

A STUDY OF SOME CURIOUS PAINTING PHENOMENA.*

BY

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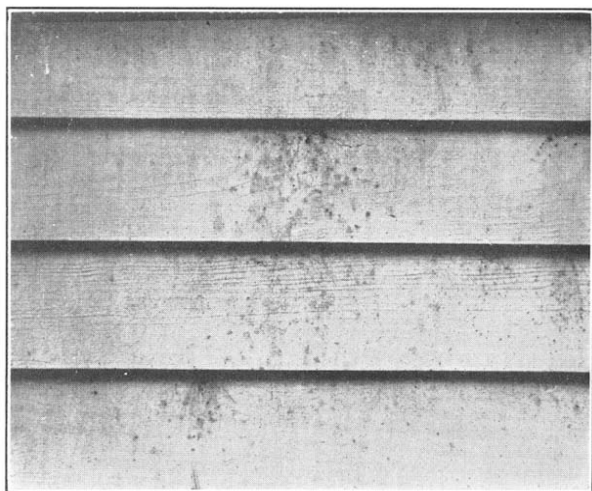
Mildew and Its Prevention.

UPON a recent trip to New Orleans the writer's attention was called to several structures, the beauty of which was marred by fungous growths which were referred to by the painters as mildew. The condition was not universal, but appeared to prevail upon certain types of paint. Upon such paints it was found to be most severe in the sections which were shaded by trees or in partially-sheltered nooks where dampness would be maintained for a considerable period of time. If a window shutter had remained fastened back against the side of a dwelling for a month or so, the covered surface, upon inspection, would be found several shades darker than the rest of the house, many dark mildew spots being exhibited. The under sides of veranda roofs, as well as porch columns, also suffered severely in the same respect. It was quite apparent that the paint had in such instances remained soft or become softened by the action of moisture, thus presenting a surface to which adhered insects, cobwebs, and various organic substances carried by the wind. Since many of the streets of the city contained dust which may have originally been part of canal or river bottoms, it is quite apparent that much decayed animal or vegetable matter could be entrained by soft paint, thus supplying the spores responsible for fungous growths. Structures painted for several years with yellow paint seemed especially subject to fungus. It was found that the custom at one time was to use a colonial yellow for the body of houses, this paint having been prepared from carbonate of lead, using ochre as a tinting material. Recent experiments¹ have shown

* Communicated by the Author.

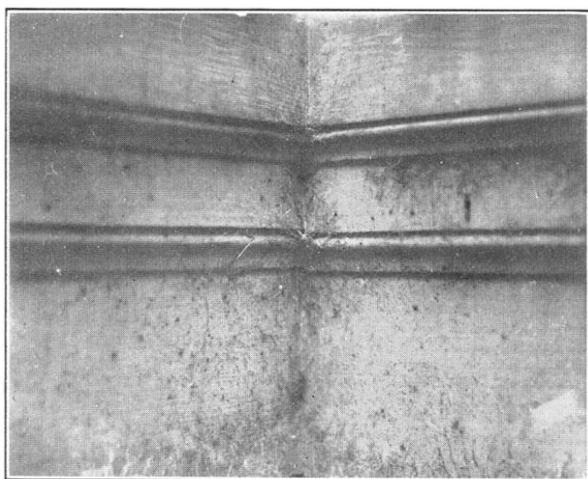
¹ Report of Sub-Committee X on Inspection of White Paint Test Fence at Washington, D. C., *Proc. A. S. T. M.*, vol. xiii, part i, pp. 287-311.

FIG. I.



Section of dwelling showing growth of "mildew."

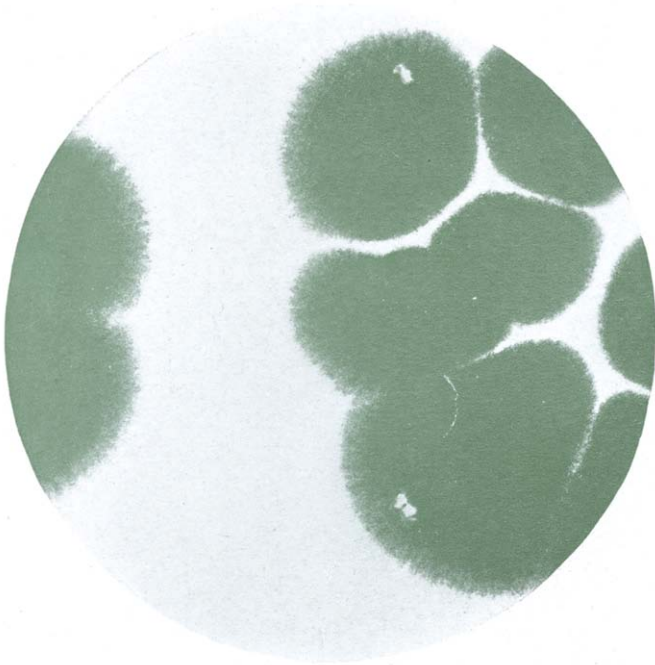
FIG. II.



Appearance of painted surface marred by fungous growth.

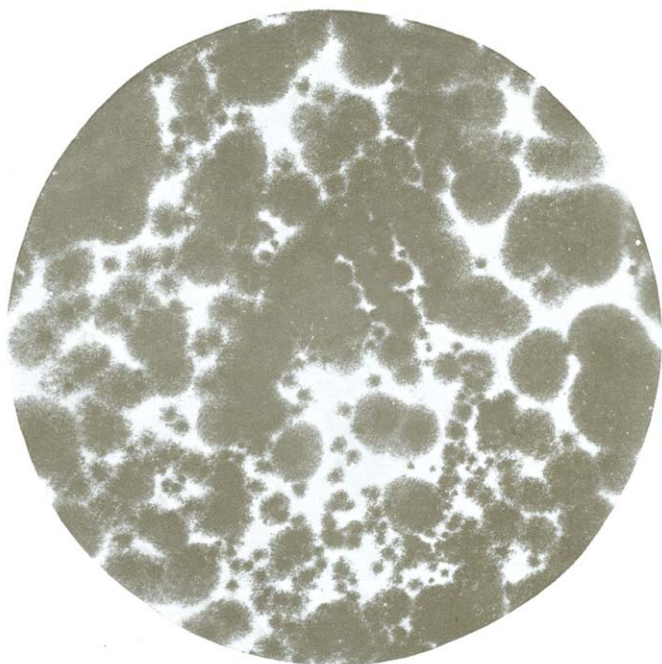
that lead paints mixed with inert or silicious pigments never dry properly and are subject to great darkening, caused by the retention of dust particles.

FIG. III.



Species of green *Penicillium* obtained from mildew on painted surface

FIG. IV.



Species of *Penicillium* (olive green). (See text.)

During the inspection trip sections of painted surfaces showing marked formation of "mildew" were collected on lead-coated structures at Hearstville Levee, Carrollton, St. Charles Avenue, Bayou St. John, and other outlying points of the city. In some instances the mildewed surfaces were lightly scraped with a clean knife, the darkened scrapings being collected in a special envelope. Small pieces of wood with the fungus intact were also removed. For the purpose of examining these specimens, it was thought advisable to prepare a culture medium which would exert an inhibitory action upon ordinary bacteria which might be present upon the specimens but which would allow the rapid propagation of the fungous spores. Since cypress is one of the most important woods used for construction purposes, especially in the South, a cypress decoction was decided upon. This was prepared in the following manner, from a section of cypress wood obtained in New Orleans: Fifty grammes of finely-divided wood shavings were boiled in a half litre of distilled water. The decoction was filtered and 1½ per cent. by weight of thread agar was added. After steaming to obtain solution, the mass was filtered, tubed, and sterilized at 120° C. for fifteen minutes.

The infected paint specimens were embedded in the melted special agar placed in Petri dishes. The spores scraped from some of the infected areas were dusted upon the surface of set agar in similar dishes. These were placed in an incubator arranged with an electric thermostat set at 37° C. At the end of periods ranging from twenty-four to ninety-six hours marked growths developed on every plate. The moulds grown in this manner were of mixed types. The various kinds of fungi were isolated, and pure cultures were grown on agar in test-tubes, subsequently plating out the different species in Petri dishes. Some of these are shown in Figs. III to VI. The colors shown by the halftones are not exactly representative. Figs. VII to IX show their appearance under the microscope. Since the staining of fungi is a very difficult operation, some trouble was experienced in preparing slides for examination and photomicrographic record. It is felt, however, that those shown are fairly representative of some of the various species grown.

The two principal types of fungi which were developed from the mildewed surfaces were shown to be species of *Aspergillus*

and *Penicillium*. In order to determine the relative resistance of these fungi, small sections of the specimens on agar were placed on painted boards which were kept in a chamber at a temperature favorable to their growth. In this test the black *Aspergillus* present proved most hardy, the others seeming dormant unless kept constantly moistened. In one test the black mould in a week's period exerted a most destructive effect upon a board coated with

FIG. V.



Species of *Aspergillus* (black) with spot of *Penicillium* (green) in centre. The effect of this fungus on painted surfaces is shown in Fig. X.

white lead in oil. Apparently the oil served as a most favorable medium for its development, thus playing one of the leading rôles in the reactions which resulted in the destruction of the paint and exposure of the wood. This action is recorded in Fig. X. The development of the fungi in every instance was much more rapid upon paint coatings which were soft and subject to retention of moisture. Paints which presented a firm, hard, moisture shedding surface resisted the fungi and prevented germination of the

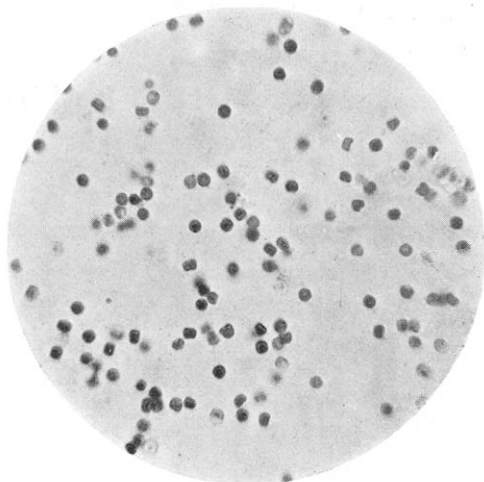
FIG. VI.



Species of green *Penicillium* that has developed yellow pigmentation in media.
(Yellow undercolor not shown in plate.)

spores. The board tests were then duplicated by floating the painted specimens inoculated with fungi upon the surface of water contained in a tank. The same comparative results were obtained. The paints which dried with a soft, tacky film were prepared from white lead. Those which dried to a hard, resistant film were composite paints containing white lead and zinc oxide. From twenty-five to fifty per cent. of the latter pigment was used to produce a resistant film. The oil used in all paints was linseed oil, to which was added five per cent. of liquid drier. Although it is possible that the absence of "smuts" on

FIG. VII.

Spores of the green *Penicillium*. $\times 1400$.

paints containing zinc oxide may be due to the formation in the paint film of a zinc salt which acts as a powerful fungicide, the writer is inclined to believe that the real value of the zinc is to be ascribed to its film-hardening characteristics. The addition of turpentine is also to be advised, since more rapid oxidation and firmer films are obtained.

It is customary for the lumber mills in some sections of the South to float the timber in adjacent ponds previous to sawing. These ponds sometimes contain dirty water filled with decayed vegetable matter and covered with colored scum. It is possible that various substances favorable to fungous growths are thus

soaked up by the wood. When cut, used as siding, and painted, these substances may be leached out on some occasions. It is possible that this effect would be prevented by treating new lumber with a coat of zinc chloride solution previous to painting. The writer's tests indicate the high fungicidal value of such treatment. It is likely, however, that the use of hard-drying, dust-resisting paints would prevent the growth of fungi which might be present on the wood used. Before leaving the subject of mildew, it is of interest to quote from the findings of G. Massee,² who records a peculiar pink-colored fungi growing on white lead paint in a conservatory:

"A New Paint-Destroying Fungus.

(*PHOMA PIGMENTIVORA*, MASSEE.)"

"Among the most remarkable of fungi is one that elects to grow on fresh paint. It flourishes in the greatest profusion in hot-houses, its development being apparently favored by a high temperature and constant humidity, as it is but rarely observed on paint elsewhere. About a month or two after a hot-house has been painted, more especially if white paint has been used, numerous small, pale rose-colored specks appear on the paint; these specks gradually increase in size and change to a purple, or sometimes dark red, color, suggesting the idea of blood having been sprinkled over the paint. In course of time the discolored areas extend considerably and form broadly-effused patches several inches across. About a week after the colored patches are fully developed, their surface becomes studded with minute, blackish-red warts. Each wart is a fungous fruit, containing myriads of very minute spores, which in due course are dispersed and start new points of infection.

"When the spores of the fungus are sown on a streak of wet white paint, a faint roseate tint appears in about a week's time, and within three weeks fruit is produced in abundance, and the deep purple characteristic blotches are well developed. Spores sown on a thin

² Royal Botanic Gardens, Kew, *Bull. of Miscel. Information*, 1911, London.

smear of pure linseed oil germinate as readily as in paint, but the mycelium remains colorless, and, so far, no fruit has been produced. The result is the same when the spores germinate in ordinary nutritive media or in water. No germination takes place when the spores are sown on a streak of pure white lead or carbonate of lead (pigment). Hence this substance alone is not a suitable medium for the growth of the fungus, although its presence is necessary to enable the plant to complete its normal course of development, and it is also the constituent from which the fungus produces as a by-product the purple-red coloring matter, which is collected in oily-looking drops within the cells of the mycelium, the cell-walls themselves remaining colorless. The red color suggests that the white carbonate of lead undergoes some chemical change induced by the presence of the fungus, resulting in the formation of red oxide of lead. This matter, however, requires careful investigation. The presence of two per cent. of carbolic acid in paint completely arrests the development of the fungus. The following is a technical description of the fungus:

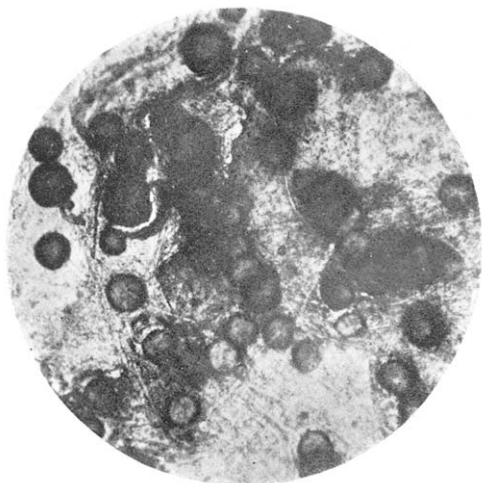
“ ‘ *Phoma pigmentivora*, Massee. *Maculae* suborbiculares, determinatae, laete rosaceae vel rosaceo-purpureae, 1-8 cm. diametro. *Perithecia* in maculis laxe gregaria vel confertiuscula, vix prominula, purpureoatra, subglobosa, contextu parenchymatico, ostiolo vix papillato donata, 125-150 μ diametro. *Sporulae* ellipsoideae, hyalinae, 4-6 \times 2-2.5 μ . ’ ”

Washing of Paint Caused by Inferior Oil.

That microorganisms may play an important rôle in the behavior of materials of painting is the conclusion of the writer, based upon recent investigations into the causes of certain painting defects which have been referred to by the painter as saponification or washing. This condition is generally indicated by the appearance of a white deposit at the base of porch columns and by the paint assuming a soap-like condition if rubbed. Although the instances of such actions are rare, an apparent epi-

demic has recently been shown to exist in one community. The writer has made an inspection of the structures where the trouble occurred, collecting samples of the washed paints for analysis. The investigation also included the analysis and examination of the materials used in the paint, including the oil that was mixed by hand with the paste paint. Almost invariably the oil used was found to contain considerable moisture. When a bottle containing the oil was shaken, large numbers of water bubbles would appear and the oil would form a cloudy emulsion. The

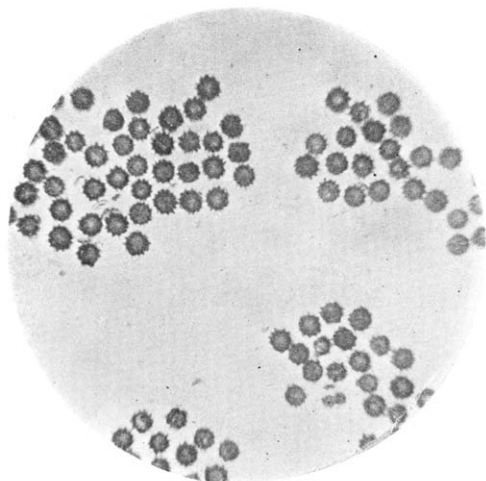
FIG. VIII.

Mycelium and sporangia of the black *Aspergillus*. $\times 110$.

oil also contained a large percentage of mucilaginous or albuminous matter which is commonly called "foots." In the pressing of flaxseed, the oil is filter-pressed. This, however, takes out only a portion of the suspended matter. After standing a short period of time, certain types of albuminous matter in solution in the oil begin to precipitate out, forming flocculent precipitates which are known as "foots." Improperly filtered oil, that is rushed to the consumer without proper clarification, always contains such impurities. Portions of the foots from the various samples of oil collected were placed upon sterile agar, and in a few days marked growths of a peculiar pink-colored mould were

obtained (see Fig. XI). This mould was identified as a species of *Fusarium* by V. K. Charles, Assistant Mycologist, Bureau of Plant Industry. Portions of this mould placed upon oil seemed to have a marked effect in changing the constants of the oil, free acid being produced. This result gave a clue to the causes of the washing of paint in which the infected oil was used, and indicated the nature of the intricate reactions which would be occasioned in the drying paint films. The enzymes and micro-organisms in the foots apparently exert a fat-splitting action, the

FIG. IX.

Spores of the black *Aspergillus*. $\times 1400$.

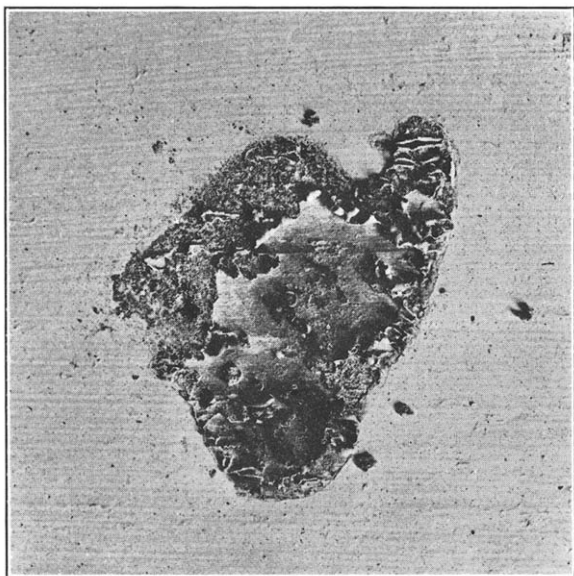
oil being broken up into glycerine and fatty acids, causing the formation of soap-like products which are acted upon by moisture. The glycerine formed in the film is, of course, non-drying in nature, serving to keep the paint soft and tacky, in which condition it readily attracts moisture from the air. The moisture thus absorbed by the film emulsifies with the soft paint, some of which washes off, depositing upon any convenient surface.

The writer has found that there is no selective action in the washing of the paints; in other words, there is no greater tendency for a lead paint to wash than a zinc paint. This was confirmed by the analysis of the washings piled up at the base of

some hollow fluted porch columns at various residences. Some of the paints applied were made of lead and some of lead and zinc pigments. In every instance lead was found present, zinc being detected in the washings from some zinc-containing paints.

Attention has been brought to the fact that the washing of paint is not of uniform occurrence. It may be noticed upon the porch columns but not upon the body and trim of a house, or it may be noted only upon certain sections of the main structure.

FIG. X.



Effect of black fungi upon soft drying paint.

The writer has observed that in most instances where washing is shown it is generally upon a hollow column or surface, the back of which may hold moisture. It is likely that the moisture stored up in certain places is responsible for starting the complicated reactions which have been previously referred to. It is also possible that the painter, when making up various batches of paint, may use in one batch that portion of the oil which contains the largest quantity of foots and moisture. The section upon which this batch of paint is used would, of course, show the

FIG. XI.



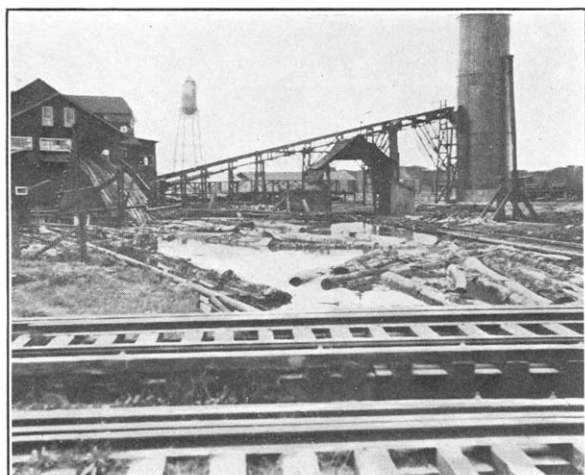
Pink mould growing from "foots" of infected oil.
(Species of *Fusarium*.)

greatest amount of washing. That such types of washing are periodical could be explained by the fact that infected seed occurs in quantity only in such years as the flax crop is poor. In the writer's opinion, the prevention of such trouble lies in the use of a well-filtered, perfectly-clarified, moisture-free oil.

"Rusting" or Brown Spotting.

Another painting defect, the cause of which may be traced in some instances to the action of microorganisms or their prod-

FIG. XII.

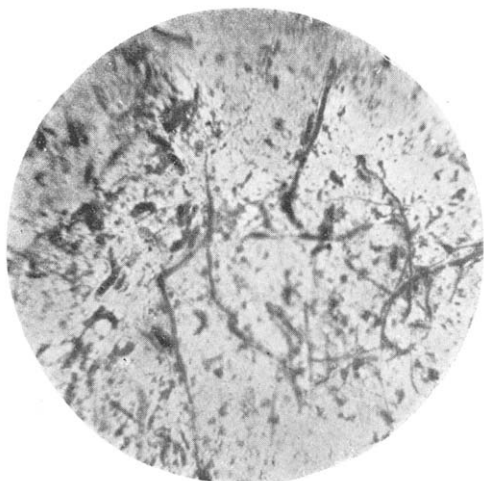


Lumber mill showing log pond. (See text.)

ucts, is the so-called "rusting" or brown spotting of paints. This condition is generally noticed upon the ceilings of porches, small brown spots about a quarter of an inch in diameter appearing through the paint film like resin exudations. These spots have an astringent acid taste. This condition, moreover, is generally found upon jobs where the type of washing of paint previously referred to has been recorded, thus indicating that the trouble might be of similar origin. Several of these small, brown-colored spots which appeared upon painted surfaces were recently collected and examined. In some instances these drops were shown by chemical analysis to contain resinous ingredients.

and in other instances metallic substances in combination with organic products. They are generally very soluble in water, yielding rather thick, viscous solutions upon boiling and filtration. When the paint is made of lead, organic salts of lead are found in the solution. If zinc is present in the paint, zinc salts may also be found by analysis. As a result of the investigation, the writer is firmly convinced that the formation of these drops may be traced to two distinct causes. In some instances the soluble matter contained in the wood may be brought to the sur-

FIG. XIII.

Mycelium and spores of the pink mould. $\times 1400$.

face, exuding at certain places in the paint film and drying up to small, round globules. In certain types of wood there are exceptionally large amounts of soluble constituents which may appear, especially in damp weather and upon surfaces which are not exposed to the sun. Such water-soluble substances apparently have a solvent effect upon the lead and zinc contained in a paint, the compounds formed being deposited upon the surface of the paint in the form of globules. This condition, however, would occur only upon new wood. When wood has been painted for three or four years, it has weathered to such an extent that the water-soluble materials are pretty well leached out. It has

been found, however, that brown spotting occurs most often upon repainting jobs, especially when the oil used in the paint has been of the type examined by the writer, containing moisture and foets of an infected nature. In such cases the hydrolyzing action of the enzymes, which takes place when such oil is used, apparently increases the tendency of the oil to break up

FIG. XIV.

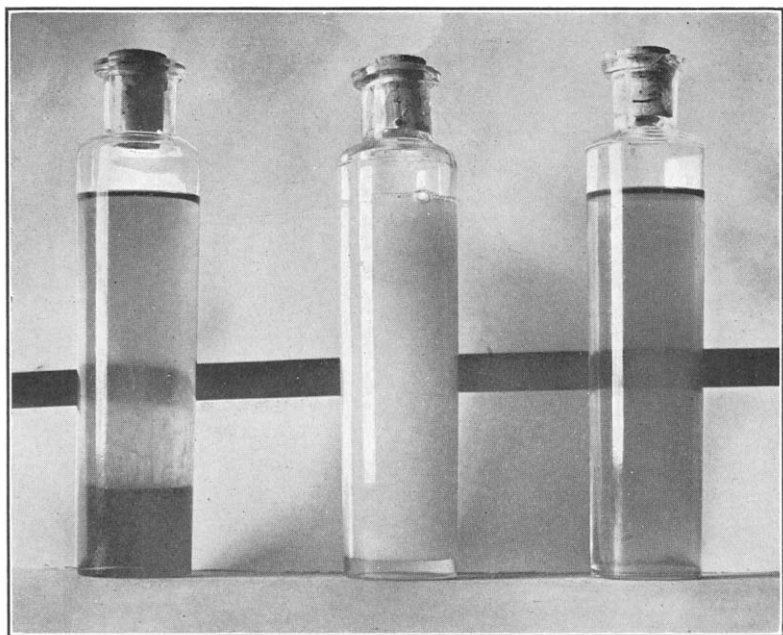


Growth of fungi upon porch column.

into various fatty acids, including formic acid. This has a solvent effect upon the lead and zinc pigments, producing lead and zinc formates which are water-soluble and possessed of an astringent taste. It is therefore likely that such water-soluble metallic compounds, when produced, come as the result of reactions within the oil itself in many instances, and would again indicate the necessity of using properly-clarified oil. The writer

has previously pointed out that proper weathering of new wood before painting will largely do away with the type of spotting that comes from the water-soluble constituents of such wood.

FIG. XV.



Three samples of linseed oil. Black line in back of bottles shows relative clarity. Oil in middle bottle contains considerable moisture and "foots." Oil in end bottle contains a large amount of infected "foots" deposited at bottom.

It is apparent, however, that the selection of satisfactory oil is an even more important consideration, especially upon repainting work.

Immunization of Oils.

Assuming that some types of oil³ may even be responsible for defects developing in paints while in storage and previous to use, the question of immunization is one worthy of consideration. Although the writer has previously shown that steriliza-

³ "Changes Occurring in Oils and Paste Paints, Due to Autohydrolysis of the Glycerides," by H. A. Gardner, *JOURNAL OF THE FRANKLIN INSTITUTE*, May, 1914.

tion of the oil is possible by the application of heat, this procedure may not be feasible in many instances. The same effect, however, may often be produced in the paint mill under ordinary manufacturing processes. It is well known that considerable heat is developed when mixtures of oil and pigments are run through buhrstone mills, the temperature of the paint depending upon the rate of grinding and set of the plates. Temperatures up to 240° F. have even been recorded, and this is more than sufficient for sterilization. It is probable that many oils have thus been rendered harmless, whereas they might have caused trouble had they been mixed cold with hand paddles. Moreover, the hot paste paint as it issues from a mill is in a condensed form, unobtainable by hand stirring. The writer has recently made a study of the chemical phenomena which may result from the storage of such paints in their warm condition. In one instance the hot paste was immediately thinned and canned. In another instance the paste was allowed to cool before thinning and canning. In the latter case the paint proved to be in the most satisfactory condition after storage. When the hot paste is immediately canned, the continued warmth of the product is apt to set up slight hardening with certain pigments. It is probable, however, that the use of a water-cooled spout at the point of exit from the mill plates would sufficiently cool the issuing paste so that storage before canning would not be necessary.

Conclusion: From the previous considerations it is apparent that many painting defects may be prevented through the use of paints of the composite class, based upon white lead pigments but containing sufficient zinc oxide to present a firm, hard film.

When paste paints are thinned by the painter, only clarified, well-settled, moisture-free linseed oil should be used.

The writer wishes to acknowledge the valuable assistance of T. M. Rector in the experimental work.