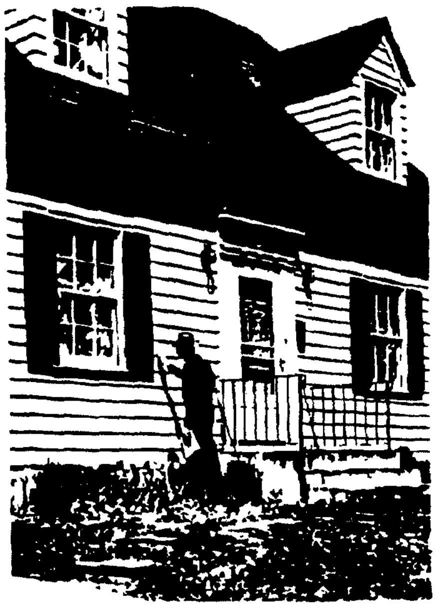
EXTERIOR HOUSE PAINT

By

S. WERTHAN



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Exterior House Paint*

By S. WERTHAN

The New Jersey Zinc Company (of

For the purpose of this paper I will consider hous
to the protective and decorative coatings used on surface
which contain as their major vehicle component an unb
further differentiate them from some of the other oil veh
such as metal protective, barn, trim and trellis, etc., pai
discussion to paints that contain an appreciable percen
pigment.

The painting of buildings and other structures is
from before the beginning of history, but painting for pr
White lead, the first white opaque pigment to be used
known to the early Romans. Pliny in the first century
facture. The early artists prepared their own paint by
ment with oil or other medium. While the records do n
its first use as a house paint, it apparently was someti
teenth century. The first white lead plant in the Unite
Philadelphia in 1804 by Samuel Wetherill and Sons.
produced about the middle of the century. The firs
mixed paints are commonly accredited to D. R. Averil
who in July, 1867 patented a paint of this type and be
and sale. The prepared paint industry, as a real indust
started until the late seventies or the early eighties.

It is interesting that although, during the past hal
been many developments and changes in house paint
products never entirely replaced the old and the various
used today. These include:

1. Straight White Lead Paints
2. White Lead-Zinc Oxide-Inert Paints
3. Lithopone-Zinc Oxide-Inert Paints
4. Zinc Sulfide Pigments-Zinc Oxide-Inert Pai
5. Titanium Pigments-White Lead-Zinc Oxide
6. Titanium Pigments-Zinc Oxide-Inert Paints

Besides changes in the composition of the pigm
been a few changes in the composition of the nonvo
straight raw linseed oil to combinations of various typ
heavy bodied oils.

A combination of basic carbonate of white lead, li
and drier was the first exterior house paint to be ge
a painter no longer buys the dry basic carbonate of lea
and reduces it to paint in his shop, some continue to ma

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* An address presented at Wayne University as a part of their Te
under the auspices of the Detroit Paint and Varnish Production Clu
Varnish and Lacquer Association

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by reducing lead-in-oil paste with linseed oil, volatile thinner, and liquid drier as their grandfathers did fifty years ago

While zinc oxide was also reported by Pliny, there is no mention of it being used in paint until late in the eighteenth century. Apparently some was used in house paint in America about 1830, for it is recorded at about that year the house of Dr Fowler, in the vicinity of Franklin, New Jersey, was painted with zinc oxide made from the zinc ore deposits for which that region is famous. There is no record of the type of vehicle used About the same time, the Frenchman, Leclaire, started the manufacture of zinc oxide and the promotion of its use in paint in place of white lead because of its nontoxic qualities and the retention of its brilliant whiteness even in the presence of sulfide gas It was not long until zinc oxide ground in a stand oil (heavy kettle bodied oil) vehicle was being used in Europe on both exterior and interior wood surfaces Based on the limitations placed at the start of this article, this paint (Old Dutch enamel) cannot be considered a house paint Still it was not long until painters, recognizing the merits of zinc oxide, added some to the white lead in preparing their house paint *Thus was born the lead-zinc type of house paint*

This was also about the time that the manufacture of ready-mixed paint started. The grinder, who had been marketing various brands of white lead and zinc oxide pastes, was well informed regarding the blending of these two white opaque pigments and extending them with barytes and the siliceous inerts This was the official birth of the White Lead-Zinc Oxide-Inert mixed paint. In reality, the painters had for some time, unknowingly, prepared their own mixed pigment paint

The late George B Heckel in "The Paint Industry—Reminiscences and Comments" describes in his inimitable style the period of "laissez faire" in American paint manufacturing when under such descriptions as "We guarantee the white lead in this package to be absolutely pure," the Basic Carbonate of White Lead in the white lead pastes varied from 100 to 0 per cent of the pigment Two typical brands contained approximately 62 per cent B C W L—28 per cent zinc oxide—10 per cent barytes and 25 per cent B C W L—25 per cent zinc oxide—50 per cent barytes, respectively Strange as it then seemed, frequently the results obtained by painters with these pastes were superior to those obtained with straight white lead pastes But the excessive use of inerts because of their low cost in ready mixed paints resulted in the opinion that the presence of any inert was a sign of inferior quality. Although it has long been established that an exterior paint containing the correct types of inerts is superior to an inert-free paint, the impression still prevails that inerts are used only to lower cost

In 1920, after protracted pigment and paint investigations, our Company developed and recommended to the industry Lithopone-Zinc Oxide-Inert paint. For many years prior to this time, lithopone had been used as the basic white opaque pigment for interior paints Because the lithopones of that time were light sensitive, tended to darken when exposed to sunlight, they had found little use in exterior paints In 1919, Albalith, a light resistant lithopone, was developed, thus providing a lithopone suitable for use in exterior paint. The suggested paints contained several innovations in exterior house paint formulation, which, although known to many chemists,

had never been promulgated These formulations conta
The zinc oxide could be either a lead-free or a leaded gr
grade of zinc oxide was used, the paint contained no lead
lead-less ready-mixed paint. The work of our laborato
siliceous inerts, such as silex, fibrous magnesium silicate,
mica, impart definite beneficial properties to the paint
abuse of the use of inerts or extender pigments had dev
paint containing them, we did not hesitate to proclain
recommend 20 per cent in the lithopone-zinc oxide p
studies also established that some heat-bodied oil in th
the application, flow and film properties of paint, and it
that 10 per cent of the oil be kettle bodied oil of "Q" visc
paints, since they possessed higher-hiding and were lov
lead-zinc inert paints, met with considerable favor.

At about the same time, titanium-barium pigment w
manufacturer Similar to lithopone, it is a composite pig
sulfate and titanium dioxide instead of barium sulfate an
ing the twenties and thirties, many exterior house pain
containing titanium barium pigment They contained
or at least one of them and usually some siliceous inert
to have a slight advantage over lithopone paint in hiding
a tendency to replace lithopone by high strength lithop
which had become commercially available.

With the advent of titanium dioxide, the trend was
ium-barium pigment with titanium dioxide and the high
inerts. This resulted in improved and lower cost pain
advantages of the siliceous inerts, the white pigment ma
the paint manufacturers a zinc sulfide composite pigmen
was a combination of water ground mica and fibrous
and a titanium composite pigment containing magnesiu
ert base Paints were formulated using either of these pi
zinc oxides Another composite titanium pigment in w
is anhydrous calcium sulfate became available. Althou
pigment was limited almost entirely to interior paints,
the rutile titanium dioxide type of pigment, there has b
it in exterior house paint.

Although, as has been mentioned, paints containing
ous types of pigmentation are still being manufactured
formulations today contain a combination of titanium
zinc oxide, and inerts; or titanium dioxide, zinc oxide a

Contrary to the many variations in the compositi
there have been few changes in the vehicle. The comb
seed oil, turpentine, and liquid drier, used originally,
without modification excepting that a boiled (one cont
fined linseed oil might be substituted for the raw oil or p
the turpentine The first and only modification up to
the composition of the vehicle was the previously menti
a small percentage of the raw oil by kettle bodied oil
provements were undoubtedly retarded by one or two ill

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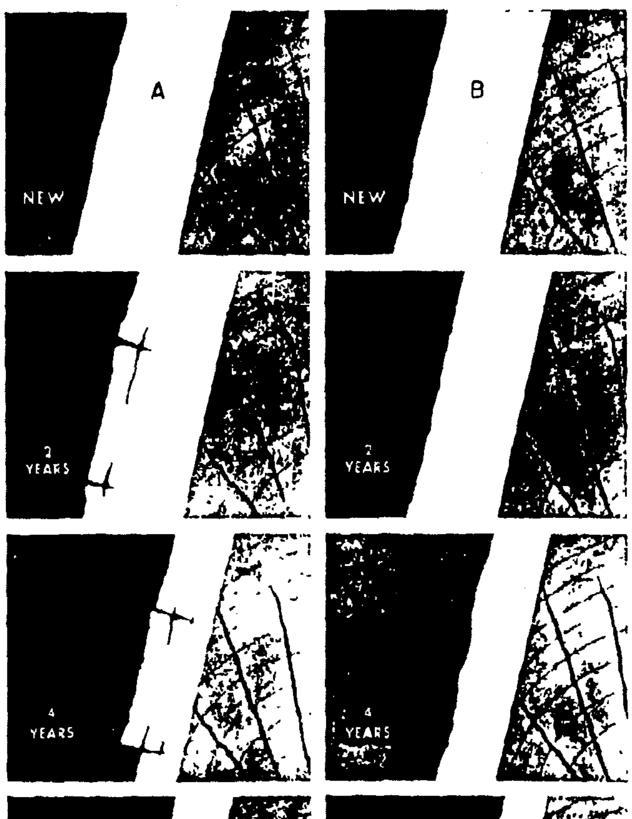

Figure 1

in enamelized type vehicles which resulted in some disas
To conserve oil during the war, the Government, on the a
better informed paint technicians, compelled the paint m
more heavy bodied oil and volatile thinner in their exte
Thus was broken down the supposition that the oil in
paint must be raw linseed oil The superior results that
with the bodied oil paints have led to a more general u
has also been demonstrated that replacement of a portio
by other drying oils need not be detrimental Generally
cent of the oil in today's highest grade exterior house
oil, and this oil may be linseed or some other type of dr
use of alkyds and other types of resin vehicles is being
merits have not been established

Paint films being organic coatings naturally deterio
to the elements, the method and rate of this deteriora
service obtained from the paint The large variety of e
in use today may be partly attributed to the lack of a
relative importance of their different properties Anoth
the paint's properties are only one factor, and frequen
determining the service that will be obtained from the
are the type and condition of the surface to which the
application, the climatic conditions under which it is ap
the weather and other conditions to which the film is
many laboratories have made extensive investigations to
for exterior house paint, no one has developed a satisfa
ation. While there are tests for specific properties, the
depend on actual exposure tests (panel or house) to de
that may be anticipated from a paint.

An exterior house paint serves a dual purpose, th
and the beautification of the surface to which it is appli
of the paint film includes the progressive disintegration o
by chalking, sloughing, checking, and cracking, and fai
under surface, such as blistering, peeling, and scaling of
erties, besides these integrity factors, that influence th
film are degree of retention of gloss, color (white or tint

It seems opportune at this time to discuss the relatio
of the paint to its various properties. We will consider
the pigment, the composition of the vehicle, and the rat
the binder in the dry film Although exterior house pa
not been a definite scientific process, there are certai
reasons for the combinations of pigments that have been
consider some of the facts that are known regarding the
by the various pigments to the paint

Figure 1.—Magnified cross-section drawings illustrate the c
characteristics that have taken place as house paints have evolve
coatings (column A) into composite pigment paints (colum
sloughing off of the older paint has been replaced by balance
trolled erosion in modern paints, making possible a coating tha
during its service life but also leaves a sounder foundation for r
ings are from The New Jersey Zinc Company's motion pictu

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All of the white pigments (titanium, zinc sulfide, zinc oxide, and lead) impart opacity or hiding, although they differ appreciably in this property. On a weight basis, pure rutile titanium dioxide rates highest and white lead lowest. When white lead and zinc oxide were the only opaque white pigments, their opacity was a major consideration in their use, but today with the much higher hiding titanium and zinc sulfide pigments available, their contribution to the paint opacity is a minor consideration for the inclusion of lead and zinc in the pigmentation.

The characteristics that the various white pigments impart to a linseed oil paint have been determined by weathering tests. For a number of years, our laboratory has exposed many series of clapboard test panels painted with single and mixed pigment linseed oil paints, covering the various pigments and combinations of pigments used in exterior house paints. The weathering characteristics of the films have proved very enlightening. I will only take time to mention a few of these characteristics.

During exposure to the weather, the straight basic carbonate of white lead paint film accumulates dirt, becoming increasingly dirty. They also are darkened by sulfide fumes. After about one year of exposure, a characteristic crowfoot type of checking starts to develop. With continued exposure, these checks increase in depth and severity and form little islands of film. The exposed layers of the film flake off in small pieces taking surface dirt with them. Thus neither a uniformly clean nor attractive appearance is obtained. In general, the cohesive strength of the film is less than the adhesion of the film to the wood surface, so over a number of years a portion of the film remains. It is this property that has resulted in a continued acceptance of this paint. The film has little resistance to mildew, and this type of discoloration may be encountered in localities where mildew is prevalent. The tinted paints do not fade but darken and develop a muddy appearance.

The weathering process is slightly different in the case of basic sulfate of white lead. The basic sulfate film is weaker than the basic carbonate paint film. It does not develop visible checks, but the surface layer disintegrates and sloughs. During early exposure, the film holds dirt, but goes through cycles of cleansing due to the sloughing of the exposed surface of the film. While the film does not develop the pronounced checks and cracks of the B C W L film, its failure to wood is more rapid. The film is also susceptible to mildew and sulfide darkening. The tinted film tends to fade.

The zinc oxide film is much stronger than either of the lead films. There is very little apparent surface disintegration and the film retains its gloss over a long period of exposure. The film becomes progressively dirty especially during the winter months. There is a tendency for the traces of acidic gases in the atmosphere to react with the surface particles of zinc oxide in the film to form soluble salts or soaps, which with rain act as cleansing agents. While the film remains intact during many years of exposure, it eventually develops cracks and ultimately pieces of the film flake from the wood. Zinc oxide possesses fungistatic properties, and thus the film is resistant to mildew growth. The tinted film holds its tint very well (the best of all the white pigment films): the tint does not fade but shows a slight tendency to become more intense.

A leaded zinc oxide film is a strong film but not so s
free zinc oxide film. The film shows good gloss retention, a
ly slight surface disintegration develops. Ultimately, as
lead-free zinc oxide, cracking and flaking of the film fro
The film shows less dirt retention and better cleansing c
the lead-free zinc oxide film. It is also resistant to the g
The tinted film is definitely poorer than the lead-free zinc
retention; it shows a slight tendency to fade. (You note t
istics of the leaded zinc oxide paint film are what would b
the film characteristics of its two pigment components.)

The zinc sulfide pigments produce weak films, althoug
what with the inert component. Straight zinc sulfide prod
film, followed by high strength lithopone, lithopone, and t
cate base pigment, which is the weakest. They all fail by
erosion of the film. The rate of erosion of the films is i
their strength, except that, due to the reinforcing propert
base, especially the mica, the erosion of the siliceous ba
delayed. The erosion keeps the films quite clean. The fil
high resistance to mildew, especially in the case of the
ment in which magnesium silicate appears to be a food fo
The discoloration of the film caused by copper metal is m
the case of other white pigment films.

The anatase titanium dioxide pigments produce
films of the white opaque pigments. In the case of these
of the composite pigments tend to be stronger than that of
ium dioxide. They all fail by erosion or sloughing of the
anatase titanium dioxide and the magnesium silicate b
chalk the fastest and generally there is a heavy layer of r
the surface of the film. Usually only one year is requir
chalk to the wood. The rapid chalking results in good
anatase titanium dioxide rating highest among the white
cleansing characteristics and maintenance of whiteness
barium and calcium base pigment films chalk and erode sl
but tend to hold more dirt and to develop cracking or slo
anatase titanium dioxide pigment films are susceptible to
the calcium and magnesium silicate base pigments. The
dioxide paints are the poorest of all the white pigment
tention. The films fade severely.

The rutile titanium dioxide pigments produce stron
anatase pigments. The rutile titanium dioxide paints var
type and rate of weathering depending on whether they co
or non-chalking grades and the straight titanium dioxide o
ment. All of the rutile titanium dioxide paint films chalk
the corresponding anatase pigment films. In general, th
rapid enough to prevent the accumulation of dirt. Thi
photogenic yellowing results in the films during exposure
bright whiteness of the anatase pigment films. This dev
film whiteness is especially prevalent in the nonchalkin
titanium dioxide. The slow erosion of this grade results

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for the film The pigments are susceptible to mildew, the calcium base-chalk resisting grade produces paint films more susceptible than any other white pigment films Also, the tendency for this pigment film to retain dirt is very pronounced The rutile titanium pigment paints possess definitely better tint retention than the anatase and rate next to the zinc sulfide pigments They tend to both fade and to become muddy

Inerts such as whiting, calcium sulfate, silica, and magnesium silicate in linseed oil develop practically no hiding They offer little protection for the linseed oil binder so the films fail rapidly In the chemically nonreactive extender, such as silica and magnesium silicate, the bond between the inert and the oil binder is very weak, and the film failure is by disintegration or chalking In the case of the calcium pigments, where soap formation may occur, a stronger bond between the pigment and binder exists and disintegration may be accompanied by checking and cracking. None of these extender pigments possess fungicidal properties, and some are actually food for the mildew fungi In general, inerts have slightly detrimental effects on tint retention

Water-ground mica is an inert that warrants separate consideration Like the other siliceous inerts, it develops practically no hiding and produces weak films But because of its thin laminar particles, it apparently protects and reinforces the film. While the other inert-linseed oil films disintegrate within a year when exposed to weather, the mica paint film maintains its integrity for several years

Although explanations have been given for a few of the specific weathering characteristics of these various single pigment paint films, it seems desirable that some further reasons for their weathering characteristics be presented before we consider the formulation of multiple pigment paints

The lead and zinc oxide pigments are chemically active, that is they react with organic acids in the vehicle or formed in the film during exposure to produce soaps Thus there is a direct chemical bond between some of the pigment particles and the organic binder The soaps tend to form on the surface of the pigment particles which may result in a gradual transition in the film from pigment particle to soap to organic binder Both lead and zinc soaps are burr shaped, thus providing a further reinforcing effect The chemical bond between pigment particles and the organic binder tends to produce strong films. The lead soaps are softer and more plastic than the zinc soaps It is the ultra-violet rays in the sunlight that are most destructive of an organic film Zinc oxide is opaque to ultra-violet light and thus shields the binder from these destructive rays The basic white lead pigments are transparent to the ultra-violet light and permit the progressive oxidation and disintegration of the film by these rays It is the combination of these and other factors that impart to white lead films and to the zinc oxide films their weathering characteristics

Zinc sulfide does not react chemically with organic acids to form soaps, but it is organophilic in nature The zinc sulfide pigment particles in a paint film are well wetted by the organic binder While the strong chemical bond that exists in the case of zinc oxide is absent, still the oleophilic nature of the pigment imparts a degree of strength to the film The pigment does not

possess a high degree of opacity to ultra-violet light ra
vent the progressive disintegration of the film

Titanium dioxides do not react chemically with the
vehicle to form soaps They also are hydrophilic rather t
rutile titanium dioxide is definitely more oleophilic tha
anatase pigment is not opaque to ultra-violet light while
possesses a fairly high degree of opacity. These properti
chalking and disintegration of the anatase titanium dio
the greater durability of the rutile film.

In general, the extender pigments are chemically in
in nature and so tend to produce weak films Fibrous
and water-ground mica because of the relatively large si
their particles provide reinforcing properties In the case
ments, some calcium soaps may be formed by reaction
ents of the vehicle Then the particle size of the precipi
and nodular These facts may explain the poorer weath
of their films Also, the inerts account for the difference
tween the straight zinc sulfide and titanium dioxide film
composite pigments.

The weathering characteristics of paints composed
ations of these white opaque and extender pigments cou
similar manner. It would be found that their weathering
resultants of the weathering characteristics of the co
Thus, a formulator having a clear knowledge of the wea
tics of the individual pigments can select the combina
desired weathering characteristics Exterior house paint
be extremely simple if there were not many other prop
considered. These include ease of paint manufacture, s
in the package during storage, and paint and film prop
sistency, brushing, leveling, drying, opacity, gloss, colo
similar to our discussion of weathering, the characte
various pigments on each of these properties could be pre
beneficial to consider vehicle constituents in a similar n
effects of the ratio of the pigment to the binder on the v
ties Because of limited space, it is better that we move
ent day paint formulation. I will try to call attention to
vehicle properties as they arise during the discussion.

Perhaps the first consideration to the paint formulat
lead and zinc oxide were the only available white pigm
dollars paid a painter for a day's labor and anything less
paint was heresy Sufficient lead and zinc could be pu
provide ample hiding with three coats But today, whe
is general practice and even one coat painting is being pr
receive as much by the hour as their grandfathers did by
obtained with lead and zinc must be reinforced with high
such as the titanium and zinc sulfide Usually the desire
by the inclusion of from 1 to 1-1/3 pounds titanium dio
pounds of ZnS) in a gallon of the paint Based on the pe
pigment, this is usually about 15 per cent titanium di

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learned for best whiteness and cleansing properties, this should be the anatase grade

Starting with this 1 to 1-1/3 pounds anatase titanium dioxide, let us go ahead and formulate an exterior white house paint. Our single pigment exposure tests tell us that an anatase titanium dioxide paint film is weak, chalks very rapidly and is susceptible to mildew, also that zinc oxide and leaded zinc oxide films are strong, resist chalking and are fungistatic. They, therefore, are logical pigments to use with anatase titanium dioxide. Experience has shown that 2¼ to 3 pounds lead-free zinc oxide or 3½ to 4½ pounds leaded zinc oxide should be used with 1 to 1-1/3 pounds anatase titanium dioxide. On a percentage basis, the 15 per cent titanium dioxide in the pigment requires about 30 per cent lead-free or 47 per cent leaded zinc oxide.

We are now on the road toward balanced weathering, that is controlled erosion and cleansing properties. The weathering of the film can be further modified through the addition of white lead pigments. White lead is usually used more because of paint properties other than the weathering of the film. It is believed to beneficially affect paint mixing and grinding, paint application and flow, paint drying under adverse application or exposure conditions and to aid adherence of the film to the wood surface. The quantity used varies from none to three or four pounds in the gallon of paint or 0 to 30 per cent of the pigment.

This pigment composition of the white paint now is:

	Pounds	*Per cent*
Anatase Titanium Dioxide	1 to 1-1/3	15
Zinc Oxide	2¼ to 3	30
White Lead	0 to 3 or 4	0 to 30

This combination contains a high proportion of active pigments and on weathering may become too strong a film. It might under abrupt changes in stress-strain conditions, such as may be caused by the sudden freezing of a water-saturated film, develop cracks or lose adherence to the wood surface. As our tests have shown us inert extender pigments produce weak films. Through the inclusion of inert pigments, the film can be weakened in a very desirable manner. The particles of extender pigment distributed throughout the film provide many points or foci where strains developed in the film may be released by microscopic ruptures between the binder and the inert particles instead of by large cracks in the film.

As previously stated, the most effective inert extender pigment is water ground mica. This inert besides providing the multiple foci for release of strains reinforces the film. Usually five ounces to a pound or three to ten per cent of the pigment is sufficient. The cost of water-ground mica, and its dusting and poor paint-making properties have retarded its adoption by the paint formulator. The other siliceous white extender pigments, which provide some of the benefits obtained from water-ground mica, are usually selected. Among these fibrous magnesium silicate is rated highest. Experience indicates that ¾ to 1½ pounds or 10 to 20 per cent of the pigment is required although more may be beneficially added

The composition of the pigment portion of our white

	Pounds
Anatase Titanium Dioxide	1 to 1⅓
Zinc Oxide	2¼ to 3
White Lead (B S W L or B C W L)	0 to 3 or 4
Fibrous Magnesium Silicate	¾ to 1½

We now have indicated 4 to 9-5/6 pounds or 60 to 9
composition of the pigment of our white house paint. We a
pigment since the content in white house paint will vary fr
to eleven pounds, and then we must account for 100 per ce
This is best accomplished by increasing the content of in
ment. In the case of the formula containing no lead rath
magnesium silicate to make up the pigment deficiency, i
increase the zinc oxide content by approximately ten per ce
per cent mica. Also, in any of the formulas, should extra
desired, extra anatase titanium dioxide should be added wi
increase the zinc oxide content by approximately ten per ce
white house paint is:

	Pounds
Anatase Titanium Dioxide	1 to 1⅓
Zinc Oxide	2¼ to 3¼
B C W L and/or B S W L	0 to 3 or 4
White extender Pigments	1½ to 4

You will note that we actually have three types of pigm

	I *per cent*	*II* *per cent*
Anatase Titanium Dioxide	15	15
Lead-free Zinc Oxide	40	
Leaded (35%) Zinc Oxide		47
White Lead		
Inert Extender Pigments	45	38

While No. III is perhaps more representative of the major
commercial paints, there is a definite trend toward No. II a
I (fumeproof paint).

The paint formulator has considerable leeway withi
modify these basic pigment formulations to meet his spec
lowering the quality of the paint. He may raise the tita
opacity, increase the zinc oxide to improve mildew resis
ground mica for greater weather resistance, etc.

We could consider the pigment composition of tinted p
manner, but it will not be necessary. In a white tint base
anatase titanium dioxide, a rutile titanium dioxide or a zin
will be used, because of the superior tint retention they in
film. Since the tinting pigments usually impart appreciabl
of the opaque white pigment is not required. Also, because
ing tendencies of the zinc sulfide and the rutile titanium
greater protection they and the tinting materials provide
heavy chalk and too rapid erosion is not encountered. Goo
be prepared using only white lead and zinc oxide as the o
ments. Formulations similar to those shown for white

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rutile titanium dioxide replaces the anatase are frequently used, although the titanium content is usually reduced. Also, a zinc sulfide pigment formula such as the following has found considerable favor as a white tint base:

	Per Cent
Lithopone	50 to 60
Zinc Oxide	30 to 40
Mica and/or Magnesium Silicate	10 to 20

In the pigment composition of his white tint base, the paint formulator has even more leeway than in his white in the selection and proportioning of his pigments. There has been some tendency to use a titanium-calcium composite pigment for the white opaque pigment both in the tint base and white paint. While this pigment has an advantage over combinations of titanium dioxide and siliceous inerts in the gloss imparted to the film, it is at a disadvantage in dirt retention, mildew resistance, and the weathering of the film. Pigmentations containing titanium dioxide with very high contents of a ground natural chalk are being suggested. While they are low cost, there should be a greater tendency to encounter film failures than with those that I have previously presented.

As stated earlier, there are three factors to consider in formulating paint, that is composition of the pigment, composition of the vehicle, and the ratio of pigment to vehicle. In general, house paint vehicles consist of linseed oil, bodied linseed oil, volatile thinners, and liquid driers. The properties of the vehicle depend on those of the constituents and the proportions in which they are combined. Refinement of the oil to improve its color has no influence on the weathering characteristics of paint prepared with it. A normal raw linseed oil with an acid number of two to four is entirely satisfactory if best whiteness of the liquid paint is not a requirement, since the yellow color of the raw oil film is bleached on exposure of the paint film to the sun. If best color in the can is desired, a refined light colored oil is preferable.

The bodied oil should be a heat bodied oil in which temperature and conditions have been controlled so that progressive bodying of the paint will not occur because of its reaction with the active pigments. Oils possessing viscosities over a wide range are suitable. The viscosity of the bodied oil and the ratios of untreated oil, bodied oil, and volatile thinner in the vehicle are interrelated. Optimum combination is dependent on the relative importance the formulator places on various paint properties and the quantity and composition of the pigment with which it is to be combined. The film formed by a heat bodied oil is more weather resistant than that formed from an untreated oil. The transformation of a raw linseed oil film to a solid and then the disintegration of the film is caused by oxidation. In the cooking of an oil, the increase in viscosity (or the first stage in film formation) is due to polymerization. The oil when exposed as a film continues to solidify and then disintegrates because of oxidation. But its disintegration will be slower than that of the raw oil film because part of the film formation was due to polymerization. Thus from the paint durability angle, it would be preferable that all the oil in the paint vehicle should be one that had been polymerized to a high viscosity. There are other paint properties that make this undesirable. First, the pigment in the paint must not settle to a hard

mass during prolonged shelf storage. The good wetting
properties of bodied oil would promote settling of the p
house paint must not offer too great resistance when being
reasonably large brush. So the high viscosity oil could onl
greatly reduced with a volatile thinner. But the consister
(that is the yield and flow properties) must be adjusted so
of desired thickness is applied to a rough surface it will fill
without the contour of the irregularities being reproduced
surface of the film. Also, there should be sufficient flow in
the deep brush marks will level out without there being a
paint to sag. These properties are best obtained when the
both untreated and bodied oil. The proportion of bodied oil
viscosity. It may be from perhaps 15 per cent to 50 per cen
the viscosity from "Z-6" to "X." The higher the percentag
the viscosity of the bodied oil, the higher must be the perce
thinner in the vehicle. While a bodied oil of Z-5 or Z-6 an
tent of only two-thirds of the vehicle was used in the oil-co
made during the war, in the post-war paints there is a tren
oil content to provide a thicker nonvolatile paint film. Vari
can be used and equally excellent durability can be obtaine
sentative combination is one part bodied oil of Z-2 to Z-3
parts raw linseed oil, with the total oil in the vehicle 72 to

This discussion has been restricted to linseed oil. Ma
being considered as partial replacement for linseed oil. I
to discuss this phase of the subject, but will say that there
to believe that such substitution can be made. Our own
great deal of evidence that replacement of the bodied lins
bodied oils can be made with no deleterious effect on a
properties.

Either turpentine or a petroleum spirit may be used t
consistency and application characteristics. While vario
of the soluble soaps of the drying metals lead, manganese,
calcium are used, a combination of lead and manganese nap
erally favored. A suitable combination is approximately 0.5
0.015 per cent Mn, based on the total oil content in the vehic

We have discussed the composition of the pigment and
of the vehicle; all that remains to complete our paints is to d
portions of the two. The ideas on this are quite diversi
studies were made several years ago covering the lead-zinc
barium pigment-lead-zinc-inert, and lithopone-zinc oxide-in
in which a representative composition of the vehicle was 80
refined linseed oil, 8 per cent bodied linseed oil (Q viscosity)
volatile thinner and drier. These studies indicated that ther
limited range for the pigment volume content of the nonv
optimum paint durability. This range was generally accepte
30 per cent pigment volume. During the war when the no
was changed to a combination of very heavy bodied oil and
volatile content increased to over 30 per cent, it was neces
the pigment content to obtain paints of application consisten

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varied in pigment volume but averaged about 35 per cent In the present day paints that I have outlined, in which the oil content of the vehicle is 72 to 76 per cent, the pigment volume in the nonvolatile film of paints of brushing consistency generally falls between 30 and 35 per cent Studies that have been made indicate that the pigment volume of present day paints may be varied appreciably without changing the durability of the paint and that the 30 to 35 per cent is within the optimum range In fact, exposure results indicate that if the pigment-vehicle ratio is selected to produce correct paint application consistency, both the paint durability and the pigment volume will fall within the optimum range Therefore, our paints will be made to correct application consistency with the assurance that optimum durability will be obtained from the specific pigment and vehicle combinations. Before leaving this subject, I wish to mention that one organization has recently promulgated the idea that oil requirements of the pigment are the controlling factor. They propose that the magnesium silicate in the pigmentation be replaced on an equivalent oil requirement basis by a ground natural whiting. Since the oil requirement of the whiting is much lower than that of the magnesium silicate much more is used and thus the total pigment volume in the dry film increased several per cent Further data are needed, more to determine the merits of the ground natural whiting as an inert than the soundness of the oil requirement theory.

The paint manufacturer has learned that although he produces an excellent paint, the results obtained with it may be far from excellent. Additions made by the painter, poor application, painting under unsuitable conditions of weather or temperature, improper preparation or an unsatisfactory surface, or abnormal exposure conditions may result in premature failure of the best paint. Paint manufacturers in their endeavor to overcome these difficulties print directions on the labels of the paint container But experience has proved that frequently the user does not read the directions, and if he does, may not follow them

In a further attempt to overcome some of the failures due to improper reduction of the finish coat paint for the priming coat to poor preparation of the surface to be painted and to the use of woods that present a paint adherence problem, special priming paints were formulated There is no question that better results were obtained with these special primers than when the prewar raw linseed oil type house paint was used for the priming coat These priming paints were the first to be formulated with an appreciable percentage of bodied oil in the vehicle In fact, the composition of the vehicle does not differ greatly from that used in present day regular house paints, except that some of the primer vehicles contain a small percentage of varnish Since the primer serves a different purpose than the finish paint, its requirements are somewhat different The primer paint film should possess good adherence to the wood, maintain distensibility, and not be detrimentally affected by moisture It should be compatible with the finish coat and dry with low sheen so that it promotes neither separation nor failure of the finish coat film Since it is not exposed to the atmosphere, it does not need the high resistance to mildew and dirt nor the good maintenance of whiteness and tint that are so important in the finish coat paint For this reason, many formulators use little zinc oxide in their special primer but

depend on white lead for reactivity and soap formation and va
hardening effect. They also take advantage of the good durabi
opacity of rutile titanium dioxide or the excellent buffering
Cryptone MS (zinc sulfide-magnesium silicate pigment). To
tional opacity and film thickness, they tend to use higher pig
than in finish coat paint. There are two types of pigmentati
favor. (a) titanium, lead, and inerts, and (b) Cryptone M
zinc oxide. The vehicle generally contains more, but a lower vis
oil than used in regular house paint, and the zinc oxide-free
usually contain some resin varnish. Aluminum powder prim
been promoted. While their resistance to water is good, they ha
vantage of frequently causing alligatoring of the finish coat a
are gray they require two coats of the white finish paint.

While the special primer two-coat system possessed adv
two coats of the prewar raw linseed oil type paints, its advant
coats of today's house paint is questionable. Since present day p
pared with a similar type of bodied oil vehicle, as a priming coat
many of the properties of the special primers. They posse
penetration and dry with sufficiently low gloss to provide good
the second coat. The paint can be packaged at a consistency s
coat application without any additions being made by the paint
paint manufacturer is assured of the composition of the paint f
the advantage that the painter will make no error and apply a
lated only for the primer coat as a finish coat.

As in the case of the various pigment compositions for
excellent results can be obtained with or without the use of a s
It is this fact, that desired results can be obtained in various w
mits the paint technician to use his knowledge and ingenuity i
his paints and that provides the healthy competition that
industry.

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