. By volume formulas D and E are practically identical in content of total pigment but by weight they contain 67.8 and 64.4 percent respectively.

Formulas D and E illustrate the new position of the "extending" pigments since titanium dioxide came into wide use. Prior to that time the proportion of magnesium silicate in formula B, about 20 percent of the pigment by volume or 10 percent by weight, was roughly the maximum for transparent pigment in paints generally accepted as properly "first grade." When barium sulfate is used instead of magnesium silicate in formula B the percentage by weight is 15 rather than 10 because of its smaller bulking value. Formula E, however, which is unquestionably a first grade paint of the present day, contains more than 21 percent magnesium silicate in the pigment and is much superior in hiding power to formulas A and B, being slightly better even than formula C in that respect. In formula D there is barium sulfate to the extent of 30 percent of the pigment by weight although the buyer of the paint will not realize that fact from the common way of printing the formula on the label unless he knows that titanium-barium is 70 to 75 percent barium sulfate.

Comparison of the five formulas shows clearly that it is impossible to tell laymen how to distinguish between use of "extenders" as adulterants and their use to supply pigment bulk beyond the requirements of opacity so long as laymen are presented with the complicated formulas by weight. Even in the days when the lead and zinc paints alone were to be considered, the rule that "extenders" should not exceed 10 to 15 percent of the pigment was properly applicable only so long as the total pigment was 66 percent or more of the paint, but now that the paints containing titanium pigments must also be included the rule has no validity at all.

To all practical purposes formulas D and E are essentially the same, yet buyers are likely to be misled by the fact that the label for formula E discloses a large proportion of "extender" whereas the label for formula D apparently discloses none. To the user of paint "extenders" have exactly the same effect whether they are put in by the pigment manufacturer or by the paint manufacturer. Now that the public is thoroughly accustomed to titanium pigments in paint it would be much simpler and more reasonable if the composite titanium pigments were indicated on formula labels just as the composite leaded zinc oxides have long been indicated, namely, by stat-

measure, developed several years ago at the Bureau of Standards, has come into considerable use. The first application of the process in the documentary field was by the National Archives of the United States. It was chosen as the best, and in fact, the only feasible means of laminating the vast number of documents received by the National Archives, which require such treatment. The process is speedy and has many advantages. The sheeting is applied by means of heat and pressure, no adhesive being used, and a homogeneous unit is obtained, as the cellulose sheeting is actually forced into the pores of the paper. The acetate sheeting used is very stable, has high transparency and strength, is very thin, is easily cleaned with water, and is resistant to insects. These are all properties that are particularly desirable for documentary purposes.

Four commercial operators make a business of laminating documents with the acetate sheeting. Two of these use only heat and pressure; the other two use an adhesive in addition. An adhesive permits lamination at lower temperatures and pressures, but care must be taken that the adhesive is stable, and that it will not cause deterioration of the laminated paper.

Because of the high stability and other good qualities of the acetate sheeting, as shown in the Bureau's reports, it is also finding considerable use in the form of envelopes for the protection of stamps and other kinds of sheets, where lamination is not desirable.

A New Set of Chemicals

Chemists have long pondered on how to utilize the chemical value of the paraffins—methane, ethane, propane, etc.—the principal constituents of natural gas. No chemical process has been found of sufficient activity to break down the inertness of these paraffins, to attach chemical groupings of controllable reactivity that would make them commercially useful. The very name par-affin, "no affinity," was given on account of their inertness. (Englishmen call certain liquid petroleum products paraffin, and Americans call the solid wax of petroleum by this same name, but this is not inconsistent, since these, as well as the gases referred to, are all members of the long series of true paraffins.) Initial compounds have now been made which may be handled in conventional ways to produce a great variety of chemicals new to commerce. This has been made possible by the technique of nitration in the gaseous form. It is understood that Commercial Solvents Corporation is to have a production unit in operation by the end of 1939.

The nitroparaffins, as the first reaction products are called, consist so far of nitromethane, nitroethane, and four other individuals. These are colorless, mild-odored, heavy liquids which boil in the useful range of 212-300°F. They are direct and active solvents for nitrocellulose and for a wide range of synthetic and natural resins as well as for fats and some dyes. Mixed with alcohols, they are solvents for commercial cellulose acetates. Nitroethane is a heat sensitizer which brings about the gelling of rubber latex; chlorinated nitroparaffins, on the other hand, have attracted considerable attention as anti-gelling agents, useful in rubber cements.

The great anticipated use for the nitroparaffins is as raw materials for further chemical reaction, to produce a whole family or group of families of chemical derivatives. The first publicized use is for making explosives, suitable for warfare or for blasting purposes in peacetime. The nitromethane used is not itself an active explosive, but after being reacted with formaldehyde forms a nitrotrialcohol, which is the basis for nitration to a compound comparable with nitroglycerine.

Nitroalcohols may also be used in conjunction with fatty acids to form emulsifying agents likely to find uses in polishes, of either the oily or watery type. Market surveys indicate that ammonia derivatives of nitroparaffins may command markets in numerous industries, due to their marked reactivity, for use in the manufacture of synthetic organic chemicals.

Opportunity now exists for the organic chemist to use the nitroparaffins and their derivatives as raw materials for industrial derivatives in great variety. The field is wide, and at this stage appears to offer good prospect for a healthy new branch of chemical industry.

—*Ind. Bull. No. 146.*

Sebacic Acid as a Plasticizer

It appears as though B. O. has another use besides serving as an incentive for the manufacture of soap. Sebacic acid, an important constituent of perspiration, is now manufactured on a commercial scale, and is incorporated as a plasticized in certain synthetics. The final product is said to be practically free from odor.

AS A MATTER OF POLICY

The National Paint Bulletin does not usually publish articles which are anonymous. However, to encourage candid and honest expression of opinion in controversial matters, the Editor will respect the confidence of any correspondent who prefers to have his name omitted from appearing in print. So, if you have any pet views or want to "get something off your chest," just let us know about it; you will probably feel better afterwards.—J. R. S.

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ing the ingredients of the composite pigments separately. Formulas C, D and E, which according to the conventional formula label contain basic sulfate white lead and zinc oxide, were made in fact with cofumed leaded zinc oxide. The titanium pigments might just as well be handled in the same way, namely, by listing the percentages of titanium dioxide, and of barium sulfate, magnesium silicate or calcium sulfate and letting the public forget that there are pigments with such strange names as titanium-barium, titanium-magnesium, and titanium-calcium.

In connection with the resolution favoring formula labeling adopted last fall by the National Paint, Varnish and Lacquer Association, the Scientific Section published a special circular on "Nomenclature for Formula Labeling" that deserves more serious consideration by the industry than it seems to have received so far. It recommends that each ingredient be reported separately and that ambiguous terms such as "titanium white" and presumably "titanium pigment", which might mean any one of the titanium pigments or a mixture of them, be avoided. It also recommends that "inert" pigments be reported by their chemical names, which would preclude lumping them together under the names "inert pigments" or "extenders." Standardization and improvement of the nomenclature of formula labeling should prove helpful both to the industry and to its customers; it is to be hoped that this circular will mark the beginning of a sustained effort to make paint formulas more easily understandable by the public.

It is not always appreciated even by technologists that the terms "inert pigments" and "extenders" have a double meaning, namely, chemical inactivity and optical transparency. The two properties were at one time nearly always concomitant, at least among white pigments but that is no longer true. Titanium dioxide is chemically inactive but optically very opaque whereas calcium carbonate is optically transparent in linseed oil but probably is chemically active. In the interest of mutual understanding it is desirable to avoid the terms "inert pigments" and "extenders", using instead terms that clearly indicate whether the reference is to chemical or optical properties. For chemical properties suitable terms are chemically active and chemically inactive pigments. It should be remembered, however, that chemical activity is by no means confined to formation of soaps.

For further details about the Forest Products Laboratory procedure for expressing paint formulas in proportions by volume reference is made to Industrial and Engineering Chemistry, Vol. 29, p. 1018, (Sept. 1937). The system leads to a "technical man's shorthand" by means of which the formulas of the five paints of Tables 1 and 2 can be expressed completely enough for most practical purposes in the following very concise symbols:

Formula A — LZ_{55}, p/nv 23, division O.

Formula B—$(LZ_{30})_{80}$, p/nv 28, division N.

Formula C — LZ_{54}, p/nv 27½, division L.

Formulas D and E—$TL_{27}Z_{24}$, p/nv 28½, division L.

The system of classification proposed by the Forest Products Laboratory for giving paint users the information they need for intelligent understanding of the composition of paints would describe the five formulas of Tables 1 and 2 in the following terms:

Formula A—Type LZ with high content of white lead and very high content of zinc oxide, *Division* O.

Formula B—Type LZ with high content of white lead and medium content of zinc oxide, *Division* N.

Formula C—Type LZ with high content of white lead and very high content of zinc oxide, *Division* L.

Formulas D and E—Type TLZ with medium content of white lead and medium content of zinc oxide, *Division* L.

TABLE 1
Formulas in percentages by weight

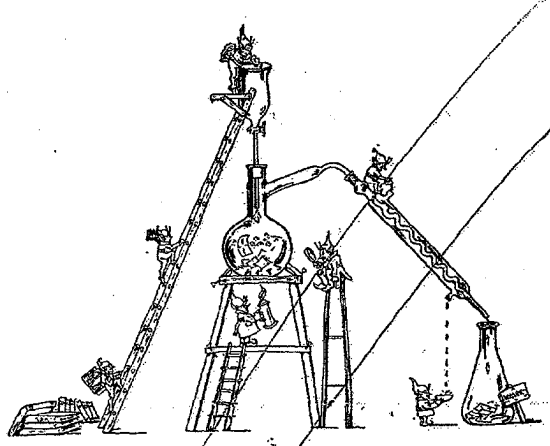
Designation	Formula A	Formula B	Formula C	Formula D	Formula E
Unit	Percent	Percent	Percent	Percent	Percent
Pigment	62.6	67.2	68.7	67.8	64.4
Vehicle	37.4	32.8	31.3	32.2	35.6
Pigment composition:					
Basic carbonate white lead	50.0	60.0	23.0	20.0	22.36
Basic sulfate white lead	.....	.....	27.0	14.0	15.30
Zinc oxide	50.0	30.0	50.0	26.0	29.70
Titanium-barium pigment	.....	.....	.....	40.0	.....
Titanium dioxide	.....	.....	.....	.....	11.17
Magnesium silicate	.....	10.0	.....	.....	21.47
Vehicle composition:					
Linseed oil	83.46	86.76	89.87	82.6	79.8
Bodied linseed oil	.....	.....	.....	7.3	7.1
Drier and thinner	16.54	13.24	10.13	10.1	13.1

TABLE 2
Formulas by volume according to the Forest Products Laboratory system of classification

Designation	Formula A	Formula B	Formula C	Formula D	Formula E
Unit	gallons	gallons	gallons	gallons	gallons
Basic carbonate white lead	0.091	0.125	0.051	0.042	0.041
Basic sulfate white lead	.....	.....	0.064	0.031	0.030
Zinc oxide	0.109	0.075	0.135	0.065	0.066
Titanium-barium pigment	.....	.....	.....	0.131	.....
Titanium dioxide	.....	.....	.....	.....	0.036
Diluent allowance	.....	.....	.....	.....	(0.095)
Opaque pigment	0.200	0.200	0.250	0.269	0.268
Magnesium silicate	.....	0.050	.....	.....	0.095
Total pigment	0.200	0.250	0.250	0.269	0.268
Linseed oil	0.660	0.645	0.670	0.596	0.593
Bodied linseed oil	.....	.....	.....	0.057	0.057
Nonvolatile	0.860	0.895	0.920	0.917	0.913
Drier and thinner	0.140	0.105	0.080	0.083	0.087
Total paint	1.000	1.000	1.000	1.000	1.000

FACTORIUM

This is a special department devoted to the interests of tired technical or business men who do not have the time to read and absorb the mass of available technical literature. Essentially, the following statements are a series of pertinent facts which have been boiled down by your editor to a concentrated residue, distilling off the unnecessary or less interesting preliminary discussions. Although the following information is given in only a few pages, it nevertheless represents a condensation of hundreds of pages of the recent voluminous mass of technical paint literature. It should be pointed out also, that these are not intended to serve as abstracts, reviews or digests. The primary object is merely to state in concentrated form, the conclusions of extensive investigations which have come to our attention. Although we use great care in the selection of the statements regarding their authenticity, it is difficult, of course, to assume any responsibility for the merit or validity of the statements.



793. **The secret of good varnish making, according to Dr. Robert J. Moore** lies in the proper dispersion of the oil resin polymers. Those containing completely polymerized dispersions, unaffected by oxidation, give excellent films. Resin wax dispersions of increased strength and moisture resistance can be made satisfactorily with halowax. Moore also has disclosed a method for making ultraconic dispersions. Surface forces, such as surface tension, play a very important part in colloids and emulsions.

794. **Copper naphthenate is now being used in the paint industry** for a variety of purposes. A solution of 20% copper naphthenate in petroleum thinner will control *Merulius lacrymans*, and other fungi attacking wood. It can be used also in termite control, for preserving shipping bags and as a anti-fouling composition in ship bottom paints. Copper naphthenate is made by combining copper with the naphthenic acids found in petroleum. A uniform product is now on the market which is soluble in kerosene, toluene, turpentine and in many other common solvents.

795. **Red lead paints show a great decrease in negative potentials** while uncoated steel shows a decided increase. A steel rod dipped in water containing red lead and washed of any visible traces shows a passive state. Zinc dust acts as a reducer, while red lead as an oxidizer. Together they would act rather upon each other than upon the metal surface. Graphite is an inert pigment and acts well when mixed with red lead. Iron oxide does not have the lubricating properties of graphite, but is much cheaper and can be used with red lead as an anticorrosive.

796. **In Russia, new type paints are being made** with albuminous binders, derived from oil seed press cake and extraction wastes. Promising results are also expected with specially prepared water paints. To this end, about 98% of cellulosic material is removed from the finely ground press cake and extraction waste by sifting the residue and emulsifying with 5% to 10% sodium hydroxide. The emulsions obtained from the waste products of castor, soybeans, cotton, flax and sunflower seeds can be mixed with suitable pigments and 1.65% to 3.3% phenol to give stable dry mixtures, pastes or ready-mixed paints.

797. **The frothing of varnishes can be prevented** by the use of cholesterol and vegetable phosphatides. Some of the natural components of rubber latex have also been found useful for this purpose.

798. **In Germany, it has been found that the refractive index of emulsion vehicles is a very important factor.** For instance, it has been concluded that the luster of bronze finishes is affected, the hiding power of pigments is varied and the compatibility with other materials is determined. The bronze luster of Milori blue is especially affected by the refractive index.

799. **Like nitrocellulose, chlorinated rubber needs a plasticizer,** but its range of compatibilities is much wider so that all the usual plasticizers and even oils and soft resins are effective. In general, it is not compatible with cellulose derivatives or simple vinyl resins, and its solubility relations make it incompatible with shellac, copal or any resin soluble only in alcohol. Its paint products include those made solely with synthetic plasticizers; oil blends; oil-free blends; and a variety of varnishes in which chlorinated rubber is only a minor ingredient. In the plasticized finishes, both plasticizer and pigment should be chemically inert in order to utilize the extreme chemical resistivity of chlorinated rubber. High weather resistance is also achieved in these finishes. In the oil blends pigmentation must not exceed a critical value beyond which elasticity rapidly decreases. In the resin blends, those with alkyd resins are outstanding, giving such highly elastic coatings that they can be used on metal for stampings. Many of the commercial products are combinations of oil and resin blends. Among the chlorinated rubber primers, those with red lead have much faster drying time than red lead in oil. Many coatings for special purposes are improved by a small addition of chlorinated rubber. Aside from high resistance to chemical attack and good mechanical properties, the chlorinated rubber paints are useful for rust prevention, protective coatings on concrete and masonry, special finishes on light metals and wood, paints for

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National Real Estate Journal Sept. 1939

(4)

Some Painting Problems and the Answers

by F. L. Browne
Senior Chemist, Forest Products Laboratory
Madison, Wisconsin

THE life of paint is limited to a few years; the coating must be maintained by applying more paint from time to time. From five to six times as much house paint is required for renewal of old coatings as is consumed in the initial painting of new woodwork. Those who make and sell paint are in the habit of thinking of all these paint jobs as separate transactions independent of the jobs that went before or are to come after them. The house owner, to be sure, buys his paint jobs one at a time, but his real interest is in a coating satisfactorily maintained over a long period of years. Much of the misunderstanding and disagreement about paint comes from failure to appreciate that paint maintenance is a long-term matter, made up of a succession of paint jobs that must fit together into a harmonious whole.

Paint maintenance is successful when it comes up to reasonable expectations both as to continuance of the chosen decorative effect and as to cost. Owners' expectations, however, vary widely. Some, following tradition of long standing, expect to repaint no more often than intervals of eight or ten years. Others, whose decorative standards may be more exacting, are willing to paint every four or five years. A negligible few may be willing to paint still more often. Practically no one, however, expects ever to be put to the extra expense of completely removing old coating before applying a new one and any maintenance program that leads to such eventuality may be regarded as unsuccessful.

All of the above expectations can be satisfied with good house paints now on the market, but no one kind of paint is capable of satisfying all of them. It is idle, therefore, to attempt to discuss good paint in general terms—we must discuss it with reference to the kind of maintenance program for which it is suitable.

The Cure for Poor Paint

Although the writer has rarely encountered really inferior paints in the cases of paint complaints he has examined, he is told repeatedly by paint manufacturers and others that much inferior paint is made and sold. The Federal Trade Commission and Better Business Bureaus take action against notoriously bad paint from time to time, but they can deal only with paints so inferior in quality that their sale is a downright fraud. Paints that are merely inferior in quality, but not clearly fraudulent can be dealt with effectively only by clearly defining good paint. When the regional lumber manufacturers were preparing their pamphlets on painting instructions for insertion in bundles of bevel siding they found that there is only one kind of good paint defined in such a way that it can be discussed in general recommendations. That paint is pure white lead, commonly known as lead and oil. Other kinds of good paint are identified for sale by trade brand only, vary widely in composition, but conform to no standards by means of which the various kinds and grades can be recognized by the users.

The Forest Products Laboratory has recently shown that it is perfectly practicable to define good paints of all kinds in such a way that they can be set apart from inferior paints. In fact, it is technically feasible to classify paints in a logical manner. The proposed "grading" rules, though technical in nature, are much simpler than the various grading rules for lumber. While some technologists of the paint industry recognize the desirability of classifying paints, the paint industry has not adopted it.

"Moisture" Failures and Their Cure

Access to moisture behind painted woodwork is the cause of one large class of early paint failures. The moisture may get in through carelessly designed or erected joints in the construction, or by condensation of moisture laden air from inside of the house when it comes in contact with the cold back surfaces of the exterior woodwork. Trouble from condensation has probably increased materially in recent years because of the greater use of thermal insulation, which makes the back surfaces of exterior woodwork colder by letting heat escape from inside, and because of provision of air washing and humidification in modern heating plants. Condensation of this kind is more troublesome in the northern parts of the country, but in more southern areas where studs are sometimes covered with drop siding without sheathing and heating is accomplished with inadequately vented open gas burners, condensation on or in the sidewalls or under the roof sometimes occurs as a result of the large amount of moisture formed in the combustion of gas.

Condensation in sidewalls and attics can be prevented by keeping moisture from passing through the walls. This can be accomplished by the correct installation of vapor barriers on the *inside* of the studs and *underside* of attic floor joists. In houses already erected two coats of aluminum paint on the interior surfaces of side walls and ceilings under the attic make an effective vapor barrier over which other wall decoration may be applied. Where moisture arises from open gas burners

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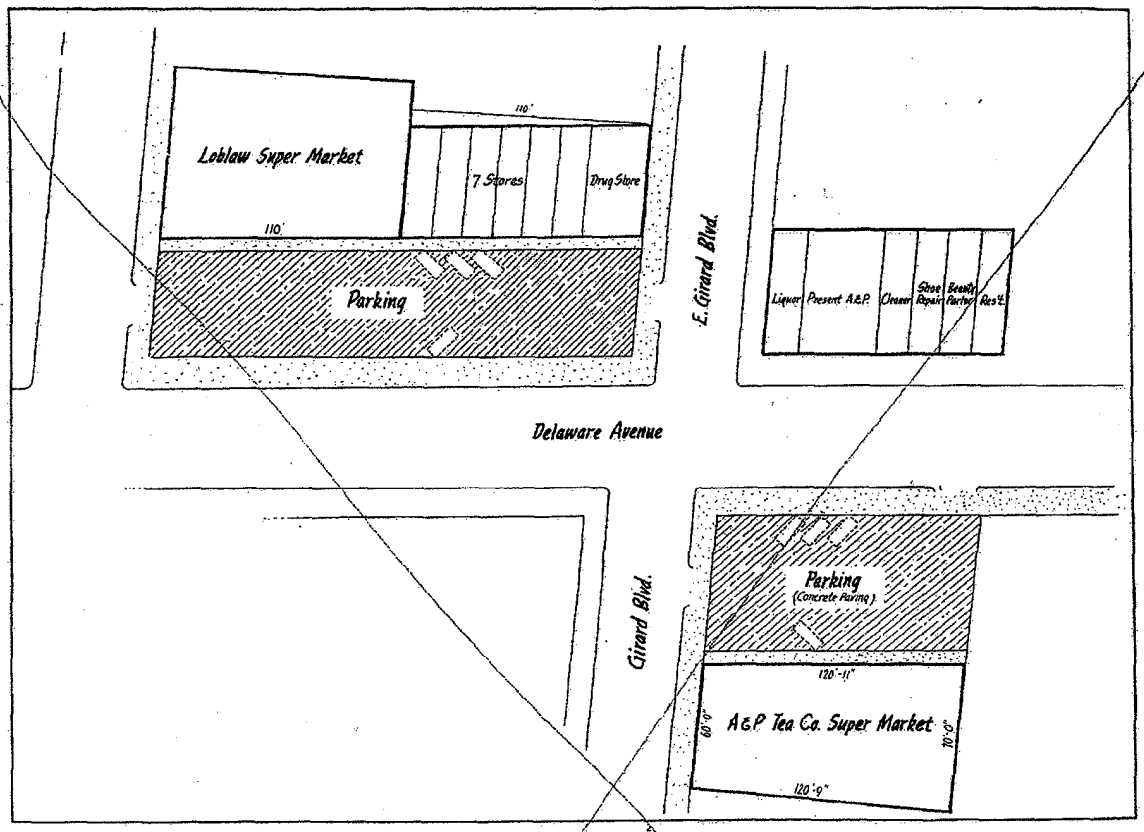


lowing the same lines as the old central districts (there are exceptions of course), with very little thought given to the automobile or its effect.

"Small business districts in themselves, providing for merchandise, services and amusement, will spring up during the next decade, providing beautiful parking facilities and all of the stores, shops, offices and theatres to which a person is accustomed. They will have proximity to the walking shopper as well as to the automobile.

"We here in western New York have attempted new developments incorporating the idea of parking, and are planning others. In Kenmore, New York, an entire block of land was taken and the buildings were set back seventy feet from Delaware Avenue, providing double-lane parking in front, with the lot concreted, well drained and well lighted. This development will house a large Loblaw super market and seven shops, the whole development being as complete a shopping unit as possible.

"From our observation, we note that most people prefer to drive up in front of a building, get out of their cars and go into a store, rather than go to the rear and then walk around. Front parking lots are generally much better kept by the merchants than rear lots, and are therefore more attractive. A front parking lot is much more convenient for quick stops and quick purchases, which applies to Monday through Friday business.

"We have done another development in Rochester at Ridge Road and Dewey Avenue, where only rear parking was provided. In any such development involving a large frontage your principal profit comes from the shops, since the large stores bring the customers and the small stores are more or less parasites, paying rent based on the major attraction. We have noted that where only rear parking is provided, customers are inclined to go into the rear of the large stores, do their shopping, go back out the rear into their cars, and away, without seeing the shops in front; therefore, the shops do not get the full benefit of the major attractions and it hurts the rental value.

"In ordinary parking developments you do not always have the flow of pedestrian traffic up and down in front of the stores—rather it flows from the parking lot to the store, and back. In the Rochester development, a variety chain is now building and the community is rounding itself out, and while the parking facilities will act as a stabilizer, they are not ideal.

"We are attempting another development now which will provide both front and rear parking, it being the thought that the rear parking will take care of all overflow, which is particularly important during heavy week-end shopping and for theatre parking.

"In order to have ideal parking facilities, there should be enough area so that you will not have any need to worry about congestion. The flow of traffic in and out of your development should be free of all restrictions. To charge even a nominal sum or require a customer to buy something is a restriction that keeps people away. Parking must be as free as water in order to be the most successful.

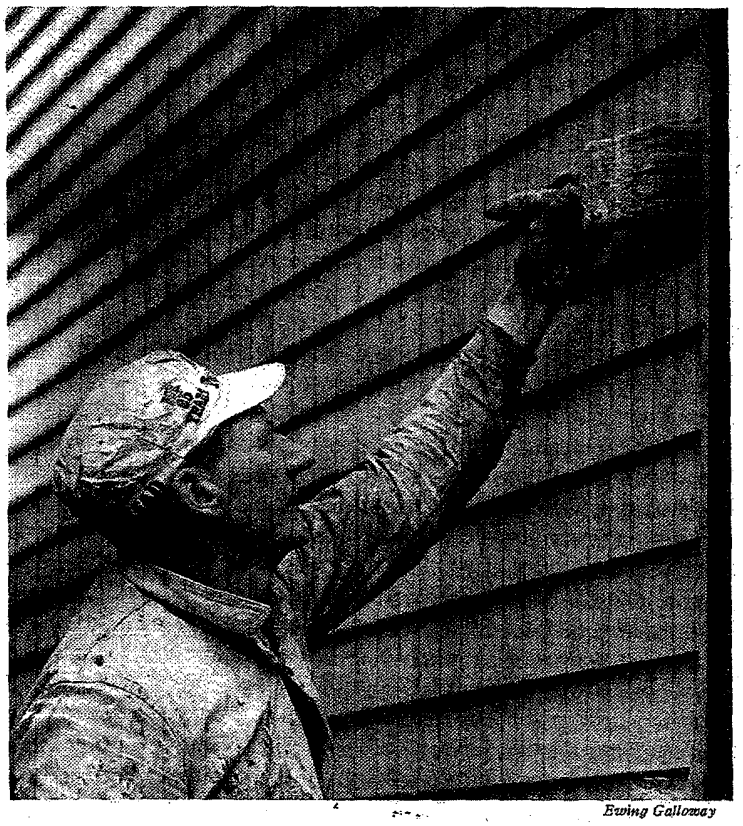
"Because you are providing convenience in order to create habits, and in creating habits you are creating values, since merchants will pay rent in accordance with the business they can do, and their business is dependent upon the great god 'Habit'."

FLB 001025

it should be carried off by means of adequate flues.

Much moisture is evaporated in houses during normal living operations such as cooking, bathing, laundry work, and the breathing of persons and plants. Families undoubtedly vary in their living habits that affect the amount of moisture evaporated and the amount that can subsequently escape when the house is ventilated by opening windows. House owners should be taught that condensation on windows is an indication that the relative humidity indoors is higher than the house can carry safely with the prevailing temperature out of doors and that reduction of relative humidity by opening windows and adjustment of the heating plant is desirable until the condensation is re-evaporated. In northern climates storm windows are necessary, whether or not the windows are weatherstripped, both to save heating expense and to prevent condensation without limiting the house to unreasonably low relative humidity during cold weather.

Fortunately the problems of moisture leakage and condensation are becoming generally appreciated and at least for new houses and some of those already erected, we now have effective means of keeping the woodwork dry. To be sure there remains the serious undertaking of educating those concerned with the erection of houses and the house owners themselves, but there are reasonable grounds for believing that in time moisture as a large cause of unsuccessful paint maintenance can be eliminated.



Ewing Galloway

● If the paint job (particularly the repaint job) goes wrong, don't blame it all on the painter. "More complaints about paint jobs are caused by incorrect programs of maintenance than by poor lumber, poor paint, bad application, or moisture." The main thing is a sensible program of maintenance

The Cure for Mistakes in Applying Paint

Much unsuccessful painting comes from faulty technique in applying paint. The most common blunders arise from the painter's very human desire to do the work with the smallest amount of expensive material possible. In some cases in which the bounds of safety are overstepped the painter was not intentionally dishonest, he was merely mistaken in his judgment or unfamiliar with the limitations of the material with which he was working. It should be remembered that the painter's judgment is necessarily based on insufficient information because, except in the case of lead and oil, he does not have practical knowledge of the composition of the paint he is using, and there are no generally accepted standards of correct application. Commercial paints differ in composition far too widely to conform to any general standards of application, and since they are not recognized by classes, each paint presents a separate problem in application. Often the painter is asked to apply a paint that came on the market long after he learned his craft and differs seriously as respects application from anything he has been trained to use correctly.

To be sure, directions for application are usually printed on the label on paint containers. The painter is often chided for paying little attention to such directions, but when manufacturers' directions are studied carefully in relation to the composition of their products it becomes clear at once that manufacturers' ideas of correct application are just as divergent and illogical as painters' practices.

The Cure for Mistakes in Paint Maintenance

In the writer's experience more complaints about paint jobs are caused by incorrect programs of maintenance than by poor lumber, poor paint, bad application, or moisture. Neither the paint manufacturer nor the painter, as a rule, has much control over maintenance, because the house owner (or his agent) generally decides when painting shall be done, how much work he is willing to pay for, and often what brand of paint shall be used. Efforts to attain more successful paint maintenance, therefore, must take into account the necessity of teaching house owners how to space jobs correctly and how to choose the right kinds of paints for their purposes.

Many house owners have no definite plan for spacing paint jobs, and merely wait until the old coating goes to pieces before trying to renew it. In this group many have no intention of painting more often than every eight or ten years. Since we have no white paints that can be relied upon to remain durable for such long periods, those who follow such programs are more inter-

FLB 001026

ested in the ability of the paint to stand neglect well than they are in its durability. They want a soft type of paint that breaks up slowly by crumbling so that it does not look too unkempt during the period of neglect and after neglect can be safely repainted without expensive removal of the old coating. Pure white lead paint, if used exclusively, will behave in this way, and is largely responsible for the fact that so many owners are accustomed to maintenance programs involving long periods of neglect.

MOST of the newer paints, however, are made to provide greater durability and superior appearance, which can be provided only by making harder paints that break up finally by cracking, curling, and flaking, and therefore cannot be neglected safely. Of course, practically all paints are advertised as wearing away slowly by chalking, leaving a fine surface for repainting, and avoiding the defects of cracking and scaling, but such claims are made on the assumption that repainting will be done before the end of the period of durability and before neglect begins; they do not mean that the paint is suitable for those who expect to let their coatings go through periods of neglect.

There are two ways of successfully linking together the maintenance program and the kind of paint for those with unduly long intervals between painting. One way is to convince the house owner that it will be worth his while to change his program to permit him to use paints of harder type satisfactorily. The other way is to sell him the kind of paint that will serve satisfactorily in the program to which he is accustomed. To persuade him to buy a paint unsuited to the program he intends to follow, however, is simply to add one more to the number of those who are dissatisfied.

A large proportion of paint complaints that come to the writer's attention occur on houses that have been painted at reasonable intervals with good paints well applied on woodwork that remains dry and yet the paint fails far too soon and often in a manner not characteristic of the normal behavior of the paint last used. In all these cases, however, two or more paints of distinctly different composition have been used for successive paint jobs or successive coats in the same paint job. Some of the combinations show up repeatedly in different complaints. Some well known combinations frequently occurring in complaints are white paints over yellow ochre primer or paint, almost any house paint over clear varnish, and white paints over full color paints like deep red, brown, green, or black. Unfortunately technical exposure tests in the past have been confined chiefly to initial paint jobs or repainting with the same kind of paint, but some past records of tests involving combinations of paints differing in type have been discovered, the outcome of which reveals the same abnormalities of behavior found when these combinations of paints are seen on houses.

The evidence that good paints are not all compatible with one another is now conclusive, but there is much difference of opinion about the seriousness of the problem. Some hold that incompatibility occurs only in a few extreme cases such as those named in the preceding paragraph. The writer believes, on the basis of both observations of houses and of technical exposure tests, that the principle of incompatibility is very much more far reaching. Combinations of white paints, differing materially in content of zinc oxide, for example, have been observed to deteriorate more rapidly and in a less satisfactory manner than corresponding coats made up entirely of either one of the paints separately. A great deal of research will be necessary to establish all of the ramifications of the principle of compatibility, but when it has been done many of the present mysteries of house paint maintenance will be cleared up. A large proportion of the Forest Products Laboratory's research on painting is now directed toward this problem.

Until future technical study discloses the extent to which paints may differ in composition and still remain compatible, the conservative practice in maintenance is to start out with a good paint when the woodwork is new and thereafter maintain it at proper intervals with paint of essentially the same composition. Switching from one kind of paint to another is doubtful practice unless the particular combination so produced has been tested or found satisfactory by previous experience. Certainly those combinations of paints that have frequently led to difficulty should be avoided. At the present time the only white paint that is used consistently by large numbers of house owners is pure white lead because it is the only paint recognized by type as well as by manufacturer's brand. In the writer's opinion the high regard in which white lead paint is held by so many good painters and paint users is due largely to this consistency in its use. When white lead is applied over paints of other kinds it often fails prematurely and in an abnormal manner, indicating that it is just as subject to the requirement of compatibility with previous paints as are paints of other kinds.

The Need of Classification of Paints

The cure for bad programs of paint maintenance, therefore, lies in a classification of paints that will make it possible to teach house owners how to buy the right kinds of good paint for their purposes and how to get out of the paints they buy the good service of which they are capable.

Consideration of the causes of unsuccessful paint maintenance and consequent loss of public confidence in painted exterior woodwork shows that our most serious troubles have come not so much from jerry building and inferior paint as from efforts to improve building methods and paints that have made the situation more complicated and unduly technical for craftsmen and laymen. Thermal insulation and modern heating plants are distinct improvements over past practices but, unless appropriate precautions are taken to control condensation on cold parts of the structure, they tend to increase the number of houses in which moisture leads to early paint failures and other difficulties. In a similar way modern developments in paint have given us better paints than we ever had before, but there are now so many kinds of good paint on the market and they vary so much in composition, manner of correct application, and compatibility with one another that painters and house owners do not know how to use them all correctly. Merely offering the public good paints that are capable of giving successful service is not enough to re-establish confidence in painted woodwork unless we likewise make it possible for each good paint to be so applied and maintained that it will give the good service of which it is capable. To accomplish that purpose the technical complexities of application and maintenance must be simplified sufficiently to bring them within the comprehension of craftsmen and house owners.

FLB 001027

Some Causes and Cures for Painting Troubles

by F. L. Browne
Senior Chemist, Forest Products Laboratory
Madison, Wisconsin

WHENEVER paint coatings on wooden walls of houses fail unreasonably soon, say in less than two years after they have been applied, the failure is almost always due to certain circumstances called, for convenience, "abnormal conditions of exposure." Failure under such conditions is not a question of the kind of wood upon which the coating is applied, the quality of the paint, or the craftsmanship of the painter. The staff of the Forest Products Laboratory has observed the troubles in question on all of the kinds of wood commonly used for house siding, with paints of all the varieties generally accepted as of first quality as well as with cheap paints, and rarely has there been any possibility that poor workmanship on the part of the painter was responsible. The fault lies in the abnormal conditions of exposure, and the only certain cure is to search out the abnormal conditions and change them into normal ones. Attempts to overcome difficulties of this kind by using special priming paints, special paints, special liquids or unusual amounts of liquids for thinning ordinary paint are, in the writer's opinion, of very doubtful merit.

The most common form of paint failure under abnormal conditions of exposure is that known as blistering and peeling. The failure, however, sometimes appears in other forms that at first glance do not seem at all related to paint blistering, such as paint scaling, some kinds of discoloration of coatings, and blue stain in the wood beneath the coating. Sometimes blistering and peeling occur along with the other defects. All such troubles with painted wood may well be discussed together because of their common origin.

Present information about the effects of abnormal conditions of exposure upon paint coatings is based chiefly upon examinations of occupied buildings which have given trouble. The staff of the Forest Products Laboratory has been called as consultants in such cases for many years. In addition a limited amount of laboratory experimentation has been done with miniature "houses" warmed and humidified inside and set out of doors during cold weather. Many characteristic paint defects have thus been reproduced under partially controlled conditions.

Most cases of paint trouble due to abnormal conditions that have been brought to the attention of the Forest Products Laboratory have been on widely scattered houses whose neighbors experienced no such difficulties. Many of them have been cheaply built houses, but on the other hand many have been relatively expensive houses on which every effort seems to have been expended to build properly.

In practice, abnormal conditions of exposure almost always involve, as an essential factor, the access of large amounts of moisture to the unpainted sides of the boards. The conditions are greatly aggravated when the temperature on the unpainted side is materially higher than that on the painted side, as is the case on the outside walls of heated buildings during cold weather. Causes of abnormal exposure conditions that have been observed repeatedly may be classed as follows:

Type A.—Rain water seeping through leaky joints left by poor carpenter work or faulty design.

1. Poor fitting between siding and corner boards, between siding and casings of doors or windows, and between siding and drip caps over window and door headers or sills beneath such openings.

2. Joints in window frames forced open to permit swollen sash to move freely. When the sill and head of the window frame are housed into the jamb, this is an easy way to make the sash move freely, but it leaves an opening to admit water. If the jamb is housed into the sill and head, the joint cannot be forced open in this way.

3. Omission of metal flashing or its incorrect installation over doors and windows or at the junction between porch or dormer roof and side wall or chimney.

4. Incorrect junction between shingle side wall and water table where the upper part of the side wall is shingled and the lower part sided. This junction should either be protected by metal flashing or the shingles lapped over the water table carefully to see that no openings are left through which rain water can gain entrance.

5. Seepage into the joint between porch column and plinth block or porch floor.

6. Leaking roofs, eave troughs, or down spouts when so located that the water gains access to the interior of the side walls.

7. Frozen gutters failing to carry off the water from snow melting on the roof and letting it back up beneath the shingles to gain access to the interior of the side walls.

Abnormal exposure conditions of Type A may occur on either heated or unheated buildings and, with the exception of No. 7, in any climate. However, heating the interior of the building during cold weather tends to aggravate the resulting difficulties with paint coatings. The only sure remedy is to locate the leaky joints and repair them until they are water tight.

Type B.—Moisture originating within the building and carried by air circulating within the hollow outside walls.

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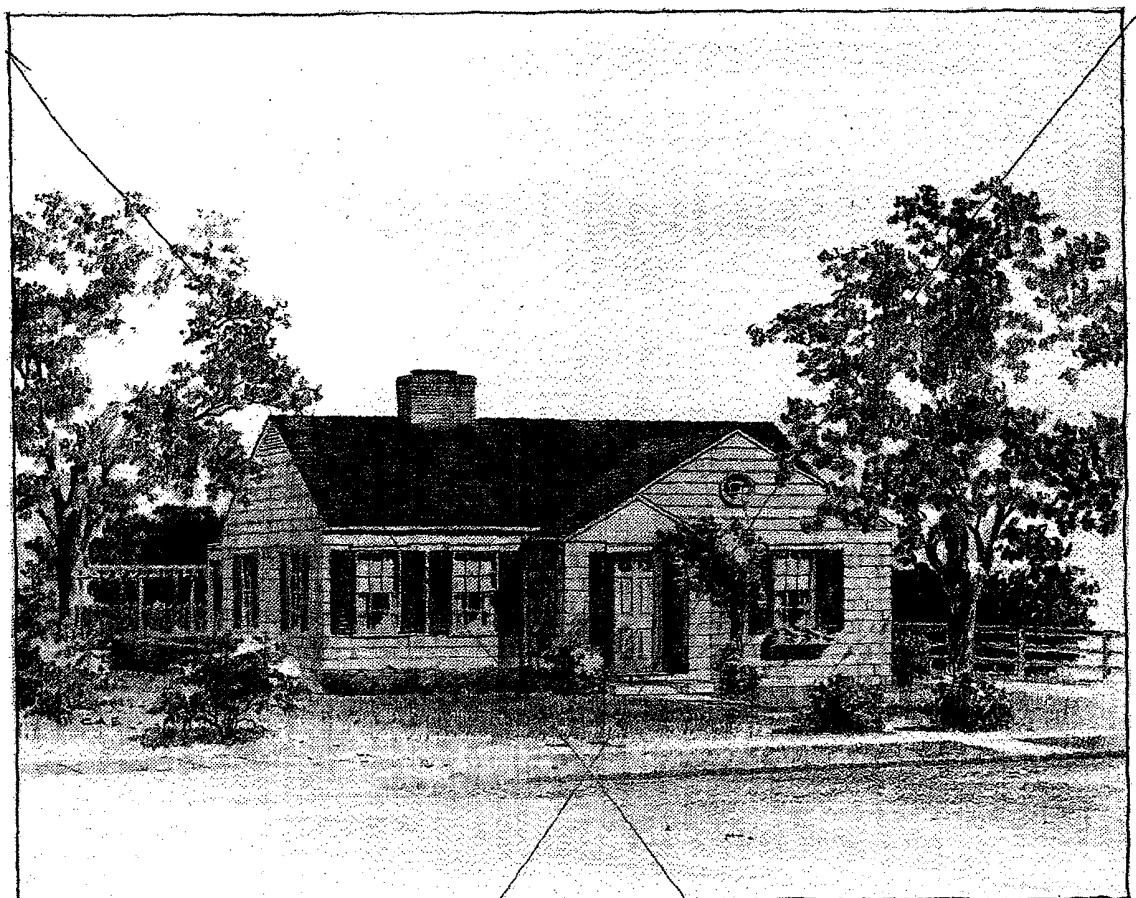
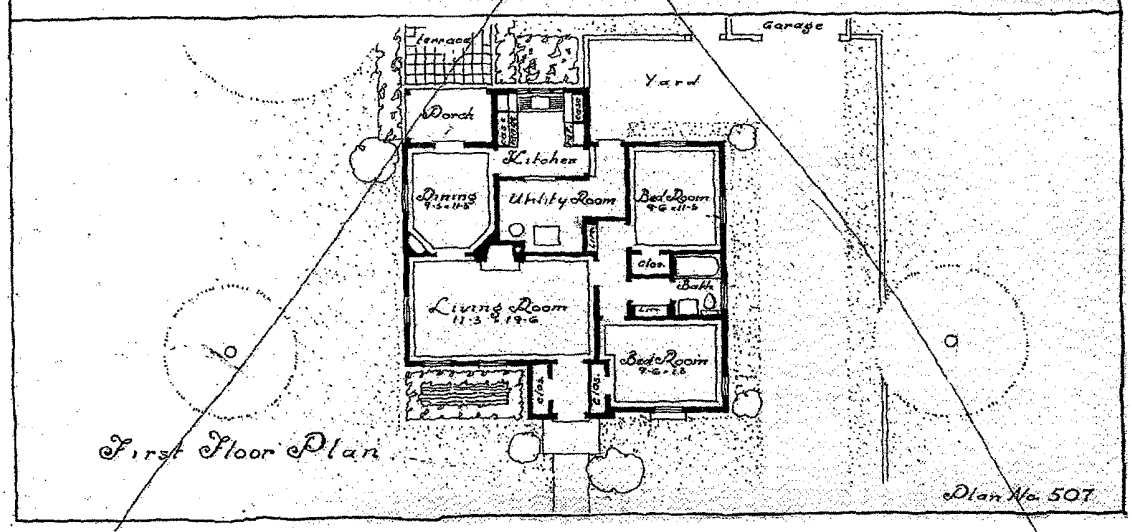




This five-room American Colonial done in the cottage style, this month's NATIONAL REAL ESTATE JOURNAL Plan Service design, has but 15,310 cubic feet. It is smaller than most houses done by Architect Willard Walker for the Plan Service series, yet its rooms, because of their good proportion and convenient arrangement, are thoroughly adequate for the family of good taste and modest means

foresee some conflict, but in the broad
ral outlook I think it is a good thing.
nally, the matter of paint compatibility

brush," "B. O." and the like, and I think it would be advisable to avoid this kind of advertising in the paint industry; but it seems likely that we can proceed to some rational

chloride, a salt of the weak ammonium hydroxide (NH_4OH) and the strong hydrochloric acid (HCl), in water solution gives an acid reaction due to hydrolysis. An active

FLB 001029

When moisture laden air comes in contact with surfaces at sufficiently lower temperature, water condenses.

1. Attempting to hasten the drying of wet plaster or other building moisture by heating the interior of a building under construction without adequate circulation to carry off the moisture laden air. New buildings should be dried by circulating fresh air through windows and doors. Marked difference in temperature between interior and exterior permits water to distil from plaster to sheathing and siding through the hollow side walls. By leaving temporary openings at the top and bottom of the air spaces between studding, enough circulation through the side walls can be insured to prevent such action while the building dries.

2. Designing parts of buildings in such a way that stagnant air spaces are enclosed by wood walls within which the air may become moist and warmer than the outside air. Porches built beyond the foundation with skirting extending down to the ground and no provision for ventilating the enclosed air space are common causes of trouble. Hollow ornamental walls extending beyond the foundation and hollow columns with leaky joints admitting rain water at the bottom require ventilation.

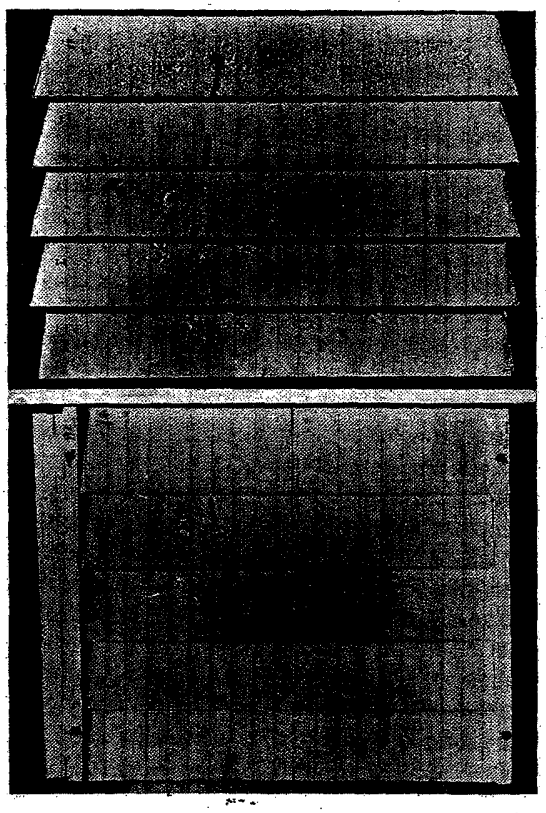
3. Lack of ventilation in unused attics. During cold weather water may condense beneath the cold roof and drain down toward the cornice. If the top course of siding is placed below the frieze board the water is directed between siding and sheathing, coming directly in contact with the backs of the painted clapboards.

4. Failure to secure a water-tight basement. Building in soil that is not adequately drained and using basement walls and floors that are not waterproofed may result in a damp basement and a circulation of the moist air through the hollow side walls of the building to condense behind the siding. Plumbing leaks left uncorrected may also produce this result.

5. Activities within the building that humidify the air. The bathrooms and kitchens of dwellings tend to show blistering and peeling of paint from their outside walls sooner than other rooms. Frame buildings, originally designed as dwellings, when used for purposes like laundering often give rise to severe blistering and peeling of paint.

THE channels of circulation for air within the hollow exterior walls of frame buildings are controlling factors in abnormal exposure conditions. The subject has not yet been studied carefully and much remains to be learned about it. In general the direction of movement of air enclosed in the space between lath and plaster on one side and sheathing and siding on the other is upward along the warmer side and downward along the colder one. When the building is being heated during cold weather, the warmer side is the lath and plaster so that the upward air current moves along that side until it meets an obstruction, which may be a plate or a fire stop, where the air current is deflected and starts downward along the colder sheathing and siding side. This downward current of air is likely to circulate through the joists in the sheathing and building paper (even though waterproof building paper is used) and to pass out between boards of siding. The escape of air between clapboards may be helped or hindered by wind blowing on the outside wall according to the angle at which the wind strikes the wall.

In cold weather the temperature at the back of the siding where air is escaping may easily be below the dew point even though the air may have had a low relative humidity when it first entered the hollow side wall from the interior of the building. Thus air chilled from 70° F. begins to deposit its moisture as water or ice at 32° if the initial relative humidity was 25%, at 15° if the initial relative humidity was 11%, and at 1° if the initial relative humidity was 5%. Since the coldest surfaces in the side wall with which the circulating air may come in contact are offered by the back of the siding and the front of the building paper, these are often the



● **Blistering and discoloration of white lead paint (lower panel) and of a high grade prepared paint (upper panel) produced in laboratory experiments on "miniature houses." Both troubles are due to excess moisture**

points at which condensation sets in. The amount of the condensation will depend upon the amount of circulation and will naturally be greatest near the points in the side wall where the upward current of air is deflected by a window frame, plate, or fire stop so that the air starts its downward course along the sheathing and siding side of the wall. The effects on paint coatings of condensation of moisture behind the siding are commonly found most marked on the parts of the walls corresponding to the points of deflection of the air currents.

The fact that the effects of moisture condensation are often most marked near fire stops should not be regarded as an argument against the inclusion of fire stops in frame buildings. Fire stops are desirable, often necessary. Their omission in a building in which trouble from moisture condensation was experienced would not necessarily overcome the difficulty, though it might shift the location of its most marked development.

Forms of Paint Failure Under Abnormal Conditions

Failure under abnormal conditions may appear as blistering, peeling, or scaling, in which the coating is removed bodily from the wood, or as a discoloration, which mars the appearance of the coating. The discoloration may be due to substances leached from the wood by water, substances carried by water from other places

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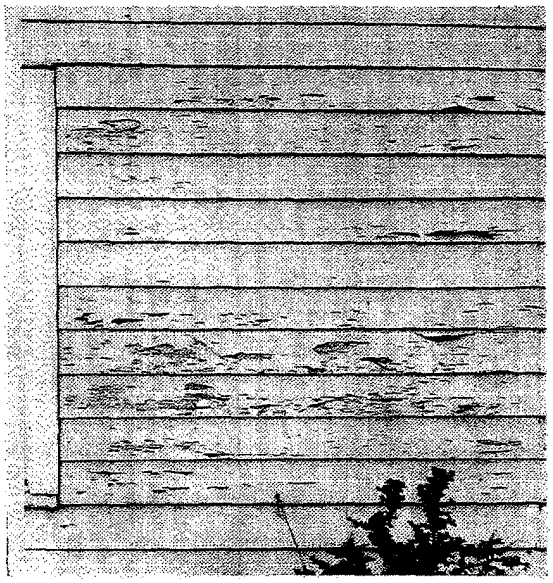
within the structure, or blue-stain fungi growing in sapwood beneath the paint coating.

Blistering, Peeling, and Scaling

The characteristic form in which paint coatings fail under abnormal conditions is blistering and peeling or scaling. Blistering always precedes peeling, though the trouble often escapes notice or fails to arouse anxiety until the peeling is well under way. From their shape it is obvious that blisters are due to a fluid pressure beneath the coating forcing it away from the surface. When observed soon after their formation, blisters are sometimes found to be hollow, sometimes filled with water, but if the blistering conditions continue they always become filled with water. If the wood is of a kind that contains colored substances soluble in water the water in paint blisters is colored with them.

Sometimes water soluble extracts from the wood do not become highly colored until they break through the coating and come freely in contact with air. Deposits of such substances over paint blisters often look like resin exuding from the wood.

The mechanism of the movement of water through wood and the development of pressure behind paint coatings is still obscure, but the following considerations are helpful in gaining an understanding of the sort of forces that are at work: From half to more than three-fourths of the volume of a piece of dry wood is air that is enclosed in the cavities of the wood. Ordinarily this air remains at atmospheric pressure because the cavities communicate with each other and with the surface through the openings in the pit membranes, but as soon as the wood becomes wet and there is free water in the cavities, the minute openings in the pit membranes become covered with films of water which can be dislodged only by high pressures. It has been shown that pressures of approximately 20 to 40 kilograms per square centimeter are required to force air through wet wood. Once wood begins to hold free water, therefore, its enclosed air is effectively trapped and the pressure acting on the air may rise above that of the atmosphere. Increase in pressure in the trapped air may be occasioned by rise in temperature, by evaporation of some of the free water, or by displacement of air by further amounts of free water.



● **Paint scaling within a year after painting, in a house examined by experts of the Forest Products Laboratory. The trouble was caused by condensation of moisture behind the siding when the interior was warm and the outside cold**

While still turgid or filled with water, paint blisters can be broken easily and the coating peeled off though it does not necessarily peel of its own accord. As the abnormal conditions give way to normal conditions and the wood dries, the blisters often shrink back into place so completely that the coating may seem to be as sound as ever. The good appearance is deceiving, however, for a few months exposure under normal conditions may lead to scaling. Since the coating is now thoroughly dry and somewhat aged it is no longer tough and pliable, but is hard and fragile, so that the failure is of a sort easily confused with paint scaling under normal exposure. It often happens that scaling is the first sign of failure that comes to the houseowner's notice because the stage of blistering occurred during cold weather when he did not inspect the painted surfaces very carefully.

In scaling, the pieces of paint coating that become detached may include the entire thickness of the coating so that the wood beneath is left quite bare, or the separation may take place between coats of paint, leaving the oldest coats still in place. In general, intercoat scaling is most likely to be encountered on repainted surfaces, the newer coats scaling from the older ones, though it is occasionally seen on surfaces painted for the first time, especially if the first coat of paint differs markedly in composition from the others or if the first coat was allowed an exceptionally long time to dry before applying the others.

The susceptibility of paint coatings to blistering and the size of the blisters formed vary materially with a number of factors of which one of the most important is the age of the coating. Coatings blister most easily soon after they have been applied and hardened. At that age the coatings are very pliable and the blisters formed are likely to be numerous but small in size and sharply rounded. If the coating has time to age and become less pliable before abnormal moisture conditions arise it does not blister as quickly and the blisters are less numerous but larger in size and less sharply rounded. Blisters have been observed that were many inches across and the coatings could be peeled off in strips several yards in length. Coatings that reach an advanced age before abnormal moisture conditions arise become too hard and unyielding to bulge out into rounded shapes recognizable as blisters, but their grip upon the wood may nevertheless be broken so that failure promptly takes place by cracking and scaling. Very old coatings that are chalking or checking deeply or cracking badly do not seem to fail in the manner characteristic of abnormal moisture conditions; it may be that they are too readily permeable to vapors for pressure to develop beneath them, or perhaps they do so fail, but the failure is indistinguishable from

(Please turn to page 54)

foresee some conflict, but in the broad ral outlook I think it is a good thing.

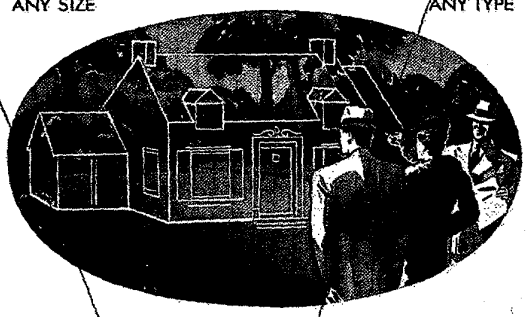
"Brush, B. O. and the like, and I think it would be advisable to avoid this kind of ad-

chloride, a salt of the weak ammonium hydroxide (NH_4OH) and the strong hydro-

FLB 00103

"Built in 30 days"

ANY SIZE ANY TYPE



makes vacant lots easy to sell

Of course you have *vacant houses* on your list—for sale or for rent. But how often have you had the experience of showing a good prospect everything on your list—without making a sale! Nothing met your prospect's requirements.

This need not happen any more. Now you can sell a vacant lot and guarantee to have a finished house on that lot—in not more than 30 days. You can guarantee that the house not only will be ready for occupancy, but that in every detail it will fit your prospect's needs and specifications. It will be a house he will always be proud of—a house that will stay "new" longer—comfortable to live in and economical to maintain. The house will be eligible for F.H.A. Insured Mortgage Loan.

The Precision-Built method of construction is revolutionary. But it is thoroughly tested. $3,000,000 of Precision-Built Homes have been erected within the past 3 years.

You work with your local architect—or from our architect-designed plans. You work with local lumber dealer, local contractor and local labor. All materials are standard, quality materials—bought locally. You help your community, while you are building your own sales. We invite you to write today for the full facts. You need to know about this up-to-the-minute, fully tested source of new profits for you!

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have faithfully paid their rent and their bills, but who have not been able to gather together a stake for a down-payment.

Outside the immediate profit motive we believe it is our business and duty to put all people in homes who can afford to pay for them. We believe that a nation of home owners is a stronger and more stable nation than one of renters could ever be, and at the same time the plan, making home ownership more general, offers one of the most effective weapons against social unrest.

During the October National Convention our committee will be happy to show visiting Realtors, not only our particular project, but what is being done throughout Southern California under the Title I program.

Some Causes and Cures for Painting Troubles

(Continued from page 44)

paint flaking or scaling under normal conditions of exposure.

Paint mixed with a high ratio of pigment to linseed oil, which is accomplished practically by substituting turpentine for part of the linseed oil (not by merely adding turpentine), is more resistant to blistering and finally forms fewer, though larger blisters than similar paint mixed rich in linseed oil. It is good practice to mix paint rich in pigment because it improves the appearance of the coating and makes it last longer. Substitution of bodied linseed oil or of some kinds of varnish for part of the linseed oil in paint also increases the resistance of coatings to blistering. The addition of varnish to paint by paint users, however, is not to be recommended without competent technical advice in the selection of the varnish because most varnishes are unsuited for such use. The most resistant paint to blistering so far tested at the Forest Products Laboratory is linseed oil paint made with pure basic carbonate white lead, mixed with a high ratio of pigment to linseed oil, and allowed to age several months before subjecting it to abnormal moisture conditions. Moreover on houses painted with white lead paint that have been brought to the Laboratory's attention because of abnormal moisture conditions the complaint has been about discoloration more often than about blistering or peeling.

It must be emphasized that, although the composition of the paint does affect the ease and form of blistering, all good paints are subject to failure under abnormal moisture conditions so that the only certain remedy for such troubles is removal of the faulty conditions.

The kind of wood painted is likewise of little practical significance as far as paint blisterings is concerned. The Laboratory has seen badly blistered paint on all kinds of wood commonly used in building and has made paint blister experimentally on all woods that it has tested. No differences have been found between wood species in the case of blistering or in the form of the blisters. Within any species, however, some boards or parts of boards seem notably less subject to blistering than others. In general paint blisters more readily over heartwood than it does over sapwood under the condi-

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Building $3,000 Houses with Title I Financing

(Continued from page 31)

prospective purchasers. This enlarges the operative builders' field considerably, and in conjunction with a lot-selling project such as ours, developer and contractor working hand-in-hand, it offers as nearly perfect a set-up as has been devised to date. This provision is especially valuable in enabling us to have a few "samples" on hand instead of one.

Our firm does not handle the construction of the house itself; we merely act as agents for a contractor working exclusively on houses we have sold. We sell the building job, pre-built, in conjunction with the lot. We must, of course, see to it that all jobs give satisfaction and this is why the homes are built under the supervision of the Builders' Control Service. This outfit is in position to give prompt attention to the job in hand so that the work is not delayed and is properly performed. Building thirty or forty houses at a time makes this of utmost importance.

At the time the purchase agreement is made up we see that the Certificate of Conformity of the Federal Housing Administration is properly filled out and signed, as well as plans and specifications, credit statement, and contract with contractor being properly drawn and signed. We also accept, from the prospect, a fee of $20, half of which goes to the Federal Housing Administration and which we hold subject to acceptance of the deal by the lending institution, and the other half to the bank; all to be returned in case of failure to qualify.

We also will hold the lots, when necessary, for a reasonable length of time until the necessary funds are gathered together to make the down-payment and take care of the initial charges.

We see a definite need for housing of this type and are willing to risk our lots because we believe the program, under the revised Title I plan, is sound, practical and of real service.

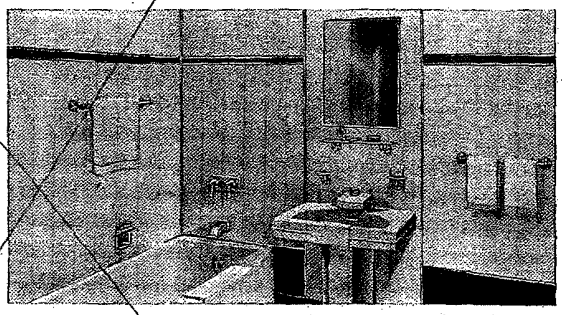
What the Buyer Gets for His Money

The figure quoted for the entire cost of the project as it is delivered to the purchaser covers lot, and two-bedroom house, garage, incinerator, cement apron from garage to paved alley, public side walk, curbing, as well as provision for all utilities brought to the structure ready for use, such as sewer, light, water, telephone, and gas.

The model house used for demonstration purposes shows exactly what is included in the quoted price. Landscaping, fences, drive-ways or walks from kitchen to garage, etc., have not been installed as they are not included in the price quoted. We found this saved considerable confusion and definitely eliminated mis-understandings as to what the buyer was actually paying for. He gets exactly what he sees, no more and no less. The contractor is willing to install extra things for cash but most buyers do the work themselves. The neighbors help one another in doing this work.

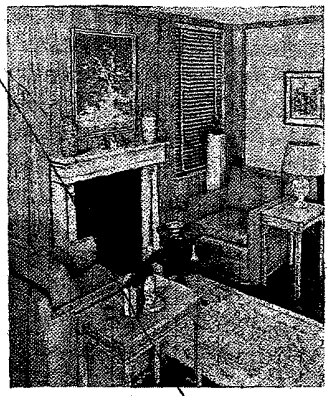
Title I, Class 3 allows for quantity production of quality homes on terms which the low-income groups can afford to pay. It brings into its fold those persons who

A kitchen magically transformed by Marlite—as this one was—captures the interest of prospective tenants . . . keeps old ones satisfied.



Marlite bathroom installations—like this—create a favorable impression with prospects. A damp cloth keeps its glass-smooth surface gleaming.

*Living rooms, resplendent in Marlite Genuine Wood-Veneers and *Carstenite panels attract a higher type clientele . . . command higher rent. When used in modernizing commercial properties these materials impart added refinement and individuality . . . help to attract new tenants.*



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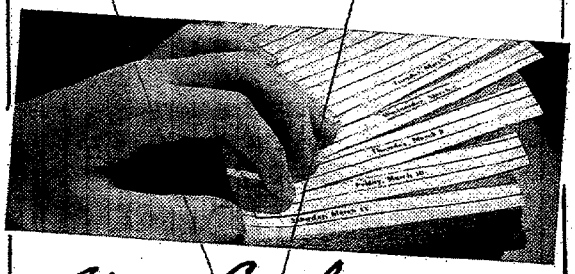

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or another on any wood. Moreover, the water-soluble extractives of redwood and western red cedar give them desirable properties, for the durability of their heartwoods against decay is known to reside in the extractives present. Under normal conditions of exposure both woods hold paint coatings especially well and there is good evidence that the extractives exert a favorable influence on the life of the coatings.

Discoloration of paint with extractives from redwood and western red cedar is usually more marked on some boards than on others. In part this may be due to differences in the amount of extractives in the boards or to their concentration near the surfaces of the boards during drying, but it probably is due still more largely to details in the construction of the house that make the abnormal conditions more pronounced in some spots than in others. For example, both blistering and discoloration tend to occur near windows or doors or just outside of plates or fire stops in the house walls.

Abnormal conditions of a kind that permit water to seep out between clapboards and run over the painted surface are likely to produce discoloration even on woods other than redwood or western red cedar because the water may leach colored substances from building paper or composition shingles, or may carry dirt and deposit it upon the painted surface in irregular patches.

Certain fungi grow in moist sapwood of practically all species of wood and stain it dark blue or black. The defect is known as "blue stain." Like all other fungi, blue stain organisms can grow only in moist wood. When infected wood dries the fungi stop growing and remain dormant, though the discoloration persists. Sapwood that has become blue stained during seasoning may be painted without danger of the stain coming through the paint, provided that the wood subsequently remains dry. But if abnormal conditions arise so that the wood again becomes wet the organisms begin to grow once more and will penetrate through the coating, bringing the stain into view. The fact that a piece of sapwood is bright before painting does not prove that it will not blue stain if the wood later becomes wet because it may be infected even though the fungi have not developed far enough to reveal the color.

There is no evidence that the composition of the paint has any influence on the facility with which blue stain penetrates the coating under conditions permitting the fungi to grow.

Blue stain may occur in the sapwood of any species. A few species with naturally durable heartwood contain no sapwood in the highest grade in which the lumber is sold in commerce. In all but the highest grade of these species and in all grades of other woods, there may be some sapwood. The proportion of the boards of comparable grade in different species in which sapwood may be present varies widely because some kinds of trees contain more sapwood than others in the parts of the logs from which the select grades of lumber are cut.

Blue stain coming through paint may be distinguished from mold and lichen growing on the coating itself by the fact that blue stain is confined to the areas immediately over sapwood and the color is revealed deeply imbedded in the wood when the coating is scratched away with a penknife.

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TECHNICAL BULLETIN No. 804 • JANUARY 1942

42

Classification of House and Barn Paints

As Recommended by the United States Department of Agriculture

By

F. L. BROWNE
Senior Chemist

Forest Products Laboratory
Forest Service

UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

For sale by the Superintendent of Documents, Washington, D. C. • Price 10 cents

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FOREWORD

The enormous quantity of paint used on wooden farm buildings accounts for the definite interest of the Department of Agriculture in developing the best methods of selecting and applying paint and maintaining painted surfaces. The variety and complexity of the paints on the market and the inability of the ordinary user to understand the statements of paint composition printed on the container labels are impediments to intelligent paint selection and use.

This bulletin, which will be followed by other publications dealing with paint application and maintenance, describes a system of classifying paints by groups, types, and grades. It is based on principles familiar to paint technologists and some paint users. The system is the result of many years of research on the painting of wood by the Forest Products Laboratory of the Forest Service. Its adoption by manufacturers will allow a decided simplification of the technical statements on paint-container labels, and will make it possible to tell paint users more clearly and effectively how to identify the many kinds of paints on the market, what the characteristics of each kind of paint are, and how each should be applied and maintained. The classification system places no limitations upon the formulas used by paint manufacturers, and leaves the manufacturer complete freedom to change and improve his formulas at any time. Its adoption will provide a basis for the more intelligent selection and use of paint.

Earle H. Clapp

Acting Chief, Forest Service.

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Technical Bulletin No. 804 • January 1942

UNITED STATES
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

Classification of House and Barn Paints

As Recommended by the United States Department of Agriculture

By F. L. Browne
Senior chemist, Forest Products Laboratory,[1] Forest Service

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INTRODUCTION

Why Classification Is Needed

The need for classification arises because methods of selling paint either afford the user little of the knowledge of paint composition that is desirable for its intelligent selection, application, and maintenance, or require him to master far more technical detail than is at all necessary (*19, p. 5*).[2] Most paints are proprietary products sold under the manufacturer's trade-mark or brand but, like many other products of commerce, conforming to no generally recognized standards of composition or performance. If paint is bought by brand alone the buyer is not in a position to know of the many kinds of paint available, some of which may be more suitable than others for his purpose. The manufacturer, on the other hand, supplies the paint without adequate knowledge of the individual's needs. This lack of mutual understanding between maker and user of paint gives rise to unsatisfactory paint service, as has been pointed out elsewhere (*6, 8*).

Directions for application are printed on the labels of most proprietary paints, but the limited space available makes such directions seriously inadequate. It is not possible to compress the craft of

[1] Maintained by the U. S. Department of Agriculture at Madison, Wis., in cooperation with the University of Wisconsin.
[2] Italic numbers in parentheses refer to Literature Cited, p. 35.

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painting into 500 words. Even during apprenticeship or in vocational schools painters cannot be taught adequately the necessary craftsmanship when they do not know the composition of the paints with which they work or why some of them require different procedures.

Users' need of knowledge of the composition of paint was appreciated as long ago as 1905 when the State of North Dakota required by law that proprietary paints, unless composed wholly of white lead, zinc oxide, linseed oil, turpentine, and drier, bear a statement of the formula on the label (*16; 19, pp. 183–188*). This and a few similar laws in other States are still in effect. It now seems to be widely recognized that such laws have raised the general level of quality of the paints sold in the States in which they prevail (*16, 17*) and probably in the rest of the Nation as well. The National Paint, Varnish and Lacquer Association now urges its members to print the formula on the label whether or not the law demands it (*1, 2*). Most house and barn paints now on the market in the retail trade bear the formula on the label.

Formula labeling, however, though it undoubtedly has proved helpful, has not provided the kind of knowledge of paint composition needed for intelligent selection, application, and maintenance of paint by the user. Those experienced in dealing with property owners' complaints about unsatisfactory service know that poor quality of the paint is a relatively unusual cause of difficulty. More often trouble arises chiefly from mistakes in the use of paints of good quality, which in turn come from ignorance of the characteristics and limitations of the particular paints chosen (*4, 5*). The shortcoming of formula labeling is the fact that paint formulas, as will be seen later on, are too complicated to mean very much to ordinary paint buyers (*6, 8*), who need a reasonably simple interpretation of them in nontechnical terms.

Classification simplifies the expression of paint composition for laymen by presenting those few aspects of composition that reveal the major characteristics of the paint and ignoring technical details about which the paint user need not be greatly concerned. Classification merely identifies the many paints by kind independently of trade brand, so that the purchaser can exercise an intelligent choice and so that painters and other paint users can be given practical advice about proper application and maintenance. On the other hand, classification omits many details of composition that enter into the proper manufacture of the paint but can wisely be left entirely to the judgment of the manufacturer.

It should be emphasized that the classification system is designed to deal adequately with the problems of craftsmanship in the use of paint, not with the problems of competence and integrity in the manufacture of paint. The system of competitive trade brands, which identifies the manufacturer with his products and in effect places his seal of responsibility on them, operates to put well-made paint conveniently at the public's disposal. The classification system in no way alters the significance and utility of the trade brand. The trade brand, however, although successful in making it easy to buy good paint, has not proved helpful in getting good paints so used that they give the good service of which they are capable.

Improvement in craftsmanship in the use of paint must be achieved by instruction of those who buy and apply it. Convincing instruction,

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however, cannot be purely arbitrary, but must include a reasonable understanding of the principles upon which it rests. When the many classes of paint are made easily identifiable it becomes possible to develop and disseminate sound principles of craftsmanship in use and maintenance. The highest service of classification, therefore, is as a preliminary step in the establishment of generally recognized techniques of painting and paint maintenance.

Classification Outlined

A broad classification of paints according to field of use has long been recognized in trade practice. House paints are intended primarily for painting the exterior of buildings, especially the exterior woodwork. Barn paint often means red paint made with iron oxide intended for farm buildings. Such paints are used also for painting metal roofs and therefore are sometimes called barn and roof paints. Barn paint may also mean a cheaper grade of house paint for use in painting farm buildings. Trim paints, which are usually made only in certain deep colors, such as green or blue, are intended for painting blinds, trim, and other minor areas of the exterior of houses. Porch and deck paints are for exterior surfaces subject to the mechanical wear of traffic. There are also wall paints, floor paints, enamels, cement paints, implement paints, and the like. The classification according to use is indicated on the label. This bulletin deals chiefly with house paints and barn paints.

Paints are classified also by color. Each brand of house paint includes white, black, and a number of colors up to as many as 32. These classifications by field of use and by color are, of course, practical and necessary but they do not go far enough.

The system of the Department of Agriculture adds classifications by group, type, and grade according to the composition of the paint. These three divisions of the classification are necessary because the concepts on which they are based have long been familiar to paint users and are too well established to be easily changed. The concept here called group has led to the familiar distinction between white lead paint, lead and zinc paint, "titanium-lead-zinc paint," etc. (*21*, *22*). The concept of type has led to the designation of paints as high or low in content of white lead and of zinc oxide (*23*). The concept of grade is that expressed by common reference to first-grade and second-grade paint (*19*, *p. 3*). In the past, however, such terms have been used loosely, without authoritative definitions. It is proposed to define group, type, and grade precisely.

Group is determined primarily by the principal pigments with which the paint is made. Thus pure white lead paint, in which the pigment is white lead, is paint of group **L**. If changed to gray, cream, or other light color by adding small proportions of colored pigments, it is still classified as group **L**. On the other hand if a large proportion of colored pigment is incorporated to make paint of deep color it becomes paint of group **CL**. Lead and zinc paints contain both white lead and zinc oxide and in addition they may contain certain inexpensive colorless pigments and small proportions of colored pigments. Such paints are of group **LZ**. Titanium-lead-zinc paints contain besides white lead and zinc oxide either titanium dioxide or one of the pigments of which titanium dioxide is the white ingredient, and in addition

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usually contain inexpensive colorless pigments. Such paints are of group **TLZ**. Red barn paint in which the principal pigment is ferric oxide is classified as group **F**. In some of the other paint groups the nature of the liquid portion of the paint as well as its principal pigments is taken in to account in the designation of the group.

Type is determined by the proportions of lead pigment and zinc oxide in the total pigment of the paint. It has long been recognized by technologists and laymen alike that white lead and zinc oxide are the essential ingredients of most house paints, especially of white paint and paints of light colors, and that their proportions govern very largely the wearing properties of the paint (*7, 9, 12, 13, 14*). Some other lead pigments must be considered similar in effectiveness to white lead. Types are defined in terms of the sum of the lead pigments and zinc oxide in the total pigment by volume and the ratio of lead pigment to zinc oxide. They are designated by descriptive phrases and also, for convenience in discussion, by number and letter symbols. Following are some of the more important types:

Type 1A: Very high content of lead pigment and zinc oxide with very high ratio of **L/Z**.

Type 2B: High content of lead pigment and zinc oxide with high ratio of **L/Z**.

Type 3B: Medium content of lead pigment and zinc oxide with high ratio of **L/Z**.

Type 3C: Medium content of lead pigment and zinc oxide with low ratio of **L/Z**.

Type 5: Very low content of lead pigment and zinc oxide.

Grade is determined by rules, to be described later, that constitute a rough estimate of certain paint properties of importance in connection with application; for example, the extent to which the paint may be thinned, how thick a coating it may be practicable to apply, how thick the coating will be after it has dried, and whether it will have good opacity (power to hide what is underneath). Six grades are recognized, of which grade 1 contains higher proportions of the more essential ingredients and is suitable for a wider range of adjustments by thinning, spreading rate, and the like, to meet the individual requirements of the job, than paints of the lower grades. In general, any paint can be reduced in grade merely by thinning it with linseed oil or turpentine. For that reason paints are graded according to their composition after they have been thinned as directed by the manufacturer in the directions printed on the label.

In the past use of the term "grade" in connection with paints, the significance has been primarily with respect to selling price. When a manufacturer offers two brands of paint, that at the higher price is first grade and the other is second grade, regardless of composition or quality. One manufacturer's first grade may be essentially the same paint that another offers as second grade. In the classification system here described, grade bears only an incidental relation to selling price and is defined basically in terms of characteristics relating particularly to technique of application. Within any one group and type the manufacturing cost will normally prove higher, the higher the grade, but such comparison does not hold, at normal prices of raw materials, outside those limits. For example, a paint of group **LZ**, type 1B, grade 3 may be more costly to manufacture than another paint of group **SLZ**, type 4C, grade 1.

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Use of Classification

Under the classification system, paint labels bear the following information: (1) The name and trade brand of the manufacturer; (2) a statement of the field of use, such as house paint or porch and deck paint; (3) the color of the paint, as white, cream, dark green; (4) a statement of the formula of the paint; (5) directions for application; (6) the classification mark reporting the classification by group, type, and grade according to the system of the Department of Agriculture. Of these six items only the last is new and differs from long established practice. The other five retain all of their past significance. A suitable method of stating the classification and formula is illustrated in figure 1.

In purchasing paint, the ordinary user continues to give first thought to the trade brand because he looks to the reputation of the manufacturer for competence and integrity in supplying paint of good quality, for the reliability of the rest of the information on the label, and for responsible business dealings. Items 2 and 3 obviously come next in order of attention. Item 4, the formula of the paint, need not be considered at all by the user unless he has special reasons for wishing to buy paints made with certain ingredients, as for example farmers interested in growing soybeans and wishing to buy paints containing soybean oil. The formula is primarily for the consideration of technical men and helps greatly in making the classification system self-enforcing because it facilitates checking the classification mark against the formula. The fact that incorrect classification marks can be easily detected by competitors and by paint buyers with technical training builds up confidence in the system.

Item 5, directions for application, remains necessary under the classification system and may be expected to acquire greatly increased importance. In the past, both makers and users of paint have tended to treat label directions perfunctorily (*8*), largely because of the inadequate exchange of information between maker and user and the failure to recognize the relation between paint composition and technique of application. Item 6, the classification mark, makes it possible to surmount this obstacle by giving the paint buyer the knowledge he needs without overburdening him with unnecessary technical detail.

In reading the classification mark, paint users should be taught to consider first the group and type and to turn to the grade only after they have settled upon group and type. Group and type are of primary importance in determining certain basic tendencies in the behavior of paint during service, such as soiling with dirt, resistance to mildew or to hydrogen sulfide, chalking, fading of colors, wearing away by erosion, checking, cracking, and ultimate form of disintegration if repainting is postponed too long. Choice among the groups and types available on the market is partly a matter of the program of maintenance. Paints that are advantageous when repainted at reasonable intervals may be unsuitable if a very long interval is to elapse. Choice is also partly a matter of compatibility between paints, since good paints often behave abnormally when applied over previous coatings of paints of very different characteristics. Since all kinds of paint have their disadvantages as well as their advantages, there will be greater general satisfaction in the choice if the user's desires in the matter can be allowed to operate intelligently.

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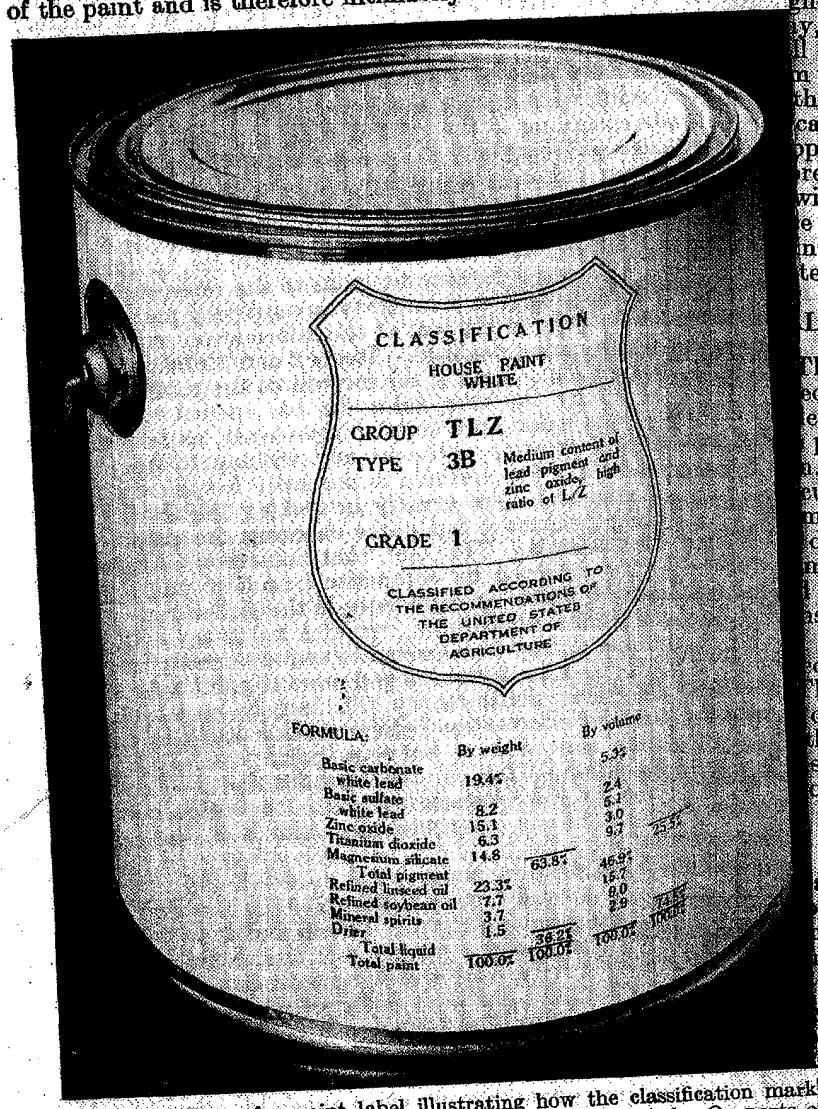

FIGURE 1.—Part of a paint label illustrating how the classification mark
formula for a popular kind of house paint may be printed. On parts o
label not shown in the illustration the manufacturer's trade-mark is dis
conspicuously and directions for application are given. The formula is pr
both in weight percent, which is customary, and in volume percent, as
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FORMS OF PRESENTING LABEL FORMULAS

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published communication from Lyman J. Briggs, director of the National Bureau
T. Trigg, president of the National Paint, Varnish & Lacquer Association, Octob

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After group and type have been settled, grade should be considered, since it determines important questions about the working properties of the paint and is therefore intimately connected with the directions for application. Detailed discussion of the relation between grade and technique of application properly belongs in a more popular presentation of the subject (*15*), but by way of illustration it may be pointed out that, if paints are applied by brush, high-grade paint usually will be greater than paint of lower grade, because it is such that it must be applied with a technique of application properly only when it is economically worthwhile to use high-grade paint.

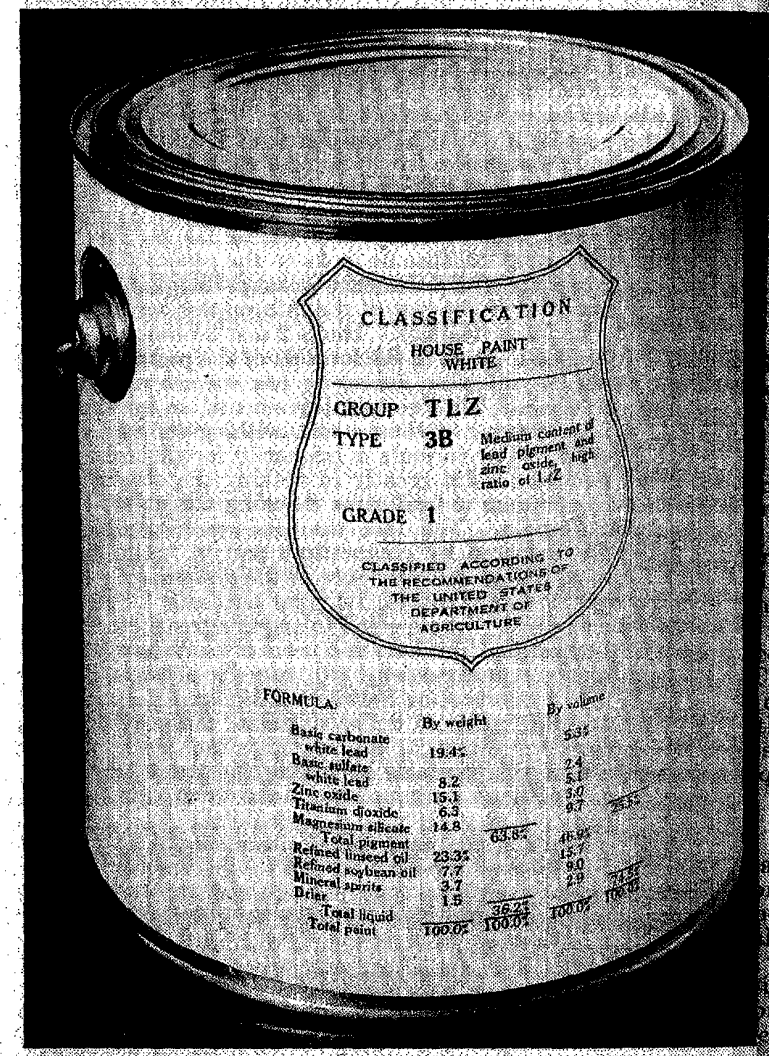

FIGURE 1.—Part of a paint label illustrating how the classification mark and formula for a popular kind of house paint may be printed. On parts of the label not shown in the illustration the manufacturer's trade-mark is displayed conspicuously and directions for application are given. The formula is printed both in weight percent, which is customary, and in volume percent, as proposed by the National Bureau of Standards.

out that, if paints of the same group, type, and color but of varying grade are applied at say 600 square feet per gallon, a thicker film of dried paint and one of greater opacity will in general be produced by high-grade than by low-grade paint. Putting the matter in another way, to produce a dried film of paint of given thickness, less paint will usually be required with a higher grade and the opacity of the film will be greater. Some paint jobs can be done equally satisfactorily with paint of higher or lower grade provided that the technique of application is adjusted accordingly. Other paint jobs can be done properly only with paint of high grade. There may be times when it is more economical to do a job with paint of rather low grade than to do it with high-grade paint—for example, when the condition of the surface is such that, to paint it at all, an abnormally large amount of paint must be consumed. The paint grades, therefore, serve as guides to technique of application.

CALCULATING CLASSIFICATION FROM PAINT FORMULAS

The classification of the paint is calculated from the formula and directions for application given on the label, not from the more detailed manufacturing formula used in the paint factory. Obviously the public declaration of the formula should agree with the classification. When the label formula is stated adequately the classification calculated from it agrees with that calculated from the manufacturing formula, but inaccuracies or ambiguities in the label formula give rise to discrepancies. Formulas that comply with the recommended Nomenclature for Formula Labeling of the National Paint, Varnish and Lacquer Association (*18*) are adequate, provided that the proportions of each ingredient, including colored pigments in tinted paints, are stated with sufficient precision, and provided further that the directions for application are clear and definite.

The remainder of this bulletin deals with the methods of calculating the classification of house and barn paints from the formula as it appears on the label. By following the prescribed methods of calculation, any house or barn paint can be classified provided that a reasonably adequate statement of the formula is available.

Forms of Presenting Label Formulas

Label formulas, in conformity to custom and to State laws, are reported in weight percent. The National Bureau of Standards [3] has proposed that they be reported both by weight and by volume, in parallel columns, as indicated in figure 1. It is recommended that this practice be adopted by manufacturers cooperating in the classification plan.

Some manufacturers report the percent of ingredients to two decimal places, for example, "pigment, by weight, 63.72 percent." Others round off all fractions, thus, "pigment, by weight, 64 percent." The former practice implies greater precision than is feasible in manufacturing operations, whereas the latter admits uncertainties large enough to alter border-line classifications. It is therefore recommended that the percent be reported to one decimal place, as illustrated in figure 1.

[3] Unpublished communication from Lyman J. Briggs, director of the National Bureau of Standards, to Ernest T. Trigg, president of the National Paint, Varnish & Lacquer Association, October 5, 1939.

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The label formula in weight percent, following long custom, may be expressed in one or the other of two basic forms (*18*), both of which are further subject to certain variations. The form most widely used, referred to subsequently as example 1, divides the paint into two parts, the pigment and the liquid (also called the vehicle), each of which is reported in percent of total paint, and then itemizes the pigment ingredients in percent of total pigment, and the liquid ingredients in percent of total liquid. Example 2 itemizes all ingredients, both pigments and liquids, in percent of total paint. The two forms and their variations can be made clear by using each of them to express typical label formulas for the same paint, namely, the paint already exemplified in figure 1.

Example 1, Variation A

In variation A the pigment or the liquid or both are only partly itemized and the balance of the information is given in footnotes. In the illustration below the composition of the white lead and the drying oil is explained in footnotes.

	Percent
Pigment, by weight	63.8
Liquid, by weight	36.2
	100.0
Composition of pigment, by weight:	
[1] White lead	43.2
Zinc oxide	23.7
Titanium-magnesium	33.1
	100.0
Composition of liquid, by weight:	
[2] Drying oil	85.7
Mineral spirits	10.2
Drier	4.1
	100.0

Footnotes on label

	Percent
[1] Composition of white lead:	
Basic carbonate	70.4
Basic sulfate	29.6
	100.0
[2] Composition of drying oil:	
Refined linseed oil	75.2
Refined soybean oil	24.8
	100.0

It is usually considered unnecessary (though it is desirable) to explain the titanium-magnesium in a footnote provided that it consists of 30 percent by weight of titanium dioxide and 70 percent of magnesium silicate, which is the composition of the composite pigment sold under that name (*3, pp. 625–626*). The statement in the label formula, however, does not mean necessarily that the composite pigment was used but merely that titanium dioxide and magnesium silicate are present in the proportions indicated. Any additional magnesium silicate or titanium dioxide is itemized separately in the

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	Percent
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	36.2
	100.0
	43.2
	23.7
	33.1
	100.0
	85.7
	10.2
	4.1
	100.0

	Percent
	70.4
	29.6
	100.0
	75.2
	24.8
	100.0

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tion of the composite pig-
'6). The statement in the
essarily that the composite
m dioxide and magnesium
ıdicated. Any additional
itemized separately in the

formula. On the other hand the separate listing of basic sulfate white lead and zinc oxide does not mean necessarily that the two pigments were actually used separately; they may represent the component parts of the composite pigment, leaded zinc oxide (*14*) — in this case a leaded zinc oxide containing 35 percent by weight basic sulfate white lead. Mineral spirits and drier are often lumped together without itemization in a footnote. Other manufacturers report them separately in the formula as shown but without indicating how much of the drier is volatile and how much nonvolatile. The content of nonvolatile in drier is seldom reported clearly.

Example 1, Variation B

Variation B differs from A only in the manner of stating the footnotes. Instead of itemizing them in percent of the composite ingredient explained by the footnote, they are itemized in percent of total pigment or of total liquid, so that the sum of the items is numerically equal to the percent of the composite ingredient appearing in the main part of the formula. Thus the two footnotes under variation A would here appear as follows:

	Percent
[1] Composition of white lead:	
Basic carbonate white lead	30.4
Basic sulfate white lead	12.8
	43.2
[2] Composition of drying oil:	
Refined linseed oil	64.4
Refined soybean oil	21.3
	85.7

In printing footnotes the phrase "composition of ————" is sometimes omitted.

Example 1, Variation C

No footnotes appear in variation C:

	Percent
Pigment 63.8 percent of paint, by weight:	
Basic carbonate white lead	30.4
Basic sulfate white lead	12.8
Zinc oxide	23.7
Titanium dioxide	9.9
Magnesium silicate	23.2
Total	100.0
Liquid 36.2 percent of paint, by weight:	
Refined linseed oil	64.4
Refined soybean oil	21.3
Mineral spirits and drier	14.3
Total	100.0

The titanium dioxide and magnesium silicate might also be reported as one item, titanium-magnesium, as in the illustration given for variation A. If leaded zinc oxide is used it might appear as "35-percent leaded zinc oxide, 36.5 percent."

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Example 2

Although example 2 may appear in any one of the three variations described for example 1, it is usually presented as variation C, as follows:

	Percent
Basic carbonate white lead	19.4
35-percent leaded zinc oxide	23.3
Titanium-magnesium	21.1
Refined linseed oil	23.3
Refined soybean oil	7.7
Mineral spirits	3.7
Drier	1.5
Total	100.0

A few manufacturers print the formula according both to example 1 and to example 2 in parallel columns in some such manner as the following:

Pigment 63.8 percent, liquid 36.2 percent of the paint, by weight:

	Pigment percent	Liquid percent	Total percent
Basic carbonate white lead	30.4	-----	19.4
Basic sulfate white lead	12.8	-----	8.2
Zinc oxide	23.7	-----	15.1
Titanium-magnesium	33.1	-----	21.1
Refined linseed oil		64.4	23.3
Refined soybean oil		21.3	7.7
Mineral spirits and drier		14.3	5.2
Total	100.0	100.0	100.0

Volume Analysis

PREPARED PAINTS

Paints are classified on the basis of their composition by volume, not by weight. Not only are the formulas by volume simpler, but paints are usually sold by volume; and volume rather than weight is nearly always the dominant property governing the technique of application. The process of converting the formula by weight to the formula by volume is called for convenience "volume analysis." It requires knowledge of the volume occupied in paint by unit weight of each ingredient in the paint. This factor is called the bulking value and is listed in tables 1 and 2 for the ingredients commonly used in house and barn paints. More extensive tables of bulking values will be found elsewhere (*11, pp. 455–578*). The significance of the column headed "Diluent allowance" in table 1 is explained later under "Diluent allowance for very opaque pigments."

The names of pigments listed in table 1 have definite significance and require no additional explanation when used in label formulas except that those names preceded by an asterisk (*) should be designated C. P. in the label formula, signifying "chemically pure" and indicating that there is no admixture of pigment of low opacity (see paragraph 6 in the section on Ambiguities in label formulas). When the names so marked are used without the designation C. P., the bulking value given in the table will be used in the volume analysis but the diluent allowance will be zero. Names of less definite meaning that should be further explained by means of footnotes or otherwise are listed subsequently in table 19, p. 28.

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TABLE 1.—*Data on paint pigments for volume analysis of label formulas and classification*

Name of pigment and chemical symbol occasionally used	Bulking value per pound	Diluent allowance	Symbol for use in classification
Opaque white pigments:	*Gallons*		
Antimony oxide (Sb_2O_3)	0.0209	0.00	A
Basic carbonate white lead	.0176	0	L
Basic sulfate white lead	.0187	0	L
Lead titanate ($PbTiO_3$)	.0164	3.00	L
Lithopone	.0279	0	S
Titanated lithopone	.0282	.52	ST
Titanium-barium (25 percent TiO_2)	.0279	.16	T
Titanium-barium (30 percent TiO_2)	.0283	.37	T
Titanium-calcium	.0384	0	T
Titanium dioxide (TiO_2)	.0308	3.20	T
Titanium-magnesium	.0387	0	T
Zinc oxide (ZnO)	.0215	0	Z
Zinc sulfide (ZnS)	.0300	1.40	S
Zinc sulfide-barium	.0286	.26	S
Zinc sulfide-magnesium	.0361	0	S
Opaque colored pigments:			
Aluminum (in flake form)	.0470	4.00	C
Basic lead chromate	.0170	2.00	L
Black oxide (Fe_3O_4)	.0250	3.00	C
Blue lead (basic sulfate white lead and carbon)	.0189	0	L
Cadmium red (cadmium lithopone)	.0250	1.00	C
Cadmium yellow (cadmium lithopone)	.0280	1.00	C
Carbon (C)	.0660	5.00	C
*Chinese blue (ferric ferrocyanide)	.0650	3.00	C
*Chrome orange (lead chromate and oxide)	.0170	2.00	L
*Chrome yellow (lead chromate and sulfate)	.0200	1.00	L
Chromium oxide (Cr_2O_3)	.0230	0	C
Chromium oxide hydrate ($Cr(OH)_3$)	.0320	0	C
Copper aceto arsenate	.0370	0	C
Copper phthalocyanine	.0790	0	C
Cuprous oxide (Cu_2O)	.0200	3.00	C
Ferric ferrocyanide ($Fe_4[Fe(CN)_6]_3$)	.0650	3.00	C
Ferric oxide (Fe_2O_3)	.0240	4.00	F
Ferric oxide hydrate ($Fe(OH)_3$)	.0300	2.00	F
Ferric hydroxide ($Fe(OH)_3$)	.0300	2.00	F
Graphite	.0540	4.00	C
Hydrated chromium oxide ($Cr(OH)_3$)	.0320	0	C
Hydrated ferric oxide ($Fe(OH)_3$)	.0300	2.00	C
*Iron blue (ferric ferrocyanide)	.0650	3.00	C
Lampblack	.0660	5.00	C
Lead (in flake form)	.0240	4.00	C
Lead chromate ($PbCrO_4$)	.0200	1.00	L
Litharge (PbO)	.0127	0	L
*Lithol red	.0800	0	C
Magnetic oxide (Fe_3O_4)	.0250	3.00	C
Manganese dioxide (MnO_2)	.0300	4.00	C
Mercury oxide (HgO)	.0107	3.00	C
Mineral black	.0450	1.00	C
*Para red (paranitraniline red)	.0800	0	C
Paris green (copper aceto arsenate)	.0370	0	C
*Prussian blue (ferric ferrocyanide)	.0650	3.00	C
Red lead (Pb_3O_4)	.0135	1.00	L
*Red toner	.0800	0	C
*Toulidine red	.0800	0	C
Tuscan red	.0310	0	C
Ultramarine	.0500	0	C
Van Dyke brown	.0720	0	C
Zinc chromate ($ZnCrO_4$)	.0350	0	C
Zinc dust	.0170	0	C
Pigments of low opacity:			
Aluminum hydroxide ($Al(OH)_3$)	.0400		
Aluminum silicate	.0470		
Barium sulfate ($BaSO_4$)	.0270		
Barytes (barium sulfate)	.0270		
Blanc fixe (barium sulfate)	.0275		
Calcium carbonate ($CaCO_3$)	.0443		
Calcium phosphate, ($Ca_3(PO_4)_2$)	.0450		
Calcium sulfate, anhydrous ($CaSO_4$)	.0430		
Calcium sulfate, hydrated ($CaSO_4.2H_2O$)	.0510		
Chalk (calcium carbonate)	.0443		
China clay (kaolin)	.0460		
Clay (kaolin)	.0460		
Diatomaceous silica	.0510		
Fibrous talc	.0421		
Gypsum (hydrated calcium sulfate)	.0510		
Kaolin	.0460		
Magnesium aluminum silicate	.0450		
Magnesium carbonate ($MgCO_3$)	.0660		

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TABLE 1.—*Data on paint pigments for volume analysis of label formulas and classification*—Continued

Name of pigment and chemical symbol occasionally used	Bulking value per pound	Diluent allowance	Symbol for use in classification
Pigments of low opacity—Continued.	*Gallons*		
Magnesium silicate	0.0421		
Mica	.0420		
Paris white (calcium carbonate)	.0443		
Silica (SiO_2)	.0453		
Siliceous matter (in earth pigments)	.0430		
Slate flour	.0430		
Talc (magnesium silicate)	.0421		
Terra-alba (hydrated calcium sulfate)	.0510		
Whiting (calcium carbonate)	.0443		

TABLE 2.—*Bulking values*[1] *for paint liquids*[2]

Name of liquid	Bulking value per pound	Name of liquid	Bulking value per pound
Nonvolatile liquids:	*Gallons*	Nonvolatile liquids—Continued.	*Gallons*
China-wood oil, see tung oil		Tung oil, bodied	.1225
Fish oil, refined	0.1288	Resin	.1100
Fish oil, bodied	.1260	Varnish nonvolatile	.1225
Linseed oil, raw, boiled, or refined	.1288	Drier nonvolatile	.0860
Linseed oil, bodied, or blown	.1260	Volatile liquids:	
Linseed oil, heavy bodied, or heavy blown	.1225	Dipentene	.1600
Menhaden oil, see fish oil		Drier (liquid drier or japan drier)	.1250
Perilla oil, raw or refined	.1288	Mineral spirits	.1550
Perilla oil, bodied	.1260	Naphtha (varnish makers and painters naphtha)	.1600
Soybean oil, refined, clarified, or refiltered	.1300	Solvent naphtha	.1550
Soybean oil, bodied	.1260	Turpentine	.1280
		Water	.1200

[1] The bulking values for some of the liquids listed are subject to appreciable variation. When liquids are used of which the bulking values differ materially from those recorded in table 2, it is recommended that the manufacturer report the correct specific gravity of the liquid in the label formula as indicated by the following example: "bodied tung oil (sp. gr. 0.975)." When the specific gravity is so reported the bulking value will be calculated from the equation $B=1\div8.33G$ in which B is the bulking value and G is the specific gravity.

[2] For a list of names of uncertain meaning for paint liquids and rules for dealing with them, see table 19, p. 28.

When the label formula is printed according to example 1, in which the pigments and liquids are itemized separately, the first step in the volume analysis is to convert example 1 to example 2. The formula given to illustrate example 1, variation A, is thus converted by means of the calculation in table 3.

TABLE 3.—*Calculation No. 1, first stage, to convert values in formula in example 1, variation A, to example 2 values*

Ingredient	Fraction of composite ingredient (see footnote on label)	Step 1—multiply by fraction of pigment or liquid	Step 2—multiply by percent of pigment or liquid in paint	To get percent of ingredient in paint
Basic carbonate white lead	0.704	0.432	63.8	19.40
Basic sulfate white lead	.296	.432	63.8	8.17
Zinc oxide		.237	63.8	15.12
Titanium-magnesium		.331	63.8	21.12
Refined linseed oil	.752	.857	36.2	23.31
Refined soybean oil	.248	.857	36.2	7.71
Mineral spirits		.102	36.2	3.69
Drier		.041	36.2	1.48
All ingredients				100.00

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If the multipliers in columns 2 and 3 of table 3 are written as fractions (0.704 instead of 70.4 percent) and those in column 4 as percents the resultant figures in column 5, or the desired formula according to example 2, come out in percents again. The results in the last column are recorded to two decimal places when the computation is to be carried further, but for printing on the label they would be rounded off to one decimal place.

When the label formula is printed in example 1, variation B or C, step 1 of the computation in table 3 is eliminated, as shown in table 4.

TABLE 4.—*Calculation No. 1, first stage, to convert values in formula in example 1, variation B or C, to example 2 values*

Ingredient	Fraction of pigment or liquid	Step 2—multiply by percent of pigment or liquid in paint	To get percent of ingredient in paint
Basic carbonate white lead	0.304	63.8	19.40
Basic sulfate white lead	.128	63.8	8.17
Zinc oxide	.237	63.8	15.12
Titanium-magnesium	.331	63.8	21.12
Refined linseed oil	.644	36.2	23.31
Refined soybean oil	.213	36.2	7.71
Mineral spirits and drier	.143	36.2	5.17
All ingredients			100.00

After the formula has been obtained in terms of example 2, it is necessary to break down a number of composite ingredients or mixtures that may be reported into their component parts before proceeding further with the volume analysis. In the illustration given for example 2 (p. 10) the "35-percent leaded zinc oxide, 23.3 percent" must be broken down into "basic sulfate white lead, 8.2 percent" (0.35×23.3) and "zinc oxide, 15.1" (0.65×23.3). It is essential later on to know the proportions of lead pigments and of zinc oxide separately. Other composite ingredients that must usually be broken down to compute the classification are the iron oxide pigments, reduced colored pigments, varnish, bodied oils that contain volatile thinner and mixtures of volatile thinner and drier. Adequately reported paint formulas contain all the data necessary for breaking down the composite ingredients; procedures to be followed when necessary data are omitted in the formula will be described later. A few composite ingredients whose proportions are well standardized (*3*, *3a*) need not be broken down. Pigments such as titanium-magnesium and lithopone, for which bulking values are listed in table 1, may be treated as though they were single ingredients.

The second stage in the volume analysis is to convert example 2 from the weight to the volume basis (table 5). When the weight-percent of the several ingredients is multiplied by the bulking values of the ingredients in gallon per pound, as listed in tables 1 and 2 (step 3), the volume of each ingredient per 100 pounds of paint is obtained, of which the sum is the volume in gallons of 100 pounds of paint, or in the case illustrated, 6.397. The weight of 1 gallon of this paint, of course, is 100÷6.397=15.6 pounds, which, if the label formula is given accurately to one decimal place, should agree within 0.2 pound with the weight per gallon determined by test of a sample of the paint.

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If the label formula is given less precisely or contains ambiguities for which assumptions must be made, the calculated and determined weights per gallon may vary more widely, but if the disagreement exceeds 0.4 pound either the formula is very inadequate or the sample is unrepresentative and the classification of the product is doubtful. On dividing each number in column 4 of table 5 by their sum (step 4), the volume of each ingredient in gallon per gallon of paint is obtained. These numbers multiplied by 100 give the formula of the paint in volume-percent as shown in figure 1.

TABLE 5.—*Calculation No. 1, second stage, to convert percent of ingredients by weight to fractional volume per gallon of paint*

Ingredient	Percent weight or pounds per 100 pounds	Step 3—multiply by bulking value (gallon per pound)	To get gallons per 100 pounds of paint	Step 4—divide each item by total to get fractional part of 1 gallon
Basic carbonate white lead	19.40	0.0176	0.341	0.0533
Basic sulfate white lead	8.17	.0187	.153	.0239
Zinc oxide	15.12	.0215	.325	.0508
Titanium-magnesium	21.12	.0387	.817	.1277
Refined linseed oil	23.31	.1288	3.002	.4693
Refined soybean oil	7.71	.1300	1.002	.1567
Mineral spirits	3.69	.1550	.572	.0894
Drier	1.48	.1250	.185	.0289
All ingredients	100.00		6.397	1.0000

The third stage in the volume analysis is the calculation of the content of opaque pigment, total pigment, and total nonvolatile matter in the paint after it has been thinned for finish coat according to the manufacturer's directions (table 6). The properties of paint during application and subsequent service are governed by the composition of the paint as used. If the paint is thinned with oil or turpentine before application its composition is necessarily altered. Some prepared paints are so made that they have the desired composition and consistency for finish coat as soon as the contents of the container are thoroughly stirred. Other so-called prepared paints are too thick in consistency as they come from the container and must be thinned by adding liquid. (The amount of such thinning directed by different manufacturers varies from zero to as much as one-half gallon per gallon of paint.) Semipaste and paste paints must be thinned with still larger proportions of liquid. Before paints can be graded, therefore, it is necessary to calculate their composition when ready for application as finish coat in accordance with the manufacturer's instructions. The group and type of the paint, however, are not altered by thinning and can be determined either from the composition in the container or the composition when ready for finish coat.

In the illustration in table 6, all of the pigments are opaque and the drier, in the absence of a statement of its content of nonvolatile matter, is considered entirely volatile matter. It will be assumed that the directions for application call for thinning the paint with one-half pint of linseed oil and one-half pint of turpentine per gallon for use as finish coat.

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TABLE 6.—*Calculation No. 1, third stage, to calculate content of opaque pigment, total pigment, and total nonvolatile matter in thinned paint*

Ingredient	Gallon of ingredient per gallon of paint	Step 5—add oil and spirits for finish coat (½ pint each)	Step 6—divide each item by total to get gallon of ingredient per gallon of finish paint
Basic carbonate white lead	0.0533		
Basic sulfate white lead	.0239		
Zinc oxide	.0508		
Titanium-magnesium	.1277		
Opaque pigment	.2557		0.227
Total pigment	.2557		.227
Refined linseed oil	.4693		
Refined soybean oil	.1567		
Total nonvolatile	.8817	0.9442	0.839
Mineral spirits	.0894	.1519	.135
Drier	.0289	.0289	.026
All ingredients	1.0000	1.1250	1.000

In column 2 of table 6, the total opaque pigment is the sum of the values for white lead, zinc oxide, and titanium-magnesium, all of which are considered opaque pigments for the purpose of classification. Since there are no other pigments present in the paint chosen for the illustration, the total pigment is equal to the opaque pigment. The total nonvolatile is the sum of the total pigment and the linseed and soybean oils, or 0.8817. The small amount of nonvolatile matter in the drier is ignored because it is not reported in the formula and the error thereby introduced in the calculations is negligible. If the manufacturer's directions called for application of the paint for finish coat as it comes from the can, without any thinning, the calculation would end with the values recorded in column 2, but for the illustration chosen the thinning recorded in column 3 is assumed to be specified. When the volumes of opaque pigment, total pigment, and total nonvolatile are readjusted for the thinning (steps 5 and 6), as recorded in column 5, they form the basis for classifying the paint. The instructions to thin the paint for finish coat do not alter the group and type in which the paint is classified, but in the illustration chosen the paint would be grade 1 if application without thinning were called for, whereas it is grade 3 when thinned with 1 pint of liquid per gallon.

PASTE AND SEMIPASTE PAINTS

The volume analysis of paste paints and semipaste paints is made in exactly the same way as that for prepared paints, taking into account the manufacturer's directions for thinning the product for finish coat. To illustrate the calculations a semipaste paint of the following label formula is assumed:

Pigment, by weight, 81.0 percent:	*Percent*
Basic carbonate white lead	30.4
Basic sulfate white lead	12.8
Zinc oxide	23.7
Titanium-magnesium	33.1
Total	100.0

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Liquid, by weight, 19.0 percent:	Percent
Linseed oil	65. 7
Mineral spirits	27. 7
Drier	6. 6
Total	100. 0

If it is assumed further that the directions call for addition of 3 quarts of linseed oil to 1 gallon of the semipaste paint for finish coat, the volume analysis would be as shown in calculation No. 2, table 7.

TABLE 7.—*Volume analysis of a semipaste paint (calculation No. 2)*

Ingredient	Fraction of pigment or liquid	Step 2—multiply by percent of pigment or liquid in paint	To get percent of ingredient in paint	Step 3—multiply by bulking value (gallon per pound)	Gallons per 100 pounds of paint	Step 4—divide each item by total to get fractional part of 1 gallon	Step 5—gallons of finish paint obtained	Step 6—divide each item by total to get gallon of ingredient per gallon of finish paint
Basic carbonate white lead	0.304	81.0	24.62	0.0176	0.433	0.0930		
Basic sulfate white lead	.128	81.0	10.37	.0187	.194	.0416		
Zinc oxide	.237	81.0	19.20	.0215	.413	.0887		
Titanium-magnesium	.331	81.0	26.81	.0387	1.038	.2228		
Opaque pigment						.4461		0.255
Total pigment						.4461		.255
Linseed oil	.657	19.0	12.48	.1288	1.607	.3450		
Total nonvolatile						.7911	1.5411	0.881
Mineral spirits	.277	19.0	5.27	.1550	.817	.1754	.1754	.100
Drier	.066	19.0	1.25	.1250	.156	.0335	.0335	.019
All ingredients			100.00		4.658	1.0000	1.750	1.000

DILUENT ALLOWANCE FOR VERY OPAQUE PIGMENTS

The volume analysis leads to a summation of the content of opaque pigment, total pigment, and total nonvolatile in the paint when mixed for application as finish coat. These summations become the basis for classifying the paint with respect to grade. The pigments listed in table 1 under the heading "Pigments of low opacity" contribute practically nothing to the opacity of house and barn paints, although they do add some opacity to water paints and to some flat wall paints for interior use (*24*). The pigments of low opacity, which were formerly regarded as adulterants by many authorities (*23; 20, p. 386*), must now be considered necessary ingredients in paints that contain material proportions of very opaque pigments (*10*). In the volume analysis of house and barn paints, therefore, the pigments of low opacity are counted in the summation for total pigment but not in that for opaque pigment.

The opaque pigments listed in table 1 contribute materially to the opacity of paint but some of them are much more effective in that respect than others. In house and barn paints, which require a relatively high content of total pigment for reasons other than opacity (*7, 9, 12, 13*), the custom is to dilute the very opaque pigments by

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mixing them with pigments of low opacity. This custom is recognized in the volume analysis by counting as part of the opaque pigment a "diluent allowance" representing a volume of pigment of low opacity sufficient to make the mixture approximately equal in opacity to the white leads and zinc oxide on a volume basis. The diluent allowances for very opaque pigments established for purposes of volume analysis are listed in table 1. The composite pigments, lithopone, titanium-calcium, titanium-magnesium, and zinc sulfide-magnesium, are given zero diluent allowance because they contain the appropriate porportion of pigment of low opacity to make them equal in opacity to the white leads and zinc oxide. Other composite pigments, such as titanated lithopone, titanium-barium, and zinc sulfide-barium, contain smaller proportions of pigment of low opacity and are therefore given small diluent allowances.

The diluent allowance for titanium dioxide is derived from the proportions by volume of titanium dioxide and magnesium silicate in titanium-magnesium by the calculations shown in table 8. The diluent allowance for titanium dioxide is therefore 0.762÷0.238=3.2. The diluent allowance for zinc sulfide is calculated in similar manner from the proportions by volume of zinc sulfide and magnesium silicate in zinc sulfide-magnesium.

TABLE 8.—*Derivation of diluent allowance for titanium dioxide*

Step in calculation	Titanium dioxide	Magnesium silicate	Titanium-magnesium
Pounds per 100 pounds titanium-magnesium	30	70	100
Multiply by bulking value in pounds per gallon	0.0308	0.0421	
Gallons per 100 pounds titanium-magnesium	.924	2.950	3.874
Divide both items by total	3.874	3.874	
Gallon of ingredient in 1 gallon titanium-magnesium	.238	.762	1.000

Table 9 illustrates the use of the diluent allowance in volume analysis, with the titanium dioxide and magnesium silicate listed separately instead of the composite pigment titanium-magnesium. The titanium dioxide is listed among the opaque pigments with a space below for its diluent allowance. The magnesium silicate is recorded after the opaque pigment. In step 4 the diluent allowance, 0.0973, is written in parentheses to indicate that it is added in the summation of opaque pigment but not in the summation of total pigment. Thus the opaque pigment is 0.256, but in total pigment the diluent allowance is omitted and the magnesium silicate, 0.0974 added, bringing the rounded off total to 0.256. The results shown in the last column of table 9, of course, agree with the previous illustration of calculation No. 1 in which the titanium dioxide and magnesium silicate were listed together as titanium-magnesium.

In table 9 the opaque pigment and the total pigment happen to be equal because the quantity of pigment of low opacity (magnesium silicate) is equal to the diluent allowance for the very opaque pigment (titanium dioxide). In actual practice, however, the pigment of low opacity may exceed, equal, or be exceeded by the diluent

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TABLE 9.—*Calculation No. 1 (as in tables 4, 5, and 6) with titanium dioxide and magnesium silicate listed separately*

Ingredient	Weight-percent	Step 3—multiply by bulking value	To get gallons per 100 pounds of paint	Step 4—each item divided by total to get fractional part of 1 gallon
Basic carbonate white lead	19.40	0.0176	0.341	0.0533
Basic sulfate white lead	8.17	.0187	.153	.0239
Zinc oxide	15.12	.0215	.325	.0508
Titanium dioxide	6.32	.0308	.194	.0304
Diluent allowance	.0304	3.2	.0973	[1](.0973)
Opaque pigment				.2557
Magnesium silicate	14.80	.0421	.623	.0974
Total pigment				.2558
Refined linseed oil	23.31	.1288	3.002	.4693
Refined soybean oil	7.71	.1300	1.002	.1567
Total nonvolatile				.8817
Mineral spirits	3.69	.1550	.572	.0894
Drier	1.48	.1250	.185	.0289
All ingredients	100.00			1.0000

[1] Added into total of opaque pigment, but not into total pigment.

allowance. Calculation No. 3, shown in table 10, illustrates the case in which the pigment of low opacity exceeds the diluent allowance and in consequence the paint contains less opaque pigment than total pigment.

TABLE 10.—*Calculation of thinned paint values in which the content of total pigment exceeds the opaque pigment (calculation No. 3)*

Ingredient	Weight-percent	Step 3—multiply by bulking value	To get gallons per 100 pounds of paint	Step 4—each item divided by total to get fractional parts of 1 gallon
Basic carbonate white lead	19.44	0.0176	0.342	0.0500
Zinc oxide	15.92	.0215	.342	.0500
Titanium dioxide	5.55	.0308	.171	.0250
Diluent allowance	.0250	3.2	.0800	[1](.0800)
Opaque pigment				.205
Magnesium silicate	14.63	.0421	.616	.0901
Silica	5.28	.0453	.239	.0350
Total pigment				.250
Linseed oil	34.16	.1288	4.400	.6436
Total nonvolatile				.894
Mineral spirits	3.31	.1550	.513	.0750
Drier	1.71	.1250	.214	.0313
All ingredients	100.00		6.837	1.000

[1] Added into total of opaque pigment, but not into total pigment.

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Table 11 (calculation No. 4) illustrates the frequent case in which the diluent allowance for very opaque pigment exceeds the quantity of pigment of low opacity used in the paint and the resultant content of opaque pigment recorded is greater than that of total pigment. In such cases the content of opaque pigment is a theoretical value and might more exactly be called the equivalent opaque pigment. It represents the volume of pigments of the degree of opacity of white lead and zinc oxide that would be necessary to provide the same opacity. The content of total pigment, on the other hand, is always a real value, representing the total volume of pigments of all kinds actually present in the paint.

TABLE 11.—*Calculation of thinned paint values in which the theoretical content of opaque pigment exceeds the total pigment (calculation No. 4)*

Ingredient	Weight-percent	Step 3—multiply by bulking value	To get gallons per 100 pounds of paint	Step 4—each item divided by total to get fractional part of 1 gallon
Basic sulfate white lead	18.14	0.0187	0.340	0.0501
Zinc oxide	15.80	.0215	.340	.0502
Titanium dioxide	10.00	.0308	.308	.0454
Diluent allowance	.0454	3.2	.1453	[1] (.1453)
Opaque pigment				.291
Magnesium silicate	16.81	.0421	.708	.1043
Total pigment				.250
Linseed oil	32.74	.1288	4.217	.6210
Total nonvolatile				.871
Turpentine	4.88	.1380	.673	.0991
Drier	1.63	.1250	.204	.0300
All ingredients	100.00		6.790	1.000

[1] Added into total of opaque pigment, but not into total pigment.

TINTED PAINTS

The volume analysis of tinted paints is made in exactly the same way as that for white paints. Table 12 (calculation No. 5) is representative of paints of moderate depth of tint, such as buff or stone color.

In table 12 it should be observed that some of the colored pigments used for tinting, such as ferric oxide and carbon, contribute to the content of opaque pigment to an extent far out of proportion to the relatively small percent of these pigments by weight in column 2. In reporting label formulas for tinted paints it is common practice to omit the percent of colored pigments in paints of light or medium depth of tint. For example, the National Paint, Varnish and Lacquer Association recommends such omission when the tinting colors amount to "less than 5 percent" (*18*). In table 12 the tinting colors amount to 4.39 percent of the paint by weight but they account for 23 percent of the calculated content of opaque pigment; without the tinting colors the opaque pigment would amount to 0.215 gallon instead of 0.281 gallon per gallon of paint. This indicates why tinting pigments should be reported more carefully. (See item 8, p. 31.)

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TABLE 12.—*Volume analysis of tinted paint (calculation No. 5)*

Ingredient	Weight-percent	Step 3—multiply by bulking value	To get gallons per 100 pounds of paint	Step 4—each item divided by total to get fractional part of 1 gallon
Basic carbonate white lead	10.97	0.0176	0.193	0.0300
Zinc oxide	19.43	.0215	.418	.0649
Lead titanate	11.77	.0164	.193	.0300
Lead chromate	1.61	.0200	.032	.0050
Ferric oxide	2.68	.0240	.064	.0099
Carbon	.10	.0660	.007	.0011
Diluent allowance				[1] (.1400)
Opaque pigment				.281
Magnesium silicate	16.66	.0421	.701	.1087
Total pigment				.250
Linseed oil	31.50	.1288	4.057	.6304
Total nonvolatile				.880
Mineral spirits	3.71	.1550	.575	.0823
Drier	1.57	.1250	.196	.0305
All ingredients	100.00		6.436	1.000

[1] Diluent allowance added into total of opaque pigment, but not into total pigment:
For lead titanate, 0.0300×3.0=(0.0900)
For lead chromate, .0050×1.0=(.0050)
For ferric oxide, .0100×4.0=(.0400)
For carbon, .0010×5.0=(.0050)
(.1400)

COLORED-PIGMENT PAINTS

Paints made with colored pigments, pigments of low opacity, and little or no white lead or zinc oxide may well be called colored-pigment paints. Such paints often contain some varnish in the vehicle. Table 13 (calculation No. 6) illustrates the volume analysis of an iron oxide barn paint.

TABLE 13.—*Volume analysis of colored-pigment paint (calculation No. 6)*

Ingredient	Weight-percent	Step 3—multiply by bulking value	To get gallons per 100 pounds of paint	Step 4—each item divided by total to get fractional part of 1 gallon
Ferric oxide [1]	16.71	0.0240	0.401	0.0500
Diluent allowance	0.500	4	.2000	[2] (.2000)
Opaque pigment				.250
Calcium sulfate [1]	25.09	.0430	1.079	.1344
Calcium carbonate	4.53	.0443	.201	.0250
Magnesium silicate	7.74	.0421	.326	.0406
Total pigment				.250
Linseed oil	18.88	.1288	2.432	.3030
Soybean oil	12.36	.1300	1.607	.2002
Bodied tung oil	4.25	.1225	.521	.0649
Resin	2.33	.1100	.256	.0319
Total nonvolatile				.850
Mineral spirits	6.34	.1550	.983	.1225
Drier	1.77	.1250	.221	.0275
All ingredients	100.00		8.027	1.000

[1] Components of venetian red.
[2] Added into total of opaque pigment, but not into total pigment.

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As already explain

Paints are assigne
pal opaque pigment
The following symb
L, lead pigments, as
Z, zinc oxide and the
T, titanium dioxide a
in table 1.
S, zinc sulfide and th
table 1.
A, antimony oxide, a
F, ferric oxide or hy
ments, includin
C, colored pigments
(e), vehicles containin
the total vehicl
(r), vehicles containin
(re), vehicles containin
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These symbols ar
dients of the paint.
titanium dioxide, or
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and barn paints, th
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Table 14 lists th
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Determining the Classification

As already explained, paints are classified by group, type, and grade.

PAINT GROUPS

Paints are assigned to groups according to the nature of the principal opaque pigments and of the vehicle with which they are made. The following symbols are used to describe the groups concisely:

- **L**, lead pigments, as indicated in table 1.
- **Z**, zinc oxide and the zinc oxide in leaded zinc oxide.
- **T**, titanium dioxide and the titanium dioxide in titanium pigments as indicated in table 1.
- **S**, zinc sulfide and the zinc sulfide in the zinc sulfide pigments as indicated in table 1.
- **A**, antimony oxide, as indicated in table 1.
- **F**, ferric oxide or hydrated ferric oxide and the ferric oxide in iron oxide pigments, including the earth pigments such as ochre, umber, and sienna.
- **C**, colored pigments other than **L** or **F** pigments, as indicated in table 1.
- **(e)**, vehicles containing 15 percent or more by volume of bodied oil, based on the total vehicle (nonvolatile liquid plus thinners).
- **(r)**, vehicles containing resin or varnish.
- **(re)**, vehicles containing resin and bodied oil to the extent of 15 percent or more of the total vehicle, by volume.

These symbols are combined to indicate the characteristic ingredients of the paint. Thus group **TLZ (e)** means that the paint contains titanium dioxide, one or more of the lead pigments, zinc oxide, and bodied oil to the extent of at least 15 percent of the total vehicle. There are no symbols for pigments of low opacity, which are not taken into account in assigning paints to groups. Likewise there are no symbols for unbodied drying oil or volatile thinner. For most house and barn paints, therefore, the symbol for group contains only the capital letters standing for opaque pigments.

In combining the symbols to indicate groups, the letters **L, Z, T,** and **S** are used whenever the paint contains any of the pigments for which the letters stand, no matter how small the proportion may be. The letters **F** and **C**, however, are not used when the colored pigments they represent are present only in minor proportions for the purpose of providing color, which is the case in most tinted paints. Tinted paints may be defined as paints that contain both opaque white pigments and colored pigments with the white pigments exceeding the colored pigments in volume. Paints in which the only opaque pigments are colored pigments or in which the colored pigments equal or exceed the opaque white pigments in volume are called colored pigment paints. In tinted paints the letters **F** and **C** are used in the group symbol when the respective colored pigments they represent amount to 20 percent or more of the volume of total pigment. In colored-pigment paints the letters **F** and **C** are used whenever the paint contains any of the pigments represented, except that letter **C** should be omitted if it represents less than 20 percent of the **L** and **F** pigments by volume.

Table 14 lists the groups that comprise most of the house and barn paints on the market. The list is not exhaustive, however, and is intended primarily to illustrate the method of combining symbols to describe the paint groups.

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TABLE 14.—*Groups of house and barn paints*

WHITE PAINTS AND TINTED PAINTS

Group	Major constituents of—	
	Pigment	Vehicle
L	White lead	Unbodied drying oil.
LZ	White lead, lead titanate, or both, and zinc oxide.	Do.
TLZ	White lead, lead titanate, or both, zinc oxide, and titanium dioxide.	Do.
TLZ(e)		Bodied and unbodied oil.
TZ	Titanium dioxide, zinc oxide	Unbodied drying oil.
TL(r)	Titanium dioxide, white lead	Unbodied oil, bodied oil, and resin.
SLZ	Zinc sulfide, white lead, and zinc oxide.	Unbodied drying oil.
SZ	Zinc sulfide and zinc oxide	Do.
STLZ	Zinc sulfide, titanium dioxide, white lead, zinc oxide.	Do.

TINTED PAINTS AND COLORED-PIGMENT PAINTS

F or C added to any of the above symbols for white paints, as FLZ or CLZ.	The white pigments indicated by letters L, Z, T, or S plus F or C pigments, respectively, in the amount of 20 percent or more of the total pigment by volume.	Unbodied drying oil, but if resin or much bodied oil is present add the symbols (r), (e), or (re), as required.

COLORED-PIGMENT PAINTS

L	Lead chromate, red lead, or blue lead	Unbodied drying oil.
LZ	Lead chromate and zinc oxide	Do.
F(r)	Ferric oxide or ferric hydroxide	Unbodied oil, bodied oil, and resin.
FZ	Ferric oxide, zinc oxide	Unbodied drying oil.
CZ	C pigment and zinc oxide	Do.
CL(re)	Chrome green or other mixture of C and L pigments.	Unbodied oil, bodied oil, and resin.
CLZ	Chrome green and zinc oxide or other mixture of C, L, and Z pigments.	Unbodied drying oil.
C(e)	C pigment	Unbodied and bodied oil.
CF(e)	C and F pigments	Do.

PAINT TYPES

Paints are assigned to types according to the proportion of lead pigment and zinc oxide in the total pigment by volume. Account is taken of the sum of lead pigment and zinc oxide, L plus Z, and of the ratio of lead pigment to zinc oxide, L/Z. Five ranges of L plus Z are recognized as follows:

	Range
1. Very high content of lead pigment and zinc oxide	80 percent or more.
2. High content of lead pigment and zinc oxide	60 to 79.9 percent.
3. Medium content of lead pigment and zinc oxide	40 to 59.9 percent.
4. Low content of lead pigment and zinc oxide	20 to 39.9 percent.
5. Very low content of lead pigment and zinc oxide	0 to 19.9 percent.

Four ranges in ratio of lead pigment to zinc oxide are recognized as follows:

	Range
A. Very high ratio of lead pigment to zinc oxide	Over 3/1.
B. High ratio of lead pigment to zinc oxide	3/1 to 1/1.
C. Low ratio of lead pigment to zinc oxide	Less than 1/1 to 1/3.
D. Very low ratio of lead pigment to zinc oxide	Less than 1/3.

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A type is described by naming the range of **L** plus **Z** and the ratio of **L/Z**, for example, "type high content of lead pigment and zinc oxide with high ratio of lead pigment to zinc oxide." For brevity this type may be referred to as "type 2B." In type 5, which has very low content of lead pigment and zinc oxide, the ratio **L/Z** has practically no significance and is omitted.

In the paint illustrated in table 5, the content of lead pigment as obtained by step 4 is the sum of the basic carbonate white lead and the basic sulfate white lead, or 0.0772. Since the content of zinc oxide is 0.0508, **L+Z**=0.1280, which is 50.1 percent of the total pigment and **L/Z**=1.52. The paint, therefore, is group **TLZ** type 3B.

In calculation No. 2 (table 7), **L**=0.0930+0.0416, or 0.1346 and **Z**=0.0887. **L+Z**=0.4461, or 50.1 percent of the total pigment and **L/Z**=1.52. The paint, therefore, is of the same group and type as No. 1.

In calculations Nos. 3 and 4 (tables 10 and 11), **L+Z**=40.1 percent of the total pigment and **L/Z**=1.0. These paints also, therefore, are group **TLZ** type 3B.

In calculation No. 5 (table 12), some of the lead pigments have diluent allowances which are counted in computing the content of **L** pigment, thus:

Basic carbonate white lead	0.0300
Lead titanate	.0300
Diluent allowance for lead titanate	(.0900)
Lead chromate	.0050
Diluent allowance for lead chromate	(.0050)
Total **L** pigment	.1600

(L+Z)÷0.250=90.0 percent of the total pigment and **L/Z**=2.47. The paint, therefore, is group **LZ** type 1B.

In calculation No. 6 (table 13) the paint contains neither lead pigment nor zinc oxide but does contain ferric oxide. The vehicle contains resin and bodied oil amounting to 0.0968. The vehicle amounts to 0.750 (1 minus the total pigment), so that the resin and bodied oil amount to 0.0968÷0.750×100=12.9 percent of the vehicle. Accordingly the paint belongs to group **F** (r) type 5. If the resin and bodied oil amounted to 15 percent or more of the vehicle the paint would be group **F** (re) type 5.

Although in times past house and barn paints of all of the possible types have been offered on the market, type 1D is now entirely obsolete, types 1C and 2D are practically obsolete, types 2A, 2C, 3A, 3D, and 4B represent only a few paints that fall slightly beyond the borders of neighboring types, and types 1A and 4A each represent almost entirely paints of a single group. Most house and barn paints, therefore, fall in one of the types 1B, 2B, 3B, 3C, 4C, 4D, and 5.

In practice paints of any one group are made only in a limited number of types, sometimes in one type only. Table 15 indicates the types in which the more important groups of paint commonly appear on the market.

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TABLE 15.—*Types in which the more important groups of house and barn paints are commonly made*

Groups [1]	Remarks	Types commonly made
L	White lead paint in white or tints, red lead, blue lead, or chrome yellow paint.	1A.
LZ	White and tinted paints	1B, 2B.
CLZ or FLZ	Deeply tinted paints	3B, 3C, 4C, 4D, 5.
TLZ	White and tinted paints of manufacturer's *first* grade	2B, 3B, 3C.
TLZ	White and tinted paints offered as second grade	4B, 4C, 5.
TZ or SZ	White and tinted paints	4D, 5.
TL	do	4A.
SLZ	do	3B, 3C, 4B, 4C, 5.
S or T	Cheap white and tinted paints	5.
CL or CLZ	Colored-pigment paints	4B, 4C, 5.
F FZ C CF CZ	Colored-pigment paints	5.

[1] The groups are listed with reference to the ingredients of the pigment *only*. Some of these pigment combinations are usually in vehicles containing bodied oil or bodied oil and resin and the complete group symbols contain the added marks (e), (r), or (re).

PAINT GRADES

House and barn paints, with the exception of house-paint primers and enamels or "enamelized paints," are graded on the basis of their content of opaque pigment, total pigment, and total nonvolatile as revealed by the volume analysis, step 4 or 6, according to whether the paint is intended for application without thinning or with thinning for the finish coat. The rules for grading are given in table 16. A paint is assigned to the highest grade for which it meets all three requirements.

TABLE 16.—*Grading rules for house and barn paints*

Grade	Minimum content of—		
	Opaque pigment (equivalent)	Total pigment (actual)	Total nonvolatile
1	0.250	0.250	0.870
2	.210	.230	.800
3	.170	.210	.730
4	.130	.190	.660
5 [1]	.090	.170	.590

[1] Grade 6 is applied to any paint failing to meet requirements of grade 5.

The paint of calculation No. 1, as delivered in the container, contains (table 6) 0.2557 opaque pigment, 0.2557 total pigment, and 0.8817 total nonvolatile. If the paint were intended for application as finish coat without any thinning it would meet all the requirements for grade 1. When thinned with oil and turpentine according to the instructions, however, the paint contains (table 6, step 6) 0.227 opaque pigment, 0.227 total pigment, and 0.839 total nonvolatile. The highest grade for which it then meets all requirements is grade 3. Accordingly the paint is classified as group **TLZ** type 3B grade 3.

The semipaste paint of calculation No. 2, when thinned as directed for finish coat, contains (table 7) 0.255 opaque pigment, 0.255 total

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pigment, and 0.881 total nonvolatile, which meets all requirements for grade 1. The paint is therefore classified as group **TLZ** type 3B grade 1.

The paint of calculation No. 3 (table 10), if it is to be applied without further thinning, contains 0.205 opaque pigment, 0.250 total pigment, and 0.894 total nonvolatile, which meets all requirements for grade 3. The paint is therefore classified as group **TLZ** type 3B grade 3.

The paints of calculations Nos. 4 and 5 (tables 11 and 12), provided that the instructions call for application for finish coat without thinning, meet all requirements for grade 1 and are therefore classified, respectively, as group **TLZ** type 3B grade 1 and group **LZ** type 1B grade 1.

The paint of calculation No. 6 (table 13), if applied without thinning, contains 0.250 opaque pigment, 0.250 total pigment, and 0.850 total nonvolatile. It meets all requirements for grade 2 and is accordingly classified as group **F(r)** type 5, grade 2.

House-paint primers and undercoaters made with the property of controlled penetration are graded according to the rules of table 17. The required content of opaque pigment and of total pigment is the same, grade for grade, as those for house and barn finish paints but materially lower contents of total nonvolatile are demanded because the vehicles used in primers of the kind in question necessarily contain larger proportions of volatile thinners. Group and type are determined for house-paint primers in exactly the same way as for finish paints.

TABLE 17.—*Grading rules for house-paint primers*

Grade	Minimum content of—		
	Opaque pigment (equivalent)	Total pigment (actual)	Total nonvolatile
1	0.250	0.250	0.730
2	.210	.230	.660
3	.170	.210	.590
4	.130	.190	.520
5 [1]	.090	.170	.450

[1] Any primer failing to meet grade 5 is classified as grade 6.

Enamels and "enamelized paints" for exterior use are graded on the basis of their content of opaque pigment and of total nonvolatile according to the rules of table 18. Products to come under the rules of table 18 instead of those of table 16 must contain bodied oil or resin and bodied oil to the extent of 15 percent or more of the vehicle by volume and the group symbol will therefore contain the mark (e) or (re). In addition the label must indicate clearly that the product has the characteristics of enamel or is intended for uses in which enamel or "enamelized paint" is customary. Porch and deck paints, for example, are commonly expected to be enamels, and colored pigment paints intended for shutters, trim, and other minor areas of house exteriors are frequently more enamel- than paint-like in properties.

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TABLE 18.—*Grading rules for enamels and enamelized paints*

Grade	Minimum content of—	
	Opaque pigment (equivalent)	Total nonvolatile
1	0.290	0.550
2	.250	.490
3	.210	.430
4	.170	.370
5 [1]	.130	.310

[1] Any enamel failing to meet grade 5 is classified as grade 6.

AMBIGUITIES IN LABEL FORMULAS

A number of ambiguities have become widely prevalent in label formulas. Many of these probably arise from the belief that paint buyers examine the formulas only in a cursory, qualitative manner so that full details are unnecessary. The procedure of classification, however, is quantitative and requires reasonably adequate details in the formula. Since all doubtful points are given the interpretation least favorable to the quality of the paint, the paint manufacturer's best interests are served by making the formula as complete and accurate as practicable.

Inadequacies and ambiguities in label formulas are dealt with according to the rules given in this section to make sure that the paint will not receive a more favorable classification than it would receive if the formula were more clearly stated.

1. *Omission of statement of content of pigment and of liquid percent of paint when the formula is reported by example 1.*—In this case the formula is inadequate and the paint cannot be classified unless a sample is available with which the weight per gallon can be determined. The missing data can be calculated from the weight per gallon if the formula is adequate in all other respects.

2. *Uncertain names for white lead and zinc oxide or incomplete statement of their composition.*—Basic carbonate white lead is sometimes reported under the following names: White lead carbonate, carbonate white lead, lead carbonate, basic lead carbonate, carbonate of lead, and basic carbonate of lead. Although some of these names are incorrect, they will be interpreted as basic carbonate white lead. Similarly basic sulfate white lead will be understood by any of the following alternative names: White lead sulfate, sulfate white lead, lead sulfate, basic lead sulfate, sulfate of lead, and basic sulfate of lead, except that lead sulfate as an ingredient of chrome yellow may be considered lead chromate for the purpose of the volume analysis. "Sulphate" is an older spelling of sulfate that is still widely used in label formulas.

When white lead is reported without further explanation it will be assumed to consist entirely of basic carbonate white lead. Occasionally white lead is still further abbreviated to lead; if it is clear that the name is applied to a white pigment it will be taken to mean basic carbonate white lead, not metallic lead. Similarly, zinc oxide is sometimes called zinc white or merely zinc.

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When white lead and zinc oxide are lumped together without further details, sometimes under the name lead and zinc, the mixture will be assumed to be half basic carbonate white lead and half zinc oxide by weight. The terms lead-zinc pigment and lead-zinc, on the other hand, usually mean leaded zinc oxide and will be so interpreted.

When leaded zinc oxide is reported without further details of composition it will be assumed to consist of equal parts by weight of basic sulfate white lead and zinc oxide.

3. *Uncertain names for titanium pigments.*—In some label formulas names of indefinite meaning appear, such as: Titanium, titanium white, titanium pigment, titanium-barium, and titanox. When there is uncertainty about the nature of the titanium pigment it will be assumed to be titanium-barium (25 percent TiO_2) as listed in table 1.

The following names approved by the American Society for Testing Materials (*3, pp. 625–626*) and by the National Paint, Varnish and Lacquer Association (*18*) will be interpreted as indicated:

Titanium dioxide, commercially pure titanium dioxide containing on analysis not less than 97 percent of titanium dioxide. Titanium oxide is a synonym for titanium dioxide. Titanium dioxide pigment, however, will be considered to mean titanium-barium (25 percent TiO_2) as listed in table 1.

Titanium-magnesium or titanium-magnesium pigment, 30 percent of commercially pure titanium dioxide and 70 percent of magnesium silicate by weight. On analysis it should contain not less than 28 percent of titanium dioxide.

Titanium-calcium or titanium-calcium pigment, 30 percent of commercially pure titanium dioxide and 70 percent of anhydrous calcium sulfate by weight. On analysis it should contain not less than 28 percent of titanium dioxide.

Titanium-barium or titanium-barium pigment, 25 percent of commercially pure titanium dioxide and 75 percent of barium sulfate by weight. On analysis it should contain not less than 24 percent of titanium dioxide.

When titanium-barium containing 30 percent of titanium dioxide (not less than 28 percent on analysis) is used its composition should be clearly revealed either by a footnote or by printing the percentage of titanium dioxide by weight in parentheses after the name, thus, "titanium-barium (30 percent titanium dioxide)." If the manufacturer so desires, the actual content of commercially pure titanium dioxide and of pigment of low opacity in any of the composite titanium pigments may be listed separately in the label formula.

Lead titanate, for purposes of classification, is considered a lead pigment, not a titanium pigment. It should always be listed clearly as lead titanate in the label formula.

4. *Uncertain names for zinc sulfide pigments.*—Zinc sulfide pigments of uncertain name will be assumed to be lithopone as listed in table 1.

The following names approved by the American Society for Testing Materials (*3a, pp. 633–634*) and the National Paint, Varnish and Lacquer Association (*18*) will be interpreted as indicated:

Zinc sulfide, commercially pure zinc sulfide containing on analysis not less than 97 percent of zinc sulfide. Zinc sulfide pigment, however, will be taken to mean lithopone as listed in table 1.

Lithopone, 28 percent of commercially pure zinc sulfide and 72 percent of barium sulfate by weight. On analysis it should contain not less than 26 percent of zinc sulfide.

Zinc sulfide-barium or zinc sulfide-barium pigment, 50 percent of commercially pure zinc sulfide and 50 percent of barium sulfate by weight. On analysis it should contain not less than 45 percent of zinc sulfide. The term "double strength lithopone" will be taken to mean zinc sulfide-barium.

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Zinc sulfide-magnesium or zinc sulfide-magnesium pigment, 50 percent of commercially pure zinc sulfide and 50 percent of magnesium silicate by weight. On analysis it should contain not less than 45 percent of zinc sulfide.

Zinc sulfide-calcium or zinc sulfide-calcium pigment, 50 percent of commercially pure zinc sulfide and 50 percent of anhydrous calcium sulfate by weight. On analysis it should contain not less than 45 percent of zinc sulfide. This pigment, which is not listed in table 1, should be broken down into its two ingredients in computing the volume analysis.

Titanated lithopone, 15 percent of commercially pure titanium dioxide and 85 percent of lithopone by weight.

5. *Use of trade names for paint ingredients.*—Paint ingredients should not be reported in label formulas by trade names subject to copyright. When trade names are so used the ingredient must be identified satisfactorily before the paint can be classified properly. The comprehensive "raw materials indexes" in Gardner's Physical and Chemical Examination of Paints, Varnishes, Lacquers, and Colors (*11, pp. 455–578*), list most of the paint ingredients by trade brand together with information necessary to identify the nature of the ingredient and with the bulking values. Whenever ingredients reported in label formulas can be clearly identified by means of these raw materials indexes the bulking values reported therein may be used in the volume analysis and classification. A few trade names sometimes found in label formulas are listed in table 19.

TABLE 19.—*Ambiguous names and trade names for paint ingredients*

Name [1] of ingredient	Composition to be assumed when no further explanation is given in the label formula (proportions are given in percentages by weight), or equivalent of term	See paragraph indicated in section on Ambiguities
Albalith	Trade name for lithopone	4, 5
Aliphatic hydrocarbons	Mineral spirits	13
Alkyd resin	Resin, see table 2	
Aluminum flake	Trade name for aluminum silicate	5
Aluminum paste	65 percent aluminum, 35 percent mineral spirits	
Aqueous suspending agent	Water	14
Aqueous bodying agent	do	14
Aromatic hydrocarbons	Solvent naphtha	13
Asbestine	Trade name for magnesium silicate	5
Ash	Drier nonvolatile	12
Bakelite resin	Trade name; count as resin, see table 2	
Basic carbonate of lead	Basic carbonate white lead	2
Basic lead carbonate	do	2
Basic lead sulfate	Basic sulfate white lead	2
Basic sulfate of lead	do	2
Bone black	8 percent carbon, 92 percent calcium phosphate	9
Brown oxide	30 percent ferric oxide, 70 percent siliceous matter	9
Calorized	Bodied (descriptive of a drying oil)	10
Carbonate of lead	Basic carbonate white lead	2
Carbonate lead	do	2
Chrome green	Chrome green, reduced, see below	9
Chrome green, c. p.	Chrome green, medium, see below	9
Chrome green, c. p., light	90 percent lead chromate, 10 percent ferric ferrocyanide	9
Chrome green, c. p., medium	75 percent lead chromate, 25 percent ferric ferrocyanide	9
Chrome green, c. p., dark (or deep)	60 percent lead chromate, 40 percent ferric ferrocyanide	9
Chrome green, reduced	15 percent c. p. chrome green, 85 percent barium sulfate	9
Celite	Trade name for diatomaceous silica	5
Colloidal solution	Water	14
Cryptone	Cryptone MS, see below	4, 5
Cryptone BA	Trade name for zinc sulfide-barium	4, 5
Cryptone CA	Trade name for zinc sulfide-calcium	4, 5
Cryptone MS	Trade name for zinc sulfide-magnesium	4, 5
Dicalite	Trade name for diatomaceous silica	5

[1] The names in this list either should not be used in label formulas (for example, the trade names) or when used require further explanation of their composition in terms of the ingredients listed in tables 1 and 2. When the further explanation is lacking, arbitrary assumptions about their composition will be made as indicated in the second column and discussed in the paragraph of the section on AMBIGUITIES IN LABEL FORMULAS indicated in the last column of the table.

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TABLE 19.—*Ambiguous names and trade names for paint ingredients*—Continued

Name of ingredient	Composition to be assumed when no further explanation is given in the label formula (proportions are given in percentages by weight), or equivalent of term	See paragraph indicated in section on Ambiguities
Drier and thinner	Assume the drier to be 5 percent of the sum of the nonvolatile liquids and that the balance is mineral spirits.	12
Drop black	8 percent carbon, 92 percent calcium phosphate	9
Drying oil	Use bulking value for linseed oil	10
Durmolized	Bodied (descriptive of a drying oil)	10
Emulsified oil	Water	14
Emulsion	do	14
Ester gum	Resin, see table 2	
Extender	Barium sulfate	7
Extending pigment	do	7
Ferrite yellow	Trade name for ferric hydroxide	5
Fixed fatty oil	Use bulking value for linseed oil	10
Gloss oil	50 percent resin, 50 percent mineral spirits	11
Glycerol phthalate	Resin, see table 2	
Heat-treated	Bodied (descriptive of a drying oil)	10
Hydrogenated naphtha	Use bulking value for mineral spirits	13
Indian red	50 percent ferric oxide, 50 percent siliceous matter	9
Inert	Barium sulfate	7
Inert pigment	do	7
Iron oxide	Use bulking value for ferric oxide but no diluent allowance	9
Ivory black	8 percent carbon, 92 percent calcium phosphate	9
Japan drier	Drier	
Keystone filler	Trade name for mineral black	5
Lead	Basic carbonate white lead when obviously meaning a white pigment but do not confuse with lead in flake form.	2
Lead and zinc	50 percent basic carbonate white lead and 50 percent zinc oxide when obviously meaning white pigments.	2
Lead carbonate	Basic carbonate white lead	2
Leaded zinc oxide	50 percent basic sulfate white lead, 50 percent zinc oxide	2
Lead oxide	Red lead	9
Lead paste	90 percent lead in flake form, 10 percent mineral spirits	
Lead sulfate	Basic sulfate white lead but when part of chrome yellow count as lead chromate.	2, 9
—lith (suffix)	Trade name usually meaning lithopone but see Limeolith below.	5
Lithopone, double strength	Zinc sulfide-barium	4
Limeolith	Trade name for calcium carbonate	5
Liquid drier	Drier	
Metallic brown	50 percent ferric oxide, 50 percent siliceous matter	9
Metro-Nite	Trade name, use bulking value for magnesium silicate	5
Monastral blue	Trade name for copper phthalocyanine	5
Ochre	20 percent ferric hydroxide, 80 percent siliceous matter	9
Organic color	Use bulking value 0.08, diluent allowance 0	9
Oxide black	Black oxide	
Oxide brown	30 percent ferric oxide, 70 percent siliceous matter	9
Oxide of iron	Iron oxide, see above	9
Oxide of lead	Red lead	9
Oxide of titanium	Titanium dioxide	3
Oxide of zinc	Zinc oxide	2
Oxide red	30 percent ferric oxide, 70 percent siliceous matter	9
Oxide yellow	30 percent ferric hydroxide, 70 percent siliceous matter	9
Ozlo lead-zinc pigment	Trade name for leaded zinc oxide	2, 5
Persian Gulf oxide	70 percent ferric oxide, 30 percent siliceous matter	9
Phenolic resin	Resin, see table 2	
Ponolith	Trade name for lithopone	4, 5
Prince's mineral	50 percent ferric oxide, 50 percent siliceous matter	9
Processed	Bodied (descriptive of a drying oil)	10
Pyrax	Trade name for magnesium silicate	5
Ramapo blue	Trade name for copper phthalocyanine	5
Red oxide	30 percent ferric oxide, 70 percent siliceous matter	9
Resin ester	Resin, see table 2	
Rosin ester	do	
Sesquioxide of iron	Ferric oxide	9
Sienna, burnt	30 percent ferric oxide, 70 percent siliceous matter	9
Sienna, raw	30 percent ferric hydroxide, 70 percent siliceous matter	9
Silica and silicates	Magnesium silicate except when part of an earth pigment, when it is siliceous matter.	7, 9
Silicates	Magnesium silicate except when part of an earth pigment, when it is siliceous matter.	7, 9
Siliceous pigments	Siliceous matter	9
Soap solution	Water	14
Solution	Water	14
Spanish oxide	80 percent ferric oxide, 20 percent siliceous matter	9
Sublimed white lead	Basic sulfate white lead	2
Sulfate of lead	Basic sulfate white lead but when part of chrome yellow count as lead chromate.	2, 9
Surfex	Trade name, consider as calcium carbonate	5
Suspending agent	Water	14

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TABLE 19.—*Ambiguous names and trade names for paint ingredients*—Continued

Name of ingredient	Composition to be assumed when no further explanation is given in the label formula (proportions are given in percentages by weight), or equivalent of term	See paragraph indicated in section on Ambiguities
Syan blue	Trade name for copper phthalocyanine	5
Synthetic drying oil	Count as varnish nonvolatile	10
Thermolyzed	Bodied (descriptive of a drying oil)	10
Thinner	Mineral spirits	13
Thinner and drier	Assume the drier to be 5 percent of the sum of the nonvolatile liquids and that the balance is mineral spirits.	12
Ti-Bar	Trade name for titaniumbarium	3, 5
Ti-Cal	Trade name for titaniumcalcium	3, 5
Timonox	Trade name for antimony oxide	5
Ti-Pure	Trade name for titanium dioxide	3, 5
Titanium	Titanium-barium (25 percent TiO_2)	5
Titanium dioxide pigment	do	3
Titanium pigment	do	3
Titanium white	do	3
Titanolith	Trade name for titanated lithopone	4, 5
Titanox	Titanox B, see below	5
Titanox A (or AA)	Trade name for titanium dioxide	3, 5
Titanox B	Titanium-barium (25 percent TiO_2)	3, 5
Titanox B30	Titanium-barium (30 percent TiO_2)	3, 5
Titanox C	Titanium-calcium	3, 5
Titanox L	Lead titanate	3, 5
Titanox M	Titanium-magnesium	3, 5
Ti-Tint	Trade name for titanium dioxide (colored)	3, 5
Ti-Tone	Trade name for titanated lithopone	4, 5
Umber, burnt	40 percent ferric oxide, 10 percent manganese dioxide, 50 percent siliceous matter.	9
Umber, raw	40 percent ferric hydroxide, 10 percent manganese dioxide, 50 percent siliceous matter.	9
Varnish	40 percent varnish nonvolatile, 60 percent mineral spirits	11
Varnish base	Varnish nonvolatile	11
Vegetable drying oil	Use bulking value for linseed oil	10
Venetian red	8 percent ferric oxide, 92 percent anhydrous calcium sulfate	9
Volatile	Mineral spirits	13
White lead	Basic carbonate white lead	2
White lead and zinc oxide	50 percent basic carbonate white lead, 50 percent zinc oxide	2
White lead carbonate	Basic carbonate white lead	2
White lead sulfate	Basic sulfate white lead	2
Yellow ochre	20 percent ferric hydroxide, 80 percent siliceous matter	9
Yellow oxide	30 percent ferric hydroxide, 70 percent siliceous matter	9
Zinc	Zinc oxide when obviously meaning a white pigment, but do not confuse with zinc dust.	2
Zinc sulfide-calcium	50 percent zinc sulfide, 50 percent anhydrous calcium sulfate	4
Zinc sulfide pigment	Lithopone	4
Zinc white	Zinc oxide	2

6. *Use of chemical symbols for paint pigments.*—Table 1 lists some chemical symbols occasionally appearing in label formulas, that represent pigments consisting of a single chemical compound. As a rule chemical symbols are used only to provide supplementary information about the composition of pigments and to make that information as explicit as possible, as for example, "iron oxide (Fe_2O_3, 100%)," as indicating a commercially pure iron oxide. The chemical symbol presumably means the content of the ingredient in question that would be found by chemical analysis. The chemical symbol may also be used to show the proportion of the essential constituent in a pigment that is a mixture of substances for which there are no recognized standards; for example, "raw sienna (Fe_2O_3, 32%)." In this example the essential colored ingredient is really ferric oxide hydrate or ferric hydroxide, $Fe(OH)_3$, but the analytical chemist would report it in terms of ferric oxide.

Among the manufactured colored pigments known as dry colors, the term "C. P.," which stands for chemically pure, is commonly used, as previously stated, to indicate absence of admixture with pigments of low opacity. For example, "C. P. chrome green" means

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that the pigment consists entirely of lead chromate and ferric ferrocyanide. The term "chrome green" alone is less definite because it might mean a "reduced chrome green," which is a mixture of c. p. chrome green and such pigments as barium sulfate and kaolin.

7. *Inadequate reporting of pigments of low opacity.*—Vague terms such as: Inerts, inert pigments, extenders, and extending pigments will be assumed for purposes of classification to mean barium sulfate. The terms silicates, silica and silicates, and siliceous pigments will be assumed to mean magnesium silicate, except that silicates, siliceous pigments, and siliceous matter, when clearly shown to be part of iron oxide, sienna, umber, or ochre, will be considered pigment of low opacity having a bulking value of 0.043 gallon per pound.

8. *Omission of colored pigments in formulas for tinted paints.*—In tinted paints in which the content of colored pigments is small—say, less than 5 percent of the total pigment by weight (*18*)—it is common practice to report only the white pigments and pigments of low opacity, omitting the colored pigments. Some manufacturers may not have an accurate record of the content of colored pigments in their tinted paints. The colored pigments with high diluent allowances, however, contribute to the equivalent content of opaque pigment calculated in the volume analysis to an extent far greater than their actual proportions by weight. Carbon and ferric ferrocyanide, which have high bulking values as well as high diluent allowances, are especially powerful contributors. It is recommended, therefore, that colored pigments having diluent allowances of 2 or more be reported in the label formula whenever they are present to the extent of 1 percent or more of the total pigment by weight, and that colored pigments with a diluent allowance of 4 or 5, or with a diluent allowance of 2 or more and a bulking value of 0.05 or more, be reported whenever they are present to the extent of 0.5 percent or more of the total pigment by weight.

If the colored pigments in tinted paints are not reported in the label formula, no allowance for their contribution to the equivalent content of opaque pigment can be made in the volume analysis. This may result in assigning the paint to a lower grade than it would have if the colored pigments were reported.

9. *Inadequate description of colored pigments.*—In colored pigments that are mixtures of a colored ingredient and ingredients of low opacity, such as venetian red, iron oxide, sienna, umber, ochre, bone black, and reduced chrome green, the proportion of the colored ingredient should be stated in a footnote or otherwise. If such supplementary information is not provided, the proportion of colored pigment will be assumed to be as listed in table 19, in which minimum, or nearly minimum, contents of colored ingredients are assumed. Thus, failure to report the content of colored ingredient in the label formula will often result in underestimation of the equivalent content of opaque pigment in the paint, and possibly in its assignment to a lower grade than would be the case if the label formula were more nearly complete. In tinted paints containing only small proportions of colored pigments, the underestimation will be much less serious than it may be in deeply tinted paints and particularly in colored-pigment paints.

Particular care is needed in describing chrome green. Not only are there the c. p. and reduced chrome greens, but c. p. chrome green,

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being itself a mixture of lead chromate and ferric ferrocyanide, may contain also lead sulfate or basic carbonate white lead. The proportions of the lead pigments and ferric ferrocyanide vary very widely according to the color desired. Since the lead pigments are heavy and ferric ferrocyanide is light in weight, the bulking value likewise varies widely. The chrome greens are classified broadly according to color as light, medium, and dark or deep. The light chrome greens contain the highest proportions of lead pigments and have the lowest bulking values. The composition of chrome green should be stated in the label formula by means of a footnote or otherwise and in calculating the volume analysis it should be broken down into lead chromate, ferric ferrocyanide, and, if a reduced chrome green, pigment of low opacity; all of the lead pigments in chrome green, however, may be counted as lead chromate. The assumptions to be made when the composition of the chrome green is inadequately reported are listed in table 19.

10. *Incomplete description of drying oils.*—Unless otherwise indicated in the label formula, drying oils will be assumed to be raw, boiled, or refined oils as listed in table 2. The terms drying oil, vegetable drying oil, and fixed fatty oil, which sometimes appear in label formulas, will be assumed to imply oil having essentially the same specific gravity as raw linseed oil and the bulking value for raw linseed oil will be used in the calculations. The terms heat treated, processed, thermolyzed, calorized, or durmolized, when used to describe drying oils, will be assumed to mean bodied drying oils as listed in table 2. When tung oil is reported it will be assumed to be bodied tung oil as listed in table 2. The term synthetic drying oil will be assumed to mean a product having the bulking value listed for varnish nonvolatile in table 2.

When bodied oil is reported in the label formula it is recommended that its specific gravity be given as supplementary information either in a footnote or in parentheses, thus, "bodied tung oil (sp. gr. 0.975)." When the specific gravity is so reported the bulking value calculated from it ($1 \div (8.33 \times 0.975) = 0.1231$ for the bodied tung oil cited) will be used in the volume analysis.

11. *Incomplete description of varnish.*—The term varnish, when not described adequately by a footnote or otherwise, will be assumed to include volatile as well as nonvolatile components. For the purpose of volume analysis it will be counted as 60 percent by weight of mineral spirits and 40 percent varnish nonvolatile, as listed in table 2.

12. *Incomplete description of drier.*—Unless the volatile and nonvolatile portions of drier, liquid drier, or japan drier are reported, all of it will be counted as volatile liquid with the bulking value given in table 2 under the heading Volatile liquids. When the nonvolatile content of drier is reported, it will be counted in the volume analysis as part of the nonvolatile liquid in the paint, using the bulking value listed in table 2 under the heading Nonvolatile liquids.

Very often the drier and the volatile thinner are lumped together as a single item in the label formula under some such description as thinner and drier, or merely drier. In such case, the drier, as listed in table 2 under the heading Volatile liquids, will be assumed to amount to 5 percent by weight of the sum of the nonvolatile liquids and the

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remainder to be volatile thinner. For example, if the composition of the liquid is reported to be:

	Percent
Linseed oil	45
Tung oil	15
Resin	5
Thinner and drier (or, drier)	35
Total	100

the drier will be assumed to amount to 3.25 percent and the volatile thinner 31.75 percent. When the term turpentine and drier is employed, the balance in excess of the drier will be accepted as turpentine.

Sometimes drier and thinner are reported separately but the amount of drier is disproportionately large. Thus the foregoing example might read:

	Percent
Linseed oil	45
Tung oil	15
Resin	5
Thinner	20
Drier	15
Total	100

If the drier exceeds 6 percent by weight of the sum of the nonvolatile liquids it will be readjusted according to the above rule before making the volume analysis; that is, the drier credited will be limited to 5 percent of the sum of the nonvolatile liquids and the remainder added to the thinner.

13. *Incomplete description of volatile thinner.*—Unless otherwise clearly indicated, the volatile thinner will always be assumed to be mineral spirits as listed in table 2. Naphtha will be understood to mean varnish makers and painters naphtha obtained from petroleum, unless it is called solvent naphtha or is otherwise shown to be derived from coal tar. The terms aliphatic hydrocarbons and aromatic hydrocarbons will be assumed to mean, respectively, mineral spirits and solvent naphtha. When the thinner used has a bulking value that differs materially from the one that would be assumed for it from these rules, it is recommended that its specific gravity be reported in the label formula.

14. *Sophisticated names for water.*—Ingredients reported under such names as: Emulsion, emulsified oil, suspending agent, aqueous dispersing agent, aqueous bodying agent, colloidal solution, soap solution, and solution will be considered to consist entirely of water.

15. *Uncertainties in the directions for application.*—Label directions for application usually include instructions for the first painting of new exterior woodwork and for subsequent repainting over old paint. In addition, separate instructions are often given for painting new woodwork in three-coat and in two-coat work. Occasionally instructions are given for repainting in one-coat work. As a rule the various instructions differ only with respect to thinning of priming and undercoats and call for the same thinning or for no thinning for finish coat in all cases. If, however, they differ with respect to thinning for finish coat, the volume analysis will be computed for each set of instructions and the paint may have to be graded differently according to the purpose for which it is to be used.

If separate thinning instructions for finish coat are given for use of the paint in warm and in cold weather the volume analysis and grade

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will be calculated for the directions given for warm weather, provided that the extra thinning for cold weather, beyond that for warm weather, consists entirely of volatile thinner and does not exceed ½ pint per gallon for prepared paint and 1 pint per gallon for semipaste or paste paint.

If the thinning instructions for finish coat specify a permissible range of thinning proportions, for example, "thin with 1 to 2 pints of turpentine per gallon" or "thin with not more than 2 pints of turpentine per gallon," the maximum addition of liquid will be assumed in calculating the volume analysis and grade.

If the thinning instructions for finish coat call for thinning but set no definite limit, for example, "thin with turpentine as required," it will be assumed that prepared paint will be thinned with 1 quart of turpentine per gallon and that semipaste and paste paints will be thinned with 1 gallon of linseed oil per gallon.

If the directions make it clear that less thinning than would be assumed by applying these rules is preferred by the manufacturer the volume analysis and grade will be computed on the basis of the preferred procedure. For example, directions sometimes read: "The paint has the correct consistency for finish coat as it comes from the package but it may be thinned ———."

If directions printed on the label conflict with directions given in a color card or other sales literature the directions printed on the label will be followed in the volume analysis and grading.

If no directions for application are printed on the label it will be assumed that prepared paint will be thinned with 1 quart of turpentine per gallon and semipaste or paste paint with 1 gallon of linseed oil per gallon.

SUMMARY

This bulletin presents a procedure for classifying house and barn paints by group, type, and grade, evolved as a result of more than a decade of research by the Forest Products Laboratory of the Forest Service. The system of classification described is recommended by the Department of Agriculture as a step toward obtaining more lasting and satisfactory service of paints on wood, and as an aid to paint users in identifying correctly the kind of paint needed for specific purposes, the characteristics of the paint offered, and how the paint should be applied and maintained.

The information presented here is of value primarily to paint technicologists concerned with determining the paint classifications to be printed on labels or with checking the printed classifications to see that they agree with the formulas. Paint users will in the main depend on less technical information based on this material, but those who are willing to master the technical details will be able to use this bulletin in the classification of any paints that bear a formula on the label, or for which the formula can be obtained.

The procedure proposed involves the addition of a simple classification mark to each paint label, which will indicate (1) the main group to which it belongs, such as "white lead" or "titanium-lead-zinc"; (2) the content of white lead or zinc oxide; and (3) the relative quantities of opaque pigment, total pigment, and total nonvolatile.

The bulletin presents the necessarily intricate calculations upon which this simple system of classification is based.

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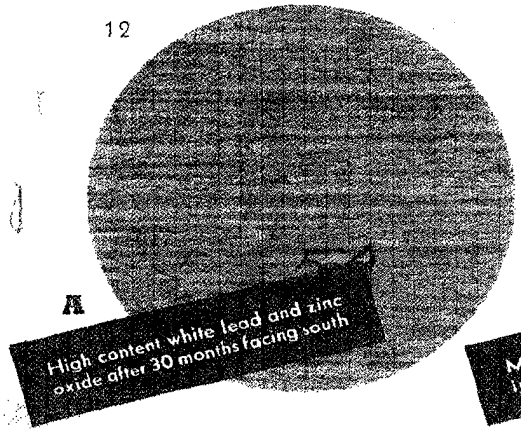
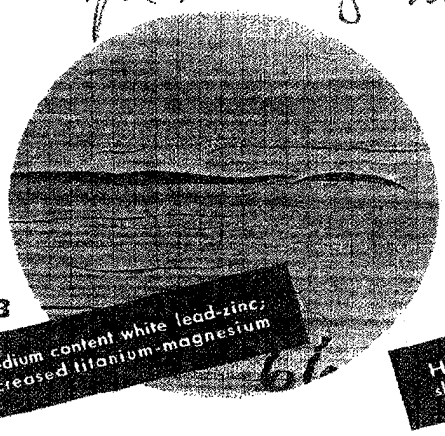
FLB 001074

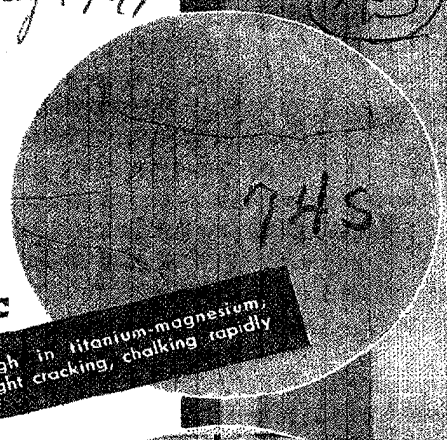
Successful Farming May 1941



A High content white lead and zinc oxide after 30 months facing south



B Medium content white lead-zinc; increased titanium-magnesium



C High in titanium-magnesium; slight cracking, chalking rapidly

D Aluminum primer, two coats white (left) versus three coats of white

E One coat over "special primer" (left) versus two coats of white

The Right Paint for Your Job

YOU'LL find paints have changed since your last painting job. For one thing, nearly all paints now bear a statement of the composition, or formula, on the label.

Understanding what that composition means in terms of the performance to be expected of the paint, however, is difficult because most paint formulas are complicated. The Forest Products Laboratory proposes a system of classifying paints into groups, types, and grades based on composition which would make it easier to explain.

The simplest white paint and by far the oldest is pure white lead paint, often called "lead and oil." It is usually purchased in the form of a soft paste rather than a liquid paint and by weight rather than by volume. Soft-paste white lead is sold in white only; to obtain light colors it must be tinted on the job with colors-in-oil.

Soft-paste white lead usually contains 89 percent white lead, nine percent linseed oil, two percent turpentine; and is so labeled. No other paste paint should be called "white lead" or "lead and oil."

The new development in white lead paint is its sale in the prepared form, in light tints as well as in white, and by the gallon instead of the pound. It costs more that way but may be more convenient for those not accustomed to thinning paste paint on the job and tinting it. The formula for a liquid white lead paint of good quality should read:

Pigment, by weight (basic carbonate white lead)	71%	Linseed oil	86%
Liquid, by weight	29	Turpentine and drier	14
	100%		100%

The important figure is the one in boldface type, which should not be less than 70 percent if the paint is to be considered of good quality.

Pure white lead paint, which belongs to Group L of the Forest Products Laboratory's classification, still has some important advantages over newer kinds of paint. First, when bought in paste form, it is essentially a "standard" product, is therefore easy to buy with assurance of good quality, and at retail prices is usually cheaper in net cost than other white paints of comparable quality. Second, for those who do not paint often enough to keep the paint coating from disintegrating seriously between times, white lead paint is the wisest choice because it breaks down very slowly and by a fine crumbling that always leaves an easy surface to repaint.

MOST paints of good quality sold in the prepared form, in white and the lighter colors, are now paints of Group TLZ. The name "titanium pigment" as used in paint formulas means a mixture of titanium dioxide and extending pigments in unspecified proportions. Titanium-magnesium means a definite mixture of titanium dioxide and magnesium silicate. Titanium dioxide is a brilliantly

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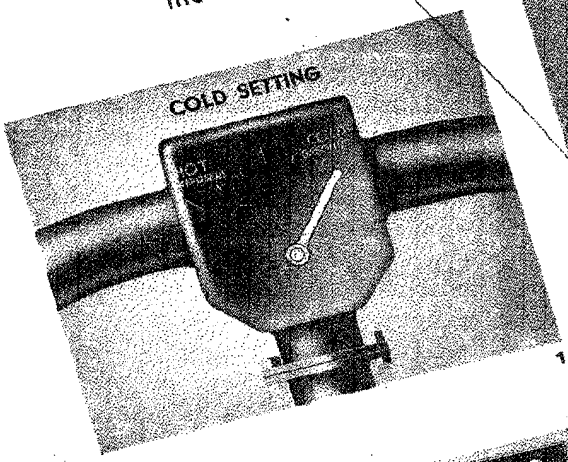
Fuel Clinic for Your Tractor

The much-discussed question of high- or low-compression motors gets an airing



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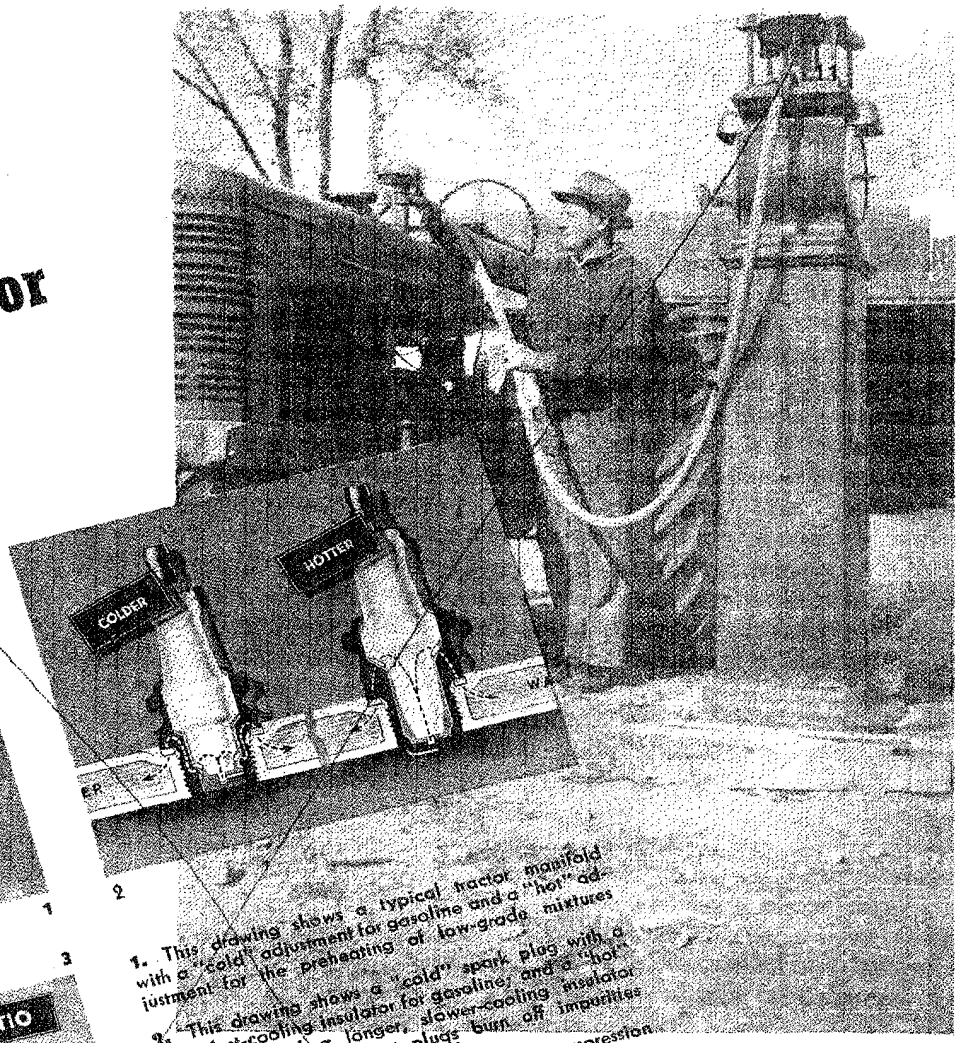

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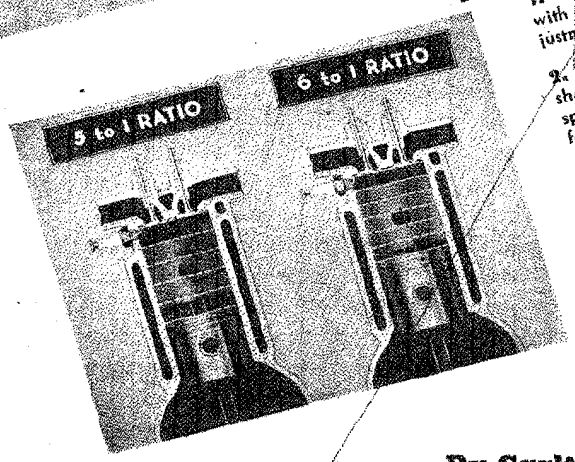


3

1. This drawing shows a typical tractor manifold with a "cold" adjustment for gasoline and a "hot" adjustment for the preheating of low-grade mixtures

2. This drawing shows a "cold" spark plug with a short, fast-cooling insulator for gasoline, and a "hot" spark plug with a longer, slower-cooling insulator for low-grade fuels. Hot plugs burn off impurities

3. This drawing shows two different compression ratios of tractors. In the six-to-one ratio, piston rises higher in cylinder and gives fuel-air mixture tighter squeeze. Compress motor fuel as much as it will stand

4. Motor fuels are rated by a scale of octane numbers which are simply a measurement of the anti-knock quality. A high or low grade refers to this rating

By Carlton Stoddard

CHECKING into tractor-operating habits, I find that a good many tractor owners are the victims of a misfit between the engine and the fuel they are burning. It is not an argument of one fuel against another. Local tank wagon prices and the state gasoline tax in many cases make one type of fuel the logical choice. Rather, *it is a case of adapting your tractor to the fuel you select.*

You needn't be an engineer to conduct a fuel clinic of your own for your tractor this spring. You may be surprised at what you learn. In this story, I'll try to bring to light the simple, fundamental points of harmony between your tractor engine and the rations in its fuel tank.

If your tractor motor is "sweet," it walks away with the load and conserves fuel. If it is off-key for the fuel you are burning, the signs to look for are a knock or ping, overheating, sluggishness, or too big an appetite.

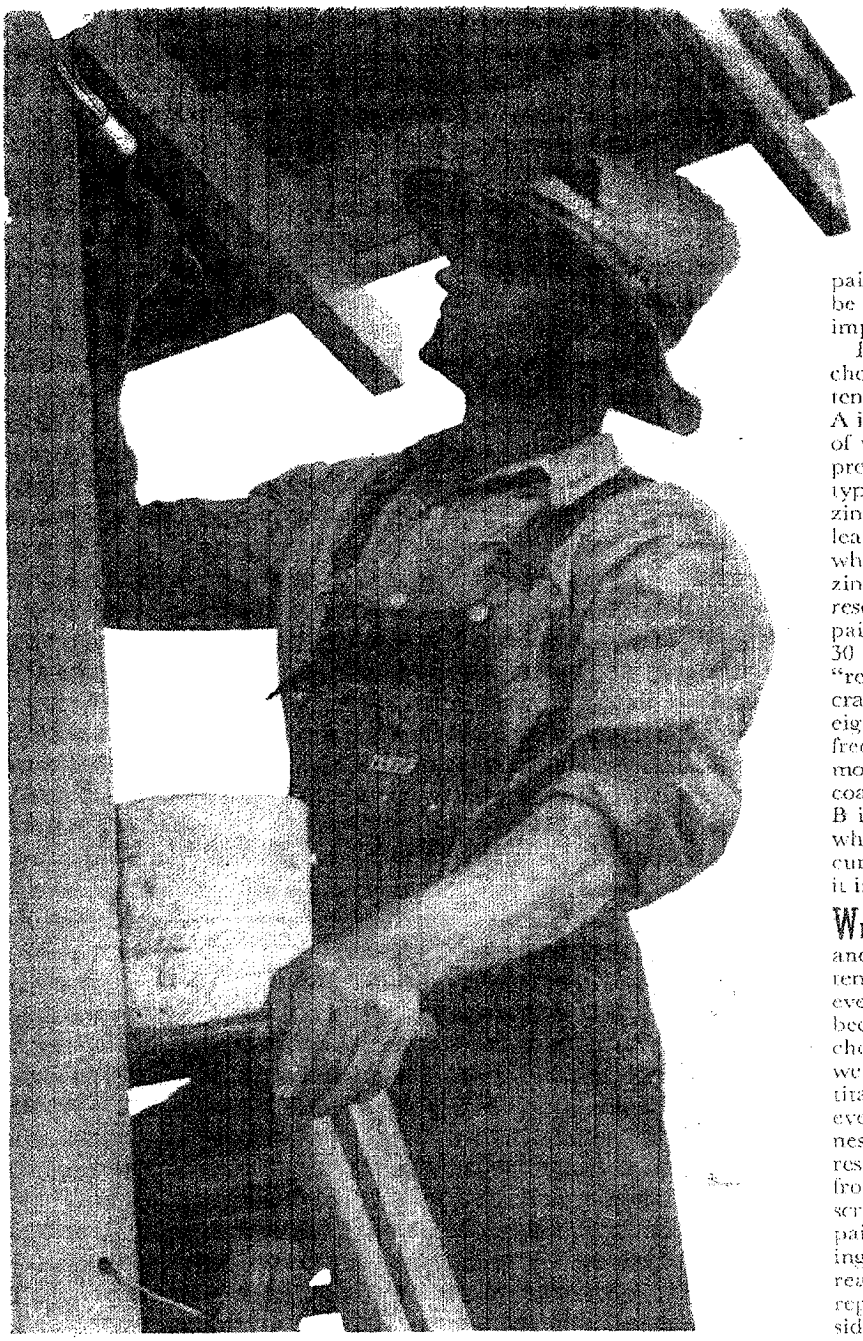
One factor to consider in your tractor fuel clinic is *compression.* Fuel-air vapor in the cylinders is like a coiled spring—the more it is compressed, the greater the recoil force. The basic *compression ratio* of different tractors varies, to begin with. Compression ratio is simply the volume of fuel-air mixture in the cylinder at the bottom of the downstroke in proportion to its volume compressed at the top of the upstroke. Low-compression tractors have a ratio of four to one or less, medium-compression tractors about five to one, and high-compression tractors six to one or over.

To get the maximum power from *any* fuel it should be compressed as much as it will stand. Beyond that point it will detonate or explode violently in the cylinders. You hear it as ping—ignition with a "bang" rather than a "push." Prolonged ping may hammer and heat your motor unt. the pistons or connecting rod bearings break down.

FUELS are rated by a scale of octane numbers which are simply a measurement of "anti-knock." Here is a rough octane scale [*Continued on page 52*

FLB 001076

By Dr. F. L. Browne,
U. S. Forest Products Laboratory



McManigal

white pigment having several times as much opacity as white lead or zinc oxide; hence a little titanium dioxide in paint goes a long way.

CHEMICALLY titanium dioxide resembles silica, or sand, and in paint-making titanium dioxide, except for its great opacity, has the same effect as the extending pigments. It has none of the chemical effects of white lead and zinc oxide. A titanium pigment in linseed oil makes a paint that chalks away completely in a short time; to make it a durable paint reasonable proportions of white lead and zinc oxide must be added. The real novelty of the TLZ paints is not that they contain a little titanium dioxide but that they contain much more extending pigment and yet have as much or even greater opacity than the old LZ (lead-zinc) paints.

Paints high in content of white lead and zinc oxide waste away slowly by chalking but they hold dirt and become gray in consequence. By reducing the content of white lead and zinc oxide, chalking is speeded and the paint stays cleaner but of course chalking must not be allowed to go so rapidly that the durability is impaired.

Figures A, B, and C illustrate the development of checking and cracking in TLZ paints as the content of white lead and zinc oxide diminishes. Paint A is classified as type 2B, which has a high content of white lead and zinc oxide, with the white lead predominating over the zinc oxide. Paint B is of type 3C, having medium content of white lead and zinc oxide with a little more zinc oxide than white lead. Paint C is of type 4C, having low content of white lead and zinc oxide with considerably more zinc oxide than white lead. These three paints represent reasonably well the range in types of TLZ paints now on the market. Note that paint A after 30 months facing south shows fine checking in a "reticulate" (network) pattern, but no coarse cracking. The checking began, however, after only eight months. Paints B and C remained entirely free from checking and cracking for nearly 24 months but after 30 months they both show much coarse cracking, which is fairly conspicuous. Paint B is beginning to curl at the edges of the cracks, which leads very soon to flaking. Paint C is not yet curling and may not do so, but on the other hand it is chalking away rapidly.

WISE choice among the paints of types 2B, 3C, and 4C should depend upon the program of maintenance the buyer expects to follow. If he repaints every three to four years, type 4C offers advantages because of its cleanliness and long freedom from checking and cracking, but it does not hold tints well even when special "chalk-resistant" kinds of titanium dioxide are used. If the buyer repaints every four to five years, type 3C offers good cleanliness, fair tint-retention when made with chalk-resistant titanium dioxide, and fairly long freedom from checking and cracking; but a good deal of scraping and sanding to remove loose and curling paint must be done if the intervals between paintings are too long. Type 2B holds tints still better, is reasonably clean, and is fairly easy to prepare for repainting. Its early checking, which may be considered a temporary disadvantage, is in reality an important protective measure against more serious difficulties later on. Those who may wait more than five years between paintings will probably be better satisfied with type 2B than with either of the others, but they will be still safer if they use pure white lead paint.

Paints can be classified accurately from their formulas only after certain complicated calculations have been made. A rough estimate can be made, however, by comparing formulas with the representative formulas given in the table (page 30) which illustrate typical paints of types 2B, 3C, and 4C—presumed to be prepared paints.

For paint of type 2B the white lead and zinc oxide amount to $41+14+27=82$ percent of the pigment. For paint of type 3C the white lead and zinc oxide come to $17+17+32=66$ and for paint of type 4C to $15+25=40$ percent of the pigment. If on examining the formula of a paint you find that the sum of the white lead and zinc oxide falls above 55 but below 75 percent of the pigment, the paint is probably of type 3B or 3C, (3B if the white lead greatly exceeds the zinc oxide). If the paint is of good quality the percentage of pigment in the paint should vary with the proportion of white lead and zinc oxide in the pigment as indicated by the three examples. *Continued on page 30*

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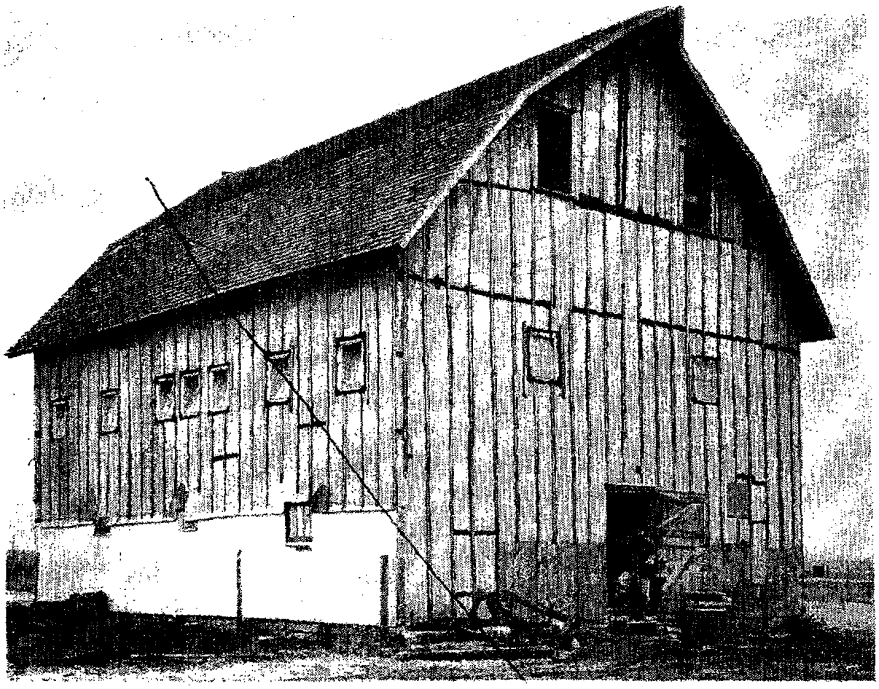
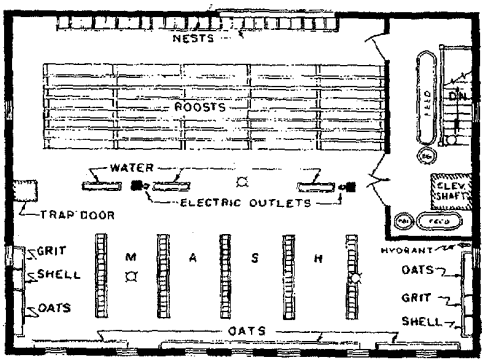


The shift to tractors on the Guy Gee farm, Livingston County, Illinois, left waste space in the 32- by 40-foot barn. Altho now 50 years old, its loft was made into a snug poultry house for 370 hens at a cost of $250, including electric wiring and weatherproofing. An elevator at one end makes the handling of feed and bedding easy. There is a cleanout chute at the other end. During season, eggs go to a local hatchery, at other times to auction or the local market

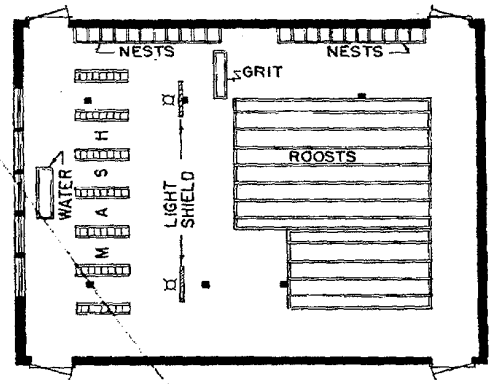


Poultry Adopts the Old Horse Barn

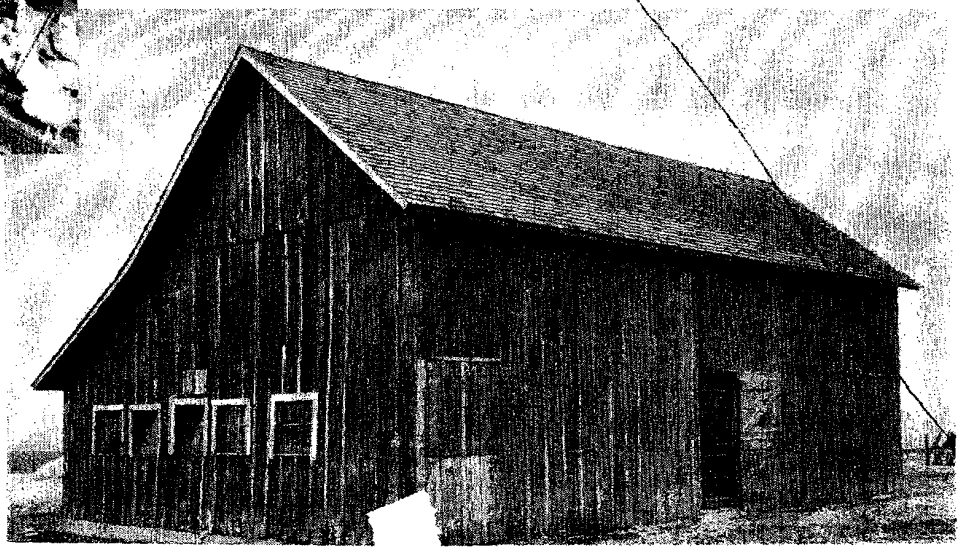
Number 2 of a Series on What to Do With Old Horse Barns

By F. J. Keilholz,
University of Illinois

"FOR RENT" signs have gone up on even some of the finest horse barns since almost 12 million draft animals disappeared from the American farm scene. Fred Adams and Guy Gee, farming near Forrest, Illinois, have demonstrated how this otherwise waste space and expensive overhead can be turned into profit with poultry. Adams rents his place, but his landlord told him if he wished to convert the barn into a poultry house to go ahead. The flock is now one of the farm's major enterprises. Guy Gee made his hayloft into a poultry house which, like that made by Adams, is electrically lighted and soon will be equipped with convenient running water.



Fred Adams and Daughter Ruth in their poultry house made from a barn. A renter, he spent $69 on job



Fred Adams, Livingston County, Illinois, tore the horse equipment out of this 40-year-old barn and used half of it for hens in 1939. Returns were so pleasing he completed the other half and went into the winter of 1940 with 300 White Leghorns. Lumber from an old granary was used to make an inside wall. Straw is blown into the top of the barn

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MICHIGAN ARCHITECT AND ENGINEER
AUGUST 1941

Durability of Paint Jobs Studied

DISCUSSING data obtained from a series of experiments conducted by the Forest Products Laboratory at Madison, Wis., Dr. F. L. Browne reports that the durability of paint on the exterior of houses has been found to depend on the depth of the coating, regardless of whether this was obtained by two thick coats or three thinner ones. When modern paints of high opacity are used, it has been discovered that the thickness needed for good durability is much greater than that merely needed to hide the wood.

Two-coat painting, where one paint is used for both applications, or a combination of special primer and conventional prepared paint for the finish is employed, often gives rise to short-lived paint jobs because the necessity of building satisfactory film thickness has not been fully appreciated by paint manufacturers, painters and paint users, it is explained. Two-coat systems consisting of a special primer and a finish paint made for application in heavy coats are, however, less likely to be applied too sparingly.

Experimental research has demonstrated a superiority of well-designed special primers over self-priming for painting such woods as Douglas fir and southern yellow pine, but it has also been shown that primer and finish paint should be designed carefully for use together, because a primer may give good results with some finish paints and prove incompatible with others.

Declaring that the two-coat system of house painting has changed in the last decade from a practice ignored and condemned by the industry to one recommended by a majority of paint manufacturers, Dr. Browne continues:

> Some of them advocate it enthusiastically, whereas others accept it in public but regard it in private with misgiving or disapproval. Much painting with two-coat systems has been thoroughly satisfactory and much of it has proved seriously lacking in durability. The successful work demonstrates that a substantial economy is realizable from the practice. The unsuccessful work demonstrates that the conditions necessary for a satisfactory two-coat job are not yet understood thoroughly by all manufacturers and users of paint.
>
> Accepted practice formerly required a minimum of three coats for initial application and two coats for repainting. In the course of long experience and competition, materials and procedures were adjusted so that three coats would supply sufficient paint to ensure satisfactory results but would avoid any wasteful excess.
>
> Serious rebellion against these standards began about 1920, when a boom in house construction following a long stagnant period found labor costs far higher than they had ever been before. To meet the demand for two-coat initial application, painters had to invent a new technique in which the full amount of paint previously applied in three coats was put on in two by greatly reducing the spreading rate of both coats. The new technique was one of painting in thick coats. The economy was effected entirely in labor, not in material.
>
> The greatly diminished spreading rates, however, involved the further requirement that the paint for both coats be unusually high in content of total pigment so that the consistency would be favorable for application in thick films without running and sagging and without wrinkling during drying.
>
> We may call this technique of initial painting the two-coat system with self-priming. When done honestly by workmen who had mastered the technique, it proved far more than a temporary expedient and compared favorably in durability with good three-coat work. When done incompetently, the shortcomings were usually apparent before the painter could escape responsibility for them.
>
> Study of special primers overthrew the traditional theory that priming paint for wood should be low in content of pigment and high in content of volatile thinner to promote deep penetration into the wood. Deep penetration, in fact, proved to be wasteful and even harmful because it consists of vehicle alone, separated from the paint film, and isolated in the cavities of wood cells beneath the treated surface. Useful penetration is limited to the filling, with pigment and vehicle together, of those wood cavities that open directly into the surface on which the paint is applied.
>
> When used according to the self-priming technique, ordinary house paints penetrate wastefully and can be improved by restraining undue penetration. One means of controlling this is to incorporate bodied oil in the vehicle. Another means that seems to be less widely appreciated is formulation with a high level of pigmentation favoring application of low spreading rate—that is, in thick coatings.
>
> Complete elimination of zinc oxide from special primers is recommended by one school of thought on the subject and is opposed by another. Conclusions about its use must be subordinated to the more fundamental problem of compatibility between primer and finish. The finish paints on the market differ so widely in properties that no one primer can be expected to prove compatible with all of them. When the finish contains no zinc oxide, the primer should be zincless; on the other hand, some zincless primers produce alligatoring (intersecting circles) and intercoat flaking of finish paints containing zinc oxide, which is corrected when zinc oxide is incorporated in the primer also.
>
> Since the special primers with controlled penetration lend themselves readily to a high level of pigmentation favoring application in thick coats, may be made with a high content of opaque pigment, and offer great protection against spotted chalking and fading, they were proposed as a particularly effective means of meeting the demand for two-coat initial painting.
>
> Careful attention to spreading rate in its relation to

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thickness of coating is now more usual than it was in 1920 because of the much greater opacity of modern paints. With many special primers and finish paints of the present time, satisfactory hiding can be obtained with only half the thickness of coating necessary for good durability. Hiding, therefore, can no longer be relied upon to gauge adequacy of film thickness.

The logical development of two-coat initial painting is one-coat repainting. So far there seems to be little commercial exploitation of the possibility on the part of paint manufacturers, although one maker of a two-coat system recommends it to some of his customers but does not yet print it in his label directions. In practice much one-coat repainting has been done for many years. When repainting is done at reasonable intervals, before the old surface starts to crumble or flake seriously, one generous coat of highly pigmented material, such as is suitable for the finish of a two-coat system, is sufficient.

In the series of exposure tests at the Forest Products Laboratory, the three-coat jobs with self-priming were materially more durable than the two-coat jobs, as was expected from the difference in the estimated thickness of the coatings. It is pointed out, however, that the two-coat jobs, even without the benefit of special primers with controlled penetration, held gloss uniformly just as long as the three-coat applications or the two-coat jobs with special primers. Uneven gloss and spotted chalking were found to be caused by inexcusably scanty application and did not require special primers for their correction.

The most durable coatings by far were discovered to be those done in three-coat work with aluminum primer. This proved true with each of the eight finish paints. The average durability of fifty months was nine months greater than the next best average durability recorded, and fifteen months greater than the durability with self-priming. Mica primer improved the durability of three-coat work by five months on the average, but flake lead impaired the durability slightly.

It was noted that substitution of a suitable unpigmented priming oil for the priming layer of three-coat work may leave the durability practically unimpaired, even though the film thickness is somewhat reduced, thus permitting a slight saving in cost of material for the job. However, it was warned that under such conditions there is serious risk of early development of conspicuous alligatoring.

The durability of the two-coat jobs with the different special primers varied greatly, from twenty-six to forty-one months. Five of nine special primers with controlled penetration made two-coat jobs equal or superior in durability to the three-coat work with self-priming, even though the estimated film thickness in the three-coat examples was materially greater. It is believed that still better durability would have been obtained if these primers had been used for three-coat work or if the finish paints had been designed for and applied in deeper coats to build up the film thickness to that of the three-coat jobs with self-priming.

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The Right Paint for Your Job

[*Continued from page 73*]

The liquid in house paint of good quality should contain not more than 15 percent volatile thinner and drier (mineral spirits and turpentine are acceptable volatile thinners but water is not) and the balance should be linseed oil—except that soybean oil may be substituted for not more than one-third of the linseed oil. A small proportion of tung oil is likewise acceptable.

ANOTHER new development of recent years is the special priming paint for use with house paint. Formerly one paint was used for all coats of any one paint job, tho the paint was thinned with a little extra linseed oil and turpentine for priming coats. The old practice is slightly cheaper than the modern one but better results are obtained with the special primers whenever the job calls for more than one coat of paint.

The special primers are of two kinds, each for a different purpose. Aluminum priming paint is especially useful for the first paint job on new woodwork of such woods as Douglas Fir and Southern Yellow Pine, which have wide bands of hard, dark-colored summerwood from which paint tends to flake off too early. Figure D shows the advantage of this use of aluminum priming paint. The left-hand halves of the four boards were painted with one coat of aluminum priming paint and two coats of white paint; the right-hand halves were painted with three coats of the white. The first and third boards were of Douglas Fir and the second and fourth of Southern Yellow Pine. They were exposed facing south for 45 months before the photograph was taken.

The label should indicate clearly that the aluminum paint is designed primarily for painting exterior woodwork. Aluminum paints offered for many painting purposes including wood merely incidentally have not, in the writer's experience, proved capable of giving the results shown in figure D.

The second kind of special primer for house painting is commonly described as "house paint primer" or "house paint undercoater" with the property of "controlled penetration." Primer and finish paint should be made by the same manufacturer for use together. Very often the primer and finish paint together are called a "two-coat system" and the recommendation is made that new woodwork may be painted with two coats, one of primer and one of finish paint. Figure E shows that the special primers of good quality when so used are in fact much superior to the older method of using the finish paint for both coats. The left-hand halves of the four boards shown were "two-coated" with primer plus paint but the right-hand halves simply received two coats of the ordinary house paints. On Douglas Fir and Southern Yellow Pine, however, the "two-coat system" is not so durable as three-coat work starting with aluminum primer.

If five years is considered a reasonable interval between paintings for the house, the service buildings (because of farmers' tendencies to let them go twice as long) need 10-year paint. Red paint can be made to last 10 years, but no white paint will do so. Another good choice for service buildings is aluminum paint (two coats) of the kind already described for priming wood.

RED paint has great opacity. It does not take a great deal of it to hide wood and give it a red color. To last 10 years, however, at least one gallon of red paint of the very best quality must be applied for every 250 square feet of surface on new, smooth woodwork. Rough, weatherbeaten woodwork takes still more paint, at least one gallon for every 200 square feet. If the painting is done in two coats, the first coat should be applied at 450 square feet per gallon on smooth wood and 350 square feet per gallon on rough wood and the second coat at 550 square feet per gallon on smooth wood and 450 square feet per gallon on rough wood. Red barn paint of the best quality can be so applied but most of the barn paints on the market cannot.

Red barn paint of good quality should contain not less than 55 percent pigment, of which at least 33 percent should be ferric oxide. The balance of the pigment is usually described as calcium sulphate, "silicates," or calcium carbonate. A few red barn paints contain a small porportion of zinc oxide, which is a desirable ingredient. The liquid should contain not more than 15 percent mineral spirits and drier and there should be no water. The balance of the liquid should be largely linseed oil, but as much as one-third of it may be soybean oil and it may contain a small proportion of resin. When part of the liquid is reported as "varnish" it should be assumed that somewhat more than half of the "varnish" is mineral spirits. The term "varnish solids" or "fixed oils and resins" means non-volatile material containing no mineral spirits. Varnish gives red paint a higher degree of gloss and somewhat more resistance to mildew, but too much varnish or varnish of poor quality impairs durability and makes it difficult to apply enough paint.

Good red paint may be made for a somewhat lower price than good white paint but not for the extremely low price that has become customary for red barn paint.

Representative Formulas for Paints of Group TLZ and Types 2B, 3C, and 4C

	Type 2B	Type 3C	Type 4C
Ingredients as usually reported	(High content of white lead and zinc oxide)	(Medium content of white lead and zinc oxide)	(Low content of white lead and zinc oxide)
	% by weight	% by weight	% by weight
Pigment in paint	**66.0**	**62.5**	**59.0**
Pigment composed of:			
Basic carbonate white lead	41 } *(82)*	17 } *(66)*	— } *(40)*
Basic sulfate white lead	14	17	15
Zinc oxide	27	32	25
Titanium-magnesium	18	34	60
	100	100	100
Liquid in paint	34.0	37.5	41.0
Liquid composed of:			
Linseed oil	85	85	85
Mineral spirits and drier	15	15	15
Total	100	100	100

Note: The italicized figures in parentheses are to be calculated by the buyer by adding together the figures in the formula as indicated by the brackets. The sums so obtained should then be used to gauge roughly the minimum *content of pigment in the paint*, indicated by boldface type, if the paint is of good quality. The higher the italicized figure is found to be, the higher the boldface figure should be.

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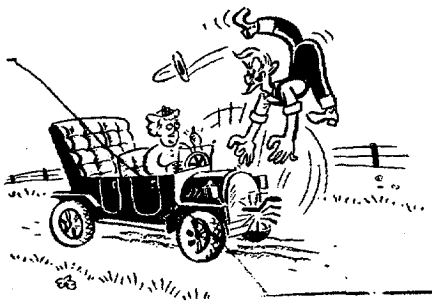

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The Answer:

The war .....
Farming .....
Politics, nation
Money, cost of
Weather .....

(Asked of women): In general, what subjects do you think are most often talked about among your women friends and acquaintances these days?

The Answer:	All Farmers
The war	56%
The draft	16
Household activities	14
Gossip	13
Family, children	10

Percentages total more than 100 because most respondents named more than one subject. (Only leading subjects listed.)

HOW TO APPLY COATS OF PAINT

Browne Reports Durability on Exterior of House Depends on Thickness.

Durability of paint on the exterior of houses depends on the thickness of coating whether the thickness is provided by two thick coats or by three thinner ones, according to a report by Dr. F. L. Browne of the Forest Products Laboratory, Madison, Wis., to the American Chemical Society, which will hold its 102d national meeting in Atlantic City, N. J., September 8 to 12.

When modern paints of high opacity are used, the thickness of coating needed for good durability is much greater than that required merely to hide the wood Dr. Browne says.

Two-coat painting where either one paint is used for both coats, or a combination of special primer and conventional prepared paint for the finish is employed, often gives rise to short-lived paint jobs because the necessity of building satisfactory film thickness has not been fully appreciated by paint manufacturers, painters, and paint users, he explains. Two-coat systems consisting of a special primer and a finish paint made for application in thick coats are less likely to be applied too sparingly.

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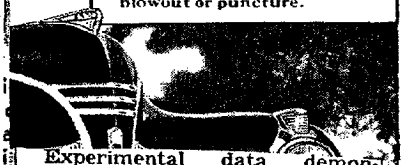

Experimental data demonstrate a superiority of well-designed special primers over self-priming for painting such woods as Douglas fir and southern yellow pine, Dr. Browne adds, but they show also that primer and finish paint should be designed carefully for use together because a primer may give good results with some finish paints and prove incompatible with others.

"The two-coat system of house painting during the past decade has passed from a practice ignored or condemned by the industry to a recommendation made by a majority of paint manufacturers," Dr. Browne points out. "Some of them advocate it enthusiastically whereas others accept it in public but regard it in private with misgiving or disapproval.

"Much painting with two-coat systems has been thoroughly satisfactory and much of it has proved seriously lacking in durability. The successful work demonstrates that a substantial economy is realizable from the practice. The unsuccessful work demonstrates that the conditions necessary for satisfactory two-coat painting are not yet understood thoroughly by all manufacturers and users of paint."

IN OPERATION, IN UPKEEP
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painting army buildings

Please return to
F. L. Browne
Forest Products Laboratory
Madison, Wisconsin

N41698.51

FLB 001083

PAINTING ARMY BUILDINGS

Prepared by
F. L. Browne
Principal Chemist
Forest Products Laboratory
Madison, Wisconsin

for

Army Service Forces
Corps of Engineers
Repairs & Utilities Branch

1944

FLB 00108

PAINTING ARMY BUILDINGS

FOREWORD

The policy for interior and exterior painting, as published in War Department Circular No. 269, 27 October 1943, amended by WD Circular No. 237, 12 June 1944, is as follows:

1. GENERAL.—a. Serious shortages of manpower and material as well as present limitations on funds make mandatory the exercise of strictest economy in painting and repainting of War Department owned, leased, controlled, or sponsored buildings, structures, and facilities, and machinery and equipment for their maintenance.

b. Only the most urgently needed painting and repainting will be permitted. Serious physical deterioration of building, particularly interiors and vertical exterior surfaces, will not result from lack of paint; therefore, peacetime standards of appearance and maintenance will not be upheld.

2. EXTERIOR PAINTING.—In the case of theater of operations and mobilization type troop housing and appurtenant installations, painting and repainting will be limited to sash, doors, and trim. Wood construction at Government-owned manufacturing plants may be one coat of creosote oil stain

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or cottonseed oil gum stain, and doors, sash, and trim may be painted unless already stained. Untreated gypsum siding may be painted on the exterior where practicable with two coats of exterior resin emulsion paint (Civil Aeronautics Specification No. 577).

3. INTERIOR PAINTING.--a. In temporary buildings, interior painting will be limited to hospital buildings used by patients, bakeries, cold storage rooms, service clubs, guest houses, exchanges, induction buildings, weather forecasting rooms at base weather stations, and chemical warfare and ordnance plants where necessary to reduce hazards resulting from the handling and processing of explosives and explosive and toxic gases. When considered necessary and approved by the commanding officer of the installation, materials and equipment may be furnished to organizations desiring to perform the work of whitewashing or painting their kitchens, kitchen storerooms, and mess halls. Army Engineer Service funds may be used for this purpose, except where Army exchanges are concerned. Interior painting in exchanges will be paid for from nonappropriated funds. Use of War Department funds for labor for such projects is not contemplated. (A.G. 600.12 (1 Jun 44).)

b. Necessity for painting and repainting in permanent buildings should be determined on the individual merits of each case, taking into consideration the use of the room, fenestration, and existing wall finish. In addition to painting of hospital buildings used by patients, bakeries, cold storage rooms, service clubs, guest houses, induction buildings, and weather forecasting rooms at base weather stations, painting in other permanent buildings may be justified in the following instances:

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(1) In rooms whose use requires a high degree of sanitation and whose present condition falls below the minimum set by the post surgeon.

(2) Where conditions, such as excessive water or condensation in shower and toilet rooms, cause rapid deterioration of unprotected materials.

(3) In rooms such as shops, office, and classrooms where difficult visual tasks require a degree of illumination which otherwise would have to be obtained by rewiring and/or the installation of additional or new lighting fixtures.

(4) In chemical warfare and ordnance plants where necessary to reduce hazards resulting from the handling and processing of explosives and explosive and toxic gases.

c. No painting will be authorized even in the above excepted cases where improved appearance is the only consideration. In any case, painting will be limited to a minimum number of coats.

4. PAINTING OF MAINTENANCE MACHINERY AND EQUIPMENT.—Repainting of machinery and equipment used in the maintenance of buildings, structures, and facilities will be approved only when existing coatings will no longer protect surfaces against deterioration tending to impair functional characteristics, and when necessary as a safety measure. Fine finishes will not be specified. Quality of finish will be the minimum required to prevent rapid

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deterioration of equipment. (A.G. 600.12 (23 Oct 43).)

The decision to suspend exterior painting for the duration of the emergency was based on the results of research made by the Forest Products Laboratory, U. S. Department of Agriculture, in cooperation with the Repairs and Utilities Branch, O.C.E. The report of the study by Dr. F. L. Brown, Principal Chemist, which concludes that deferred painting will not impair the useful life of Army buildings, is published for the information of all concerned.

J. S. BRAGDON,
Brigadier General, U.S.A.
Chief, Military Construction Division.
Office of the Chief of Engineers.

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PAINTING ARMY BUILDINGS

The original plan for the wood buildings of cantonment type erected at Army posts in 1940 to 1942 was to leave the siding unpainted. For that reason, southern yellow pine lumber of common grade, which contains many knots, was considered to be suitable. After construction had been started, considerations of appearance and morale of the men (the United States was not yet at war) led to the decision to paint the buildings despite the adverse paint behavior to be expected over the knots. There were many other conditions unfavorable for good painting: much of the lumber was green, the painting had to be done in haste amidst construction and occupancy of the posts, much painting had to be done in the winter, and serious changes in the painting specifications were made during the progress of the work as materials and labor became critical. Nevertheless, paint jobs of very satisfactory quality were generally obtained. On the whole, the quality of the paint work was equal to that commonly done on new residences, either publicly or privately owned. Except for the defects that were bound to occur over knots, the paint jobs on cantonment buildings have proved as durable as those done in other programs of mass construction. Cantonment painting has proved to be almost entirely free from the early blistering and peeling of the coatings that are caused by moisture in sidewalls and have plagued so many privately owned buildings.

The paint jobs on cantonment buildings are now from two to four

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years old. On the difficultly paintable woods such as southern yellow pine, good maintenance of paint calls for repainting after 3 to 4 years. If, in the midst of war and a serious shortage of manpower, it is considered necessary to maintain a well-painted appearance on cantonment buildings, a program of repainting might well be started during 1944 or 1945. On the other hand, if appearance alone is not considered sufficient reason for repainting at this time, there is no reason why it cannot be deferred until the need for improving appearance is deemed urgent. Postponement of repainting until the war is over, even if that takes another 4 years or more, will not impair the usefulness, shorten the life, or increase the overall cost of maintaining cantonment buildings.

Painting of wood buildings with protective oil paint is not as customary in other countries as it is in the United States, In Switzerland, wooden buildings, including wooden buildings of the Swiss railways, are commonly left unpainted to weather naturally. In Sweden, farm buildings are decorated with a "red wash", which is a water paint somewhat analogous to whitewash or to casein paint, but lacking in protective power against wood weathering. Even in America painting with oil paints was not generally customary in colonial times. It is reliably reported that a barber in Massachusetts Bay Colony was driven from the Colony because of his arrogance in having his house painted.

The oldest wood buildings in America, the Fairbanks House at Dedham, Mass., and the old Schoolhouse at St. Augustine, Fla., have stood

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more than 300 years without paint or other protective treatment. The House of Seven Gables at Salem, Mass., has never been painted. Christ Church at Cambridge, Mass., though now kept well painted, reveals a long history of paintlessness in the weatherbeaten condition of its siding. Yet the Yankees always have been reputed to be a thrifty people.

Painting of barns and other farm buildings is still far from universal practice in most parts of the country. In any of the longsettled sections of the United States and Canada there is no difficulty in discovering barns that have remained in constant use without paint for half a century or more. Where the exterior wood was an inch or more in thickness and was kept from contact with the ground or other sources of continued dampness, it usually has required little or no replacement. Strained efforts have been made to show by statictical surveys that paint maintenance prolongs the life of farm buildings, but such conclusion is reached by including in the unpainted group buildings that are not maintained in any way. Neglect to make needed repairs may ruin a building; one of the major benefits of paint maintenance comes from the periodic inspection and repair that usually precede painting. It is practicable, however, to make the inspection and repair at suitable intervals without painting.

Paint is not a wood preservative; it is not used for the purpose of preserving wood against decay. Wood rots only when it remains damp for considerable periods of time. Wood freely exposed to the weather does not rot when conditions permit it to dry out rapidly soon after each wetting.

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When there are poorly designed joints into which water may seep and be held for a long time, rot may take place. Wood that is continually in contact with dampness cannot be kept from becoming wet, because paint coatings merely retard the absorption of moisture; they do not prevent it. Experience shows that coatings on continuously damp wood soon blister and peel. Poorly designed joints seldom can be kept tight with paint: since paint retards the drying as well as the absorption of moisture by wood, painting woodwork with poor joints may hasten rather than retard decay.

The cantonment buildings that the writer has seen were planned carefully with regard for the prevention of decay. Foundations are usually concrete capped with termite shields. The space between ground and wood floor is usually ample and well ventilated. The wood, skirting, fencing off the space, is kept from contact with the ground or with the concrete foundations. There should be practically no decay of the woodwork in such cantonment buildings whether or not they are kept painted. In a few cases, regrading of the land near the buildings has been done in such a way as to partly cover the wood skirting with soil. This may eventually result in rotting of the skirting, but painting will not prevent the decay. The wood steps with handrails at the doors of the buildings involve some joints that are hard to keep tight and may in time cause some decay which would be hastened rather than retarded by frequent painting. Unless some of the cantonment buildings continue in use for many years, the replacement of steps and handrails will be an item of trivial importance.

Wood exposed to the weather is subject to weathering which can be

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prevented by adequately maintained coating of protective paint. Weathering results in a slow erosion of wood from the exposed surface at the rate of roughly 1/4 inch a century for softwoods such as the pines. The process also involves strains within the wood that tend to cup or warp thin boards and loosen nails. The 1/2-inch bevel siding that is widely used for private residences is too thin to stand weathering well over very long periods of time and, if left totally unprotected by paint or other treatment, may need replacement in 30 to 50 years. Even so, it is considerably cheaper to replace such siding every 30 years than it is to paint it every 4 or 5 years. Painting, therefore, is not a means of reducing maintenance costs but is an expense that is justifiable when the appearance of weatherbeaten wood is considered unsatisfactory and protection against the weathered appearance is deemed worth the cost.

Cantonment buildings are sided with ship-lapped or tongued- and-grooved drop siding well nailed over lumber sheathing. Even if left entirely unprotected, the siding should last many years with little or no replacements. Paint maintenance, therefore, should be regarded strictly as a matter of appearance. If it is decided to repaint at this time, there will be an increase in the overall cost of maintaining the buildings which can be justified only if the improvement in appearance is considered to be worth the price.

If it is decided to defer repainting for another two or three years, the cost of repainting at that time will be slightly greater than it would be

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now, because more work will be needed to prepare the surfaces for repainting and more paint will be used. The increase in painting cost, however, will be less than the depreciation charge for painting done now.

(All of the photographs that follow, except figure 4, were taken by the author. The signboard shown in figure 4 is now in the possession of Mr. George M. Hunt of the Forest Products Laboratory).

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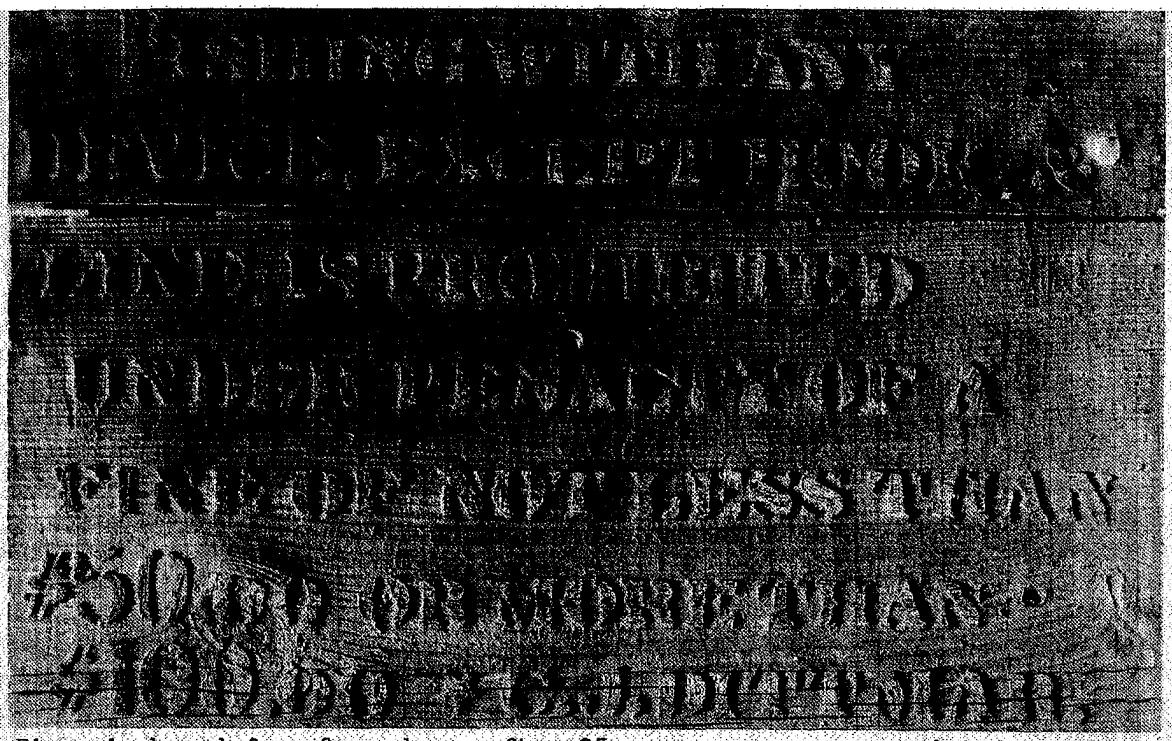
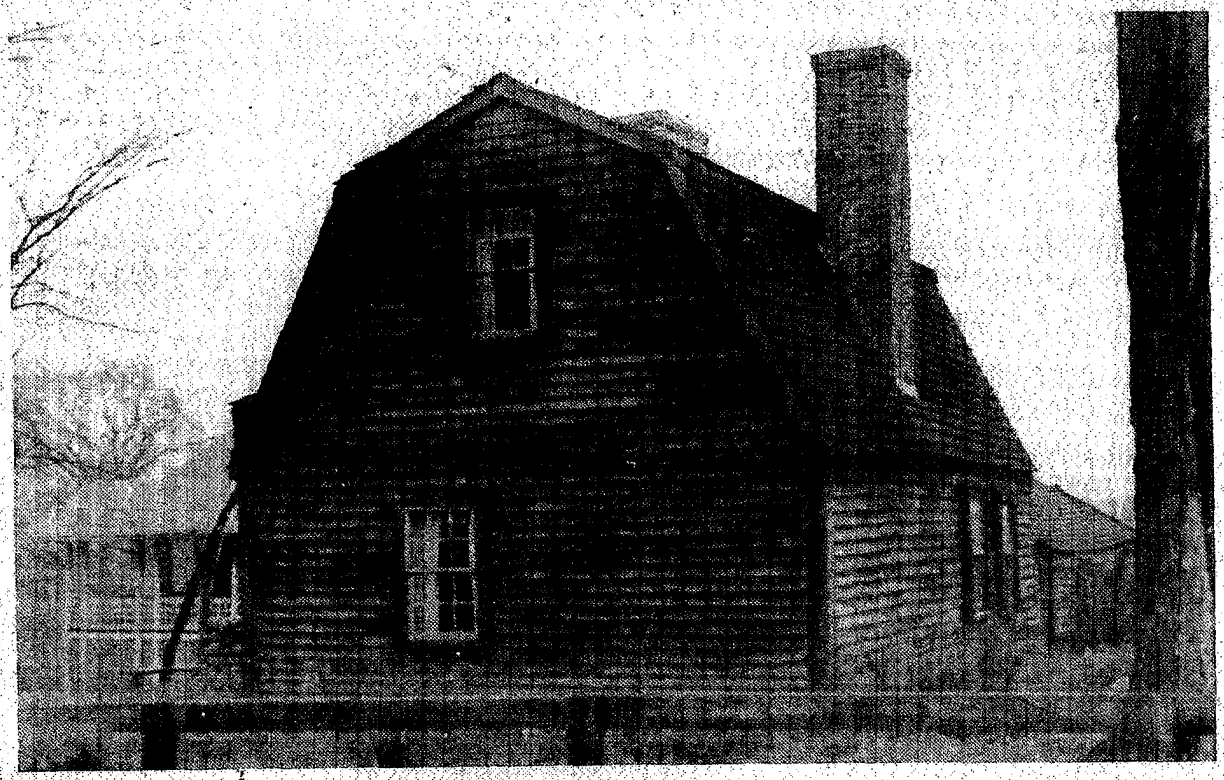


Pine signboard free from decay after 25 years exposure, unpainted except for the durable black paint used for the letters. By measuring the difference in level between the protected letters and the unpainted background on this and other signs of known period of service, it is calculated that unpainted softwood weathers away at the rate of approximately 1/4 inch a century.



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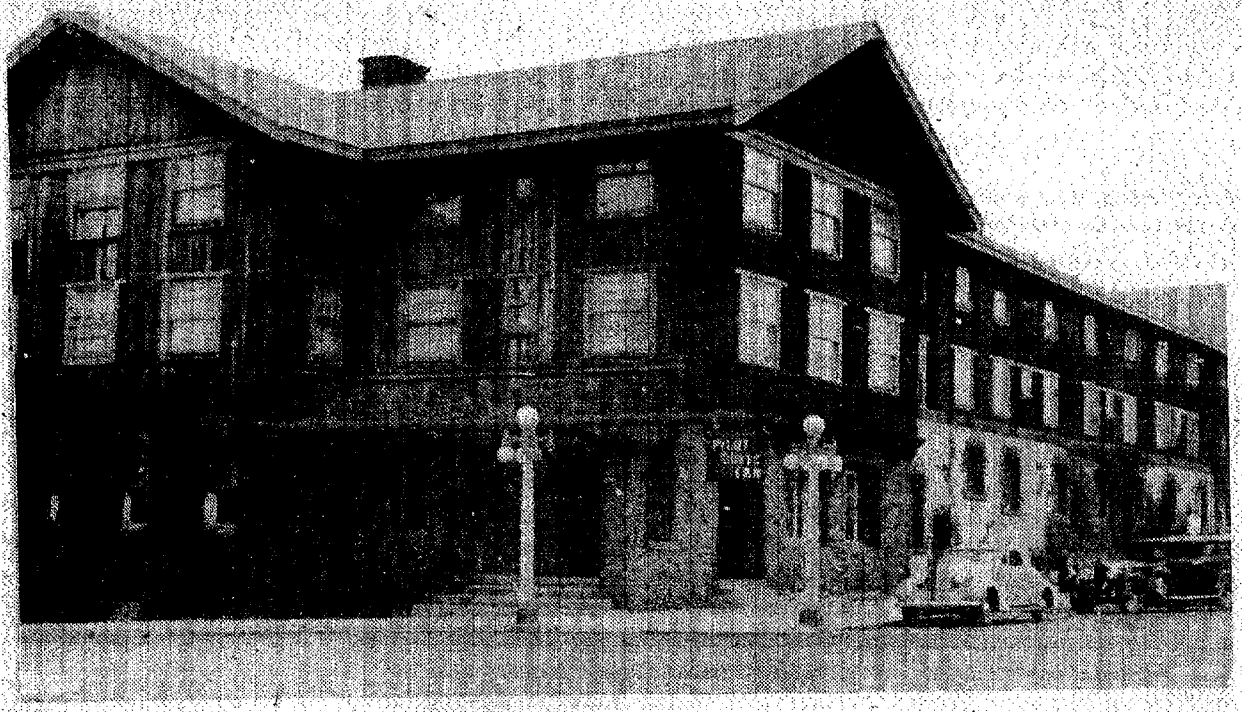
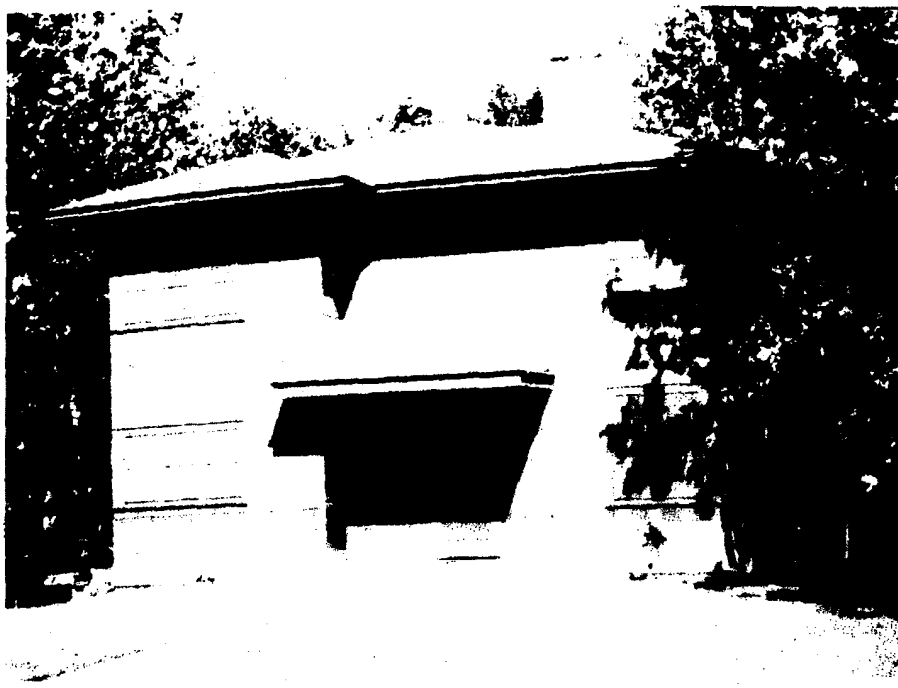
LEFT:
The Fairbanks House at Dedham, Mass., erected in 1636 and never painted. Some of the thin siding was replaced in 1903 (photograph taken in 1935) but the window frames, corner boards, and barge boards and all structural woodwork are believed to be the original.

RIGHT:
One of the houses of the Amana Colony built at Amana, Iowa, in 1858 (photograph taken in 1927) and left with the siding unpainted for reasons of economy, but window sash and doors were kept painted.



Unpainted exterior woodwork in modern architecture: A hotel at Bend, Oregon, the upper stories of which are covered with vertical siding of ponderosa pine left unpainted to obtain the weatherbeaten appearance.



A residence at Madison, Wis., kept in the natural wood appearance
from time to time. The oil is low in protective value but, if re
enough, keeps the wood from turning gray in color.

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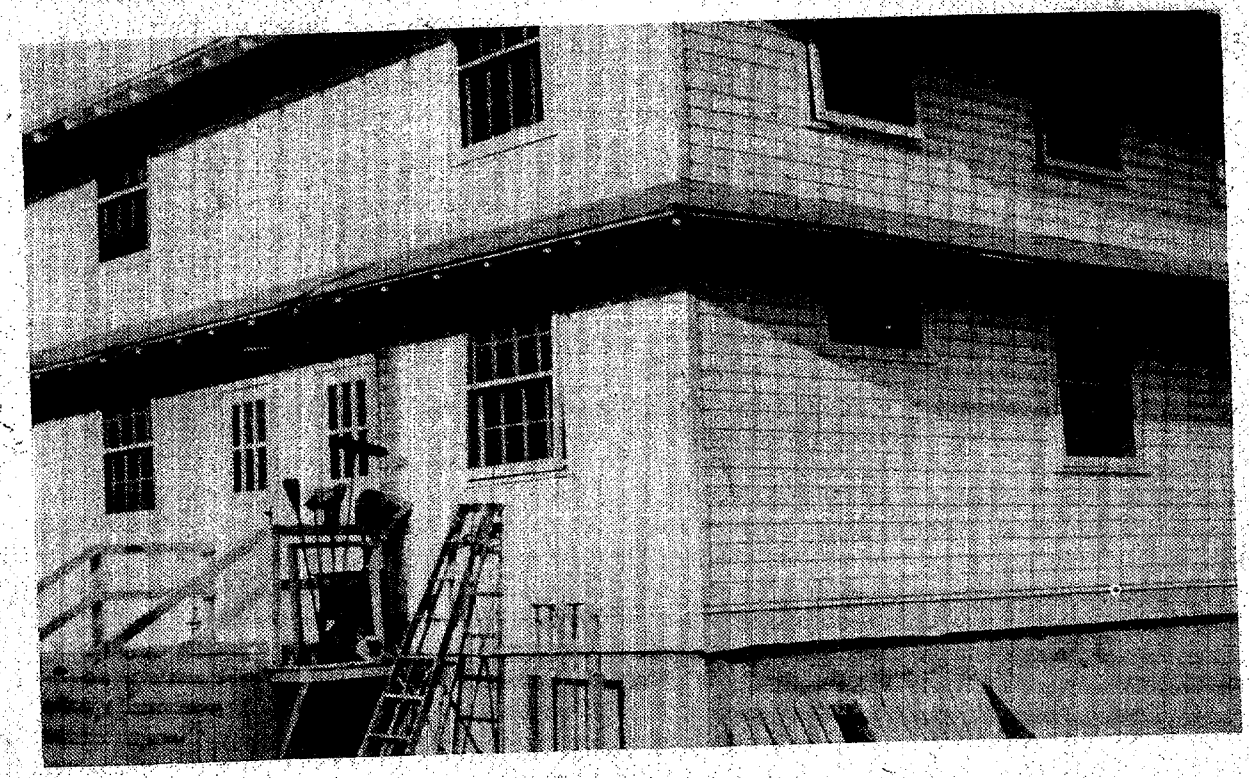
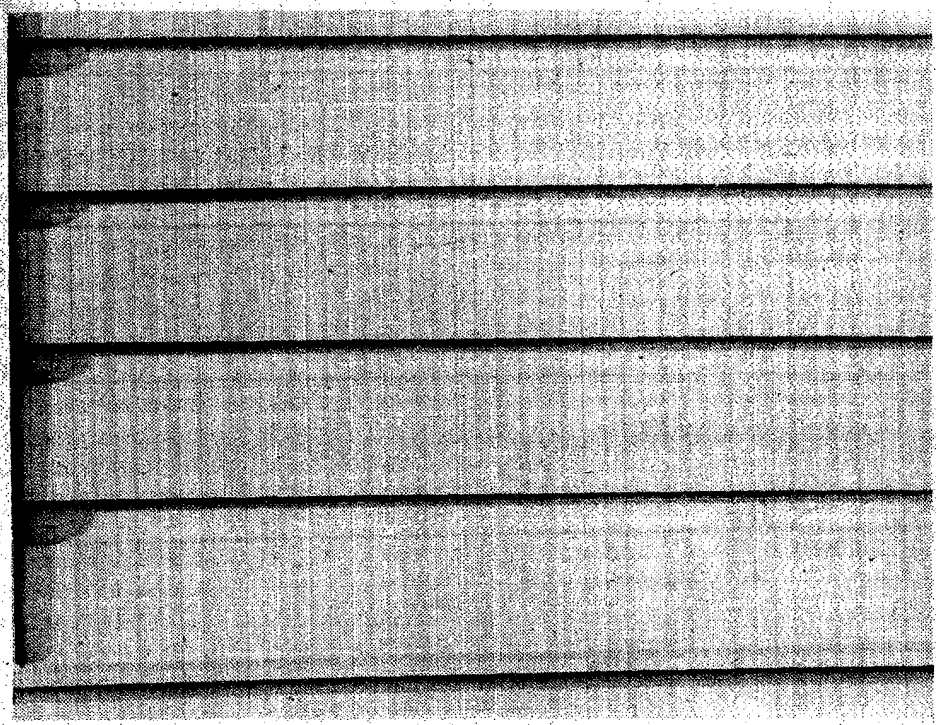
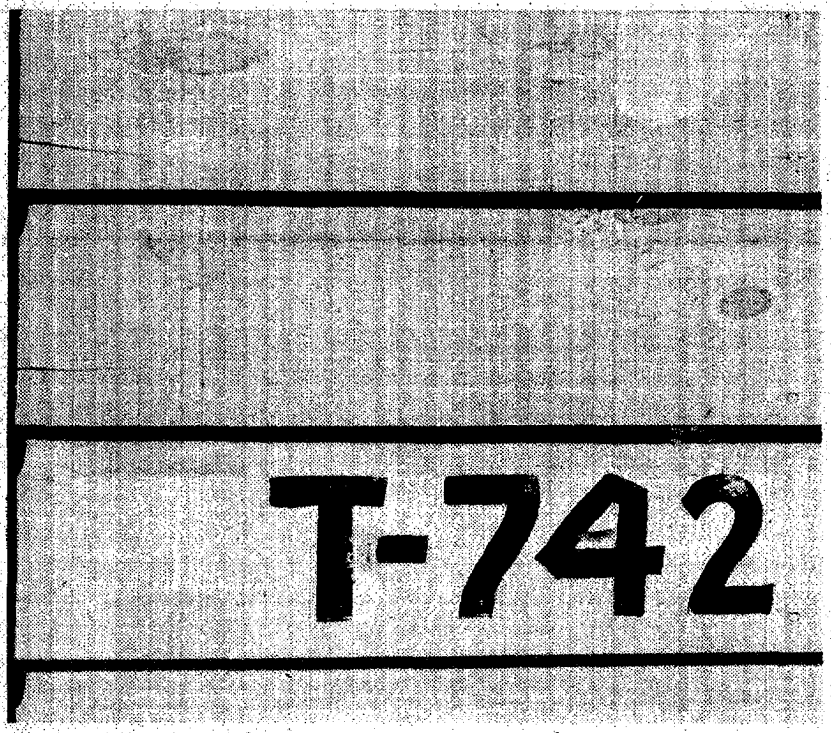
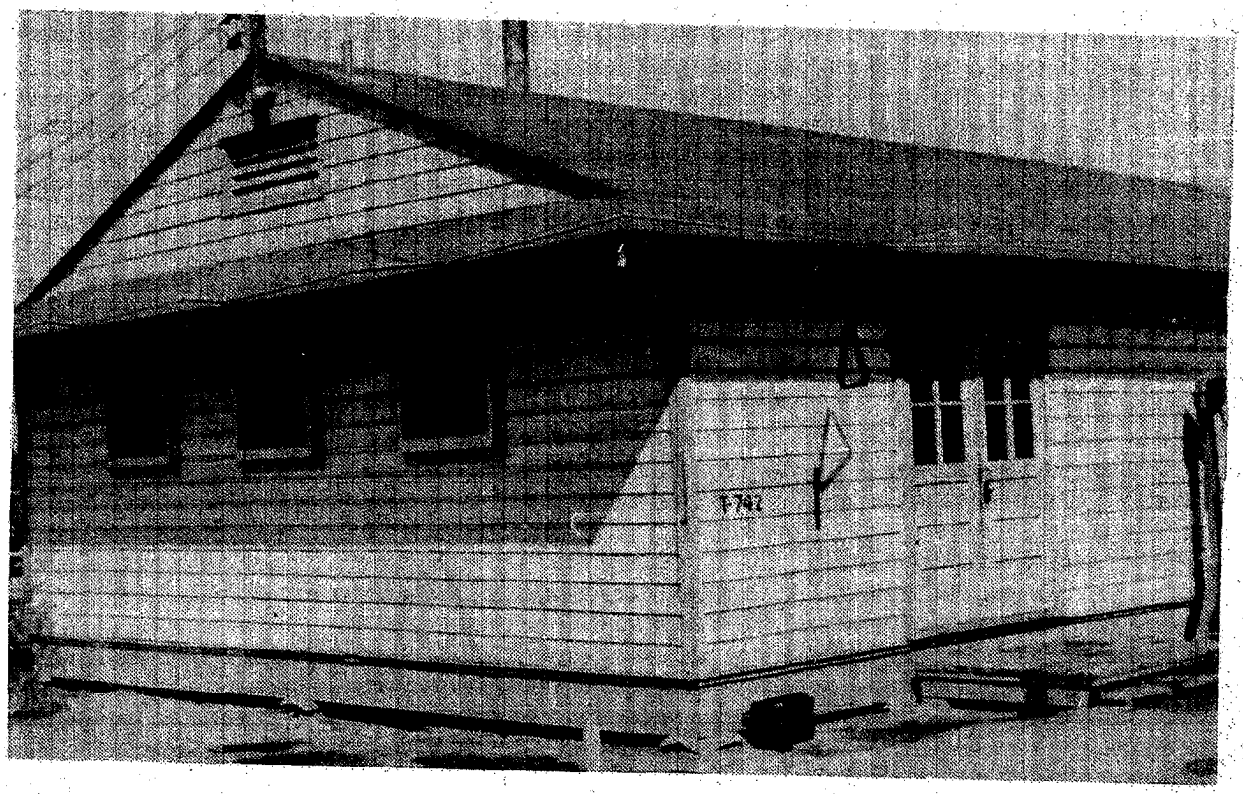


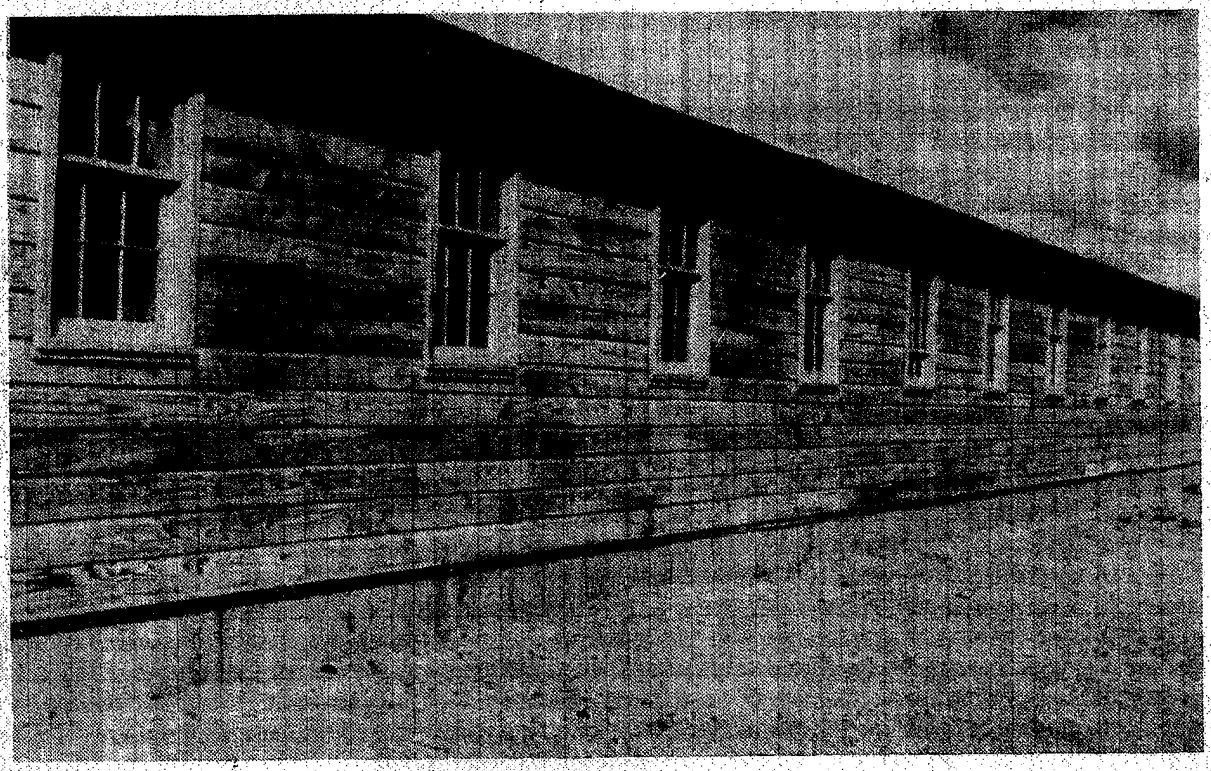


First cantonment-type barracks erected at Ft. Meyer, Va. Dry lumber of a select grade, free from knots, together with pure white lead paint combined to make a paint job in almost perfect condition 18 months after the painting was completed. Compare with figure on next page which shows the effect of knots in the common grade of lumber used for most of the cantonment buildings.



How knots in common grade of lumber mar the appearance of a paint job less than 1 year old at Camp Lee, Va., although special care was taken on this building to spot-prime the knots with aluminum paint.





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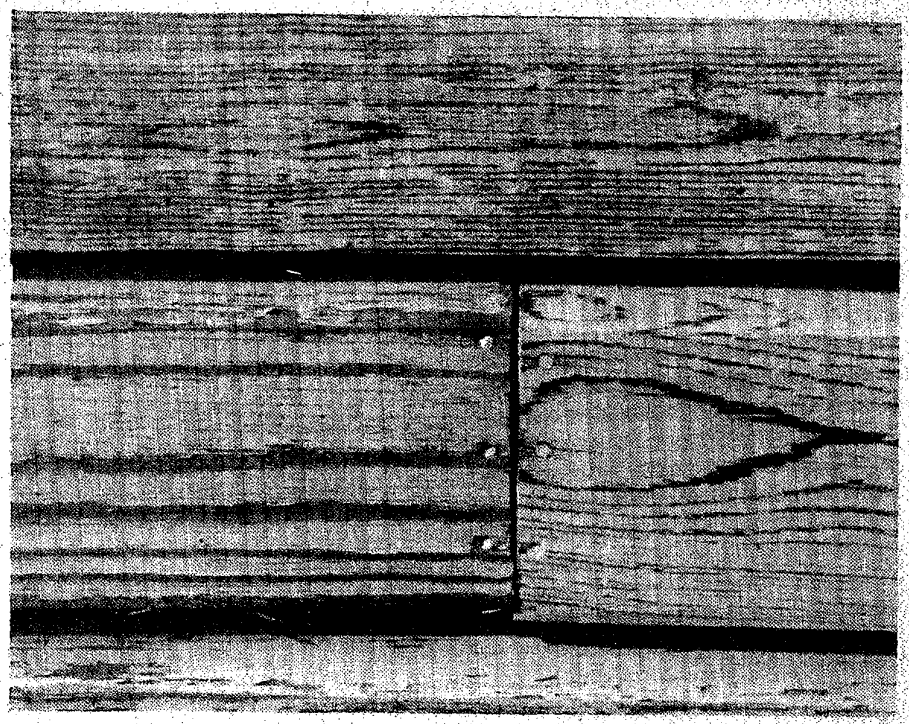
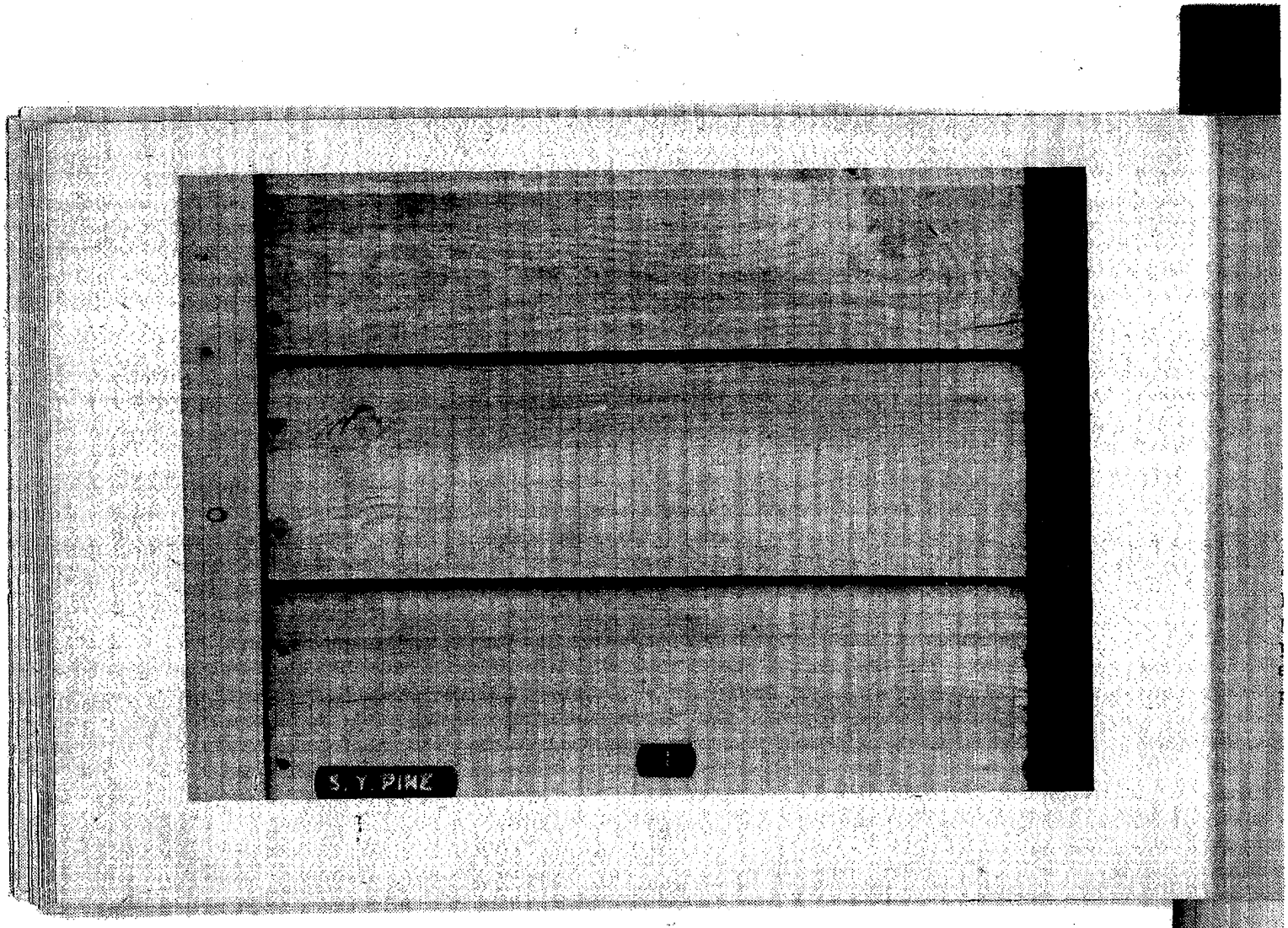
A hospital building at Ft. Bliss, Tex. on which paint has failed unusually completely because of a combination of wood of high density and omission of a third coat paint that was initially contracted for. Even with the advanced paint flaking, however, the boards remain straight, fit tightly, and the nails remain firm. It makes little difference whether this building is repainted now or is allowed to remain as it is for some years.





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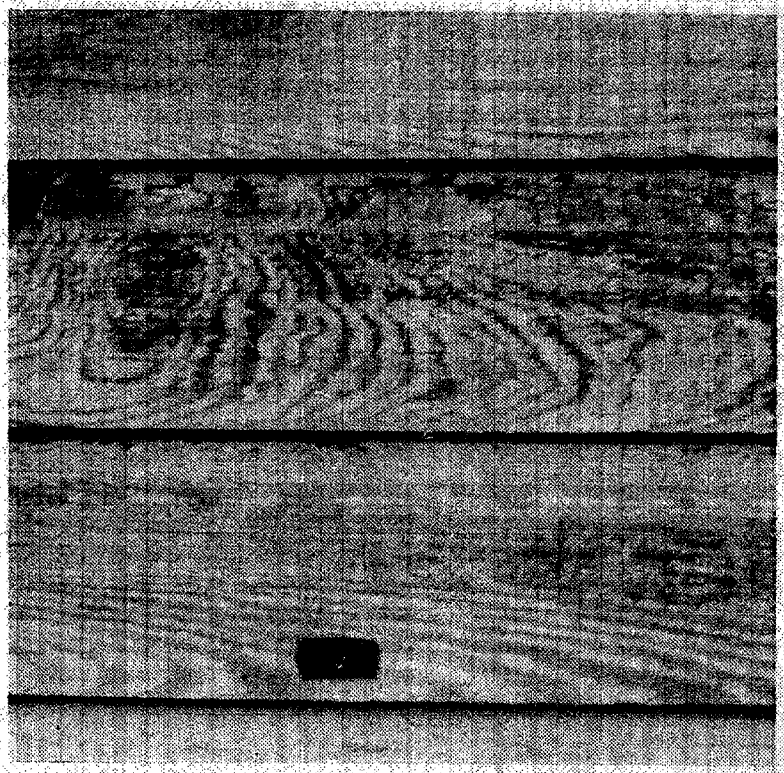
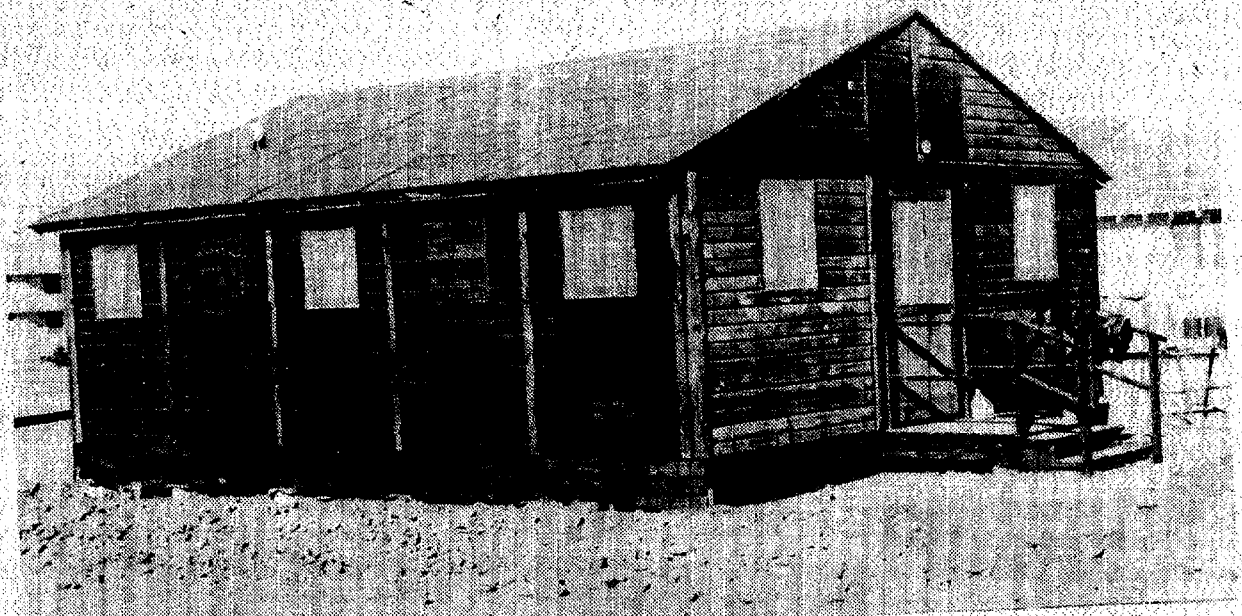
Southern yellow pine lumber, similar to that used in cantonment buildings, still in good condition on the test fences of the Forest Products Laboratory, Madison, Wis., 11 years after the last painting. These panels were erected in 1924 and painted with three coats of pure white lead paint (left panel) of of lead and zinc paint (right panel), repainted with one coat of paint in 1927, and not again painted until photographed in 1938.





One of a number of unpainted buildings moved to Camp Wolters, Texas, after many years of service in the Civilian Conservation Corps. The Post Engineer at Camp Wolters reported that these buildings were considered very satisfactory.

National Real Estate and Building Journal
March, April, May 1946

(46)

By F. L. BROWNE, *Chemist*
U.S. Forest Products Laboratory
Madison, Wis.

Some Things You Should Know About Post-war House Paints

Are today's paints as good as pre-war? Why are house paints made with [illegible]ed oil? How thick should a coat of paint be? What about so-called plastic paints? Answers to questions such as these are here given in an informative article, prepared for the Journal by a chemist who has done exhaustive research on paints at the U. S. Forest Products Laboratory. This is the first of a series, and will be of special interest to property managers and operative builders

FIVE years of shortages of materials and labor for civilian painting plus a need for much new housing are expected to result in great activity in house painting as soon as paints and painters are again freely available. At the same time the cost of applying paint has increased, making it more than ever desirable to use paints of the best quality and to apply them with the least labor consistent with durability.

"Plastic Paints"

The post-war paints for maintaining houses do not differ greatly from pre-war paints. No startlingly new materials for paint making have been discovered or are known to be in prospect. Rather, the past five years have been a time of substitutions and shifting of formulas to deal with scarcities of customary raw materials. Nevertheless, public interest in technology has been stimulated by wartime developments in synthetic rubbers, resin glues, resin sheet materials, resin impregnated materials, molded products, and other synthetic substances that are popularly lumped together under the general name of "plastics." It is therefore widely supposed that there are or soon will be radically new paints. Alive to this expectant frame of mind, a few manufacturers have marketed so-called "plastic paints" or plastic substitutes for paint, often with spectacular claims for their performance.

Investigations of "plastic paints" by the National Paint, Varnish and Lacquer Association and by Better Business Bureaus have revealed most of them to be ordinary paints sold under the new name. They may be paints of good quality at higher than customary prices or paints of inferior quality at the price of good products. Some are paints of thick consistency to be applied in coatings of several times the usual thickness, consuming several times the usual amount of paint, but alleged to be durable "for a lifetime." It happens, however, that coatings of house paint last longest when they are about 0.005 inch thick to begin with; much increase in film thickness beyond that optimum tends to produce shorter life and a more difficult surface to prepare for repainting. Calling paint a plastic does not alter its behavior.

Although the name plastic in connection with paint or varnish should warn buyers to be cautious, it is only fair to point out that there is no authoritative definition of plastic as a kind of material. All coating materials are plastic in the sense that by suitable methods of application they can be made to conform to the shape of the surface on which they are spread, and in service, must usually retain enough plasticity to submit to moderate changes in shape or dimensions of the substrate. Late in the 1920's, paints were called plastic if they could be tooled after application to produce decorative surfaces of rough texture, chiefly for interior walls and ceilings. The vogue for plastic paints of that kind passed when it was found that they are hard to keep clean and hard to repaint, but stippling paints, which are still popular, may be considered plastic paints of that type. A new variety of plastic paint may be molded on surfaces of plywood or other materials in a hot-press at the time the plywood is being glued together; it may prove useful in making prefabricated houses but is unsuitable for painting on the job.

Some technologists consider it proper to call paints or varnishes plastic if they are made with "synthetic" drying oils or resins. Varnishes, however, are frequently made with mixtures of synthetic and natural materials and it is difficult to draw the line clearly between the synthetic and the natural products. Ester gum, which is manufactured by combining resin from pine trees with glycerol from

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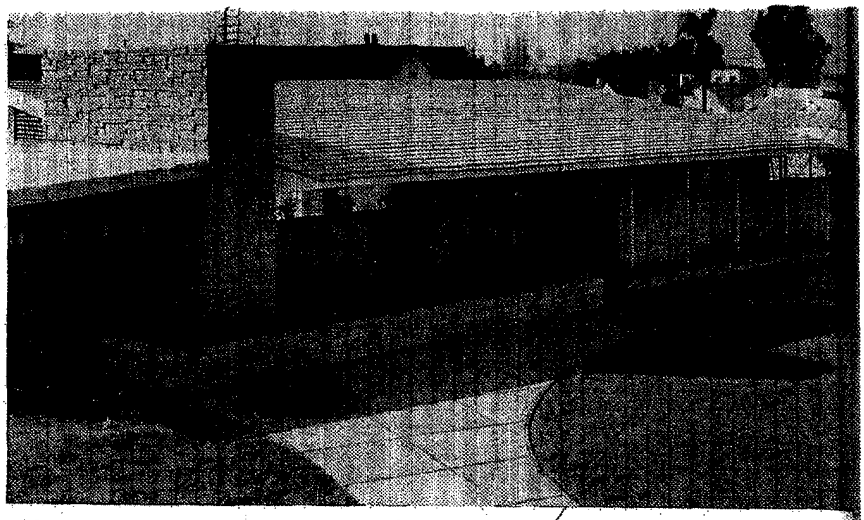
Features

- Aluminum moulded over insulation board form its roof shingles
- Heat-absorbing window glass in the bedroom
- Exterior walls of redwood plywood, joined by splines, and varnished with new coating
- Soundproof sliding doors
- Flush lighting designed on principles of sealed-beam headlights
- Germ-killing sterile lamps
- New spectrum lighting in greenhouse
- Television, record - changers, and inter-communication system
- Rubberized plastic walls for bedrooms
- Packaged bathroom, with pear-shape tub, plexiglas revolving turret-type shower door
- Electrical toothbrushes, hair-driers, and special compartment for drying hosiery
- Neon-lighted linen closet shelving
- Structural translucent corrugated glass partitions
- Miniature inside gardens in living room
- Roller-type doors on kitchen cabinets
- Grease filter in kitchen suction fan
- Plastic sink top and drain
- Console-type refrigerator, with drawers that pull out
- Automatic package receiver
- Innumerable appliances, including Precipitron, clothes drier, moduflow thermostats, frozen food cabinet, garbage disposal unit, and dishwasher, radiant infra red gas heater



Aluminum roof, redwood paneling, horizontal lines . . .

A new type of flush lighting, which utilizes the principles of sealed-beam headlights, diffuses a high percentage of light into rooms without wastage. Fluorescent indirect lighting is used in the living room. Neon tubes light bookcases, and can be regulated to low, medium or bright by turning a dial. Continuous strips of neon and fluorescent lighting are used in kitchen cabinets and linen closets. Germ-killing sterile lamps are provided in the kitchen and bathrooms. In the greenhouse a new type of lamp, containing spectrum colors in the glass, brings out the full beauty of the flowers in natural colors. A new type of switch which works in relays permits the use of bell wire to the switches, eliminating costly conduit. A continuous electric outlet strip is installed in the baseboards. Plastic push plates are equipped with tiny bulbs which glow at night.

Every room has radio reception equipment. Standard, F.M., phonograph or Muzak (music over telephone wires) may be dialed, in either the living room, master bedroom, second bedroom, kitchen and patio — all four types in various rooms at one time. A television receiver is built to the right of the fireplace. An automatic record changer is connected to the radio installation by relays. A home recorder permits the recording of voices or radio programs.

An inter-communication system connects master bedroom, kitchen, barbecue, front door, service door and hobby shop.

Bedroom walls are covered with a rubberized plastic material similar to wallpaper with designs impregnated into it.

The master bedroom, 13 feet by 20 feet, has high windows which prevail in other rooms. Instead of walk-in closets, storage walls are provided with sectional drawers and compartments. The dressing table is equipped with an 11-foot wide mirror. In a cabinet beside the bed a master switch controls all lights in the house.

The master bathroom resembles the "packaged" or ensemble type, and if it proves popular, may be manufactured for general use. The Burns model was forged without dies. The tub is pear-shaped, with the wide end usable for a shower. The shower door is a revolving turret-type, made of translucent plastic.

A hamper for soiled linen is built under the lavatory. A full-length, radiant, infrared gas heater gives instantaneous heat for early morning bath or shower. It is designed to heat the body not the air in the room.

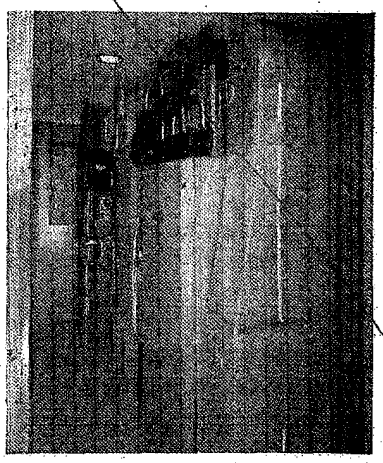
A new type of circular concave mirror lighted from the rear by a circular fluorescent lamp magnifies the face. An electrical toothbrush with special heads for various members of the family is attached to a spring cord which pulls out and then automatically goes back when not in use. An electrical shaver is attached to a similar cord. Directly overhead is a sunlamp permitting suntan treatment while shaving. Immediately behind is another lamp for drying milady's hair. A special compartment for drying ladies' hosiery is also provided. The medicine cabinet is large enough to hold even a half-gallon of rubbing alcohol. Immediately below is a storage space for towels. The water closet flushes by merely leaning back. A miniature radio is adjacent.

A feature of the entrance hall is the structural translucent corrugated glass partition directly in front of the doorway, and two miniature inside gardens.

Living and dining areas are combined, divided only by a U-shaped

(Please turn to page 40)

Utility room, air conditioner, precipitron



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Second, the high cost for labor in painting on the job together with the relatively thick coating necessary for durability on exterior woodwork, makes it economically necessary to use paints of maximum content of nonvolatile ingredients and minimum content of volatile thinner in order to build the required 0.005 inch of coating with the fewest possible applications. Good house paint of a decade or so ago, when three coats were usually considered necessary for painting new woodwork, was likely to consist of approximately 23% pigments, 67% linseed oil, and 10% volatile thinner and drier by volume. (The percentages by weight, as reported in the formulas printed on paint labels, vary considerably according to the specific gravity of the pigments used.) The nonvolatile ingredients, pigments plus linseed oil, amounted to 90% by volume. For the first coat the paint might be thinned with one pint of linseed oil and one pint of turpentine per gallon and applied so that one gallon covered 600 square feet of surface, which left about 0.0013 inch of coating after the volatile thinner escaped and some of the oil was absorbed by the wood. The second coat might be thinned with one pint of turpentine per gallon and applied at 700 square feet per gallon, which brought the thickness of coating to 0.0032 inch. The final coat applied without thinning at 800 square feet per gallon brought the coating to 0.005 inch. Enamel could scarcely be made with as much as 21% pigment and 44% resin and drying oil, requiring 35% by olume of thinner and drier. If applied in the same way three coats would build only 0.0037 inch of coating, making a fourth coat necessary to reach 0.005 inch. On interior surfaces that are not exposed to the rigors of weathering, 0.003 inch of coating is enough provided that the enamel is made with highly opaque pigments. For painting at the factory where application costs are much lower, it is usually cheaper to apply four coats of fast-drying enamel than three coats of slow-drying paint.

The third reason for preferring oil paints for houses is that oil paints, made with a high proportion of pigments including reasonable proportions of white lead and zinc oxide, dry satisfactorily under a far wider range of weather conditions and wear out in a manner more suitable for repainting than enamels do. Painting on the job must frequently be done in colder or damper weather than is best for the drying of coatings. Extremely bad conditions should be avoided, of course, but practicable house paints must withstand much variation from the ideal. Oil paints have marked advantages over enamels in that respect. The manner in which coatings of house paint wear out is important in view of the fact that the coating probably will be renewed at least seven or eight times during the life of the house. Removal of the old coating before repainting is much too expensive to be considered except as a last resort in cases of great difficulty. Good house paint, therefore, should wear out in a manner requiring minimum effort to prepare the surface for repainting. The ideal would be a coating that remained everywhere firmly adherent and unbroken, merely wearing gradually thinner until it no longer concealed the underlying woodwork completely. Some oil paints approach the ideal under favorable circumstances. All coatings, however, lose their plasticity and become brittle after exposure to the weather for several years. Once embrittled they are inclined to crack, after which they may curl and come loose along the cracks and flake or scale off. The safest paints for economical long-time maintenance are probably those oil paints that develop many fine but inconspicuous cracks with little or no tendency to loosen or curl along the cracks. Such paints can be recoated with confidence and little expense for scraping off loose paint. Paints formulated to delay cracking unduly are inclined to crack conspicuously, forming an uncertain foundation for repainting. The resin in enamels, which produces greater hardness of coating early in its life, causes increased brittleness later on which tends to aggravate cracking, curling, and uncertainty of repainting.

(Next month Mr. Browne will discuss oil-restricted house paints and the pigments used in house paints, as part of the series of three articles.)

Good house paints should wear out in such a way as to require minimum preparation in preparing the surface for repainting. The best oil paints for long-time maintenance develop many fine but inconspicuous cracks with little or no tendency to loosen

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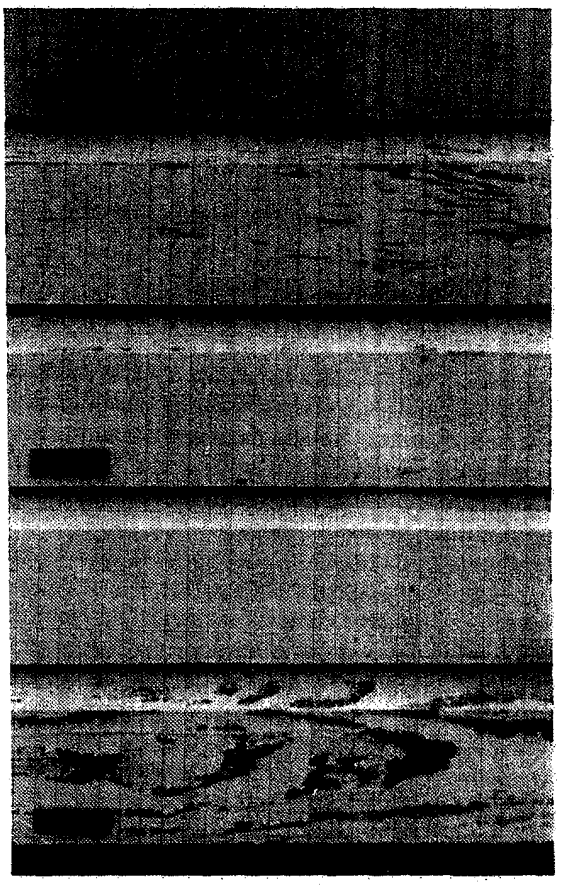
saponification of fats is commonly considered a natural resin by varnish makers but a synthetic resin by the molding plastics industry. Paint users, therefore, should be skeptical of the designation plastic paint; such paints should be examined critically for unreasonable claims or prices but some of them may be satisfactory products.

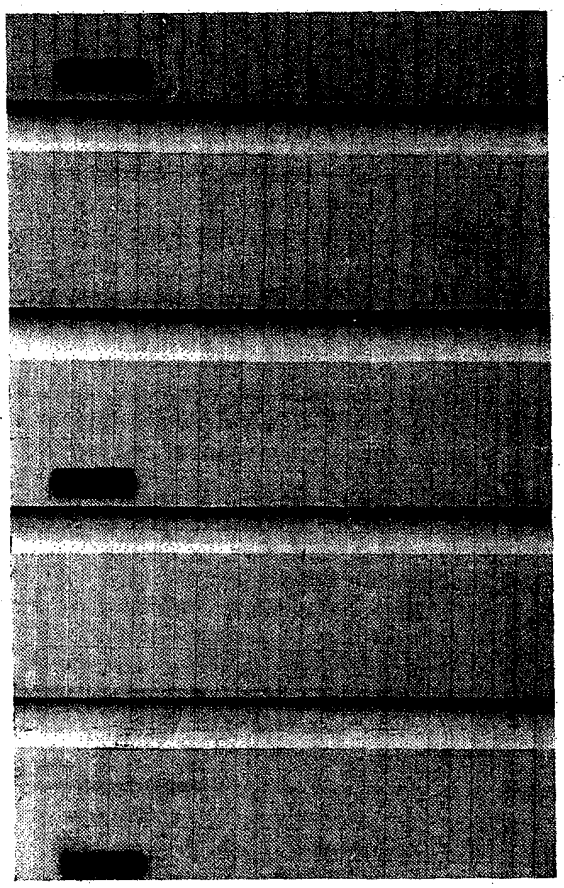
Why House Paints Are Made With Linseed Oil

Paints suitable for the exteriors of houses have always been linseed oil paints. They have differed greatly in the kind and amount of pigments with which they were made but the vehicle or liquid portion of the paint has been linseed oil or similar drying oil with a small proportion of volatile thinner and drier. Paints for most other purposes, such as interior wall paints, interior enamels, floor paints, and paints for factory-made products are enamels in which the vehicle is largely varnish or lacquer. Varnish is made by incorporating resin with drying oil, usually by heating them together, and then adding a large proportion of volatile thinner. Lacquer is made by dissolving resin and cellulose ester such as nitrocellulose in suitable solvents. The proportion of volatile thinner in varnish must be large because the mixture of resin and oil is extremely viscous by the time incorporation is complete; in lacquer the proportion of volatile liquids must be still larger to keep the resin and cellulose ester in solution at useful viscosity. Modern synthetic resins have revolutionized varnishes and lacquers during the past 20 years but have had very little effect on house paints. There have as yet been no synthetic drying oils suitable for replacing linseed oil in house paints.

There are three important reasons why oil paints are preferred for house painting. First, paints made with drying oils have certain application properties that are prized by painters and are unattainable in enamels. Oil paint has a comfortable "slip" under the brush whereas enamel tends to "pull." Oil paint can be applied at any spreading rate from as little as 300 to more than 1,200 square feet per gallon according to the needs of the job but enamel can be applied easily within only a narrow range of spreading rates characteristic of the particular product. Oil paint has the quality of staying just where the painter spreads it but enamel readily forms "runs" and "sags" if applied somewha too generously and it tends to draw away from sharp edges of boards. Oil paint levels off slight irregularities in the underlying surface and leaves slight brush marks that obscure blemishes such as planer marks, hammer marks, and raised grain, which are nearly always present in lumber that has not been carefully smoothed immediately before painting. Enamels leave no brush marks, follow the contour of the surface almost exactly, and accentuate its blemishes.

The test areas shown in the left of this photograph were primed with the paint used for the finishing coat, somewhat thinned. The panels on the right were primed with one coat of house-paint primer followed by one coat of finish paint. Photographed after 36 months of exposure facing south, these show that the "self-primed" areas have failed to the point of needing repainting but the areas with house-paint primer are still good for another 12 months of service. Same boards of Douglas fir and yellow pine were used





Some Things You Should Know About POST-WAR HOUSE PAINTS

Protection is paramount — but lasting life and beauty are also going to be demanded of post-war house paints. In this second article of a series of three a noted chemist discusses oil-restricted house paints; the percent by volume of oil, pigment and thinner to insure maximum coverage, thickness and life; and the basic proportions of white lead and zinc oxide pigments that should be included in oil paints to provide firm drying and durability under all conditions

By F. L. BROWNE
Chemist

U. S. Forest Products Laboratory
Madison, Wisconsin

PAINTS of a decade ago, containing typically 23% pigments and 67% linseed oil by volume, which is about 5.2 pounds of linseed oil per gallon, were somewhat too rich in linseed oil. Several generations of painters have been taught as apprentices that "oil is the life of paint" and painters are still inclined to overload their paints with it. Thorough technical research, however, proved that most oil paints perform better when the pigments form a higher proportion of the dried coating than the 25.6% by volume represented in the foregoing composition. For best results the pigments should occupy 28 to 30% of the volume of the dried coating. In enamels the proportions should be 30 to 40%. The maximum proportion of pigment in the wet paint at the time of application, however, is usually limited to 25 to 26% by volume in order to keep good brushing qualities. The best house paints during the five years prior to July, 1943, therefore, commonly contained 25 to 26% pigments, 61 to 65% linseed oil, and 10 to 13% by volume of volatile thinner and drier. Such paints contained 4.75 to 5.05 pounds of linseed oil per gallon.

During the war linseed oil, in common with other vegetable oils and fats, was in short supply. As a means of conserving oil the War Production Board limited the amount of vegetable oil in house paints to a maximum of 3.75 pounds per gallon, which would be 47.6% of the paint by volume. Paint containing 25% pigments, 47.6% raw linseed oil, and 27.4% volatile thinner and drier would be thin and watery to the point of impracticality. To restore normal consistency it is necessary to thicken part of the linseed oil by heating it at 550° to 600°F. for several hours. Such thickened oil is called bodied oil; it is not to be confused with boiled oil, which contains metallic driers but has about the same viscosity as raw oil. The wartime oil-restricted paints, therefore, were made typically with 25 to 26% pigments, 24% raw linseed oil, 23% bodied linseed oil, and 27 to 28% volatile thinner and drier.

The oil-restricted paints are intermediate in composition and properties between oil paint and enamel. For that reason they have sometimes been called enamelized paints. In ease and flexibility of application the oil-restricted paints are distinctly inferior to oil-rich paints but are much superior to true enamels. If oil-restricted paint is applied at the same spreading rate used for oil-rich paint the oil-restricted paint will form a thinner and proportionately less durable coating than the oil-rich paint. The tendency, however, is to apply oil-restricted paint at a lower spreading rate, in which case it may form as thick a coating and give practically the same performance as oil-rich paint but a larger amount of oil-restricted paint will be needed for the job.

To illustrate, let us assume an oil-rich paint made with 25% pigments and 62% raw linseed oil by volume and having a consistency known to paint technologists as "90 Krebs units." When such paint is applied as a finish coat it is apt to be spread over 700 square feet per gallon, which forms a coating 0.0020 inch thick when dry. Assume further that, to comply with the wartime restrictive order the paint was altered to contain 25% pigments, 24% raw linseed oil, and 23% bodied linseed oil and that by selecting suitable grades of pigments and bodied oils the consistency of the paint was about 65 Krebs units, that is, noticeably thinner or more watery in consistency than the oil-rich paint. In that case the oil-restricted paint probably would be applied at 700 square feet per gallon but the coating would be only 0.0016 inch thick, roughly four-fifths the thickness of the coating of oil-rich paint. The customary amount of paint would be consumed in painting a given building, only three-fourths of the usual amount of oil would be used, but there would be a significant sacrifice in the durability of the paint job.

In practice, however, the oil-restricted paints were made at nearly the same consistency as the previous oil-rich paints, namely at 90 Krebs units for the example cited. To the painter stirring his paint to make it ready for application the modified paint seemed to be the same as the paint he had previously used. Nevertheless, the effect of the bodied oil was such that he was apt to

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apply it at 575 rather than 700 square feet per gallon, in which case the coating formed was 0.0020 inch thick. The oil-restricted paint then gave a paint job equal in coating thickness and in durability to that previously obtained with oil-rich paint but nearly 25% more paint and labor were consumed and almost as much linseed oil was used to do it. The oil-restricted paints, therefore, make painting more expensive.

Although large proportions of bodied oil are disadvantageous in house paint, small proportions may serve useful purposes. For many years it has been common practice to make paints with about 5% of bodied oil and 57% of raw oil rather than with 62% of raw linseed oil. When used in moderate proportions that do not make it necessary to increase the proportion of volatile thinner the bodied oil is helpful in adjusting the consistency and application properties of the paint. The proportion of bodied oil may be increased to as much as 9% with 53% raw linseed oil before the paint acquires enamel-like properties and increase in content of volatile thinner becomes necessary. Some authorities, therefore, believe that post-war paints probably will be made typically with 25 to 26% pigments, 8 or 9% bodied oil, 52 to 55% raw linseed oil, and 10 to 13% thinner and drier by volume. They will probably contain about 4.75 pounds of linseed oil per gallon.

The 25 to 26% by volume of pigments in house paints may be made up of any one of a great number of combinations of available pigments. The period between the two World Wars was one of active exploration of the numerous possibilities during which there was great diversity in the pigmentation of the paints offered by different manufacturers. Competition, however, has gradually eliminated obsolete combinations until it seems likely that most of the post-war paints will be comparatively uniform in the essential aspects of pigmentation.

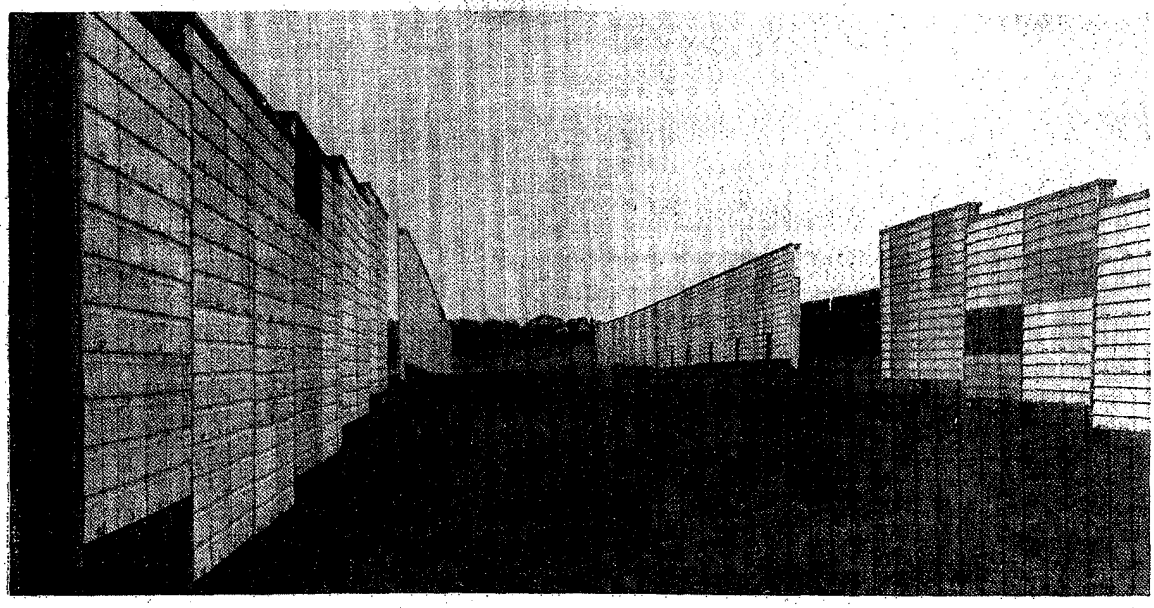
White Lead and Zinc Oxide in Paints

Oil paints require a certain proportion of white lead and zinc oxide to provide firm drying under all conditions of weather in which painting must be done and to make coatings sufficiently durable. Zinc oxide and the white leads, including basic carbonate white lead and basic sulfate white lead, are believed to react chemically with linseed oil or with products formed from it during drying and aging. Although the chemistry is not fully understood there is no doubt about the need for white lead and zinc oxide in house paints. Opinions differ, however, about the minimum proportions necessary for good service. Formerly it was thought that 70 to 90% of the total pigment (18 to 23% of the paint) should be white lead and zinc oxide. It is now realized that paints with such high proportions of the chemically active pigments become unduly dirty after a year or so of service and that the coating begins to check or crack sooner than is necessary. Paints in which 40 to 50% of the pigment consists of white lead and zinc oxide are less inclined to become dirty, are much slower in developing checking or cracking, and yet are even more durable than the older paints with high content of chemically active pigments. A few experts recommend as little as 35% lead and zinc pigments in the total pigment (about 8.75% of the paint). A conservative view is that the white lead should be between 5 and 8% and the zinc oxide between 5 and 6% by volume of the paint when the total pigment is 25%.

The minimum proportions of white lead and zinc oxide required for their chemical effects provide less than half the opacity demanded of modern white paints. The balance of opacity needed to make a coating of 0.005 inch thick completely hide the underlying surface is imparted by incorporating one of the very opaque white pigments, titanium dioxide or zinc sulfide. About 3.6% of titanium dioxide or 6.3% of zinc sulfide suffices for the purpose. It is undesirable to add much more than the required opacity because some painters will then apply too little paint for good durability. Titanium dioxide is usually preferred to zinc sulfide for the best paints, probably because the reputation of zinc sulfide has been impaired by its wide use for many years in the cheaper grades of house paint.

(Next month Mr. Browne will discuss chalking, deep color paints, and new special house paint primers in the last article of this series.)

Paint test panel fences of the U. S. Forest Products Laboratory at Madison, Wisc.



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Some Things You Should Know About Post-War House Paints

Less paint — longer life. New paints plus new methods give more value for your paint dollar. In this, the last in a series of three articles Mr. Browne tells property managers and operative builders how new controlled-penetration primers plus one coat of finish paint are more durable than the old penetrating primers plus two coats of finish. Also discussed are the types of light paints than can be safely tinted without chalking, the wearing qualities of chemicals that go into "deep color" paints, and methods of classifying house paints

By F. L. BROWNE, *Chemist*
U. S. Forest Products Laboratory
Madison, Wis.

OF the 25% by volume of total pigment in good paint, 10% has been assigned to white lead and zinc oxide and nearly 4% to titanium dioxide, leaving a balance of 11% still to be accounted for. In white paint the balance is made up of inexpensive pigments of low opacity, commonly called extending pigments or extenders. The more important extending pigments are: magnesium silicate, magnesium aluminum silicate, silica, mica, and barium sulfate. Certain mixtures of very opaque pigments and extenders are treated as though they were single substances and given names of their own. Among such composite pigments are: titanium-barium pigment, which contains titanium dioxide and barium sulfate; titanium-magnesium, which contains titanium dioxide and magnesium silicate; lithopone, which contains zinc sulfide and barium sulfate, and zinc sulfide-magnesium, which contains zinc sulfide and magnesium silicate. The oldest of the composite pigments, lithopone and titanium-barium, were actually manufactured as mixtures but some of the more recent ones are merely mechanical mixtures. Since the extending pigments were used generously in cheap paints long before the very opaque pigments were developed, many paint manufacturers have been reluctant to report extenders in the formulas of their best paints. By lumping the extender together with a very opaque pigment under the name of a composite pigment direct reference to the extender is avoided. In modern paints the extenders are not to be considered adulterants unless they are used to the exclusion of the requisite proportions of chemically active and opaque pigments. The time has passed when any apology need be offered for the presence of extending pigments in good paints.

Tinted paints, a term that includes nearly all colors commonly used for buildings except deep shades of red, yellow, green, brown, blue, and black, are white paints to which small proportions, rarely as much as 1% by volume, of the necessary colored pigments have been added, replacing a corresponding proportion of titanium dioxide or extending pigment. Most of the colored pigments, even in very small proportions, add materially to the durability of paint. On the other hand, chalking must be kept within closer bounds in tinted than in white paints because the color apparently fades as soon as chalking begins. Paints containing high proportions of white lead and zinc oxide fade less markedly than paints low in chemically active pigments. For that reason some manufacturers use more lead and zinc and less titanium pigment in their tints than in their white paints. The kind of titanium dioxide preferred for white paints, which has the crystalline form of the mineral anatase, leads to objectionable fading of tints. White paints containing titanium dioxide, therefore, should not be tinted on the job by the painter. Instead he should use cream or light gray paint for tinting or, better, use the "white base for tinting" sold by many manufacturers. For tinted paints there are other kinds of titanium dioxide called "nonchalking" which are either specially treated anatase titanium dioxide or titanium dioxide with the crystalline form of the mineral rutile. The term nonchalking is an exaggeration. All house paints should chalk as they wear away but the rate of chalking should be held within reasonable limits.

The colored-pigment paints or "colors," which are deep shades of red, yellow, green, brown, blue, and black, necessarily differ greatly from the white and tinted paints. The requirement of color excludes the opaque white pigments in any but minor proportions. The chemical effects of white lead and zinc oxide are thereby excluded. Iron oxide, however, seems to have some of the desirable effects of the chemically active pigments. The most important red, yellow, and brown pigments are rich in iron oxide. Lead chromate, an important but expensive bright yellow pigment, seems to be similarly effective and basic lead chromate, which is bright orange in color, is a basic pigment like white lead. These pigments, therefore, make good oil paints that can be made much like white paints except that iron oxide or lead chromate replaces the opaque white pigments. Pigments of low opacity play the same part in colored-pigment paints as they do in white paints. Red and brown paints made with iron oxide, however, often contain a substantial proportion of varnish, replacing part of the linseed oil, to make them dry faster and harder and to make the coating more glossy. Addition of the varnish makes it necessary to increase the content of volatile thinner, which results in coatings somewhat thinner than those of good white paints but the great durability of the colored-pigment paints makes the loss in film thickness of minor importance.

Green paints are commonly made with chrome green pigments, which are mixtures of lead chromate and ferric ferrocyanide, often with substantial proportions of pigments of low opacity. Green oil paints of good quality would be relatively expensive, consequently the content of chrome green is generally limited to the amount needed for color and opacity and the vehicle consists largely or entirely of varnish instead of linseed oil. Blue paints are made similarly with ferric ferrocyanide and black paints with one of the carbon pigments or with one of the carbon pigments together with a considerable proportion of iron oxide pigment. Such paints,

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Expenses — Home Purchaser: The purchaser of a home will be entitled to deductions for interest paid on mortgage and real estate taxes. All such expenses as insurance, repairs, maintenance, cleaning, etc., are considered personal expenses and are not deductible.

Expenses — Renter: Although the rent paid by the renter of necessity includes the factor of taxes paid by the owner, these taxes are not deductible by the renter except in the case of the stockholder-tenant of a co-operative apartment.

Stockholder-tenants are now permitted to deduct from their personal returns amounts paid or accrued to a co-operative apartment corporation to the extent that such amounts represent such stockholder-tenant's proportionate share of real estate taxes paid or incurred by the corporation on the apartment building and land on which it is situated and of interest paid or incurred by the corporation on its indebtedness contracted in the acquisition and construction of such property.

Depreciation: Depreciation is not allowable as a deduction on a home that is occupied by the owner. If, however, part of the building is rented, a prorata part of the depreciation is allowable if this part of the property is used in a trade or business or used as an investment property.

In investment property, depreciation is deductible against other income of the owner if the income from the property itself is not sufficient from which to deduct the depreciation. It is, of course, necessary that a division be made between cost of land and the cost of improvements. Depreciation is allowable on the improvements only.

Capital Expenditures: Capital expenditures are never deductible at the time they are incurred. They must be depreciated over their life. On leased property they may be amortized over the term of the lease or their life, whichever is the lesser.

Costs of repairs are an expense or a capital charge, depending upon whether the life of the asset has been extended or made more useful. Where a new property has just been purchased, it is held that all repair charges necessary to make it usable are capital expenditures.

Insurance Premiums: Under the most recent rulings, a taxpayer, even though on the cash receipts and disbursements basis, may not deduct more than one year's insurance premium in his return for any one year. In other words, he must carry forward as a prepaid item amounts paid on insurance beyond the one year in the same manner as one on the accrual basis must do.

Losses — When Deductible: Losses must be deducted in the year in which the loss was definitely ascertained. A partial loss can sometimes be made where it can be shown that the assets from which payments will be received have been reduced to a point that only a small percentage of the claim can be collected.

In the case of corporations, all losses ascertained during the taxable year are deductible.

Individuals are limited to losses occurring in a trade or business or transactions entered into for profit.

Individuals, however, are entitled to deduct casualty losses even though they have no relation to a trade or business or transactions entered into for profit.

Casualty losses are losses from accidents, casualties, and theft not compensated for by insurance, such as: auto accidents; jewelry and auto theft; fire to home, furniture, and other household articles; and losses due to storms.

Demolition of Buildings — When Deductible: A loss is usually allowable on the voluntary removal of a building if the property has been held for a considerable time by the taxpayer. However, if the building has recently been acquired, it is usually contended by the Bureau that the property was purchased with this in mind and, therefore, no loss is allowable. If, however, it can be shown that some change has occurred with the use of the property which could not have been foreseen at the time of its purchase, it could perhaps be shown that the property was not purchased with the idea of the demolition of the improvements in mind. It would depend entirely upon all the circumstances surrounding the situation to determine as to whether it is a proper deduction.

Intra-Family Transactions: Difficulty often arises when an attempt is made on the sale or exchange of property when the transaction involves directly or indirectly members of families or where an individual is dealing with a corporation in which he and his family own more than 50% of the value of the outstanding stock, or between two corporations if more than 50% of the value of the outstanding stock in both are owned by the same individual, or if one of the corporations was a personal holding company, or between the grantor and the fiduciary of a trust, or between a fiduciary of one trust and the fiduciary of another trust, if there is a common grantor, or between the fiduciary and beneficiary of the same trust.

It is contended in these situations that it is not an arm's length transaction and that the transaction may be for the purpose of securing the tax deduction and is, therefore, not a bona fide transaction.

Lance Joins Association

Ormie C. Lance, for 13 years secretary of the Northwestern Lumbermen's Association, joined the National Door Manufacturers' Association on April 15, as secretary-manager. Mr. Lance succeeded W. M. Steinbauer, former secretary-manager, who recently resigned to become associated with the Wabash Screen Door Company.

Construction Cost Indexes

Statistics compiled by U. S. Department of Commerce.	1946	1945					
	January	*January*	*March*	*May*	*July*	*September*	*November*
American Appraisal Co.:							
Average, 30 cities.....1913 equals 100....	283	266	267	268	270	272	278
Atlanta.....do.....	293	271	273	274	276	279	287
New York.....do.....	280	270	270	270	271	272	275
San Francisco.....do.....	249	241	241	243	244	245	248
St. Louis.....do.....	278	256	259	259	266	270	275
Associated General Contractors (all types) .....1913 equals 100....	241.0	226.8	227.8	229.3	230.0	231.0	238.0
E. H. Boeckh and Associates, Inc.:							
Residences:							
Brick:							
Atlanta.....U. S. Average 1926-29..... .....equals 100....	140.8	129.4	131.6	131.6	132.4	134.1	135.5
New York.....do.....	173.1	157.9	159.5	159.5	160.1	162.6	165.1
San Francisco.....do.....	150.6	145.3	145.5	146.3	146.3	146.3	148.0
St. Louis.....do.....	157.7	146.7	150.1	153.2	153.8	154.8	156.6
Frame:							
Atlanta.....do.....	142.6	131.2	133.6	133.6	134.4	135.3	137.1
New York.....do.....	173.7	159.5	161.1	161.1	161.7	163.0	165.0
San Francisco.....do.....	147.7	143.4	143.6	144.4	144.4	144.4	145.8
St. Louis.....do.....	158.3	146.2	149.3	154.3	154.9	155.4	157.6
Federal Home Loan Bank Administration:							
Standard 6-room frame house:							
Combined index....1935-39 equals 100....	138.2	134.5	135.0	135.1	135.5	136.3	137.3
Materials.....do.....	135.3	131.7	132.3	132.5	133.0	133.3	134.2
Labor.....do.....	144.2	140.1	140.4	140.4	140.6	142.4	143.5

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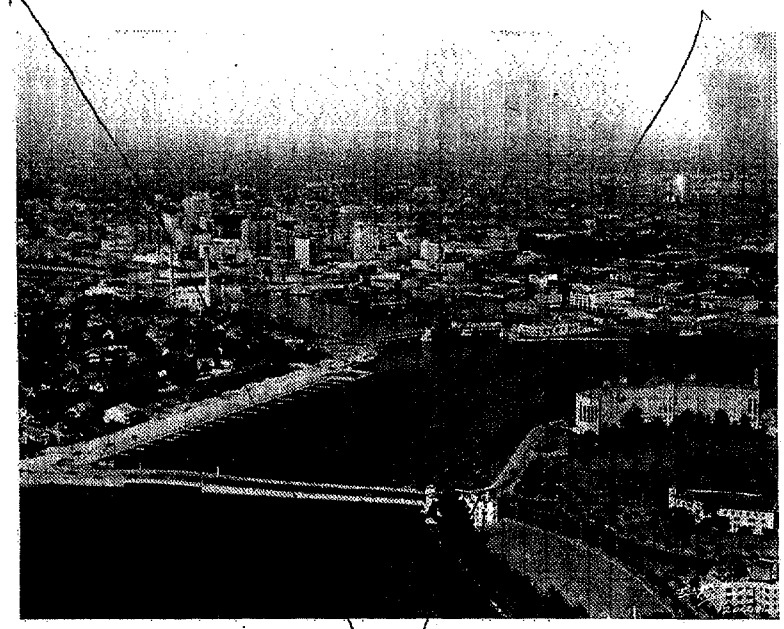


In the foreground, Davis Islands . . . which made news during the Florida land boom

Florida Developer Plans to Get Group Bids On Homes Planned by Site-Buyers

AS AN ADDED incentive for buying home sites in Davis Islands, a Tampa subdivision, W. Howard Frankland, president of the owner corporation, has announced a plan to facilitate construction of new homes by a group contract to a single contractor.

Families planning new homes may select their own architects, and turn in the blueprints to the company for a formal bid-letting. Contractors bidding on the home units will make both a group bid and separate estimate of the cost of each individual home. These will be submitted in separate envelopes. The second envelope, containing the estimates on the individual homes, will not be opened until after the low-bidding contractor has been selected. Prospective new home owners may sit in on the bidding session, and, of course, will be shown the bids on their new homes after the contractor has been selected.

Mr. Frankland believes group bidding will result in a saving on materials because of large scale buying, but in today's tight market, the amount of such a saving may be questionable. When houses are constructed in close proximity, a certain labor saving can be effected by a group operation, as operative builders know.

Davis Islands was planned and developed by D. P. Davis, a former Tampa newsboy who foresaw a new suburb built by dredging land from the bottom of Tampa Bay. At a municipal election in April, 1924, approval was voted for development of the project. Six months later, when the lots were offered for sale, all records for land sales in Tampa were broken. Within a few hours $1,683,500 had been spent on 306 lots. The Florida land boom was underway.

Davis Islands withstood the collapse of the boom, and has continued to develop as a residential district. Its 832 acres now contain many fine homes, apartments and hotels, as well as municipally-owned tennis courts, yacht basin and hospital, all within five minutes of the center of Tampa. Its streets, the narrowest of which are 60 feet wide, are all paved, and all utilities are in.

Mr. Frankland heads a corporation which acquired the property from absentee ownership three months ago. Other officers are F. H. L. French, vice-president; Wallace C. Tinsley, vice-president, and Alfred Dana, secretary-treasurer.

Post-War House Paints—

(Continued from page 32)

which are really enamels, should seldom be used for the priming coat on woodwork; instead the wood should be primed with gray priming paint made with white pigments and linseed oil and the colored-pigment paint should be used for the finish coats only.

House Paint Primers

The old practice of priming new woodwork with a priming paint made by thinning the finish paint with linseed oil and thinner is wasteful because much of the oil penetrates relatively deeply into the wood, where it does little good, and negligible progress is made toward building the required 0.005 inch of coating. House-paint primers were designed to prime bare wood more effectively and to make it possible to build satisfactory coating thickness with only two coats of paint, one of primer and one of finish paint. The modern primers contain as much pigment as good finish paint, namely 25 to 26% by volume. About 40% of the pigment or 10% of the paint by volume is white lead and 3 or 4% is titanium dioxide to give sufficient opacity; the remaining 11 or 12% is extending pigment. The linseed oil amounts to 40 to 47% of the paint by volume, about half of which is bodied linseed oil. The thinner and drier amount to 27 to 34% of the paint by weight. The bodied oil together with the generous amount of pigment provide the characteristic known as "controlled penetration," which prevents excessive penetration of oil into the wood. The substantial proportion of thinner is necessary to make paint spread properly on bare wood. House-paint primer of this kind can readily be applied at 450 square feet per gallon and followed by one coat of good finish paint applied at 550 square feet per gallon to build a coating 0.0045 inch thick. Such two-coat work has repeatedly been shown to be even more durable than the older practice of building similar coating thickness with a thin, penetrating primer followed by two coats of finish paint.

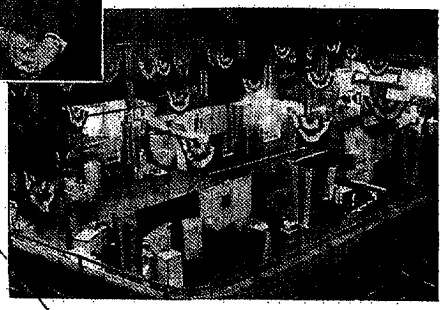
Classification of House Paints

Although most house paints bear a statement of composition, or formula, on the label, the composition is reported in percentages by weight rather than by volume. Paint ingredients vary so greatly in specific gravity that a general discussion of paints in terms of percentages by weight becomes

FLB 001117

Estimated 50,000 People Attend Memphis Home Show

Formulating plans for the NAHB Southeast Area Conference held at Memphis are: front row, left to right, Frank W. Cortright, Wallace E. Johnson and Joseph W. Meyerhoff. Standing at left is John B. Goodwin and on the right is Sam Russell



Panoramic view of the Memphis Home Show — a display of model homes, home appliances and building materials at Ellis Auditorium

An estimated 50,000 people viewed the Home Show in Memphis, Tenn., held in conjunction with the Southeast Area Conference of the National Association of Home Builders annual convention, April 19-20. The Home Show, open to the public from April 18 to 24 featured 87 exhibits of new homes, home appliances, new materials and treatments.

The two-day home builders convention featured panel discussions and talks by industrial and governmental representatives. Main speakers were Joseph W. Meyerhoff, president of NAHB, and Raymond M. Foley, commissioner of FHA. Panel discussion topics were home financing, moderated by Curt C. Mack, assistant underwriting commissioner, FHA, and materials for G.I. homes, chairmanned by Wallace E. Johnson, regional vice-president of NAHB, and moderated by Robert P. Gerholz, a former president of NAHB.

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hopelessly intricate. For that reason the United States Department of Agriculture has proposed that paints be classified by group, type, and grade according to their composition by volume and that the classification be printed on the label. The oil-rich white paint described in this article would be classified as **group TLZ type 3B grade 1** if it was made with the higher proportions of white lead and zinc oxide suggested and as **group TLZ type 4C grade 1** if it contained the lower proportions of white lead and zinc oxide. The classification system is described in detail in U.S.D.A. Technical Bulletin No. 804, "Classification of House and Barn Paints As Recommended by the United States Department of Agriculture," which can be purchased for 10 cents from the Superintendent of Documents, Washington, D.C. Another helpful publication on paints is U.S. Department of Commerce, Building Materials and Structures Report BMS 105, "Paint Manual with Particular Reference to Federal Specifications."

Monthly Reports—

(Continued from page 28)

cost for checks and stationery and bookkeeping expense.

However, in my opinion, it would prove more practical to handle the income for each building on a separate ledger sheet. The income could be classified separately with the aid of a few columns because the same bank from which disbursements were made in connection with this group of buildings would control all deposits. One entry per day would represent the total receipts of that day, as accounted for on the duplicate rent coupons.

On this same sheet the closing entries for the monthly statement could also be posted. For instance, receipts less disbursements would show either the check to balance for account of owner, or the credit balance which would constitute a part of bank balance and trial balance at the close of the month.

When the property manager's leasing department informs the accounting department that the lease has been properly closed, the accounting department records the period of the lease, the amount due per billing period, the decorating or other charges or allowances, and any special clauses. All this is done from the office copy of the signed lease. The tenant's card contains a digest of the terms of the lease, recorded at the time of the original drawing of the lease from the tenant's application. It is used thereafter as a source of billing, as well as the accounts receivable record. It is also used by the manager as a basis for setting up his earning record of commissions.

The owner, upon receipt of this monthly statement, proceeds to make entries in his books of account. No matter what method of accounting he uses, such information is simple to record when reported, as follows, in columnar fashion:

1. Space occupied (Suite No.)
2. Tenant (Name)
3. Arrears (From last report)
4. Current Rent (From billing record)
5. Other charges (Details, per symbols)
6. Adjustments (Details)
7. Received (Cash)
8. Arrears (To next report)
9. Remarks (If any)

All this should be set forth upon a statement which conforms to standard typewriter spacing, and should be on a single form of uniform size for filing.

Classification of Disbursements. In my opinion, the following ten categories are adequate to cover the analysis of the usual monthly operating charges:

1. Advertising
2. Wages
3. Commission
4. Decorating
5. Electricity
6. Fuel
7. Maintenance and repairs
8. Management fee
9. Miscellaneous
10. Uniform expense and upkeep

Below and separately may be shown such items as:

11. Real estate taxes
12. Water
13. Federal and state pay roll taxes
14. Insurance
15. Mortgage interest
16. Building improvements

If the owner desires a further analysis of his expenses for decorating, repairs, supplies, insurance, and commissions, the manager may detail them to meet his requirements. Since the owner is regularly sent all receipted vouchers, he may

(Please turn to page 38)

FLB 001118

Pointers From Your Paint Farm

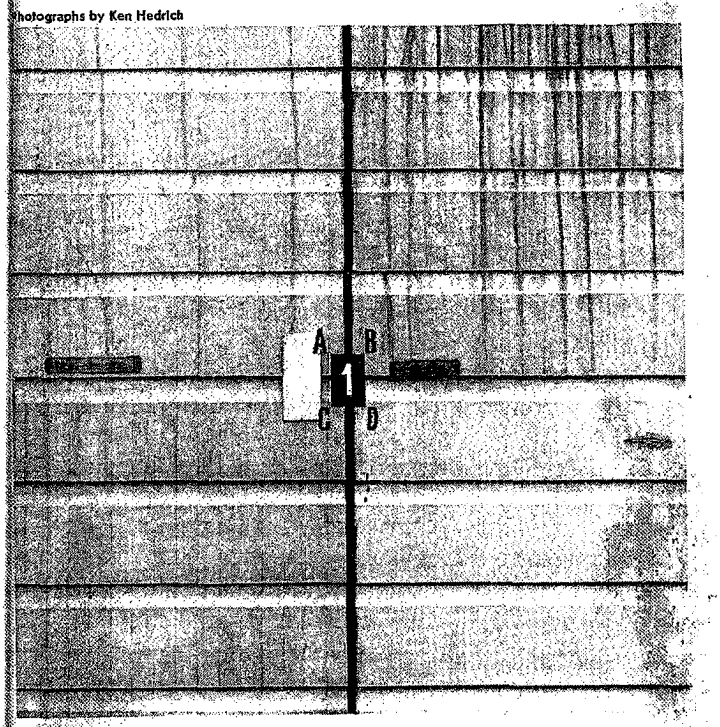
Successful Farming Sept 1946

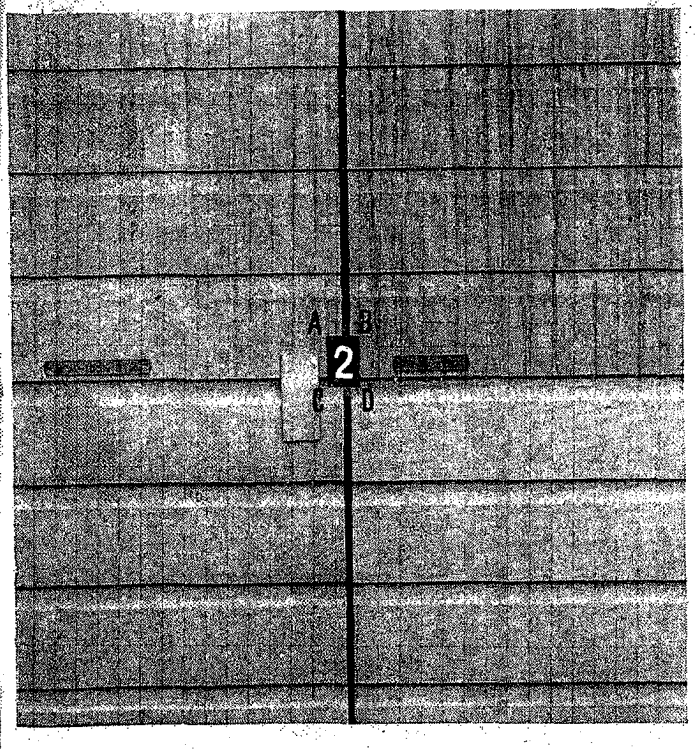
(47)

Photographs below and right, taken in 1946, show paint behavior as tested at Forest Products Laboratory's "farm," Madison, Wisconsin

BY F. L. BROWNE
U. S. Forest Products Laboratory

Photographs by Ken Hedrich





← 1 and 2 Paints get dirty, clean themselves

Painted with three coats on the north side of the test fence in 1936, later repainted as follows: 1A & 2A. One coat every 3 years, last time in 1945; 1B & 2B. Two coats every 3 years, last time in 1945; 1C & 2C. Two coats every 4 years, last time in 1944; 1D & 2D. One coat every 5 years, last time in 1941. The dirtiest paint, A's and B's, is only 1 year old. Two-year paint on C's has begun to clean itself. Five-year paint on D's has been clean for two years or so. White paint looks best in the last half of its life. Pure, white-lead paint on 1A to 1D. Titanium-lead-zinc paint of Group TLZ, Type 3B on 2A to 2D. White-lead paint gets dirtier than TLZ paint but, like most other paints, it cleans itself by chalking as it gets older.

3 and 4 Tinted paints (light colors) fade →

Painted with three coats on south side of test fence in 1939. Redcedar and white-pine siding. Paints on 3 all tinted to match a gray color. Small pieces now tacked to the boards show the color at the start. The paints on 4 were the same except they were tinted to match a buff color. All the paints were of Group TLZ but they differed in amount of lead and zinc pigments or in kind of titanium pigment as follows: A's & B's. High in lead and zinc pigments, Type 2B; C's & D's. Low in lead zinc pigments, Type 4C; A's & D's. Titanium pigment of the chalking variety; B's & C's. Chalk-resistant variety of titanium pigment. A's and B's faded least, C's faded badly, D's faded most, in fact they soon turned almost white.

5 and 6 Wear and color changes in red barn paint →

Painted with two coats on south side of fence, 5 in 1940, 6 in 1939. Douglas-fir and southern-pine siding. 5A. Best paint sold by Maker X; pigment 54% by weight of which factory-made iron oxide 22%, zinc oxide 5%. Wore fairly well, color faded. 5B. Cheaper paint by Maker X; pigment 51% of which iron oxide only 15%; much varnish in liquid. Color good but did not wear well. 5C. Best paint of Maker Y; pigment 54% of which natural iron oxide 25%; some varnish in liquid. Wore well, color darkened. 5D. Cheaper paint by Y; pigment 50% of which iron oxide (Venetian red) 15%; some varnish in liquid. Wore well, but more paint was needed for a given area. 6A. Pigment Spanish oxide 56% of which iron oxide 83%; varnish in liquid. 6B. Pigment Spanish oxide 64%; no varnish. Paints in 6A and 6B had too much iron oxide for best wear and best color. 6C. Pigment 53% of which iron oxide (Spanish oxide) 25%. Wore well but faded badly. 6D. Pigment 59% of which iron oxide (Spanish oxide) 50%. Best wear shown but color darkened slightly.

See the author's how-to discussion of paints and painting on page 52 →

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FLB 001119

Pointers from your paint farm

(Continued from picture pages 28-29)

By F. L. Browne
U. S. Forest Products Laboratory
Madison, Wisconsin

IF YOU'RE putting off painting your farm buildings to wait for marvelous new paints developed during the war, you will be well advised to wait no longer but to be content with good paints that are much like those you bought *before* the war. Paint research during the war was chiefly on making paints to hide objects rather than to decorate them, to turn out war material as quickly as possible for a rough but brief life, and to find substitutes for some of the materials usually used for making civilian paints. For farm paints, reconversion is mostly a matter of picking up where progress was broken off.

Most paints for outside wood and metal in buildings are oil paints. That is, the "vehicle" or liquid portion of the paint is chiefly linseed oil. Other drying oils such as soybean oil may replace linseed oil in part. A small amount of mineral spirits or turpentine, which evaporates while paint dries, is necessary to give the right consistency for brushing or spraying. Very small proportions of driers are needed to make paint dry fast. The driers are soaps of lead, manganese, or cobalt that will dissolve in linseed oil.

PAINT designed for economical application and long life contains a minimum of volatile thinners so that a film thick enough to be lasting can be built with as few coats as possible. Good paint also should be able to be spread easily on smooth or rough surfaces, and should level off slight depressions in boards, stay where it is put without "runs" or "sags," leave slight "brush marks" which add to the good looks of most buildings, dry satisfactorily in all kinds of weather in which painting is done, and wear in such a manner that it can be repainted at suitable intervals. Good oil paint will do all these things for you.

Paints can be made in which the vehicle consists partly of raw linseed oil and partly of varnish. Varnish, however, requires much extra mineral spirits to make the paint brushable or sprayable. Extra paint, either more coats or thicker coats, must therefore be applied to get enough dry paint on the surface to wear well.

Many efforts have been made to make such paints popular by calling them synthetic paints, quick-drying paints, or enamelized paints. So far, however, their disadvantages have outweighed any advantages claimed for them except in certain paints of deep colors like dark green, blue, or black.

Latest effort to put them over makes use of the name "plastic paint," or just plain "plastic," because of the public interest in the molded plastics, sheets, fibers, rubbers, and glues. The plastic paints are no more suitable for upkeep painting than they were when they were called synthetic paints.

Beginning in July, 1943, a kind of enamelized paint was made necessary by an order of the War Production Board limiting the amount of drying oil in house paints to 3.75 pounds per gallon in order to conserve vegetable oils. Good oil paints normally contain 4.75 to a little over 5 pounds of oil per gallon.

Mineral spirits is substituted for the amount of drying oil left out. Linseed oil is *still* in short supply. Altho the restrictive order is no longer in effect, most manufacturers still make oil-restricted paints. The oil-restricted paints are somewhat cheaper to make and therefore may remain on the market as long as they can be sold at the price of good, oil-rich paints. Competition will eventually drive them back to the field of low-priced paints, where they started.

In *Successful Farming* for May, 1941, page 12, I told you about the kinds of house paints of good quality sold at that time. They were described in terms of a classification proposed by our Forest Products Laboratory, and suggestions were made for recognizing them from the formulas printed on the labels by all reliable paint manufacturers. The system of classification is now published in detail in U.S.D.A. Technical Bulletin No. 804, *Classification of House and Barn Paints As Recommended by the United States Department of Agriculture*, which can be bought for 10 cents from the Superintendent of Documents, Washington 25, D. C.

The white or light-colored paints described at that time were pure white-lead paint, which is paint of Group L (lead) Type 1A, Grade 1; and three kinds of mixed-pigment paints of Group TLZ (titanium, lead, and zinc), Type 2B, Grade 1; of Group TLZ, Type 3C, Grade 1; and of Group TLZ, Type 4C, Grade 1. The postwar paints probably will not differ from them very greatly, and I mention them here to refresh your memory.

PURE white-lead paint, which is the oldest kind of white paint, is still one of the best paints for farm buildings. It has excellent painting qualities, it holds tints *better* than TLZ paints, and it wears away by slow chalking and a fine checking and crumbling that leaves a good surface for repainting. In particular, it stands neglect well. That is, repainting can be postponed for several years beyond the normal fourth or fifth year without producing an unkempt appearance or leaving a difficult and expensive surface to prepare for repainting. Such delay in repainting is common in farm work.

The shortcoming of pure white-lead paint is a tendency to become grayed with dirt during the first year or two after application, particularly on the more heavily shaded areas of buildings. You'll notice this on page 28.

You may buy pure white-lead paint in the form of soft paste containing 89 percent white lead, 5 percent [*Turn to page 54*]

Pointers From Your Paint Farm

[*From page 52*]

linseed oil, and 2 percent turpentine by weight. To make 6⅜ gallons of Grade-1 paint, mix 100 pounds of the paste with 3¼ gallons of linseed oil and 1 pint of liquid paint drier. To make light colors, the white must be tinted with colors-in-oil. Pure white-lead paint may also be bought in the prepared form in white, and also in a variety of light colors. Grade-1 paint, in the prepared form, contains not less than 71 percent pigment by weight, and not less than 86 percent of the liquid is linseed oil.

The TLZ paints, as compared to the white-lead paints you've just read about, have the advantage of a brighter appearance, particularly in white, and less graying from collection of dirt. I'm afraid you'll have to take my word for it because the pictures on pages 28 and 29 won't show the entire difference between L and TLZ paints. You need to see the actual paints out in the daylight to check the real differences.

TODAY'S TLZ paints may have lower proportions of white lead and zinc oxide than were generally used in 1941. Lowering the proportion of the lead and zinc pigments improves some properties of TLZ paints but makes other properties worse. There is, therefore, much difference of opinion about best proportions.

Too little lead and zinc causes too rapid chalking and early failure of the TLZ paint. The very lowest proportion cannot be set exactly, but the white lead and zinc oxide together certainly should not be less than 40 percent of the pigment by weight. Paints near the minimum proportion, which belong to Type 4C, stay relatively clean and may not check or crack for a long time, but they chalk very freely, do not hold tints well, and if they are neglected they may crack and scale badly. As the amount of lead and zinc is increased, there is greater graying by dirt and earlier checking and cracking but less severe chalking, less fading of tints, and less objectionable cracking and flaking if neglected.

A safe view for you to take is that TLZ paints of medium content of white lead and zinc oxide (which belong to Type 3B if they have more lead than zinc or to Type 3C if they have more zinc than lead pigment) represent a good compromise between the advantages and disadvantages. In such paints, the white lead and zinc oxide together is usually between 60 and 70 percent of the total pigment by weight.

Some titanium pigments chalk more freely than others. The chalking varieties are best for making white paint because the paint becomes less grayed with dirt, but for tinted paints the chalk-resistant varieties are best to avoid fading. White TLZ paints of Types 3B, 3C, or 4C should not be tinted on the job. If suitably colored paint of those types cannot be purchased, a cream or a gray paint may be further tinted on the job or, better, a special "white base for tinting," offered by some manufacturers, may be used.

It is worth keeping in mind that tinted paints will wear longer than white paints. As a rule, the buff or gray tints shown in the photographs on page 29 will last 6 years where the corresponding white

FLB 001120

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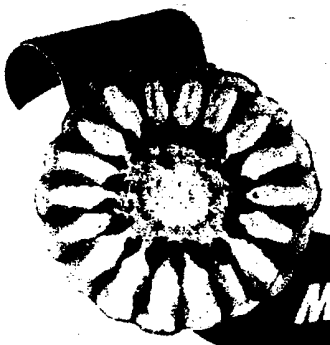

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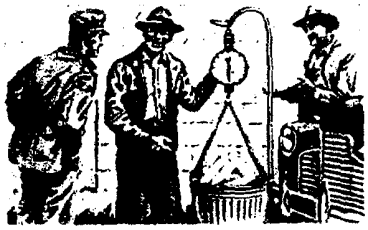
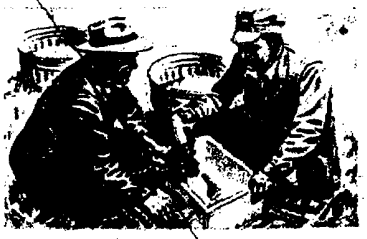
HOW THE CHECKS ARE MADE



YIELD CHECKS are made in farmers' fields where Pfister Hybrids have been grown alongside of *competitive hybrids under* the same conditions. A predetermined number of hills of each hybrid is picked *from* adjoining rows and the corn accurately weighed. This gives EAR CORN YIELD.



THEN THE EARS of each hybrid are shelled into separate containers. The shelled corn is accurately weighed. This gives the SHELLED CORN YIELD.

MOISTURE TESTS are made and weights reduced to No. 2 corn. This determines the winner on the basis of *dry shelled corn yield per acre. And in 2,325 such checks,* Pfister Hybrids WIN 8 out of 10 TIMES.

FLB 001122

paint will begin to break down in little more than 4 years. Farm property offers a great deal of surface for paint upkeep. It has seldom been repainted often enough for best paint performance.

Moreover, good paint service requires good lumber for its foundation. Knotty grades of lumber, for example, yield poor paint jobs.

The heavier softwoods, like Douglas fir and southern yellow pine, do not hold paint as long as woods of light weight, like redcedar and white pine. When painting the heavier woods for the first time, or after an old coating has worn away practically completely, it is worth while priming them with aluminum house paint. (Do not use aluminum paint designed for painting metal.) Two coats of white or light-colored paint are needed over the aluminum primer. Douglas-fir plywood is best primed with aluminum house paint both to make the paint last longer and to give plywood as much protection against checking as possible.

Three coats formerly were considered necessary in painting new woodwork. Modern paints, however, are of higher grade than used to be the case. With present Grade-1 paints and special house-paint primers, new woodwork can be painted adequately with two coats, one of primer and one of finish paint.

The paint should be spread thicker however, because good wear requires a coating about .005 inch thick, whether it is put on in two coats or in three. In three-coat practice the first coat may be spread at 600, the second at 700, and the third at 800 square feet per gallon.

Modern, 2-coat practice is to apply one coat of special primer, without any thinning, at 450 square feet per gallon and one coat of finish paint at 550 square feet per gallon. There is no saving in the amount of paint but there is a saving of labor of applying a third coat.

RED barn paints of good quality are particularly suitable for farm buildings because of their moderate cost, great durability, and pleasing color at all seasons of the year. Unfortunately many barn paints on the market have been of poor quality in an effort to make them too cheaply for farmers who mistakenly put low cost per gallon over long-time service. See color panels on page 29.

Paints made with certain natural iron oxide (not laboratory- and factory-produced iron oxide) such as Spanish oxide, weather to a darker, somewhat purple shade as shown. Sometimes zinc oxide is added to iron oxide. Zinc oxide is helpful in combating growth of mildew on barn paints, a difficulty which you'll find wherever there is much dampness.

Venetian red (as compared to Spanish iron oxide) makes paints that hold a brighter red color. Venetian red is a manufactured pigment that contains iron oxide and calcium sulfate. The iron oxide in the best Venetian reds amounts to 40 percent of the pigment by weight.

But whether you wish the purple-red of Spanish, the red-red of Venetian, the brightness of TLZ, or the self-cleaning of white lead in oil in the latter years of its service, the point I'm trying to make is to read the formula on the label and to learn what it means, so that you can know what you are buying and use it to your best advantage. Please don't think that low price per gallon of paint means low cost for the job or low cost per year of service. END

FLB 001123

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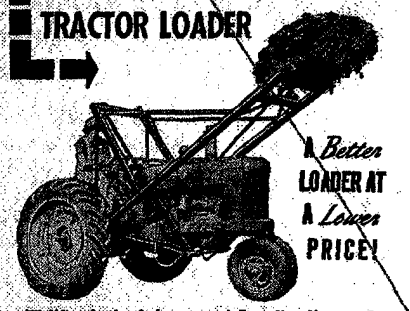

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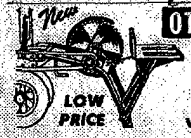

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Good Tiling Will Boost Your Farm Income

[*From page 33*]

wise, this field was farmed in the regular rotation. The first season after the field was tiled, corn was planted, with the result that no part of the crop was lost. In fact, ponds have completely disappeared.

Field B was in pasture from 1936 until this spring, when it was plowed and planted to corn. The wet spots were tiled in 1943. However, it was not until this year that the soil had opened enough for the planting of tilled crops.

BECAUSE Field C was wet in spots, it was considered good only for pasture, and no attempt was made to farm the land before tile was put thru. Last year, this field was planted to corn and averaged 65 bushels to the acre.

For many years, when it wasn't too wet, Field D averaged 45 bushels of corn, or 20 bushels of soybeans. But in 1944, the first season after tiling, corn in this field averaged 55 bushels, and last year the soybeans went 33 bushels to the acre. One of the most noticeable differences is that before tiling, the crops often stood by while operators waited for the field to dry off enough to harvest the crop.

A quick look at the drawing of the farm will give you an idea of the plan that Engineer Moss worked out. While the outlet is far from the ideal solution, there was no choice but to drain this side of the farm into a marsh running into the southeastern corner of Field C.

Carl points out that, all too often, protection and maintenance of tile outlets have resulted in plugged and ineffective systems. Frequently, he has found that ditches, long neglected, have silted and filled in to such an extent that the tile outlets have become plugged. Thus, eventually, the entire drainage system lies useless. To safeguard against outlet trouble on the Wolf farm, a cement headwall with apron protects the tile opening.

It is not at all uncommon to plow up 2- and 3-inch tile that were laid 60 to 80 years ago. But today, drainage specialists recommend 5-inch tile as the smallest to be used anywhere in the drainage system.

WHERE tile was buried scarcely 2 feet beneath the surface 50 years ago, erosion has now reduced this depth to as little as 18 inches. Tile at this depth was in little danger when horses and lighter machinery were used, but the heavier machinery now used on farms has broken and dislocated many lines. In planning tiling systems, Carl aims to have tile buried from 3 to 4 feet deep in mineral soils. In the case of muck soils, which have been drained previously, he recommends a depth of at least 5 feet.

In addition to more protection for the tile, greater depth of tile lines lowers the water table and results in an expanded root system for the crops. The value of suitable depth is shown by an experiment on the Jennings County Experiment Station in Indiana, where drainage has been studied since 1921. Production from undrained land has been compared with that from land tiled at various depths.

In all cases, the land with tile laid 42 inches deep gave the greatest production. Eight crops of corn have averaged 57.6 bushels over tile 42 inches deep, 51.3 bushels over tile 24 inches deep, and 40.8 bushels on the undrained land. Wheat has averaged 25.6 bushels on the deeply drained soil, 19.9 bushels over the shallow tile, and 15.6 bushels on the undrained land.

Layouts like the one on the Wolf farm test the ingenuity of the engineer. As Mr. Moss points out, "You just can't run a tile line thru a rise of ground, and hit a pond on the other side by following the water-flow level. You absolutely need a level and must know what you are doing. If you tile by eye or follow the flow of water your tile will be laid to an uneven grade, and invariably you will come out too high or too low on the far side."

With the exception of a slightly higher corner, Field D was covered with laterals, 100 feet apart and extending thru the fence line into Field B. Laterals 1,100 and 1,200 feet long are 6-inch tile, while laterals only half this long are 5-inch. These laterals connect into Main No. 1 which runs about 130 feet in from the end of the field. Main No. 1 starts as 15-inch tile, and steps down to 10 inches, then 8 inches, and finally to 6 inches as the carry-off out on the far end of the main decreases. Sizes of mains and the laterals, too, are in proportion to the amount of water they are expected to carry. Carrying capacity is affected directly by slope of fall and the size of tile used.

DISTANCES recommended between laterals vary according to the type of soil. For instance, on the heavy, clay soils, laterals should be placed from 40 to 60 feet apart. On the lighter, silt-loam soils, distance between laterals may be 70 to 90 feet. Laterals on sandy loams may be 100 to 125 feet or more apart, and in most muck soils the lines may be 150 feet apart.

That character of the soil also has a bearing on the distance laterals should be spaced is shown by a comment from Virgil Overholt, extension agricultural engineer in Ohio, "Most of our tile in this state were installed 30 to 60 years ago. At that time drainage was satisfactory with the lines spaced 4 to 8 rods apart. But in recent years, water is not moving thru the soil as rapidly, and many farmers have found it necessary to split this distance by laying new lines between the old laterals. And small wonder, since a cubic foot of this soil weighs from 15 to 20 pounds more than the original virgin soil. This change has been brought about by too many cleanly cultivated crops."

The Wolf farm-layout diagram on page 32 shows that Main No. 2 extends into Fields C, B, and A where it is joined to Main No. 3. Laterals from Mains 2 and 3 cut across or tap low spots in these fields.

Can drainage systems be repaired profitably, and put into good working condition? That's the question we asked drainage experts from Minnesota to New York State. Drainage specialists agree that while some tile can be repaired at little cost, in other cases it may be far more satisfactory to install a new system.

IF THE old system is plugged at the outlet because of a faulty headwall or silt in the drain ditch, the outlet can be repaired, or the ditch can be dredged. Broken tile in the line can be repaired.

"Where tile lines, laid up a draw, have been broken by erosion," Mr. Lynes, trouble shooter for the Mason City (Iowa) Brick and Tile Company, points out, "repair is useless; [*Turn to page 125*

FLB 00112

1947 Browne

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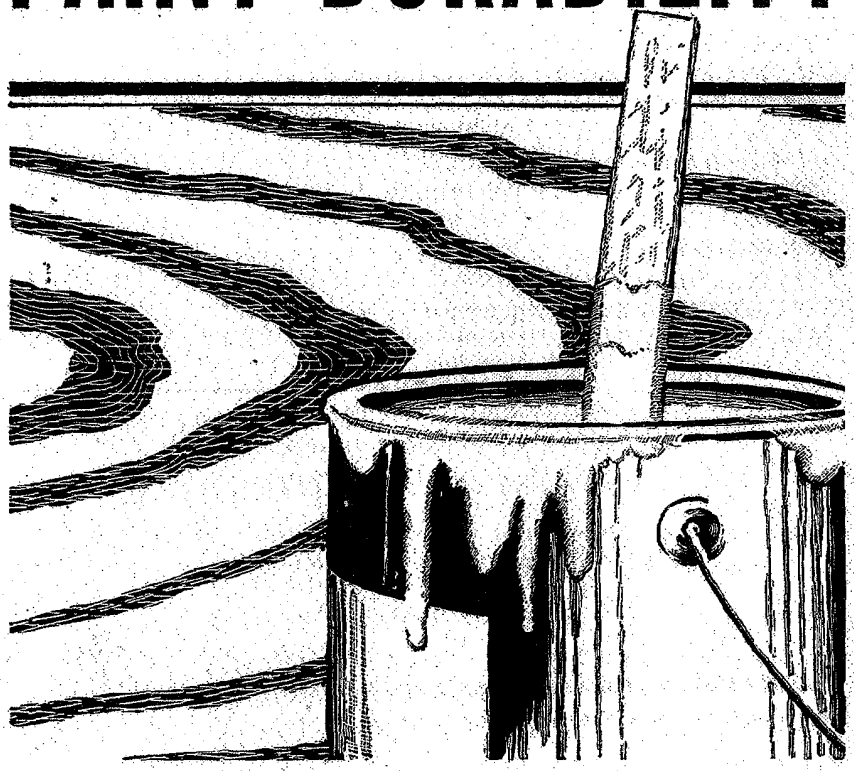
WOOD PROPERTIES AND PAINT DURABILITY



UNITED STATES DEPARTMENT OF AGRICULTURE

Miscellaneous Publication No. 629

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By F. J

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WOOD PROPERTIES AND PAINT DURABILITY[1]

By F. L. Browne, *chemist, Forest Products Laboratory,*[2] *Forest Service*

The longer a coat of paint lasts the lower the over-all painting costs will be. Information about how wood takes and holds paint is therefore of interest to all who use paint on new wood.

SOME kinds of wood hold coatings of outside house or barn paint longer than others. Even when all boards are of the same kind of wood, some stay coated longer than the rest. Moreover, when coatings wear out, the original grain pattern of the board is revealed by the sloughing paint, as shown in figure 1. The reasons behind this behavior largely explain the painting characteristics of wood. When the best woods cannot be selected for painting, careful choice of paints and painting methods the first time the wood is painted will partly offset the shortcomings of the wood. This publication explains how paint is affected by wood, and offers some suggestions for painting the more difficult woods.

Other factors besides the nature of the wood affect the durability of paint coatings, such as composition of the paint, skill with which the painting is done, number of times the surface has been painted, degree of shelter from the sun and rain (fig. 2), and climatic and local weather conditions. Under highly unfavorable conditions of service, the coating may wear out before there is time for the nature of the wood to show its effect. This publication, however, is concerned mainly with how wood affects the behavior of coatings of *good* paint, well applied and maintained, under ordinary conditions of service.

WOOD PROPERTIES THAT AFFECT PAINTING CHARACTERISTICS

The properties of wood that affect paintings are density and texture; content of resins, oils, and moisture; and defects, such as knots.

DENSITY AND TEXTURE

Among softwoods (conifers) the painting characteristics of a board depend primarily upon the amount and distribution of summerwood. Each year of its life a tree adds an annual ring composed of summerwood and

[1] Supersedes Leaflet No. 62, Why Some Wood Surfaces Hold Paint Longer Than Others.

[2] Maintained at Madison 5, Wis., in cooperation with the University of Wisconsin.

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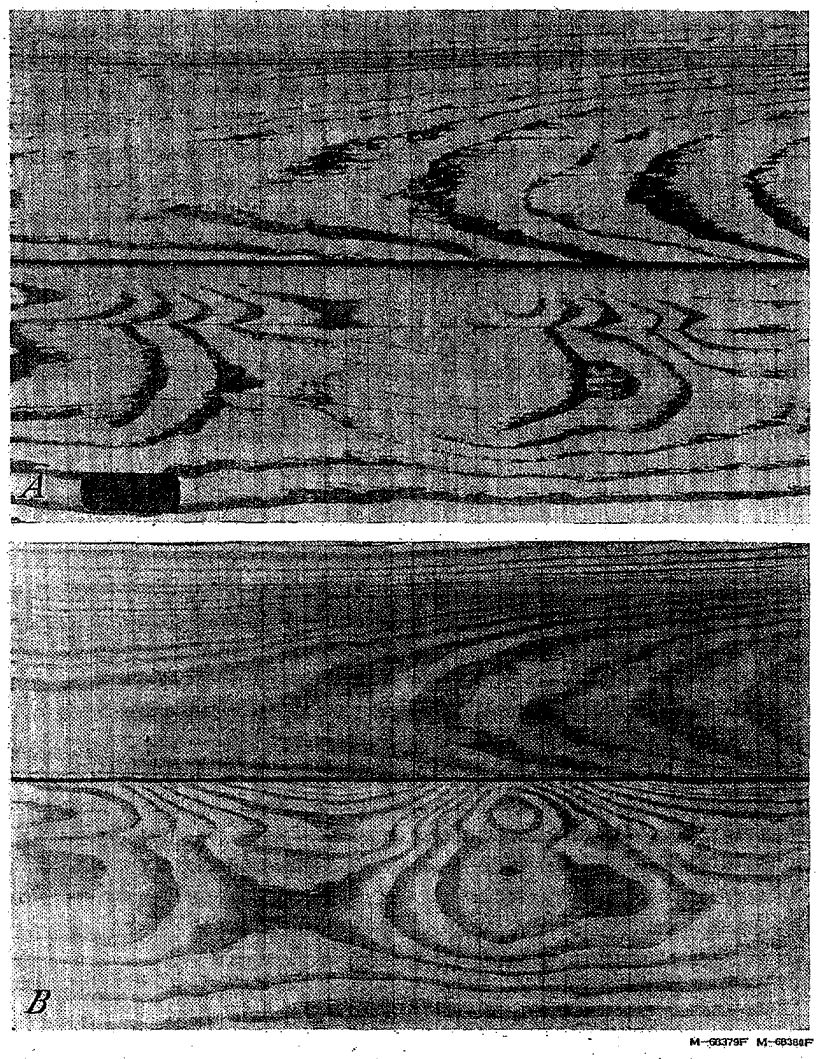

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Figure 1.—Paint fails soonest over the bands of summerwood in softwoods. *A*, These two boards were painted with white paint and exposed to the weather for 5 years. *B*, The same boards after remaining paint was taken off with paint remover, showing the dark bands of summerwood, indicated by the paint-bare areas in *A*.

springwood. Summerwood is the dense, horny, dark-colored portion of the annual growth ring, formed in the tree late in the growing season. It has wood cells with thick walls and small cavities. Springwood is the softer and lighter (in weight and color) portion of the growth rings, formed in the early part of the growing season, and has wood cells with thin walls and large cavities. Paint oils penetrate farther into summerwood than into

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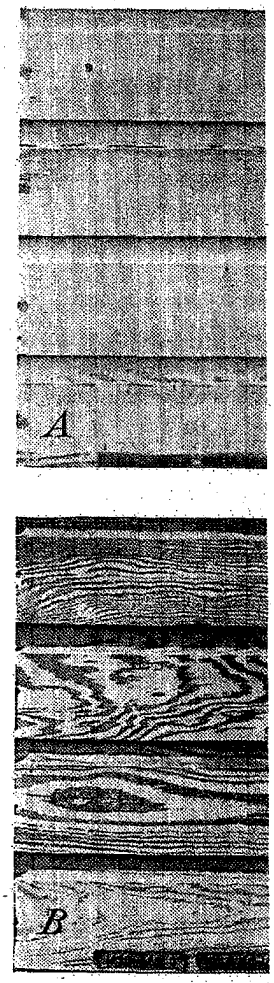

Figure 2.—Paints last lon
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B, facing south.

springwood, but the oil that penetrates is separated from the coating and does not help to hold the coating in place. New paint sticks firmly to both springwood and summerwood, but when the coating becomes old and brittle, it comes loose from the smooth summerwood, though it usually is held securely on the springwood. If the bands of summerwood are narrow enough the coating may bridge over the summerwood and remain in place, but if the bands are wide the coating breaks loose from them. Therefore, boards with narrow bands of summerwood are best for painting.

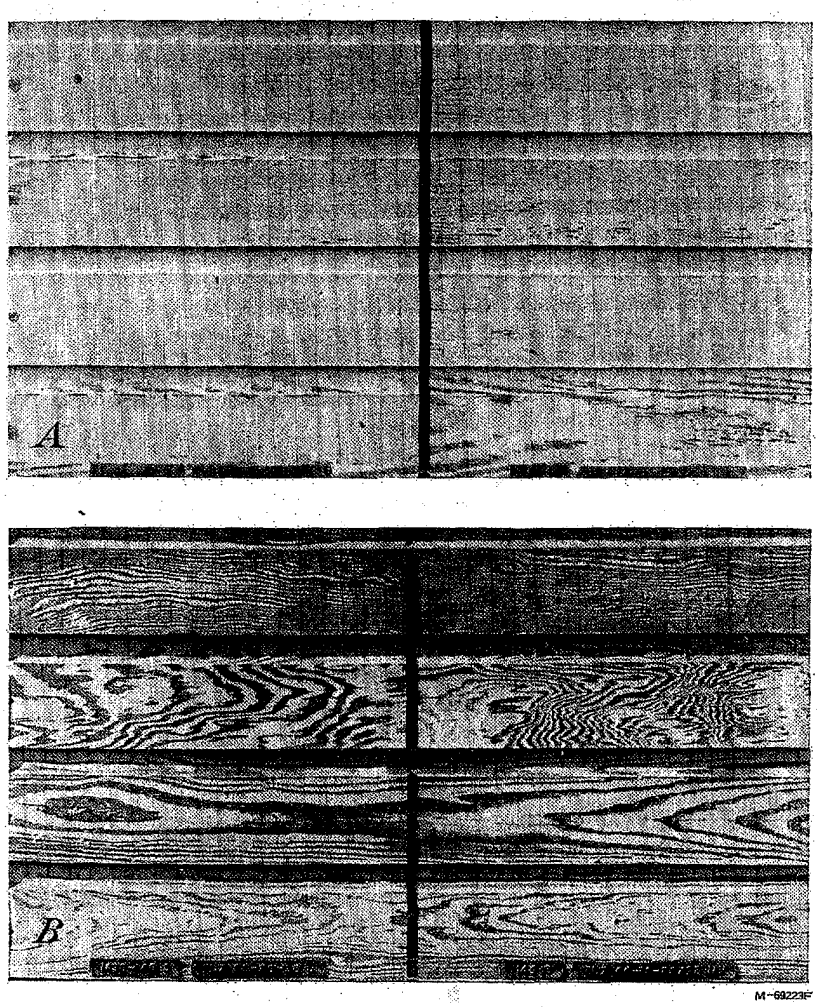

Figure 2.—Paints last longer in the shade than in strong sunshine. Two house paints (one at the left, another at the right) applied on Douglas-fir and southern yellow pine, after exposure to the weather for 8 years; *A*, facing north, and *B*, facing south.

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The width of the summerwood bands in softwood usually varies with the density (weight per unit of volume) of the wood and the rate of tree growth, being narrower when the density is low or the tree growth is slow. The density of softwood lumber is low when the proportion of summerwood is small. If a tree grew slowly, however, the bands of summerwood may be narrow even if the density is high because there are then many growth rings per inch of radius of the log (fig. 3). The manner of cutting the boards

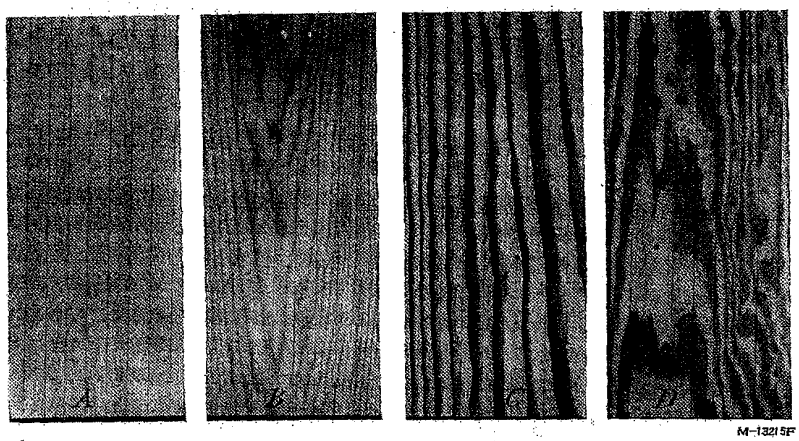

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Figure 3.—Paint-holding characteristics depend on wood texture and density. Boards *A* and *B* held paint well; boards *C* and *D*, poorly, when they were painted with house paint and exposed to the weather. Board *A* had 36 annual rings per inch of radius of the log and at 6-percent moisture content weighed 25 pounds per cubic foot; *B* had 27 annual rings and weighed 30 pounds; *C* had 6 rings and weighed 30 pounds; *D* had 15 rings and weighed 46 pounds.

from a log also affects the width of the summerwood bands exposed on the painting surface. Edge-grain boards (called quarter-sawn in hardwoods) have narrower bands of exposed summerwood than flat-grain boards. They are cut from the logs at right angles to the annual growth rings, and the edges of the growth rings appear on the painting surface of the boards. In flat-grain boards, which are cut at a different angle, the faces of the growth rings appear (fig. 1). In flat-grain boards, the side that was nearer the bark often holds paint longer than the opposite side.

Hardwoods (broadleaved trees) differ in structure from softwoods. Hardwoods have fibers and pores. The size and arrangement of the pores, which are much larger than the fibers, govern the painting characteristics of the wood. Hardwoods such as oak, with pores larger than those in birch, are poorly adapted to painting with ordinary house paints because pinholes are left in the coating over the large pores. The pinholes not only are unsightly, but lead to early failure of the coating. The best hardwoods for painting are those of medium to low density, such as yellow-poplar, with pores no larger than those in birch.

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RESINS AND OILS

Resins and oils in well-seasoned wood have less effect on painting than is generally supposed. The resin in pine lumber seems to shorten slightly the life of paints containing zinc oxide, but this unfavorable effect can be prevented by using modern priming paints free from zinc oxide. The essential oils in cypress and some of the cedars may delay the drying of some paints, but they prolong the life of the coatings.

In green lumber, however, the effects of resins and oils may be serious. Resin may exude when the painted wood is warmed by the sun or otherwise, and either push through or loosen the coating. Oils in unseasoned wood may completely prevent drying of some paints.

Occasionally on dry wood, but more often on wood that has been only partly dried or has become moist after seasoning, there is a discoloration of white or light-colored paint over the heartwood of ponderosa or white pines. The discoloration comes from brown substances in the resin of the heartwood, which are evidently more active when the wood is damp than when it is dry.

MOISTURE CONTENT

Paints last longest on wood that has been well seasoned but which has regained some moisture so its moisture content is 12 to 15 percent. Paints applied to very dry wood are slightly less durable. As a rule, however, it is best to paint wood when it has about the average moisture content that is expected to prevail during service.

Wet wood, the moisture content of which is over 25 percent, is in an uncertain condition for painting because there is grave danger of failure of the coating by blistering (fig. 4) and peeling. Blistering and peeling result from pressure against the back of a coating caused by expansion of air and water trapped in wet wood. Moreover, woods like redwood and redcedar, which contain colored substances soluble in water, may discolor paint applied while the wood is wet. Even if wood is dry when painted but later absorbs enough moisture to become thoroughly wet, there is danger of blistering, peeling, or discoloration.

KNOTS AND OTHER DEFECTS

Knots in wood produce serious blemishes in paint coatings. In pine lumber the paint over knots is often discolored by yellow or brown substances from the wood. End-grain wood in the knots of any wood often absorbs enough oil from paint to destroy the gloss of the paint. Both discoloration and oil absorption can be prevented by applying shellac or other spirit varnish over the knots before painting, but the paint is likely to crack badly and may flake from the knots fairly soon. Large knots are likely to crack even after they are painted, and the cracks may be too large to fill with new paint.

Pitch streaks or pitch pockets in wood mar paint coatings by causing the paint or crack or bake off, or by exuding resin.

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Blue stain in sapwood can be concealed by paint as long as the wood can be kept dry. If at any time the wood becomes damp, however, the fungi causing the stain may become active and push through, discoloring the paint.

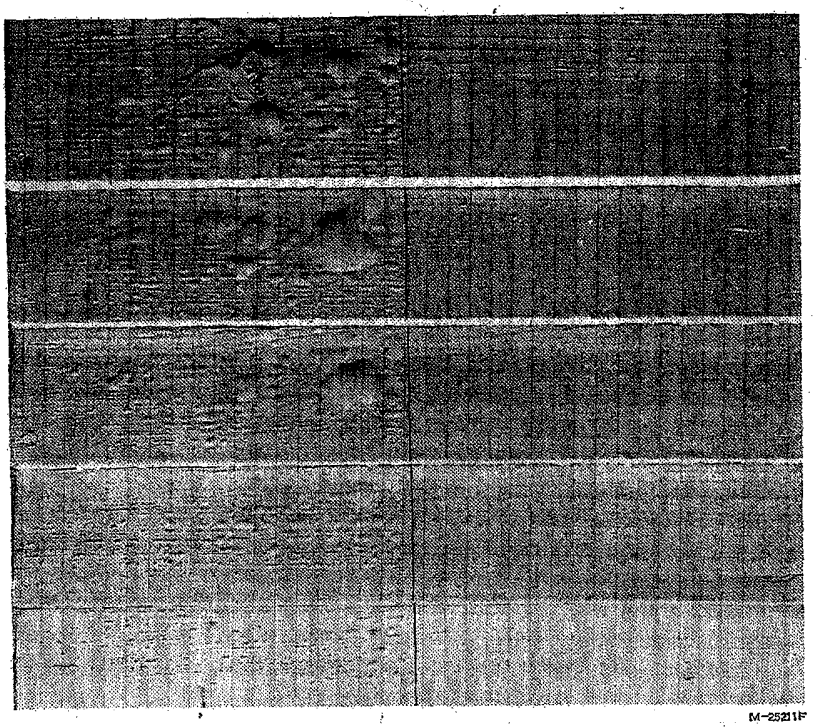

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Figure 4.—Blistering of paint coatings on wood siding caused by condensation of water behind the siding during cold weather. The badly blistered coating at the left consisted of three coats of a good-quality house paint. The slightly blistered coating at the right consisted of two coats of the same house paint applied over a priming coat of aluminum house paint. Paint failures of this kind can be entirely prevented only by permitting no water to get behind painted woodwork.

SELECTING THE BEST WOOD FOR PAINTING

Wherever wood is to be kept well-painted for a long time the cost of paint maintenance can be reduced by selecting kinds of wood that hold paint coatings most satisfactorily (fig. 5).

SELECTION BY SPECIES

Since paint-holding qualities are affected by the kind of wood, and woods are marketed by species, the easiest method of selecting woods for painting

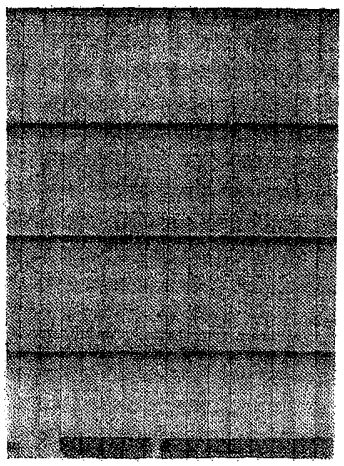

Figure 5.—Paint wears longer on s
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upper boards at right), and on s

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Group II: Eastern white pi
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Group III: White fir, the h
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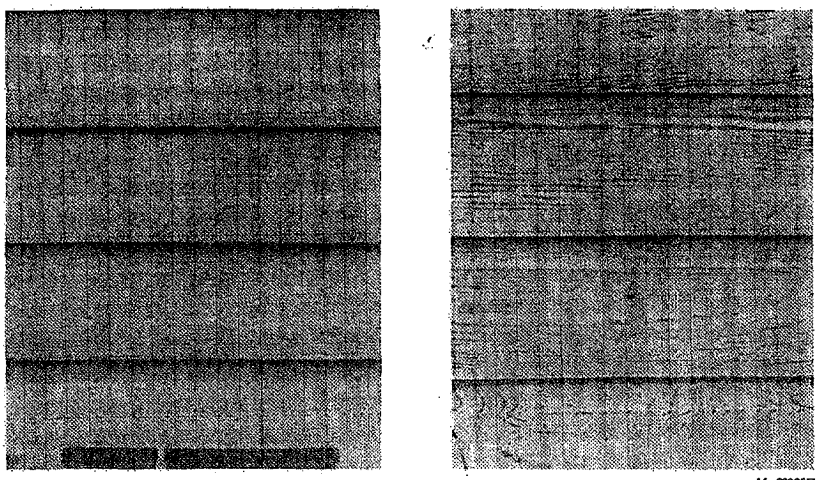

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Figure 5.—Paint wears longer on some woods than on others. A good house paint, after 8 years of exposure to the north, on western redcedar (two upper boards at left), on eastern white pine (two lower boards at left), on Douglas-fir (two upper boards at right), and on southern yellow pine (two lower boards at right).

is by species. Species alone, however, is not the most effective basis for selection because there are wide variations in painting characteristics among boards of any one species. The commercially important native woods, when purchased in lumber of the higher grades, are classified for painting characteristics into five groups:

Group I: The cedars, baldcypress, and redwood, all of which are softwoods. Woods of group I hold all of the common kinds of house and barn paints well.

Group II: Eastern white pine, sugar pine, and western white pine, all of which are softwoods. On woods of group II, paints containing zinc oxide are slightly less durable, but other paints are as durable as on woods of group I.

Group III: White fir, the hemlocks, ponderosa pine, and the spruces of the softwoods; aspen, basswood, cottonwood, magnolia, and yellow-poplar of the hardwoods. Paints deteriorate somewhat more rapidly on woods of group III than on woods of groups I and II. On ponderosa pine, paints containing zinc oxide are less durable than paints free from it.

Group IV: Douglas-fir, southern yellow pine, and western larch of the softwoods; beech, birch, the gums, and maple of the hardwoods. Paints deteriorate more rapidly on woods of group IV than on woods of groups I, II, and III. On southern yellow pine, paints containing zinc oxide are less durable than paints free from it.

Group V: Ash, chestnut, elm, hickory, oak, and walnut, all of which are hardwoods with large pores. Woods of group V require wood filler to fill the pores before smooth coatings of paint or enamel can be applied.

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SELECTION BY GRADE

Most lumber is graded for sale. In softwood lumber the better grades for painting are the select grades. Select grades of lumber permit few knots, pitch streaks, or pitch pockets. Common grades in which defects are numerous cannot be expected to hold paint as well as the select grades.

SELECTION BY KIND OF GRAIN

Some woods are cut into lumber in such a way that the boards in the highest grade are always edge-grain. The term "vertical grain" is sometimes used instead of edge-grain; among hardwoods the term "quarter-sawed" has the same meaning. For good painting, edge-grain lumber should be purchased whenever possible. When flat-grain boards are used, it is desirable to turn them so that the bark side will be the surface exposed for painting. The bark side is the side toward which the annual growth rings are convex.

SELECTION BY DENSITY AND TEXTURE

In commercial shipments of many kinds of lumber there will be found a wide range in density, and in width of growth rings. Paint maintenance can often be improved by setting aside those boards that are much above the average in weight or in width of summerwood bands. The heavy, wide-ringed boards may be used for construction that will not be painted, for less important parts of the structure, or for parts that receive little sunshine. (Paint will last longer on any board if it is in a shaded rather than a sunny place.) As a rule, the time for repainting a house is determined by the wearing out of paint on the poorest boards.

SUGGESTIONS FOR PAINTING THE HEAVIER SOFTWOODS

The forests of the United States produce much more lumber of species classed in groups III and IV than of species in groups I and II. For that reason woods that tend to shorten the life of paint coatings often must be painted. In such cases the unfavorable effect of the wood can be reduced by careful selection and application of paint the first time the structure is painted.

Painting should be done as soon after erecting the woodwork as is practicable, usually within a week. It is not good practice to allow wood to weather for weeks or months before painting. The first or priming coat of paint may be applied, if convenient, before the lumber is delivered at the site of the building. If this is done, both sides of the boards should be primed to avoid the cupping or warping that might otherwise occur from unequal rate of change in moisture content on the two sides. Although priming of butt ends is often omitted, the best practice is to

paint the butt ends
before fastening them

If woods of groups
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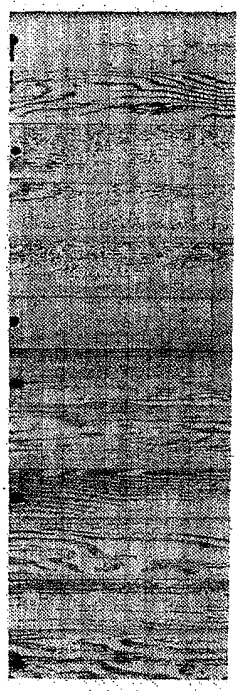

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paint the butt ends with primer after cutting and fitting the boards, but before fastening them in place.

If woods of groups III and IV are primed with aluminum house paint before applying house paint of the desired color, they can be made to hold their paint coatings nearly as long as woods of groups I and II (fig. 6).

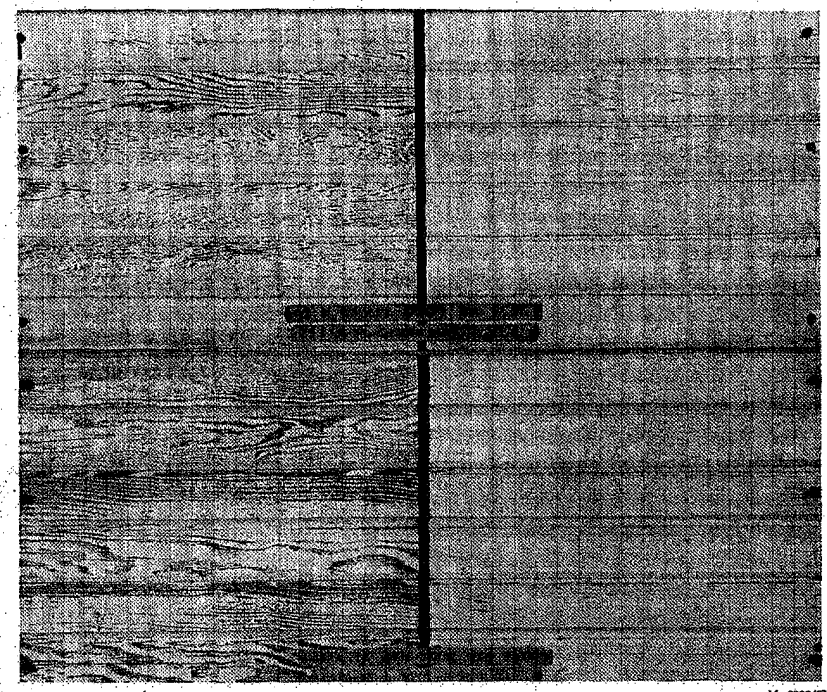

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Figure 6.—Aluminum priming paint improves the durability of house paints on woods that have wide bands of summerwood. These painted panels of Douglas-fir were exposed to the weather for 5 years, facing south. The left-hand halves were painted with three coats of white paint; the right-hand halves were painted with one coat of aluminum house paint followed by two coats of the same white paint that was used on the left-hand halves.

Aluminum house paint is made for use on exterior woodwork; aluminum paints or enamels made for other purposes are unsuitable for priming wood. The paint job consists of one coat of aluminum house paint followed by two coats of house paint of good quality. So applied, white paint or any of the light colors should last about 4 years on woods of groups III or IV before further painting is necessary. Paints of dark color may last 2 or 3 years longer. When repainting, apply only the white or colored paint.

Next best to aluminum house paint for priming woods of groups III and IV are modern house-paint primers that contain no zinc oxide and that

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have the property commonly called "controlled penetration" (fig. 7). Many manufacturers of commercial house paint now make such house-paint primers. The painting may be done in either three- or two-coat work. If three coats are applied, the house-paint primer may be thinned with a small proportion of turpentine or mineral spirits and applied so that 1 gallon of the mixture covers about 600 square feet of surface. After that,

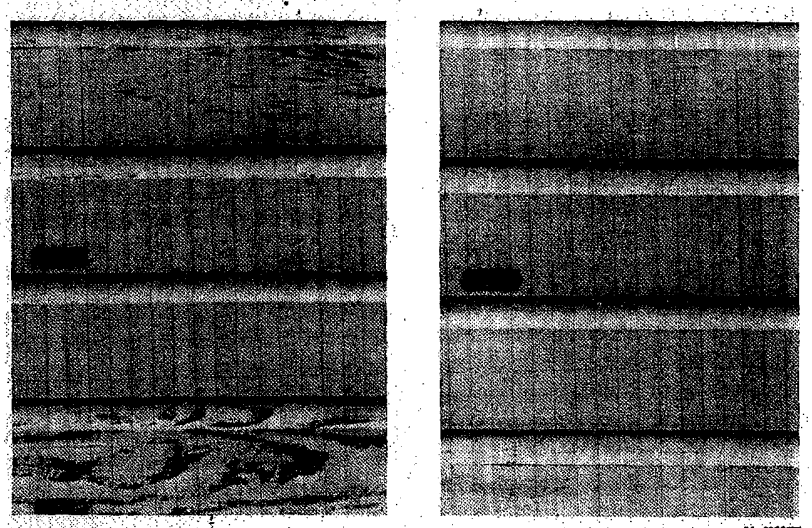

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Figure 7.—Special house-paint primer makes it possible to paint all woods satisfactorily, even those of group IV, with only two coats. Panels at the left and at the right are adjacent areas of the same boards of Douglas-fir (first and third boards from the top) and of southern yellow pine (second and fourth boards). The panel at the left was painted with two coats of white paint; the panel at the right was painted with one coat of special primer and one coat of the same white paint. Panels were exposed to the weather, facing south, for 3 years.

two coats of house paint in white or a chosen color should be applied, and each coat spread over 700 square feet to the gallon of paint.

In two-coat work the house-paint primer is not thinned and is applied in a thicker coating so that a gallon covers no more than 450 square feet of surface. A single coat of good house paint is sufficient over such a primer coat, provided it is applied so that a gallon covers no more than 550 square feet of surface.

Thus, although the best paint service is most easily obtained when wood of the most favorable kind has been selected, good paint service is possible even on the less suitable kinds of wood if the right kind of paint is applied properly the first time the wood is painted.

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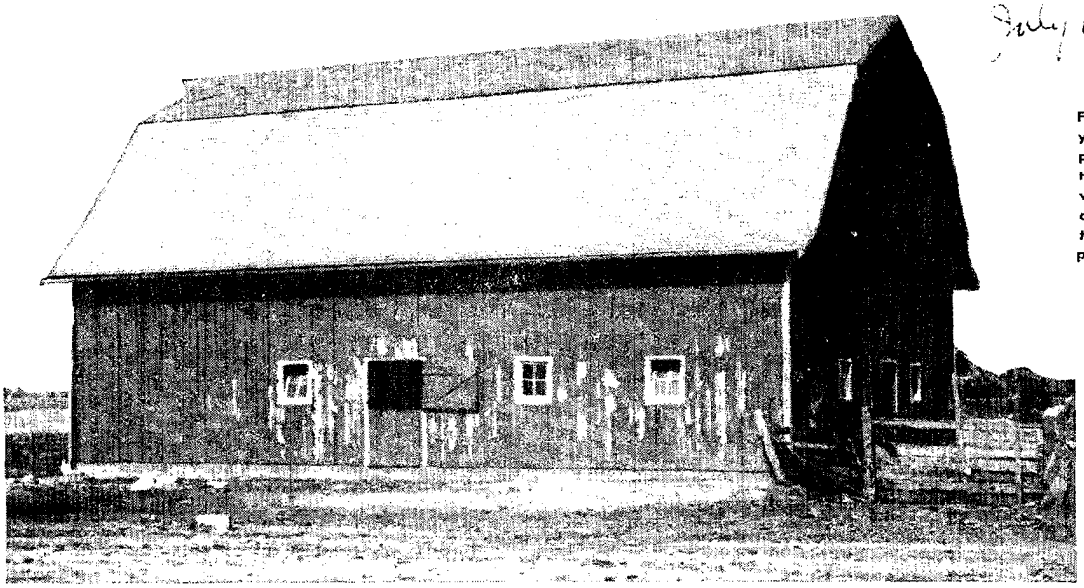

Failure of red barn paint less than a year after the barn was built and painted, caused by insufficient ventilation within the barn during winter weather. Moisture from the cows condensed behind the painted siding until the wood became wet, whereupon the paint blistered and peeled.

PAINTING THE BARN

by F. L. BROWNE

THREE objects conspicuous in the American countryside long were painted red, the country schoolhouse, the railway freight car, and the farmer's barn.

A generation ago the little red schoolhouse largely dropped from the trio, except in poetry and the biographies of political candidates. The country schoolhouse now is less often little; even when it is the paint is usually white, in harmony with the note of cheerfulness that has replaced the hickory switch in modern teaching. Railroads have toyed with colors other than red for freight cars but in recent years they have returned to red for their first choice. Now it is the red barn that is threatened by a change in style as some farmers switch to brighter colors, particularly to white paint.

The dominance of red paint in the past did not come by accident. There were sound reasons for it. To begin with the combination of red paint for the barns with white paint for the farm house has always seemed to establish a suitable sense of proportion. White is pretentious, it attracts attention, and makes a house look larger. Red of the shades used for barns is modest and retiring; it tones a large building down until it merges into the background. A white farm house stands out prominently among red barns but among white barns it is overpowered by the more and less attractive buildings.

The present popularity of white for farm buildings suggests that farming is coming to be considered more as a business enterprise than as a way of living. Perhaps it should be; but, if so, cows in white barns must be prepared to pay more rent for their quarters than cows that are contented in red barns, for it costs more to keep buildings white than to keep them red.

Red Paints Have Longer Life

White paint is costly because it contains excessive white pigments such as white lead, zinc oxide, and titanium dioxide. Red paint seldom contains any white pigments; instead it is made of iron oxide pigments which are moderate in cost. Cost of the paint itself, however, is a lesser item in the cost of painting because it usually takes three or four times as much for labor as for the paint.

The main economy in favor of red paint comes from its longer life. Good red paint lasts twice as long as the best white paint. To keep white paint in good condition it is usually necessary to paint every four or five years but red paint can be made durable enough to go ten years, though it must be admitted that it takes a better grade of red paint than the majority of those now on the market.

The plain fact of the matter is that most farmers in the past have not succeeded in keeping up a schedule of repainting their barns every ten years. Often the painting is done when farm crops bring good prices rather than when the old coating has worn out. For that reason the manner in which paints wear out is important for farm painting.

Paints that wear away slowly by a fine crumbling remain more presentable in appearance and are easier to prepare for repainting than paints that crack badly, curl up, and fall off in large scales. Good red paints are more likely to take the favorable way of deteriorating than are most of the present day white paints. Moreover, a partly worn-out red paint presents a much less offensive appearance than a similarly worn-out white paint, for the white paint calls attention to its shabby condition whereas the red paint shrinks into the background.

Painting Weathered Wood

Wood that is allowed to go long after the paint has worn out becomes roughened by weathering; the once smoothly planed surface gives way to a fuzzy, splintery one, channeled by ever deepening cracks. The deterioration proceeds slowly, for it takes a century for one-fourth inch of the wood to weather away. Because of the long time so often allowed to pass between paintings of farm buildings, such weatherbeaten wood is the rule rather than the exception on American farm buildings.

Wood weathering has two consequences as far as further painting is concerned. First, twice or three times as much paint is needed to paint a given area once the wood has become weathered, for the roughened surface takes up extra paint. Second, the new paint job lacks the spick and span appearance it would have on smooth wood. Whenever new boards are inserted among weathered boards in repairing a building before painting it, the new boards stand out conspicuously by their glossier, smoother, and brighter appearance.

There is a trick in painting weatherbeaten buildings by which time and money may be saved. Instead of applying two full coats of paint in the attempt to make it look as nearly as possible like paint on smooth wood, thin the paint to the consistency of a rich shingle stain and apply only one coat, just enough to saturate the wood surface and to impart a uniform red color. The result should be a stained appearance with little or no glossiness rather than a painted appearance.

For use as a stain, a red paint of good quality is needed. It should be made with plenty of iron oxide pigment and with a vehicle containing much linseed oil and little or no varnish. It may be thinned with a quart of linseed oil and a quart of paint thinner to a gallon of paint.

The red barn paints now on the market are seldom of the best quality. The manufacturers seem to strive to make the cheapest red paint that will last about as long as good white paint will. Iron oxide is such an excellent paint pigment that a red paint of decidedly inferior quality will equal good white paint in durability. What the farmer really needs, however, is red paint capable of lasting twice as long as the best white paint. Such red paint, of course, will cost more than the paints now generally available but it need not cost more than good white paint does. During recent years some of the farmers' cooperatives have sold red barn paints of distinctly better quality than is obtainable from other suppliers.

Commercial Paint Standards

A serious obstacle to the improvement of the general quality of barn paints is the lack of accepted commercial standards of paint quality. To be sure, most paints made by reliable manufacturers carry a statement of composition, or formula, on the label. Paints, however, are complicated materials. Most paint buyers know too little chemistry to gain much information from paint formulas.

The United States Department of Agriculture has proposed that the paint industry adopt a system developed by the Forest Products Laboratory for classifying house and barn paints by group, type, and grade. If paints were labeled according to some such clearly defined classification, buyers would have less difficulty in finding paint of the quality they need. In addition, makers of best quality paint would find it easier to get a fair price for it despite the competition of inferior paints. So far, however, the paint industry has been opposed to the establishment of classification or other forms of commercial standards.

The proposed classification system recognizes six grades of paint numbered from grade 1, the best, to grade 6, the poorest. There is no real need for so many grades; some of them certainly would disappear if the industry adopted commercial standards of any kind. Before the war many of the brands of house paint in white or light colors were of grades 1 or 2. During the war "oil-restricted" forms of house paint were devised in an effort to conserve scarce linseed oil. The best of such paints were of grade 3. Present house paints are still mostly of that kind.

Red barn paints were nearly all of "oil-restricted" varieties long before the war. Few barn paints offered under the brands of paint manufacturers are classifiable better than grade 5 except among those sold by farmers' cooperatives, some of which offered paints attaining grade 3.

The high grade red barn paints can usually be recognized from the formula printed on the label. As a rule, the formula gives (Turn to page 527)

The author, F. L. Browne, is chemist with the U. S. Forest Products Laboratory, Madison, Wisconsin.

N41698.57 FLB 0011

Club Heifer to Herd Owner

D. T. GRUSSENDORF

Jim, County Agricultural Agent D. T. Grussendorf, and Valeria discussing production figures

A PUREBRED Holstein heifer set the course of young Jim Witte's life. In a way, the two grew up together. The heifer, christened Snowball by Jim, was only a calf when he received her as a gift from his father on his thirteenth birthday.

Like countless thousands of dogs and ponies given to young boys by their parents, Snowball soon became the focal point of all Jim's teenage interests. His proprietary pride in her erased any adolescent doubts he may have had about the future, aroused in him an enthusiasm for dairy farming that has carried through the last 12 years.

Ownership of Snowball led directly to Jim's enrollment in 4-H club dairy work back during the dark depression days. He was active just three seasons before he and his heifer developed into championship material.

In a state nationally known for its high quality cattle, Snowball, under the boy's careful management, achieved the best milk production record among all Minnesota 4-H animals. Jim's part in this accomplishment was rewarded with a trip to the National Dairy Show.

He decided to increase still further his "know-how" of the dairy game. So, upon graduation from high school, he and his brother, Charley, enrolled at the University of Minnesota's North Central School of Agriculture. Two years later the boys were back, looking forward to the day they could start their own farms.

Today the Witte name is synonymous with quality herds, quantity production in the farming area immediately adjacent to the head of the Great Lakes.

From 1 to 28

Snowball was the nucleus around which young Jim built up a herd now numbering 21 head. He milked her eight years and she gave birth to eight calves before she finally threw a stifle joint.

At present, Jim's herd includes 19 registered Holsteins. St. Louis County agricultural officials unhesitatingly term it one of the ten top dairy herds in northern Minnesota. Some near-equal cattle have also been developed by his brother.

Young Jim Witte is married now. He met his wife, Valeria, at a 4-H club party in January, 1944. She, too, had been a 4-H'er since her first days of high school, turning her talents into the field of home economics.

On Stoney Brook farm, Jim and Valeria demonstrate daily that a 4-H background can and does provide rich dividends in adult life. Still more important, they are proving that farming holds an attractive future for enterprising youth.

Their example stands as a defiant disavowal of a long-accepted fallacy in St. Louis County, that "you can't make a living on a cut-over area farm." With the Wittes, and others like them, rest Northern Minnesota's hopes for a rehabilitation of its agriculture.

The present market places the value of Jim's herd at approximately $10,000. The farm, which has under cultivation about 100 of its 260 acres, would sell for an equal amount.

Life at the Wittes today centers around those purebred Holsteins. Snowball taught Jim an early lesson that successful dairying is a three-way combination of good cattle, liberal feeding, and careful management. That combination is practiced rigidly at Stoney Brook farm.

The cultivated land is given over almost entirely to hay crops, yielding about 75 tons per year. Jim mixes the hay and grain ration for his herd according to his own formula. He knows from experience it pays to feed his cattle well, because they possess the inherent ability to convert the major share of that feed into rich milk rather than flesh.

Good Herd Average

And, as Snowball did, his Holsteins show the results of Jim's knowledge. Last year they averaged 538.6 lbs. fat per cow, compared to the Minnesota mean of about 190 pounds.

Scrupulous cleanliness is the rule in the Witt barn. The same maxim applies in the new mil house, where every morning a cooper creamery truck stops to pick up the production.

While dairying is Jim's main source come, he has added a lucrative sideline cent years by keeping pace with the rapi creasing interest in artificial breeding. are now four bulls in his herd, led by a month-old, 1,700-pound registered He named St. Louis King Rue Ormsby La purchased from the St. Louis county poor f purebred herd.

Because of his reputation for high qu high producers, Jim's insemination service i constant demand. At $5 per service, he av aged two a day during 1946, all within a mile radius of his place.

His own herd increases by about 10 calves per year, but he usually sells most of them after selecting the best two or three heifers. Since he started his Stoney Brook farm, Jim has registered 30 calves. Requests to buy his purebred stock come from all over the Northwest.

Average age of the Witte herd today is four years, as young by usual standards as its owner is in the dairy game. But its management has been such that the ten present producers should maintain their record herd average for another six years.

At 25, Jim keeps an open mind on dairying, is a constant caller at government agricultural offices, stands ready to institute new procedures on his farm at any time. He is enrolled in pasture improvement pro- (Turn to page 521)

Jim and Ormsby Bessie Minnie, a top producer, at milking time

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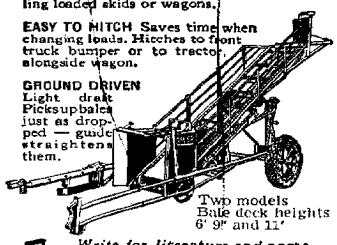

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Painting the Barn

(Continued from page 517)

the percentage of pigment and the percentage of "vehicle" or "liquid" in the paint, and then it gives the percentage of each ingredient in the pigment and of each ingredient in the vehicle. A red paint of grade 1 contains at least 54 per cent pigment, and at least 30 per cent of the pigment is "ferric oxide", which is the chemists' name for iron oxide. At least 85 per cent of the vehicle is linseed oil, soybean oil, or other "drying oil" and "resin."

A red paint of grade 3 contains at least 48 per cent pigment, at least 26 per cent of the pigment is ferric oxide, and at least 70 per cent of the vehicle is drying oil and resin. Those who wish detailed, though necessarily technical, instructions for interpreting paint formulas will find it in "Classification of House and Barn Paints as Recommended by the United States Department of Agriculture", by F. L. Browne, Technical Bulletin No. 804 of the U. S. Department of Agriculture, obtainable for 15 cents from the Superintendent of Documents, Washington, D. C.

What Kind of Red Paint

There are two popular preferences among many farmers that work against development of a 10-year barn paint. One is the desire for an unduly bright red color. The other is a leaning toward unduly glossy or shiny paint.

Among many kinds of iron oxide pigments suitable for paint making the brightest reds are usually those known as venetian red. They are made by heating together limestone and iron sulfate, a waste product of the iron and steel industries. Not more than 40 per cent of a good venetian red pigment is iron oxide. The rest is calcium sulfate, which acts in the paint as an extending or cheapening pigment.

The 10-year red paint probably needs more than 40 per cent iron oxide in its pigment. It may contain extending pigment, but calcium sulfate is much less desirable for that purpose than other extenders such as calcium carbonate and magnesium silicate. The preferred iron oxide pigments are often darker in color than the venetian reds, tending more toward maroon. New synthetic iron oxide pigments are now being developed that may match the venetian reds in color without their disadvantages.

Red paint made with linseed oil or linseed and soybean oils has only a moderate degree of glossiness. To make it highly glossy a large part of the oil must be replaced with varnish. The high gloss obtained in that way seldom lasts very long and is likely to give way to a dingier condition of faded dullness than is ever reached by the high grade paints made chiefly with oil.

The very glossy paints have other shortcomings. They produce an enamel-like surface that accentuates the imperfections in the lower grades of lumber commonly used for farm buildings. They are unsuitable for use like stains on weatherbeaten wood and they fall far short of the 10-year durability of the best red paints.

Applying Paint

Long-lived paint jobs require good application as well as good paint. The most common mistake of workmanship in farm painting is that called stingy application. Not enough paint is applied to make a coating thick enough to wear a long time. Smooth wood such as new lumber needs about 3½ gallons of grade 1 paint on 1,000 square feet of surface. It may be applied in three coats of a little over a gallon each or in two coats of 1¾ gallons each.

If the paint is of lower grade, however, it usually takes more of it to make the required thickness of coating. Instead of 3½ gallons of grade 1 paint, it may take 4¼ gallons of grade 3 paint or more than 5 gallons of grade 5 paint. Not less than 3 coats are needed to apply such large quantities of paint. Of course the absence of recognized grading of paints leads most painters to treat all paints alike, with the result that the low grade paints are almost sure to be applied stingily.

Spray Painting

Farm buildings usually offer a chance for substantial savings in cost of applying paint by using spray guns instead of brushes. When skillfully done, spray painting is fully as satisfactory as brush painting. Too often, however, spray painters have tried to save on paint as well as on labor. When paint is to be sprayed it should not be thinned much more and certainly should not be spread less generously than when it is brushed.

There are times when the best of paints, competently applied, soon fail through unsightly peeling and scaling. It is not unusual, for example, to see a cow barn with the paint scaling badly from the siding outside the cow stalls but with the paint in good condition outside the haymow. Such paint failures commonly result from insufficient ventilation inside the barn during the winter season. Moisture from the animals, instead of being carried off in the air escaping at vents, condenses behind some of the wood siding. When painted boards become wet in that way the paint may be expected to blister promptly and later on to peel or scale off. A report discussing means of preventing condensation in barns is obtainable from the Forest Products Laboratory, Madison, Wis.

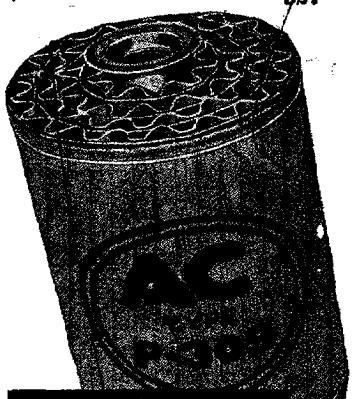
Our past practices in farm painting on the whole have fallen short of the standard of reasonably good paint maintenance. Material improvement in painting practice should be economically attainable provided that the most durable kinds and qualities of paint are selected and used wisely for the purpose.

To Study Trace Minerals

The Associated Press carried a story recently to the effect that Johns Hopkins University has received a half-million-dollar endowment for the study of the physiological effects of the so-called "trace elements."

Known as the McCollum - Pratt Fund, in honor of E. V. McCollum, an authority on nutrition, and John Lee Pratt of Fredericksburg, Va., university trustee and donor of the gift, the sum will be used to study the function of copper, boron, cobalt, manganese, and other minerals in living organisms.

Dr. Isaiah Bowman, president of the university, said the principal and interest will be expended over a ten-year period. Known as trace elements because living beings contain them only in very small quantities, the minerals so designated must, nevertheless, be present to avoid deficiency diseases.



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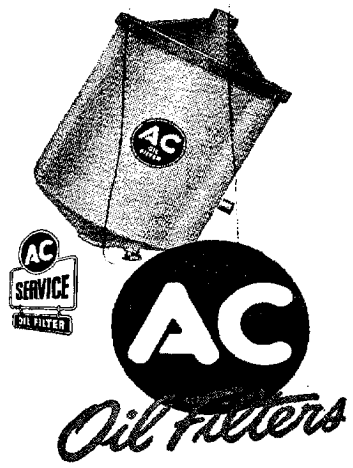

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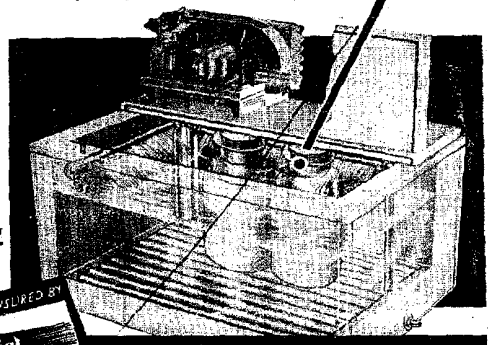

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Holstein Convention at Kansas City

THE 63rd annual convention of the Holstein-Friesian Association of America, held at Kansas City June 1-4, attracted more than 700 delegates, members, and friends of the world's largest dairy breed association. The hosts from Kansas and Missouri were generous in their hospitality, providing an interesting program for the ladies as well as the men.

Highlight of the convention was the "open house" at the world famous Clyde Hill Farms at Clyde, Missouri. There more than one thousand visitors saw with a great deal of interest the progress and development of one of the greatest Holstein herds in the country, made possible through the combined efforts and conscientious work of the industrious herd manager, Joseph Gemmeke, in charge of the herd for the past 25 years, and of the Sisters of the Benedictine Convent of Perpetual Adoration.

Most remarkable in the building of this herd has been the splendid development of great cow families, including the 30 females in the herd today descended from "Old Zuba", 16-year-old queen of the Clyde Hill herd. Zuba, now in her 13th lactation, has 207,781 lbs. milk and 6,735 lbs. fat to her credit, and was not tested during her first two periods. Her best record was 766.4 lbs. fat at 14 years of age, and she now has 625 lbs. fat in her first 232 days, milking over 100 lbs. milk a day and making 116 lbs. fat in one month.

All of the females in the herd and most of the herd sires used have been home bred. One could go on indefinitely about the breeding program and management practices carried out at the institution, but most visitors agreed the herd combines type, production, longevity, and reproduction in a manner that is the dream of most breeders.

Clyde Hill has received the progressive breeder award seven consecutive years and the herd holds the all-time HIR average for herds of 590.4 lbs. fat on 39 head. The herd is milked three times daily. Since 1944, the herd has averaged 547 lbs. or better each year. The last classification score was 85.8 on 50 head.

At the convention proper, the delegates went on record in favor of an amendment which makes the official formerly called secretary, now executive secretary, who shall be the chief executive officer of the corporation, subject to the direction and control of the board of directors and of the committees thereof. The by-laws were also amended to the effect that an assistant secretary shall be provided.

Although some difference of opinion was voiced, the association went on record placing the director of extension subject to the direction and control of the executive secretary. Also included in the reorganization setup is the discontinuing of the title, "Superintendent of Advanced Registry."

Throughout the convention the California delegation provided a great deal of enthusiasm for holding next year's meeting in San Francisco and a resolution to that effect was passed unanimously. An effort to cut down convention expenses was made when Secretary Norton proposed an amendment to increase the active member requirement for additional delegates from any district from 150 to 250, but the amendment was defeated.

A very excellent speaker was heard on the open forum, Dr. Kenneth McFarland, superintendent of public schools at Topeka, Kansas. His pleasing blend of information, inspiration, and good humor made him a lasting favorite with the convention group.

In the secretary's annual report it was pointed out that applications for registry during the year reached a total of 166,830, a gain of 10.2% over 1946. Similarly, transfer applications totaled 112,939, a gain of 5.1% and membership applications totaled 1,624, a gain of 6.5% over the previous year. Other activities showed the same upward trend. Advanced Registry made a 12.8% gain, while herd test moved up from 874 herds in 1946 to 1,083 in 1947, a gain of 24%. The upward spiral in herd classification was even more rapid. During the year, 18,835 animals were classified, a gain of 31.5% over the previous year. Despite the increase in business in all departments, increased costs were also reported and the net result was a financial loss for the year of $11,686.04.

In the report of the director of extension, Glen Householder pointed out that during 1947 a new all-time "high" was established for registered Holsteins sold in public auctions when 14,926 head were sold in 238 sales in 29 states for an average of $418. One of the major efforts of the extension service, including more service to breeder-group managed sales, has been to bring would-be buyers in contact with breeders having surplus seed stock for sale.

An all-time high was also recorded in 1947, both for number of organized Holstein clubs functioning throughout the nation and their total membership. Householder emphasized that the most helpful sign for the future in organized Holstein activity is the fact that the junior Holstein club is making progress.

Newly elected president of the Association is Owen D. Young, of Van Hornesville, New York. Other officers include S. B. Hall, Troutdale, Oregon, vice-president; H. W. Norton, Jr., executive secretary, and Glen M. Householder, director of extension service, both of Brattleboro, Vermont.

New board members include Carl G. Wooster (retiring president) New York; Frank Pellissier, California (re-elected); Howard Clapp, Wisconsin, to fill vacancy created by John Wuethrich, Wis., (resigned); T. H. Benton, New Jersey; and T. Hobard McVay, Kansas.

Following the annual banquet Wednesday evening, the convention group turned out for the national convention sale Thursday, in which 71 animals sold for an average of $1,250 a head, with the top female, Pabst Reburke Rag Apple, bred heifer consigned by Pabst-Knutson, Wisconsin, bringing $4,500 to top the sale. She was purchased by Signor Jose Leon, Buenos Aires, Argentina. Top bull of the sale, Pabst Roamer Gallant, also consigned by Pabst Farms, Inc., sold for $4,000 to the Manning Creamery Co., Iowa.

The occasion was an amateur musicale. The kind-hearted hostess spied a lonely looking little man huddled in a corner of the room, and paused to make conversation.

"Tell me," she finally asked, "do you play any musical instrument?"

"Not away from home," the little man replied.

"How peculiar," remarked the hostess. "What instrument do you play at home?"

"Second fiddle," the little man replied.

50

C O P Y

(from The Mississippi Valley Lumberman, January 7, 1949)

FORMAN, FORD AND CO. ANNOUNCES GRADE 1 HOUSE AND BARN PAINTS

Grade 1 paints, offering, for the first time in the history of the paint industry, an advanced, scientific grading of paint as an aid to the consumer, is being announced by Forman, Ford and Co. of Minneapolis at this year's Northwestern Lumbermens Association convention.

While grade identification is not new to the marketing of products in America, being common on many farm products, it is an innovation with paint. In some respects it ranks with legislation introduced in North Dakota by Ladd in 1905 requiring publication of formulas on all paint sold in that state.

The background of grade labeling in paint is primarily the story of the Forest Products Laboratory in Madison, Wis., a unit of the United States Department of Agriculture. For 30 years this laboratory has maintained exposure test panels and, in many cases, men from the Laboratory have scrutinized the test panels maintained by commercial manufacturers. In recent years this work has been primarily under the jurisdiction of Dr. F. L. Browne, senior chemist of the Forest Products Laboratory.

Based upon the many years of records maintained by the Laboratory, and on his own experience, Browne, in January of 1942, authored Technical Bulletin No. 804 of the United States Department of Agriculture. In this bulletin, he published the components and their proportions for various grades of paint and established the actual grades of paint that would define the quality of paint.

Dr. Browne, in his Bulletin No. 804, emphasizes that the classification system simply gives paint users information that they can understand as compared to the difficulty of comprehending a paint formula. Forman, Ford and Co. feels there can be no conflict over the use of such a classification system that supplements Trade Brands as compared to recent attempted legislation that called for virtual elimination of branded products to be supplanted by grade classification only. They present classification of paint as a means of providing greater understanding and satisfaction to paint users.

So important does Forman, Ford and Co. believe this program to be, they brand these products under their firm name, Forman, Ford, the first time in the company's 66 years they have honored a product with their name, it was pointed out. They further establish this new brand with the addition of Grade 1 on the label (see illustration). At present, the Forman, Ford Grade 1 label will be applied only to outside white, exterior primer and red barn paint.

The United States Department of Agriculture specifies that use of the classification system requires presentation on the label of the Classification Seal. Each can of Forman, Ford Grade 1 paint displays this seal. On it is shown the group (which applies to the pigments and vehicles used), the type (which indicates the content and ratio of lead and zinc) and the grade of the paint.

Comparison of certain paints now on the market under the U.S.D.A. classification system has produced some startling results, Forman, Ford says. Of a number of paint formulations, examined on cans purchased through normal commercial channels, there was no house paint higher than a Grade 2 with the average of the better known brands a Grade 3 classification, some even as low as Grade 6, it is claimed. Forman, Ford and Co. believes the American people are entitled to buy paints of highest quality and feels paint of such quality can be offered under the classification seal of the United States Department of Agriculture. They likewise say their Grade 1 products will retail at a price equal to or below that of certain nationally distributed brands graded and found to be of lower classified grade.

For dealers or any person interested in the comparative grades of paint, the Forest Products Laboratory at Madison, Wis., will analyze and grade any formula submitted to them on the basis of their classification by group, type and grade. All that is necessary is to mail a copy of the formula and directions for use as shown on the label to the Laboratory.

Also in Western Building, March 1949 pg. 4

57

A Standard of Quality for Paint

By F. L. BROWNE

*Chemist, Forest Products Laboratory**
Forest Service,
U. S. Department of Agriculture

YOU can now buy paint labeled by the maker with both his trade brand and a classification recommended by the U. S. Department of Agriculture. The classification is a form of quality standard. It tells briefly what kind and grade of paint you are buying. The trade brand tells, as it always has, who made the paint and expects to be held responsible for it. Together, classification and trade brand supply all that is needed to buy from reputable sources with an eye to quality as well as to price.

The USDA classification plan was suggested by the Forest Products Laboratory after more than 20 years of research in the painting of wood. Under the plan there is a classification for every kind of house or barn paint for wood buildings. Any maker or dealer in paint is free to use the classification on his labels. No law requires it, however, and no agency of government need be consulted about it. But when the classification is used the paint must conform in fact to the classification claimed for it. Misbranded paint is unlawful.

The law in some States requires the composition, or formula, of paint to be printed on the label. The policy of most of the industry is to print the formula even in States that do not require it. Such formulas, however, are much too complicated and too technical to mean much to the average buyer. The USDA classification is based on the printed formula. It merely shows what the formula means in plain symbols that can be explained easily to the public.

Paints are classified by *group*, *type*, and *grade*. The words stand for ideas already familiar to those who have learned anything at all about the way paint is made.

The idea of "group" comes from the common practice of speaking of white lead paint, lead and zinc paint, titanium-lead-zinc paint. In this alphabet age, such terms are soon shortened to initial letters, such as L for white lead paint, LZ for lead and zinc paint, and TLZ for titanium lead-zinc paint. L stands for any of the lead pigments, Z for zinc oxide, and T for titanium dioxide. Other letters needed for some paints are S for zinc sulfide, F for iron oxide, and C for the remaining colored pigments. In classifying a paint, then, the group symbol first tells the kind of pigments of which it is chiefly made.

Second, the group symbol tells what kind of liquid or vehicle is in the paint. In the best white paints or paints of light color, it is taken for granted that the liquid is ordinary linseed oil or a similarly useful oil. But if much of the oil has been thickened by special processing, the brushing and spreading properties of the paint are altered. The paint works more nearly like enamel. Such paints are called enamelized paints or, since they contain less oil and more thinner, oil-restricted or oil-conservation paints. They are classified by group by adding the small letter e in parentheses after the capital letters for the chief pigments. Thus, paint of group TLZ(e) is titanium-lead-zinc paint containing much thickened oil; but paint of group TLZ with no added small letter contains little or no thickened oil. In the paint trade, thickened oil is called bodied oil.

Some paints, especially colored paints with little or no white lead or zinc oxide, contain more or less varnish. Varnish is a combination of resin with bodied oil. Good red barn paint, for example, often has some varnish in it. The classification by group shows the presence of varnish by the symbol (re). A barn paint may belong in group F(re); if it contains a little zinc oxide to help keep it free from mildew, as some of them do, it may belong in group FZ(re). Sometimes there is resin but little or no bodied oil, in which case the group would be FZ(r).

THE idea of "type" in classifying paints comes from the practice of speaking of paints as high or low in lead pigment or in zinc oxide. These pigments act chemically on linseed oil in a way necessary to make paint last a long time outdoors. The type symbol tells how much lead and zinc there is in the pigment part of the paint without going into tiresome detail about it.

There are five ranges in content of lead and zinc, counted together. There is the very high range, the high range, the medium range, the low range, and the very low range. They are represented, in the order named, by numbers 1, 2, 3, 4, and 5. There are also four ranges in ratio of lead to zinc, the very high,

* Maintained at Madison 5, Wisconsin, in cooperation with the University of Wisconsin.

N41698.59 FLB 001143

the high, the low, and the very low. They are represented in the order named by letters A, B, C, and D. Thus, paint of type 3B has "medium content of lead pigment and zinc oxide with a high ratio of lead to zinc." Paint of type 4C has "low content of lead pigment and zinc oxide with low ratio of lead to zinc." In type 5, the letter is left out because the ratio of lead to zinc is of no interest when there is so little of them present anyway.

THE idea of "grade" in classifying paints comes from the practice of speaking of paints as first grade or second grade, meaning as a rule that the first grade is more expensive but better in quality than the second grade. In the USDA classification there are six grades. They are numbered from grade 1, the highest, to grade 6, the lowest.

When paint of grade 1 is properly mixed for application, each gallon contains at least 0.25 gallon of equivalent opaque pigment, at least 0.25 gallon of total pigment, and at least 0.87 gallon of total nonvolatile. The exact meaning of the terms may be left to the paint chemists. The equivalent opaque pigment tells how well the paint hides the surface underneath. The total pigment gives information about the spreading properties of the paint and about the structure and durability of the coating it makes. The total nonvolatile shows how much of the paint remains in the coating after it has dried. For the grades lower than grade 1, the requirements are scaled down according to a published table.

In general, the higher the grade of the paint, the less paint and labor are needed to do a job of given quality. Some jobs, such as painting new woodwork with but two coats of paint, require the highest grade of paint if they are to be done properly. Other jobs, such as painting new woodwork with three coats, can be done equally well either with the highest grade paint or with somewhat more paint of a medium grade. Still other jobs, such as painting badly weatherbeaten wood, take so much paint because of the rough surface that money may sometimes be saved by using a well-made paint of low grade.

Paint buyers should think of grade chiefly as a guide to the way paint should be used for best and most economical service. Although grade 1 of suitable group and type is likely to be the best purchase for most work even if it costs a little more, good work can still be done in many cases with paint of grade 2 or grade 3. On the other hand, a grade-1 paint can be a bad choice if it is of a group or type unsuitable for the purpose.

Another point to remember is that the painter lowers the grade of a paint when he thins it with either linseed oil or paint thinner. It takes good workmanship along with good paint to get good painting.

The classification mark on the label of a paint, therefore, must state three things, the group, the type, and the grade. It should also bear the statement, "Classified according to the recommendations of the United States Department of Agriculture, Technical Bulletin No. 804."

For several years past, many brands of white and light-colored house paint have been of the classifications group TLZ(e) type 3B grade 3; or group TLZ(e) type 3C grade 3; or group TLZ(e) type 4C grade 3. Sometimes the grade is as low as 4. At present there is a general trend toward less bodied oil, represented by (e) in the group symbol, and toward higher grade Some brands have fully resumed prewar quality and are classified as group TLZ type 3B grade 1 or with type 3C or 4C in place of type 3B.

Among paints of group TLZ, those of types numbered 1 or 2 would be unduly expensive. They would also get dirtier and stay dirty longer than paints of types numbered 3 or 4. Paints of group LZ must be of type 1 or type 2 if they are to be of high grade. Although such paints were once widely sold, they are now uncommon because they are costly and get dirty. Pure white lead paint, usually classified as group L type 1A grade 1, is an excellent paint for some uses, especially where repainting may be put off longer than is generally desirable.

Part or all of the titanium dioxide in group TLZ paints is sometimes replaced by zinc sulfide. Such paints are of group STLZ or group SLZ. There are also leadless paints of groups TZ, SZ, or STZ for use particularly where there may be hydrogen sulfide in the air, which blackens paint containing lead. The leadless paints are type 4D or, if they are low-grade paints, sometimes type 5.

White or light-colored paints of high grade should never be made in type 5. To be sure that they contain enough lead pigment and zinc oxide, the buyer may well insist upon one of the types numbered 3. Those of types 4C or 4D may be satisfactory but there is less assurance that they are.

The house-paint primers now sold by most paint makers are usually of group TL(e), TL(re), TLZ(e), or TLZ(re) and of type 4A or 4B. Most of them are of grade 3 but a few are as high as grade 1. The primers nearly always contain bodied oil or varnish to give them the desirable quality called "controlled penetration." It is usually wise to buy primer and finish paint of the same trade brand, because each should be made properly for use together.

Paints of dark colors cannot have much white pigment. Except in barn painting, their chief use is for trim and minor areas on buildings. The best trim paints of dark colors are usually enamels to be used over house-paint primer. Some of the groups in which they may classify are c(re), C(e), CF(re), and CFZ(re). The type is generally 5, less often one of the types numbered 4. They may be made in any of the grades.

Red barn paints may be of groups F, F(e), F(re), F(r), or, if they contain a little zinc oxide, Z after the F in any of these groups. They are nearly always of type 5. For many years most brands of barn paint have been of low grade to sell at low prices. Grades 5 and 6 are common. Until recently a barn paint better than grade 4 has been rare. Now, however, there are a few brands of grade 1 on the market.

CLASSIFICATION is new in paints. Few brands, yet, have the classification on the label. But from the formula printed on the label anyone may calculate the classification if he can do simple arithmetic and has the patience to learn the method. All the necessary details are printed in a pamphlet that can be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for 10 cents. It is called "Classification of House and Barn Paints as Recommended by the United States Department of Agriculture," by F. L. Browne, U. S. Department of Agriculture Technical Bulletin No. 804.

FLB 001144

Wood Working Digest Apr, 1949 (52)

FINISHING

HOUSE PAINT AND OUTDOOR FURNITURE

By F. L. Browne*

We are publishing this excerpt from a report not because we think of many our readers as house painters, but for reasons. First, much of what applies house paint will have an application for our readers interested in outdoor furniture. Second, this development is the result of more than 20 years of research in painting wood and of real interest to all connected with the paint industry.

YOU CAN NOW buy house paint labeled by the maker with both his trade brand and a classification recommended by the U. S. Department of Agriculture. The classification is a form of quality standard. It tells briefly what kind and grade of paint you are buying. The trade brand tells, as it always has, who made the paint and expects to be held responsible for it. Together, classification and trade brand supply all that is needed to buy from reputable sources with an eye to quality as well as to price.

Any maker or dealer in paint is free to use the classification on his labels. No law requires it, however, and no agency of government need be consulted about it. But when the classification is used, the paint must conform in fact to the classification claimed for it. Misbranded paint is unlawful.

The law in some states requiries the composition, or formula, of paint to be printed on the label. The policy of most of the industry is to print the formula even in states that do not require it. Such formulas, however, are much too complicated and too technical to mean much to the average buyer. The USDA

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Information on a Typical Label

HOUSE PAINT
White
Group T L Z
Type 3B Medium content of lead pigment and zinc oxide, high ratio of L
Grade 1

FORMULA:	By weight		By volume	
Basic carbonate white lead	19.4%		5.3%	
Basic sulfate white lead	8.2		2.4	
Zinc oxide	15.1		5.1	
Titanium dioxide	6.3		3.0	
Magnesium silicate	14.8		9.7	
Total Pigment		63.8%		25.5%
Refined linseed oil	23.3%		46.9%	
Refined soybean oil	7.7		15.7	
Mineral spirits	3.7		9.0	
Drier	1.5		2.9	
Total Liquid		36 2%		74.5%
Total Paint	100.0%	100.0%	100.0%	100.0%

Classified According to the Recommendations of the United States Department of Agriculture

classification is based on the printed formula. It merely shows what the formula means in plain symbols that can be explained easily to the public. Paints are classified by group, type, and grade.

Group Symbols

The idea of "group" comes from the common practice of speaking of white lead paint, lead and zinc paint, titanium-lead-zinc paint. These terms are shortened to initial letters: L for white lead paint, LZ for lead and zinc paint, and TLZ for titanium-lead-zinc paint. L stands for any of the lead pigments, Z for zinc oxide, and T for titanium dioxide.

The group symbol tells what kind of liquid or vehicle is in the paint. In the best white paints or paints of light color, it is taken for granted that the liquid is ordinary linseed oil or a similarly useful oil. But if much of the oil has been thickened by special processing, the brushing and spreading properties of the paint are altered. The paint works more nearly like enamel. Such paints are called enamelized paints or, since they contain less oil and more thinner, oil-restricted or oil-conservation paints. They are classified by group by adding the small letter e in parentheses after the capital letters for the chief pigmnets .Thus, paint of group TLZ (e) is titanium-lead-zinc paint containing much thickened oil; but paint of group TLZ with no added small letter contains little or no thickened oil.

Some paints, especially colored paints with little or no white lead or zinc oxide, contain more or less varnish. Varnish is a combination of resin with bodied oil. Good red barn paint, for example, often has some varnish in it. The classification by group shows the presence of varnish by the symbol (re). A barn paint may belong in group F(re); if it contains a little zinc oxide to help keep it free from mildew, as some of them do, it may belong in group FZ(re). Sometimes there is resin but little or no bodied oil, i which case the group would be FZ(r

Classifying by Type

The idea of "type" in classifyi paints comes from the common pr tice of speaking of paints as high

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4/4 to 8/4 Red Gum
4/4 to 8/4 Cypress
4/4 to 6/4 Red Oak
4/4 White Oak

Appalachian Stock
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4/4 to 8/4 Poplar
5/4 Red Oak (step stock)
5/4 to 8/4 Red Oak and Hickory (vehicle stock)

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low in lead pigment or in zinc oxide. These pigments act chemically on linseed oil in a way necessary to make paint last a long time outdoors. The type symbol quickly tells how much lead and zinc there is in the pigment part of the paint.

There are five ranges in content of lead and zinc, counted together. There is the very high range, the high range, the medium range, the low range, and the very low range. They are represented by numbers 1, 2, 3, 4, and 5, respectively. There are also four ranges in ratio of lead to zinc, the very high, the high, the low, and the very low. They are represented in the order named by letters A, B, C, and D. Thus, paint of type 3B has "medium content of lead pigment and zinc oxide with high ratio of lead to zinc."

Meaning of "Grade"

"Grade" in classifying paints means that the first grade is more expensive but better in quality than the second grade, etc. In the USDA classification there are six grades. They are numbered from grade 1, the highest, to grade 6, the lowest.

When paint of grade 1 is properly mixed for application, each gallon contains at least 0.25 gallon of equivalent opaque pigment, at least 0.25 gallon of total pigment, and at least 0.87 gallon of total nonvolatile. The exact meaning of the terms may be left to the paint chemists. The equivalent opaque pigment tells how well the paint hides the surface underneath. The total pigment gives information about the spreading properties of the paint and about the structure and durability of the coating it makes. The total nonvolatile shows how much of the paint remains in the coating after it has dried. For the grades lower than grade 1, the requirements are scaled down according to a published table.

FLB 00114

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*Name on request.

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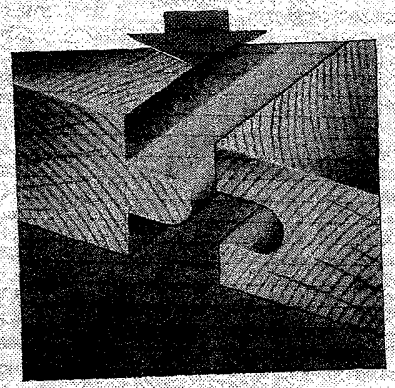

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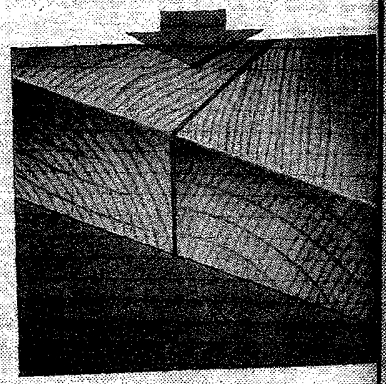

In general, the higher the grade of the paint, the less paint and labor are needed to do a job of given quality. Some jobs, such as painting new woodwork with but two coats of paint, require the highest grade of paint if they are to be done properly. Other jobs, such as painting new woodwork with three coats, can be done equally well either with the highest grade of paint or with somewhat more paint of a medium grade. Still other jobs, such as painting badly weather-beaten wood, take so much paint because of the rough surface that money may sometimes be saved by using a well-made paint of low grade.

Paint buyers should think of grade chiefly as a guide to the way paint should be used for best and most economical service. Although grade 1 of suitable group and type is likely to be the best purchase for most work even if it costs a little more, good work can still be done in many cases with paint of grade 2 or grade 3. On the other hand, a grade-1 paint can be a bad choice if it is of a group or type unsuitable for the purpose.

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Requirements for Classification

The classification mark on the label of a paint, therefore, must state three things, the group, the type, and the grade. It should also bear the statement, "Classified according to the recommendations of the United States Department of Agriculture, Technical Bulletin No. 804."

For several years past, many brands of white and light-colored house paint have been of the classifications group TLZ(e) type 3B grade 3; or group TLZ(e) type 3C grade 3; or group TLZ(e) type 4C grade 3. Sometimes the grade is as low as 4. At present there is a general trend toward less bodied oil, represented by (e) in the group symbol, and toward higher grade. Some brands have fully resumed prewar quality and are classified as group TLZ type 3B grade 1 or with type 3C or 4C in place of type 3B.

Among paints of group TLZ, those of types numbered 1 or 2 would be unduly expensive. They would also get dirtier and stay dirty longer than paints of types numbered 3 or 4. Paints of group LZ must be of type 1 or type 2 if they are to be of high grade. Although such paints were once widely sold, they are now uncommon because they are costly and get dirty. Pure white lead paint, usually classified as group L type 1A grade 1, is an excellent paint for some uses, especially where repainting may be put off longer than is generally desirable.

Part or all of the titanium dioxide in group TLZ paints is sometimes replaced by zinc sulfide. Such paints are of group STLZ or group SLZ. There are also leadless paints of groups TZ, SZ, or STZ for use particularly where

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Classification is new in the paint industry. As yet, few brands have the classification on the label. But from the formula printed on the label anyone can calculate the classification if he can do simple arithmetic and has the patience to learn the method. All the necessary details are printed in

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a pamphlet that can be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. It is called "Classification of House and Barn Paints as Recommended by the United States Department of Agriculture," by F. L. Brown U. S. Department of Agriculture Tech nical Bulletin No. 804.

• • •

*Mr. Browne is a chemist at the Forest Pro ucts Laboratory, Forest Service, U. S. Depa ment of Agriculture, Madison, Wis.

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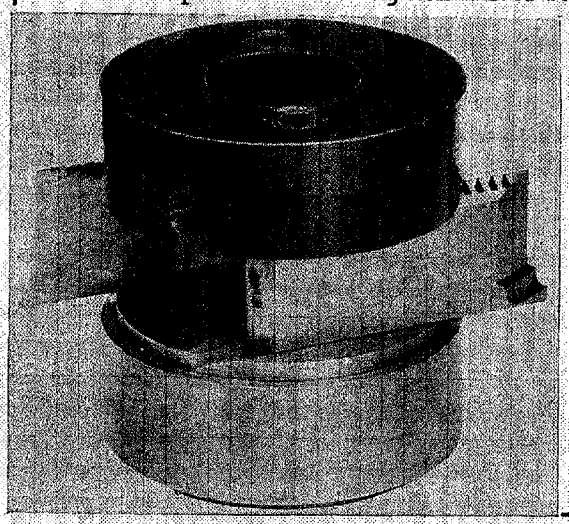

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FLB 001149

National Real Estate and Building Journal
Nov. 1951 (53)

How to use natural wood finishes

With the trend to modernize traditional architectural styles, natural wood finishes have become increasingly popular for home exteriors. They can add substantially to the appearance and salability of homes built for sale if they are correctly applied and properly maintained

By F. L. BROWNE*

NATURAL finishes for wood siding on the exteriors of houses have become increasingly popular during the past 15 years. Woods that have a rich brown or red color of their own, such as redwood and western red cedar, lend themselves particularly well to natural finish, though woods of paler color, such as cypress, pine, knotty pine, and Douglas fir are sometimes finished in that way.

Those who have learned to use suitable materials for a natural finish and to apply and maintain them correctly have usually found them pleasing and satisfactory. On the other hand some who have tried natural finishes without first learning what they require have been disappointed and have changed back to the older practice of hiding the wood under a coating of house paint.

The first thing to learn about natural finishes is that they are much less durable and therefore must be renewed much more frequently than coatings of house paint. House paint should go at least four years before needing renewal but natural finishes nearly always need renewal at least once a year. On parts of a house that are fully exposed to sunshine and rain, natural finish usually needs renewal every six months until it has been done three or four times, after which the intervals may be somewhat longer, though seldom more than 12 months. On more sheltered parts of the house yearly renewal may suffice and in deep shade the intervals may be even longer.

As a rule the lowest courses of siding on the south side of the house are most severely exposed and need most frequent renewal of natural finish where as the highest courses of siding and the overhang under the eaves of the north side are the most sheltered and can go longest between renewals. Trees of neighboring houses, however, may shift the locations of greatest and least exposure to other parts of the house.

Need for renewal of finish becomes evident when the luster or glossiness originally imparted to the wood by the finish fades to the dullness of unfinished wood. Another test is to splash water on the surface to see whether the water rolls off quickly in droplets or spreads on the wood and is soon absorbed. In the latter case fresh application of finish is in order.

Needed renewal of finish must not be delayed too long, for if it is postponed unduly the wood begins to acquire a gray color that turns still darker gray when more finishing eventually is done. To restore the desired color after serious grayness has developed the surface must be scraped or sandpapered until the wood is bright again. If the wood is allowed to become roughened and cupped as well as grayed by weathering, the restoration of a smooth, bright surface becomes very laborious. For that reason the timely renewal of natural finish simply cannot be neglected. Similar neglect of coatings of house paint is less serious.

There is no way of keeping wood very long with exactly the color and nearly complete absence of gloss with which it comes from the lumber yard. A finish that could do so would enjoy a good market. But any protective finish that can be applied necessarily penetrates slightly into the wood, displaces air from wood cells, and seems to deepen the color of the wood even if the protective material has no color of its own. Moreover, by filling the pores in the wood, the protective material makes the surface smoother and therefore imparts at least a moderate degree of luster or glossiness. As time passes there is further change of color because sunlight gradually darkens the color of most woods by changing yellows and reds toward brown. Even the weakened sunlight that gets through windows eventually darkens interior woodwork. If, in addition, the protective finish itself darkens with age, as most of them do, still more change in color must be expected. Fortunately, aged wood is still more attractive than freshly cut wood.

Natural finishes may be divided into three broad types, the oil finishes, the wood sealer finishes, and the varnish finishes. They differ in the composition of the material used, in the appropriate methods of application, in the resulting appearance, and in important characteristics of performance. The paint industry, however, has no such generally-recognized classification of finishes; the trade names of commercial products do not necessarily indicate the type to which they belong. Thus a material may be sold as a "log cabin oil" and yet turn out to be either a sealer or a varnish. The user must judge from such information about the composition as may be given on the label and particularly from the way the product behaves when he starts to apply it.

OIL FINISH. The natural finish with the lowest degree of luster or gloss is the oil finish. It also darkens the color of the wood more than other natural finishes do because the oil penetrates farther into wood. Moreover the oils are inclined to continue darkening with age more than most seals or varnishes

* Chemist, Forest Products Laboratory, maintained by the Forest Service, U. S. Department of Agriculture, at Madison, Wisconsin, in cooperation with the University of Wisconsin.

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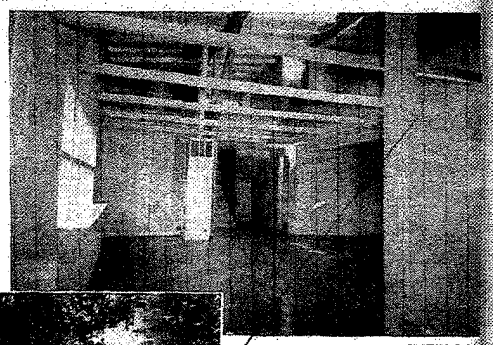
Imagination converts run-down structures into profitable investments

BEFORE

AFTER



INTERIOR

From Shamble to Showplace

EVERY community has white elephants . . . those rambling structures that serve no particular purpose. They take up valuable land. They may be a blight on the community. But with imagination, they can be converted into useful dwellings . . . and at a profit.

Realtor-Builder H. E. Russell of Richmond, California, does just that. He searches for old, run-down structures that have possibilities. He converts them into new, attractive quarters. He landscapes the lot. He improves the appearance to such an extent that property values in the surrounding area are increased, making the venture profitable for him and for neighbors.

As a sample of his imagination, Russell just finished converting an aged structure, once a chickenhouse, into a modern dwelling. When Russell took on the task, the building was a blot on the landscape. Its ancient paint was peeling, boards were rotting, and the site was strewn with debris. From these apparent ruins, Russell built such an attractive home that even after a 10-day public showing it still draws sight-seers from the surrounding area.

"Operation Chickenhouse" began when Russell saw that the location had possibilities . . . a panoramic view of a near-by city park and a sloping lot lined with acacia and fruit trees.

Major structural changes started by sheathing existing wood with fireproof asbestos in order to meet rigid building codes. The lower half of the exterior walls was then covered with Johns-Manville Flexboard and the upper half finished with kiln-dried, rough-sawed, clear heart tongue and grooved redwood. New supporting columns were set on steel plates, and the original beams were replaced with heavy new ones.

The lot is high at the back and slopes gently to the avenue at the front. A paved parking space, large enough for three cars, now commands the lower part of the lot. Trees which partially blocked the view were cut down, the larger ones being retained as part of the landscaping plan. A brick patio, 12x50 feet, was built on the high portion of the lot back of the house.

A striking interior feature is an open mezzanine studio above the main living area. Access to the brick patio is from the studio, which adjoins two small bedrooms and a half-bath, also on the mezzanine level. Total floor space on this level is 746 square feet.

Non-glare windows now overlook the patio on the sunny side of the dwelling. These windows flood the open studio with sunlight and provide additional light for the living area below. Another unusual feature is that the mezzanine may be reached by stairways at both ends of the downstairs area, which, with the open studio, help create a feeling of spaciousness.

One-quarter-inch U. S. Plywood was used for all interior walls and partitions. Beams in the main living area are exposed and painted a pale yellow. Interior redwood panels are waxed to bring out the fine grain.

The main floor includes a dining area and kitchen, which are under the mezzanine, a shower room and a large storage area. Total area on the main floor is 1250 square feet. The house is heated by a Lennox High-boy gas heater, 75,000 btu, located at one end of the main floor.

The entire project required 58 actual working days for completion. Total cost of remodelling the house was $9,500. Russell sold the converted property for $17,500.

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do. The darkening, however, can be largely corrected by incorporating a little pigment in the oil as is described farther on.

The simplest and oldest oil finish is ordinary linseed oil, either raw linseed oil or boiled linseed oil. Unless the work can be done in warm, dry weather it is best to use boiled oil or else to add about one-sixth of a pint of liquid paint drier to a gallon of raw oil. Most painters also like to add some volatile thinner to linseed oil, thinking that it makes the oil penetrate deeper. That is not the case, but thinning the oil helps to avoid leaving any excess oil on the surface. Turpentine, mineral spirits, or other thinner sold for mixing with paint may be used but do not add more than a half gallon of thinner to a gallon of oil.

The oil may be applied by brushing, spraying, or mopping. Two good coats are needed for new wood. But it is most important to see that all of the oil sinks into the surface of the wood. If, after the second coat has been applied and has stood 20 to 30 minutes, there are any glossy places where excess oil stands on the surface, it should be wiped off before it has time to harden. Coatings of linseed oil are unsatisfactory not only because they are too glossy but because they are inclined to run or to wrinkle when they dry. In any event, coatings of oil are too soft, tend to hold dirt, and become mildewed easily.

In renewing the oil finish after it shows signs of wear, one fresh application should suffice. Again, any excess not drawn into the wood should be wiped off. (Do not forget that oily rags are a fire hazard. Burn them promptly or keep them in a tightly closed metal container until they can be burned.)

Trade-brand products may be purchased at paint stores. They are often called log oils or log cabin oils because the natural finishes for exterior woodwork first became popular for summer cottages built of peeled logs. The commercial products are usually made of bodied linseed oil, tung oil, or other drying oils and thinners. Bodied oils have been heated or treated chemically to increase the viscosity greatly, after which a greater proportion of inexpensive thinner must be added to restore suitable viscosity for application. The bodied-oil finishes do not penetrate so deeply into wood as raw or boiled oil does and therefore do not darken the color of the wood so much. The product approaches the properties of a wood sealer more and more closely as the degree of bodying is increased.

The trade-brand oils should be applied and maintained just as has been described for the raw linseed oil finish. Since a bodied oil is more apt to leave an excess standing on the surface than raw oil is, special care should be taken to wipe off the excess before it becomes hardened.

The oil finishes give their best service in dry places where there never are any prolonged periods of dampness, such as southern Arizona. Where dampness may linger for some time the oils are subject to attack by molds, the fungi that grow on surfaces. On finishes the condition is usually called mildew. A dark, almost black discoloration may result. Mildew can be prevented by incorporating suitable preservatives in the oil finish. Some, though by no means all of the trade-brand oil finishes, already contain preservatives. If so, the kind and amount should be stated on the label. Mere statement that the product itself is a preservative, however, is meaningless because the paint industry's use of that word may have no such significance.

If linseed oil or a commercial product not containing preservative is used, there are two ways of incorporating suitable preservative. One way is to buy one of the concentrated solutions of pentachlorophenol or other chlorinated phenols sold at lumber yards for preserving wood and to mix it with the linseed oil instead of adding turpentine or paint thinner. If the directions on the preservative say that it is to be mixed with three times its volume of fuel oil for use as a wood preservative, it may be mixed one volume of concentrated preservative to three volumes of linseed oil for a linseed oil finish.

The other way of accomplishing the purpose is to buy one of the water-repellent preservatives now sold at many lumber yards and some paint stores and apply it to the wood before the linseed oil finish is put on. In the second case most renewals of the finish can be done with the linseed oil alone, for the treatment with water-repellent preservative need not be repeated for three or four years.

The oil finishes may be further modified to advantage by incorporating a small amount of pigment in them. Usually a pigment of reddish brown color is desired to simulate the color of the heartwood of redwood or red cedar. The pale color of any sapwood present in the lumber is thereby changed to resemble the heartwood more closely and such woods as pine or Douglas fir are given a richer color. Moreover, better maintenance of color is achieved because the presence of the pigment tends to mask the gradual darkening in the color of the wood itself.

If renewal of finish should be delayed until some boards become slightly grayed from weathering, the pigment helps to restore the desired color, provided the graying has not been allowed to go too far. Finally, presence of a little pigment usually adds appreciably to the durability of the finish. Of course, the amount of pigment must be small, well short of the point at which it could give a painted or even a stained appearance.

A number of the trade-brand oil finishes on the market contain pigments. Such products, of course, should be stirred thoroughly before use and should

(Please turn to page 47)

Oil finish may be applied by brushing, spraying, or mopping. Two coats are needed for new wood. If excess oil stands on surface after second coat, it should be wiped off before it has time to harden.

FLB 001152

Use Showmanship in Renting

High occupancy rates of recent years have caused some property managers to become lax in their apartment merchandising methods. But vacancies are on the increase in some cities and experienced managers recognize the need to revitalize renting techniques now

SELLING is "making the other person want to buy what you have to offer," and renting apartments is a selling job. Some property managers have forgotten that in the past few years of a "sellers' market," but they're realizing the importance of it again as apartment vacancies increase.

In many apartment buildings the methods used in showing and renting units leaves much to be desired because they are frequently handled by operating employees — superintendents, janitors, elevator operators — who have not been properly trained. Where a trained rental agent is available, or where operating employees have been given careful instructions, the results are usually much better.

The problem is of particular importance in the smaller building, and in connection with those prospects who shop from building to building before approaching a renting agent. In such cases, the first part of the job falls upon the operating employee. If management officials only realized how many prospective leases are lost because of an initial bad impression created by the discourtesy, lack of interest, delay, or slovenliness of an employee they would pay more attention to training their men in the fundamentals of renting work.

Even if first impressions are favorable, there is a right and wrong way to present the unit to the prospect. Its advantages should be presented in such a manner that they will outweight its disadvantages in the prospect's mind. This calls for a certain amount of sales technique and a thorough knowledge of all the talking points of the building and the suite.

One of the first essentials is to keep your building in spic and span condition inside and out. Many a lease is lost in the lobby. Lobby, halls, and elevators should be kept spotless. Vacant apartments should be kept in first rate condition. One vacant apartment in each line should be decorated as a show apartment.

The person who handles rentals should be thoroughly familiar with these five steps in the sale:

1. *Approach.* There are two kinds of personality—pleasant and unpleasant. Cultivate the former. Greet prospects with a smile. Make yourself attractive to people who come into your building. Be clean and presentable. If people like you, they will want to rent in your building.

2. *Introduction.* "The voice with a smile wins." A pleasant, courteous introduction makes prospects feel at home. If they feel at home, a good start has been made.

3. *Creating interest.* Point out the good features of the apartment and building. These include exposure, light and air, cross ventilation, ceiling heights, convenience of layouts, closets, laundry, drying facilities, transportation, parks, shopping.

Points of interest in public spaces include house telephone, door interviewer, mail boxes, garbage disposal, fire towers. The main advantages of these and other features in the suite should be stressed. Radio and television outlets, size and arrangement of closets, convenience of bathroom are among the numerous features that have sales appeal.

Kitchens and bedrooms are exceptional sales features. In the kitchen you should be able to talk intelligently about the good points of the range, refrigerator, cabinets, floor covering. If the kitchen contains special lighting over work spaces this should be stressed.

In the bedroom, point out size and equipment of closets, especially linen and cedar closets, the amount of space and how it can be used for twin or double beds.

Call attention to laundry facilities, automatic machines if provided, space set aside for storage in the basement.

Be able to answer prospects immediately about the sizes of rooms, cubic capacity of refrigerators, kind of current, how many closets in an apartment. Know your neighborhood, including all its location advantages. Know the location of schools, churches, transportation facilities, playgrounds.

These things should be brought out intelligently in the course of presenting the space. Don't overwhelm your prospects with information, but let them know as many advantages as possible during the course of the conversation. Sometimes it is possible to indicate an advantage without saying anything about it.

4. *Creating desire.* At this stage of the game your prospect has become really interested in the building the course of the conversation. Sometimes it is possible to indicate an advantage without saying anything about it.

If husband and wife show a desire for privacy to discuss certain items, give them plenty of opportunity *within* the apartment. If you force them to wait until they are outside of the building, you may lose them. However, be consistently available in the adjoining room, ready to provide any information they may wish. Do everything to facilitate a decision on the *spot*!

Here are some practical pointers for the renting employee:

Always obtain the name of your prospect.

See that your prospect receives a pamphlet by the management concern describing the building and suites.

Make a report to the office of all prospects who call at the building.

Don't promise more than you can and will deliver.

Don't smoke while showing apartments or talking to prospects or tenants. Some people object strongly to smoking.

When in doubt, find out. Don't make mis-statements.

Follow up your prospects closely, but don't high-pressure them.

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Architectural Record Feb. 1952 (54)

NATURAL FINISHES FOR EXTERIOR WOOD

By F. L. Browne, Chemist, Forest Products Laboratory, Madison, Wisconsin

NATURAL FINISHES for exterior wood siding have become increasingly popular, and when applied and maintained correctly usually have been found attractive and satisfactory. On the other hand, natural finishes applied without the knowledge of what they require often have been disappointing. Woods that have a rich brown or red color of their own, such as redwood and western red cedar, lend themselves particularly well to natural finish, though woods of paler color, such as cypress, pine, knotty pine, and Douglas fir are sometimes finished in that way.

Natural Finishes Need Frequent Renewal

The first thing to learn about natural finishes is that they are much less durable and, therefore, must be renewed much more frequently than coatings of paint. Paint should go at least four years before needing renewal, but natural finishes nearly always need renewal at least once a year. On parts of a building that are fully exposed to sunshine and rain, natural finish usually needs renewal every six months until it has been done three or four times, after which the intervals may be somewhat longer, though seldom more than 12 months. On more sheltered parts of the building, yearly renewal may suffice, and in deep shade, the intervals may be even longer.

Need for renewal of finish becomes evident when the luster or glossiness originally imparted to the wood by the finish fades to the dullness of unfinished wood. Another test is to splash water on the surface to see whether the water rolls off quickly in droplets or spreads on the wood and is soon absorbed. In the latter case, fresh application of finish is in order. Needed renewal of finish must not be delayed too long. If it is postponed unduly, the wood begins to acquire a gray color that turns still darker gray when more finishing eventually is done. To restore the desired color after serious grayness has developed, the surface must be scraped or sandpapered until the wood is bright again. If the wood is allowed to become roughened and cupped as well as grayed by weathering, the restoration of a smooth, bright surface becomes very laborious. For that reason, the timely renewal of natural finish simply cannot be neglected. Similar neglect of coatings of paint is less serious.

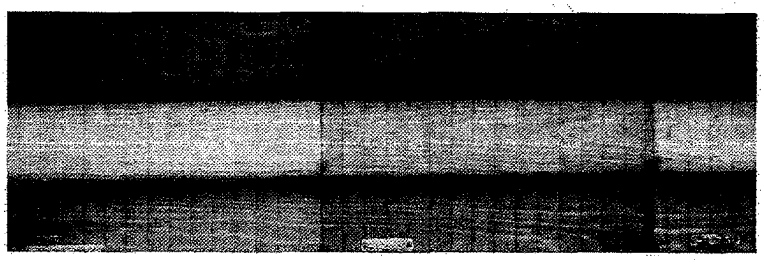
There is no way of keeping wood very long with exactly the color and nearly complete absence of gloss with which it comes from the lumber yard. A finish that could do so would enjoy a good market. Any protective finish that can be applied necessarily penetrates slightly into the wood, displaces air from wood cells, and seems to deepen the color of the wood even if the protective material has no color of its own. Moreover, by filling the pores in the wood, the protective material makes the surface smoother and, therefore, imparts at least a moderate degree of luster or glossiness. As time passes, there is further change of color because sunlight gradually darkens the color of most woods by changing yellows and reds toward brown. Even the weakened sunlight that gets through windows eventually darkens interior woodwork. If, in addition, the protective finish itself darkens with age, as most of them do, still more change in color must be expected.

Natural finishes may be divided into three broad types, oil finishes, wood sealer finishes, and the varnish finishes. They differ in the composition of the material used, in the appropriate methods of application, in the resulting appearance, and in important characteristics of performance.

Oil Finish

Oil finish has the lowest degree of luster or gloss. It also darkens the color of the wood more than other natural finishes do because the oil penetrates farther into wood. Also, the oils are inclined to continue darkening with age more than most sealers or varnishes do. The darkening, however, can be largely corrected by incorporating a little pigment in the oil as is described later.

The simplest and oldest oil finish is ordinary linseed oil, either raw oil or boiled. Unless the work can be done in warm, dry weather, it is best to use boiled oil or else to add about one-sixth of a pint of liquid paint drier to a gallon of raw oil. Most painters also like to add some volatile thinner to linseed oil, thinking that it makes the oil penetrate deeper. That is not the case, but thinning the oil helps to avoid leaving any excess oil on the surface. Turpentine, mineral spirits, or other thinner sold for mixing with paint may be used, but not more than a half gallon of thinner should be added to a gallon of oil.



Portion of a Forest Products Laboratory test panel at Madison, Wis., treated with a "redwood finish." It has been exposed to the weather for 7 months, facing south. The top board is redwood followed by white pine and cypress. Experts recommend refinishing once a year after the second application

finishes because the oil

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several years. In the crawl space warm air system, it will take place in the first year.

Warm Air Panel and Split Systems

Some engineers advocate panel heating, or, the "split" system in which the air follows a sinuous pattern in the floor or ceiling panel and then is "bled" into the room through small openings near windows.

For large houses where the total heat loss exceeds 100,000 Btu/hr, one independent heating system can take care of the total heating load, if a panel or "split" system is used. But with "perimeter" systems, when the heat loss is greater, two or more independent systems are required; and the systems can then be zone controlled.

These engineers also believe that most of the heat from the air should be dissipated in floor or ceiling panels, resulting in surface temperatures around 85 F and 100 F respectively. Temperature of air to rooms approaches that of the room.

One consulting engineering firm describes their floor panel heating system for residences, comprised of cellular clay tile topped with 2½ in. of concrete, as follows:

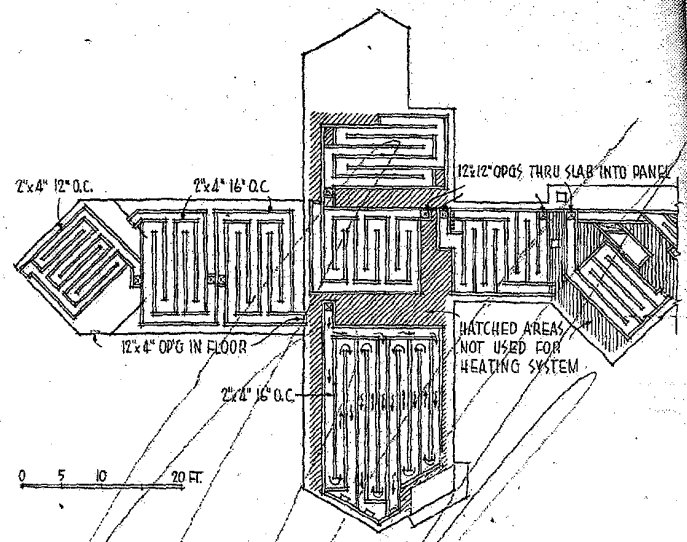
The residential installation is controlled by room thermostat and conventional warm air bonnet control except that continuous fan circulation is not used. When the thermostat signals for heat, the burner provides constant heat input to the slab until the thermostat has been satisfied. The fan is controlled by a high-low limit setting. If the fan ran continuously after the thermostat shut off the burner, the slab would continue to store heat, and the house would become too warm.

Night set-back is not recommended because then the system is forced to operate in the morning for a good while after sunrise when the outside temperature and solar effect is gradually increasing. Overheating will result.

With a fixed room thermostat setting, the off period of the burner is from 8 a.m. to around 4 p.m. During this period, the solar heat is absorbed by the floor slab, which consists of a 2½ in. concrete mass and the tile air space below providing a low heat storage. High heat storage is prevented.

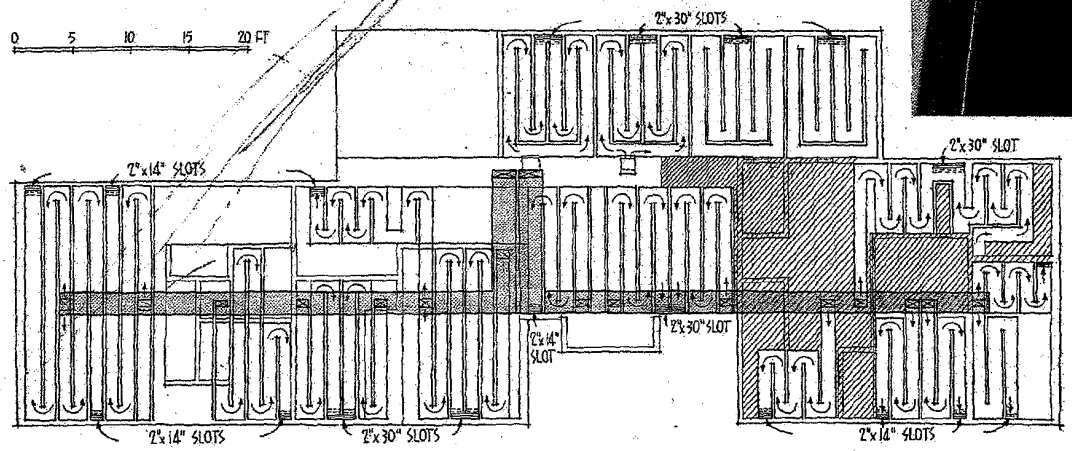
Other systems making use of noncritical materials include a floor panel system with wood sleepers laid on a concrete floor slab, and a plywood subfloor above. Ceiling panels are being constructed with gypsum board furred down from ceiling joists, and the furring strips act to guide the air in a sinuous pattern. See the two sketches on this page.

The editors wish to acknowledge the help of the following people in providing material for this article: C. W. Nessell and Randall Nelson, National Warm Air Heating and Air Cond. Assoc.; R. W. Roose, University of Illinois; and Richard P. Goemann of John D. Dillon, Consulting Engineers.



Above: portion of a large house laid out with a floor panel system consisting of wood sleepers over a concrete slab, all covered by a plywood subfloor. Trench underneath distributes heat to panels.

Below: layout of a typical ceiling panel system. Furred down ceiling is used similar to photo (note reflective insulation). Gray tone indicates large distribution duct to front panels. Slots admit air near outside walls



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Natural finishes for major areas of wood exteriors are a relatively new development. This report deals with the various misunderstandings and difficulties that have come up in the Forest Products Laboratory's consultations with architects and others. When the requirements and limitations of natural finishes are considered in advance, and the necessary precautions have been taken, natural finishes have been found both practicable and pleasing.

The oil may be applied by brushing, spraying, or mopping. For new wood, two good coats are needed. But it is most important to see that all of the oil sinks into the surface of the wood. If, after the second coat has been applied and has stood 20 to 30 minutes, there are any glossy places where excess oil stands on the surface, it should be wiped off before it has time to harden. Coatings of linseed oil that stand on the surface are unsatisfactory, not only because they are too glossy, but because they are inclined to run or to wrinkle when drying. These coatings of oil are too soft, tend to hold dirt, and become mildewed easily. In renewing the oil finish after it shows signs of wear, one fresh application should suffice.

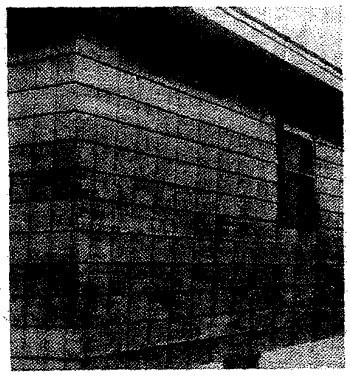
Commercial products are often called log oils or log cabin oils because the natural finishes for exterior woodwork first became popular for summer cottages built of peeled logs. These commercial products are usually made of bodied linseed oil, tung oil, or other drying oils and thinners. Bodied oils have been heated or treated chemically to increase the viscosity greatly, after which a greater proportion of thinner must be added to restore suitable viscosity for application. The bodied oil finishes do not penetrate so deeply into wood as raw or boiled oil, and, therefore, do not darken the color of the wood so much. The product approaches the properties of a wood sealer more and more closely as the degree of bodying is increased.

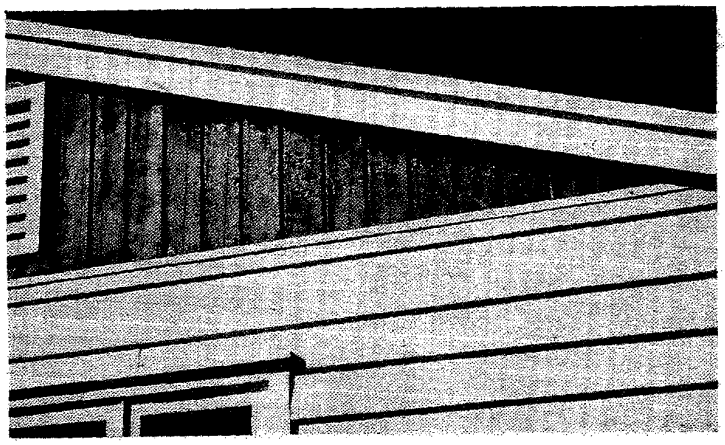
The commercial oil finishes should be applied and maintained just as has been described for the raw linseed oil finish. Since a bodied oil is more apt to leave an excess standing on the surface than raw oil is, special care should be taken to wipe off the excess before it becomes hardened.

The oil finishes give their best service in dry places where there never are any prolonged periods of dampness. Where dampness may linger for some time, the oils are subject to attack by molds, usually called mildew. A dark, almost black discoloration may result. Mildew can be prevented by incorporating suitable preservatives in the oil finish. Some, though by no means all, of the commercial oil finishes already contain preservatives. If so, the kind and amount should be stated on the label.

Suitable Preservatives. If linseed oil or a commercial product not containing preservative is used, there are two ways of incorporating suitable preservative. One way is to mix one of the concentrated solutions of pentachlorophenol or other chlorinated phenols with the linseed oil, instead of adding turpentine or paint thinner. If the directions on the preservative say that it is to be mixed with three times its volume of fuel oil for use as a wood preservative, it may be mixed one volume of concentrated preservative to three volumes of linseed oil for a linseed oil finish. The other way of accomplishing the purpose is to apply one of the water-repellent preservatives to the wood before the linseed oil finish is put on. In the second case, most renewals of the finish can be done with the linseed oil alone, for the treatment with water-repellent preservative need not be repeated for three or four years.

Adding Pigments. The oil finishes may be further modified to advantage by incorporating a small amount of pigment in them. Usually a pigment of reddish-brown color simulates the color of the heartwood of redwood or red cedar.





Some natural finishes whiten (loss of adhesion) and scale when applied to rather large areas of exterior siding. At left is a 3-year-old house in Arizona which had been refinished 1 year before the photo was taken. Above is an 18-month-old house in Madison, Wis., which had been refinished only 6 months before

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The pale color of any sapwood present in the lumber is thereby changed to resemble the heartwood more closely, and such woods as pine or Douglas fir are given a richer color. Moreover, better maintenance of color is achieved because the presence of the pigment tends to mask the gradual darkening in the color of the wood itself. If renewal of finish should be delayed until some boards become slightly grayed from weathering, the pigment helps to restore the desired color, provided the graying has not been allowed to go too far. Finally, presence of a little pigment usually adds appreciably to the durability of the finish. Of course, the amount of pigment must be small, well short of the point at which it would give a painted or even a stained appearance.

A number of the commercial oil finishes on the market contain pigments. Linseed oil or prepared oils without pigment can be pigmented just before use by adding a small proportion of burnt sienna ground in oil. About one-half pint of sienna-in-oil to a gallon of oil may be right, but the exact proportions are best determined by trial on sample cuttings of the wood.

Wood Sealer Finish

Like the oil finish, the wood sealer finish is a penetrating finish that should not be permitted to build up on the surface into a glossy coating. Sealers do not penetrate wood so deeply as oils do. For that reason, the sealers usually darken the wood less and give the surface more luster or glossiness than the oils do. The sealers, however, are less glossy than varnish finishes unless too much sealer is applied and the excess is not wiped off.

In composition, wood sealers are much like varnishes except that the sealers contain more thinner and less nonvolatile matter. Both are made as a rule by cooking resin and drying oil together in suitable proportions, incorporating driers, and thinning to proper consistency. Many kinds of resin, both natural and synthetic, may be used. The difference between a sealer and a varnish lies more in the method of application than in the composition. Wood sealer finish, like the oil finish, sinks into and saturates the wood surface without forming a continuous coating of appreciable thickness over it, as varnish finish does.

If excess sealer finish is not wiped off, what may start out as a sealer finish will end up, after one or two renewals, as a varnish finish. A good spar varnish or marine spar varnish will give sealer finish if thinned with about an equal volume of turpentine or other paint thinner and applied like the oil finish.

Although most wood sealers are more resistant to mildew than the oils are, sealer finishes are more readily attacked by fungi than are paints. Wherever there may be lingering dampness, it is advisable to have a preservative in the sealer finish. Some of the commercial products already contain preservative. Otherwise, preservative may be incorporated in a sealer finish by either of the two methods suggested for oil finishes.

Some commercial wood sealers contain pigments for the same desirable purposes already described for oil finishes. The user may also add pigments to sealers lacking them by following the methods suggested for pigmenting oil finishes.

Varnish Finish

Unlike either oil finish or sealer finish, varnish makes a highly glossy coating of appreciable thickness covering the wood. Varnish may not darken the color of the wood to begin with much more than a sealer does, but with the passage of time, there may be more darkening caused by change in the varnish itself than would be the case with a wood sealer.

Varnish is applied by brushing or spraying. At least three coats are needed for new wood, but for renewal, one coat at a time is sufficient. On new wood, the first coat may be thinned moderately with turpentine or other paint thinner. Shellac must not be used for the first coat on exterior surfaces, even over the knots in knotty pine. Succeeding varnish coats are expected to stand out without penetrating the wood and, of course, none of the varnish is wiped off.

Where there is dampness at times, varnish finishes need preservatives against mildew much like sealer finishes. Unless the varnish already contains a preservative, it is advisable to apply a water-repellent preservative to the wood before starting to put on varnish. It is seldom practicable to add a concentrated preservative to a varnish because varnish cannot stand much addition of thinner. Similarly, it is not good practice to add pigments to varnish. If pigmentation is desired, it is best to apply a pigment oil stain to the wood first and then to varnish over it.

On the whole, experience with varnish finish on large areas of exterior woodwork such as siding has not proved satisfactory. Often the varnish finish develops milky, opaque patches where the coating has lost its adhesion to the wood without breaking open. Some varnishes craze or crack in an unsightly manner, after which renewal of the finish is difficult.

Finishing Hardwoods

The methods of natural finishing described so far are suitable for all of the softwoods and for hardwoods with pores no larger than those in birch. Hardwoods with pores larger than those in birch, however, usually need special treatment for the pores after water-repellent preservative, if used, has been applied, but before oil, sealer, or varnish is put on. The treatment for pores is the application of a paste wood filler.

Paste wood filler is applied by thinning it with paint thinner to a consistency suitable for brushing, like paint, but brushing across the grain of the wood rather than with the grain.

For varnish finishes on hardwoods with large pores, use of wood filler is necessary to avoid danger of premature failure of the finish. For wood sealer finishes, the use of filler is strongly recommended, though it may not be essential. For oil finishes filler may be omitted.

Finishing Doors and Windows

Doors and windows usually need more careful maintenance of protective finish than is necessary on wood siding. Paint or trim enamel affords the most reliable means of maintaining the needed protection. Careful consideration should be given to the choice of paint or trim enamel for the exterior surfaces of doors and windows even when natural finish is selected for the siding. Paint of a color matching that of the naturally finished siding may be used if desired.

But if natural finish is wanted for doors or windows, it is probably best to apply a full varnish finish consisting of three or four coats, because varnish gives better protection against weathering than oil or sealer finishes do.

Rust Stains

Woods that contain tannins, such as redwood, red cedar, oak, and chestnut, readily produce a black color when brought in contact with iron rust and a little moisture. Other extractives present in many woods may also form strongly colored compounds with iron. Exterior woodwork, therefore, should always be fastened in place with corrosion-resistant nails, screws, or other fastenings.

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FPL Studies Natural Finishes

BY JOHN NEWHOUSE

During the past 15 years, natural finishes for wood siding on the outside of new houses have become increasingly popular.

And during that time, there has been a search of information on what finish to use, how to use it, and when to reapply the finish.

Many a person, after searching around for a "perfect" product, has given up and blindly picked out one to apply.

Sometimes the results have been disappointing. (FPL) of Madison, has come out with a pamphlet, putting together what information is known about these finishes during the comparatively few years that they have been used.

The first thing to learn about natural finishes, says the article by F. L. Browne, chemist with the laboratory, is that they are much less durable and must be renewed more frequently than house paint.

Four to One Shot

House paint should go at least four years without renewing, but the natural finishes almost invariably need renewing every year.

In parts of the house which are fully exposed to rain and sun, the finish usually needs renewal every two months until three or four coats have accumulated, after which the renewal period may be extended to a year.

On the other hand, the parts of the house sheltered from rain and sun may last longer than a year.

As a general rule, the lowest courses of siding to the south are most severely exposed, and need most frequent renewal, through trees or neighboring houses may shift locations of greatest or least exposure to other parts of the house.

The need for renewal is apparent when the lustre or glossiness lent originally to the wood by the finish fades to the dullness of unfinished wood, says the chemist. Another test is to splash water on the surface and see if it beads off quickly in droplets or spreads on the wood and is absorbed. In the latter case — renew the finish.

Will Turn Grey

And do it rapidly, says the chemist, for if it is postponed too long the wood turns a gray which becomes even more grey when refinishing finally is done.

To restore the original color, the surface must be scraped or sandpapered until the wood is bright again.

There's no way to keep wood exactly the color it is when it comes from the lumberyard, says the chemist. Any protective finish penetrates the wood, displaces air from cells, and seeps to deep in the color even though the finish has no color of its own.

Furthermore, the sunlight tends to change the color of wood by turning reds and yellows toward brown.

There are three broad types of natural finishes, says the laboratory — oil, wood sealer, and varnish.

Oil is the finish with the lowest degree of lustre or glossiness, says the chemist. It darkens the color of the wood more than other natural finishes because the oil penetrates farther. Further, it tends to darken more with age than sealers or varnishes.

But the darkening can be corrected largely by incorporating pigment in the oil.

Linseed Oil Used

Simplest and oldest oil used is linseed oil, raw or boiled. Unless the work is done in warm, dry weather, it is best to use boiled oil or add about one-sixth of a pint of liquid paint drier to each gallon of raw oil.

Oil may be applied by brushing, spraying, or mopping. For new wood, two coats are needed. It is important to see that the oil soaks into the surface. If there are glossy places after the oil has been applied for 20 to 30 minutes, they should be wiped off before the oil hardens.

The oil finishes give their best service, says the chemist, in dry places where there are never prolonged periods of dampness. When dampness lingers, the oils are subject to attack by molds, the fungi that grow on surfaces and are known as mildew.

If linseed oil, or a commercial product whose base is linseed oil, does not contain a preservative, the user can add one of the commercial solutions of pentachlorophenol available at lumber yards.

Or, one of the water repellant preservatives may be bought at lumber yards, and applied to the wood before the linseed oil finish is put on. In this case, renewals may be made of linseed oil alone, for the treatment with the water repellant preservative will last for three or four years.

Greater Durability

Burnt sienna ground in oil may be mixed with a small portion of oil and added to the larger quantity to give oil a little color and greater durability.

It is recommended, however, that the user experiment with sample cutting of wood to make sure the degree of coloration is that desired.

Like the oil finish, the wood sealer finish penetrates and should not be allowed to build up on the surface. Sealers do no penetrate as deeply as oils, and hence color less while giving more gloss.

There are many sealers on the market, sold under various trade names. Unfortunately, says the laboratory, they sometimes fail to designate whether they are wood sealers or varnishes, and the user may not know whether the material should be wiped off or not.

And the user may start out with a sealer finish and, after several renewals, wind up with a varnish type finish.

Attack by Fungi

Though more resistant to mildew than oils, sealers are more readily attacked by fungi than good oil paints. Hence it may be advisable to add preservatives. Some of the commercial products have preservatives added, as well as pigments.

Unlike either oil or sealer, varnish makes a highly glossy coating on the surface of the wood. Though the varnish may not darken the wood much more than a sealer, it may darken more with the passing of time, due to changes within the varnish itself.

Marine spar varnish tends to be more durable than ordinary spar varnish, the laboratory reports. At least three coats of varnish are needed for new wood. With only a single coat needed for renewals. On new wood, the first coat can be thinned moderately with turpentine or other paint thinner.

When renewing, however, it is difficult to limit the renewing to those spots where most needed, since the freshly applied varnish usually does not match in color and gloss the older coating. Thus the entire wall must be renewed, though some of the varnish may still be good.

When a preservative is needed, it is advisable to apply a water repellant preservative to the wood itself before the varnish is applied, since it usually cannot stand the addition of the thinning material. If pigmentation is desired, it is best to apply a pigment oil stain to the wood first and then varnish over it.

Varnish, however, has not proved particularly practical on large areas of exterior woodwork, such as siding. It may develop milky, opaque patches where the coating has lost its adhesion to the wood without breaking open.

Some varnishes craze or crack, making it difficult to renew. After two or three renewals, a thick coat develops which cracks and scales, and it then becomes necessary to remove the entire coating with varnish remover, which is

—State Journal Staff photo

The Forest Products Laboratory of Madison has issued a pamphlet on the use of natural wood finishes for wood siding on houses.

Above, Dr. F. L. Browne, laboratory chemist, who wrote the bulletin, is shown examining some of the panels which have been painted with various finishes and left to weather at the East Hill farm proving grounds.

(over)

both expensive and laborious.

The laboratory warns against using ordinary nails with woods which contain tannins, such as redwood, red cedar, oak, and chestnut, because a black stain will develop in the presence of iron rust and moisture. Galvanized iron, cadmium-plated iron, aluminum, zinc, and stainless steel are recommended.

Not Recommended

It is not a good plan to start with a natural finish on a new house as an experiment with the idea of changing to paint later if necessary, the laboratory warns.

It is better, it says, to check with persons who have had good experience with a certain material and method of application.

If necessary to paint, however, the change can usually be made. If the natural finish was of the varnish type, or a sealer which has been allowed to accumulate to a coating, strip the surface of all clear material with varnish remover.

Remove any remaining wax from the varnish remover with paint thinner or soap and water, sandpaper lightly, and paint as a new house.

If a sealer was used and is within the wood surface, it may be practicable to paint without other preparation. It is, however, a good idea to let a year elapse after the last coating of sealer.

If after that time some sealer layers remain, sand lower and lower until the gloss disappears. A priming coat of paint should precede the finish coat.

The bulletin on natural wood finishes for exterior finishes is No. R1908, and may be obtained free in single copies by writing to the Forest Products Laboratory, Madison, 5, Wis.

Architectural Record Nov. 1952

(56)

FOREST PRODUCTS LABORATORY
(Madison 5, Wis.)
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
Approved Technical Article

One of the houses of the Amana Society at Amana, Iowa, as it appeared in 1946 with ponderosa pine siding that had never been painted except for windows, doors and trim. The house was at least 40 years old, but probably was much older than that

WOOD SIDING LEFT TO WEATHER NATURALLY

By F. L. Browne, Chemist

Forest Products Laboratory,* Forest Service

U. S. Department of Agriculture

SINCE PUBLICATION of the article on "Natural Finishes for Exterior Wood" in ARCHITECTURAL RECORD (February 1952, page 196) a number of inquiries have been received about the possibility of leaving exterior wood entirely unfinished, to weather naturally. If suitable precautions are taken it is practicable to do so, but whether this is desirable is a question the architect and owner must decide. Painting, though, is likely to remain the customary treatment for exterior surfaces of smoothly planed wood, and staining for rough wood.

Nevertheless, the practicality of weathered wood is adequately demonstrated by much past experience. For the first century or so of the American Colonies, particularly in New England, wood was the predominant building material and the exterior surfaces were left unpainted to weather naturally.

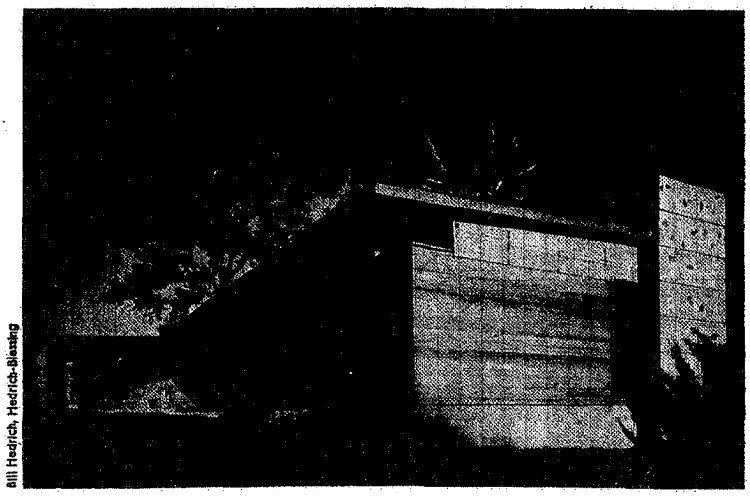
It was not merely that paint was an imported luxury. To the puritan mind of the time painting was an ungodly arrogance for anyone but a high crown official or a very wealthy merchant. There is record of the expulsion of a barber from the Massachusetts Bay Colony for aspiring beyond his station in life when he spent part of a small inheritance for painting his house.

Many of the wood buildings of the early colonial period still stand. Most of them, of course, were painted when it became socially acceptable to do so, and they have been kept painted since. But some, including two of the oldest houses that remain, have never been painted. New Englanders claim that they have the oldest wood house in the United States, now known as the Old Fairbanks House at Dedham, Mass.

The first part of the house was built in 1636. Most of the clapboard siding, however, was replaced in 1903 but has now stood nearly 50 years without paint. The oldest portion of Hartwell Farms at Arlington, Mass., also built in 1636, is still covered with the remnants of the original clapboards.

From 1858 to 1932 the Amana Society owned communally seven villages in Iowa County, Iowa. The houses were of wood and were left unpainted except for window sash and doors, which were painted. When I saw them for the first time in 1927 the houses were well main-

* *Maintained at Madison, Wis., in cooperation with the University of Wisconsin.*



Bill Hedrich, Hedrich-Blessing

The new house of architect Winston Elting has unfinished rough sawn redwood siding. A water-repellent preservative was applied to millwork, exterior beams and columns

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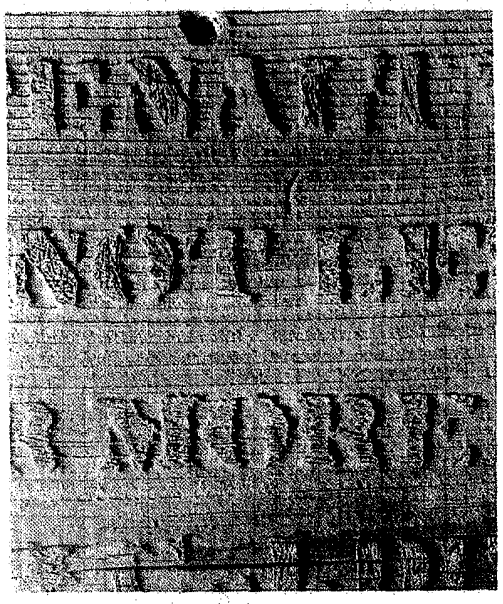

Part of a 25-year-old signboard made by stenciling letters on an unpainted background. Eroding of the unprotected wood background by weathering left the letters embossed $^1/_{16}$ in. From this and other suitable evidence, it can be predicted that wood wastes away about ¼ in. a century due to weathering

tained. The chief carpenter told me that the ½ by 6 in. bevel siding lasted from 30 to 50 years before they found it advisable to begin making replacements.

In 1946, fourteen years after the residences passed into private ownership, I again visited two of the villages. By far the most attractive and neatly kept houses were those that remained loyal to the old custom, with the siding unpainted but with corner boards, facia boards, and window and door casings, as well as sash and doors, decorated with paint.

The houses mentioned so far were all very modest dwellings, left unpainted for economy or to conform to local custom of the time. But there are at least a few examples in recent years of more pretentious buildings for which weathered wood was chosen strictly for its appearance. Two of those I know are hotels that must attract patrons to remain in business. Pilot Butte Inn at Bend, Ore., and the Redwood Inn at Scotia, Calif., are the leading hotels in their communities. Both have been in operation for several decades.

The Process of Wood Weathering

Wood such as siding and trim on buildings, if left freely exposed to the weather without protective painting or treatment, changes materially in appearance for a few months or years, after which it stays nearly unaltered for a long time. The color of the wood is affected very soon. Woods like redwood and red cedar, that owe their color largely to substances soluble in water, may first become bleached. Woods of lighter color, such as pine and spruce, may first become somewhat brown from the action of sunlight. Later all of the woods turn gray unless the building is high in the mountains, where the brown color associated with the Swiss chalet develops.

Smoothly planed wood soon begins to acquire a rough surface. First the grain becomes raised, that is, the hard bands of summerwood rise above the softer springwood between them. Then minute checks or cracks begin to appear in the surface and steadily increase in number until the surface becomes decidedly rough as the fibrous structure of the exposed wood is greatly loosened. Finally the wood substance erodes away very slowly and the boards gradually become thinner. Wood wastes away by such weathering at the rate of approximately ¼ in. a century.

Besides the many minute checks in the surface, most woods soon develop some larger and deeper checks or cracks that are easily visible and may become conspicuous. As a rule, the woods of moderate to low density acquire fewer of the conspicuous checks than do the woods of high density. Edge-grain boards check less than flat-grain boards of the same variety of wood.

As a result of the weathering process there is a tendency for boards to cup, warp and pull at their fastenings. Firmer nailing may therefore be necessary when wood is left to weather than would be required if it were kept well painted. The cupping tendency varies with width and thickness of the boards. The greater the width in proportion to the thickness, the greater is the tendency to cup and pull at the fastenings.

Although ½ by 6 in. bevel siding was considered satisfactory by the Amana Society, ¾ by 6 in. siding would serve much better. For best results the width of the boards should not exceed 8 times their thickness.

Cypress, hemlock, white pine, ponderosa pine and spruce usually weather to a light-gray color that often has a silvery sheen. A darker gray with little or no sheen is developed by red cedar, Douglas-fir, fir, southern yellow pine and redwood. Red cedar, cypress and redwood commonly acquire fewer conspicuous checks or cracks than other woods do. Similarly, cypress, red cedar and redwood generally have the least tendency to cup and pull at fastenings; whereas pine, fir, hemlock, spruce, Douglas-fir and southern yellow pine require firmer nailing to hold them in position.

Development of Weathered Appearance Takes Time

Although the appearance of weathered wood is attractive for suitable architectural effects, there is a difficulty in making use of it for new construction, in that much time is required for the change from new to weathered lumber. Moreover, the change seldom takes place evenly over the different parts of a side wall. Those boards that receive most rain and sunshine become weathered first. Usually the lowest courses of siding on the south wall become fully grayed and roughened sooner than the top courses of siding under the eaves and much sooner than courses of siding

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under a porch roof. Wide overhang at the eaves delays the weathering of more courses of siding than a narrow overhang does. Thus for a number of months, or even for a year or two, there is a mottled appearance varying from nearly bright lumber to gray weathered wood.

The unequal delay in attaining the weathered appearance can be avoided by using rough sawed rather than the smoothly surfaced lumber to begin with and applying a gray oil stain. Such a stain can be made, for example, from raw umber in oil, white lead in oil, boiled linseed oil and mineral spirits or other paint thinner. The stain need be applied only once when the house is built; by the time the stain has worn out the wood will have developed its natural weathered gray color.

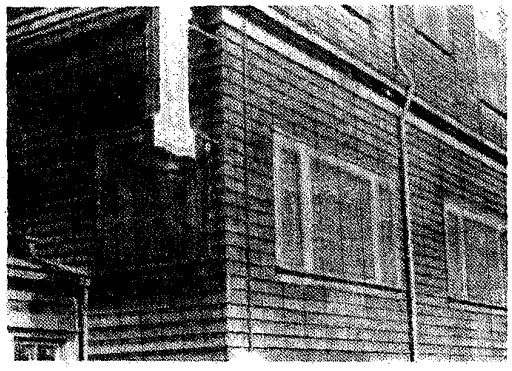
Some houses recently have used bevel siding with the planed side out and have then been given the color without the roughness of weathered wood by applying a product known as bleaching oil or sometimes as redwood bleaching oil. A number of paint manufacturers supply such products. They may be described as natural finishes of the sealer type in which there are some pigments to give the gray color. When bleaching oil is used, the wood may be kept smooth indefinitely by renewing the finish as often as proves necessary, or the first application may be allowed to wear off and leave the wood in its naturally weathered condition.

Need for Rust-Resistant Nails

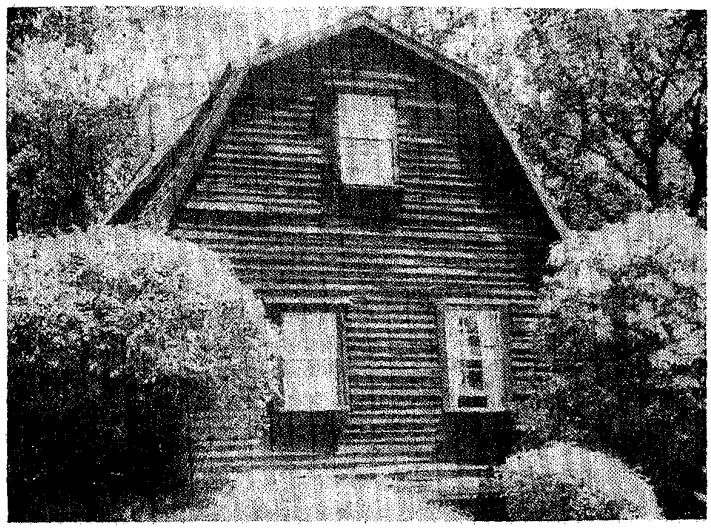
When exterior wood is to be allowed to weather naturally or is to receive a natural finish, it is particularly important to see that all nails used to fasten it and all hardware that may be placed in contact with it are highly resistant to rusting. The heads of ordinary iron nails rust rapidly, and the iron rust promptly penetrates into the wood for some distance from the nail heads. In some woods such rust makes reddish brown stains, but in woods that contain tannins, such as cedar and redwood, the stains are bluish black and very unsightly. Corrosion-resistant nails, such as galvanized nails, cadmium-coated nails or aluminum nails avoid such difficulties.

Although the weathered wood appearance may dispense with periodic renewal of paint or finish, it should not be used as an excuse for neglecting periodic inspection and careful maintenance of the building. Even when care is taken to provide firmer nailing than usual, some nails gradually become loosened and partly withdrawn by the operation of the forces of wood weathering. Every four or five years such loosened nails need to be driven in tightly again. Likewise, the same care about keeping joints tight, repairing gutters, and making other minor repairs that would be taken with a painted house, is needed when the wood is allowed to weather.

Exterior wood, then, may properly be allowed to weather naturally without protection by paint or other finish whenever it proves desirable to obtain an architectural effect in that way. For weathered wood it is wise to select the kind of wood carefully to obtain the intended result; and it is particularly wise to use lumber that is thick enough in proportion to its width, to see that it is very firmly fastened with rust-resistant nails, and to provide the same care in maintenance that would be given to a painted building.



Above: Redwood Inn at Scotia, Calif., with redwood siding and trim on first floor, redwood shingles on the second. It was 20 years old here and had never been painted. Below: the Old Fairbanks House, Dedham, Mass., built in 1636 and never painted. White pine siding was replaced in 1903. Window frame, facia wood may be the original



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Housing Research
March 1953

■ The selection of durable exterior white paint is not difficult once a few basic paint principles are understood. The primary purpose of this article is (1) to outline the functions performed by the principal ingredients which make up modern ready-mixed exterior white paint, and (2) to provide formulas which may be used by the home owner or builder as a guide in selecting paint which will retain a good appearance and gradually weather away in such a manner as to make repainting less costly. Recommendations are based on a survey of trade-brand paints available on the market in 1950, and on extensive exposure tests and observations of houses made since 1922 at Forest Products Laboratory, Forest Service, United States Department of Agriculture, Madison, Wis. The article is written in as nontechnical language as the subject will permit. Additional recommendations for a successful paint job are given for the convenience of the layman. These include such items as preparation of surface, elimination of moisture beneath the paint, frequency of repainting, and proper application techniques.

The survey of present-day exterior white house paints was sponsored by the Housing and Home Finance Agency as a part of Research Project No. O-T-24 and was performed under the direction of F. L. Browne, Chemist, Forest Products Laboratory, U. S. Department of Agriculture. This article was prepared by William A. Russell, Chief, Technical Standards Unit, HHFA's Division of Housing Research.

Selection of Durable Exterior White House Paint

Exterior painting, even when the most durable type of paint is used, is usually the largest item of maintenance expense for the owner of the average house, particularly if the exterior covering is wood siding. The cost of repainting a house often amounts to several hundred dollars, of which the largest portion by far is the cost of the labor to prepare the surface and apply the paint. The amount of paint required to repaint the average small house is seldom more than eight to ten gallons, so that the additional cost of procuring a good durable paint is very small in relation to the total cost of the repainting job, usually not more than a dollar or two per gallon. On the other hand, where care is not taken to select a durable paint, repainting is often required twice as frequently, which practically doubles the cost of paint maintenance to the owner.

All reputable companies manufacture and recommend durable house paints. These paints are, in general, trade-brand paints which are advertised to the public. They are first-line, quality-controlled products which have been developed by patient research and are commonly open-formula paints (i. e., the formula is printed on the container label). They are the paints upon which each manufacturer stakes his reputation. First-line, trade-marked paints are more carefully formulated than other less expensive paints, often referred to as "competitive" paints. The latter are often made up especially for painting contractors in order to meet competition. Mere presence of a formula on the label, however, does not insure that the paint is of first quality because laws in many states require that all paint offered for sale to the public must have the formula on the container label.

A recent nation-wide survey of dwellings made by Forest Products Laboratory, Madison, Wisconsin, under the sponsorship of the Housing and Home Finance Agency reveals that it is false economy for the home owner to use anything less than first-line, open-formula paints. The purpose of this article is to explain the functions performed by the principal ingredients of modern white paint and to provide guides which will permit any builder or home owner to select or specify paint which will retain a good appearance for a reasonable number of years. It is limited to selection of ready-mixed white paints for application to wood which is exposed to the weather. Recommendations

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herein contained are based chiefly on a survey of 60 leading brands of white paint available on the market in 1950, together with information derived from paint exposure tests during the past 30 years under the supervision of F. L. Browne, Chemist, Forest Products Laboratory, Madison, Wis. Not only paints of many different formulas have been tested, but studies have been made on all of the common woods and of the variables of application and maintenance, including actual 15-year weathering tests of typical paints under various repainting schedules.

The word "durable" as used herein refers to ability of the paint film to resist cracking, crazing, peeling, and excessive chalking, all of which have to do with the integrity of the paint film rather than the appearance of the paint. For example, a white paint on the exterior of a house may change to a gray color after prolonged weathering. The owner of the house may feel that the paint is not durable from the standpoint of appearance, although the integrity of the film may be substantially unimpaired. Paints are less durable when exposed to bright sunlight, and, as would be expected, the same paint applied in a northern latitude such as Minnesota would retain its good appearance often for several years more than if applied in one of the dry southwestern States, such as Arizona, where sunlight is much more intense.

Paint Composition

The common ingredients of modern white paint for application to exterior wood are relatively few. Basically, exterior paints are a mixture of finely ground insoluble particles, called pigments, which are suspended in an oily liquid, called the vehicle. Pigments consist of white lead, zinc oxide, titanium dioxide, and pigment extenders. Vehicles consist of raw or refined linseed oils, driers, bodied oils, and volatile thinners. By varying the amounts of these ingredients, an enormous number of paint formulas can be produced. However, certain combinations of these ingredients have stood the test of time and are known to be durable.

Of course, no paint can be expected to last forever and, consequently, repainting is required even with the most durable types of paint. It is important, however, in order that the painted surface be suitable for repainting, that the paint film retain its integrity and gradually weather or wear away by disintegration into fine dustlike particles (so-called "chalking") rather than by cracking, curling, or peeling.

No amount of repainting will remedy a paint coating which has cracked. On the contrary, tests show that repainting actually aggravates the condition. Overpainting, the building up of thick coatings by many applications of paint, often produces less durability than too thin a paint coating. It is important, therefore, that paints be of the "chalking" type so as to permit of periodic repainting without building up too thick a coating. Otherwise the paint will have to be entirely removed at great expense if durability is to be achieved.

The Pigments

To produce exterior white paints having desirable weathering characteristics, certain fundamental relations between the ingredients making up the paint must be observed. One of the most important of these is the amount of chemically active pigments contained in the paint. The pigments in white exterior paint serve several purposes. Some, especially white lead and zinc oxide, are chemically active; they neutralize the acid produced by aging linseed oil which otherwise would seriously reduce the durability of the paint. Others, especially titanium dioxide, have great covering power or opacity, which is the ability to hide or conceal what is behind them. Others provide bulk and resistance to abrasion at low cost. They are often referred to as "extenders" since they reduce the amount of higher-priced lead, zinc, and titanium pigments needed.

During the past 50 years there has been a great change in the pigments used in exterior white paint. In 1900 nearly all house painting was done with pure white-lead pigments in raw linseed oil. White lead is still one of the most important pigments in good paint. It is probably the most chemically active pigment and by reacting chemically to neutralize the acid decomposition products of linseed and other drying oils, it enables paint films exposed to the weather to retain their toughness and flexibility for a longer period of time. White lead has

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other desirable characteristics; it weathers by mild checking and chalking so as to facilitate normal maintenance repainting without the necessity for complete removal of old paint. It also makes the paint resistant to absorption of water. Tests indicate that paints made without white lead absorb up to several times as much water as those having a substantial amount of white lead, which tends to make them weather more rapidly.

Pure white lead paint remains one of the most reliable paints for maintaining its integrity even under rather adverse conditions but it is attacked by hydrogen sulphide fumes, which turn it gray in contaminated industrial atmospheres, is usually more expensive, and becomes more easily soiled by dirt than most paints made with a mixture of lead, zinc, and titanium pigments.

By 1920 many paint manufacturers had replaced a portion of white lead with zinc oxide. A pigment also chemically active, it is not affected by hydrogen sulphide. Also it acts as a fungicide to prevent the paint from mildewing. Addition of moderate amounts of zinc oxide produced a somewhat harder paint film which collected less dirt and grime, was less affected by hydrogen sulphide, and chalked less freely than straight white lead paints. These lead-zinc (LZ) paints retained their clean white appearance longer, particularly in residential areas uncontaminated with industrial fumes. Tests indicated that replacing too much of the white lead with zinc oxide results in a hard, nonelastic paint film which tends to become brittle with age and weathers by cracking and curling instead of by slight checking or chalking. This makes repainting difficult and often ineffective unless all of the old paint is first removed. These lead-zinc (LZ) paints have now almost disappeared from the market.

By 1930 a new pigment, titanium dioxide, had begun to appear in many white paints. Titanium dioxide is a chemically inert pigment of great whiteness and opaqueness. Up until this time white lead and zinc oxide provided all of the opacity; they were used in larger proportions than necessary for chemical activity in order to secure opaqueness and the use of "extenders" was limited, since most of the commonly used extenders are virtually transparent in linseed oil. Titanium dioxide, on the other extreme, is so opaque that it may be diluted with two to three times its volume of transparent pigments and still be as opaque as the lead and zinc pigments. The transparent pigments used for extenders are usually finely ground silica (sand) or some compound of silica, such as magnesium silicate (talc). They are chemically inert and are very low in cost. By substituting a mixture of titanium dioxide and these extenders for a portion of the higher-priced chemically active pigments, a considerable saving in cost of pigments is effected and the more critical lead and zinc pigments are conserved without sacrificing opaqueness or covering power.

Titanium dioxide and the silicates commonly used as extenders are chemically inert. Unlike the lead and zinc pigments they cannot be counted on to neutralize the acid products generated by the aging of linseed oil. When used in moderate amounts they improve the covering power of the paint and enable it to retain a clean white appearance without sacrificing durability. It is extremely important that they be used in moderate amounts and always in combination with sufficient amounts of chemically active pigments to neutralize the acid generated by the aging of linseed oil. Otherwise the paint will usually lack durability.

By 1950 the great majority of paint manufacturers were producing titanium-lead-zinc paints for sale as their first-grade, trade-brand paints. A survey of over 60 well-known trade-brand paints in 1950 reveals that approximately 75 percent of the brands on the market were titanium-lead-zinc (TLZ) paints. Lead-zinc (LZ) paints, on the other hand, had practically disappeared from the market and accounted for only 3 percent of those surveyed. Straight white lead (L) paints accounted for approximately 6 percent of those on the market. The remaining 16 percent were the leadless, so-called fume-resistant paints, often recommended for use around industrial areas where hydrogen sulphide blackens lead pigments. This latter class contained titanium-zinc pigments (TZ).

From the preceding it is apparent that while in the early part of this century lead or lead and zinc pigments furnished both chemical activity and opaqueness, in modern paints they are used for their chemical activity rather than for opacity because opacity is obtainable much more

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economically by using titanium dioxide and low-priced extenders.

The Vehicle

The vehicle for exterior house paint consists principally of drying oils; oils which oxidize and dry out to form tough elastic films when exposed to the atmosphere. The most important of these is linseed oil which is a vegetable oil derived from flax. Other drying oils, such as soy bean oil and tung oil, are used in varnishes but seldom in exterior house paint.

Either raw linseed oil plus necessary driers or so-called boiled linseed oil, in which the driers have already been incorporated, may be used. Raw linseed oil without driers hardens too slowly. The name "boiled" linseed oil is misleading because the raw oil is not actually boiled but is only slightly heated in combination with driers, such as soluble compounds of lead, manganese, and cobalt, until the driers dissolve in the warm oil to produce a slightly thickened oil which dries more rapidly. The better grades of raw linseed oil, which have been purified by treatment with acids or alkalies, are called "refined" linseed oils. Paints having relatively large amounts of raw or boiled linseed oil are known to the paint trade as "oil rich." They are preferred for exterior paint applied to wood, since they produce a tough elastic film. When drying oils are heated to high temperature for a considerable period of time, they become thickened in consistency and are then called "bodied oils."

In addition to the raw and boiled linseed oils, a portion of the vehicle may consist of bodied oils and resins. These are thick heat-treated oils or resins which require additional volatile thinners to provide workability. A moderate amount of bodied oils usually improves the application properties by making the paint flow out smoothly without leaving conspicuous brush marks. But too much bodied oil changes the paint into an enamel and makes it much more difficult to apply. When present in too great a proportion, bodied oils reduce the toughness and elasticity of the film to the point where it becomes brittle and is unable to expand and contract with the seasonal changes of the wood, so that cracking and curling of the paint result.

Paints containing large amounts of bodied oils and resins are known as "oil-restricted" paints and are often advertised as "enamelized," "quick-drying," or "resin-fortified" house paints. These oil-restricted paints are midway between oil-rich paints and enamels. Oil-restricted paints have some of the properties of enamels and varnishes and, accordingly, would be expected to have less durability, when exposed to the weather, than oil-rich paints.

Prior to World War II, there were only a few brands of oil-restricted paint on the market; the best brands of paint contained only a small proportion of bodied oil. Oil-restricted paint became general during the war due to a critical shortage of linseed oil. By 1948, when linseed oil again began to be in good supply, most manufacturers of good paint began to increase the unbodied oil content of their first-line paints. By 1950, some manufacturers had returned to oil-rich formulas, and most present-day, first line paints show a trend back toward oil-rich formulas.

The balance of the vehicle is composed of thinners and driers. Volatile thinners are used in order to provide the proper consistency for easy application and to reduce the thickness of film so as to increase the rate of drying. The commonly used thinners are turpentine, which is distilled from the natural resin of pine trees and a petroleum distillate known as "mineral spirits" which evaporates at about the same rate as turpentine. Both turpentine and mineral spirits evaporate almost completely during the drying period of the paint. While turpentine was originally the favored thinner, mineral spirits are entirely satisfactory and are less expensive.

To summarize, linseed oil is still the most important ingredient of the vehicle in first-grade exterior white paint. Bodied oils are used sparingly and mineral spirits have, to a large extent, replaced turpentine as the volatile thinner.

Research and experimentation in paint formulation continues, with new combinations of pigments being tried with new vehicles. Other methods of producing durable paints may be developed as our present knowledge is extended.

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Modern Paint Formulas

There are no published industry standards which would assist the home owner and builder in selecting a durable paint, despite the fact that satisfactory paints are obtainable in most paint stores. The home owner is usually confused by advertising claims and the lack of information which would assist him to identify a good paint. Today's first-grade white house paints are the result of extensive and costly research on the part of the paint manufacturing industry in an endeavor to produce good paint at a reasonable cost which will perform satisfactorily in a wide range of climatic conditions.

In order to provide a satisfactory guide for identifying a good quality paint, 60 leading brands of open-formula, first-grade white paint available on the market in 1950 were surveyed. As previously stated, 75 percent of these paints were titanium-lead-zinc paints. Some manufacturers offer a "fume-resistant" white paint, with titanium and zinc pigments but no lead, for use in industrial and other localities in which there may be hydrogen sulphide in the air.

The formulas of the titanium-lead-zinc paints surveyed varied considerably. Formulas were averaged and the average formula is shown in table 1.

Formulas of paints which have been undergoing actual weathering tests at Madison, Wis., for 15 years under various schedules of maintenance repainting were compared with the average formula. A paint which conforms approximately to the average industry formula for 1950 was found to be one of the more satisfactory of those tested.

The Federal Government has prepared specifications [1] for the procurement of white exterior paints which are known from actual experience to have good durability.

One of these, Federal Specification TT–P–102, contains a formula for white, exterior, ready-mixed, titanium-lead-zinc paint. The formula for this paint is given in table 2, according to Form A.

[1] For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 10 cents.

Table 1

Average TLZ paint of 1950 according to Form A (percent by weight)		Average TLZ paint of 1950 according to Form B (percent by weight)	
Percent total paint		*Percent total paint*	
Total pigments	62.5	White lead	16.4
Percent pigments		Zinc oxide	18.0
White lead	26.2	Titanium dioxide	9.2
Zinc oxide	28.8	Extenders	18.9
Titanium dioxide	14.7	Total pigments	62.5
Extenders	30.3		
	100.0		
Percent total paint			
Total vehicle	37.5		
Percent vehicle			
Raw linseed oil	52.0	Raw linseed oil	19.5
Bodied linseed oil	23.0	Bodied linseed oil	8.7
Thinner and drier	25.0	Thinner and drier	9.3
	100.0	Total vehicle	37.5

Paint formulas may be given in several different forms. Two of the most common forms, which for purposes of identification are arbitrarily denoted as Form A and Form B, are given in table 1. In Form A the pigment and vehicle compositions are shown separately, while in Form B the percentages of combined pigment and vehicle (total paint) are shown for the same average first-grade titanium-lead-zinc paint manufactured in 1950.

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Table 2.—Federal Specification TT–P–102, Class A Exterior, White, Ready-Mixed, Titanium-Lead-Zinc Paint According to Form A

	Percent by weight	
	Minimum	Maximum
Percent total paint		
Total pigments	62	------
Percent pigments		
White lead	31	------
Zinc oxide	25	27
Titanium dioxide, anatase type	15	17
All other pigments [1]	------	28
Matter soluble in water	------	0.8
Percent total paint		
Total vehicle	------	38
Percent vehicle		
Raw or refined linseed oil	60	------
Bodied linseed oil	16	20
Thinner and drier	------	20

[1] The other pigments shall be magnesium silicate, aluminum silicate, silica, or any mixture thereof.

A comparison of the average formula of first-quality trade brand titanium-lead-zinc white paints as shown in Form A of table 1 with Federal Specification TT–P–102 as shown in table 2 reveals that they are quite similar in many respects. Pigment contents are 62 and 62.5 percent, respectively; chemically active lead and zinc pigments are 55 and 56 percent, respectively; and totals of raw plus bodied oils are 75 and 76 percent, respectively. Principal differences are in the ratio of lead to zinc and raw to bodied oils and in proportions of pigment extenders and thinners. These do not appear to be great enough to have much effect on satisfactory performance of the paints. It should be kept in mind that the formula shown in table 1 is the average for first-quality industry paints and that the first-quality paint of many producers is in even closer agreement with the Federal Specification cited.

It may, accordingly, be safely concluded that exterior white paint having a formula that falls within the range of values between those in table 1 and those in table 2 would be expected to provide a durable paint which weathers by chalking mildly so as to facilitate maintenance repainting without costly removal of the old paint. These paints are sometimes advertised as "self-cleaning" since the weather-stained outer particles chalk off and expose white unstained particles beneath, thereby maintaining a clean appearance.

Federal Specification TT–P–103 covers white, exterior, ready-mixed, titanium-zinc paint, a lead-free paint which is recommended for industrial and other areas where hydrogen sulphide would cause white lead to turn gray. The formula for this so-called fume-resistant paint is given in table 3, according to Form A.

For industrial areas where it is customary to use a lead-free fume-resistant paint, a paint similar in formula to that shown in table 3 would be expected to give good service.

Federal Specification TT–P–104 covers white, exterior, ready-mixed white lead paint, the formula for which is given in table 4.

Where integrity of film rather than a clean white appearance is desirable, white lead paint similar in formula to that shown in table 4

Table 3.—Federal Specification TT–P–103, Exterior White, Fume-Resistant, Ready-Mixed, Titanium-Zinc Paint According to Form A

	Percent by weight	
	Minimum	Maximum
Percent total paint		
Total pigments	59	------
Percent pigments		
Zinc oxide	38	------
Total titanium dioxide	19	------
Titanium dioxide, anatase type	9.5	------
Titanium dioxide, rutile type	------	9.5
All other pigments [1]	------	43
Percent total paint		
Total vehicle	------	41
Percent vehicle		
Raw or refined linseed oil	50	------
Bodied linseed oil	20	26
Thinner and drier	------	24

[1] Other pigments shall be magnesium silicate, aluminum silicate, silica, or any mixture thereof. Calcium sulphate in an amount (maximum 22 percent) corresponding to the extender portion of the rutile titanium calcium pigment used will be permitted.

Table 4.—Federal Specification TT-P-104, Exterior White, Ready-Mixed, White Lead and Oil Paint According to Form A

	Percent by weight	
	Minimum	Maximum
Percent total paint		
Total pigments	71	73
Percent pigment		
Basic carbonate white lead	99	------
Matter soluble in water	------	0.8
Percent total paint		
Total vehicle	27	29
Percent vehicle		
Linseed oil	70	75
Thinner and drier	25	30

would be expected to give good service, especially in clean residential atmospheres.

Priming Paint

A special priming paint is generally recommended by manufacturers for the first coat on new wood or where well-weathered old paint is to be repainted. It is important that the primer and the finish coats be compatible. A primer produced by one manufacturer should ordinarily not be used with the finish paint of a different manufacturer, since formulas may be different and the oils in the two paints may react adversely and cause poor adhesion of the finish coats to the primer. Zinc-free primers are usually preferred except for fume-resistant paint (table 3) because their adhesion to the wood is usually better.

When it is impossible to get a recommended primer, a substitute primer can be made by adding 1 pint of linseed oil to 1 gallon of the finish coat paint in order to compensate for the oil which will be absorbed by the wood. It is also customary to slightly thin such a primer with not to exceed 1 pint of thinner per gallon to increase workability and penetration into the wood surface. Either turpentine or mineral spirits may be used for thinner.

For guidance in selecting a priming coat for titanium-lead-zinc paint, Federal Specification TT-P-25a is shown in table 5. Similar primers are available at paint stores and are recommended for specific use with trade-brand paints.

Where fume-resistant titanium-zinc paint is to be applied, a lead-free primer is made by adding 1 pint of linseed oil to a gallon of the finish coat paint (table 3) and up to 1 pint of turpentine or mineral spirits to increase workability and penetration into the wood surface. A primer for use with straight white lead paint is also made by adding 1 pint of linseed oil to a gallon of the finish coat paint.

Table 5.—Federal Specification TT-P-25a, Exterior Primer, Ready-Mixed, White

	Percent by weight	
	Minimum	Maximum
Percent total paint		
Total pigments	62	------
Percent pigments		
Total white lead	50	------
Basic carbonate white lead	25	------
Basic sulphate white lead	------	25
Titanium dioxide (nonchalking rutile type)	12	------
Extenders [1]	------	38
Matter soluble in water	------	0.8
Percent total paint		
Total vehicle	------	38
Percent vehicle		
Raw linseed oil	------	32
Bodied linseed oil	32	------
Resin (pale coumarone or ester gum)	------	4
Thinner and drier	------	32

[1] Extenders shall be white siliceous mineral pigment types of magnesium silicate, aluminum silicate, and silica.

Guides for Selecting Good Paints

Armed with this information, builders and home owners should be able to provide themselves with exterior white paints with good performance characteristics if they will take the following steps:

1. Buy or specify only paint that carries the formula printed on the container label.

2. When a titanium-lead-zinc exterior white paint is desired, examine the formula on the label and be sure that:

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(*a*) Total chemically active pigments (lead plus zinc) are not less than 55 percent of the pigments (34 percent of the total paint) by weight.

(*b*) White lead is 25 to 35 percent of the pigment (16 to 22 percent of the total paint) by weight.

(*c*) Zinc oxide is 25 to 30 percent of the pigment (16 to 19 percent of the total paint) by weight.

(*d*) Pigment extenders (silicates) are not more than three times the titanium dioxide, by weight.

(*e*) Drying oils (bodied plus unbodied) are not less than 75 percent of the vehicle (28 percent of the total paint) by weight.

(*f*) Bodied oils are not more than 25 percent of the vehicle (10 percent of the total paint) by weight.

3. When a good fume-resistant exterior white paint is required, for use in industrial or other areas contaminated by hydrogen sulphide, examine the formula and select one which is similar to that given in table 3.

4. When a straight white-lead exterior white paint is desired, the formula should be similar to that shown in table 4.

5. Select priming paint for titanium-lead-zinc which the manufacturer recommends for use with his finish paint. The formula given in table 5 may be used as a guide. For titanium-zinc (fume-resistant) and straight white-lead paints, add linseed oil, in accordance with manufacturer's recommendations (usually 1 pint of linseed oil to 1 gallon of paint) to the finish paint to produce a primer.

6. Owners or builders specifying paint in contracts should specify the formula. Specifying only the brand name is not sufficient, since most paint manufacturers make various grades and types of paints. There should be no "or equal" provision in the specification, because that phrase is meaningless in view of the lack of commercial standards for paints. Inspections

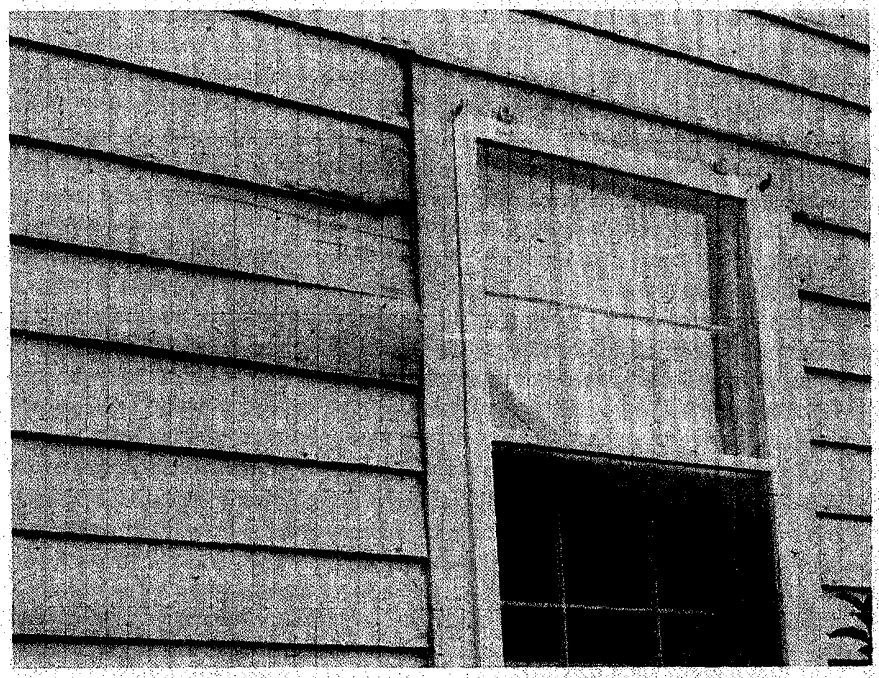

Plate I.—Durable Paint Will Not Correct Construction Defects

Note wood siding badly rotted out around a window opening which was improperly flashed. A durable paint was applied to this house 4 years before the picture was taken. The paint is still sound even on the boards which have rotted.

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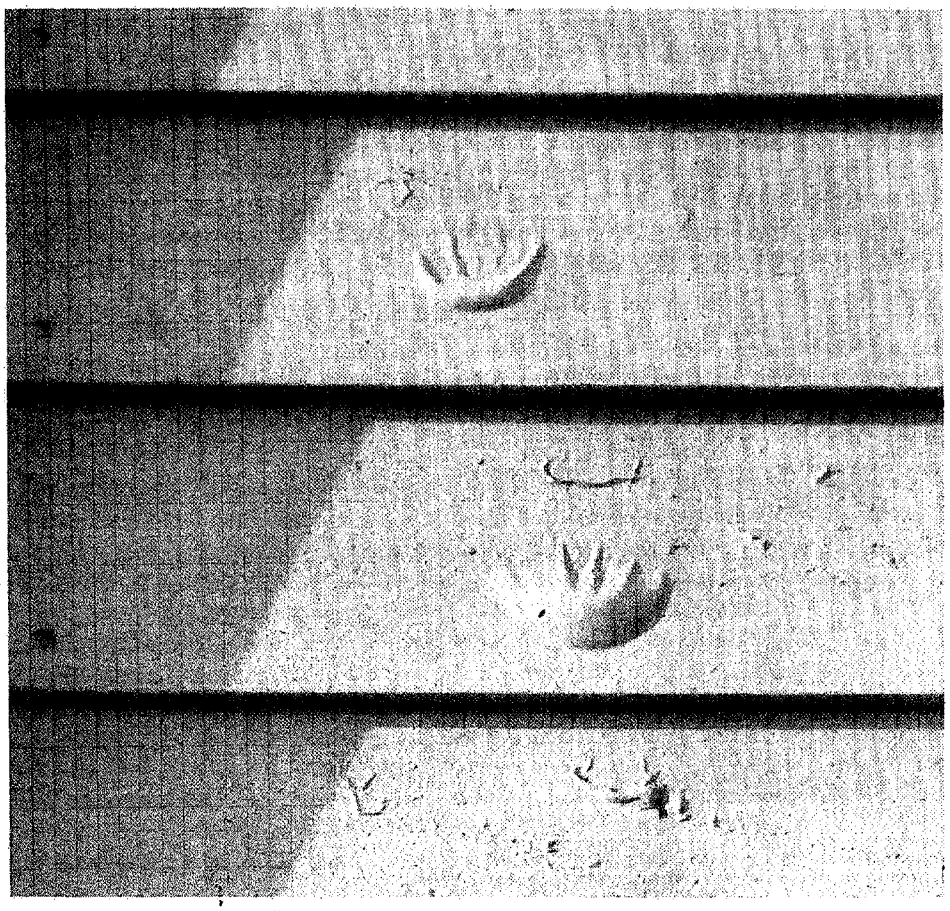

Plate II.—Blistering Caused by Condensation

Water-filled blisters which form during the spring thaw are usually caused by condensation of moisture which originates as water vapor within the house and migrates in the form of vapor into the cold cavities between the studs, where it condenses on sheathing or siding. Usually more pronounced on north side of house. Seldom found on unheated porch walls or garages.

Photo shows blisters which formed in early March on the north wall of a test building, in Pennsylvania, which had been painted with three coats of titanium-lead-zinc paint. Blistering was caused by high humidity within the building plus an ineffective vapor barrier and was not the fault of the paint.

should be made to see that the paint specified is actually used on the job.

Other Precautions

The mere selection of a durable type of paint, of course, will not insure a satisfactory or durable paint job. Even the best paint will not be durable where precautions are not taken to keep water from getting behind it. Plate I shows wood badly rotted out around a window opening due to omission of flashing over the opening. A durable paint was applied to this house 4 years before the photograph was taken and is still sound even on the boards which have rotted. Siding on an improperly constructed house may also become soaked with water due to condensation[2] of water vapor originating within the house, basement, or crawl space. This may cause blistering of the paint as shown in plate II. Conversely, improperly formulated paints would not be expected to be durable even when applied to a house which is properly constructed to keep the wood dry.

[2] See HHFA Publications, *Condensation Control in Dwelling Construction*, August 1949, 20 cents; Technical Reprint No. 1, *Crawl Spaces*, February 1950, 15 cents. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

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Plate III.—Effect of Condensation on Paint

This photograph of attached dwelling units, in southern Illinois, illustrates the effect of severe condensation on exterior paint. Wall is pockmarked with bare spots where blisters have broken and paint has peeled off. The paint on the upper portion under the eave is stained by mildew. The wall had no vapor barrier. Even the best paint will not be durable unless excessive condensation is controlled.

Causes of Nondurability

When the home owner has had trouble with the previous paint he should examine it carefully before repainting, to determine whether it was caused by moisture behind the paint or whether the paint, itself, was at fault. If the paint developed water-filled blisters during the spring thawing season after a severe winter, the lack of durability may be due to condensation. Where such is the case, no amount of repainting even with the most durable type of paint will remedy the situation. The cause of the moisture should first be corrected by applying a continuous vapor barrier on the interior face of the exterior walls or by elimination of excessive moisture in the basement or crawl space. Blistering due to condensation is usually most pronounced on the cold north wall of the house and leaves the wall pockmarked with bare spots which may be round, oval, or elongated in the direction of the grain as shown in plate III. Where blistering is due to condensation, it usually occurs only on the exterior walls of heated rooms, seldom on unheated garages or open porches.

On the other hand, cracking, scaling, and peeling, or excessive chalking of the paint with no evidence of blistering indicates that an improperly formulated nondurable paint has been used. It is usually more pronounced on the south side of the house where it is subjected to the direct rays of the sun and occurs equally on unheated and heated portions of the house, indicating that it is not due to condensation. Plate IV illustrates cracking and peeling on both the heated wall and the unheated porch gable approximately 18 months after the paint was applied. Plate V shows a home on which paint is chalking badly on both the house and the unheated garage after a short service life.

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Plate IV.—An Example of Nondurable Paint

Note cracking and peeling on both the heated wall of the house and also on the unheated porch gable indicating that a short-lived nondurable paint was applied. The house was repainted approximately 18 months before the picture was taken. Complete removal of the old paint is recommended before repainting.

Plate V.—An Example of Excessive Chalking

Paint on this home has eroded by excessive chalking after a short service life. Note that the paint has chalked off the unheated garage as well as the heated walls of the house. This indicates that an improperly formulated paint has been used. If the cause had been excessive condensation, the paint on the unheated garage would not have been affected. Complete removal of the old paint will be necessary to insure durability of future paint coats.

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Plate VI.—An Example of Over-Painting

This 25-year-old house had been painted so frequently that an excessively thick coating had been built up, as evidenced by cross-grain cracking. When an additional coat of paint was applied, blisters formed. Wood was found to be dry. The cause of the blisters was found to be due to chemical attack by the new paint on one of the oldest layers of paint, not to condensation.

The indications are that improperly formulated paints have been used of the type known to the trade as competitive paints which are manufactured down to a price in order to meet competition rather than up to a durable standard of quality.

It is, of course, sometimes difficult to determine whether lack of durability is due to improperly formulated paint, excessive condensation, or a combination of both. When the lack of durability has been identified as improperly formulated paint, it is necessary to completely remove the old paint and start over again, or the repaint job usually will not be durable. Building up thick coatings of paint by frequent repainting usually only aggravates the cracking and peeling, even when good paint is used, and may result in blistering as shown in plate VI. Where early removal of a cracked and peeling paint job is too difficult, it is usually better practice to endure the unsightly appearance until its removal becomes easier. Repainting should not be necessary more frequently than 4 years in southern climates, or 6 or more years in northern climates where sunlight is less intense. Plate VII shows clearly the effect of too frequent repainting.

Weather Conditions

The surface of the wood should be dry. Finish lumber or siding should preferably be kiln dried. If the lumber or finish has become wet, at least 1 week of dry sunny weather should precede the painting. It is best not to apply paint in cold, foggy, or damp weather. The surface should be free of dew or frost and painting should not be done when the temperature is below 50°. Summer or early fall, when the wood is thoroughly dry, is the preferable time to repaint.

Preparation of New Wood Surface

All pitch should be scraped or burned from knots and these places should be scrubbed with

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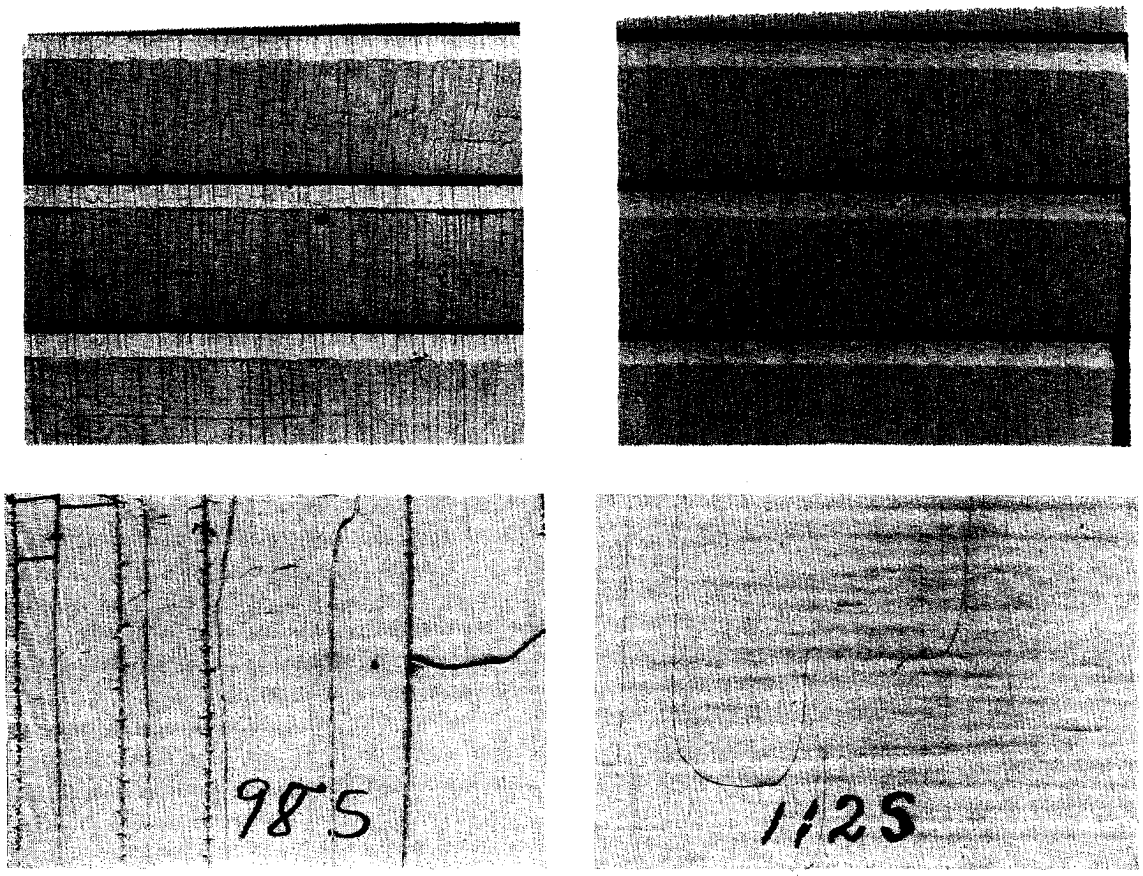

Plate VII.—Showing Results of Too Frequent Repainting

Results after 15 years of maintenance painting. Both the 18- by 22-inch upper panels were originally given a priming coat and then painted with two additional coats of titanium-lead-zinc paint. The panel on the left was subsequently given two coats of the same paint every 2 years and photographed at the end of 15-year exposure. The panel at the right was given two coats of the same titanium-lead-zinc paint every 5 years and photographed at the end of 15-year exposure. Panels 98S and 112S are closeup views of portions of the panels directly above them 1½ by 2¼ inches in size showing details of condition of the paint. The panels were constructed of southern yellow pine and Douglas fir and faced south at Madison, Wis.

turpentine prior to painting. To prevent paint from peeling or being discolored over knots, these are often spot primed a day or two in advance of applying the first or priming coat of paint. Shellac and aluminum paints have been used for sealing knots but neither has proven entirely satisfactory. A new synthetic resin base knot sealer, known as formula WP578, was developed a few years ago for sealing knots in Western pines and firs, and tests to date indicate it to be effective. The formula for this knot sealer is shown in table 6. It is produced and recommended by a number of paint manufacturers and is available at most paint stores. Knots should be sealed before the priming paint is applied.

Table 6.—WP578 Knot Sealer

	Percent by weight
Phenol-aldehyde resin spirit varnish	33⅓
Polyvinyl butyral resin	3⅓
Denatured alcohol (ethyl)	63⅓
	100

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Application of Priming Coat

The first or priming coat of paint should be thoroughly brushed and cross-brushed so that cracks and nail holes receive enough paint to wet the surfaces. The prime coat should be allowed to dry for several days, following which nail holes and cracks should be puttied.

Drying Time Between Coats

In clear warm weather, 2 or 3 days is sufficient drying time between coats. A longer time is required in cold or damp weather. Paint should not be applied over preceding coats which are not hard and dry. Drying time should not be unduly long between coats, however—seldom more than 2 weeks. Unduly long drying time between coats can be as harmful as insufficient drying time.

Repainting

The procedure for repainting depends on the condition of the old paint. Where the paint is cracked and peeling, or where heavy coatings have been built up by previous repainting and have checked badly, it is recommended that all the old paint be removed either by burning it off with a torch or by the use of paint remover. The recommended procedure for repainting is then the same as that given above for new wood.

Where the old paint has weathered by chalking off, all loose paint should be removed by wire brushing or scraping. Following wire brushing and scraping the surface should be sanded with No. 1½ or No. 2 garnet paper to further insure the removal of loosely adhering paint.

Number of Coats

For previously unpainted wood, or wood from which all the old paint has been removed, three coats are usually applied. The priming coat is spread to cover approximately 600 square feet. This is followed by a second coat which is usually thinned, in accordance with manufacturers' recommendations, with not more than 1 pint of thinner per gallon of paint and spread to cover approximately 800 square feet. The third and final coat is applied without thinning at the rate of approximately 700 square feet per gallon.

For repainting, where the old paint was of a durable type which has become well-weathered by crumbling, flaking, or gradual chalking off, two coats are usually applied. The first coat may be either a regular priming paint, or a substitute primer made by adding 1 pint of linseed oil to the finish paint to compensate for oil which will be absorbed by the old surface. The priming coat is applied in the same manner as for new wood, at a spreading rate of 450 square feet per gallon, and the finish coat is applied without thinning and spread to cover approximately 700 square feet per gallon.

Where the old paint is in good condition and shows only fine checks or mild chalking, a one-coat repainting job is recommended in order to avoid building up a thick coating. The prime coat is omitted and a thicker film is applied without thinning at a rate of 600 square feet or less per gallon in order to achieve complete coverage with one coat.

As previously stated, the building up of thick paint films by frequent repainting should be avoided, because thick films are prone to crack and curl and eventually will have to be completely removed at great expense in order to eliminate this trouble. Before repainting, the home owner should allow sufficient time for a large portion of the paint to chalk off. Present day titanium-lead-zinc paints are designed to maintain a clean white appearance in ordinary clean residential atmosphere, even though the paint has weathered almost down to the wood. It is better to err on the side of too infrequent repainting than to overpaint, and it is much less costly. The original clean white appearance can often be restored by simply washing the paint to remove the surface grime. Mere unsightliness which can be corrected by cleaning should rarely be considered sufficient reason for repainting until the coating has become well worn.

Conclusions

The success of a painting job depends principally on the following factors:

1. Selection of a durable type paint which weathers by chalking mildly.
2. Maintenance of dry wood beneath the paint by controlling condensation and preventing rainwater from getting behind the siding and trim.
3. Selection of favorable painting weather.

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4. Proper preparation of the surface to receive the paint.

5. Proper application at not too frequent intervals.

Authorities are in agreement that shopping around for paint bargains, at the expense of quality, is false economy. Builders should require painting subcontractors to furnish open formula paints of at least the standard of quality described herein and should inspect the operations of the subcontractor to make sure that the paint specified is actually used on the job. Competitive paints, which are formulated down to a price instead of up to a minimum standard of quality, should be avoided both by the builder in the original paint job on the house and by the homeowner when repainting is necessary.

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Repaint at Longer Intervals, Experts Advise

Tests Prove Painting

TOO OFTEN MAY CAUSE TROUBLE

JOHN NEWHOUSE
(State Journal Staff Writer)

Repaint your house more often than once in every six years, and you may be in for trouble.

hat's th word from the Forest Products Laboratory, now that the results of a 15-year experiment are in.

The too frequent repaintings, they have found, result in too thick a coat of paint on your house. This thick coat of paint is subject to what they call cross grain cracking.

In cross grain cracking, the cracks will run vertically to, rather than horizontally with, the siding. When it appears, it means that whole pieces of the paint are going to come off soon —perhaps from the weight of the next coat of paint alone.

To be safe, there's nothing to do but remove the paint—and that is much more expensive and time consuming, than any single painting job—and start painting all over again.

In their experiment, Drs. F. L. Browne and D. F. Laughnan, of the laboratory, tried out 12 paints over the 15 year period.

And they found that—in terms of long time economy—white lead was the most satisfactory, though not the cheapest nor necessarily the best for brightness or for hiding qualities.

Tempted to Repaint

The temptation is to repaint when the first paint job loses its luster, and may even be cracking and crumbling here and there, say Drs. Browne and Laughnan.

The obvious answer to the problem is, of course, to repaint at longer intervals. So, to determine what the interval should be, they set up a test fence and painted panels with the 12 paints at intervals from two coats every two years to two coats every six years.

Four of the paints used tell the story pretty well, as far as today's most widely used paints are concerned: a typical white lead paint; a lead-zinc paint; a titanium - lead - zinc paint, and a titanium zinc paint.

Since some woods hold paint better than others, four species of wood were used on the fence to represent siding — Douglas fir, southern yellow pine, eastern white pine, and western cedar.

Generally speaking, the white pine and cedar tend to hold paint better because the annual growth rings are narrower and have less of the hard summerwood — the slow-growing, dark part of each growing ring—from which the paint weathers faster.

At first, the weathering was about what you'd expect, with the paints breaking down either by checking and crumbling or by cracking and flaking. The checks, which go only part way through the film of paint, and the cracks, **(It's been discovered that paint has a "grain" which is determined by the direction of the last stroke of the brush and which thus usually follows the grain in the wood.)**

But, with the paint piling up with repainting, the paint cracked across the grain, giving the signal for removing the paint and starting out all over again.

Most satisfactory of the 12 paints tested, in terms of long-range economy, was the standard white lead paint, said the laboratory.

"Even under the heaviest repainting schedule — two coats every two years — it stood up without cross-grain cracking for 10 years," said Dr. Browne. "With two coats each six years, it stood up the entire 15 years without trouble. And it took a coat every three years and two every five without trouble as well."

Paint 'Dusts' Off

What it means, said the laboratory man, is that the white lead paint crumbles away at a rate which permits repainting at six-year intervals—possibly for the entire life of the house—without having to remove the old paint.

"Perhaps the most widely used first grade paints today," says an article by Fred Strenge in a recent issue of Science and Mechanics magazine, "are formulations of white lead, titanium dioxide, and zinc oxide.

"The titanium-dioxide, lead-zinc paint tested did not resist cross grain cracking as well as the white lead paint. In fact, even with the minimum of two coats each six years, it showed cross grain cracking by the time it was 15 years old.

"The best of the lead-zinc paints tested took a coat every five years and two coats every six years without showing cross grain cracking at the end of the 15 years, but any heavier repainting schedule brought trouble within the test period.

"The titanium-zinc remained free from cross grain cracking when repainted with two coats each six years."

Though white lead paint held the edge, the laboratory points out that the other paints had advantages of their own, over the more expensive white lead.

"In general," said the laboratory, "these pigments dry to a harder film than white lead and they tend to shed dirt more readily. Titanium dioxide has several times as much hiding power as either white lead or zinc oxide, and as a rule is a brighter white than the white lead paint."

Be sure to watch the label when you buy paints, the laboratory says. Most manufacturers have first quality paints, but make as well competitive lines

A typical white lead paint, as determined by federal specification, calls for at least 71 per cent of the weight of the paint to be white lead pigment and 29 per cent vehicle. Of the vehicle, at least 70 per cent must be linseed oil.

The federal specifications governing titanium—lead-zinc paint calls for 62 per cent of pigment and 38 per cent vehicle. Of the pigment, there must be a minimum of 31 per cent white lead, from 25 to 27 per cent zinc oxide, and 15 to 17 per cent titanium dioxide. The vehicle must contain 60 per cent of raw or refined linseed oil; 16 to 20 per cent of bodied linseed oil, and a 20 per cent maximum of thinner and drier.

Paint in the Fall

Late summer or early fall is the best time for painting, says the laboratory. A time when the temperature is hovering in the 70's is best. At least a week should have passed since the last rain, and the old paint and wood should be thoroughly dry.

First step is to clean off all loose paint with putty knife or scraper. Sandpaper rough edges, and prime the bare wood. If you're using a white lead paint, add linseed oil to it at the rate of one pint to the gallon and its suitable for use as a primer, too. Otherwise use the commercial primers for the type of paint you're using.

The new paint should go on at the rate of 700 feet to the gallon. If you're a beginner, you'll probably get it on too thin. So mark off a space 10 feet square and, if it takes a little more than a pint of paint, you're getting it on at the right thickness.

If you plan two coats, let a week elapse between coats.

And then, says the laboratory, don't expect it to stay as bright as it looked when you first put it on. It's got to weather off a lot until it's wise to repaint.

The American Paint Journal May 24, 1954

Clear Finishes For Exteriors Of Houses

(59)

By F. L. Browne,

Chemist, Forest Products Laboratory, U. S. Department Of Agriculture
Madison, Wis.

DURING the early colonial period in America the exteriors of wood houses were neither painted nor finished in any other way. The wood was simply allowed to weather naturally. Later on, when the materials were available and painting became socially acceptable, most of the colonial houses in towns and cities were painted. In New England at least two houses built as early as 1636 still stand and are still unpainted, the Hartwell Farms house at Arlington and the Fairbanks House at Dedham, Mass.(1) Allowing exterior wood to weather naturally has been frequent practice ever since. Sometimes it is done for economy, as in the communally owned villages of the Amana Society in Iowa from 1858 to 1932, and sometimes for an architectural effect that may be peculiarly appropriate in special cases, such as the Pilot Butte Inn at Bend, Calif., and other buildings of much pretension.

When smoothly surfaced wood is allowed to weather naturally, it changes materially in appearance for a few months or years. Thereafter it stays nearly unaltered for a long time. The color is affected very soon. Woods like redwood and redcedar, which owe their strong color to substances soluble in water, may first become bleached. Woods of lighter color, such as pine and spruce, may first become brown from the action of sunlight. High in the mountains, where precipitation is chiefly in the form of snow, the brown color may persist indefinitely but at lower elevations, where there is rain, all woods eventually become gray in color.(2) Some woods take on a lustrous, silvery gray but others turn to a dull, darker gray.

Weathering soon roughens smooth wood surfaces. First the grain becomes raised; that is, the hard bands of summerwood form ridges. Then minute checks or cracks begin to appear and steadily increase in number and size until the surface becomes decidedly rough and the fibrous structure of the exposed wood is greatly loosened. Finally, the wood substance erodes away very slowly and the boards become thinner at a rate of approximately ¼ inch a century.

Another result of the weathering process is a tendency for boards to cup, warp, and pull at their fastenings. Boards thin in proportion to their width are more seriously affected than thicker and narrower boards. To stand weathering well, boards should be no more than eight times as wide as they are thick and they should be nailed in place especially firmly with corrosion-resistant nails.

Although unprotected exterior woodwork is practicable, economical, and attractive for a limited number of purposes, it has too many shortcomings to become a popular choice for buildings of prideful occupancy. As a rule we are unwilling to part with the smooth, flat surface, straight lines and snug, well-fitted joints of newly erected woodwork, and we are not con-

The fourth in the series of lectures at the Paint Technology Course at the Illinois Institute of Technology, held last fall under the supervision of C. W. Selheimer, Professor, Department of Chemical Engineering.—Editor.

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tent to be confined to a gray color. Moreover, the transition from initially bright wood to the weathered gray color takes place slowly during a number of months and proceeds unevenly over a house because the sheltered areas change much more slowly than the fully exposed areas.

With increasing prosperity and relaxation of the rigorous social restraints of the Puritans, painting gradually became customary in the colonies, first among the wealthier merchants and crown officials and later among the rest of the citizens. Since oil paint remained an imported luxury until after the Revolution, most of the early painting was probably done with whitewash and the closely related red iron oxide water paint that is still widely used for farm buildings in Scandinavian countries. Readers of Mark Twain's "Tom Sawyer" are aware that whitewash was still popular for exterior wood in the middle of the last century. Water paints such as whitewash, which are economical only when labor is cheap, provided variety of color but did not prevent the other developments of wood weathering, surface roughening, and tendency to cup and warp.

The protective power against weathering of the oil paints, varnishes, and sealers comes from their ability to retard the rate at which moisture from rain or high humidity can penetrate into wood and dry out again after the weather changes[3]. None of the protective coatings is impermeable to moisture; in fact, they all absorb water and swell, many of them to a much greater extent than wood does[4]. But water penetrates protective coatings less rapidly than it does wood. Thus, the wood is protected against great inequalities in moisture content and the internal stresses generated by unequal moisture content.

When wood boards are exposed to the weather unprotected, each rain storm quickly wets a thin layer of wood fibers near the exposed surfaces. The moistened fibers try to swell but are restrained by the fibers more distant from the surface, which are still dry. The moistened fibers, now under compressive stress, become distorted in shape; the cavities within the fibers are narrowed and the board becomes slightly thicker. When the rain passes, the moistened fibers dry out again; but by reason of the distortion they experienced while plasticized by moisture, they now strive to shrink to something less than the width they had at the beginning. Thus, a surface layer of the board is left in tension and sufficient repetitions of the wetting and drying cycle may result in cupping, warping, or cracking.

These developments can be prevented by the action of a protective coating on the exposed surfaces in retarding the absorption of moisture by the wood fibers near the surface sufficiently to allow the moisture that gets through to diffuse through the wood enough to avoid any serious differences in moisture content within the board. When so protected, all of the wood in a board remains nearly constant in moisture content if the cycles of wetting and drying occur at short intervals of time and, if the cycles occur over long intervals, all of the wood keeps nearly in step as the moisture content and dimensions change slowly from minimum to maximum and back. In either case, internal stresses are avoided and the phenomena of weathering do not set in.

No doubt the use of protective coatings on wood became general in the Colonies on the hulls and spars of ships before it did on houses, because ships were the life blood of the economy of the times. We get the terms "spar" varnish and "naval stores" (for rosin and turpentine) from this period. A clear coating such as varnish, rather than paint, was required to permit constant inspection of the wood for first signs of failure under stress or onset of decay, in order that replacement

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House paints made with opaque pigments in linseed oil had the necessary durability and were appropriate for smoothly surfaced woodwork such as newly erected siding and trim. Rough wood, such as the sawed surfaces of rough lumber and wood that has become weathered, consume excessive amounts of paint and to many there is something incongruous about coating them with glossy house paint. Well pigmented oil stains, however, make appropriate and durable semi-opaque coatings for rough wood surfaces; such stains have long enjoyed wide use on wood shingles and are therefore commonly called shingle stains.

Clear Finishes Seldom Used

Until the last fifteen years or so, varnish or other clear, unpigmented protective finish was seldom used on major exterior wood surfaces of houses that were fully exposed to the weather. But varnish finishes have long been used on minor exterior surfaces, such as front doors, where they were nearly always at least partly protected against sun and rain by a porch roof, a sheltering overhang of some kind over the door, by deep indentation of the door in the wall, or by a protective fly screen for summer and storm door for winter. When sufficiently sheltered from sun and rain, clear finishes may go as long before needing renewal as the intervals between repaintings of the house paint on the fully exposed woodwork; or, if the natural finishes are partly protected, one extra renewal of these easily accessible areas between jobs of general repainting may suffice.

But in recent years a demand has arisen for clear finishes on major exterior surfaces of houses, particularly siding, which are fully exposed to the weather unless the house is well shaded by trees(5). The demand comes in part from a desire to retain the attractive red color of some woods, such as redwood and redcedar, or the interesting patterns of knots in common grades of lumber or the so-called pecks of heart rot in some species; in part from the desire for radical departure from past custom expressed in the popular ranch type house and other modernistic designs; and perhaps in part from the desire to get away from the plague of abnormally early failures of house paints that has been troubling us for many years. At any rate the demand did not arise from any planned merchandising on the part of the paint industry; on the contrary it caught the paint industry unprepared.

Natural Finishes Less Durable

The most important point to remember about natural finishes for house exteriors is that they are far less durable and require far more care in maintenance than good house paint or shingle stain. On the parts of houses fully exposed to sun and rain, renewal of natural finish twice a year for the first 2 or 3 years and annually thereafter may be necessary. If the property is thoughtfully landscaped, enough shade may eventually be obtained from trees to prolong the life of a natural finish so that renewal every 2 years may suffice but it is unwise to promise intervals longer than 2 years. Thus a natural finish may be practicable for a house owner of average income who expects to apply the finish himself, but it may prove too expensive for one who expects to hire painters to do the work.

Some of the characteristics often asked of natural finishes are quite beyond the possibility of realization in our present state of knowledge. For

example, some inquirers ask for a protective finish that will keep the apparent color of the raw wood as it comes from the lumber yard entirely unchanged and will not add any gloss or luster whatever to the originally glossless surface. That cannot be done short of some as yet totally unforeseen process for rendering lignin and cellulose waterproof without altering the wood structure, depositing anything in the cell cavities, or extracting any supplementary ingredients from the wood.

For the initial color of raw wood is analagous to the color of a tinted house paint after it has faded; that is, it is a structural color that depends upon the existence of many air-solid interfaces with high reflective power for light limiting the average depth to which light penetrates the surface before it is reflected back to the eye. As soon as part or all of the air in the wood cavities near the surface is displaced with a solid or liquid, which necessarily has a refractive index for light much higher than that of air, the optical system is changed, light penetrates deeper into the wood surface before it is reflected back to the eye, more wood has a chance to absorb light selectively, and the color of the wood appears to be darker.

Any protective finish necessarily displaces some of the air in the wood near the surface and therefore seems to darken the color of the wood even if the finishing material itself is entirely colorless. What actually happens is that the finish reveals more nearly the true color of the wood. At the same time replacement of some of the air near the wood surface is bound to raise the gloss level at least slightly(6).

Different clear finishes, quite apart from any inherent color of their own, vary greatly in the extent to which they bring out the true color of wood. Those finishes that penetrate deepest darken wood most. Thus raw linseed oil darkens wood more than does a varnish, even though the varnish itself is usually darker in color than the oil. A so-called penetrating wood sealer, the nonvolatile portion of which is customarily more highly bodied than that of a spar varnish, may darken wood less than varnish does, and a fast-drying spirit varnish or a nitrocellulose lacquer may seem to darken it least of all. The extent to which the materials penetrate wood in the time that it takes for them to harden thoroughly stands in the same order as their ability to darken the apparent color of the wood.

Changes In Color Take Place

Besides the initial change in apparent color brought about by application of a clear finish, further changes in color take place over a period of time. One change comes from the action of light, especially of the ultraviolet light in sunshine, on colored substances in the wood itself. Most woods darken toward brown in color. A few, chiefly exotic species of especially strong color to begin with, turn lighter in color. The change in color goes on more rapidly the stronger the illumination and the higher the proportion of ultraviolet in the light.

The change in color can be retarded by including in the clear finish some patented ingredients that are opaque to ultraviolet but transparent to visible light, but the change will ultimately take place anyway because it is brought about in the end by the visible as well as by the ultraviolet light. The other source of darkening in color that takes place as time passes comes from decomposition of the finishing material itself. Many materials, especially the drying oils and varnishes, form strongly colored decomposition products.

The protective natural finishes, if adequately maintained, prevent development of the gray color of weathered wood. But if the finish is allowed to go long enough to lose its protective power before it is renewed, the gray

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The protective natural finishes, if adequately maintained, prevent development of the gray color of weathered wood. But if the finish is allowed to long enough to lose its protective over before it is renewed, the gray color of weathered wood will appear. It develops first on the boards most fully exposed to sun and rain, usually the lowest courses of siding on the south side. Once the grayness develops, satisfactory renewal merely by applying fresh finish is impossible, for the gray color continues to show through the new finish. Restoration of the desired color requires scraping or sandpapering to remove the grayed wood before refinishing. Even then a close matching of color cannot be obtained because the newly exposed wood may be lighter in color than the rest of the wood that has darkened from the action of light.

Natural Finishes More Exacting

Thus, natural finishes are more exacting than house paint or shingle stain in their requirements for good maintenance. Paint or stain can be neglected for a time after renewal is in order without seriously complicating the renewal, but natural finishes must be renewed before they have broken down in protective power. As the criterion of the proper time to renew a natural finish, some property other than graying of the wood must be used. Perhaps the best basis for judgment can be found by observing the behavior of drops of water sprinkled on the surface of the most exposed area of the house.

Most satisfactory finishes have enough water repellency at the outset to keep water from wetting and spreading over the surface readily. As long as protection remains adequate the water rolls off readily in droplets; but as protection fails, the water spreads over and clings to the surface, and finally can be seen to penetrate and be retained for a time by the wood. When that happens, renewal of the finish must not be delayed much longer.

Exterior woodwork that is to receive a natural finish should be fastened with corrosion-resistant nails or screws. Rusting of iron nails often causes unsightly spotting of good house paints; with natural finishes such rust spots are even more conspicuous. Rust discolors wood of any kind but the spots may be especially conspicuous on woods that contain much tannin, such as redwood, redcedar, oak, and chestnut. Soluble compounds of iron react with tannins to form blue-black compounds related to some writing inks. Other extractives present in many woods may also form strongly colored compounds with iron. The discoloration at nails may spread an inch or so into the wood in the direction of the grain. Well galvanized iron, cadmium-plated iron, aluminum, zinc, and stainless steel do not discolor wood.

It is also important that the finishing material itself be free from soluble compounds of iron. Spirit varnishes that have come in contact with rusty iron, even the iron of the container in which they have sometimes been sold, may discolor wood from the reaction of iron with tannins or other wood extractives.

Similarly the use of steel wool to smooth exterior wood before finishing usually leaves particles of steel in the wood to rust and cause discoloration.

Natural finishes for exterior wood may be divided into four types: varnish, wood sealer, drying oil, and nondrying oil finishes.

Varnish finish. Paint technologists by tradition generally turn first to the varnish finish to supply the demand for an exterior natural finish. For doors, windows, and other readily accessible minor areas for which a moderate degree of protection must be maintained without fail, the varnish finish is still advisable and is usually acceptable. But when major areas, such as siding, are to have natural finish, varnish seldom gives the desired appearance and proves too troublesome to maintain.

The varnish used for exterior surfaces is, of course, a spar or a marine

spar varnish. On new wood at least three coats are advisable, the first of which may be thinned moderately with turpentine or other paint thinner. Shellac should not be used for the first coat on exterior surfaces even over knots. The varnish finish is highly glossy and resinous in appearance, qualities that are usually considered objectionable for large areas like siding, and it usually darkens seriously in strong sunlight.

When it comes time to renew a varnish finish because protection is failing on the more exposed areas, the entire house, or at least an entire side of a house must usually be revarnished because freshly applied varnish will not match the older varnish either in color or in gloss. Since the coating wears away very little on the more protected areas, a few renewals make it too thick to continue to perform satisfactorily. Alligatoring or cracking and scaling in a very unsightly pattern may then set in according to the nature of the varnish. In either case complete removal of old finish by use of varnish remover becomes necessary before refinishing can be done satisfactorily. Such removal is expensive and laborious.

Kind To Select

When varnish is used for large areas, it is best to select a kind that disintegrates by a very fine crazing followed by fine crumbling, as the old fossil-resin varnishes used to do and some ester-gum varnishes still do. Synthetic-resin varnishes often develop milky, opaque patches where the coating has lost adhesion to the wood without breaking open. The opacity is a structural phenomenon at the air-solid interfaces of the air pocket between coating and wood. Although the synthetic-resin varnishes may remain free from crazing and maintain gloss relatively long, they eventually crack, curl, and scale badly and turn out to be less durable than a varnish in which fine crazing sets in relatively early.

Varnish, in common with natural finishes, is less resista mildew than are house paints with chemically active pigments. ever there may be lingering dam to favor the growth of fungi, vari for exterior use should be made a suitable content of preserv Alternatively, the wood-work ma treated with water-repellent pres tive before the varnish is applied the woodwork contains sapwood, w is always susceptible to blue sta the presence of dampness, applic of preservative before varnishing i pecially desirable.

Wood sealer finish. The wood se finish differs from the varnish fi more in the methods of applica and maintenance than in the comp tion of the material used. As a r a wood sealer for exterior use is oleoresinous varnish, possibly of so what higher degree of body tha spar varnish, but of relatively low c tent of nonvolatile, say 30 to 40 perc by weight. It is designed to promptly and completely absorbed the wood surface after application to penetrate the wood as little possible after its initial absorption.

The wood sealer finish may be d scribed as a finish in, rather than the wood surface. It should not lea a continuous coating of appreciab thickness on the surface. For th reason one application on new woo may suffice, though two are usuall recommended. For renewal, one appl cation is nearly always enough. Sinc wood varies greatly in absorptivenes it is advisable to wipe off any un absorbed sealer shortly before it ha stood long enough to become tacky If wood sealer is applied too gener ously without wiping off the excess it is converted to a varnish finish afte a few renewals.

The wood sealer finish lacks the lustrous appearance and has much less gloss than the varnish finish. It also darkens wood less both initially and

after aging. For these reasons most users of natural finish on large areas, such as siding, prefer the sealer to the varnish finish. Moreover, the sealer finish offers important advantages over varnish in maintenance because it is practicable to renew sealer on the more exposed parts without going over the less exposed parts of a side wall where a longer time may well elapse before renewal. If care is always taken to wipe off unabsorbed sealer, there is no possibility of developing a coating thick enough to crack, curl, or scale and therefore no danger that removal of old finish will become necessary.

The wood sealer finish is nearly as sensitive as varnish to the development of mildew in damp places. Incorporation of preservative in wood sealers is therefore customary. Alternatively the wood may be treated with water-repellent preservative before the sealer is applied.

Some commercial wood sealers contain a very small proportion of colored pigment, usually to provide a color similar to that of the heartwood of redwood. Such pigmentation adds to the reliable service of the sealer, evens up the color if the wood contains some white sapwood along with red heartwood, and gives light-colored woods like pine more nearly the color of redwood or redcedar. Pigmentation has the further advantage of restoring the desired color if some of the wood has become slightly grayed before the finish is renewed.

Drying-oil finish. In climates like that of southern Arizona, where dampness never lasts long, a practicable natural finish can be made with ordinary linseed oil with or without addition of a small proportion of pigment. The oil may be raw linseed or other drying oil, with little or no thinner, or it may be moderately highly bodied oil with a generous proportion of thinner.

The oil finish produces less gloss than a sealer finish but it darkens the wood both initially and on aging more than varnish finish does. Drying oil, unless highly bodied, is less inclined than sealer to leave an excess on the surface to be wiped off. On the other hand, if overgenerous application forms a coating over the surface, the coating is unduly soft and holds dirt easily.

Drying oils are particularly susceptible to growth of mildew in damp places. For that reason the drying oil finish is impracticable in most of the more heavily populated parts of the country unless it is well fortified with an effective preservative.

Non-drying oil finishes. Since oil finishes are drawn completely and relatively deeply into the surface of wood, it is not necessary that they have drying properties. Some of the most satisfactory natural finishes do not dry. They should, however, have the property of making the wood repellent to water and, for most parts of the country, they may well contain preservatives.

The essential ingredient for water repellency in the non-drying oil finishes is a hydrocarbon wax such as paraffin. The typical water-repellent preservative may contain from 1½ to 3 percent paraffin, 5 to 10 percent resin or resin and nonvolatile oil, and 5 per cent chlorinated phenols (all by weight) in a mixture of mineral spirits and other volatile solvents. The content of nonvolatile in such products is somewhat too low for a natural finish but adjustment can be made by increasing the content of wax and perhaps that of nonvolatile oil. Some of the best of the non-drying oil finishes also contain small proportions of colored pigments.

Changing from natural finish to paint. Since house owners often choose a natural finish without having been made aware of the frequent renewal necessary to maintain them, it often happens that they soon wish to change to more durable paint finish. Special problems may arise in that case.

House paint becomes unreliable in performance if it is applied over varnish

or other unpigmented coating of appreciable thickness. All varnish or wood sealer that has accumulated until it forms a continuous coating should be taken off with varnish remover, the surfaces washed free from wax, and sandpapered lightly before paint is applied. Such removal is most necessary on the sheltered areas where the varnish remains in best condition.

Even wood on which there is recently applied wood sealer or oil finish is not in suitable condition for reliable painting. At least a year should be allowed to elapse before paint is applied and then all sheltered areas where any sheen remains should first be sandpapered or scraped well. When wood has been finished with non-drying oil finishes high in wax, several years should elapse before any attempt is made to apply paint and even then it may be doubtful whether the paint will give its normal service on the more sheltered areas. It is safer to change from the natural finish to a shingle stain in such cases.

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WOOD SIDING

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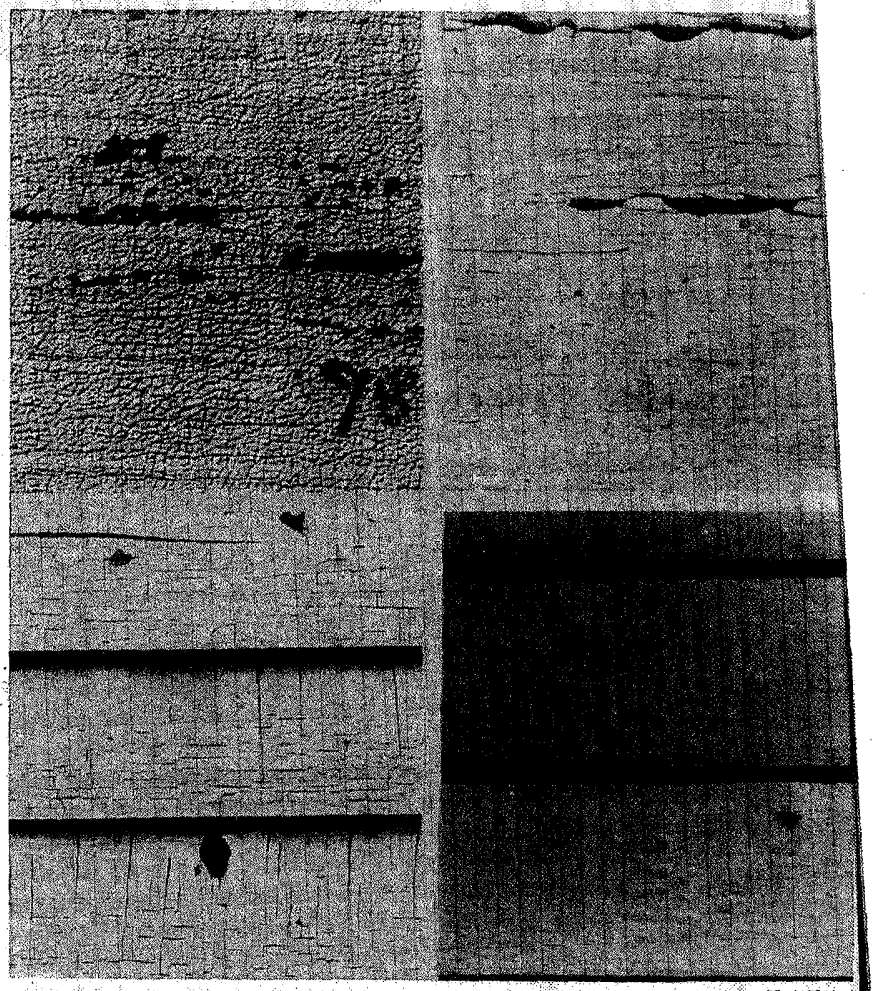

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Types of normal and abnormal paint behavior. *Upper left,* typical checking and crumbling of white lead paint; *upper right,* cracking, curling, and flaking typical of most zinc-containing paints. In both cases, it is time to repaint. *Lower left,* cross-grain cracking, an abnormality that results when paint film gets too thick; *lower right,* blistered paint, an abnormality usually caused by moisture behind the paint film. Remove paint that has cross-grain cracking to the bare wood before repainting. Where moisture has blistered paint, find and eliminate the source of water and remove all blisters and loose paint before repainting.

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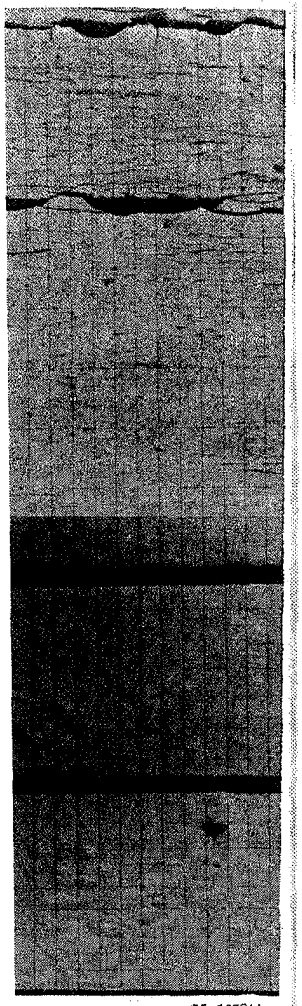

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WOOD SIDING

How To Install It, Paint It, Care For It

By the Forest Products Laboratory, Forest Service

Wood siding is put on houses for many good reasons.

For one, it will keep the bright new "face" of any home attractive for many years to come. In fact, given reasonable care, wood siding will retain its beauty for centuries, as has been amply proved by houses that date back to early Colonial times.

There are sound design and structural reasons, too, for using wood siding. Its great flexibility and variety in patterns, sizes, and colors range from the captivating simplicity of Colonial clapboard to the equally charming board-and-batten siding of modern ranch and rambler houses. In between are many other varieties and combinations that produce distinctive and attractive effects.

Then there are the hard-headed dollars-and-cents reasons, such as wood's low initial cost and the ease and speed with which it can be sawed, fitted, and nailed into place. Also, its fuel-saving value, due to the millions of tiny hollow fibers that make it a good insulator, and its natural resistance to the ravages of weather make it desirable.

There are other reasons, too, such as wood's ability to hold a wide variety of finishes—clear ones that reveal and accentuate its natural beauty, stains that impart a rustic appearance, and paints of every conceivable color. Within limits, the color scheme can be changed periodically to give a home a fresh new appearance in keeping with changing times. So it's little wonder that wood siding has come to stand for warmth, comfort, security, beauty—all the things that spell "home."

Kinds of Wood Siding

There are many kinds of wood siding on the market today (fig. 1). All will give good service, provided they are used right. For houses, bevel siding is perhaps the most widely used. It consists of boards sawed in half so that one edge is thicker than the other. Drop siding is also used, especially on houses without sheathing. To make it, boards are patterned along the upper edge and grooved or lapped on the lower. Bevel and drop siding

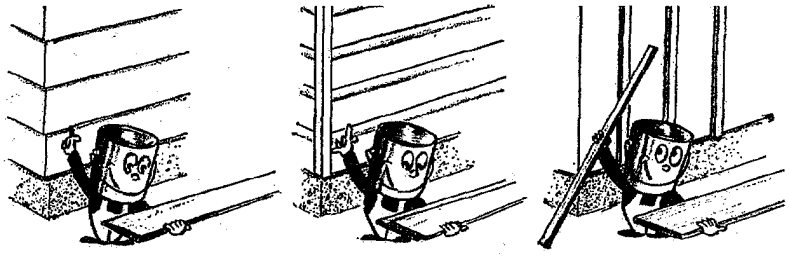

Figure 1.—Three types of wood siding. Left to right, bevel siding, drop siding, vertical board-and-batten siding.

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are applied horizontally and tend to make a house appear lower and longer.

Vertical siding is increasingly popular on one-story houses. It consists of square-edged or tongued-and-grooved boards applied vertically, usually with narrow strips called battens nailed over the joints. Vertical siding tends to make a house appear taller.

The kind of siding chosen will depend on where the house is built, its price range, and the architectural effect wanted. A range of qualities is available, from clear, edge-grained lumber to flat-grained material with knots and other characteristics that should be given special finishing treatments, depending on the effects wanted (fig. 2).

Paints last longer and give better service on softwoods of low density than on those of high density, and on edge-grained than on flat-grained boards. On woods with broad summerwood bands, a special primer (first coat) is needed for good service, as described on page 9.

The House and Its Siding

Wood siding is a part of the house, and therefore its performance is vitally affected by the rest of the structure. The whole house must be well and properly built to insure long-lasting service.

Houses are built differently today and must serve under different conditions than in grandfather's day. Insulation, weatherstripping, and generally tighter construction have cut down fuel bills and made for greater comfort, but have also created some wintertime problems in our northern States, wherever proper precautions have not been taken.

Part of the water vapor formed within a house moves through the inner surfaces of walls because of differences in temperature between the inside and outside. Under certain temperature conditions, this water vapor condenses and collects as liquid water or frost back of the siding. And much more water or frost is likely to collect back of the siding of an insulated than an uninsulated house, because the outer skin of an insulated house is colder. With the return of warm weather, this moisture can—and often does—cause the exterior paint to blister.

The problem has been further accentuated by central heating plants and indoor plumbing, which have created a great deal more water vapor in houses—vapor that has less chance to escape to the cold outdoors than is the case in the older, less tightly constructed houses.

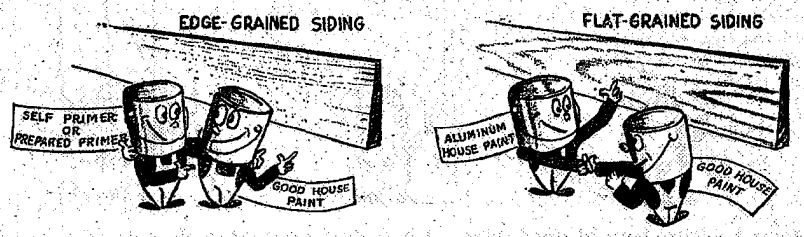

Figure 2.—Edge-grained (left), flat-grained siding.

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There are a number of things that can be done to help keep moisture out of walls. One of the most effective is to put a good vapor barrier (fig. 3) under the plaster of exterior walls in every insulated house built where the average January temperature is 35° F. or lower. Asphalt-coated paper, aluminum foil, and polyethylene film make good vapor barriers.

Rain and snow water must be kept out too. Roof gutters must be sloped and have enough downspouts or they may overflow during rainstorms and let water seep into walls through joints in the siding. Likewise, the eaves must be well flashed. This helps keep out snow melt when gutters become clogged with ice.

Good roof overhangs help a lot and metal flashing is needed in roof valleys, along dormers, and around chimneys. Window and door frames also need adequate cap flashing. Joints should be snug where siding boards butt together and against window and door trim. But siding that is fitted against roof shingles, as on dormers (fig. 4) and roofed entryways, should be about 1 inch short. Otherwise, water can soak into the end grain and cause the paint to fail.

A comparatively new treatment for the siding itself helps keep moisture out of walls. Siding can be dipped in a water-repellent preservative before it is installed, or the water repellent can be brushed on after the siding is installed and before it is painted. These preservatives are sold by lumber dealers and some paint stores. They contain waxes, resins, and oils that cause water to slide off, instead of wetting the backs of the siding boards by working through the butt joints or crawling up through the lap by capillary action.

Installing Wood Siding

Wood siding is simple to install. It is precision-manufactured to standard sizes and is easily cut and fitted and fixed in place with ordinary tools.

Courses of siding should be spaced so that a single board runs continuously above and below windows and above doors without notching. Bevel siding 6 inches wide should have at least 1 inch of

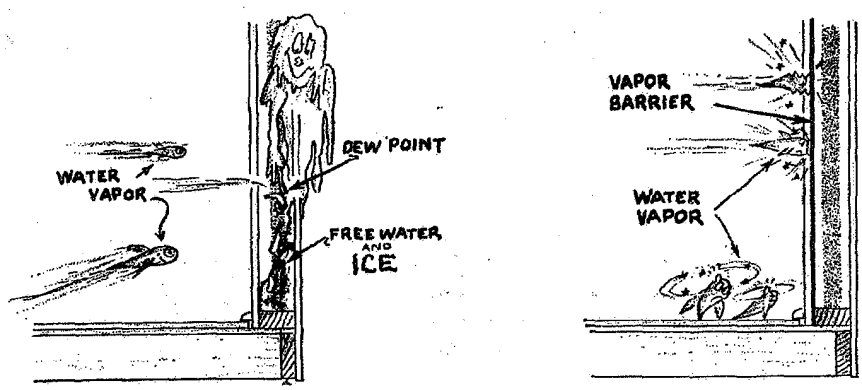

Figure 3.—How a vapor barrier prevents vapor from entering an insulated wall.

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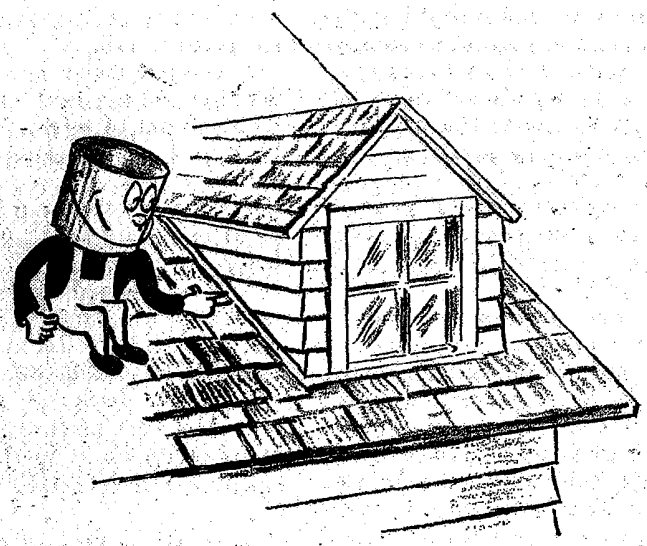

Figure 4.—Method of fitting dormer siding to roof to protect siding ends from water. Metal flashing extends back of siding and under shingles.

overlap between courses. Siding 8 inches or wider should overlap at least 1¼ inches.

Siding should be butted snugly and squarely against door and window casings, corner boards, and adjoining boards. (Corner boards should lie flat against the sheathing.) If metal corner covers are used, siding boards should be carefully cut to avoid leaving a hollow place under the corner cover where water could collect. Mitered corners should be precisely fitted for the same reason.

To fasten siding in place, zinc-coated, aluminum, or other noncorrosive nails are recommended. Plain steel-wire nails, especially the large-headed ones designed for flush driving, make unsightly rust spots on most paints. Even small-headed plain steel nails, countersunk and puttied, are likely to spot the finish with rust.

Wood Finishes

The first finishing job on a house is the most important one. It is the foundation for all subsequent finishing, and if all goes well it will remain there for the life of the house.

Selection of a finish must be made from among three broad classes: (1) natural finishes, (2) stains, and (3) paints. The choice, of course, will depend to a great extent on personal preference, considering the advantages and disadvantages of each class of finish.

Natural Finishes

Natural finishes either penetrate the wood or form a film on its surface. The penetrating finishes may be clear or pigmented; the film-forming type is usually clear.

Natural finishes of the surface-coating type give a lustrous, even

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glossy coating. These are chiefly spar varnishes. A really durable natural finish of this type has yet to be developed.

The penetrating natural finishes leave little or no continuous coating on the surface. They include oil finishes, wood sealer finishes, and water-repellent finishes. The latter penetrate wood readily and completely, but the oil finishes and especially the sealer finishes may leave some excess on the surface. For best results, the excess should be wiped off from 5 to 10 minutes after application. All three types of penetrating finish look better and last longer if they contain some pigment.

Before a natural finish is applied, it should be tried on samples of siding to be sure the effect is what is wanted. If there is likelihood that a paint finish may be wanted later, a wood sealer or an oil finish should be chosen. Although the pigmented water repellents are among the better natural finishes, they contain more wax than the water-repellent preservatives recommended for the treatment of siding. They are likely, therefore, to interfere with the drying and adhesion of house paints, whereas the water-repellent preservatives do not.

Natural finishes are not nearly so durable as paint. Therefore, they must be renewed more frequently than paint, usually every year or, at the most, every two years. Even with such attention and care, the surface-coating types may ultimately need to be removed completely to restore a satisfactory finishing surface. In any case, they must be removed entirely before paint can safely be put on.

Stains

Good shingle stains are inexpensive and much more durable than natural finishes, therefore requiring much less maintenance. They come mostly in dark browns, greens, reds, and yellows. Stains penetrate and color wood, obscuring its grain but leaving little or no surface film. Rough-sawed or weathered wood surfaces are especially suitable for stains. Good stains should last at least 5 years, and may last as long as 9 or 10. Even on planed surfaces, they will last at least as long as paint before needing renewal.

Since stains form little or no coating on the surface of the wood, they do not crack, curl, flake, or scale. Neither do they blister. Some stains, however, contain creosote, which may discolor light-colored paint applied over them later.

House Paints

House paint is the most widely used finish for wood siding and white house paint is the most popular. A good white house paint should last at least 4 or 5 years before it must be renewed; tinted paints, 5 or 6 years; and dark-color paints, 6 to 8 years (fig. 5).

House paint consists of two parts, a solid part (pigments) and a liquid part (the vehicle). The pigments include hiding (opaque) pigments and transparent (extending) pigments. The vehicle consists essentially of a drying oil (usually linseed oil), a thinner, mineral spirits or turpentine, and a small amount of paint drier or japan drier, necessary to make the paint harden promptly after application. The kind and quality of a paint are determined by the nature

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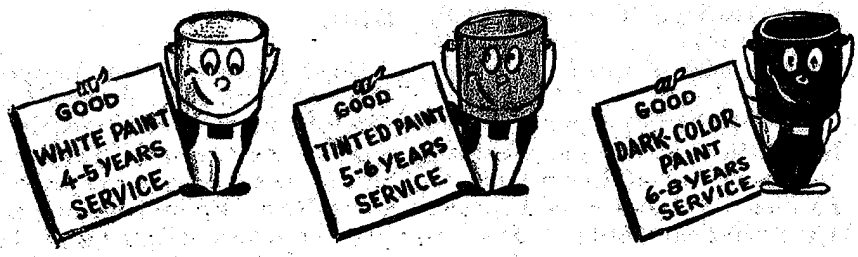

Figure 5.—Expected service life of white, tinted, and colored paints.

of its pigment, the proportion of pigment in the vehicle, and the kind of vehicle.

House paints may be classified simply according to the pigments used in them. Using this system, there are six basic kinds or types of house paints: white lead, titanium-lead-zinc, titanium-zinc, titanium-lead, titanium, and dark-color.

Each type has some of the characteristics generally considered essential in good house paint. These include durability sufficient to last 4 to 6 years before needing renewal, a normal form of wearing that insures a good repaint surface with a minimum of preparatory work, and a normally fast rate of wear from the surface. This last is to prevent the accumulation of an excessively thick film of paint when a reasonable maintenance schedule is followed (a single coat every 4 or 5 years or 2 coats every 6 years). Paint should also have a clean, highly reflective color and ability to remain free from excessive dirt collection in service. It should be nonsensitive to moisture and should not be stained by metal corrosion. Nor should it be discolored by hydrogen sulfide or organic sulfides.

No one type of house paint on the market has all of these characteristics. All have some desirable features and some that are not so desirable. In order to select the type of paint that is likely to give the most satisfactory service, the homeowner should be familiar with the conditions to which house paints are subjected in his area. He must also know which types of paint will stand up best under these conditions—which of the various paint properties are important to him under the circumstances, and which are relatively unimportant.

In terms of years of use, white lead paint is the oldest. It has been used on houses in this country since Colonial times and it is still preferred by some painters and houseowners to the other types of house paints. However, it now accounts for only a very small fraction of the total volume of house paint used in this country.

White lead paint is a durable paint that normally fails by checking and crumbling. This pattern of failure leaves a good repainting surface that requires little preparatory work. It is also a comparatively soft paint that wears away at a faster rate than most other paints. This permits a flexible maintenance program with little risk of building the paint film to excessive thickness. White lead paint is available in ready-to-use form and as a paste that can be mixed on the job with linseed oil, paint thinner, and drier.

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Because it has good tint retention, colors-in-oil may be added to make tinted paints. In addition, it resists staining by rusting metal. Probably the most important of its properties, however, is its nonsensitiveness to water. Even when exposed to water for a long time, it swells only about as much as wood does when wet. Consequently, it has little tendency to blister.

White lead paint also has some disadvantages, some of which have led many houseowners to prefer other types of house paint. For one, it has lower opacity, or hiding power, than the other types of house paint. Also, it has an off-white color that does not compare favorably with the intense, brilliant white of most other paints. One of the more serious objections is its dirt retention. Despite the fact that it wears away faster than other paints, it collects more dirt and retains it longer than most other types of paints. Another serious objection is its property of discoloring on contact with hydrogen sulfide and some organic sulfide gases that cause the formation of black lead sulfide. Because of this property, white lead paint and other paints containing lead pigment should not be used in areas where these chemicals are likely to be present in the atmosphere. Finally, white lead paint is slightly more expensive than other types of house paints.

Most paints are of the titanium-lead-zinc type. The lead and zinc content of such paints ranges from extremely high to very low, and the proportions of lead and zinc also vary widely. In general, paints of this type have a brilliant and highly reflective color, remain uniformly clean in service, and are durable. They are generally hard and wear away slowly.

Paints of this type, like most paints that contain zinc oxide, normally fail by cracking, curling, and flaking. With paints that fail in this manner, it is necessary to take certain precautions to insure a good repainting surface. The film of paint on the wood must not be permitted to become too thick and the failure must not be permitted to advance too far before repainting is done.

Zinc-containing paints have been found to swell much more than wood when wet, and must therefore be classified as moisture-sensitive. They blister more readily on contact with water than do the other types of paint. Under some conditions, contact with water may not cause zinc-containing paints to blister but may simply induce premature cracking, curling, and flaking. Precautions suggested on page 16 will help reduce contact of this type of paint with water.

Titanium-lead-zinc paints also are likely to become stained by nail rust and by the corrosion products of iron and copper screens. The lead in them accounts for their discoloration by hydrogen sulfide and certain organic sulfides.

House paints of the titanium-zinc type are sold in large volume, second only to the titanium-lead-zinc paints. Their properties are very similar to those of the titanium-lead-zinc paints. The most important difference between them is that the titanium-zinc paints do not discolor on exposure to hydrogen sulfide or organic sulfide gases, since they contain no lead or other pigments that react to form metallic sulfides of dark color. For this rea-

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son they are often referred to as "fume-proof" paints and are recommended for use where sulfide discoloration is a problem.

Paints made with titanium and lead pigments, but without zinc oxide, have appeared on the market in recent years. Most of these are sold as "breather-type" paints. They contain—in addition to titanium and lead—a high proportion of transparent (extending) pigment to binder (the nonvolatile part of the vehicle). Paints of this type are characterized by their lack of gloss.

A few paints pigmented with titanium and lead are sold as "titanized white lead." Some paints of this type contain no extending pigments, but are made with a conventional ratio of pigment to binder and therefore have as much gloss as the zinc-containing paints.

Paints of the titanium-lead type are nonsensitive to moisture and therefore blister-resistant. They have high opacity and generally rate between white lead paint and the zinc-containing paints in color quality, resistance to soiling by dirt and staining by rusting metal, and the rate at which they wear away. They fail by checking and crumbling, and provide a surface that is easy to repaint. They are, however, discolored by sulfides.

Paints made of titanium pigment alone, combined with one of several special vehicles, are now available on the market. One of the vehicles used is a long-oil alkyd resin; another is referred to as a copolymer solution. Titanium paints are sold as "blister and stain resistant" paints. Like the "breather type," they have little or no gloss.

In opacity, color, and resistanc to soiling by dirt and staining b rusting metal, titanium paints ar like the titanium-lead paints. Th titanium paints differ in that the are enamellike in their character istics and resist sulfide discolora tion. These paints normally fail b cracking, curling, and flaking, an indications are that they wear awa at a rate similar to that of the tita nium-lead paints.

Dark-color paints, sometime called trim paints or trim-and trellis paints, consist chiefly o dark-color pigments with little, i any, titanium dioxide, white lead or zinc oxide. In most trim paint the major part of the vehicle i varnish, usually an alkyd-resin va nish. Iron oxide paints—the fa miliar red barn paints—may also b classified as dark-color paint Sometimes used on houses, they ar very durable if properly made. I general, good paints of dark colo are more durable than any white o light-colored paint and less sensiti to water than are white or ligh colored paints made with zinc oxid

Paint Primers

Some paints can be used as sel primers, while others need a speci primer for the first coat on ne wood. The proper choice of prim can do much to insure a long-las ing, trouble-free paint job. In pa ticular, a primer should be free o zinc pigments, even if a zinc-co taining paint is used for the finis coat. Most paint makers provid special, zinc-free house-paint prim ers or undercoaters for use wit their mixed-pigment paints co taining zinc. As a rule, it is wis to use primer and finish paint of th same brand.

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New wood that is to be finish-coated with white lead or titanized white lead paint can be primed with the finish-coat paint (called "self-priming") or with a zinc-free, prepared house-paint primer. "Breather-type" paints and titanium-alkyd resin paints are usually used as self-primers.

A special primer is needed for flat-grained wood with wide summerwood bands (fig. 6) and wood with knots. Aluminum house paint, sometimes called "aluminum paint for wood," has been found best. Paints applied over ordinary primers are likely to flake off the summerwood rapidly, leaving unsightly blemishes. Knot sealers, which minimize "bleeding," may be used over knots in wood having narrow summerwood bands.

Selection of a particular type of house paint requires careful thought. Where moisture troubles are widespread, a zinc-free paint is to be preferred. The experience of others in the neighborhood and city is helpful in finding out what types of difficulties with paints are common and which paints serve best. The construction of the house should also be considered. Does it have a wide roof overhang to shield the walls? Has it adequate gutters and downspouts and are they properly installed? Is there a good vapor barrier along with the insulation? If the answers are yes, a zinc-containing paint stands a fair chance of success (but only over a zinc-free primer). If there is doubt, one of the zinc-free paints is the wiser choice.

Finishing Wood Siding and Trim

Questions that arise regarding the job of applying finish include: When to paint? Where to begin? How many coats?

Finish can be applied with a brush, spray, or roller. A brush is generally used and, for purposes of this publication, brush application is assumed.

Finish is best applied during warm, dry weather when several weeks of sunshine can be expected. This creates a problem with regard to houses built during fall or winter, and often builders let them stand with a prime coat until spring before finishing the job. This procedure can result in trouble. The

Figure 6.—Applying aluminum house paint as the primer on flat-grained siding and wood with knots.

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better practice in such cases is to brush water-repellent preservative on the siding, after which it can go without finish until spring.

Because water-repellent preservatives help keep rainwater out of house walls, the most effective time to apply them is before any other finish has been put on the siding. They are especially recommended for use under moisture-sensitive paints, natural finishes, or stains that contain no fungicide.

With natural finishes, 1, 2, or 3 applications may be required, depending on the type of finish used. The manufacturer's directions should be followed. In general, natural finishes are easy to apply.

Stains, too, are easy to apply. On planed wood surfaces, one application may be enough, but two applications usually result in a more durable job. Two applications are generally recommended on rough-sawed or weathered surfaces.

The answer to the question, "How many coats?" depends largely on the kind of paint selected. As a rule, a 3-coat job is recommended for new wood. Many builders apply only 2. A first paint job should be 4½ to 5 mils (thousandths of an inch) thick, which is about the thickness of a dollar bill. It is difficult, if not impossible, to apply that much by brush with 1 primer and 1 finish coat of today's average paints. In winter especially, 3 coats are needed. Exceptionally heavy coats, where paint is applied at a rate of 450 to 500 square feet a gallon, are likely to result in wrinkling, loss of gloss, and slow drying during cold weather.

With paint, an old craftsman's rule is: "Follow the sun around the house." This means that the north side should be painted early in the morning, the east side late in t morning, the south side well af noon, and the west side during la afternoon.

Morning dew or the water of brief shower should be wiped o and after half an hour of war weather sunshine painting can b gin. After many hours of ha rain, however, a day or two of dr ing is needed.

The beginning painter can lea to gage spreading rates by applyi a pint of paint evenly over a mea ured area. For example, at spreading rate of 600 square feet the gallon, a pint covers 75 squa feet, or an area of 5 by 15 feet; 700 square feet a gallon, a pint co ers 87½ square feet, or an area 5 by 17½ feet. The average begi ner tends to spread paint out t thinly.

For modern paints of avera composition, a total thickness of b tween 4½ and 5 mils results wh 1 coat of house-paint primer is a plied at 600 square feet a gallon a 2 coats of finish paint at 700 squa feet a gallon each.

In warm, dry weather, each co should dry a day or two before t next is applied. Cold or dam weather may make an extra day two advisable, but more than weeks between coats should avoided.

Finish Maintenance

Hot summer sun, wind-driv rain and hail and dust, and win snow and ice gradually take a t of even the best finish. How fr quently the finish should be r newed is governed by the rate which it weathers away. Finish vary considerably in this respe The popular natural finishes ne

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renewal every year or two. Stains, on the other hand, are very durable and should not need to be renewed in less than 5 years. There is considerable variation among paints, also, but the types most commonly used on house siding weather away at fairly uniform rates, so that definite repainting schedules are practical.

Penetrating natural finishes are easy to renew. Fresh finish is simply applied when the old finish appears to need it. As with the first finishing job, any excess of sealer or oil should be wiped off, so that formation of a surface coat is prevented.

Natural finishes that leave a surface film are more troublesome to maintain than those which penetrate the wood. Difficulties arise mainly because the finish on certain areas of a wall, such as those under roof overhangs, remains in good condition longer than that on exposed wall areas. It is recommended, therefore, that only the more weather-beaten areas be renewed. This is sometimes difficult, because these finishes are not easily blended over worn and unworn areas to give a uniform appearance. If, on the other hand, the protected areas are renewed as frequently as the unprotected ones, excessively thick coatings will be built up and will require costly removal later.

Stain finishes can be renewed without difficulty when their appearance indicates the need for renewal.

As already pointed out, a paint maintenance program is determined by the kind of paint used in the first job. The basic rule is, paint only after most of the old paint film has weathered away. Always remember that coating thickness can build up dangerously if paint is applied too frequently, with resulting abnormal behavior that spells trouble and possibly costly removal of old paint by blowtorch or paint and varnish remover.

Assume the first 3-coat paint job was 4½ to 5 mils thick. As a rule, at least 4 years are required to wear away enough zinc-containing mixed-pigment paint to make room for 1 coat of new paint applied at 650 to 700 square feet per gallon, and 6 years for 2 coats applied at 700 to 750 square feet each. White lead paint wears away about half again as fast as the zinc-containing paints. The zinc-free, mixed-pigment paints are more like the other mixed-pigment paints than pure white lead in wearing rate. Dark-color paints, including iron oxide paints, wear away most slowly of all.

The wearing rate pretty well tells what to do: 1 coat not oftener than every 4 or 5 years, or 2 coats not oftener than every 6 years, for white and tinted paints. One coat every 6 years is enough for dark-color paints.

In repainting, good practice is to use the same type of paint originally applied on the house. A change to a different type of paint may result in early failure through incompatibility. If, therefore, a paint has given satisfactory service, it should be used in repainting. If a paint has given trouble, a change to a different type may be advisable. Even then, it is best to wait at least 4 years after the last repaint job before making such a change.

When color schemes are changed, a couple of simple rules should be followed. The best practice is always to use essentially the same

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paint for repainting that was originally applied on the house. If white lead paint was used, a change from white to a tint may be made by adding colors-in-oil. However, colors-in-oil should never be added to white mixed-pigment paints. If such a paint has been used and a tint is desired, purchase the tinting-base paint made by the same manufacturer for this purpose. A change from a white or light-color paint to a dark-color paint may be made without too much risk of failure, but a white or light-color paint should never be applied over a dark-color paint.

Different paints, naturally, wear differently—and show wear differently. Paints that do not contain zinc oxide, such as white lead paint and the titanium-lead paints, normally begin to develop fine fissures, called checks, in a year or two. These slowly multiply and deepen, eventually reaching the wood, and the old paint crumbles away. Moreover, in a year or so some of these paints will soil quite noticeably. Later on, as the paint chalks and begins to crumble, the dirt will disappear; or, the surfaces can be washed with water and a cleansing agent sold by paint dealers.

Paints containing zinc oxide wear quite differently. They begin to crack through to the wood in occasional spots during the second or early in the third year, meantime having developed chalky surfaces that dull their luster. As time goes on, more cracks open, they widen and lengthen, and the paint around them curls back and flakes off.

Such normal paint behavior is best taken in stride. If possible, a repaint schedule of 1 coat every 4 or 5 years or 2 coats every 6 should be maintained. However, this ma not always be practicable. If, fo example, the original paint jo wears away in 3 years to the exten that appreciable areas of siding ar laid bare—as frequently happen with scanty 2-coat jobs—the owne will understandably want to repai at that time. This can be done wit reasonable safety because the orig inal paint film was in all likelihoo too thin to start with. All loos paint should be removed with scraper and wire brush, the bar areas should be spot primed, an then 1 coat of topcoat paint applie overall. Thereafter, the more ex tended repaint schedule should b resumed.

Finish Troubles

Paint troubles arise from vario causes. Most common are vap troubles in tightly built, insulate houses lacking vapor barriers; rai or other water that gets behind si ing; improper first priming of woo with wide summerwood bands; r painting too soon; or use of a di ferent type of paint in repaint job Evidence of paint trouble usuall comes in the form of excessively fa wearing away of the paint, as bli tering followed by peeling, or premature or excessive crackin curling, and scaling.

Once trouble has set in, the be course is to go slow. Premature r painting to cover up unsightl paint failure in the long run on makes matters worse. The coatin will be built to dangerous thic nesses on places where paint didn come off. Ultimately, the coatin will get too thick, and an abno mality known as cross-grain crack ing will set in. Once that happen there is no recourse except remo

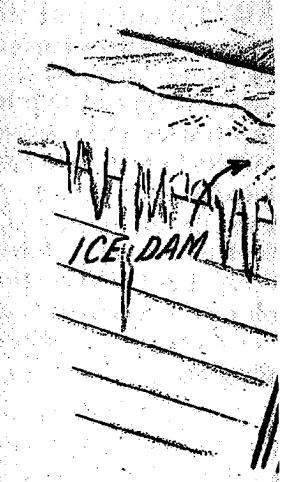

Figure 7.—How ice dams form. Sr snow-cl

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Figure 8.—Treating lap, corner, and bu

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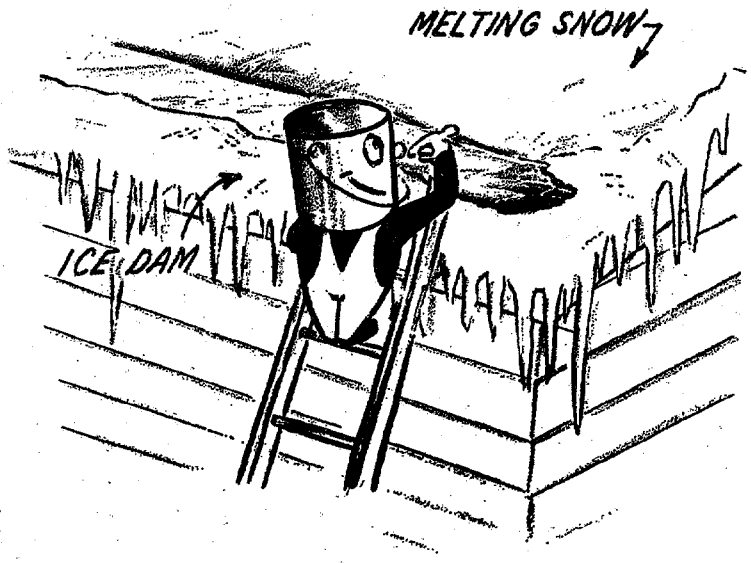

Figure 7.—How ice dams form. Snow water from upper roof freezes on cold overhang or in snow-clogged gutters, builds up dam.

ing all paint down to the bare wood and starting over.

Before any repainting is done, the probable cause of the trouble should be ascertained. If it is due to springtime blistering in the colder northern States, a better vapor barrier is probably needed. This can be obtained by painting the indoor side of the exterior walls. Two coats of aluminum paint plus 2 coats of decorative paint are best for sand-finish plaster. On smooth plaster, a primer and sealer and 1

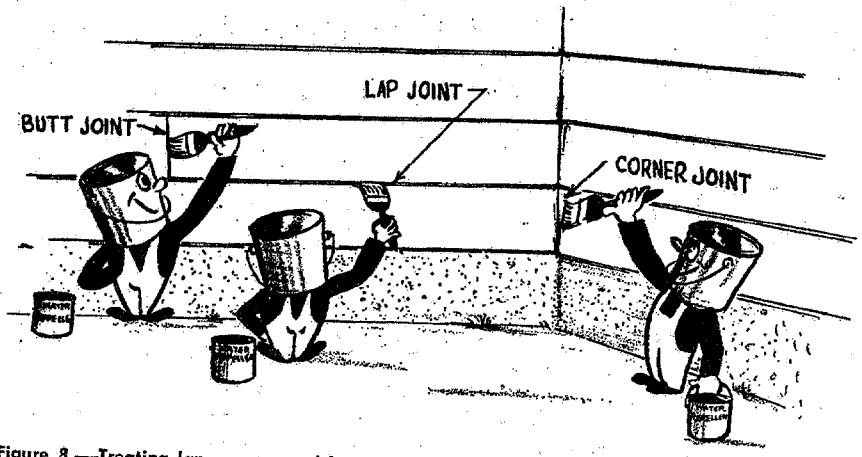

Figure 8.—Treating lap, corner, and butt joints in bevel siding with water-repellent preservative before repainting.

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coat of decorative paint make a good barrier. For gypsum board, 2 coats of rubber-base paint appear to be effective. Shutting off humidifiers will also help.

Where the trouble is due to water that gets inside the walls from the roof, leaks should be found and the gutters examined and rehung lower if necessary, especially if the trouble is due to ice damming (fig. 7). If the gutters overflow during heavy rains, additional downspouts may be needed or the gutters may need to be pitched more. If water is getting through the joints of the siding, the lap and butt joints should be treated with water-repellent preservative (fig. 8) before repainting; this type of solution is highly penetrating and creeps well into the joints to seal them against future inroads of rainwater.

Whatever the cause, it should be found and corrected before the house is repainted. Then the repaint job should markedly reduce future recurrences of abnormal paint behavior.

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Wood Siding Left To Weather Naturally

By F. L. BROWNE

Mr. Browne is a Chemist with the Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, Madison, Wis.

Judging from inquiries received from time to time at the Forest Products Laboratory, some people are intrigued by the possibility of leaving exterior wood entirely unfinished, to weather naturally. If suitable precautions are taken it is practicable to do so. But whether this is desirable is a question the architect and owner must decide. Paint or so-called "natural" finish, though, is likely to remain the customary treatment for exterior surfaces of smoothly planed wood, and stain for rough wood.

Nevertheless, the practicality of weathered wood is adequately demonstrated by much past experience. For the first century or so of the American Colonies, particularly in New England, wood was the predominant building material and the exterior surfaces were left unpainted to weather naturally.

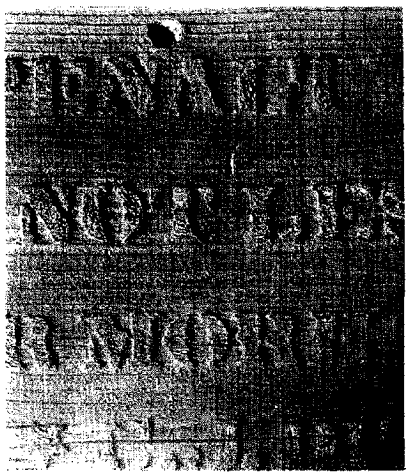
It was not merely that paint was an imported luxury. To the Puritan mind of the time, painting was an ungodly arrogance for anyone but a high crown official or a very wealthy merchant. There is record of the expulsion of a barber from the Massachusetts Bay Colony for aspiring beyond his station in life when he spent part of a small inheritance for painting his house.

Many of the wood buldings of the early Colonial period still stand. Most of them, of course, were painted when it became socially acceptable to do so, and they have been kept painted since. But some, including two of the oldest houses that remain, have never been painted.

New Englanders claim that they have the oldest wood house in the United States, now known as the Old Fairbanks House at Dedham, Mass. The first part of the house was built in 1636. Most of the clapboard siding was replaced in 1903 but has now stood nearly 60 years without paint. The oldest portion of Hartwell Farms at Arlington, Mass., also built in 1636, is still covered with the remnants of the original clapboards.

From 1858 to 1932 the Amana Society owned communally seven villages in Iowa County, Iowa. The houses were of wood and were left unpainted except for window sash and doors, which were painted. When I saw them for the first time in 1927 the houses were well maintained. The chief carpenter told me that the ½- by 6-inch bevel siding lasted from 30 to 50 years before they found it advisable to begin making replacements.

In 1946, fourteen years after the residences passed into private ownership, I again visited two of the villages. To me by far the most attractive and neatly kept houses were those that remained loyal to the old custom, with the siding unpainted but with corner boards, facia boards, and window and door casings, as well as sash and doors, decorated with paint.



Part of a 25-year-old signboard made by stenciling letters on unpainted wood. Erosion of the unprotected wood by weathering left the letters embossed one-sixteenth inch. Such evidence as this is basis for the conclusion that wood weathers away about ¼ inch in a century.

The houses mentioned so far were all very modest dwellings, left unpainted for economy or to conform to local custom of the time. But there are at least a few examples in modern times of more pretentious buildings for which weathered wood was chosen strictly for its appearance. Two of those I know are hotels that must attract patrons to remain in business. Pilot Butte Inn at Bend, Ore., and the Redwood Inn at Scotia, Calif., are the leading hotels in their communities. Both were in operation for several decades without paint.

The Process Of Wood Weathering

Wood exposed outdoors, such as siding and trim on buildings, if without protective painting or treatment changes materially in appearance for a few months or years, after which it stays nearly unaltered for a long time. The color of the wood is affected very soon. All woods change toward a brown color. Woods like redwood and red cedar, which owe their color largely to substances soluble in water, may first become bleached before the browning becomes observable. Still later all woods turn gray.

The changes in color reveal chemical changes in wood during weathering under the action of sunlight, air, and water. Only those parts of the wood close to the exposed surface are affected. The surface first dark-

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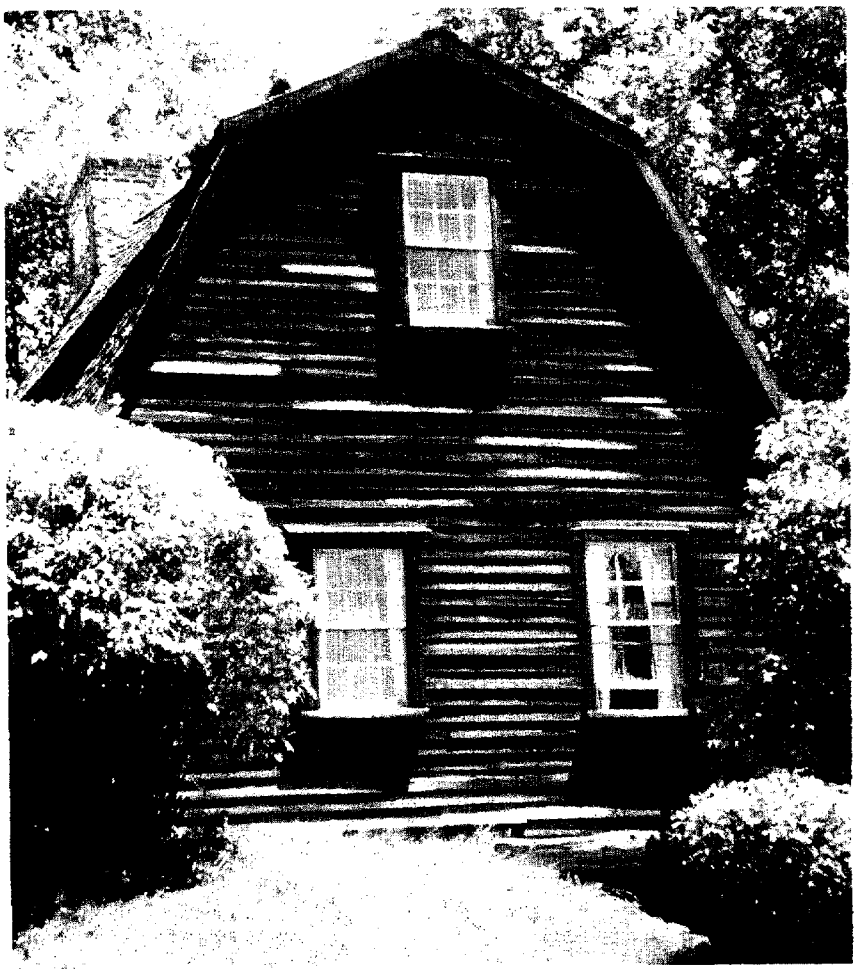
ens to a brown color that penetrates 0.02 to 0.10 inch into the board. The brown layer retains the normal arrangement of wood cells in orderly rows. The brown color comes chiefly from decomposition products of the wood lignin. Later, as rain leaches the brown decomposition products, a gray layer 0.003 to 0.01 inch thick, consisting of a disorderly arrangement of loosely matted fibers, develops over the brown layer. The gray layer is composed chiefly of the most leach-resistant parts of the wood cellulose, rain having extracted from it nearly all of the lignin and much of the more sensitive parts of the cellulose. From the cellulose the xylan and arabinan are leached most extensively, the galactan and mannan somewhat less so, and the more resistant glucosan least extensively.

As substance is lost from the surface, the brown and gray layers move more deeply into the board, but the process is so slow that only ¼ inch of thickness is lost in a century. Where precipitation occurs as snow rather than rain, as in high mountains, the lack of leaching keeps the gray layer from forming and the wood remains brown indefinitely.

Weathering produces physical as well as chemical changes. Wood near the exposed surface of a board fluctuates between wet and dry conditions more rapidly than the interior of the board. The swelling and shrinking stresses set up thereby soon begin to roughen the surface. First the grain becomes raised; that is, the hard bands of summerwood rise above the softer springwood between them. Then minute checks or cracks begin to appear in the surface and steadily increase in number until the surface becomes decidedly rough. The chemical changes in the gray layers add to the roughness and in addition make the surface of the board soft.

Besides the many minute checks in the surface, most woods soon develop some larger and deeper checks or cracks that are easily visible and may become conspicuous. As a rule, the woods of moderate to low density acquire fewer of the conspicuous checks than do the woods of high density. Edge-grain boards check less than flat-grain boards of the same variety of wood.



Old Fairbanks house, Dedham, Mass., built in 1636 and never painted. White pine siding was replaced in 1903; window frame and facia wood may be the original.

As a result of the weathering process there is a tendency for boards to cup, warp, and pull at their fastenings. Firmer nailing may therefore be necessary when wood is left to weather than would be required if it were kept well painted. The cupping tendency varies with width and thickness of the boards. The greater the width in proportion to the thickness, the greater is the tendency to cup and pull at the fastenings.

Although ½- by 6-inch bevel siding was considered satisfactory by the Amana Society, ¾- by 6-inch siding would serve much better. For best results the width of the boards should not exceed eight times their thickness.

Cypress, hemlock, white pine, ponderosa pine, and spruce usually weather to a light-gray color that often has a silvery sheen. A darker gray with little or no sheen is developed by red cedar, Douglas-fir, fir, Southern yellow pine and redwood. Red cedar, cypress and redwood commonly acquire fewer conspicuous checks or cracks than other woods do. Similarly, cypress, red cedar and redwood generally have the least tendency to cup and pull at fastenings; whereas pine, fir, hemlock, spruce, Douglas-fir, and Southern yellow pine require firmer nailing to hold them in position.

Development Of Weathered Appearance Takes Time

Although the appearance of weathered wood is attractive for suitable architectural effects, there is difficulty in making use of it for new construction, in that much time is required for the change from new to weathered lumber. Moreover, the change seldom takes place evenly over the different parts of a side wall. Those boards that receive most rain and sunshine become weathered first. Usually the lowest courses of siding on the south wall become fully grayed and roughened sooner than the top courses of siding under the eaves and much sooner than courses of siding under a porch roof. Wide overhang at the eaves delays the weathering of more courses of siding than a narrow overhang does. Thus for a year or two, there is a mottled appearance, varying from nearly bright lumber to gray weathered wood.

The unequal delay in attaining the weathered appearance can be avoided by using rough-sawed

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rather than the smoothly surfaced lumber to begin with and applying a gray oil stain. Such a stain can be made, for example, from raw umber in oil, white lead in oil, boiled linseed oil and mineral spirits or other paint thinner. The stain need be applied only once when the house is built; by the time the stain has worn out the wood will have developed its natural weathered gray color.

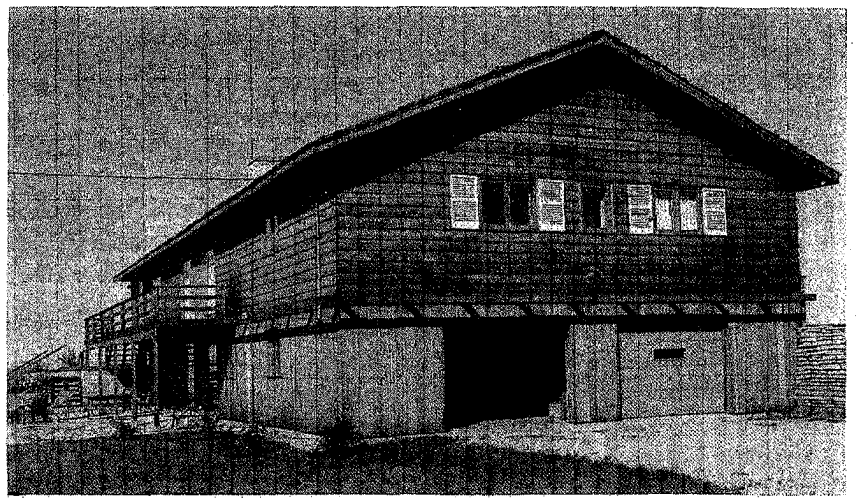
On some houses bevel siding is used with the planed side out and given the color without the roughness of weathered wood by applying a product known as bleaching oil or sometimes as redwood bleaching oil. A number of paint manufacturers supply such products. They may be described as natural finishes of the sealer type in which there are some pigments to give the gray color. When bleaching oil is used, the wood may be kept smooth indefinitely by renewing the finish as often as proves necessary, or the first application may be allowed to wear off and leave the wood in its naturally weathered condition.

Need For Rust-Resistant Nails

When exterior wood is to be allowed to weather naturally or is to receive a natural finish, it is particularly important to see that all nails used to fasten it and all hardware that may be placed in contact with it are highly resistant to rusting. The heads of ordinary iron nails rust rapidly, and the iron rust promptly penetrates into the wood for some distance from the nail heads. In some woods such rust makes reddish brown stains, but in woods that contain tannins, such as cedar and redwood, the stains are bluish black and very unsightly. Corrosion-resistant nails, such as galvanized, cadmium-coated, or aluminum nails, avoid such difficulties.

Although the weather appearance may dispense with periodic renewal of paint or finish, it should not be used as an excuse for neglecting periodic inspection and careful maintenance of the building. Even when care is taken to provide firmer nailing than usual, some nails gradually become loosened and partly withdrawn by the operation of the forces of wood weathering. Every four or five years such loosened nails need to be driven in tightly again. Likewise, the same care about keeping joints tight, repairing gutters, and making other minor repairs that would be taken with a painted house is needed when the wood is allowed to weather.

Exterior wood, then, may properly be allowed to weather naturally without protection by paint or other finish whenever it proves desirable to obtain an architectural effect in that way. For weathered wood it is wise to select the kind of wood carefully to obtain the intended result; and it is particularly wise to use lumber that is thick enough in proportion to its width, to see that it is very firmly fastened with rust-resistant nails, and to provide the same care in maintenance that would be given to a painted building.



John R. Talbot residence in Madison, Wis., built in 1958 with unfinished redwood bevel siding on upper level and vertical tongued-and-grooved siding on lower level. South end of house shown was in advanced state of weathering to characteristic gray tone when photo was taken in September 1960. Weathered siding has already given this ranch-style house an appearance of being long and comfortably established on its hilltop location—an effect enhanced by wood-shake roof.

Home Building Peak For 1961

New home starts should reach the second highest peak in U. S. history in 1961, say housing economists who claim to know.

The figure given by most of these experts is 1,424,000 new home starts in the upcoming year, with an all time high cash investment of twenty billion dollars.

Private industry will build 1,375,000 new homes in 1961, the men who profess to know claim, and 22,000 will be built on farms with smaller amounts allocated to various types of public housing.

There will be plenty of money to borrow for home purchases. Family incomes are also up. But the big thing in home building next year will be competition, and this may well force builders to put more into their houses, and to create the most livable possible product.

Mistletoe A Pest

Mistletoe may be a boon to lovers during the Christmas season, but it brings no joy to the guardians of California forests.

John R. Parmeter, Jr., assistant professor of plant pathology at the University of California in Berkeley, reports that small, leafless dwarf mistletoe looms as the No. 1 disease menace to coniferous trees in the state.

The plant is causing millions of dollars of damage annually to red and white fir, sugar and ponderosa pine, and Douglas fir.

Parmeter explained that dwarf mistletoe is a parasite which attacks tree trunks and branches, and that, although it reduces the growth rate and quality of older trees, it seldom destroys them.

Ironically, heavily-infected young trees are usually rendered worthless as Christmas trees and eventually die.

Parmeter is conducting a study of dwarf mistletoe with the aim of developing effective means of controlling it.

FLB 001205

The Multiple Use Act and the National Forests

By George S. James,

Mr. James is Assistant Regional Forester, Southern Region, U. S. Forest Service, Atlanta, Ga.

Since 1905, the Forest Service has managed National Forests under the principles of multiple use and sustained yield. Yet, as recently as June 12, 1960, the President signed the Multiple Use-Sustained Yield Act (Public Law 86-517) which directs that the National Forests be managed according to these principles. To appreciate fully the need for the Congress to reaffirm these principles, which have been followed for more than 50 years, it is necessary to understand the historical development of the National Forest program and the tremendous needs, now and in the future, for using the resources on these public forest and watershed lands.

Early History Of Forest Conservation

In the first century of American independence forest land was cheap and plentiful. Forest owners usually aimed at a quick return from cutting the timber and selling the cleared land to settlers. Some far-sighted efforts were made to check the wasteful destruction of forests, and about 1850 several states initiated action to protect their forest resources. A few passed laws encouraging tree planting. In 1873 the American Association for the Advancement of Science memorialized the Congress and the states concerning the importance of preserving the forests and the need for legislation to secure this objective. In 1876 the Congress appropriated funds for a study of the nation's forest conditions. Three extensive reports were submitted to the Congress during the seven years which followed. A small Division of Forestry was established in the Department of Agriculture in 1881, and reports and bulletins were published to increase public interest in forestry. The creative Act of Congress, approved on March 3, 1891, gave the President power to establish forest reserves from the public domain. During the next 14 years, 60 forest reserves were proclaimed, totaling about 56 million acres. The forest reserves at this time were under the administration of the Department of Interior.

Establishment Of The Forest Service And The National Forest System

On February 1, 1905, the forest reserves were transferred to the Department of Agriculture, and Gifford Pinchot became the first Chief of the Forest Service. In the next two years, the establishment of new areas by Presidential proclamation increased the size of the forest reserves to more than 100 million acres. These lands were located almost wholly in the public domain states west of the Great Plains. The name "Forest Reserves" was changed to "National Forests" in 1907.

East of the Great Plains the National Forest system got under way in 1907 with the proclamation by President Theodore Roosevelt of the Arkansas National Forest. This was soon followed by the establishment of the Ozark National Forest also in Arkansas, the Ocala and Choctawhatchee National Forests in Florida, and the Superior National Forest in Minnesota. (The Choctawhatchee has since been taken over by the Defense Department and is known as the Eglin Air Force Base.)

The Weeks Act of March 1, 1911, was a major milestone in the development of the National Forest system, in the East particularly. It authorized purchase, for National Forest purposes, of forest lands necessary to protect the flow of navigable streams. Most of the present National Forests east of the Great Plains were established by purchase under this act, since there was little public domain left. At the present time the National Forest system includes more than 180 million acres of publicly-owned forest and watershed lands in 39 states.

Development Of The National Forest Program

The 1891 legislation authorizing the establishment of forest reserves made no provision for their administration or use. This was corrected by the Organic Act of June 4, 1897, which authorized the hiring of employees to protect and administer the reserves and thus make possible their use. This basic act, with later amendments, was the one under which the National Forests were administered prior to the Multiple Use-Sustained Yield Act of 1960.

On February 1, 1905, the day the forest reserves were transferred from the Department of Interior, Secretary of Agriculture James Wilson wrote a letter to Gifford Pinchot, the first Chief Forester, laying down the basic principles which the Forest Service has continued to follow. This historic letter said, in part: "In the administration of the forest reserves it must clearly be borne in mind that all land is to be devoted to the most productive use for the permanent good of the whole people and not for the temporary benefit of individuals or companies. . . . You will see to it that the water, wood, and forage of the reserves are conserved and