CHAPTER 5. DETERIORATION OF COATINGS

Section 1. NORMAL DETERIORATION

5.1.1 GENERAL. Paints are not indestructible. Even properly selected protective coatings correctly applied on well prepared surfaces will gradually deteriorate and eventually fail. However, the rate of deterioration under such conditions is slower than when improper painting operations are carried out. Inspectors and personnel responsible for maintenance painting must be familiar with the signs of various stages of deterioration in order to establish an effective and efficient system of inspection and programmed painting. Repainting at the proper time avoids the problems resulting from painting either too soon or too late. Painting scheduled before it is necessary is uneconomical and eventually results in a heavy film build-up leading to abnormal deterioration of the paint system. Painting scheduled too late results in costly surface preparation and may be responsible for damage to the structure, which then may require expensive repairs.

5.1.2 EXTERIOR DETERIORATION. Paints which are exposed outdoors normally proceed through two stages of deterioration: generally, a change in appearance followed by a gradual degradation. If repainting is not done in time, disintegration of the paint then takes place followed ultimately by deterioration of the substrate.

5.1.2.1 <u>Change in Appearance</u>. The first stage of deterioration shows up as a change in appearance of the coating with no significant effect on its protective qualities. This change in appearance may result from any one or a combination of the following depending on the type and color of the paint used and the conditions of exposure:

a. Soiling: Exterior coatings normally gather dirt and become increasingly soiled. Among the most common sources of soil are rain-washed dirt from roofs, gutters or overhangs, smoky air, pollen, salt residues, and sap drippings from trees. Soiling increases as the paint becomes flat and somewhat rough; this is prevalent under overhangs where it is protected from washdown by rain. Dirt pickup is greater with softer paints such as linseed oil paints and is more visible on white or light colored paints. Soiling is less evident on paints which chalk rapidly since the dirt is readily washed off with the chalk during rain storms (See Figure 5-1.)

b. Color Change: Many colors, especially the brighter ones, fade and turn duller with time; tinted paints become paler. Fading is aggravated chalking since the chalk produced is generally white or very light and masks the color. Enamels and latex paints fade less rapidly than the softer linseed oil paints. Whites, especially those based on linseed oil, will yellow in areas protected from sunlight.

c. Flatting: Glossy paints lose their gloss and eventually turn flat with age. This is a sign of initial breakdown of the vehicle at the surface of the paint. Loss of gloss is soon followed by chalking. Enamels flatten (and chalk) less rapidly than the softer linseed oil paints.

5.1.2.2 <u>Degradation</u>. The second stage of normal deterioration occurs after continued exposure. The coating begins to break down, first at the

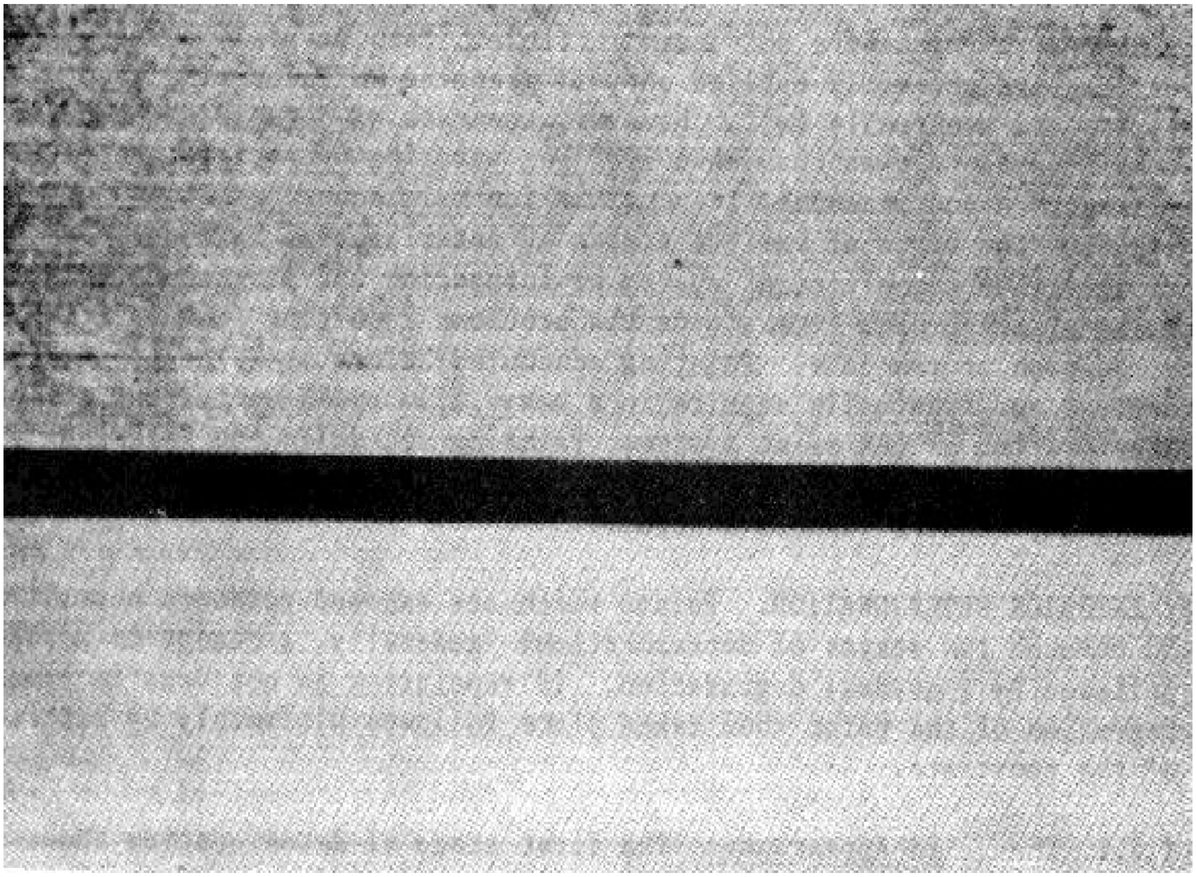


FIGURE 5-1
Soiling or Dirt Collection (Upper Panel)

surface, then, unless repainted, gradually through the coating and down to the substrate. There are two types of degradation which may take place--chalking, and checking and cracking; the degree of either depends on the type of paint and the severity of exposure.

a. Chalking: Chalking is the result of weathering of the paint at the surface of the coating. The vehicle (binder) is broken down (deteriorated) by sunlight and other destructive influences, leaving loose, powdery pigment at the surface which can easily be rubbed off with the fingers (Figure 5-2). Chalking takes place more rapidly with softer paints such as those containing linseed oil as the vehicle (binder). Chalking is more rapid in areas exposed to large amounts of sunshine. For example, in the northern hemisphere, chalking will be most rapid on the south side of the building. On the other hand, chalking will be less in areas protected from sunshine and rain such as under eaves or overhangs or even the north side of a building. Controlled chalking can be an asset, especially in white paints, since it is a self-cleaning process and helps to keep the surface clean and white. Furthermore, by gradually wearing away, it reduces the thickness of the coating, thus decreasing excessive build up of the paint film. However, do not use a chalking or self-cleaning paint above natural brick or other porous masonry surfaces as the chalking will wash down and stain or discolor these areas. Maintenance painting over exterior chalked surfaces is one of the main causes of premature paint failures. The adhesion of water-thinned paints applied to chalky

FIGURE 5-2a
Severe Chalking

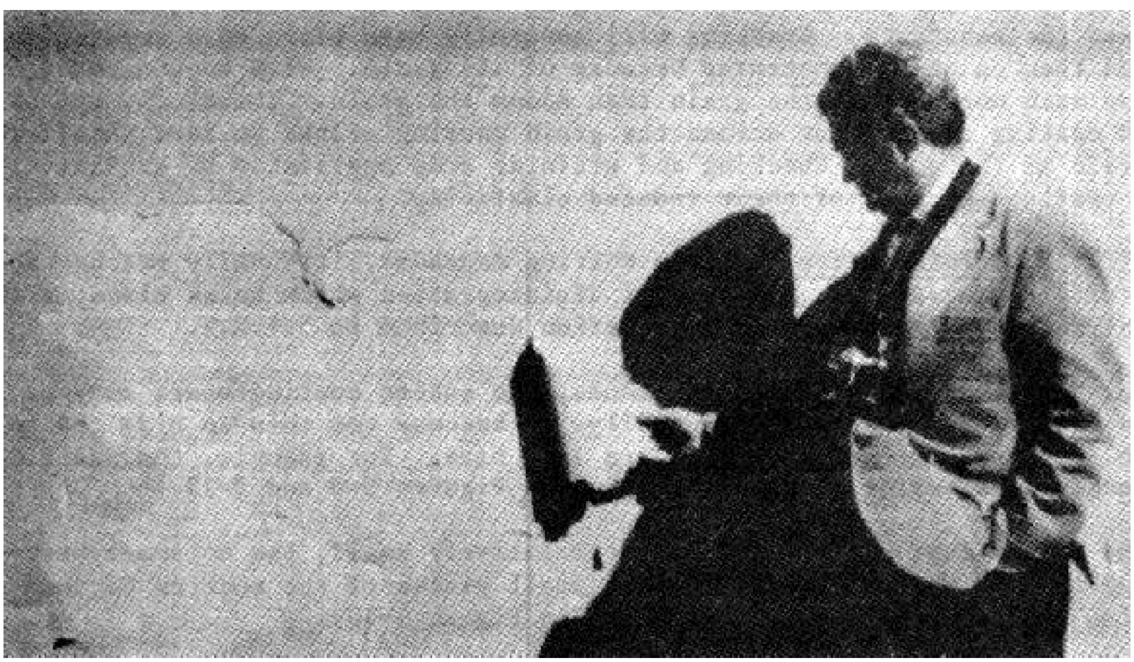


FIGURE 5-2b
A Chalky-Masonry Surface

surfaces is poor (See Figure 5-3). However, even solvent-thinned paints do not adhere well to heavily chalked surfaces (See Figure 5-4). It is important to clean off as much chalk from the surface as possible before repainting. (On concrete and masonry surfaces, the conditioner, TT-P-620, may be used on prepared chalky painted masonry to give good adhesion to subsequently applied paint). As stated in CEGS-09910, the chalk should be removed so that when tested in accordance with ASTM D 659, the chalk resistance rating should be no less than eight. Figure 5-5 illustrates the numerical ratings of degrees of chalk. The chalk resistance ratings of the building shown in Figures 5-3 and 5-4 were six or less. Also, these photographs were taken within 1 year after repainting. Thus, it is strongly recommended to measure the chalk resistance ratings of the prepared surfaces prior to repainting. The Jacobsen Chalk Tester is a convenient instrument to measure degrees of chalk on painted surfaces (Figure 5-6, Jacobsen Chalk Tester). The instrument is operated by hand to transfer chalk from a weather painted surface to a felt tape of contrasting color. The instrument is spring operated so that reproducible results may be obtained by the same or different operators. Felt tapes, either black or white, are used to record the chalk mark. The chalk spot is then compared visually with an appropriate photographic standard (See Figure 5-5).

b. Checking and Cracking: Checking and cracking describe breaks in the paint film which are formed as the paint becomes hard and brittle. Temperature changes cause the substrate and overlying paint to expand and contract. As the paint becomes hard, it gradually loses its ability to expand without breaking to some extent. Checking is described as tiny breaks which take place only in the upper coat or coats of the paint film without penetrating to the substrate. The pattern is usually similar to a crowsfoot (See Figure 5-7). Cracking describes larger and longer breaks which extend through to the substrate. (See Figure 5-8.) Both are a result of stresses in the paint film which exceed the strength of the coating. Whereas checking arises from stresses within the paint film, cracking is caused by stresses between the film and the substrate. Cracking will generally take place to a greater extent on wood than on other substrates because of its grain. When wood expands, it expands much more across the grain than along the grain. Therefore, the stress in the coating is greatest across the grain causing cracks to form parallel to the grain of the wood. Checking and graining area aggravated by excessively thick coatings because of their reduced elasticity.

5.1.2.3 Disintegration. As the coating degrades, it finally reaches the point of disintegration. The type of disintegration which takes place is the logical result of each form of degradation described in 5.1.2.2.

a. Erosion: As chalking continues, the entire coating wears away or erodes and becomes thinner. Eventually, it becomes too thin to hide the substrate. Then patches of substrate are laid bare. For example, the grain of wood substrates begins to show through (See Figures 5-9 and 5-13.)

b. Crumbling: If the cracks are relatively small, the moisture penetrating through the coating will cause small pieces of the coating to lose adhesion and fall off the substrate. (See Figure 5-10).

c. Flaking and Peeling: If the cracks are large, the eventual result is the most rapid method of deterioration--flaking and peeling. The penetrating

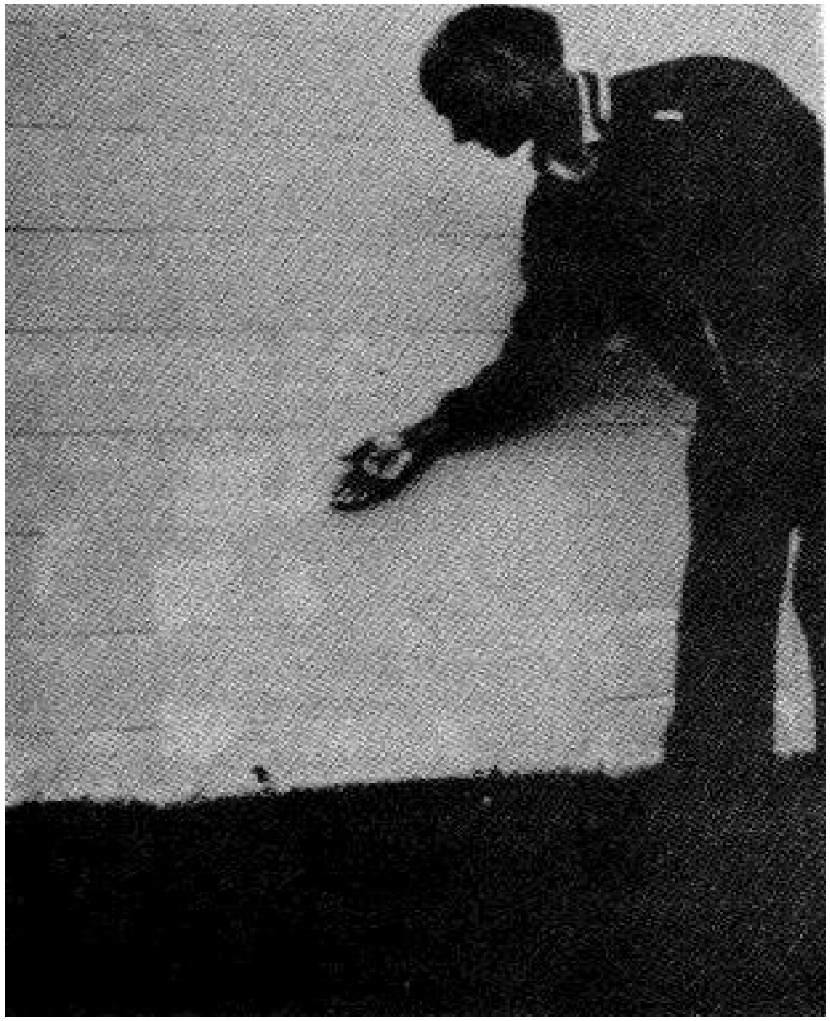


FIGURE 5-3
Failure of Water-Thinned Paint to Adhere to Chalky Surface

moisture loosens relatively large areas of the coating. The paint then curls slightly, exposing more of the substrate and finally flakes off. Peeling is an aggravated form of flaking in which large strips of paint can be easily removed. (See Figure 5-11.)

5.1.2.4 Complete Deterioration. When large areas of substrate become exposed, the coating has reached the point of complete deterioration and is in a state of neglect. Such surfaces require extensive and difficult preparation before repainting. All of the old coating may have to be removed to be sure that it does not create problems by continuing to lose adhesion, taking the new coating with it. Furthermore, complete priming of the exposed substrate will also be required, thus adding to cost and time Continued neglect may also lead to deterioration of the structure resulting in expensive repairs in addition to painting costs.

5.1.3 INTERIOR DETERIORATION. Interior coatings generally change slowly in appearance with time but do not usually degrade to any significant extent otherwise.

FIGURE 5-4
Failure of Solvent-Thinned Paint To Adhere to Chalky Surface

5.1.3.1 Change in Appearance. Interior finishes do change in appearance upon aging, though not as rapidly as exterior finishes. The changes are somewhat similar but for different reasons.

a. Soiling: All painted areas will become soiled to some extent from dust, smoke, fingerprints, fumes and residues.

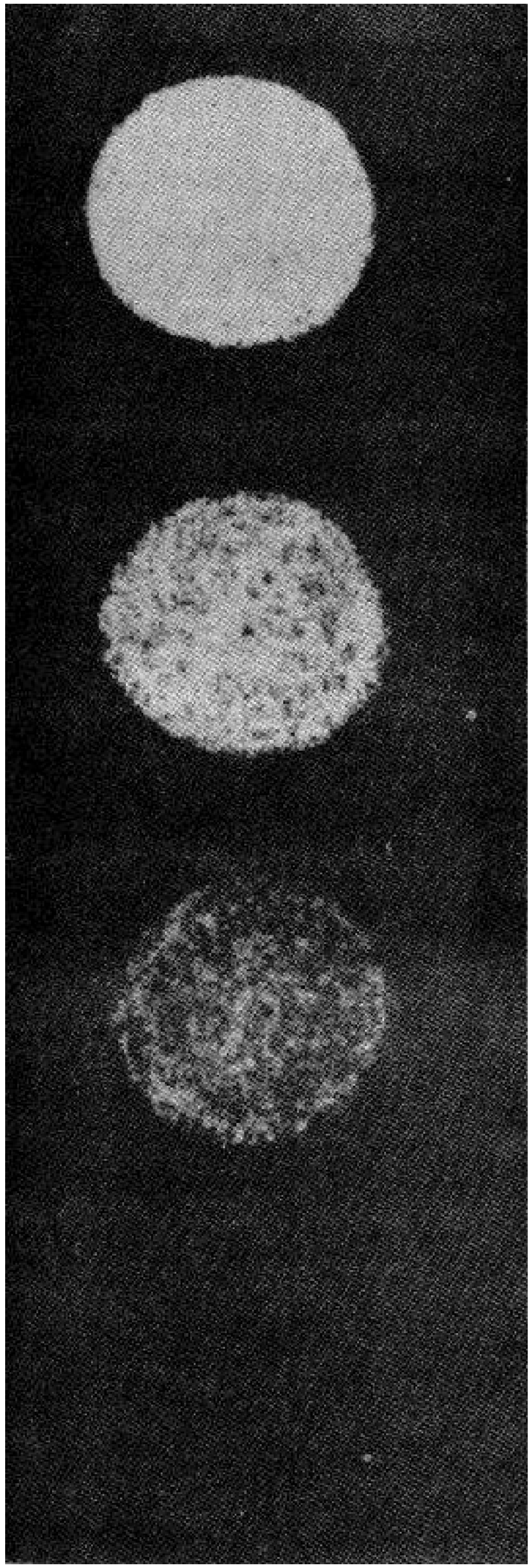


FIGURE 5-5
Degrees of Chalk

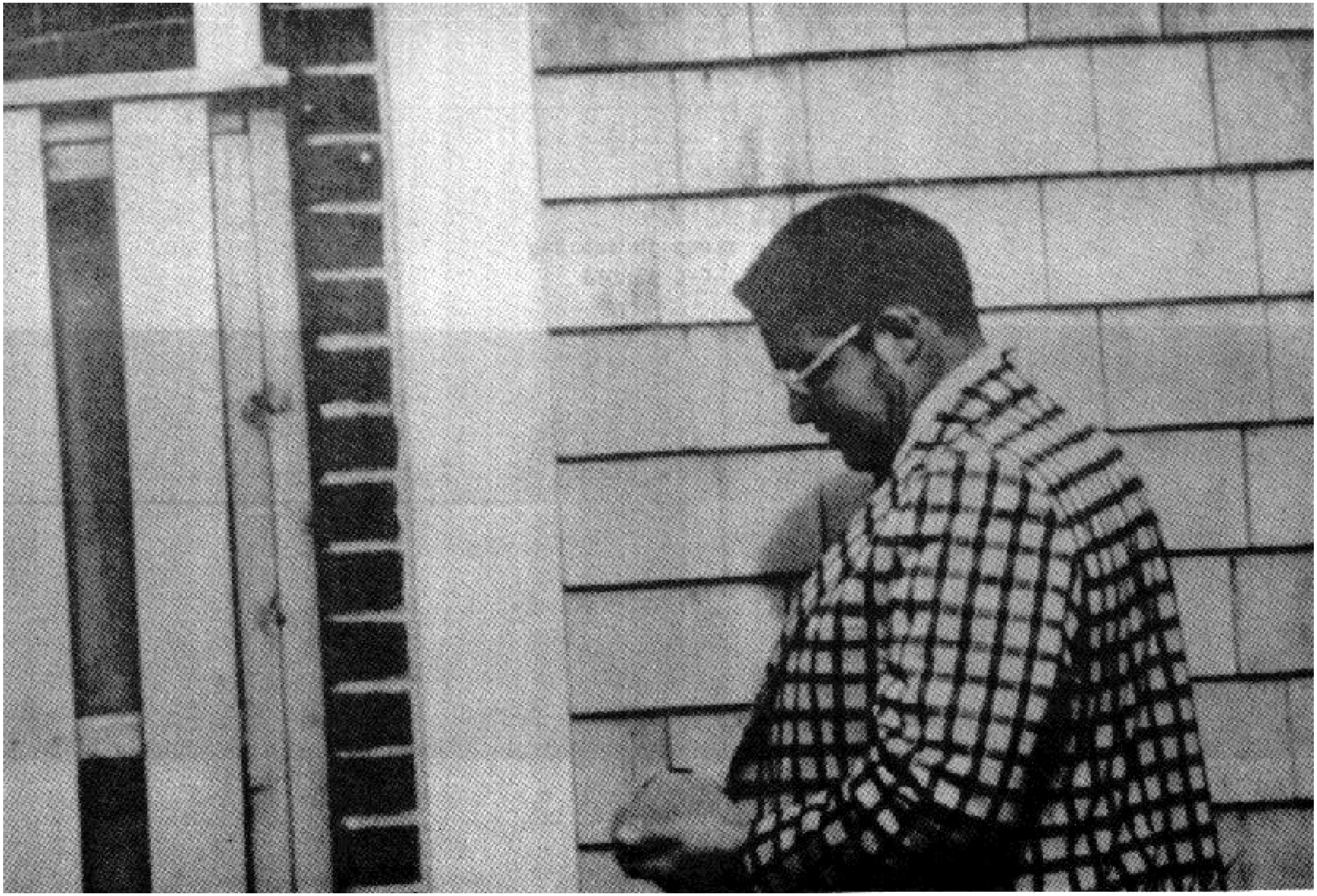


FIGURE 5-6
Jacobsen Chalk Tester

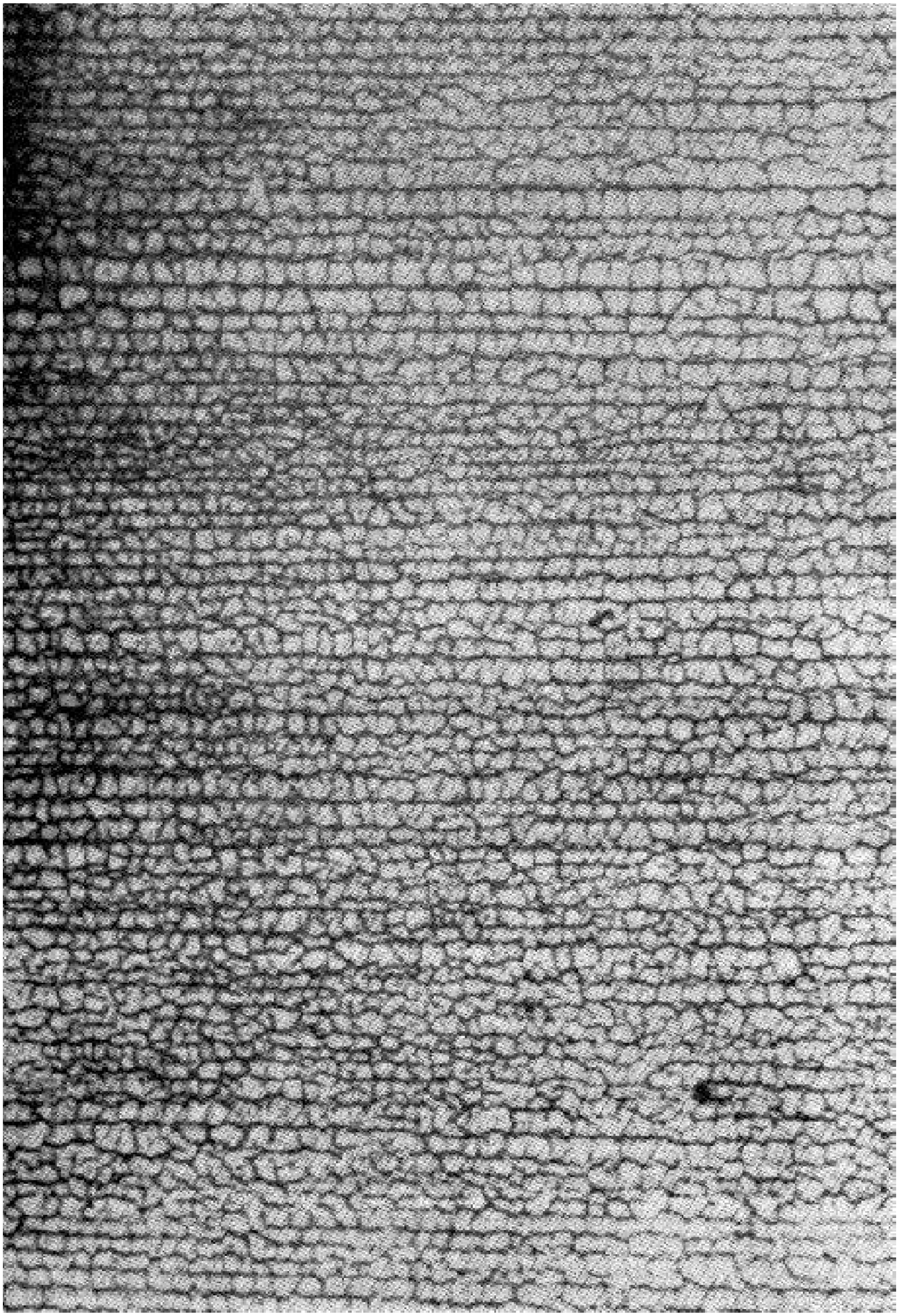


FIGURE 5-7
Severe Checking

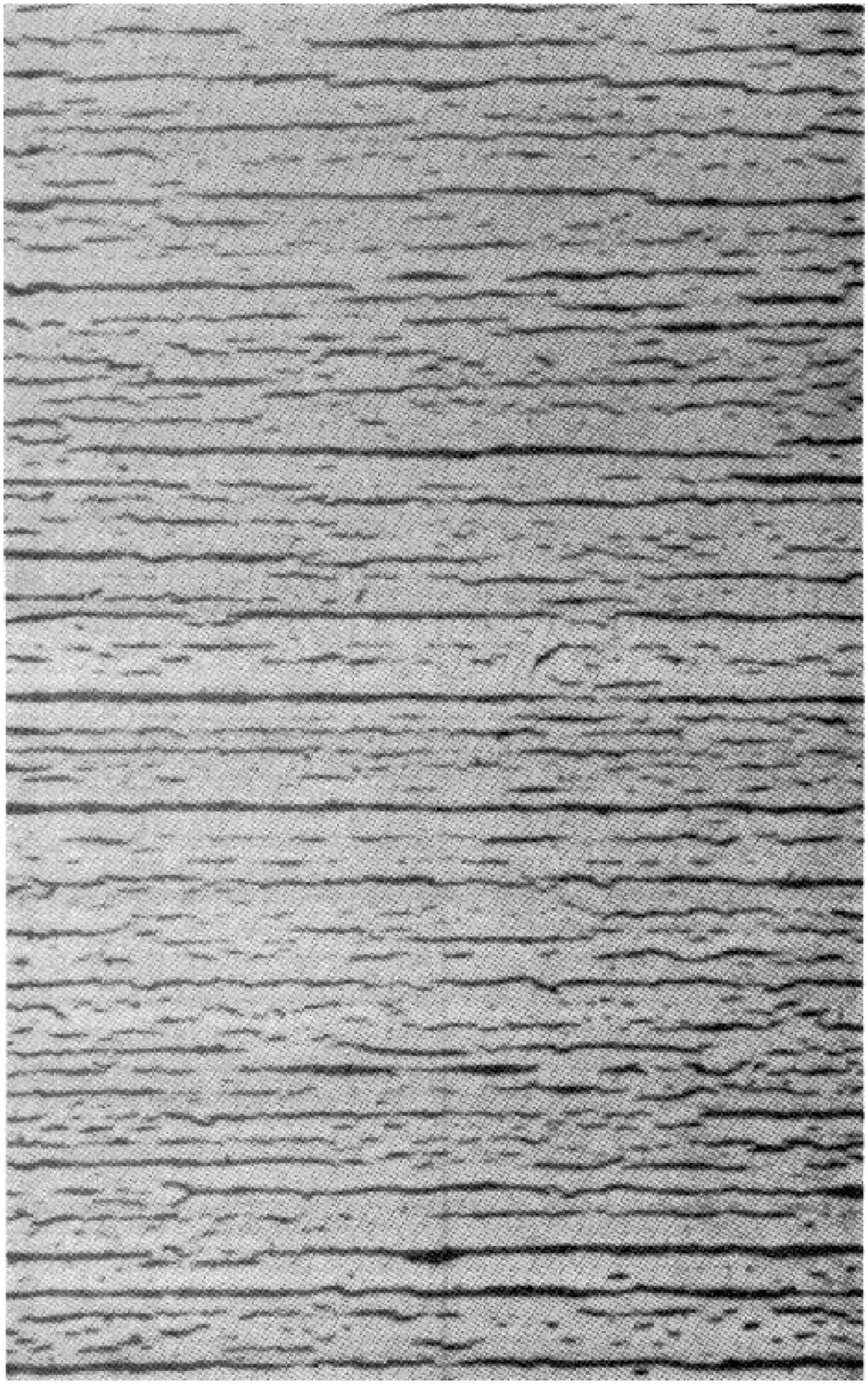


FIGURE 5-8
Severe Cracking

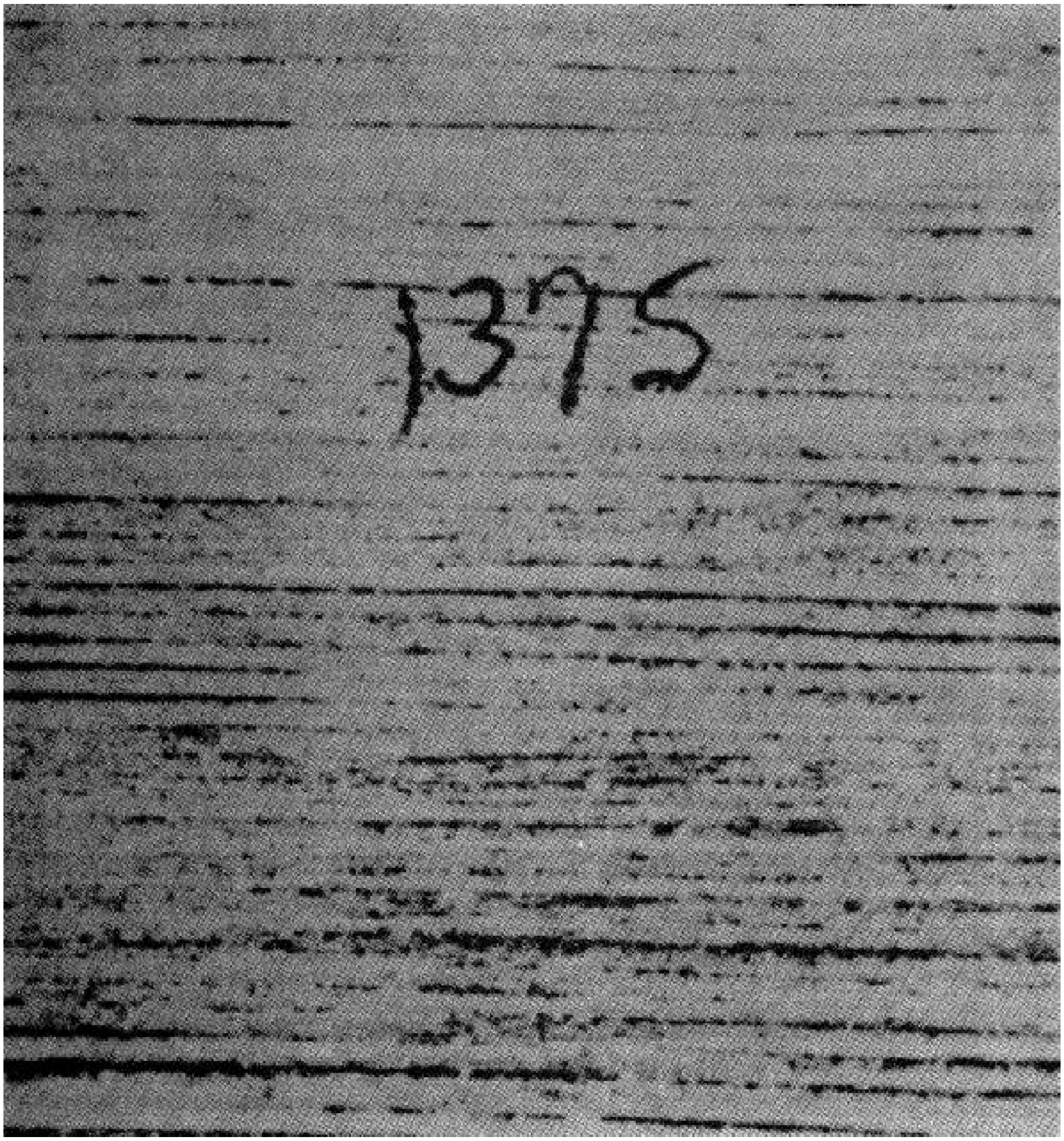


FIGURE 5-9
Moderate Erosion

b. Flatting: Glossy finishes will gradually lose some of their gloss over a long period of time, especially when they are cleaned often. However, they do not actually become flat or lose their washability.

c. Color Change: Interior finishes will change color slowly. This is generally not noticeable except when areas which were covered are compared with the surrounding area, e.g., behind pictures or chests.

5.1.3.2 Degradation. Degradation is a relatively minor problem with interior coatings. Furthermore, it generally is confined to relatively small areas.

a. Cracking: Enamels on woodwork may become brittle with age and crack, especially when the total coating thickness is excessively high. Cracking may

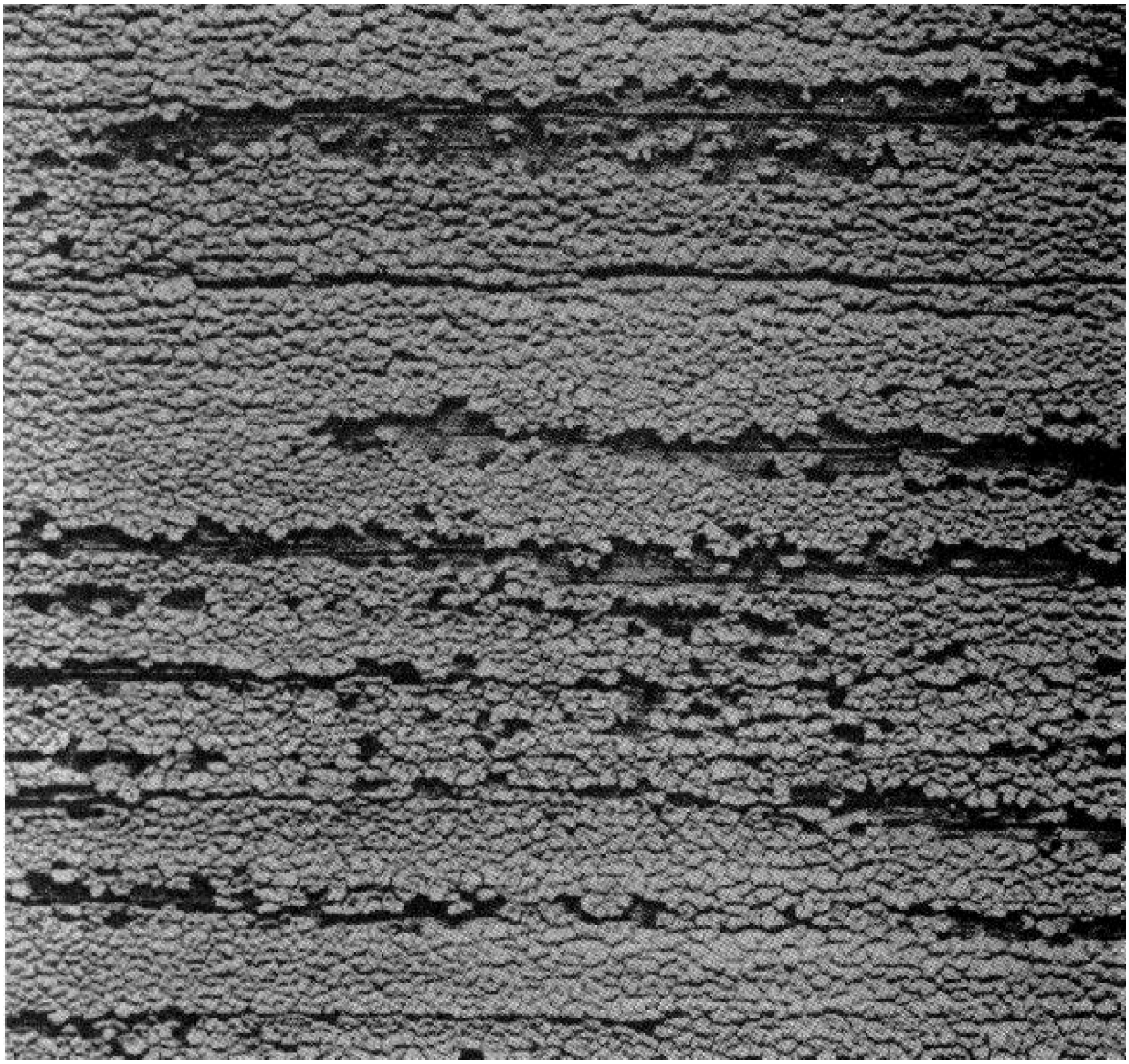


FIGURE 5-10
Normal Deterioration of a Paint by Checking and Crumbling

also show up in wall paints when the building settles slightly. The cracks usually are quite fine and may be easily repaired and touched up.

b. Wear: Areas around switches or door handles may be cleaned often during the life of the paint in order to remove fingerprints. Eventually, the paint will be removed by abrasion of the cleaner.

5.1.4 COATINGS SUBJECT TO ABRASION. Floor finishes, traffic and zone marking paints, and other coatings subject to abrasion usually wear out at points of maximum or continuous traffic long before they would tend to degrade otherwise.

5.1.5 FACTORS AFFECTING NORMAL DETERIORATION The type and degree of failure of exterior paints is affected by the environment, substrate, and design of the structure, as well as the type of paint used. The same coating may be durable under one set of circumstances but fail rapidly under other conditions.

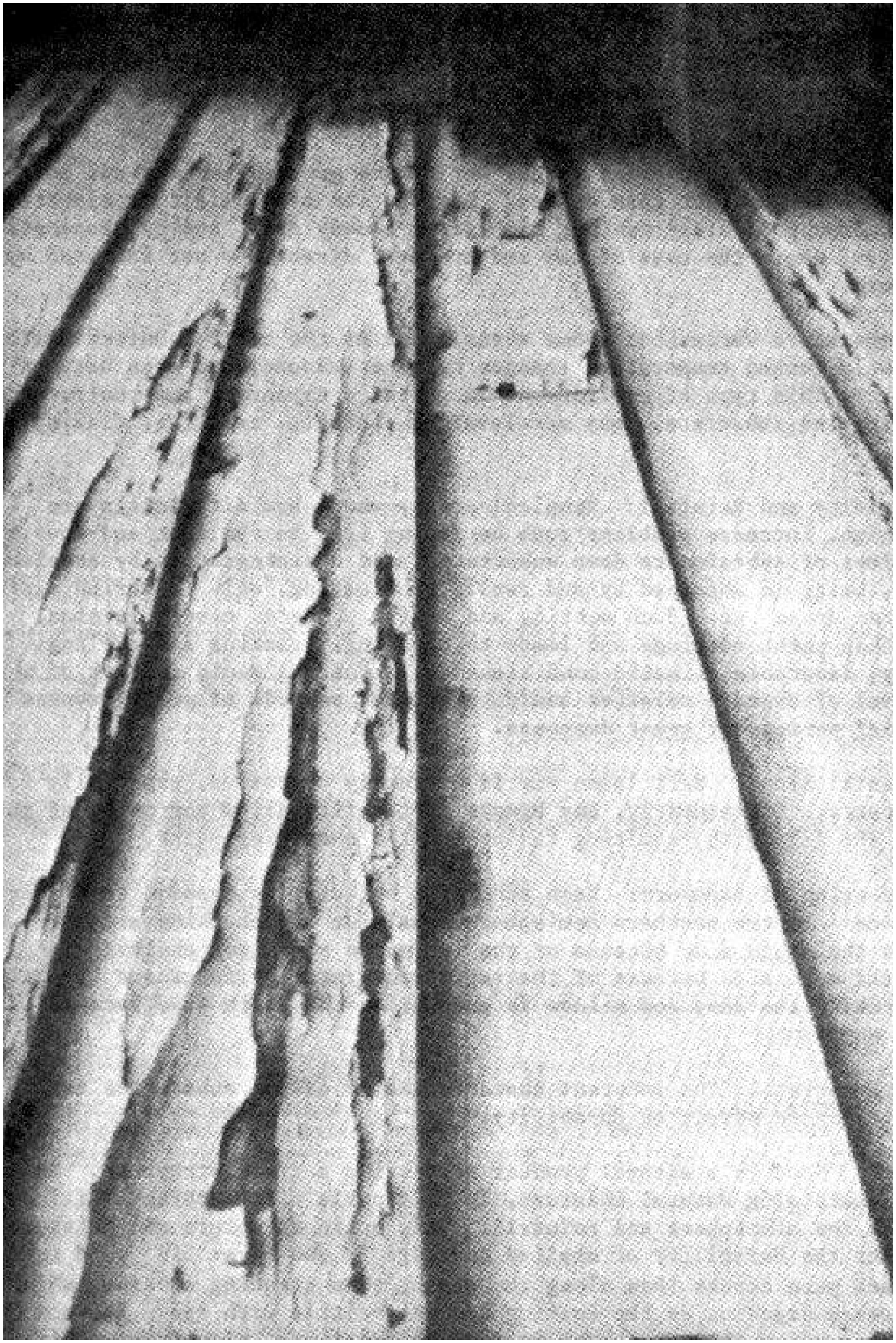


FIGURE 5-11
Severe Cracking, Curling and Flaking

5.1.5.1 Environment. The conditions of exposure have a marked effect on degradation of coatings, even on the same structure.

a. Air: Oxygen in the air, which is essential for the initial drying of many types of paints, continues to act on coatings of all types throughout their useful lives, and ultimately brings about their deterioration. Moisture and solar radiation hasten this degradative oxidation.

b. Sunlight: Certain areas in the world have greater amounts and more direct exposure to sunlight than others. Degradation by sunlight accelerated by a greater amount of clear weather with fewer cloudy days, and by closeness to the equator, where the rays of the sun are most direct and not filtered by the atmosphere.

c. Temperature Variation: Some areas, such as the central United States, show relatively marked temperature changes between seasons, and even between day and night. This type of environment exaggerates expansion and contraction of the coating and substrate, thus accelerating checking, cracking, flaking, and peeling.

d. Humidity and Rainfall: Tropical areas, where humidity levels are relatively high, increase problems such as fading (due to sunlight and dew), peeling to loss of adhesion to damp substrates, and disintegration by erosion. In addition, water is absorbed by and swells the coating, only to shrink again when the water dries out. Such wetting and drying produces severe internal stresses within paint coatings and leads to checking, cracking and curling. Consequently, favorable climatic conditions for a coating would consist of a moderate level of average relative humidity without periods of great dryness and only brief periods of great dampness.

e. Coastal Areas: Salt lade~ air is extremely corrosive, especially for steel substrates. Consequently, any breaks in the film allow corrosion of the steel under the film with resulting failure of the overlying paint.

f. Direction of Exposure: Each side of a building is exposed to different conditions. In the northern hemisphere, chalking and checking are increased on the south side because of the increased sunshine; chalking is greater on the east side because of the rapid temperature rise caused by early sunshine striking the dew; and mildew is greater on the north side because of the lack of sunshine.

5.1.5.2 Substrate. The inherent characteristics of the substrates used have a very definite effect on durability.

a. Wood: Wood is a natural product possessing a grain structure. In addition to containing natural moisture, it is capable of absorbing additional moisture from the atmosphere and rainfall. This grain structure and moisture content affect the durability of applied coatings in two ways: 1) wood tends to expand much more across than along the grain, thus creating stresses which tend to increase cracking as the coating becomes brittle with age. 2) wood absorbs water readily through cracks in degraded coatings, also from within the structure. The result is blistering, loss of adhesion, and, ultimately, peeling of the coating.

b. Metal: Iron and steel tend to corrode in normal atmospheres and especially in coastal areas. Thus, any breaks in the film will allow rusting or corrosion to spread rapidly with consequent loss of adhesion of the surrounding coating. (See Figure 5-12.) Aluminum, copper, and stainless steel are also subject to corrosion, especially in salt-laden atmospheres.

c. Concrete and Masonry: Under normal conditions, concrete and masonry do not present any unique problems if proper painting operations are carried out.

5.1.6 REPAINTING. The frequency of repainting can be determined by periodic inspection of all coatings. It is important to check on a systematic basis so that painting can be scheduled in advance, at a time when the coating is thin enough yet has not degraded to the point of disintegration. Thus, little surface preparation will be required and only one or two coats of paint may be necessary. (See Chapter 2.)

5.1.6.1 Exterior Coatings:

a. General: Repaint at the first sign of heavy chalk on the south side of the structure or general checking (50 percent of area). It is easier to paint sooner than later. For details see Chapters 4 and 8.

b. Wood: Remove disintegrated paint by scraping, wire brushing, and sanding. Sand exposed wood smooth. Wipe off all dust and loose chalked paint. Wash off dirty areas and lightly sand glossy areas (under overhangs). Prime exposed substrate. When dry, apply one coat of topcoat if paint is generally in good condition or two coats if the paint shows signs of considerable chalking or any erosion.

c. Iron and Steel: Check film thickness of paint periodically. Repaint when it decreases to 4 mils. Watch for signs of local rusting or corrosion. spot-paint as soon as possible before general surface preparation and painting are required. Remove disintegrated paint and clean area well, using the best method for the conditions and type of paint used. (See Chapter 4, section 4.) Proper surface preparation is extremely important to prevent rusting or corrosion under the new coating. Prime cleaned areas immediately.

d. Concrete and Masonry: These substrates usually present less of a problem than wood or steel under normal conditions since they neither expand excessively nor corrode. The necessity for repainting is usually determined by the condition of the paint itself. Remove disintegrated paint by mechanical treatment (see 4.4.2), and wipe off all the dust and loose chalk. Then apply one coat of masonry paint on the cleaned area, followed by a complete coat over the entire surface to be painted. No special primers are required under normal conditions.

5.1.6.2 Interior Coatings. Interior coatings generally do not require repainting as a result of normal deterioration. The most common reason for painting is to improve appearance. Cleaning, rather than frequent repainting will often be quite effective at savings in cost and time. It also will prevent excessive paint buildup. (See Chapter 7.)

5.1.6.3 <u>Coatings Subject to Abrasion</u>. Spot-paint all floor coatings and traffic stripes at points of maximum wear. Only repaint overall when the entire area appears to be worn or starts to deteriorate. See Chapters 9 and 11.

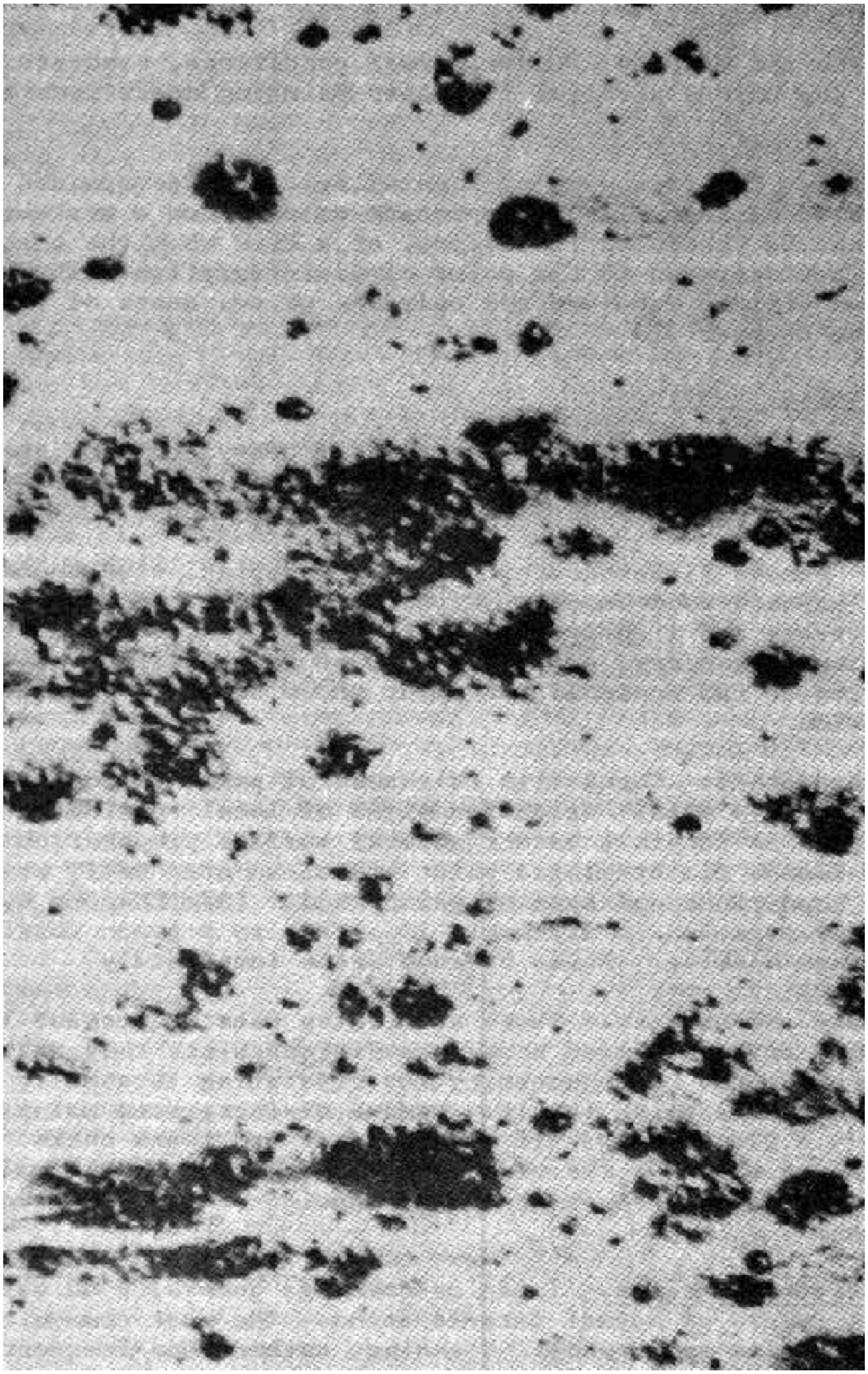


FIGURE 5-12
Rusting of Steel

Section 2. ABNORMAL DETERIORATION

5.2.1 GENERAL. When coatings deteriorate sooner than anticipated or in an abnormal manner, the cause of such premature failure must be found and corrected before repainting. The cause may be due to the substrate, the structure, the environment or the paint.

5.2.2 SUBSTRATE PECULIARITIES. Many substrates have individual characteristics which can present abnormal problems if not corrected or eliminated before or during painting operations.

5.2.2.1 Wood. Wood is a natural product which varies in a number of respects:

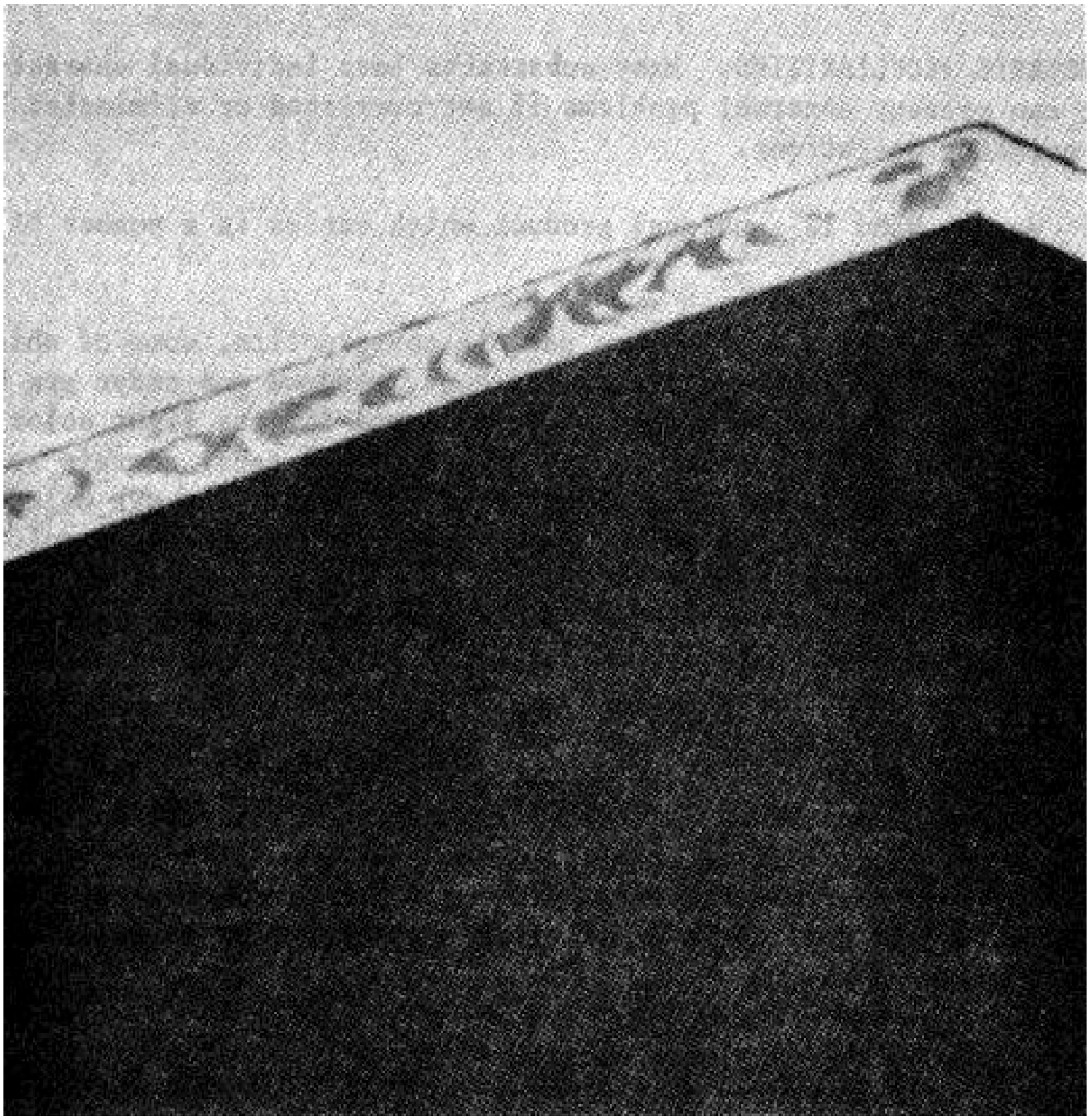
a. Type: Many types of wood are used in construction, some of which vary considerably in their characteristics, e.g., redwood and cedar are brown in color and rather uniform in grain, while pine and fir are light color and vary considerably in grain structure. Both redwood and cedar contain soluble dyes which can dissolve in moisture absorbed by the wood. The dye solution will rise to the surface of the paint, then appear as pink or brown colored streaks or spots. Staining can be eliminated by preventing moisture from getting to the wood. Prime new lumber with a good sealing paint such as an oil primer rather than a relatively porous latex paint. Once the moisture is removed, no further staining should occur. The stain on the surface eventually should be washed off by rainfall.

b. Spring and Summer Wood: Trees grow more rapidly in the spring than during the summer. Consequently, the springwood tends to be relatively soft with wide bands, whereas summerwood is harder and has narrower bands. Each type absorbs water and expands to a different degree causing stresses at the junction of the two bands.

When cracking does take place, it generally starts along these junction lines. Adhesion will be poorer on the more dense summerwood so that peeling will start in this area actually showing the grain pattern. (See Figure 5-13.)

c. Edge Grain and Flat Grain: The method of sawing the lumber will determine the pattern of the wood produced. If the saw cuts radially, facing the center of the log, it will cut directly across the growth bands forming an edge grain, which shows up as parallel lines or bands. If the saw cuts at right angles to the radial lines, band widths will vary considerably throughout each piece of lumber. This flat grain pattern is more interesting for furniture but is less useful for painting. The larger the grain pattern, the greater will be the problem with differential absorption and ultimate cracking along the grain junction lines with subsequent flaking and peeling. Southern yellow pine is a marked example of this problem, which is exaggerated even further because of its high resin content. (See Figure 5-14.)

d. Knots: All trees have branches which start well within the trunk. Therefore when boards are cut, especially flat grained, they will contain cross sections of these branches or knots. This is more of a problem with pine which is cut from smaller trees with many branches are compared with redwood which comes from very large trees with few branches. These knots contain resinous



Dark areas show failure over summer-wood in flat grain southern yellow pine.

FIGURE 5-13
Spring and Summer Wood

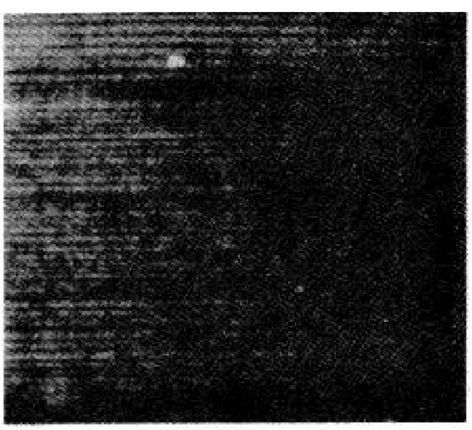
material, which, under the heat of the sun, will melt and bleed through the paint. (See Figure 5-15.) The discolored area also becomes brittle from the resin and cracks long before the rest of the coating. To overcome this, remove all paint from the knots and surrounding area down to the wood. Seal with knot sealer and repaint with at least two coats of the same paint as used in the surrounding area.

e. Resinous Materials: Some pine, especially of lower grades, contains pockets of pitch or resin similar to that found around knots. This resin will rise to the surface and discolor and eventually degrade the paint in that area. Such areas should be cleaned, sealed with knot sealer and repainted. If the pitch pocket is below the surface, a hole should be drilled to allow drainage and then puttied and sealed before painting. Small isolated spots of pitch, which appear on the surface and have not harmed the paint, can be removed by scraping and washing with mineral spirits.

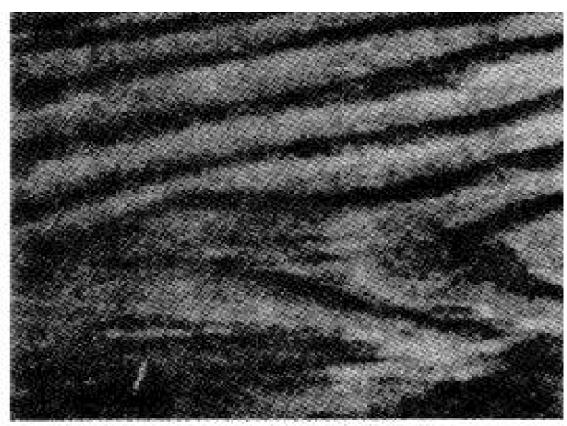
f. Green Lumber: Fresh lumber contains a considerable amount of water. Most of this must be removed before use, not only to prevent shrinkage after installation but to prevent blistering, cracking, and loss of adhesion of the applied paint. Be sure that all lumber used has been properly dried and kept dry before painting.

5.2.2.2 Metal. All metals are much more uniform than wood: They expand uniformly in all directions so that adhesion loss because of uneven stresses is much less of a problem than with wood. Some types of metals do present certain problems which can cause abnormal deterioration.

a. Iron and Steel: Both of these rust when exposed unprotected. If moisture penetrates through holidays, thinly coated sharp corners or breaks in the film, rust is formed. This rust will increase in area, lifting the edge of the film around the break, then creep underneath the film and continue the process. Thus, the paint deteriorates quite rapidly around each area of exposed metal. (See Figure 5-16.) Rusting is accelerated in humid atmospheres and even more so in marine atmospheres. Rusting will also spread under the paint film in areas which have been insufficiently cleaned. Such poor practice leaves rusted areas in which moisture and air can be trapped when painted. The area should be adequately cleaned depending on the coating to be applied. See Chapter 8 for minimum surface preparation for the type of paint used, Table 8-1 or appropriate primers and Appendix D-4, Tables 11 and 15, for complete paint systems.



Edge Grain



Flat Grain

FIGURE 5-14
Wood Grain

b. Galvanized Steel: Galvanized steel is steel sheet coated with zinc and then treated with chemicals to prevent white rust (a white deposit which forms when zinc is exposed in humid areas). The combination of the zinc metal and chemical treatment often creates problems of adhesion of applied coatings after exposure. If the incorrect paint system is used, extreme flaking and peeling may take place after a year or so of exposure, especially when wide temperature changes take place. (See Figure 5-17.) Allow galvanized steel to weather, if at all possible, and use appropriate primers. See Table 8-2, Chapter 8, and Appendix D-4, Table 16.

c. NonFerrous Metals: The most common nonferrous metals which are painted are aluminum and copper. Although both of these metals do corrode, their corrosion products do not tend to expand as rapidly as in the case of iron and steel. They should be cleaned thoroughly to obtain optimum adhesion. Since nonferrous metals are relatively soft and thin, this must be done with care to avoid damaging the substrate. Then apply the coatings recommended in Appendix D-4. Tables 11 and 16.

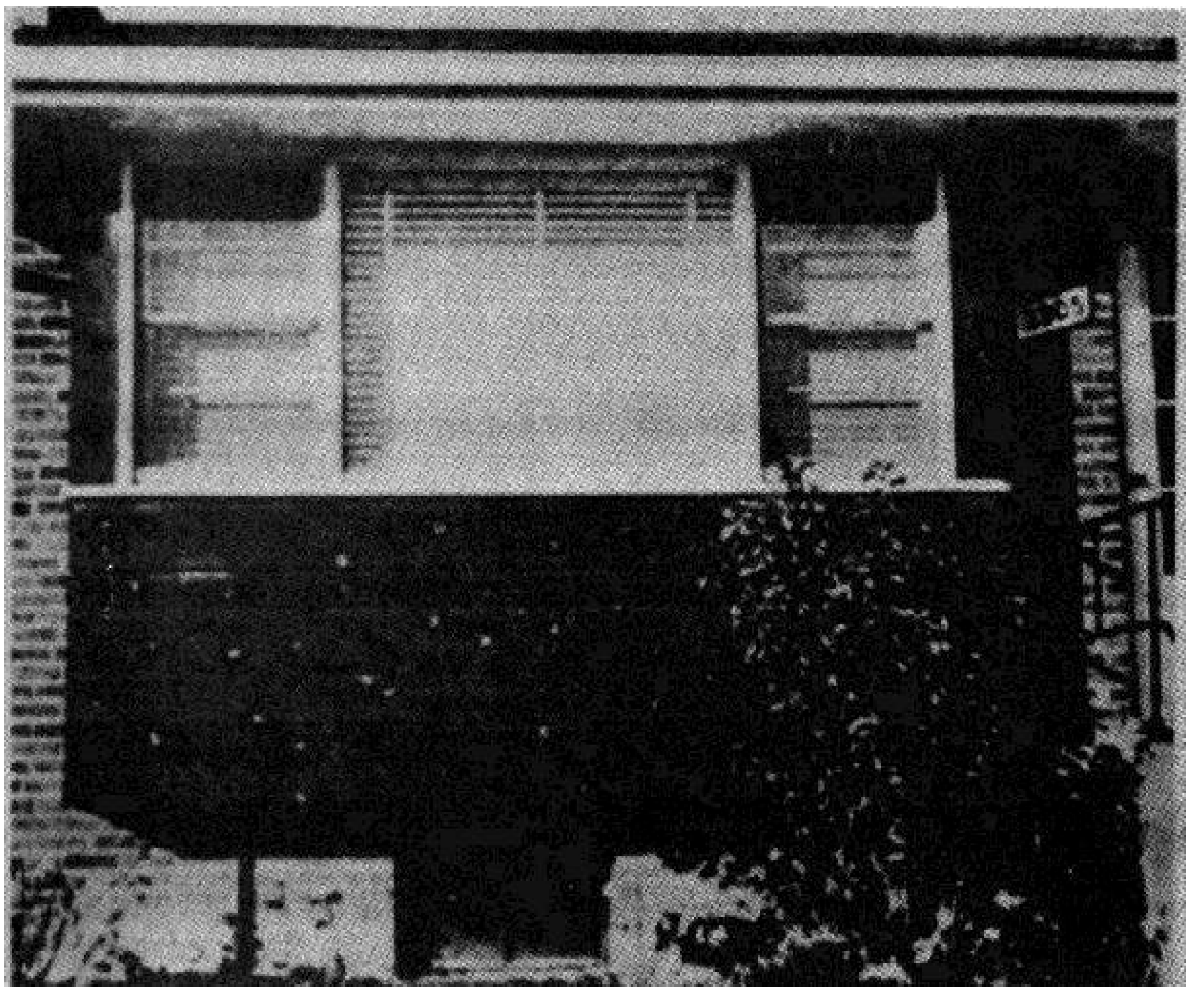


FIGURE 5-15
Bleeding Around Knots

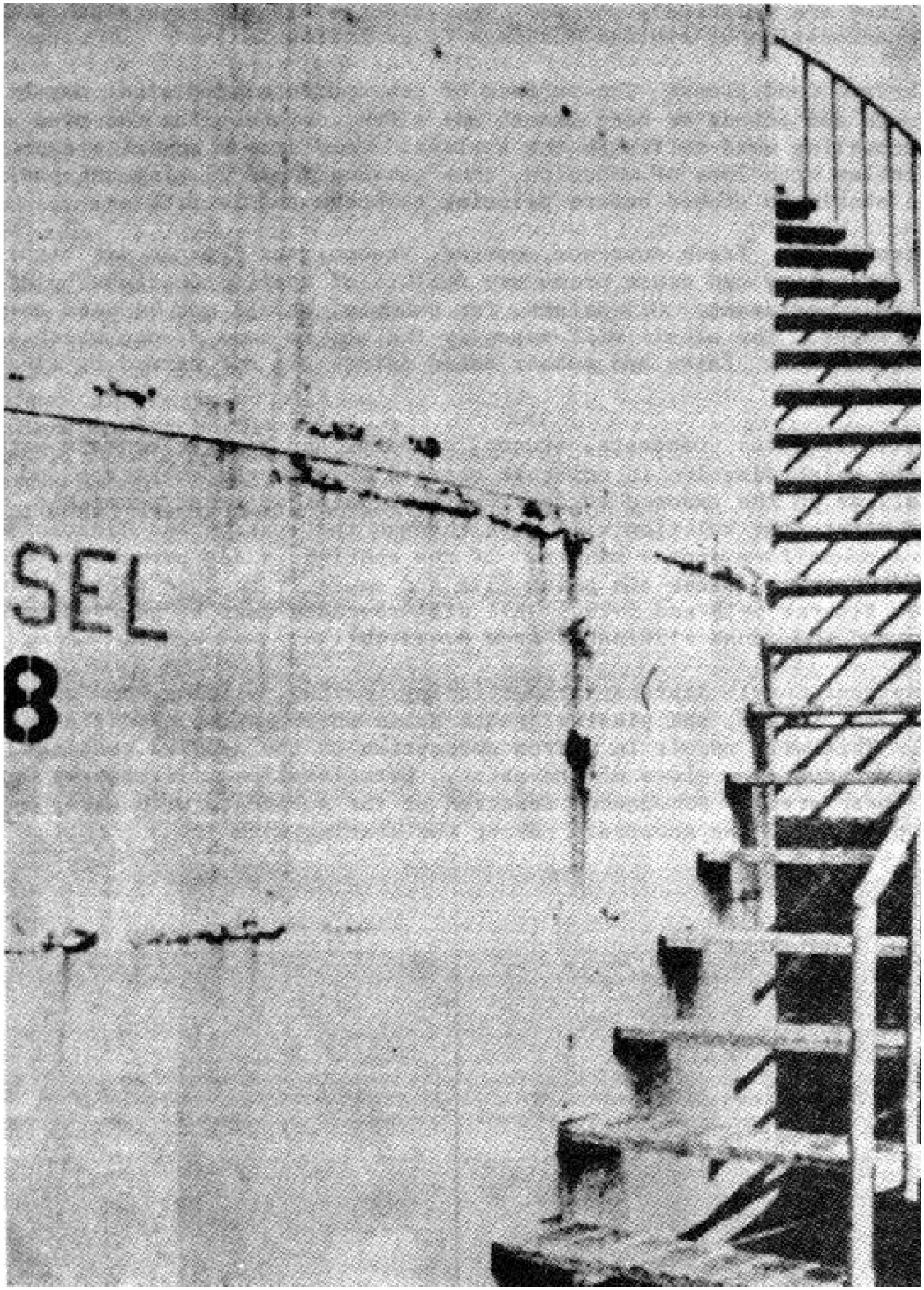


FIGURE 5-16
Rusting at Welds

5.2.2.3 Concrete, Stucco, Masonry, Plaster. All of these substrates have three things in common. They are hard, they all contain lime and other soluble salts, and they are relatively porous. The effect of these properties on the abnormal deterioration of applied coatings is as follows:

a. Surface Conditions: The surface of new concrete or plaster may be somewhat rough and porous or very smooth and slick, depending on the type and degree of troweling used to finish the surface. Very smooth concrete can create a problem with loss of adhesion, thus causing rapid flaking and peeling. The surface should be etched before painting to prevent this problem.

b. Alkalinity: Fresh concrete, mortar, stucco, and plaster are highly alkaline. Alkalinity can cause premature failure of applied coatings unless they are alkali resistant. Oil paints, for example, should not be used on alkaline surfaces. The alkali will saponify the oil to form a soap which has no binding qualities. Latex and rubber based paints are not harmed by alkali in the substrate.

c. Efflorescence: Concrete, stucco, masonry, and plaster contain water soluble salts which dissolve in moisture carried through the substrate and then crystallize on the exposed surface. If the paint is water permeable, e.g., latex paint, the solution will pass through the coating and discolor the surface in a nonuniform spotty manner. If the coating is not permeable, the salts may be deposited under the paint film and cause it to lose adhesion in spots. (See Figures 5-18 and 5-19.) All efflorescence must be removed before repainting, and the cause eliminated (see 4.4.3.4b).

d. Improper Cure: Improper proportioning, mixing, placing, and/or curing of concrete, stucco, and plaster create areas which may be of different porosities. This will result in uneven absorption of the applied coatings, which shows up as uneven gloss of the paint. Deterioration will also be more rapid over these areas. Subsequent reaction of the substrate with water may also cause popping of the substrate taking the coating with it.

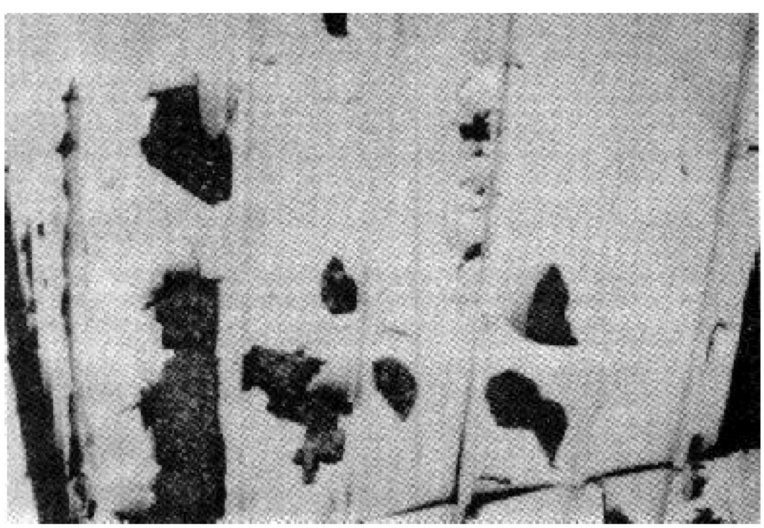


FIGURE 5-17
Peeling from Galvanized Steel

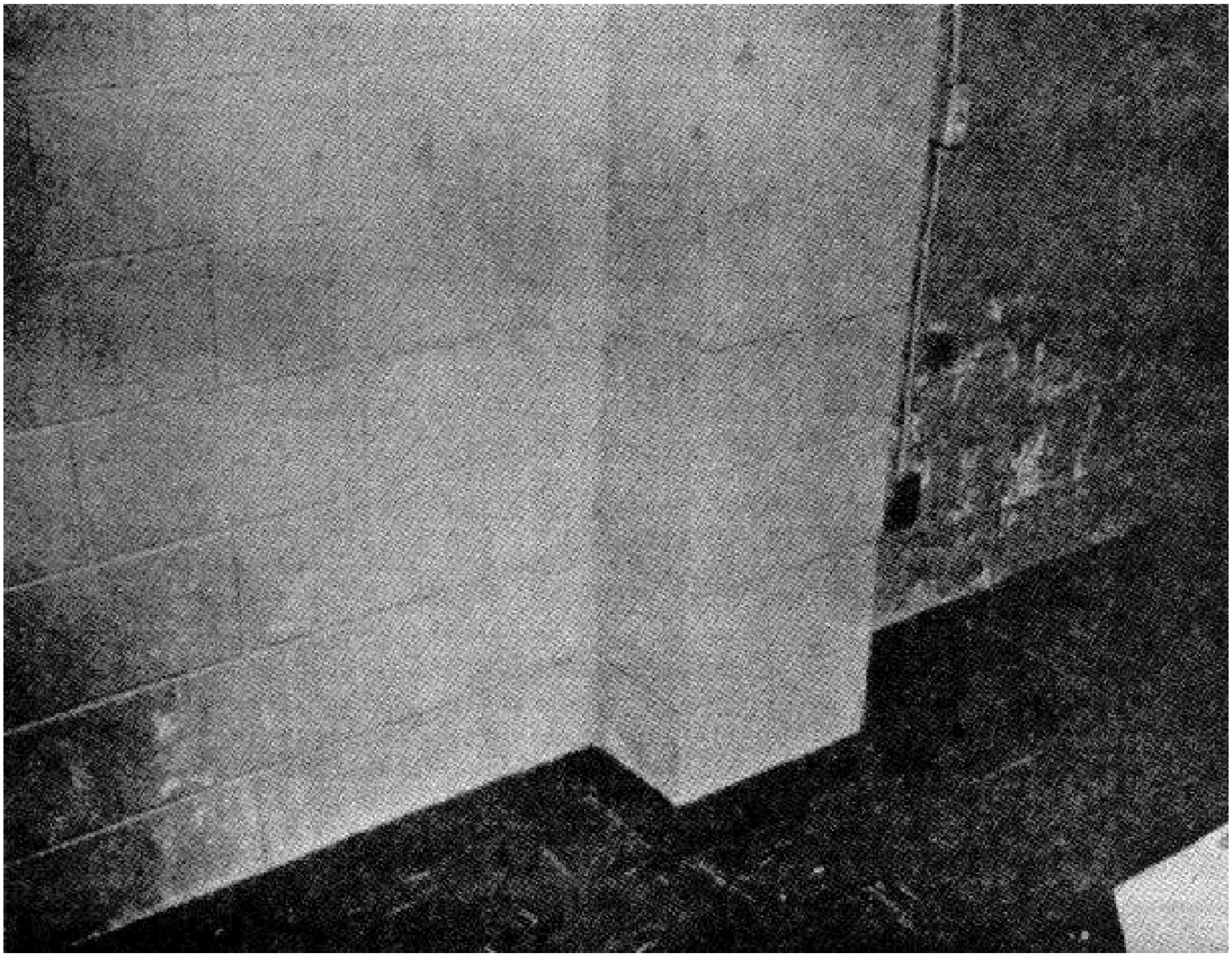


FIGURE 5-18
Efflorescence on Concrete Block Wall

5.2.3 ABNORMAL ENVIRONMENTS. Unusual conditions of exposure are a major cause of abnormal deterioration of coatings.

5.2.3.1 Humidity or Moisture. Moisture may cause abnormal deterioration in two ways: it may cause flatting or formation of mildew (fungi).

a. Flatting: If moisture, in the form of fog, rain, or dew lies on the surface of newly applied paint before it is thoroughly dry, it may cause a spotty or complete loss of gloss of the paint. This is primarily an appearance problem which makes a new paint job look inferior. (See Figure 5-20.)

b. Mildew (Fungi): Paint coatings exposed in humid climates or in warm, damp rooms, e.g., shower rooms, may be attacked by fungi which feed on the coating. Mildew will grow and become quite unsightly; eventually it will accelerate degradation of the coating. (See Figures 5-21 and 5-22.) In its early stages it looks like dirt, but it cannot be washed off as easily. The presence of mildew can be determined by using household bleach; this will bleach mildew, whereas it has no effect on dirt. Hard drying paints such as enamels, or paints containing zinc oxide, are more resistant to mildew. Use

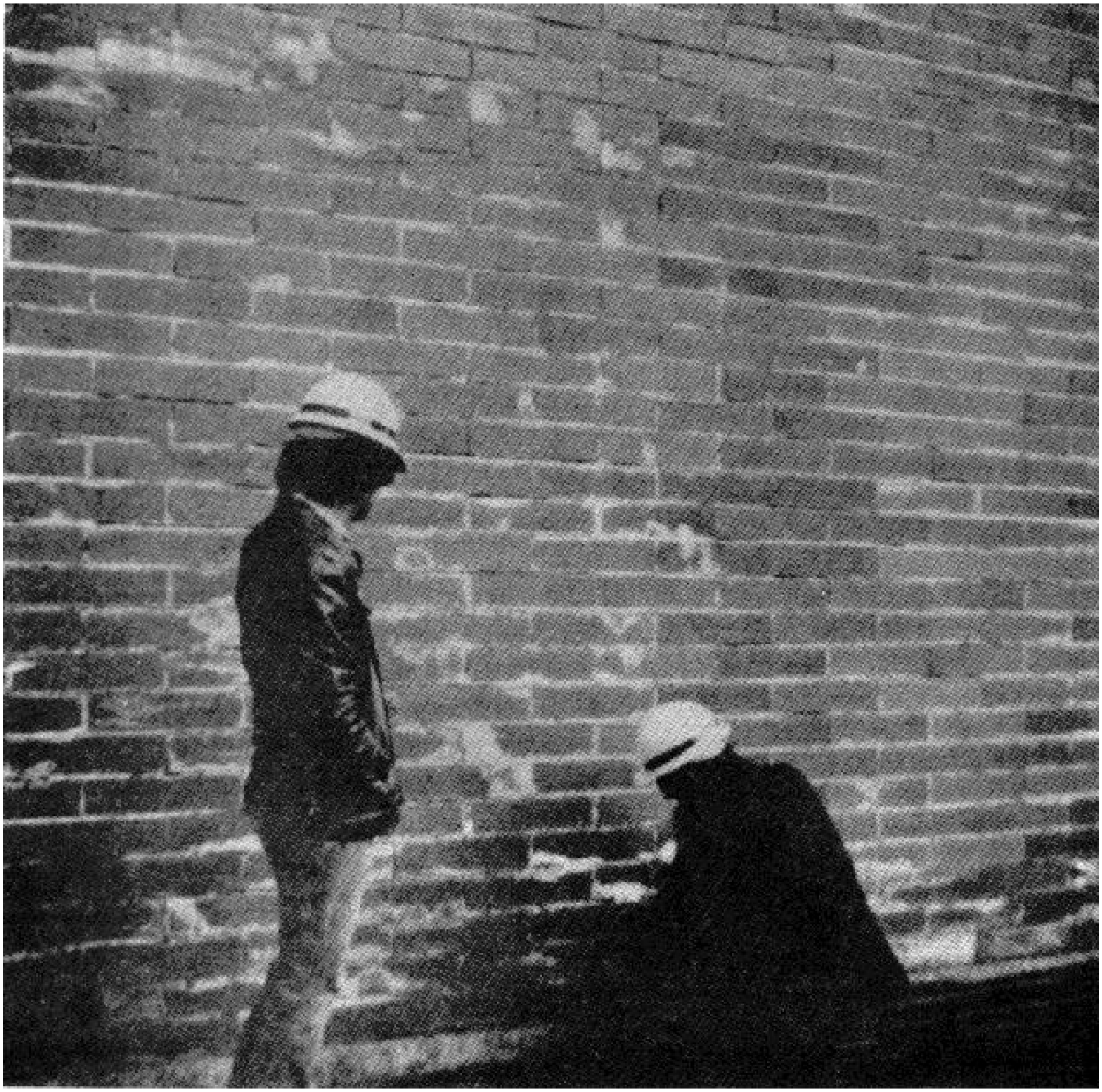


FIGURE 5-19
Severe Efflorescence on Brick Wall

specially formulated moisture-resistant and mildew-resistant paints for these exposures. (See 10.2.2.7 and Appendix D-2, Tables 10 through 12 and 14 through 16.)

5.2.3.2 Atmospheric Contamination. Smoke and fumes can adversely affect paint coatings causing discoloration and rapid failure. Sulfur-containing gases, such as sulfur dioxide and hydrogen sulfide, will discolor coatings, especially those containing lead or iron. They will also accelerate chalking and erosion. Wind drive dust will accelerate dirt collection especially on softer drying paints such as those based on linseed oil. Salt-laden atmosphere

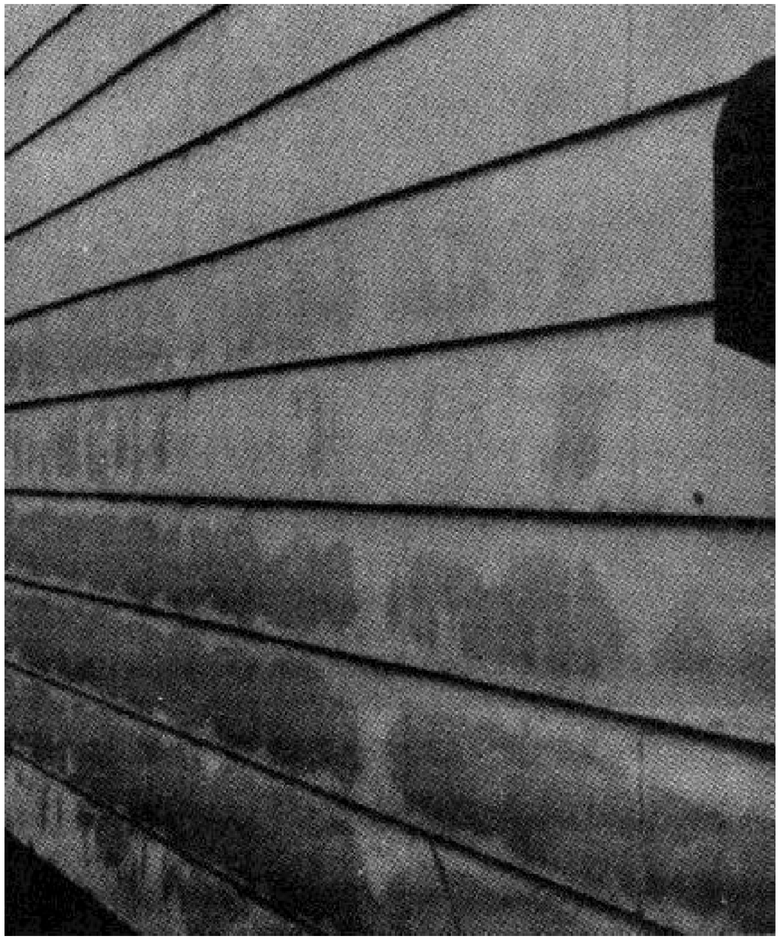


FIGURE 5-20
Spotty Loss of Gloss

in coastal areas will accelerate deterioration of coatings which are not resistant to salt. (See Chapter 8 for the proper selection of paint for use under these conditions.)

5.2.3.3 Rapid Temperature Changes. Sudden changes in temperature can create unexpected problems. A rapid drop overnight, just after painting, may cause a heavy dew or even frost to deposit on the paint film with consequent flatting. It may also retard drying so that dirt and insects can become embedded in the coating. Wrinkling can occur if the coat is excessively thick. A rapid increase in temperature may cause air entrapped in a porous substrate to increase in pressure and form dry blisters in the paint film. (See Figure 5-23.)

5.2.3.4 Wind Velocity. Excessive wind velocity during painting makes application extremely difficult. It may also cause the paint to dry too rapidly on the surface thus forming a skin which prevents thorough drying. This can lead to recoating problems and to solvent entrapment (See 5.2.6.5). In any case, durability is impaired. Do not paint when the wind velocity is above 15 miles per hour. Winds also carry dirt, tending to impinge the dirt particles on the painted surface, especially when it is fresh or soft. Grit carried by high velocity winds can also abrade cured painted surfaces.

FIGURE 5-21
Mildew (Fungi)

5.2.4 INCOMPATIBLE PRESERVATIVES AND PAINTS. The entire coating system must be compatible through each layer, from the substrate to the surface, to achieve optimum durability. Any incompatibility between substrate and paint system and between coats will reduce adhesion and accelerate deterioration associated with loss of adhesion, i.e., lifting, peeling, etc.

5.2.4.1 Incompatible Preservatives. Some wood preservatives affect paints applied over them. They may either retard drying, affect adhesion, or bleed through and discolor the paint. Creosote-containing preservatives or copper naphthenate, for example, may bleed. Zinc napthenate or pentachlorphenol can be used with no adverse effects.

5.2.4.2 Incompatible Paints. It is always safest to recoat surfaces with the same kind of paint previously used, unless experience shows that the new paint is compatible with the old paint. Incompatibility may result in the following defects, all of which affect the adhesion and ultimate service life of the paint system:

a. Lifting: This is an effect produced by the solvent in the applied paint, acting as a paint remover on the coating underneath. The result is a softening, swelling, and lifting of the coating. It can happen when paints containing strong solvents such as xylene are applied over relatively soft paints, such as oil paints. Lifting is more likely to occur when a second or third coat is applied over an undercoat which has not dried hard enough. Always be sure that the coating is not only dry but fairly hard before applying the next coat. Test a small area if not sure.

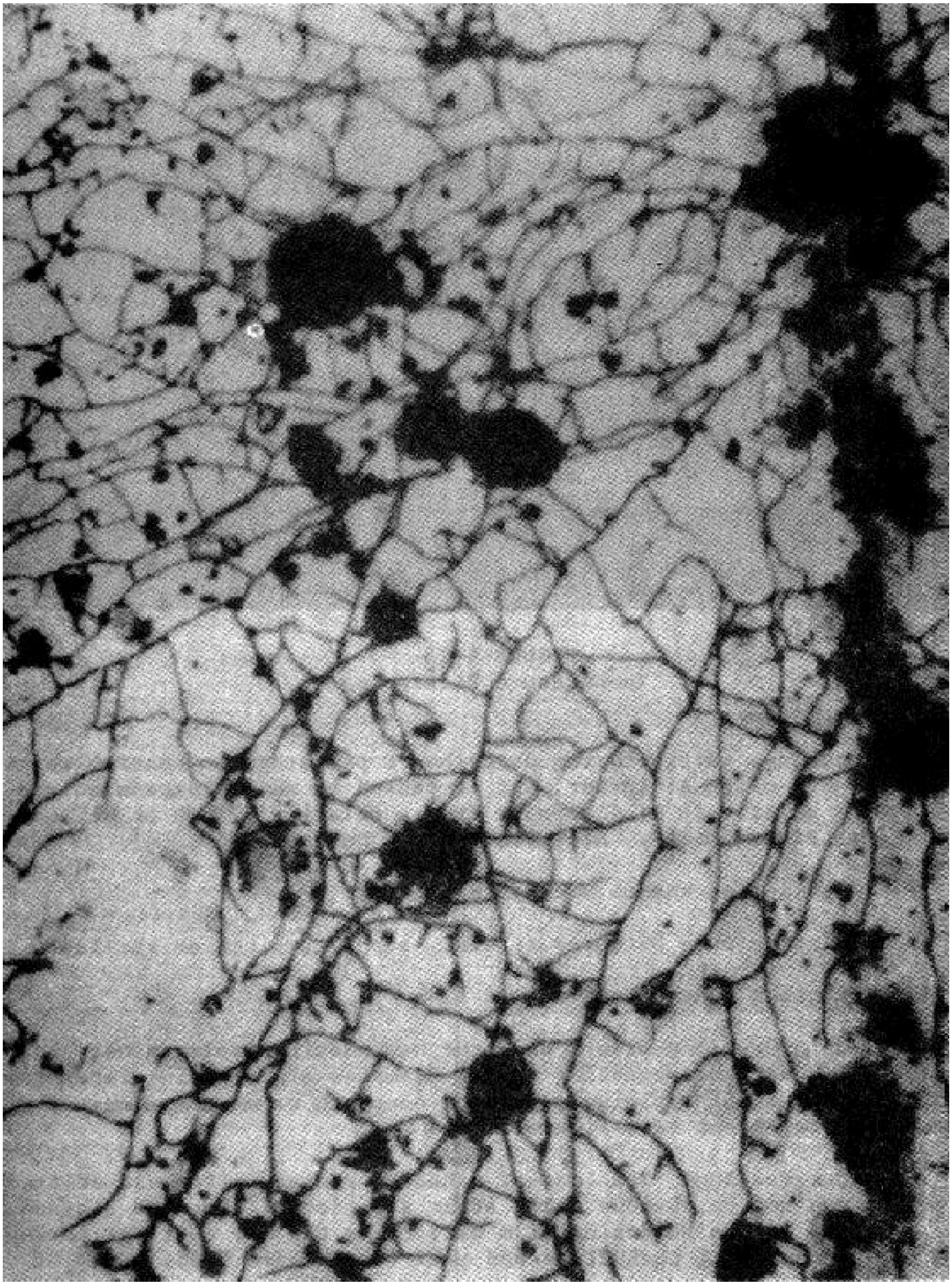


FIGURE 5-22
One Type of Fungus (Mildew) (Magnified)

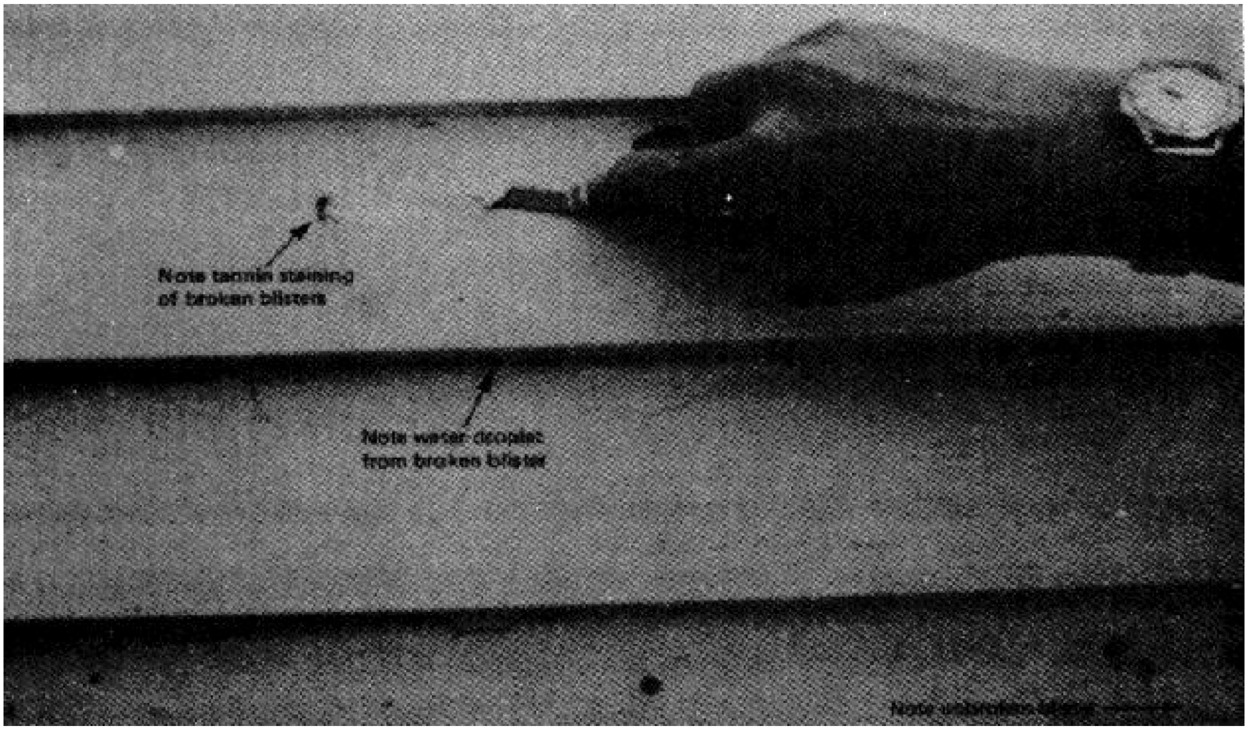


FIGURE 5-23
Temperature Blistering

b. Alligatoring: Alligatoring describes a pattern in a coating which looks like the hide of an alligator. It is caused by uneven expansion and contraction of a relatively hard topcoat over a relatively soft or slippery undercoat. (See Figure 5-24). Alligatoring can be caused by:

(1) Applying an enamel over an oil primer

(2) Painting over bituminous paint, asphalt, pitch or shellac

(3) Painting over grease or wax

c. Crawling: Crawling occurs when the new coating fails to wet and form a continuous film over the preceding coat. Examples are applying latex paints over high gloss enamel or applying paints on concrete or masonry treated with a silicone water repellent (See Figure 5-25.)

d. Intercoat Peeling: The loss of adhesion caused by the use of incompatible paints may not be obvious until after a period of time has elapsed. Then, the stresses in the hardening film will cause the two coatings to separate and the topcoat will then flake and peel (See Figure 5-26.)

5.2.5 IMPROPER PAINTING OPERATIONS. It is apparent from the problems described thus far that the painter can prevent or cause most of them by the manner in which he follows instructions. Always use recommended coating systems (primer plus topcoat, if a primer is necessary). Be sure that the surface is properly prepared and that painting conditions are within specified

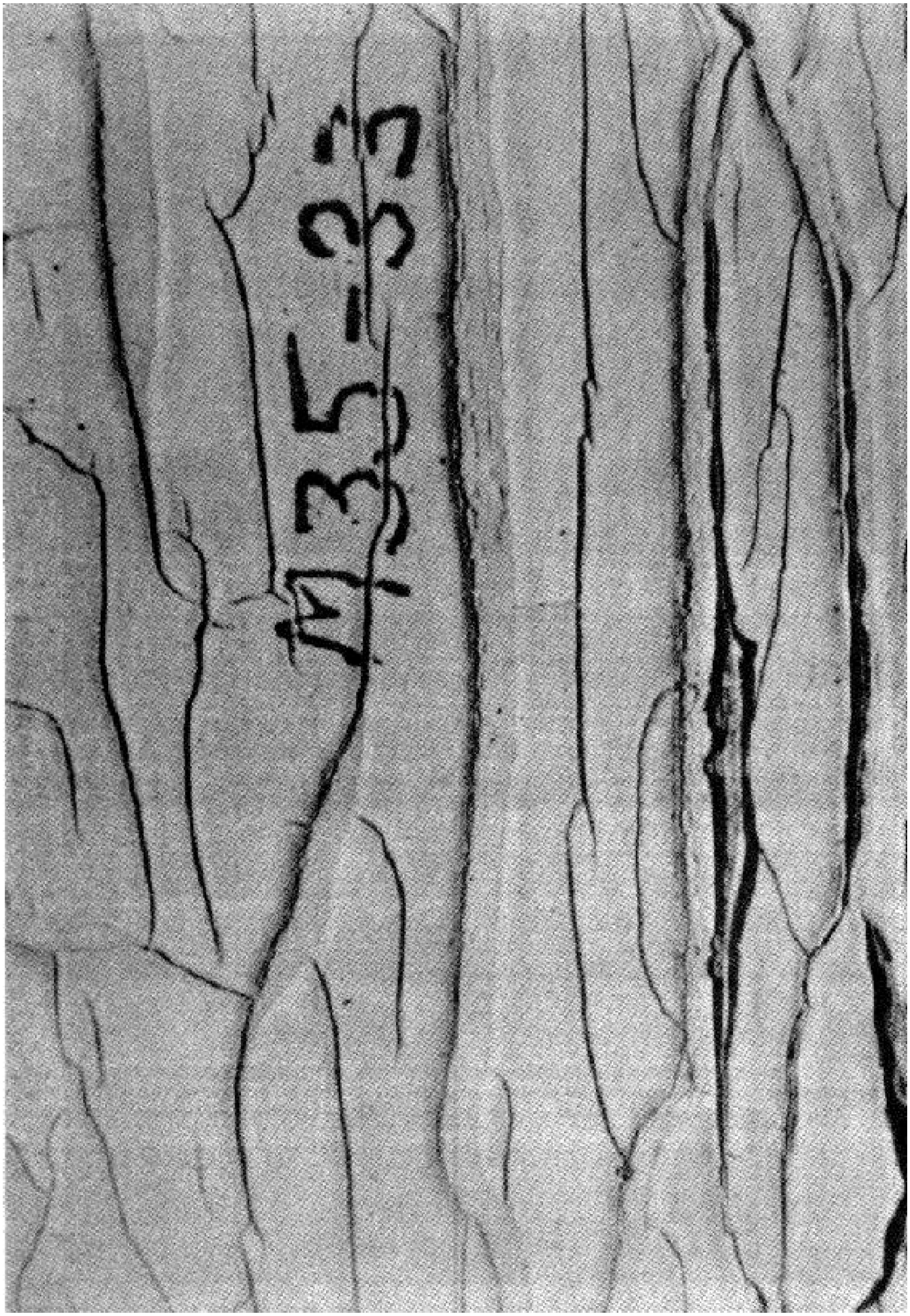


FIGURE 5-24
Alligatoring

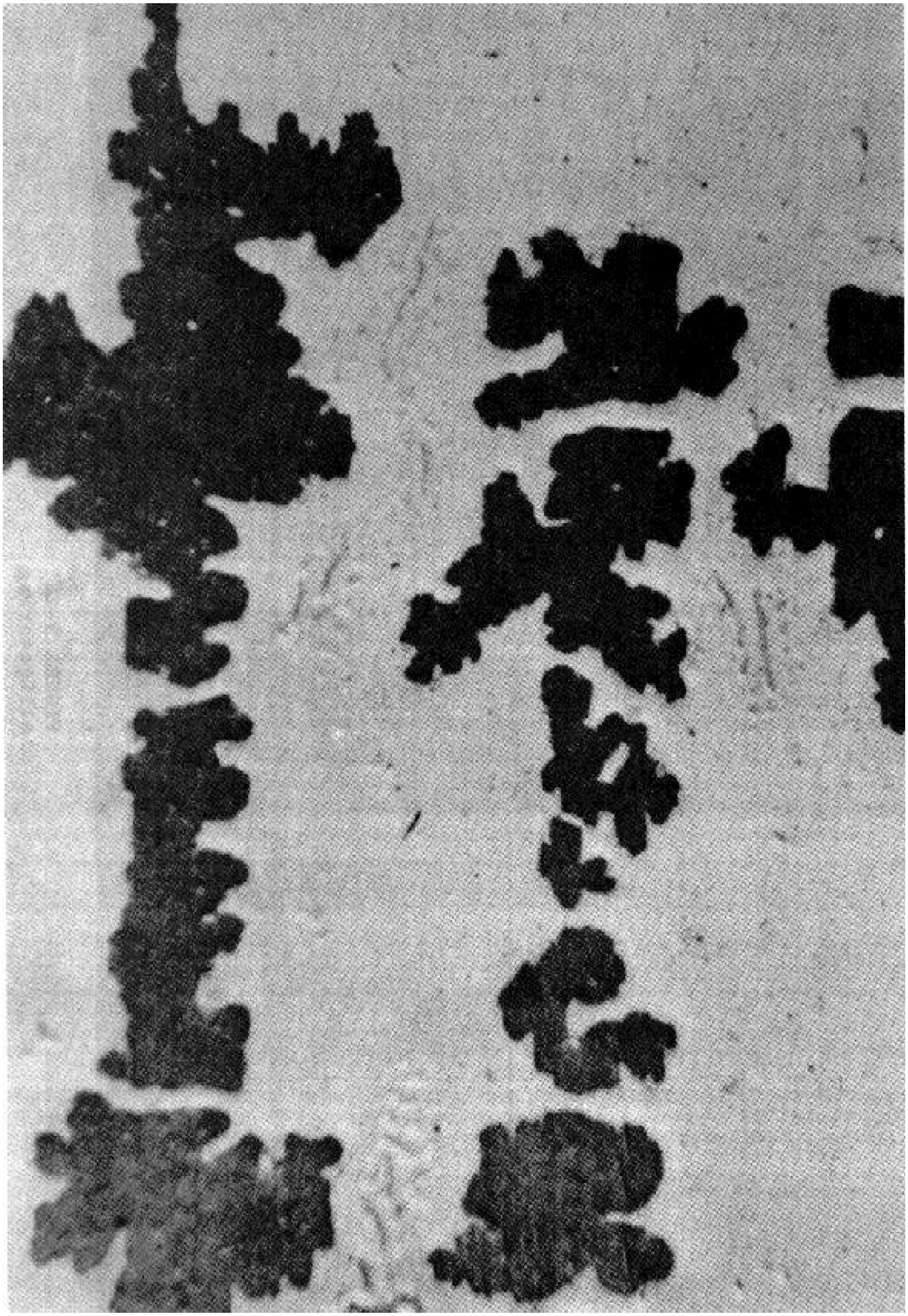


FIGURE 5-25
Crawling

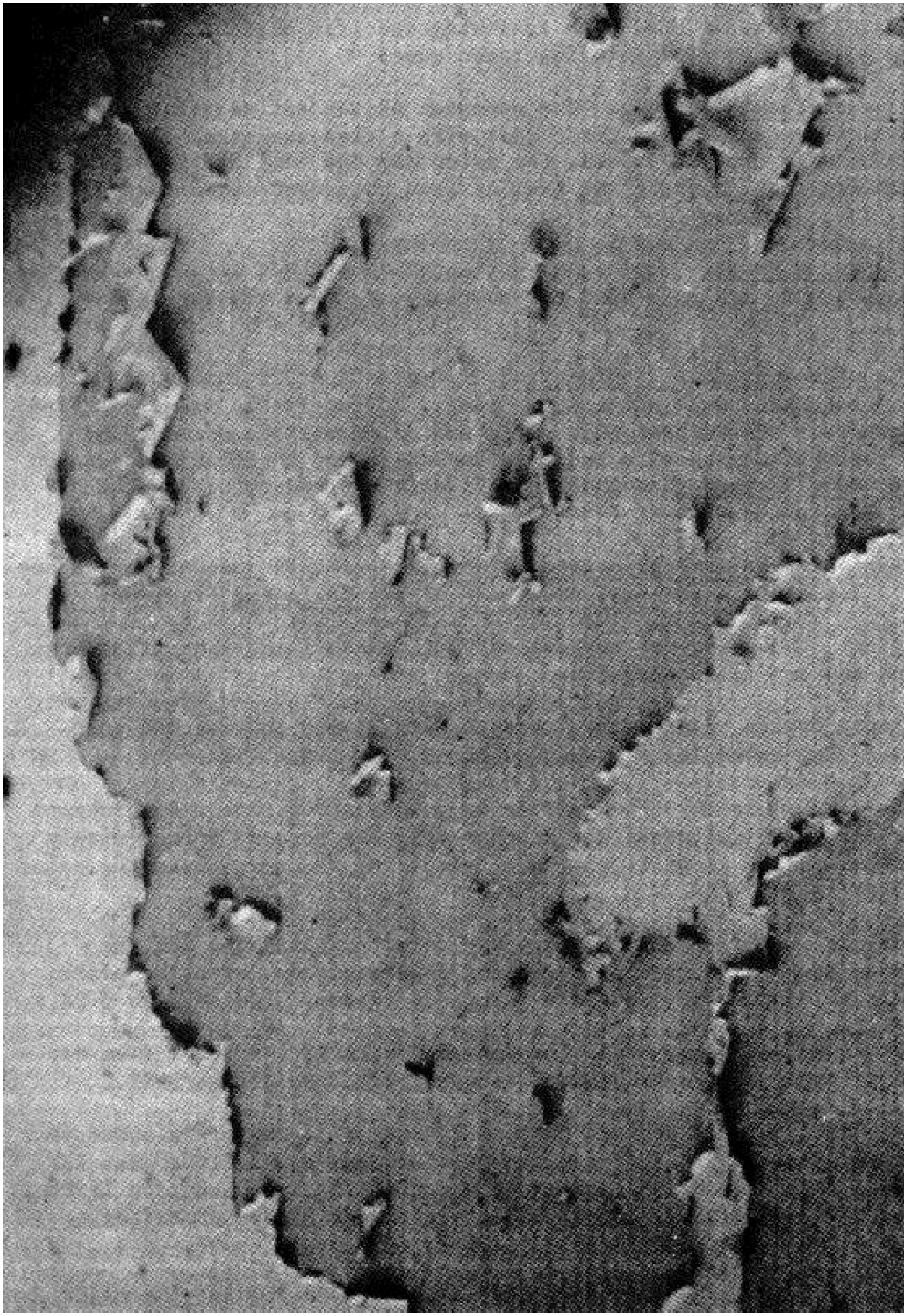


FIGURE 5-26
Intercoat Peeling

limits, e.g., temperature, humidity, etc. Follow application directions exactly. Taking short cuts or disregarding instructions are bound to accelerate deterioration of the applied coatings.

5.2.6 POOR PAINTING TECHNIQUES. The following specific actions indicate what can happen as a result of poor painting techniques:

5.2.6.1 Insufficient Cleaning. The adhesion of the entire paint system depends on direct contact of the first coat with a clean substrate. If the surface contains wax, grease, or oil, the paint may dry very slowly, crawl, or alligator. In any case, flaking and peeling from the substrate will take place.

5.2.6.2 Improper Repair. Roles and cracks which are not filled and sealed will allow moisture to get in behind the coating and cause blistering and film degradation.

5.2.6.3 Insufficient Paint Application. If paints are thinned or applied in too thin a coat, they will not last as long. If too little primer is used, especially on porous substrates, then gloss and color will be uneven, and adherence of topcoats may be affected. In any case, any chalking and erosion which takes place will wear through a thin film faster and result in the necessity for repainting earlier than normal.

5.2.6.4 Excessive Paint Application. Too much paint is just as bad as too little paint. Too heavy a coat may cause any of the following problems:

a. Sagging: The paint may curtain on vertical surfaces thus affecting its appearance and dry film thickness.

b. Drying: Drying, especially "through drying" may be retarded considerably. This may cause lifting when recoated (see 5.2.4.2.a).

c. Wrinkling: This may occur either in cold weather when the thickened paint is improperly applied or in hot weather when the topcoat dries quickly but the paint underneath is still wet. The resulting stresses cause the paint to wrinkle (See Figure 5-27).

d. Cracking: The film may not show any defects initially, but the extreme stresses present in a thick hardening film may cause cracking after exposure. This is especially true in a multicoat system. (See Figure 5-28.)

e. Blistering: In hot weather the uneven drying of the thick film may cause solvent entrapment with subsequent blistering. (See Figure 5-29.)

5.2.6.5 Insufficient Dry Between Coats. Rushing a job may also speed up its failure as a result of loss of adhesion or improper cure. If a coat is not thoroughly dry, the next coat may cause trapping of the solvent or lifting. Trapped solvent must come out eventually and will cause either pinholing, blistering, or a reduction in adhesion.

5.2.7 ENTRANCE OF MOISTURE DUE TO FAULTY STRUCTURAL CONDITIONS. The major cause of abnormal deterioration of coatings, especially those exposed outdoors, is moisture. This moisture may either come from external sources or be

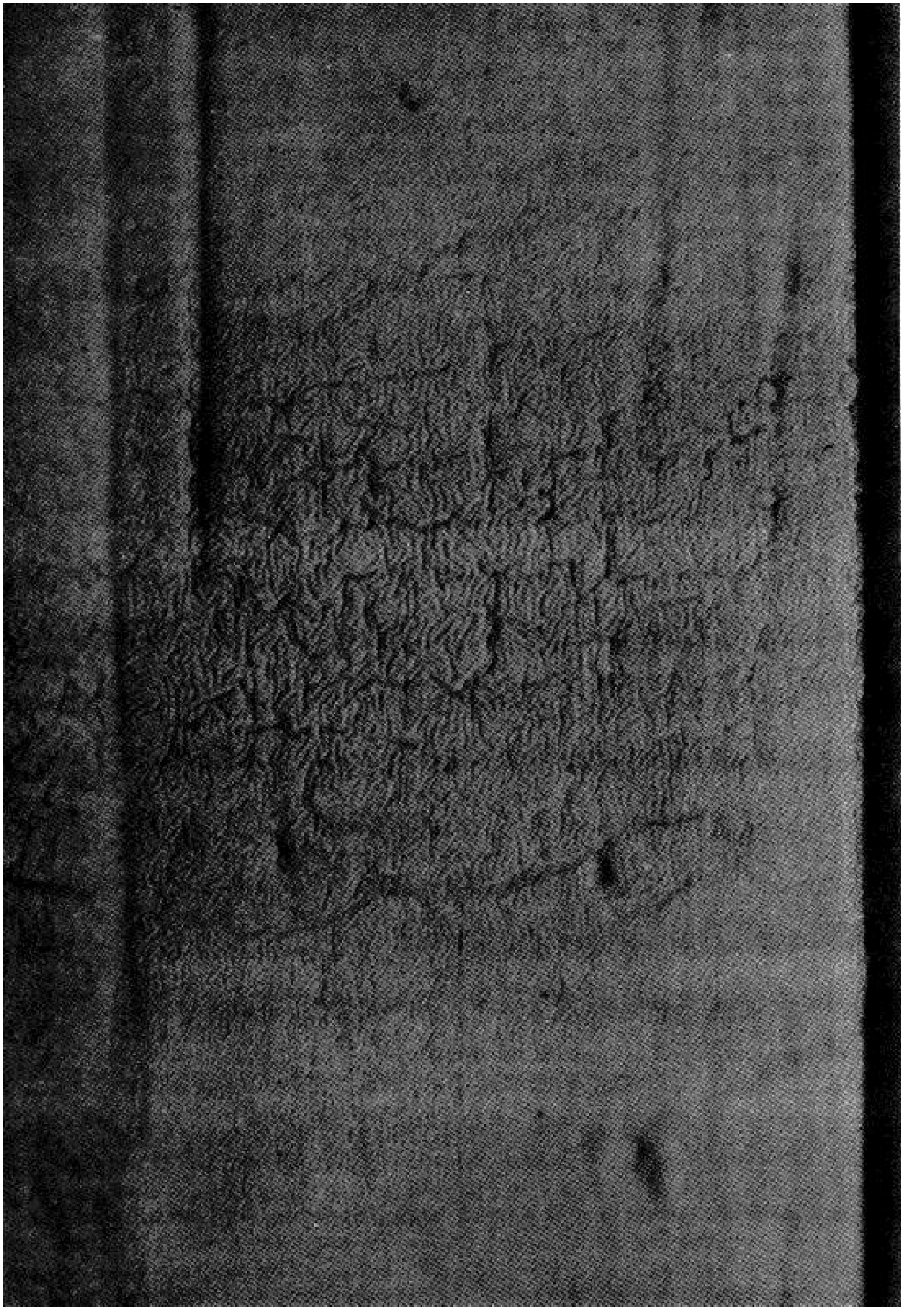
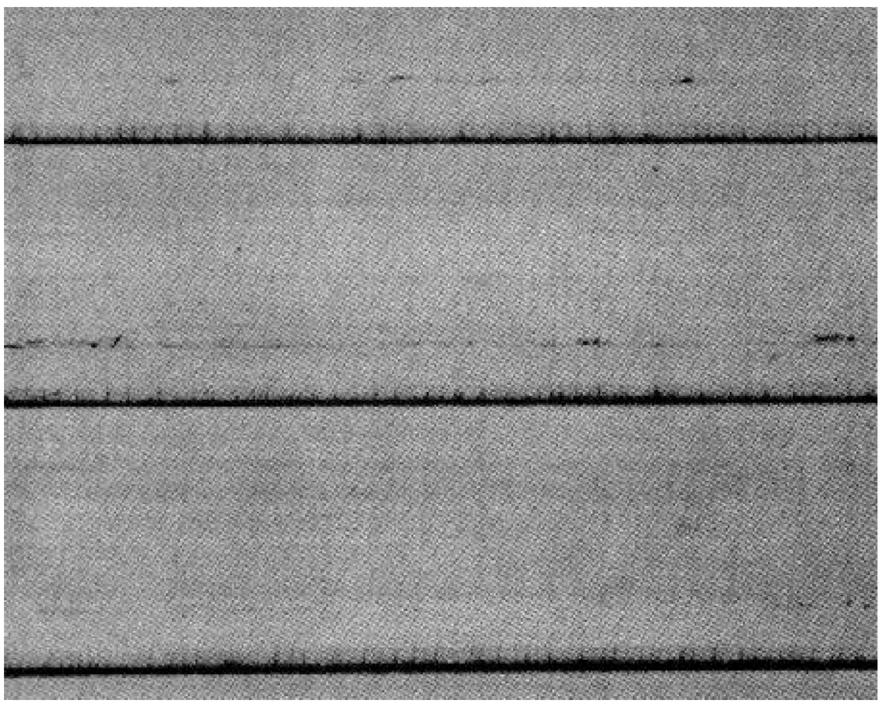


FIGURE 5-27
Severe Wrinkling

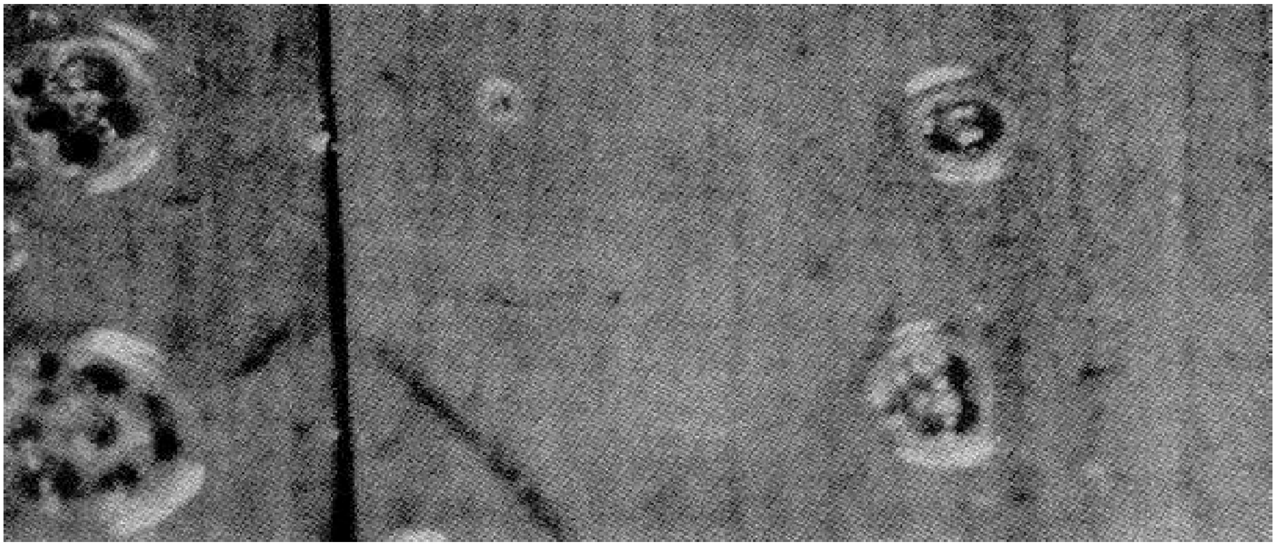
developed within the structure. This moisture can produce abnormal deterioration of applied coatings such as wood stain, mildew, blistering, and loss of adhesion, resulting in a poor appearance and eventual deterioration by flaking and peeling. (See Figures 5-29 and 5-30.) A prime reason for this problem is that the major construction materials used, i.e., wood, concrete, stucco, masonry, and plaster, are essentially porous and will allow moisture to pass through. If the walls are wet and the surface is warmed, as by sunlight, the moisture will tend to move to the outside atmosphere. If nonpermeable coatings are used (most paints other than latex paints or cement paints), this moisture will be trapped. Increased pressure will eventually cause the coating either to blister or lose adhesion. The problem is much less serious with metals, but increased contact with moisture does reduce the service life of coatings applied to them.



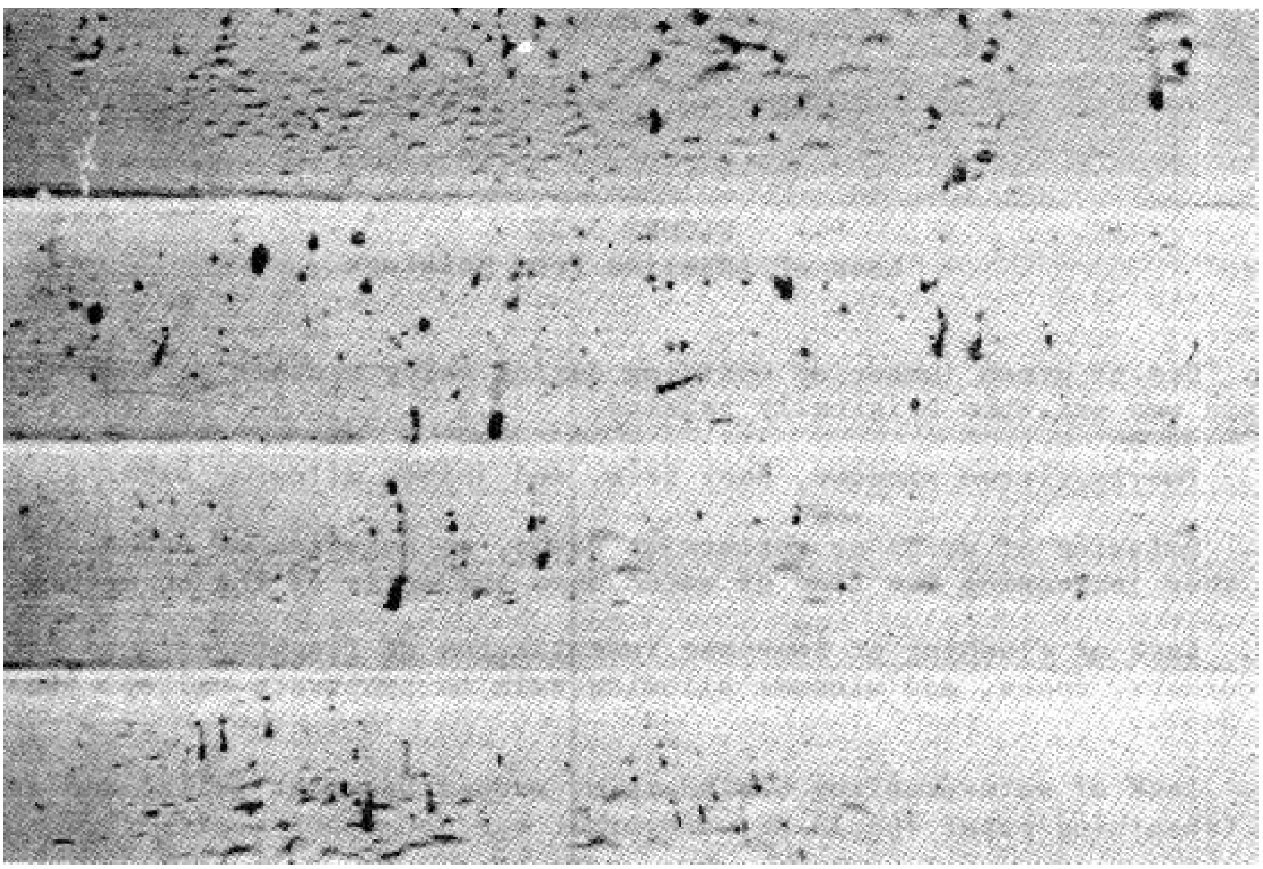
Surface painted six times in 15 years. Coating thickness is 22 Mils.

FIGURE 5-28
Cross Grain Cracking

5.2.7.1 Poor Construction. Poor quality construction which allows moisture to enter behind painted woodwork, masonry, or plaster is a major reason for discoloration and abnormal deterioration of both interior and exterior coatings. It will also eventually cause wood decay if not corrected. Report construction defects to construction personnel for correction before repainting is started. Twenty-six points of potential moisture trouble in a poorly built structure are shown in Figure 5-31. The major causes can be condensed as follows:



a. Solvent Entrapment.
Excessive application of varnish on a wood floor.



b. Moisture Entrapment

FIGURE 5-29
Blistering

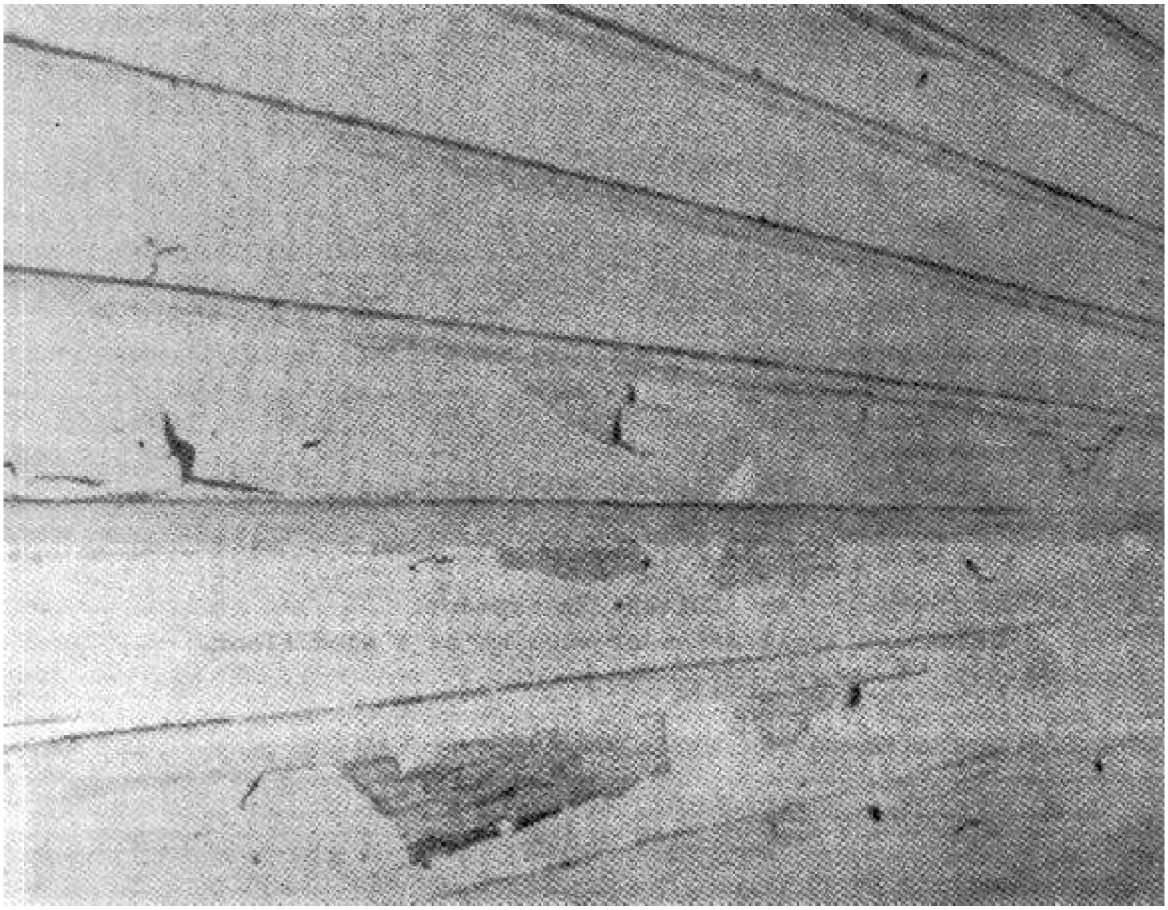


FIGURE 5-30
Loss of Adhesion from Moisture

a. Use of green lumber or building during rainy weather so that the structure was wet when originally painted.

b. Poorly fitted windows, door trim, and joints allowing water to enter.

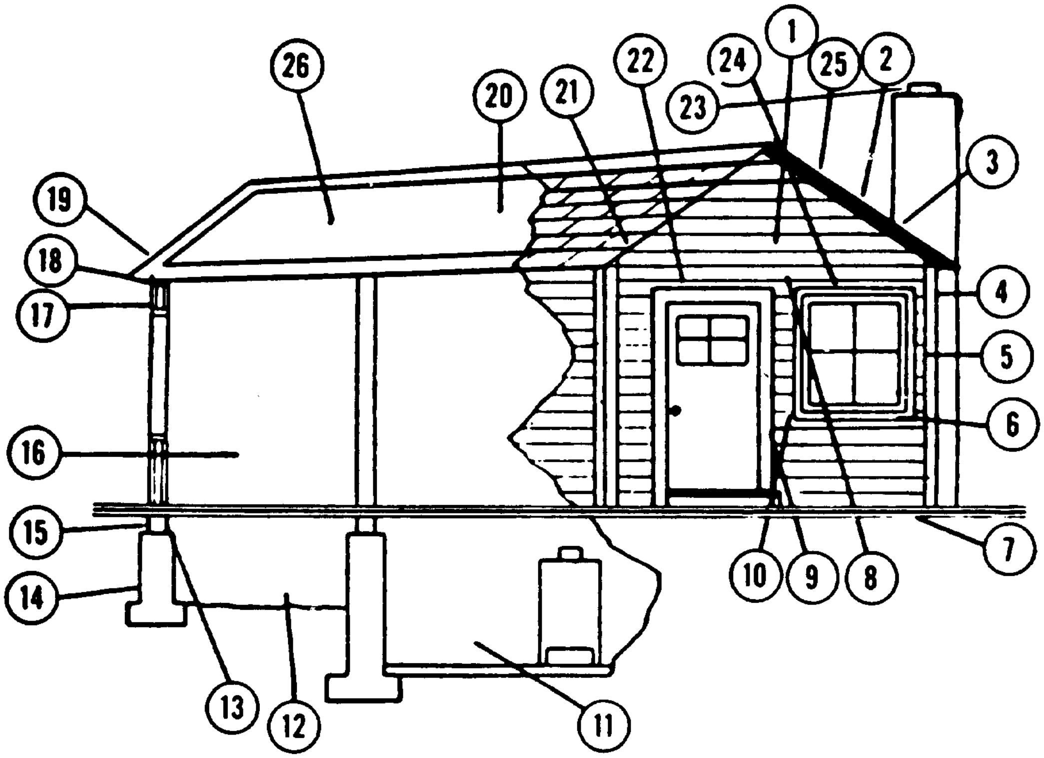
c. Omission of drips or gutters at eaves, or omission of eaves and overhangs, thus increasing the flow of water down the walls of the structure.

d. Lack of flashing or improper installation of flashing around chimneys, roof, corners, doors, and windows allowing rain to penetrate walls. (See Figure 5-32.)

e. Lack of waterproofing behind trim, around basement walls, and in crawl spaces (sheathing paper should be waterproof but not vaporproof).

f. Lack of ventilation in attics, basements, and crawl spaces allowing moisture to condense and collect on walls.

g. Direct contact of wood walls with ground or shrubbery. (See Figure 5-33.)



Twenty—six points of potential moisture trouble in a poorly—built house: 1, built with green lumber; 2 no cricket where chimney meets roof; 3, no flashing at side of chimney; 4, use of metal corner caps; 5, exposed nail heads not galvanized; 6, no window wash at sill; 7, wood contacts earth; 8, no drip or gutter at eaves; 9, poorly fitted window and door trims; 10, waterproof paper not installed behind trim; 11, damp, wet cellar unventilated at opposite sides; 12, no ventilation of unexcavated space; 13, no blocking between unexcavated space and stud wall space; 14, no waterproofing or drainage tile around cellar walls; 15, lacks foundation water and termite seal; 16, plaster not dry enough to paint; 17, sheathing paper should be waterproof but not vapor proof; 18, vapor barrier omitted——needed for present or future insulation; 19, built during wet, rainy season without taking due precaution or ventilating on dry days; 20, built hurriedly of cheap materials; 21, inadequate flashing at breaks, corners, roof; 22, poorly jointed and matched; 23, no chimney cap; 24, no flashing over openings; 25, full of openings, loosely built; 26, no ventilation of attic space.

FIGURE 5-31
Moisture from Within Structure

h. Use of nongalvanized ferrous nails which will eventually rust and loosen, allowing water to enter.

1. Painting plaster when still wet.

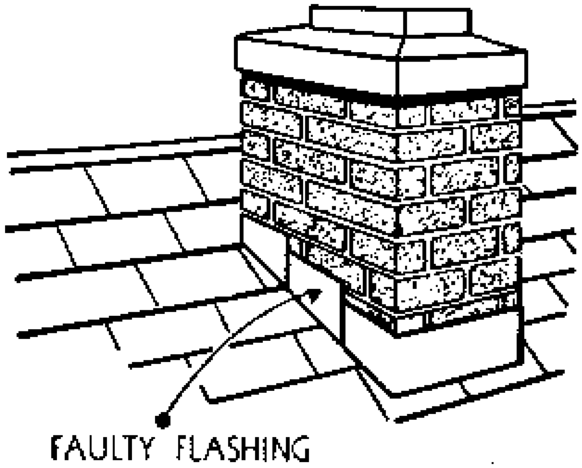


FIGURE 5-32
Faulty Flashing

j. Inadequate use of calking compound allowing rain to enter openings around windows and doors.

All of these defects either trap moisture in the walls, allow moisture to enter the walls, or trap moisture vapor which will condense on cold walls.

5.2.7.2 Moisture From Within The Structure. A major cause of excessive moisture is that developed in normal use by the occupants of the structure. There are a number of sources of such moisture. (See Figure 5-34.) They are as follows:

a. Normal Activities: Daily activities by and for the occupants of the structure can account for the following amount of moisture per person each day:

Breathing and perspiration	2 lbs
Cooking and dishwashing	1 lb
Clothes washing and drying	8 lbs
Showers--daily	1/2 lb

This adds up to a total of about 1 1/2 gallons of water developed per person per day without including moisture given off by heaters. It is important that venting be used for all equipment and that kitchens and shower rooms have exhaust fans which are kept in operation during use of facilities.

b. Humidity: The humidity within a structure should be kept fairly low especially during the cold weather when outside walls are cold. Otherwise, moisture will collect and eventually work its way into and through the walls unless the interior paint on the walls is impermeable. This usually is not a problem unless humidifiers are used with heating equipment. The following humidity levels should be the maximum within a structure for indoor air temperatures of 70° F.

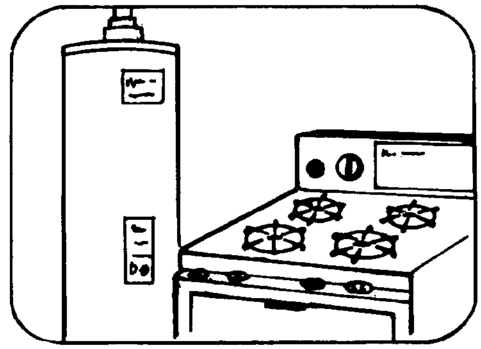
Outside temp.	°F		Inside Humidity (max.) (percent)
Below	-20	. . . .	15
-20 to	0	. . . .	20
0 to	20	. . . .	30
Above	20	. . . .	40

There are relatively low cost solutions to blistering and peeling problems if the moisture occurs by normal use and no structural defects are involved:

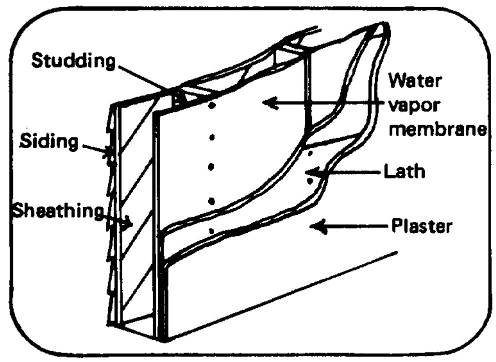
(1) Seal the inside surface of exterior walls with aluminum paint or enamel and apply breathing-type paints such as latex paints to the outside surface.

FIGURE 5-33
Moisture Peeling Caused by Contact with Ground

Gas heaters and stoves, without flues. Every thousand cubic feet of natural gas that is burned produces 10 gallons of water in the average six-room house where gas is used for heating and cooking. 16 to 20 barrels of water is thrown off in the form of vapor in a year. All this equipment should have flues to avoid the possibility of endless paint trouble.



The best way to keep water vapor from passing into the wall space is to install a vapor barrier inside the studding when the building is erected. Such a barrier formed of sheets of moistureproof material with watertight joints will stop water vapor from getting into the wall space.



Sometimes paint falls outside one room only usually the kitchen, laundry or bathroom where large amounts of steam are released into the air. Unless there is adequate ventilation to carry out the water vapor it will pass through the plaster and sweat out on theback of the siding.

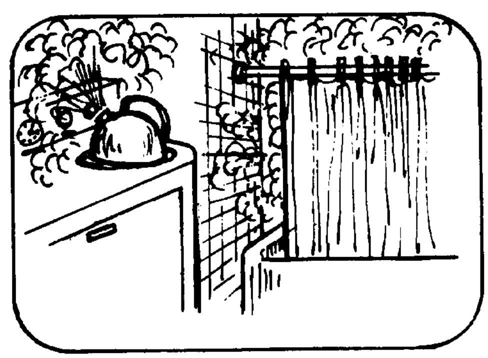
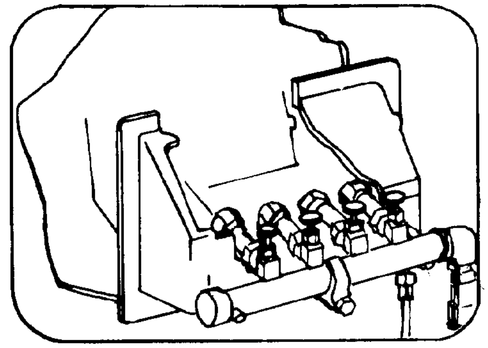
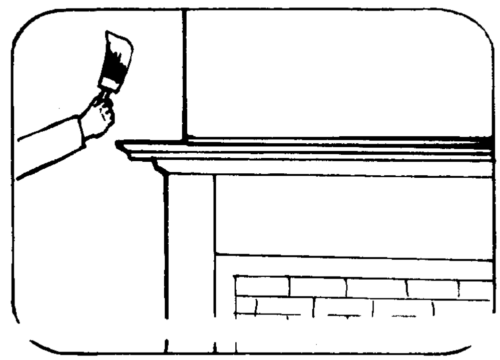


FIGURE 5-34
Moisture Problem Areas

Then there are the new type warm air heating systems, called forced draft or winter air conditioning. Their automatic humidifiers can throw off barrels and barrels of water during the winter months. Unless carefully regulated, that water vapor may quickly ruin the best outside paint job money can buy.



Many existing homes have no such protection. So for them two coats of Aluminum Paint, or one coat of Aluminum and two of high-grade enamel, are recommended on the plaster walls. Laboratory tests show that such a paint system as inside walls is 96 to 97 percent efficient in preventing moisture passage.



Excessive inside humidity in winter may cause blistering of exterior paints.

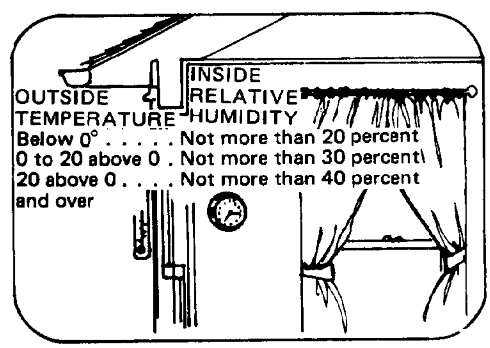


FIGURE 5-34 (Continued)
Moisture Problem Areas

(2) Vent the outside walls by the use of vents or wedges. (See Figure 5-35.)

5.2.7.3 Poor Maintenance. Structures not kept in good repair will eventually allow moisture to enter the walls and cause paint failure~. Some examples are as follows:

a. Leaking roofs caused by loosened, curled, or missing shingles

b. Plumbing leaks

c. Corroded flashing

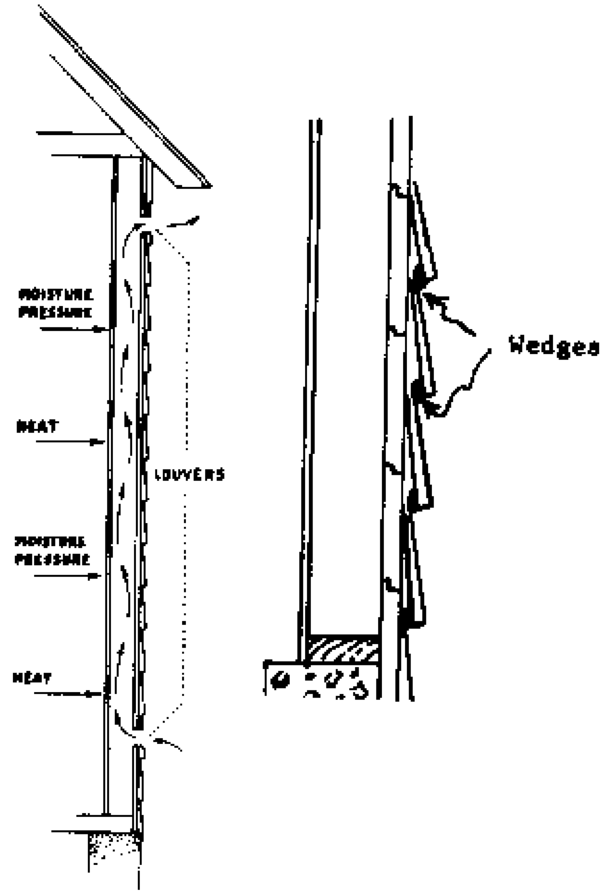
d. Broken, leaky, or clogged gutters and downspouts

e. Cracked or missing calking and glazing compound

f. Allowing water to collect in basements

g. Loose siding

All of these conditions must be corrected before painting is started.



To protect exterior walls from moisture that invades from the room side, good ventilation is necessary.

FIGURE 5-35
Venting Outside Walls