4 YEARS' RESULTS OF EXTERIOR HOUSE PAINT TEST PROGRAM

HORSE HEAD PRODUCTS

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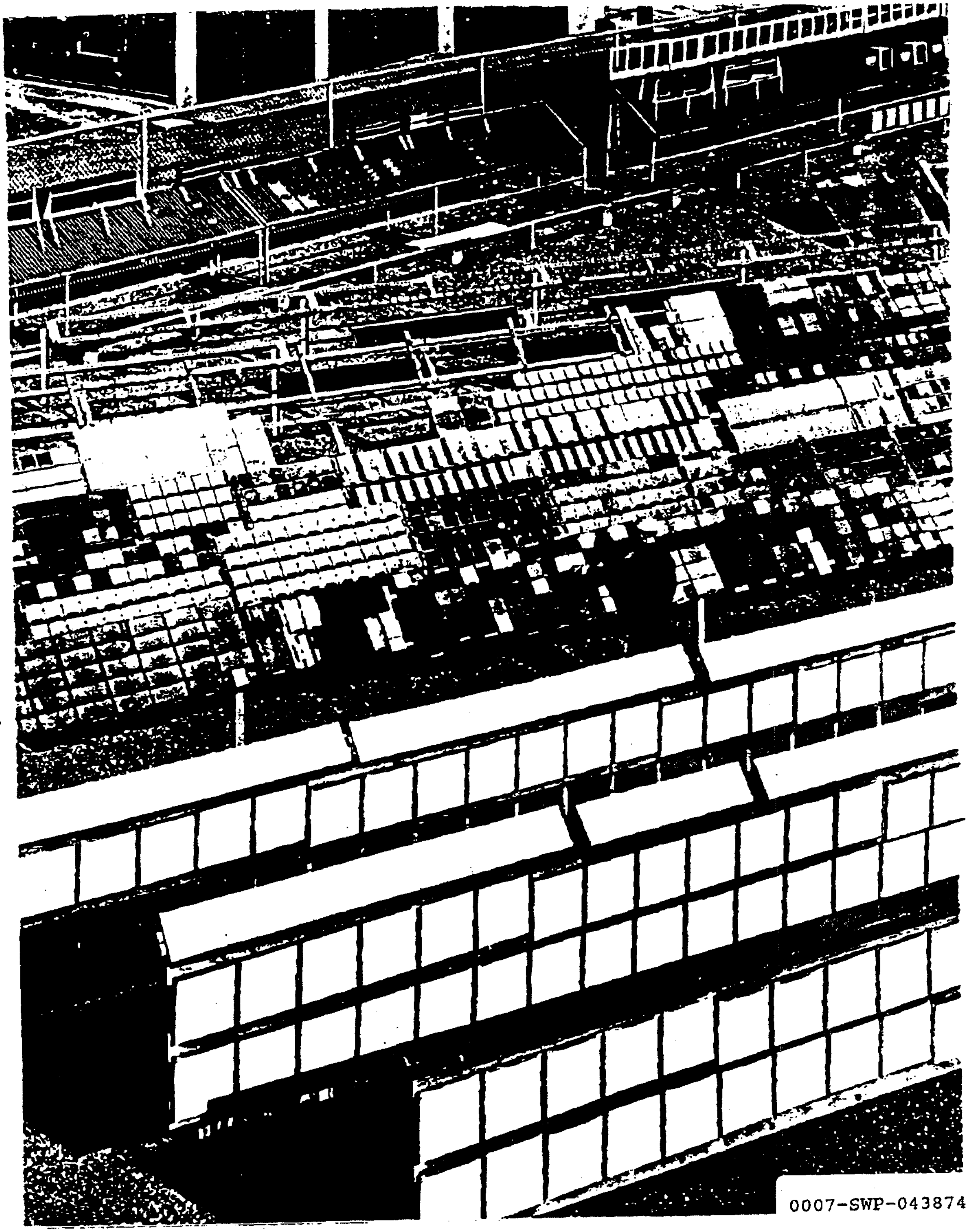

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4 Years' Results of Exterior House Paint Test Program

by S. WERTHAN*

During the past three years we have issued several progress reports[1] covering an investigation of exterior house paint formulation started by our laboratory during the war. This is an extensive study which involved the preparation of approximately 400 paints and the exposure of over 1200 test panels. The aim of the investigation was to determine optimum pigment and vehicle compositions which would result in exterior white house paint of superior performance.

A survey was made of first grade house paints on the market just prior to the war, and pigment, oil, resin and paint manufacturers were contacted to obtain information as to the pigment and vehicle compositions that should be studied.

Based on these data, the following representative pigment combinations were selected as basic pigmentations for our tests:

1. 15% TiO_2-30% White Lead-30% Zinc Oxide-25% Inerts (Siliceous)
2. 15% TiO_2-47% Leaded (35%) Zinc Oxide-38% Inerts (Siliceous)
3. 15% TiO_2-40% Lead Free Zinc Oxide-45% Inerts (Siliceous)

The indications also were that a one-to-three combination of Z-5 kettle bodied linseed oil and raw[2] linseed oil would provide a basic bodied oil type vehicle for the determination of the effects of other formulation variables. The variables covered in the various series of paints are:

Pigment Volume (Range 25 to 50 percent)
Volatile Content of Vehicle (Range 20 to 58 per cent)

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(1) "What Type of Post-War Exterior House Paint Will be Made?", Official Digest, March 1945; "Post-War Exterior House Paint," Official Digest, January 1946, and "Post-War Exterior House Paint," Official Digest, March 1947.

(2) Wherever raw linseed oil is mentioned, an unbodied oil, either raw or refined, is meant.

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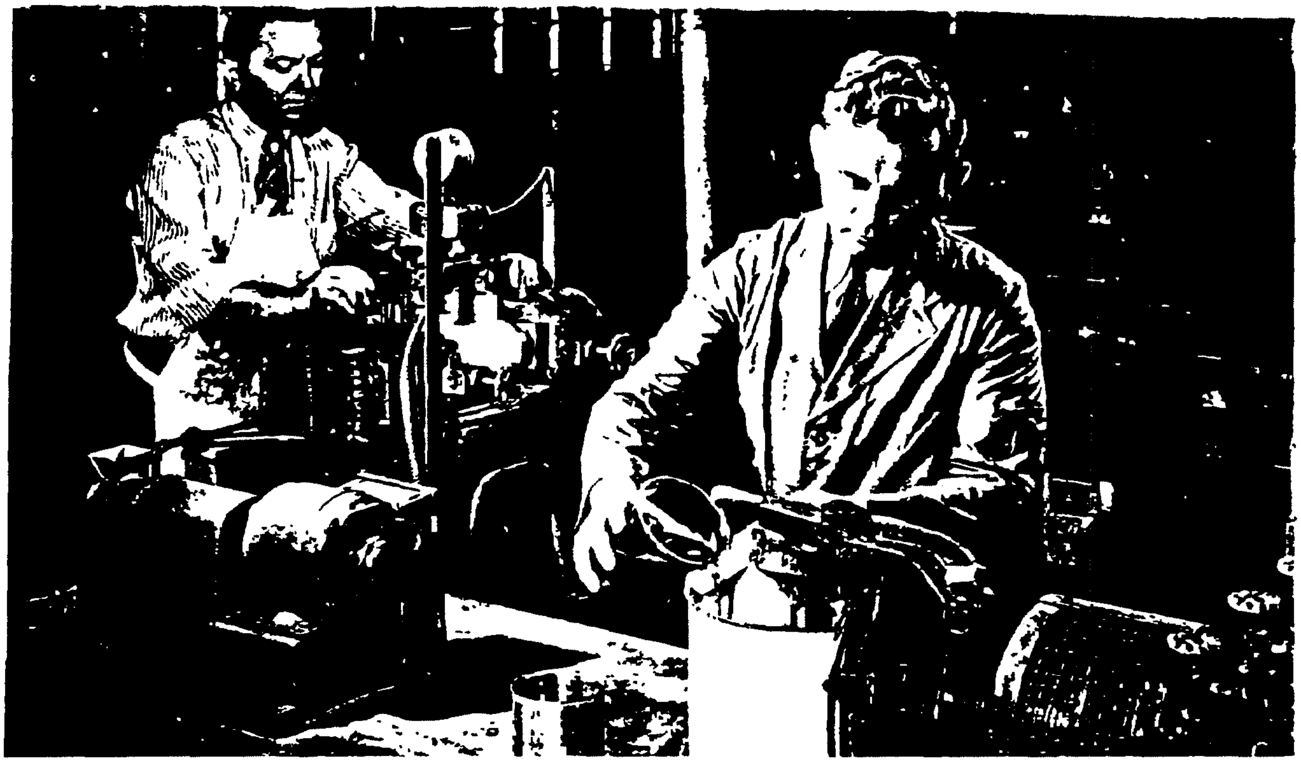
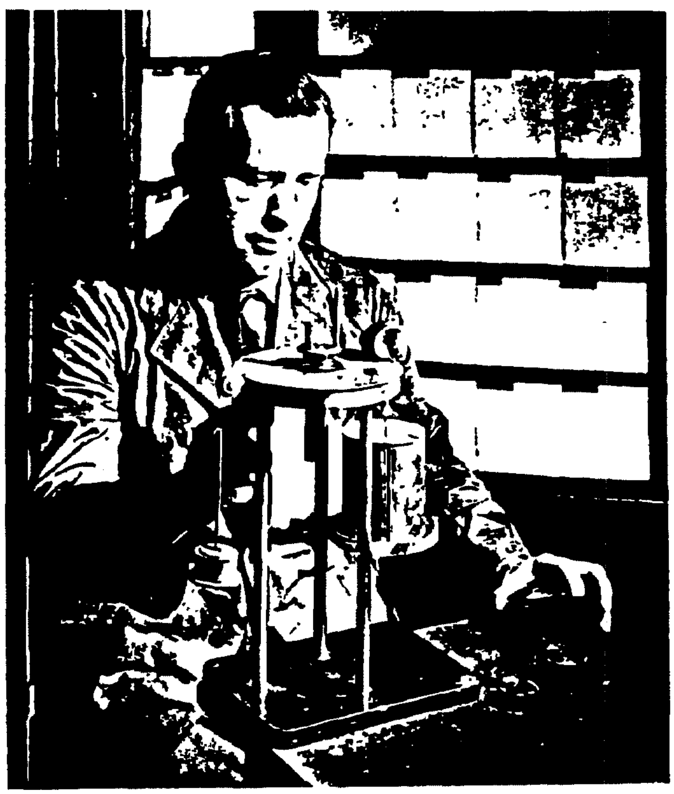


Manufacture of Test Paints

The paints for this test program were laboratory prepared by skilled operators.



Control of Consistency

Each of the test paints was formulated to possess satisfactory brushing consistency without reduction.

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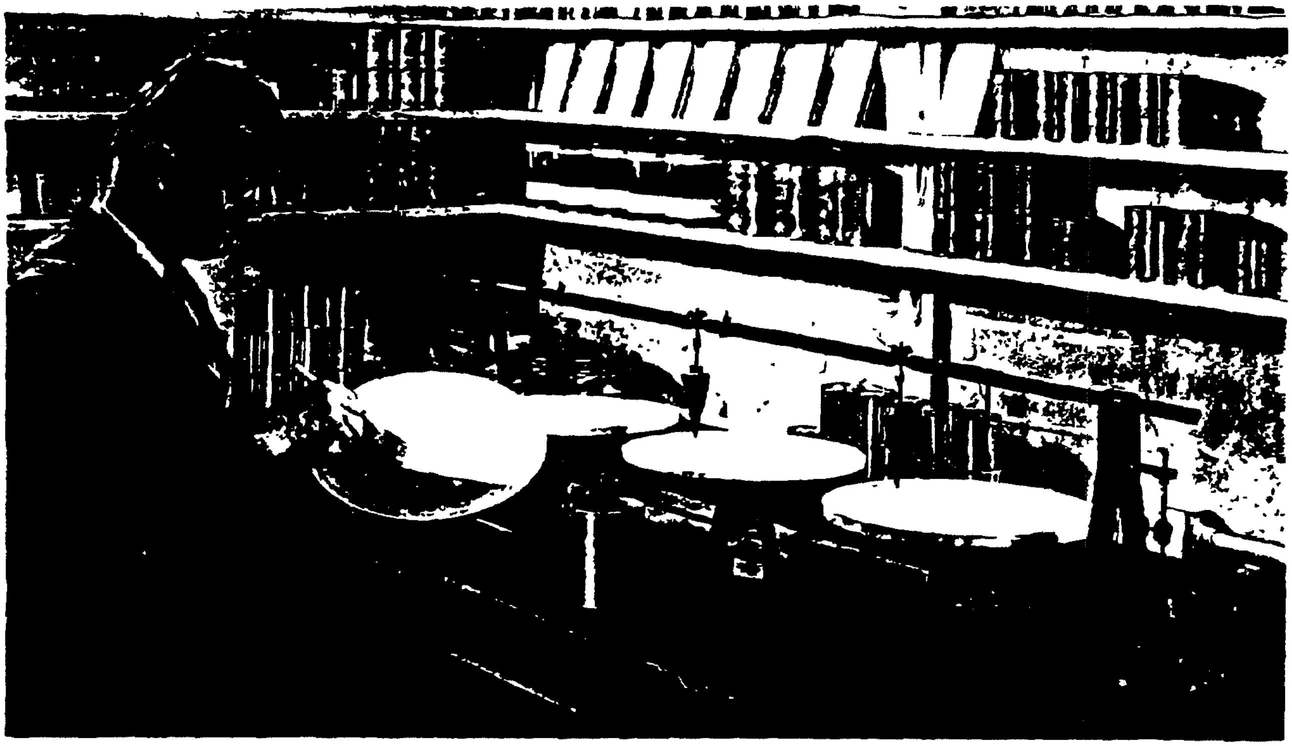
Type of Titanium Dioxide (Anatase and Rutile) (15 per cent)
Type of Zinc Oxide (Nodular, Acicular, Lead Free, Cofumed, Blended, 35 per cent Leaded, 50 per cent Leaded)
Type of Inert (Magnesium Silicate, Mica, Whiting, Gypsum, Barytes)
White Lead (B.C.W.L. and B.S.W.L.) Content (Range 0 to 41 per cent)
Leaded Zinc Oxide Content (Range 0 to 78 per cent)
Lead Free Zinc Oxide Content (Range 0 to 60 per cent)
Inert Content (Range 7 to 65 per cent)
Mica Content (Range 0 to 15 per cent)

Many other types of oils and resins were suggested as replacements for the Z-5 oil in the one-to-three combination of Z-5 kettle bodied linseed oil and raw linseed oil vehicle. The following were considered worthy of inclusion in the investigation:

1. Linseed oil kettle bodied to "Q" viscosity
2. Conjugated linseed oil
3. Conjugated soya oil
4. Maleic treated linseed oil of "Q" body
5. Kettle bodied maleic treated linseed oil
6. Maleic treated blown linseed oil
7. Bodied dehydrated castor oil
8. Pentaerythritol ester
9. Bodied pentaerythritol ester
10. Bodied maleic treated pentaerythritol ester
11. Sorbitol ester of "H" body
12. Bodied sorbitol ester
13. Two different alkyds blended with linseed oil
14. One of the alkyds cooked with linseed oil
15. A carbic-linseed oil varnish
16. A carbic-soya oil varnish

Since a repetition of the formulations used with the Z-5 vehicle with each of these combinations would have been an almost impossible undertaking for any single laboratory, only a limited series of selected pigmentations were used with them. It is believed that the data obtained, when "tied-in" with that from the Z-5 linseed oil paints, will indicate the best formulation for each specific vehicle. Paints were also included covering representative pigmentations in the pre-war raw linseed oil type vehicle, in which the binder consists of a ten-to-one ratio of raw linseed and "Q" kettle bodied linseed oils. Series of paints covering representative specification and proprietary paints of the pre-war and war periods were included as comparison standards. Also, painting systems using special primers were covered.



Drying Time Measurement

All paints were tested initially, and during years of shelf-aging, to make certain that they possessed such important physical properties as ease of brushing, non-settling and good drying.

Painting Clapboard Test Panels

A skilled painter applied the paints to test panels in a uniform manner.

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To assure that the results when available would be of practical value, all paints exposed on the fence were formulated to possess satisfactory brushing at normal application consistency.

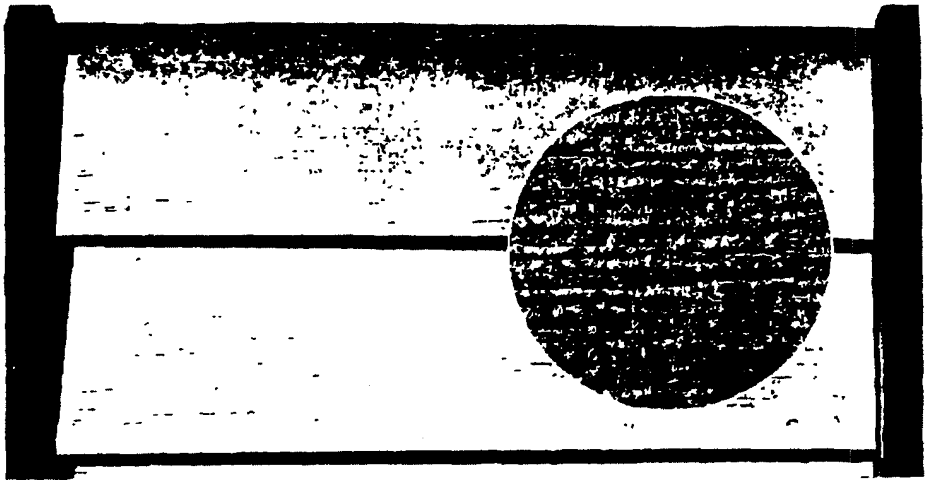
Panel Preparation and Exposure

Two types of panels were selected for the test fence exposures—assembled clapboard and single board panels. The clapboard panels consist of two new boards and two painted boards. The painted clapboards were obtained by stripping the south side of a large building to provide comparable weathered surfaces for all tests. After taking these precautions it is regrettable that through lack of foresight these boards were stored under very warm, dry conditions. They were then assembled into the test panels, painted and exposed on the fence. Shortly after exposure, paint film failures developed in many cases due to warping and cracking of the boards. The value of these tests is therefore questionable so, in general, we have based our conclusions on the tests on new wood.

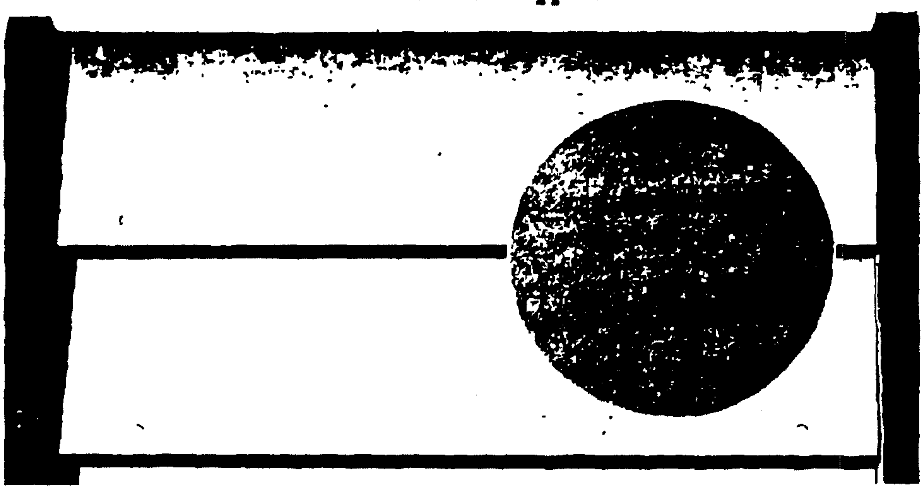
Both because the trend is toward two-coat work and to expedite obtaining results, all of the paints were applied to panels as two coats, although a number of the paints were also applied as three coats so comparisons would be available. Preliminary results showed the properties of the various experimental paints were such that reduction for priming was not necessary. Therefore, the paints were applied as first coats without reduction, but comparative exposure tests were included covering a number of the paints in which they were reduced for the first-coat application. All of the paints have been under observation for stability during shelf storage.

Because of the large number of paints it was not possible to prepare and expose all the panels at one time. They were separated into groups and the preparation and exposure of the various series of test panels on the fence extended over approximately a year. All of the paints were exposed on our test fences at Palmerton, Pa., the clapboard panels vertically and the single board panels at 45° facing south. Some of the paints were also tinted and exposed vertically on single board panels. Besides the exposures at Palmerton, several of the paints were exposed on clapboard panels at four other localities (Florida, California, Colorado and Illinois). A large percentage of the panels now have been on the fence for at least four years and have reached a stage of weathering where many final conclusions may be drawn. Most of the three-coat systems are still in excellent condition and are following the same type of weathering as the two-coat systems. It will require at least two more years' exposure before final conclusions can be drawn from them. The indications are that the relative ratings of the formulations by the two- and by the three-coat systems should be in good agreement.

Pre-War Linseed Oil Type Paint



Bodied Linseed Oil Type Paint



Exterior house paints comparable to high grade pre-war linseed oil paints can be formulated using a vehicle containing a high percentage of a heavy-bodied linseed oil.

(Two coats on new white pine—exposed 4 years—vertical, facing south. Inserts are 4 diameter magnification.)

PIGMENT FORMULA

15%	TiO_2 (Rutile)
30%	White Lead
30%	Zinc Oxide
25%	Siliceous Inerts
100%	

3

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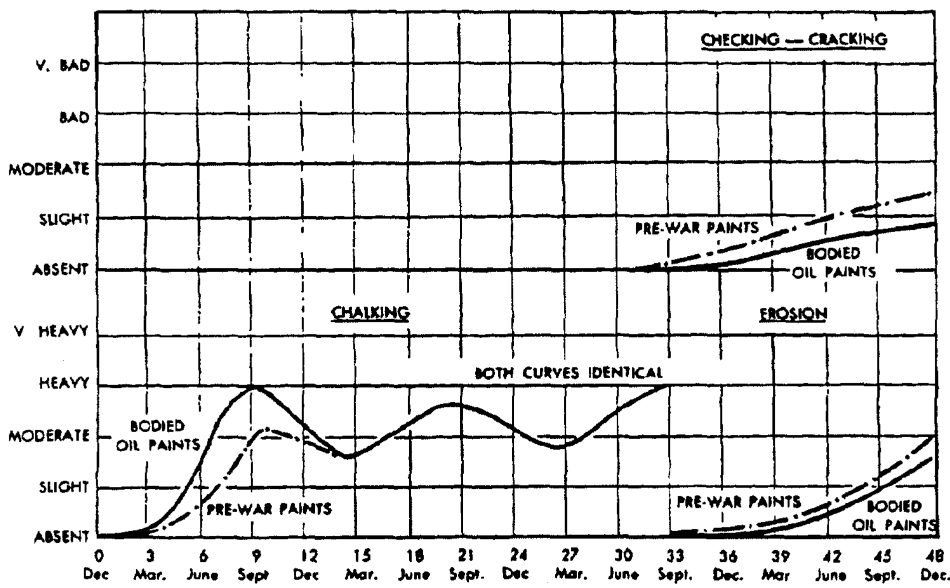
Weathering Properties of Pre-War Type vs Bodied Linseed Oil Type Paint

The weathering results now provide an answer to the question: Can as durable paint be formulated with the war type bodied oil modified vehicle as with the pre-war raw linseed oil type? Comparable exposures of paints prepared with the two types of vehicle covering a wide range of pigment compositions consistently show durability advantages for the bodied oil type paints. The graphs in Chart 1 cover the weathering of a representative set of these paints. The bodied oil paints had lower original gloss and during the first year or 15 months developed heavier chalking, but after that period the two paints were equal in these properties. In later life the bodied oil paints developed less erosion and less checking and cracking than the pre-war type. The lower gloss of the bodied oil type paints, in which we used siliceous inerts, might be considered a disavantage by some consumers. Still, we have never considered high gloss a criterion for good outside house paints.

Chart 1

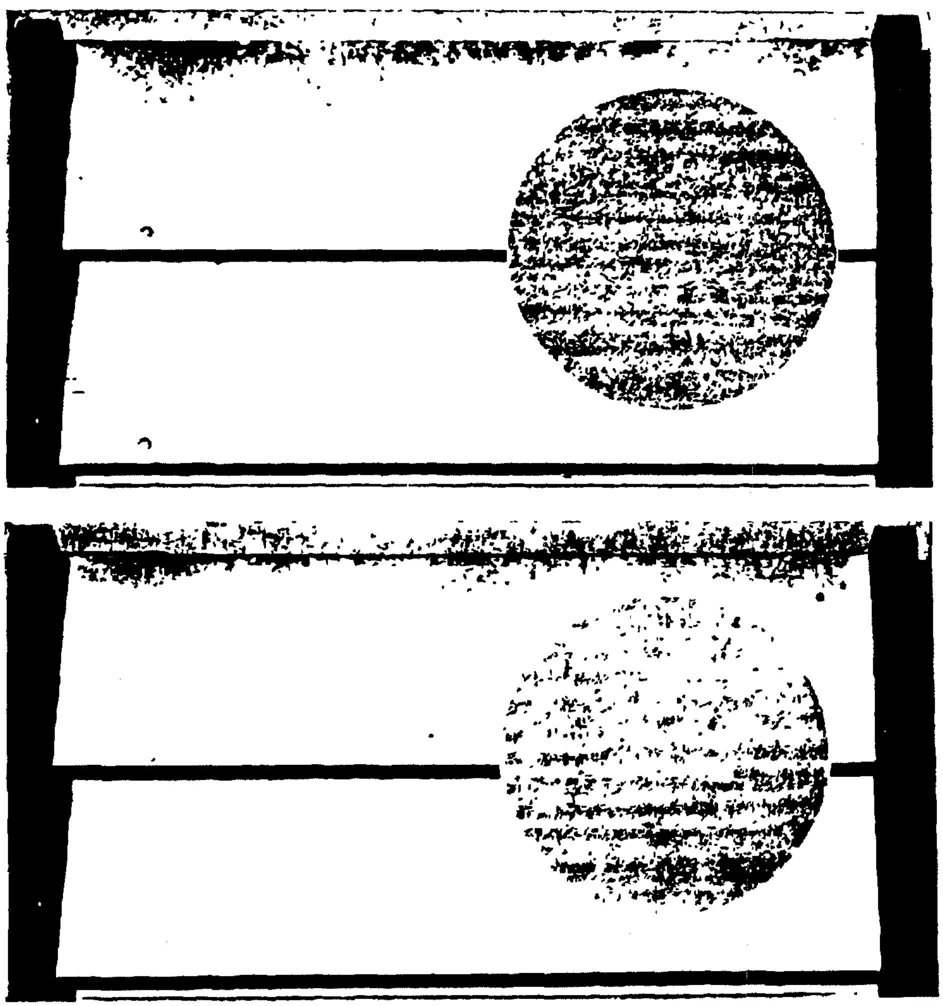


Weathering Properties of Pre-War Pigmentations in Bodied Linseed Oil Type Vehicle

The exposures have established that, using a combination of raw linseed oil and heavy kettle bodied oil as the non-volatile vehicle, durable paints are obtained with all three of the standard basic pigment combinations:

Type 1—15% TiO_2—30% White Lead—30% Zinc Oxide—25% Inerts (Siliceous)
Type 2—15% TiO_2—47% Leaded (35%) Zinc Oxide—38% Inerts (Siliceous)
Type 3—15% TiO_2—40% Lead Free Zinc Oxide—45% Inerts (Siliceous)

Graphs representing the weathering of these three paints are shown in Chart 2. These cover four years' vertical exposure facing south of two-coat applications of the



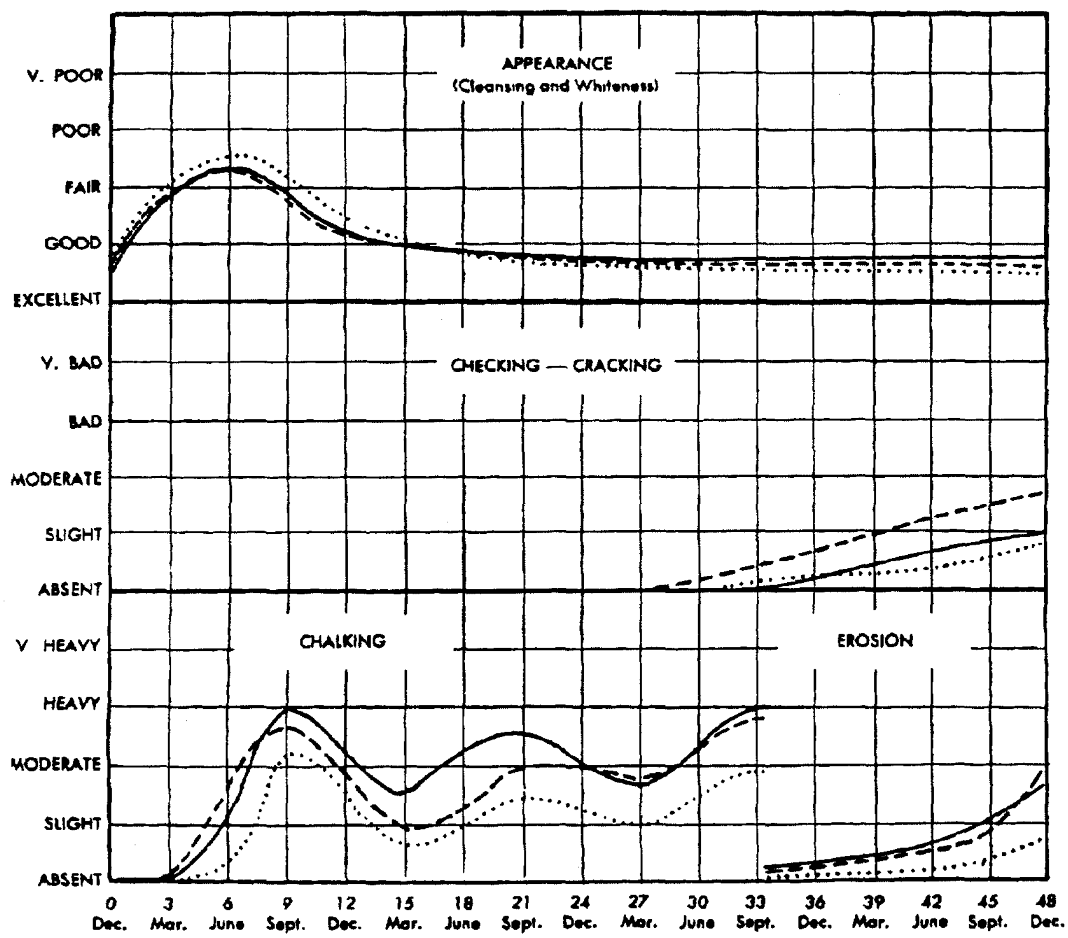
These two panels of bodied linseed oil type paints demonstrate the desirable weathering characteristics of such coatings — good appearance, chalking type of weathering with subsequent erosion, and a favorable surface for repainting.

(Two coats on new white pine—exposed 4 years — vertical, facing south. Inserts are 4 diameter magnification.)

paints to assembled test panels of new white pine clapboard siding. It is quite evident from these results that all three paints possess desirable weathering characteristics and are, after four years' service, in excellent condition for repainting. The similarity of the weathering characteristics of the three types is striking. All chalked at a reasonable rate and none developed any integrity failures until the film had become thin by erosion. The panels covering three-coat applications are still in excellent condition and should require at least two more years of exposure before they reach a repaint condition. The chalking curves are interesting. It has been our experience, as in the case of these paints, that chalking, that is, quantity of removable chalk, follows a cycle, reaching maxima in late summer and minima in late winter. As shown in the chart, when the film has been sufficiently thinned by erosion so that any wood begins to become visible, we discontinue chalking gradings and report degree of erosion.

Chart 2

Weathering Results of the Three Types of Bodied Oil Paints



——— 15% TiO_2—30% White Lead—30% Zinc Oxide—25% Inerts (Siliceous)

– – – – 15% TiO_2—47% Leaded (35%) Zinc Oxide—38% Inerts (Siliceous)

.... 15% TiO_2—40% Zinc Oxide (Lead Free)—10% Mica—35% Inerts (Siliceous)

Effect of Changes in Pigmentation of Fume-proof Paints

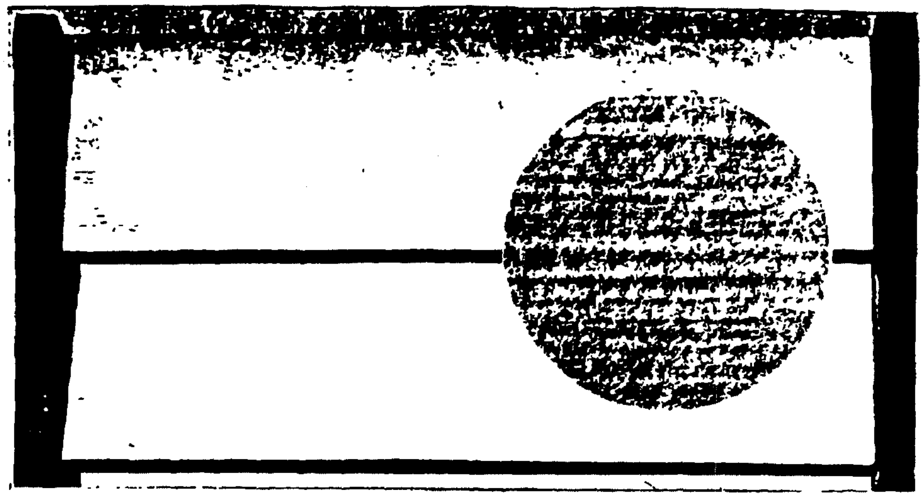
The bodied oil type vehicle permits considerable latitude in pigment formulation. This is indicated by the good durability of these three paints which cover a range of ZnO content from 30% to 50%. This feature enables paint manufacturers to produce special purpose coatings, such as *fume-proof (lead free)* paints, of superior performance.

PIGMENT FORMULAS

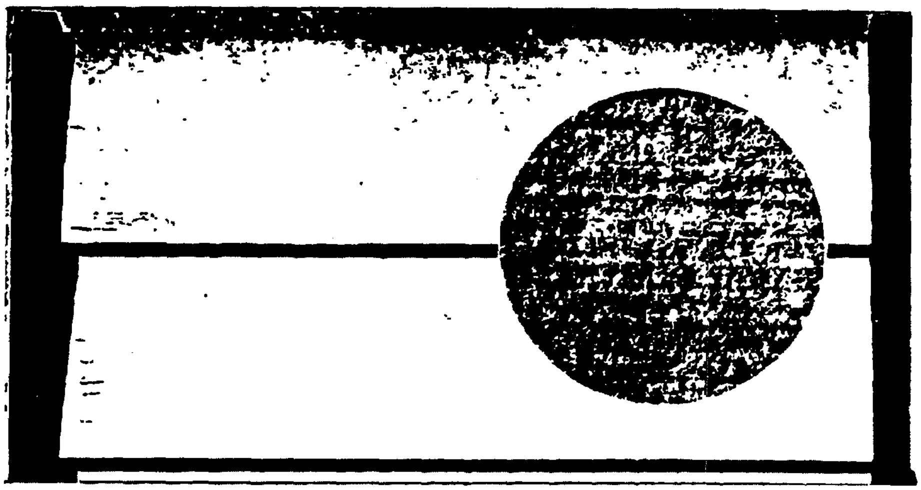
	A	B	C
TiO_2	15%	15%	15%
"XX" Zinc Oxide	30	40	50
Mica	10	10	10
Magnesium Silicate	45	35	25
	100%	100%	100%

(Two coats on new white pine—exposed 4 years — vertical, facing south. Inserts are 4 diameter magnification.)

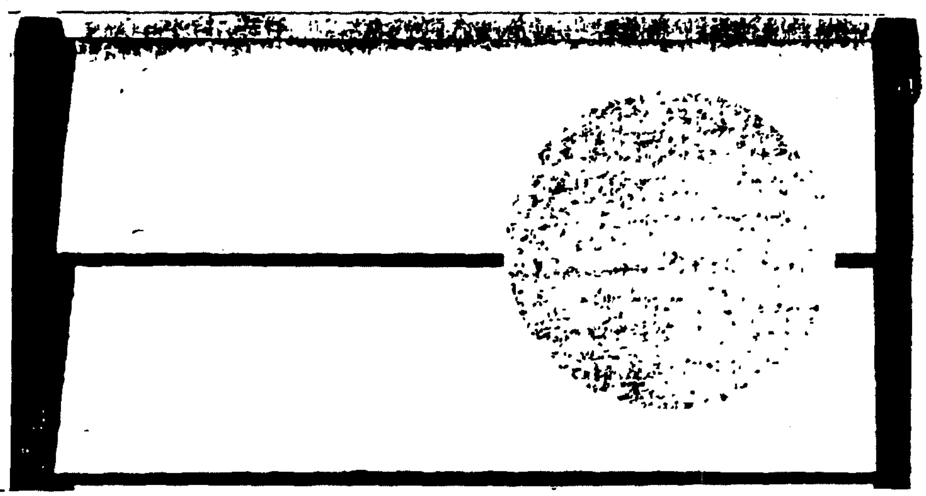
A



B



C



Effect of Changes in Pigmentations on Weathering Properties

Many variations of the three basic formulations were exposed to determine the optimum ratio of the pigment constituents in each type of pigmentation. While the titanium dioxide content in the pigmentation of these paints was maintained constant at 15 per cent, the white lead content (B.C.W.L. and B.S.W.L. from the leaded zinc oxides) and ZnO content were varied over the ranges shown in the following table. The remainder of each pigmentation consists of siliceous inerts:

Formula	*White Lead Content*	*ZnO Content*
Type 1	18 5 to 52 5%	15 to 40%
Type 2	8 5 to 35%	15 to 50%
Type 3	Nil	30 to 60%

It is interesting that these wide ranges in pigment composition did not result in marked variations in paint service. While the paints containing pigment combinations typical of those used in first quality pre-war house paints were among the best in performance, all of the paints provided reasonable service. The results indicate that the formulator has greater latitude in the pigment composition of his first grade house paint when he uses a bodied oil type vehicle. For instance, depending upon his preference, he can use high lead content or eliminate lead and still obtain paints of comparable excellent durability. Also, by judicious selections, he can use high percentages of inerts and still produce first quality paints. This flexibility enables him to formulate special purpose coatings of improved performance. For example he can produce fume-proof paints of better drying, appearance, and durability, and by increasing the ZnO content from the normal 30 per cent range up to the 50 per cent range obtain greater mildew resistance without decreasing durability.

For the many who are interested in complete paint formulations, data for the three standard bodied oil type paints are included (refer to Table 1). While our tests indicate that these paints possess outstanding weathering characteristics, the results also indicate that reasonable modifications of the basic formulations should not significantly change their good performance.

TABLE 1

Formulations of Three Standard Bodied Oil Type Paints

	Paint No 1				*Paint No 2*				*Paint No 3*			
			100 Gal				*100 Gal*				*100 Gal*	
Component	*Per Cent*		*Lb.*	*Gal*	*Per Cent*		*Lb*	*Gal*	*Per Cent*		*Lb*	*Gal*
PIGMENT	61				59				54 5			
Titanium Dioxide		15	132	4 1		15	120	3 7		15	103	3 2
35% Leaded ZnO		47	412	8 5		47	377	7 8				
Lead Free ZnO		.				.				40	275	5 9
B C W L		13	114	2 5		.		.		.		
Magnesium Silicate		25	219	9 2		38	305	12 7		35	240	10 2
Mica		.		.						10	69	2 9
		100	877	24 3		100	802	24 2		100	687	22 2
VEHICLE	39				41				45 5			
Z-5 Kettle Bodied Oil		16 5	93	11 5		16 5	92	11 4		16 5	95	11 7
Raw Linseed Oil		49 5	278	35 8		49 5	276	35 7		49 5	284	36 6
Mineral Spirits and Drier		34 0	190	29 0		34 0	189	28 7		34 0	195	29 6
		100 0	561	76 3		100 0	557	75 8		100 0	574	77 9
			1438	100 6			1359	100 0			1261	100 1
P V			33 9%				34 0%				31 5%	
Oil/Gal			3 71 lb				3 68 lb				3 79 lb	
TiO_2/Gal			1 32 lb				1 20 lb				1 03 lb	
W L / Gal			2 58 lb				1 22 lb					
ZnO/Gal			2 68 lb				2 45 lb				2 75 lb	
Hiding Power, Gal			315 sq ft				285 sq ft				270 sq ft	

Comparison of Durability of Self-Primed vs Special Primer System

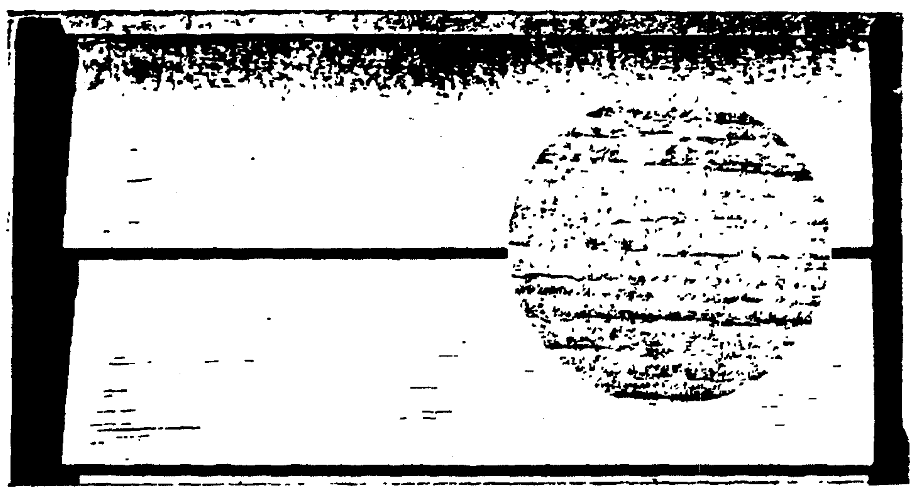
Another observation concerning the bodied oil type paint is that it provides with tw coats of a single paint the good weathering properties of a two-coat special primer sys tem. The exposures show quite consistently that a two-coat system composed of a pr

Pre-War Linseed Oil Type Paint

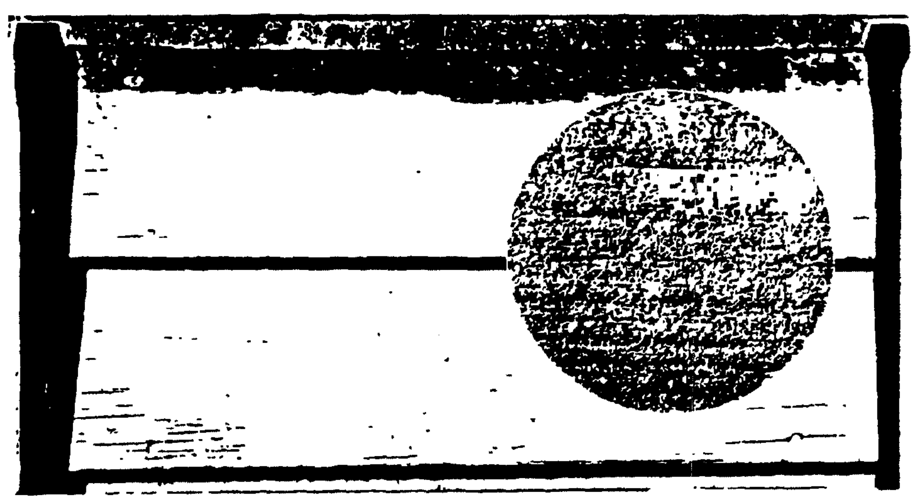
A 2-coat system consisting of a pre-war linseed oil type paint over a special primer is more durable than two coats of the pre-war paint.

(New white pine panels—exposed 4 years—vertical, facing south Inserts are 4 diameter magnification

Two coats of pre war finish paint.



One coat of special primer followed by one coat of above finish paint



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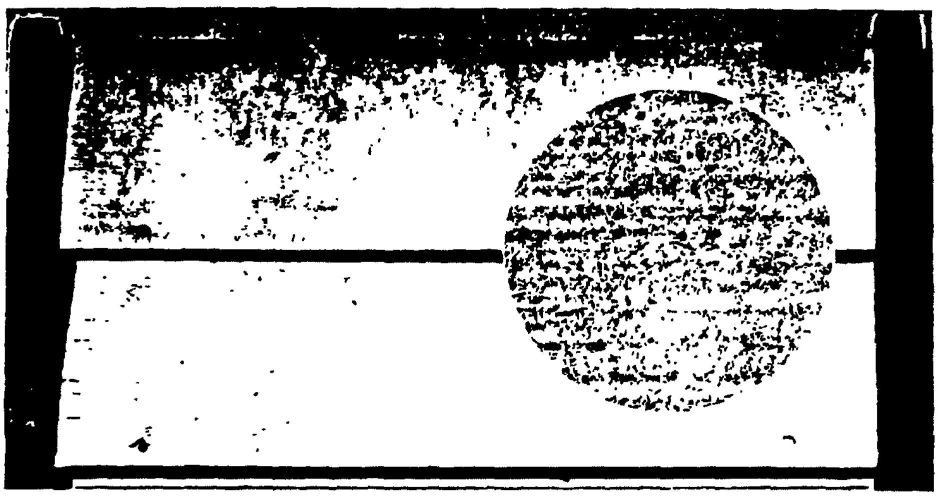
war linseed oil type paint over a special primer is more durable than two coats of the pre-war paint. In the case of the bodied oil type paint, equally as good durability resulted from two coats of the paint as from a finish coat of the bodied oil paint applied over a special primer. Such results were partly anticipated since these bodied oil type paints possess many of the properties of the special primer—the vehicle is of the controlled penetration type, the pigment-binder ratio is high and the film tends to dry with a relatively low gloss.

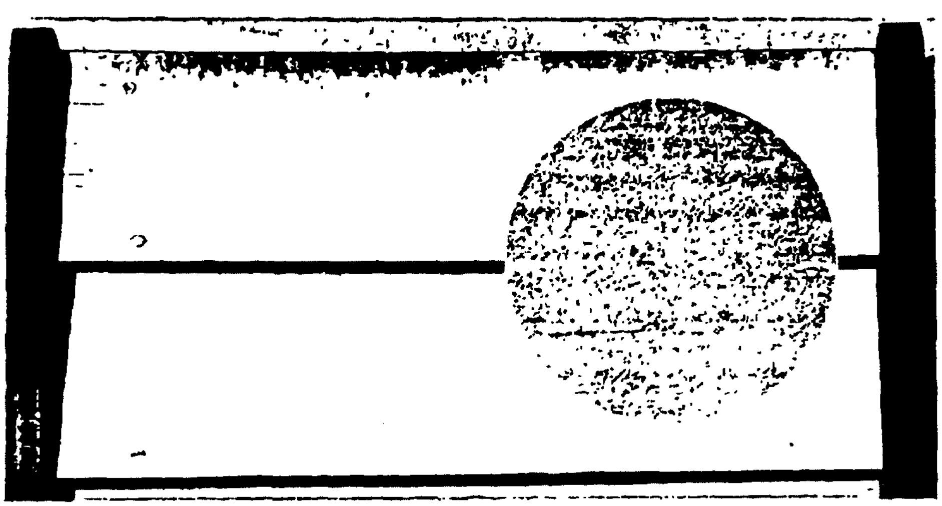
Bodied Linseed Oil Type Paint

Equally good durability is obtained with either two coats of bodied linseed oil type paint or a coat of special primer followed by a finish coat of bodied linseed oil type paint

(New white pine panels—exposed 4 years—vertical, facing south. Inserts are 4 diameter magnification.)



Two coats of bodied linseed oil type finish paint



One coat of special primer followed by one coat of above finish paint

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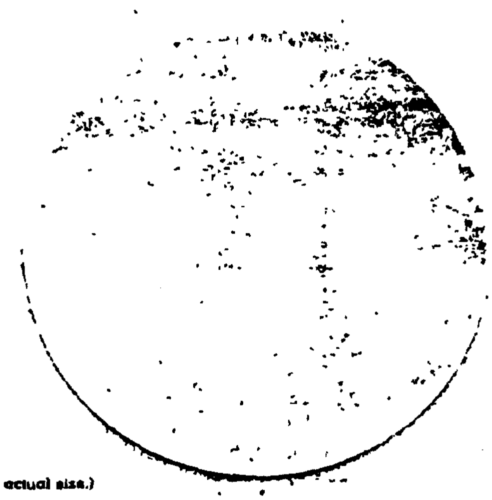
Thickness of Paint Films

The bodied oil type paint contains appreciably more volatile thinner than the raw linseed oil type. Therefore, when the two types of paint are applied at the same spreading rate on a non-porous surface, the bodied oil paint will provide a thinner dry paint film. In fact, by calculation the average thickness of the bodied oil type paint film is approximately 80 per cent of the thickness of the pre-war raw linseed oil type paint film. Our exposure panels were prepared by a painter who has been preparing them for years and care was taken to apply comparative paints covering the raw linseed and the bodied oil type vehicles at the same spreading rate. Since a thicker film of paint is generally more durable, one might expect the raw linseed oil type paint to provide the longer service. Inasmuch as our tests have shown this not to be the case, we have considered the following possible explanations for the greater durability of the bodied oil type paint. The bodied oil type paint levels much better, leaves less brushmarks, than the raw linseed oil type. The variation in the thickness of the film at the ridges and valleys of the brushmarks is greater in the case of the raw linseed oil type paint. There also is greater penetration of the binder into the pores of the wood in the case of the raw linseed oil type paint.

Calculations and measurements indicate the thickness of the paint film at the valleys of the brushmarks may be no greater in the case of the raw linseed oil type paint than in the bodied oil type paint. When applied at a spreading rate of 500 square feet per gallon, two coats of either type of paint on an impervious surface will provide a

Bodied Linseed Oil Type Paints Level Better Than the Pre-war Type



(Photographs are actual size.)

Unexposed pre-war linseed oil type paint film.

Unexposed bodied linseed oil type paint film.

wet film of 0.0064 inch. The volume content of pigment and non-volatile vehicle in the raw linseed oil type paint is approximately 89 per cent, and 72 per cent in the bodied oil type. Since any change in volume of the binder on drying is insignificant, the average dry film thicknesses of the two paints are 0.0057 inch and 0.0046 inch, respectively. Measurements made on practical brush applications of the two types of paint, using a calibrated microscope and focusing on the tops and bottoms of the brushmarks, show that the depth of the brushmarks in the raw linseed oil type paint varies from 0.0005 inch to 0.0016 inch. The depths of the brushmarks were so much less in the case of the bodied oil type paint that it was not possible to measure them accurately, still it was established that the most pronounced were less than 0.0005 inch deep. These results indicate the minimum thickness of the two films is approximately equal ($0.0057 - 0.0016 = 0.0041$ and $0.0046 - 0.0005 = 0.0041$). As shown in the photomicrographs of the films of the two paints applied on wood, some of the oil of the raw linseed oil type paint is lost through penetration into the wood. Thus, under practical use, if the two paints are applied at the same spreading rates the bodied oil type of paint should provide a slightly greater minimum film thickness than the raw linseed oil type.

Just as a chain is no stronger than its weakest link, the durability of a paint film is governed by its minimum thickness. Also, as the composition of the steel in the chain influences its strength, the type of oil in the paint film affects its durability. The recognized superior durability of polymerized oil is another factor that may account for the superior performance of the bodied oil type paint.

Comparison of Wood Penetration by Pre-war and Bodied Oil Type Paints

A. Cross section view of a film of pre-war linseed oil type paint on wood. (1400 diameter magnification.) The film has been reduced in thickness, homogeneity and strength by deep penetration of the vehicle.

B. Cross section view of a film of bodied oil type paint on wood. (1400 diameter magnification.) Controlled penetration prevents loss of vital oil into the wood, yet enables the full-bodied film to anchor itself in the outer wood cells.

House Paint Tests

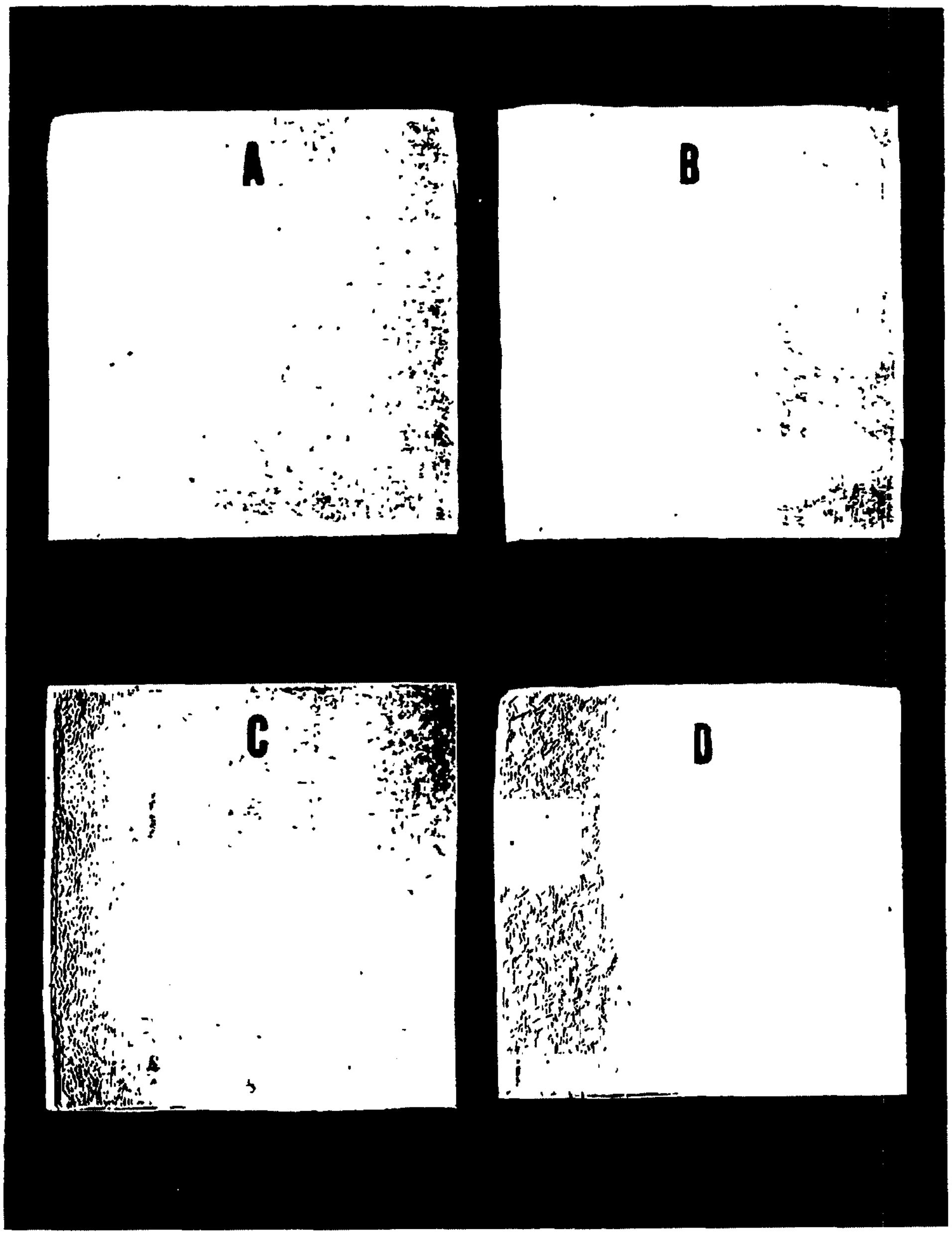
The application and weathering properties of some of these paints were studied on houses as well as on panels.

Spreading Rates of Paints

The spreading rates of these bodied oil type paints, formulated to brush as easily as the pre-war raw linseed oil type, were compared in the laboratory with those of the latter type by brushing on clapboard test panels. In these tests, under normal temperature conditions, the former had spreading rates equal to or slightly more than those of the pre-war type. We do not have comparative spreading rates for the paints applied to houses General observations, however, indicate that weather conditions may influence the relative spreading rates of these two types of paints. In cold weather, due to the bodied oil becoming more viscous, there is a tendency for a painter not to spread the bodied oil paint as far as the raw linseed oil paint During the heat of summer or on very warm surfaces, due to rapid evaporation of the volatile, there again is a tendency to apply a thicker coat to assure ease in picking up laps. The latter variation may be eliminated to some degree through the replacement of the mineral spirits in the bodied oil paint by a thinner of a slower evaporating rate.

Effect of Pigment Volume on Weathering Properties

The pigment-binder volume ratio for optimum performance in the pre-war linseed oil type of mixed pigment white house paint generally has been considered to he between 28 and 30 per cent. When the raw linseed oil vehicle in a paint is replaced by the bodied oil type, the pigment-binder ratio increases because of the higher volatile content in the bodied oil vehicle. For this reason it was anticipated that the optimum pigment-binder ratio would be appreciably higher than in the case of the raw linseed oil paint This point was covered in this investigation of bodied oil paints by formulations in which the pigment volume varied over the range of 25 to 50 per cent. While the results were not sufficiently extensive to establish definite minimum and maximum pigment volume values for optimum performance, the indications are that they will be a little higher than for the pre-war raw linseed oil paint. There is some evidence on the other hand, that by the selection of pigments of high consistency and high oil requirement properties, bodied oil type paint of excellent durability may be formulated at no higher pigment volume than pre-war raw linseed oil paint. Although it was not investigated, it is probable that if pigments of low consistency and low oil requirements are selected, durable paints can be formulated at relatively high pigment volumes.



Relative Drying of Paints

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Drying Properties of Paints

A large number of comparative drying tests under various drying conditions, from bright sunny to rainy and freezing weather, establish that the bodied oil paints possess better drying characteristics than either the pre-war ready-mixed paints or lead-in-oil paint. Largely due to their higher pigment volume and volatile content, the bodied oil paints seem to be more fool-proof and tend to produce better through-dried, non-wrinkled films over a range of practical film thicknesses and under adverse as well as normal drying conditions.

Relative Drying of Paints

(Photographs on opposite page)

The greater the thickness of film which will dry without wrinkling under cold adverse conditions, the better the drying properties of that paint. This feature is used in this illustration to show the relative drying properties of four paints on a glass plate. The films were applied by a wedge-shaped applicator, then dried under adverse conditions. Each film ranges in thickness from approximately 0.0005" at the right edge to 0.01" at the left. The severe wrinkling of the thicker portions of paints C and D indicates that such paints possess poorer drying properties than either of the bodied linseed oil type paints.

PIGMENT FORMULAS

	A	B	C	D
TiO_2	15%	15%	15%	0
White Lead	30	0	30	100%
Zinc Oxide	30	50	30	0
Inerts	25	35	25	0
	100%	100%	100%	100%

Paint A– Bodied linseed oil type
Paint B– Bodied linseed oil type
Paint C–Pre-war linseed oil type
Paint D–White lead-in-oil

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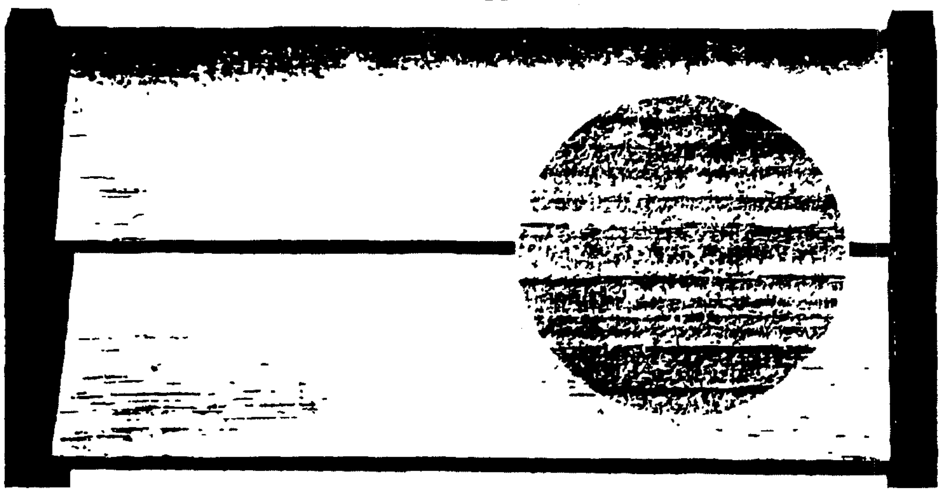
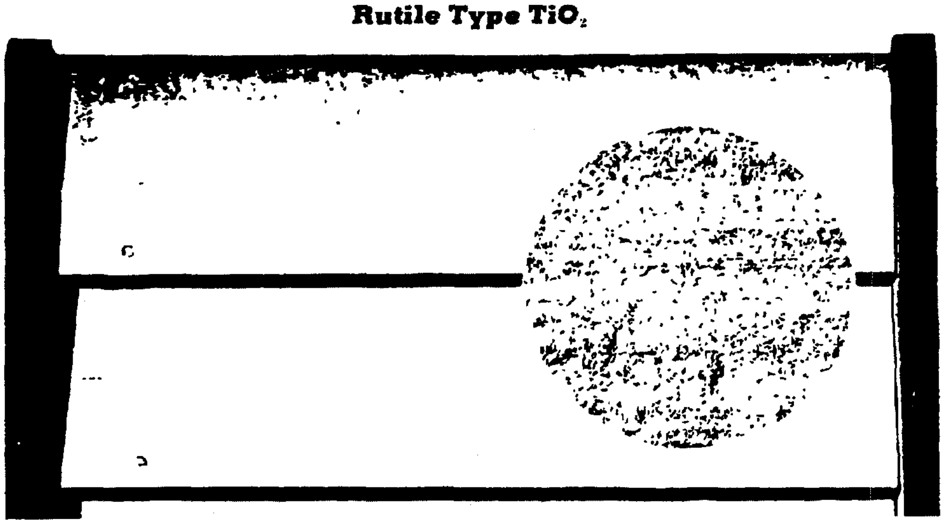
Anatase Type TiO_2



Rutile Type TiO_2



The definitely improved durability obtained with the rutile pigment, due primarily to a slower erosion rate, is shown here.

(Two coats on new white pine—exposed 4 years—vertical, facing south. Inserts are 4 diameter magnification. These paints are identical in formulation except in type of TiO_2. They consist of the following pigment combination in a bodied linseed oil type vehicle 15% TiO_2, 30% white lead, 30% zinc oxide and 25% siliceous inerts.)

0007-SWP-043894

Comparison of Anatase and Rutile Types of TiO_2

The use of anatase titanium dioxide results in better cleansing and maintenance of whiteness, whereas rutile titanium dioxide results in superior durability of a white house paint. The tendency of white house paint containing rutile titanium dioxide to develop a definite yellow discoloration may be a deterrent to its use. Still, the definitely improved durability obtainable with the rutile pigment, due primarily to a slower erosion rate, tends to make its use desirable where appearance is not the major factor. Undoubtedly, a paint system will be developed in which both the durability advantage of the rutile titanium dioxide and the appearance advantage of the anatase titanium dioxide will be realized. As anticipated, the tinted paints that contained anatase titanium dioxide faded the most rapidly and to the greatest degree, while less fading was obtained with the non-chalking type than with the chalking type of rutile titanium dioxide. Best tint retention resulted with zinc and lead pigment paints (titanium-free).

Effect of Other Bodied Oils on Weathering Properties

The large series of panels in which typical pigment combinations were used with vehicles consisting of raw linseed oil and various bodied oils and resins have weathered 3½ years and, in general, are in good condition. These results indicate that in the combination one part Z-5 linseed oil and three parts raw linseed oil, many types of heavy-bodied oil may replace the kettle bodied Z-5 linseed oil without detrimental effect on the weathering properties of the paint. At this time it appears that the bodied maleic treated linseed oils, heavy-body conjugated linseed oil, heavy-body conjugated soy bean oil, and bodied dehydrated castor oil are all satisfactory substitutes for the kettle bodied Z-5 linseed oil.

Summary of Results

The information developed by this investigation of the bodied oil type of exterior house paint is summarized in the following conclusions:

1. Exterior house paints comparable to high grade pre-war raw linseed oil paints can be formulated using a vehicle containing a high percentage of a heavy-bodied linseed oil.

2. The bodied oil paints formulated for this test program possess satisfactory consistency, packaging, shelf-storage and application properties and produce smooth films fairly free from brushmarks and of excellent drying characteristics. Their gloss and gloss retention are poorer than those of pre-war raw linseed oil paints

3. White house paints possessing excellent and approximately comparable weathering characteristics can be prepared using any of the following pigment compositions.
   (1) TiO_2-White Lead-Zinc Oxide-Inerts.
   (2) TiO_2-Leaded Zinc Oxide-Inerts.
   (3) TiO_2-Lead Free Zinc Oxide-Inerts

   In each type of formula excellent performance is obtained with those pigment combinations which were typical of first quality pre-war house paints. Still, the formulator has considerable latitude, since appreciable variations in the ratios of the pigment constituents do not greatly change the good weathering properties of these paints. This enables formulators to produce special purpose coatings of improved performance with the aid of the bodied oil type vehicle.

4. These bodied oil type paints tend to fail by chalking and erosion. They maintain good appearance until repainting is necessary and then provide favorable repainting surfaces. While they possess lower gloss and develop heavier chalk during the first year of exposure, the subsequent erosion is slightly slower than for the pre-war raw linseed oil paint.

5. Best original whiteness, retention of whiteness during exposure, and cleansing characteristics are obtained when the titanium in the pigment is the free-chalking type anatase TiO_2. Paints containing the non-chalking and chalk-resisting types of rutile titanium dioxide, and especially the rutile titanium-calcium composite pigment, are not as bright white, tend to retain more dirt, to possess poorer cleansing properties, and to develop yellow discoloration; but paints containing the rutile TiO_2 possess better durability than anatase TiO_2 paints.

6. The bodied oil paint can be used without reduction for all coats. When applied as a two-coat system, because of its controlled penetration type vehicle, it provides comparable performance to a two-coat special primer system.

7. The optimum pigment volume of the bodied oil type paint is slightly higher than for the pre-war raw linseed oil paint, due to the higher volatile content in the vehicle.

8. The tint retention of paints containing the non-chalking or chalk-resisting types of rutile titanium dioxide is better than for those based on the chalking type or the anatase grade, but tends to be inferior to the zinc and lead pigment paints (titanium-free).

9. Durable house paints can be formulated using combinations of raw linseed oil and heavy-bodied oils other than kettle bodied linseed, such as dehydrated castor, treated soya and treated linseed oils.

Further Work

As pointed out earlier in this report, it was not possible to expose all of the test panels at one time. Although the exposures on many are now considered completed, others (especially the three-coat systems) will require another year or two before final durability conclusions can be drawn from them. This study and the results of other investigations have now established that raw linseed oil alone is not the ideal exterior house paint vehicle and that bodied linseed and other bodied oils are desirable constituents. Availability and economics frequently make the use of still other oils desirable.

Last fall our laboratory initiated a new series of tests in which the use of soy bean oils as the major oil constituents of white exterior house paint is being investigated. Dehydrated castor oil and other oils will be included. As information is developed, it will be passed on to you.