SOME CAUSES OF BLISTERING AND PEELING OF PAINT ON HOUSE SIDING

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SOME CAUSES OF BLISTERING AND PEELING OF PAINT ON HOUSE SIDING

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Introduction

Whenever paint coatings on wooden walls of houses fail unreasonably soon, say in less than 2 years after they have been applied, the failure is almost always due to certain circumstances called, for convenience, "abnormal conditions of exposure." Failure under such conditions is not a question of the kind of wood upon which the coating is applied, the quality of the paint, or the craftsmanship of the painter. The staff of the Forest Products Laboratory has observed the troubles in question on all of the kinds of wood commonly used for house siding, with paints of all the varieties generally accepted as of first quality as well as with cheap paints, and rarely has there been any possibility that poor workmanship on the part of the painter was responsible. The fault lies in the abnormal conditions of exposure, and the only certain cure is to search out the abnormal conditions and change them into normal ones. Attempts to overcome difficulties of this kind by using special priming paints, special paints, special liquids, or unusual amounts of liquids for thinning ordinary paint are, in the writer's opinion, of very doubtful merit. No sound structure can be reared on a faulty foundation.

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

Present information about the effects of abnormal conditions of exposure upon paint coatings is based chiefly upon examinations of occupied buildings which have given trouble. The staff of the Forest Products Laboratory has been called as consultants in such cases for many years. In addition a limited amount of laboratory experimentation has been done with miniature "houses" warmed and humidified inside and set out of doors during cold weather. Many characteristic paint defects have thus been reproduced under partially controlled conditions. Much more study will be needed before the mechanism of paint blistering and the allied defects are really understood, but the

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

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general nature of the practical conditions that commonly give rise to abnormal conditions of exposure is now reasonably well established.[2]

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

Circumstances that Have Been Observed to Cause Abnormal Conditions of Exposure

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

In cold weather the temperature at the back of the siding where air is escaping may easily be below the dew point even though the air may have had a low relative humidity when it first entered the hollow side wall from the interior of the building. Thus air chilled from 70° F. begins to deposit its moisture as water or ice at 32° F. if the initial relative humidity was 25 percent, at 15° if the initial relative humidity was 11 percent, and at 1° if the initial relative humidity was 5 percent. Since the coldest surfaces in the side wall with which the circulating air may come in contact are offered by the back of the siding and the front of the building paper, these are often the points at which condensation sets in. The amount of the condensation will depend upon the amount of circulation and will naturally be greatest near the points in the side wall where the upward current of air is deflected by a window frame, plate, or fire stop so that the air starts its downward course along the sheathing and siding side of the wall. The effects on paint coatings of condensation of moisture behind the siding are commonly found most marked on the parts of the walls corresponding to the points of deflection of the air currents.

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

Forms of Paint Failure Under Abnormal Conditions

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

Blistering, Peeling, and Scaling

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

Sometimes water soluble extracts from the wood do not become highly colored until they break through the coating and come freely in contact with air.

Deposits of such substances over paint blisters often look like resin exuding from the wood.

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

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

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

The susceptibility of paint coatings to blistering and the size of the blisters formed vary materially with a number of factors of which one of the most important is the age of the coating. Coatings blister most easily soon after they have been applied and hardened. At that age the coatings are very pliable and the blisters formed are likely to be numerous but small in size and sharply rounded. If the coating has time to age and become less pliable before abnormal moisture conditions arise it does not blister as quickly and the blisters are less numerous but larger in size and less

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

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

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

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

Discoloration of Paint with Extractives from the Wood

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

The kind of paint and the painting methods have no bearing upon discoloration as far as is now known. The stain is a deposition of foreign material upon or within the paint coating, not a product of reaction with substances in the paint. It has been found in practice with paints of all kinds. There is no evidence that the danger of discoloration is increased by following such practices as two-coat painting on new wood, adding more than the customary amount of paint drier, reducing the time of drying between coats to a minimum, or using so-called "sealers" or "reinforcing oils," although these practices are open to serious objection for other reasons. The recommendation has sometimes been made that more than the usual proportion of thinner be used in the priming coat for the woods containing water-soluble, colored substances, or that special thinners like benzol or toluol be used in place of turpentine, but such suggestions are not well founded because the offending materials are not resins and are soluble in water rather than in paint thinners. Furthermore, the excessive use of thinners on the woods in question is bad practice because they belong to the class for which any departure from the standard proportions for the priming coat should be in the direction of more oil rather than of more thinner.

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

Discoloration of paint with extractives from redwood and western red cedar is usually more marked on some boards than on others. In part this may be due to

differences in the amount of extractives in the boards or to their concentration near the surfaces of the boards during drying, but it probably is due still more largely to details in the construction of the house that make the abnormal conditions more pronounced in some spots than in others. For example, both blistering and discoloration tend to occur near windows or doors or just outside of plates or fire stops in the house walls.

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

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

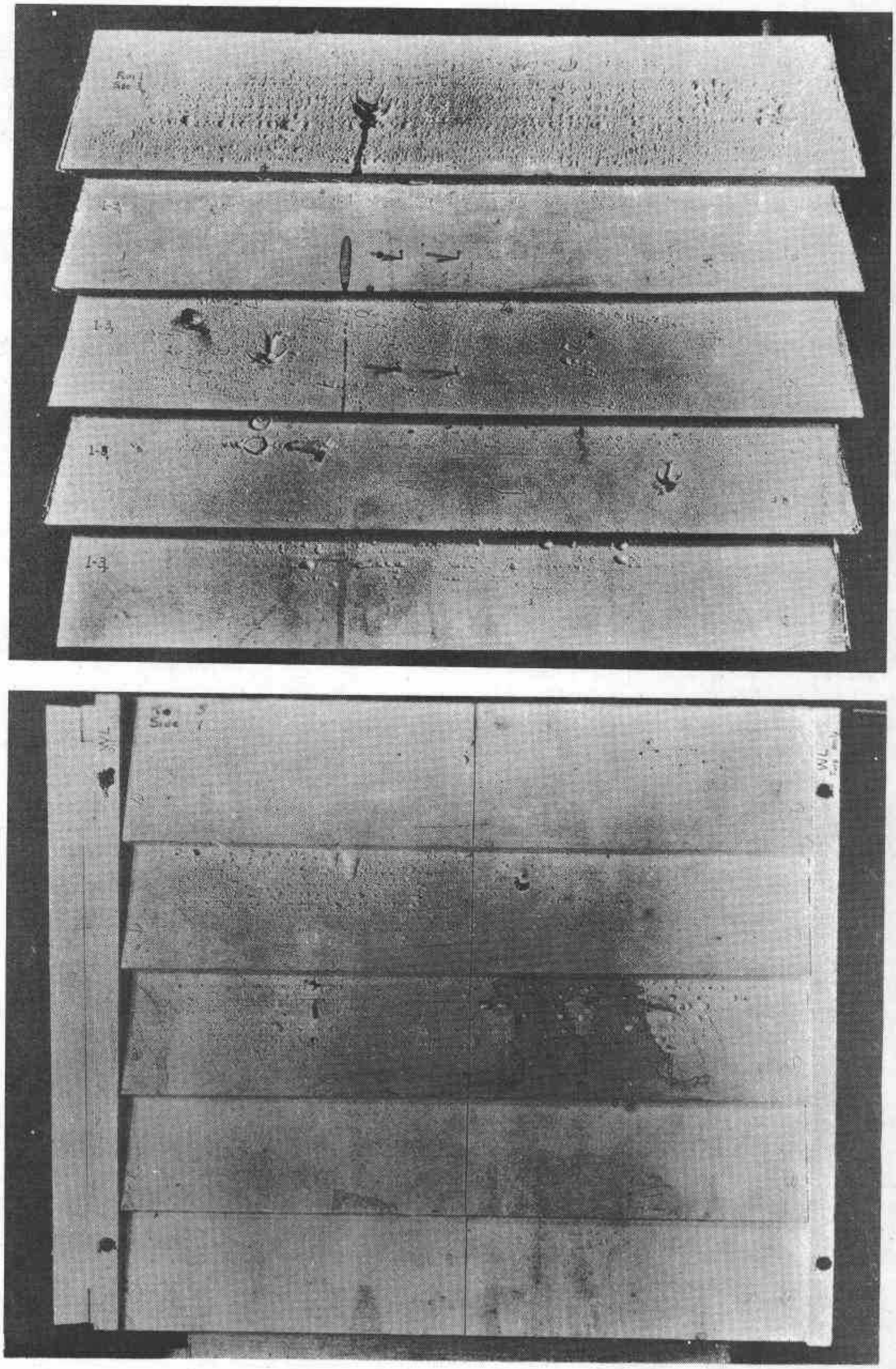
Discoloration by Blue-stain Fungi Growing in Sapwood

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

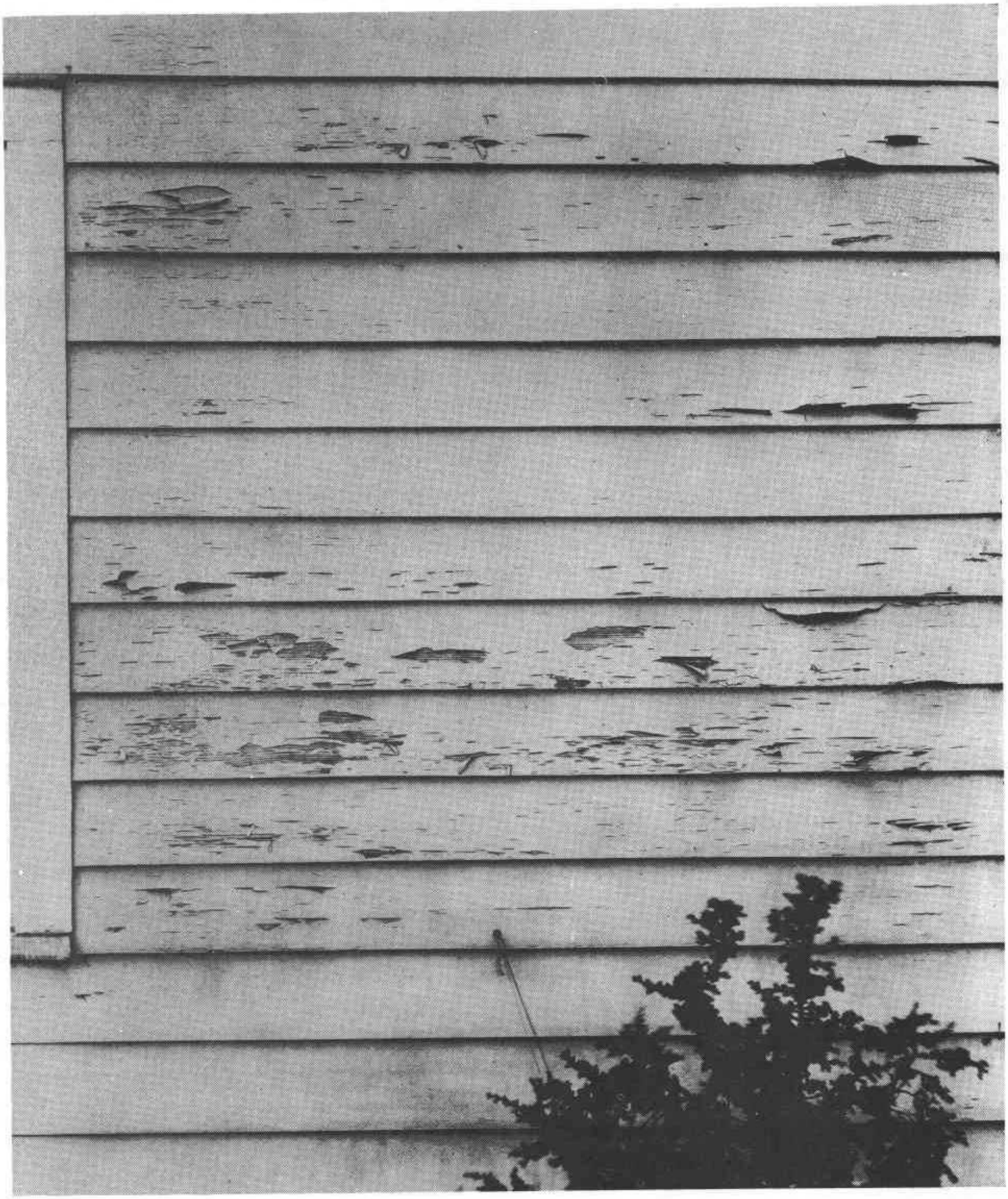
There is no evidence that the composition of the paint has any influence on the facility with which blue stain penetrates the coating under conditions permitting the fungi to grow.

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

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



Blistering and discoloration of white lead paint (lower panel) and of a high-grade prepared paint (upper panel) produced in Laboratory experiments on "miniature houses." ZM 23916F



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

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