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TIMBER STORAGE CONDITIONS IN THE EASTERN AND SOUTHERN STATES WITH REFERENCE TO DECAY PROBLEMS.

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(In cooperation with the Forest Products Laboratory of the United States Forest Service, Madison, Wis.)

CONTENTS.

INTRODUCTION.

During the past few years a large number of requests for information on the control of decay in building and factory timbers have reached the United States Department of Agriculture. In many instances the cases reported have involved serious losses, often running into the thousands of dollars.

The rapidly rising interest in the question on the part of the public may be attributed to two general causes: (1) The greater publicity being given to this work in the Department of Agriculture, particularly through the activities of the Office of Investigations in Forest Pathology of the Bureau of Plant Industry and the Forest Products Laboratory of the Forest Service, and (2) the increasing use of timber less resistant to decay, which has become very marked during the past decade.

As a preliminary to an investigation into the prevalence of decay in building timbers, with the prime object of securing some basis for the effective control of such losses, a field study covering about seven months' active work was undertaken during 1914 to determine the conditions under which lumber and structural timbers are stored, for it is a well-known fact that timber infected with wood-destroying fungi during storage may be the direct cause of outbreaks of rot in buildings when such timber is placed in situations favorable to decay.

On account of the many failures in timber in important structures during recent years,[1] such an investigation is of the highest importance, both from the standpoint of owners and contractors and from that of the timber interests themselves.

The writer has encountered a number of instances where he was informed that wood has been replaced by steel or concrete for no other reason than the failure of locally available timber to withstand decay. An increasing use of these structural materials is bound to occur unless the lumber industry takes steps to improve the quality of its product for the North American market, and the first step in this process of regeneration lies in the better sanitation of lumber storage yards, so as to remove the danger of directly transferring fungous infections from the lumber dealer to the consumer.

During the course of this study a large number of sawmills and wholesale and retail lumberyards were visited in the eastern half of the United States. The region comprised 10 States along the Atlantic coast from Maine to Florida, all of the Gulf States, and the Central States of Arkansas, Iowa, Illinois, and Wisconsin. In addition to a personal inspection of the yards, much valuable information was obtained directly from the operators.

CAUSE OF DECAY IN TIMBER.

Decay in timber is almost exclusively due to the action of fungi, the greater part of the destruction being referable to one of the higher groups of these organisms, namely, the Hymenomycetes. In the life cycle of these fungi there are two distinct phases of development: (1) The vegetative stage (mycelium) and (2) the fruiting stage.

MYCELIUM.

The mycelium consists of microscopic threadlike filaments, usually branched, which penetrate the wood either by traversing the natural longitudinal passages, such as the pores, resin canals, or cell cavities, or by passing through the walls or through the pits in the walls of the wood fibers or tracheids (Pl. I, fig. 1). The mycelium also invades the pith rays, which contain a great abundance of food mate-

[1] In this connection, see the report by F. J. Hoxie, entitled "Dry Rot in Factory Timbers," 34 p., 19 fig., Boston, 1915, published by the Inspection Department of the Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

rials readily available to the fungus and whose walls are thinner than those of the wood fibers and hence more readily penetrated.

The growth of the mycelium is conditioned by four factors: (1) The presence of satisfactory food supplies, (2) a suitable amount of moisture in the wood, (3) a temperature favorable for growth, and (4) at least a small supply of air to furnish the necessary oxygen.

Food supplies.—The mycelium, being a living, growing plant, must have nourishment for growth, and so utilizes for this purpose various constituents of the wood substance. These consist of the different compounds which go to make up wood tissue, the celluloses and ligno-celluloses being utilized as well as sugars, starches, and certain organic acids. To break down the woody tissues, which are chemically very complex, and thus render them assimilable to the fungus, certain imperfectly understood chemical substances (enzyms or ferments) are secreted by the organism. These act upon the wood substance, reducing it to simpler nutritive compounds. A number of these ferments have been isolated and studied by various investigators and their physiological and chemical action determined. They are quite specific in their action; different substances which enter into the composition of wood require different ferments to disorganize them. In general, however, the wood-destroying fungi are well supplied with the ferments necessary to produce serious disintegration of most of the constituents of woody tissues.

Moisture.—A considerable amount of moisture is necessary for rapid decay. Timber in an air-dry condition during dry weather will not ordinarily be affected, but during periods of rainy weather, when the atmospheric humidity is high, fungous infections may become serious. In highly humid stagnant air a surface development of mycelium (Pl. I, fig. 2) is possible, but under conditions of free air circulation the surface is usually kept too dry for this to occur, although the interior of large timbers may still retain sufficient moisture for decay to progress within them.

Temperature.—Wood-destroying fungi can maintain themselves over rather wide ranges of temperature, but have an optimum for most rapid development within comparatively narrow limits. According to German investigations *Merulius lachrymans* (Wulf.) Fr. has an optimum between 65° and 72° F. (18° and 22° C.); *Coniophora cerebella* (Pers.) Schröt. (=*C. puteana* (Schum.) Fr.) between 72° and 79° F. (22° and 26° C.), and *Lenzites sepiaria* (Wulf.) Fr. between 82° and 90° F. (28° and 32° C.).

Growth below these points is often considerably retarded, while a rise of 4 to 8 degrees above the optimum often causes total inhibition of growth or even death, as in the case of *Merulius lachrymans*, which is very sensitive to temperature changes above the optimum.

Air.—Under ordinary conditions the air supply within and surrounding the timber is amply sufficient for decay. Fungi develop best in still air in closed spaces, but this is due to the greater humidity rather than to air requirements, for a good air circulation dries the timber to a point unfavorable to the development of the organisms.

In the case of timber thoroughly saturated with water, however, so that the cell cavities are filled with the liquid, decay is prevented entirely through lack of sufficient oxygen.

FRUITING BODIES.

Fruiting bodies are an expression of fungous activity within the wood. They form only after decay has well started. They appear at the surface in the form of single or imbricate shelves or brackets, leathery or waxy incrustations, or, in a few cases, as mushrooms (Pl. I, fig. 3) with central or eccentric stems bearing an expanded cap at the top.

The fruit bodies of the many fungi which cause decay in timber may vary in color from white through reds and yellows to dark brown or blackish. The consistency or texture is also highly variable, from fleshy to tough and leathery, and occasionally hard and woody. In some species the under side, or outer surface where the fungus is spread out as a crust (resupinate), is smooth (Stereum, Corticium, Peniophora, Coniophora (frequently warted)). In other cases, the under side, or the outer surface where resupinate, bears numerous pores (Polyporus, Poria (Pl. II, fig. 5), Merulius, Trametes, Daedalea, Fomes). Still other species have platelike gills on the under side (Schizophyllum, Lentinus, Lenzites). Occasionally, forms with distinct spines (Pl. I, fig. 4) or teeth are encountered (Hydnum). Various other species are illustrated in Plates III to X.

HOW WOOD-DESTROYING FUNGI SPREAD.

There are two general methods by which wood-destroying fungi spread from infected to sound timber: (1) By a direct overgrowth of mycelium from an infected stick to adjoining or near-by timber, and (2) by the blowing about of spores produced by the fruit bodies or by the mycelium.

Infections by mycelium.—In wholly or partially inclosed moist spaces, such as are often found in the basements of buildings, in mines, or beneath low, poorly ventilated lumber piles, the mycelium finds sufficient moisture in the air to allow it to develop on the surface of timbers, and in this way may progress along the timber for considerable distances. Such may be the case also where timber is close piled; the writer has records where severe infections have thus passed during rainy weather from the bottom upward through piles 12 to 15 feet high. In lumber storage sheds or in the base of close piles the mycelium of several species of fungi has frequently been observed developing in great abundance, not alone on the moist foundations and lower layers of lumber (Pl. II, fig. 1), but also spreading profusely on the soil (Pl. II, figs. 2 and 3).

With some species of wood-destroying fungi the mycelium within infected timber may remain alive for long periods, even under air-dry conditions, a fact which makes the use of infected timber in building operations a dangerous procedure. As an example, we have the experimental evidence advanced by Bayliss [1] that the mycelium of *Polystictus versicolor* in wood can survive a period of four years under the dry conditions of a herbarium.

Infections by spores.—The chief purpose of spore formation in fungi, just as in seed formation in ordinary green plants, is the perpetuation of the species through reproduction. Spores serve the two-fold purpose of tiding the fungus over unfavorable periods and of allowing its rapid spread under favorable growth conditions. Nature is lavish in her methods, and the number of spores produced is often enormous. For instance, Buller [2] computed from partial counts that each pore on the under side of *Polyporus squamosus* produced in the course of a few hours an average of 1,700,000 spores, or a total of over eleven billion for the entire under surface of a fruit body having an area of 250 square centimeters (38.75 sq. in.). When one recalls that spores are either constantly or intermittently produced by a single fruit body over a long period the further statement made by Buller that "the number of spores produced by a single fungus * * * in the course of a year may, therefore, be some fifty times the population of the globe" becomes intelligible.

At least two general types of spores are recognized for most wood-destroying fungi, the most easily observed being the basidiospores produced by the fruit bodies. These may frequently be seen en masse as a white or colored powdery deposit which has fallen from the sporophores (Pl. II, fig. 4). These spores are produced on short stalks at the ends of club-shaped cells which form a palisade layer (Pl. II, fig. 6) covering the under surface of the fruit body, or, in case the fruit body is of the incrusting type, covering its outer surface. When mature, the spores are cast off the basidia into the air and are blown about by the wind. When they lodge in a moist place favorable for growth they readily germinate and produce a new infection.

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[1] Bayliss, Jessie S. The biology of Polystictus versicolor (Fries). *In* Jour. Econ. Biol., v. 3, no. 1, p. 1–24, 2 pl. 1908.

[2] Buller, A. H. R. The biology of Polyporus squamosus Huds., a timber-destroying fungus. *In* Jour. Econ. Biol., v. 1, no. 3, p. 101–138, illus., pl. 5–19. 1906.

Both the fruit bodies and basidiospores vary greatly in vitality among the different species of fungi. External temperature and moisture conditions exert a great influence, particularly when the two are working together in an unfavorable rôle.

Low temperatures appear far less injurious than high temperatures. Buller and Cameron[1] report gathering living fruit bodies of *Schizophyllum commune* from a woodpile at Winnipeg, Canada, in March at a temperature of —17° C. (1° F.), after exposure for several months at winter temperatures ranging between —15° and —40° C. (5° and —40° F.). After thawing for a few hours the fruit bodies cast spores readily. They further report that immersing an active fruit body of the same fungus in water and placing it in the open over night at a minimum temperature of —31° C. (—24° F.) did not suffice to kill the organism, although it was frozen into a solid block of ice.

Carrying the work still farther, Buller[2] exposed fruit bodies of the same fungus (previously kept dry for two years and eight months in ordinary air) to the temperature of liquid air, —190° C. (—310° F.), for three weeks in a vacuum tube. Upon removal and moistening, the fruit bodies were still alive and cast spores in abundance.

In his larger work[3] and certain later articles, the same author shows that at ordinary temperatures dried fruit bodies retain their capacity to produce spores for long periods; for instance, *Daedalea unicolor* can remain alive in the dark at least 8¼ years and *Schizophyllum commune* at least 6¼ years. Certain others may retain their vitality for only two or three years.

In the case of temperatures above the optimum, however, the injurious effect may become marked within a comparatively small range. For instance, Falck[4] states that fruit bodies of *Lenzites abietina* fail to produce spores after five days at 26° (78° F.) and the spores fail to germinate at 42° C. (108° F.). A corresponding relation is also said to exist with *Merulius lachrymans* and other species, for the same author[5] states that fresh fruit bodies of *Merulius domesticus* (=*M. lachrymans* in part) are killed in 30 minutes at 40° to 42° (104° to 108° F.) and in 15 minutes at 46° C. (115° F.); at 42° C. (108° F.) dry spores are killed in 12 to 16 hours.

In addition to spores produced in fruit bodies, another set of reproductive bodies is often produced directly by the mycelium.

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[1] Buller, A. H. R., and Cameron, A. T. On the temporary suspension of vitality in the fruit bodies of certain Hymenomycetes. *In* Proc. and Trans. Roy. Soc. Canada, s. 3, v. 6, 1912, sec. 4, p. 73–78. 1913.

[2] Buller, A. H. R. Upon the retention of vitality by dried fruit bodies of certain Hymenomycetes, including an account of an experiment with liquid air. *In* Brit. Mycol. Soc. Trans., v. 4, 1912, pt. 1, p. 106–112. 1913.

[3] Buller, A. H. R. Researches on Fungi . . . 287 p., illus., 5 fold. pl. London, 1909.

[4] Falck, Richard. Die Lenzites-Fäule des Coniferenholzes. *In* Möller, Alfred. Hausschwammforschungen. Heft 3, p. 69 and 98. 1909.

[5] Falck, Richard. Die Merulius-Fäule des Bauholzes. *In* Möller, Alfred. Hausschwammforschungen. Heft 6, p. 339. 1912.

These bodies may be borne on short stalks on the mycelial threads (conidia), or the mycelium itself may break up into short cells (oidia), or specialized thick-walled cells (chlamydospores) may form within the mycelium. The last kind of spore, on account of its thicker wall, is adapted to withstand unfavorable weather conditions; the two former kinds are usually thin walled, minute, and readily blown about by the wind.

With these fundamental facts in mind, let us now turn to a discussion of the present conditions under which timber is stored and see wherein these conditions contravene the known facts regarding the development and spread of decay-producing fungi.

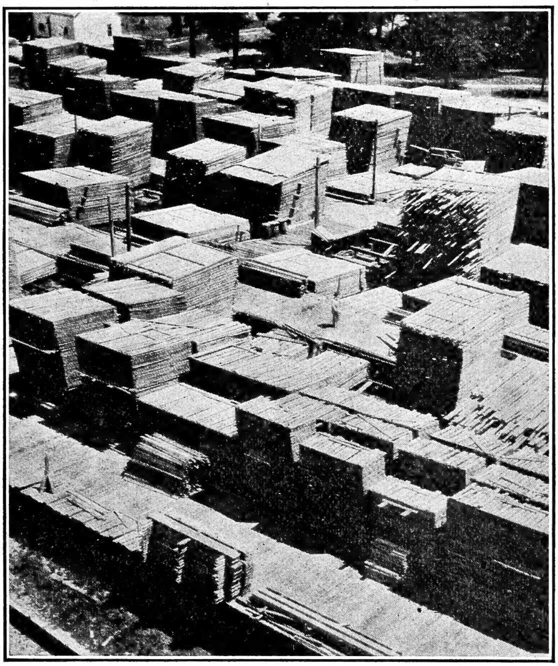

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Fig. 1.—Bird's-eye view of a clean lumber-mill yard in Arkansas, showing the usual method of open storage.

HANDLING TIMBER AT SAWMILLS.

The practice at different sawmills varies widely. A few of the larger mills, particularly in the longleaf-pine belt, put almost their entire cut through the dry kiln and then store it under closed sheds. This practice is to be highly commended, and if the storage sheds are well drained and properly ventilated beneath, no trouble from fungi should be experienced.

However, comparatively few mills have the facilities for handling their product in this approved fashion, and the great majority have kiln capacity for only the B and better grades of lumber. The remainder of the output is piled in the open yard (fig. 1), the higher grades of lumber often being dipped in sodium bicarbonate or sodium carbonate to prevent blue stain.

Some few mills of the poorer class and smaller type dispense with both kiln drying and dipping and pile their entire green stock in the open yard. The few mills of this type which the writer has visited are usually also very lax in their methods of piling and of yard sanitation.

LOCATION OF MILLS AND ITS RELATION TO DECAY.

The location of sawmills is usually determined by certain economic considerations which do not readily admit of change. Many of the mills are located either on streams or along the low and swampy Atlantic or Gulf coasts. Very often higher dry land is not available for storage purposes and then, particularly in the South, the conditions for decay are excellent. In some instances attempts have been made to fill in this low land with sawdust, bark débris, etc., with the result that the soil is made over into a most excellent culture medium for the development of wood-destroying fungi. In other cases yards, even when on comparatively high ground, are so graded as to allow drainage into the yard rather than away from it.

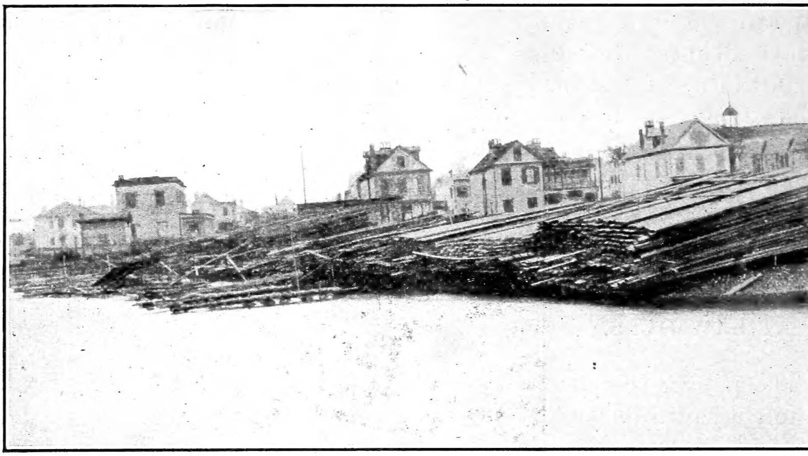

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FIG. 2.—Lumber piled at the water's edge on the Atlantic coast. High waves sweep over this during storms, wetting the lumber and producing rot.

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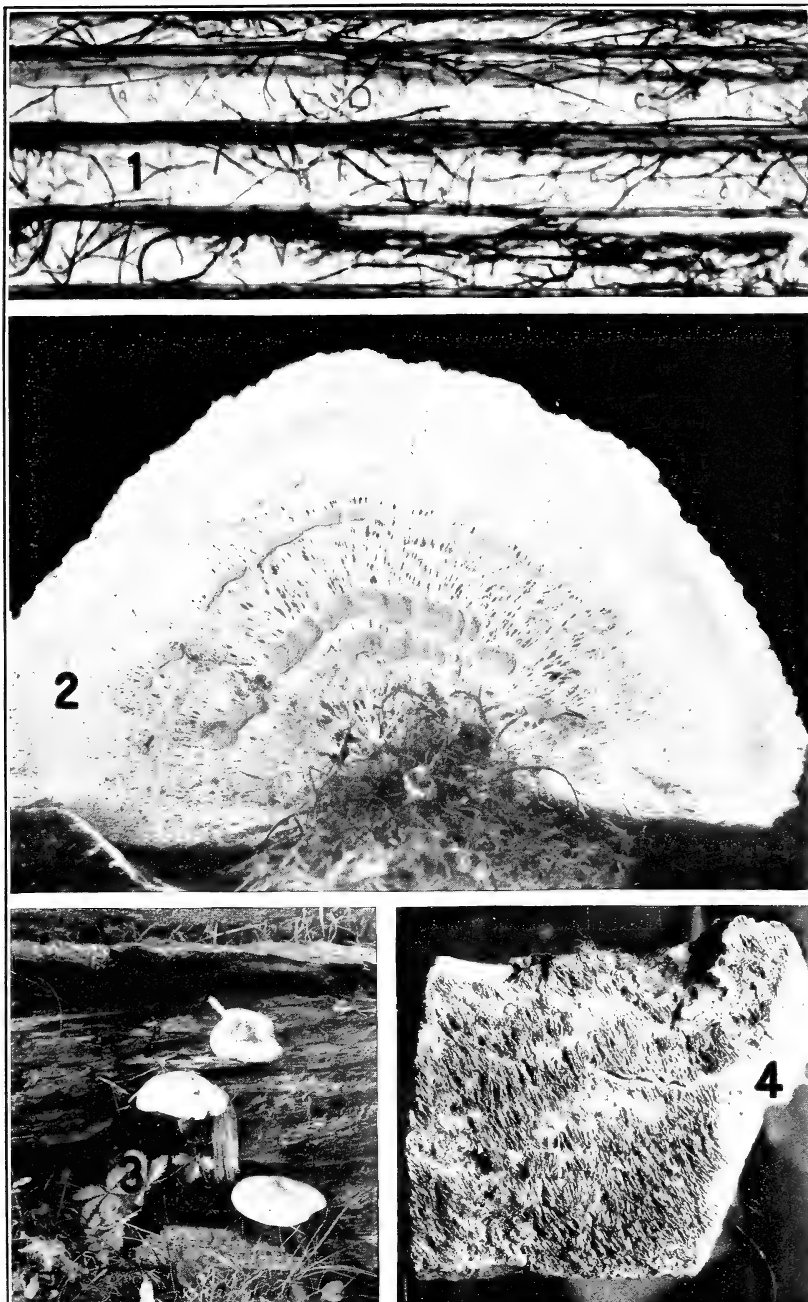
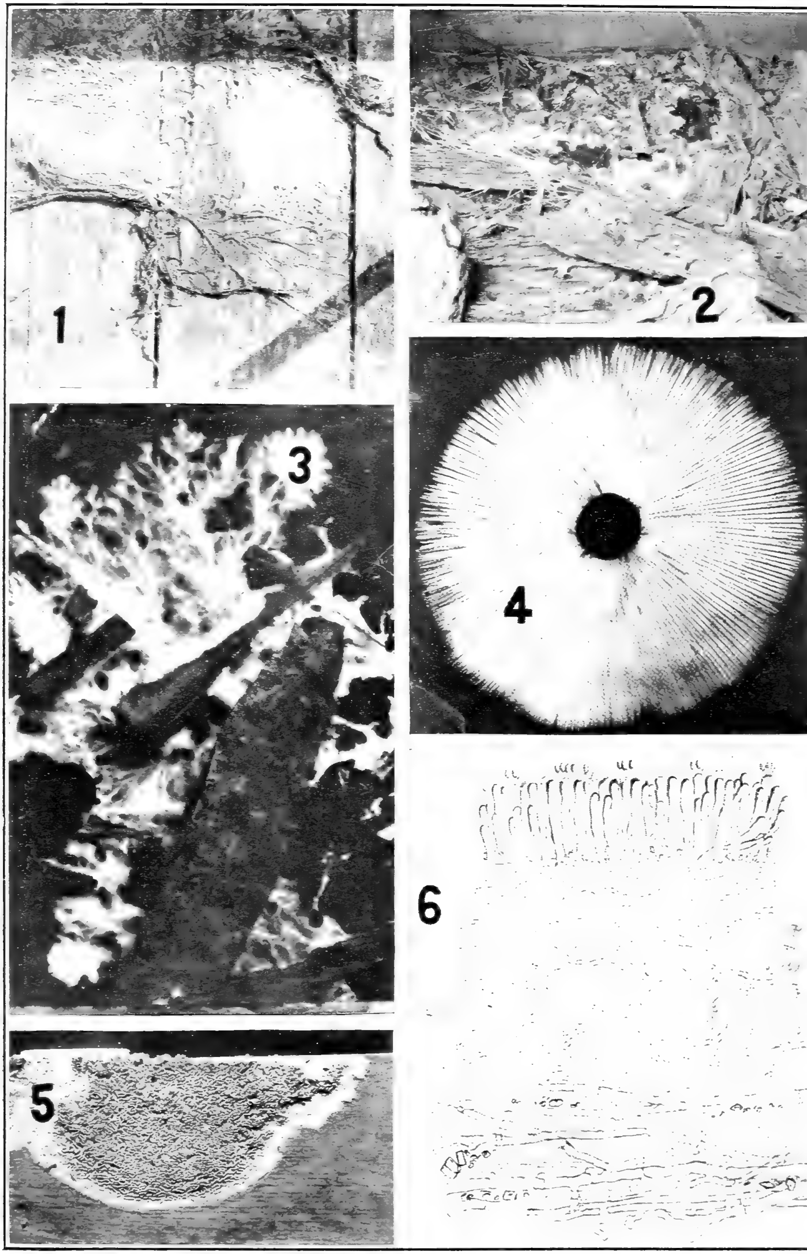
FIG. 3.—Silt deposited in the base of a lumber stack during a Mississippi River flood. This condition permits the lumber to rot rapidly.

In the coastal regions, where mills are at times located just above the level of high tide, storm waves frequently beat in from the sea



LUMBER SANITATION: WOOD-ROTTING FUNGI.—I.

FIG. 1.—Thin section of "red-heart" pine, showing fungous threads and holes where these have bored through the walls of the wood cells. FIG. 2.—Mycelium on a board from a clay mine, Joplin, Mo. FIG. 3.—The mushroom *Pluteus cervinus* on a rotten log. FIG. 4.—A species of Hydnum.



LUMBER SANITATION: WOOD-ROTTING FUNGI.—II.

FIG. 1.—Strands of mycelium of the "dry-rot" fungus, *Merulius lachrymans*, on the face of pine planks in a lumber pile at Portland, Me. (the fungus has progressed to a height of six layers or more). FIG. 2.—The same fungus on the ground and in litter beneath an open storage shed, Philadelphia, Pa. FIG. 3.—Mycelium of a white Poria on the ground and on wood fragments beneath a cotton mill, Adams, Mass. FIG. 4.—Powdery deposit of spores cast by a mushroom over night (after Atkinson). FIG. 5.—A species of Poria from a porch ceiling, Madison, Wis. FIG. 6.—Thin section of an encrusting fruit body of *Merulius lachrymans*, showing palisade layer of basidia bearing spores (after Falck).

and sweep over the lumber, wetting it and depositing silt over great quantities of the stock (fig. 2). The writer has seen instances along the Atlantic seaboard where lumber stacks at least 12 feet high were thus silted completely to the top. A somewhat similar condition exists along certain rivers during times of flood (fig. 3).

Where it is necessary to store lumber upon low swampy ground (figs. 4 and 5), the weed problem also becomes a serious factor. In the first place the growth of vegetation is so luxuriant as to require constant attention, and in the second place the ground is not even or firm enough to allow convenient mowing. The result is that sometimes the weeds are allowed to develop above the height of the foundations, thus cutting off air circulation beneath the piles and hence increasing the danger from fungi many fold.

P66F

FIG. 4.—Lumber piled on low swampy land at a Texas sawmill. The serious decay in this yard is due to the excess of soil moisture and poor circulation beneath the stacks.

QUALITY OF STOCK WITH REFERENCE TO DECAY.

The fact that American mills are utilizing their timber to a smaller size than formerly throws a greater quantity of the inferior grades upon the storage yards. Rapid deterioration in this low-grade stock may result unless it be carefully handled. In the case of many yellow-pine structural timbers it is a matter of common observation that the quality is growing decidedly poor, this being in large part due to the fact that small second-growth trees are being logged and cut into dimension sizes. In the shortleaf-pine business, in particular, a single mill rarely attempts to cut both board and dimension stock. As a rule, it is said to be more profitable to cut the better grade larger shortleaf and loblolly trees into 1 and 2 inch stock. Hence, for structural sizes the trade largely depends on certain timber mills, as well as a multitude of small portable mills operating in young second-growth timber. The storage of these less durable grades at times becomes a considerable problem, not alone at the mills but also in the retail yards. In fact, the writer has been told by certain retailers that deterioration due to decay in these low grades had become so serious with them that they had discontinued carrying such hazardous stock.

In the case of hemlock, spruces, firs, low grades of pine, and certain of the less durable hardwoods, storage difficulties are bound to develop at times during exceptionally wet seasons, but much of the trouble can be forestalled by applying the proper methods of sanitation.

P67F

FIG. 5.—Pine lumber piled in a swamp on high skids over standing water at New Orleans, La. Note the luxuriant vegetation, which checks proper air circulation beneath the piles.

It is necessary that if such material is to enter into the construction of buildings it should be entirely free from fungous infection. Responsibility for clean lumber must rest with the lumberman.

CONDITION OF STORAGE SHEDS AT MILLS.

As noted before, many mills, including some of the larger ones, are operating under serious disadvantages of location as far as decay is concerned. The better types of storage sheds are inclosed at the sides, with ample ventilation beneath (fig. 6), but those open on both sides are not uncommonly met with. The exclusion of water from stored lumber becomes a necessity when such material is put in close piles under cover, where the drying action of wind and sun does not have full play. This is particularly true where sheds are built over low swampy ground where the vapors on rising from the wet soil are more or less imprisoned, keeping the air at a high humidity. A little extra moisture in such cases may be sufficient to permit the outbreak and rapid spread of fungous infections.

The greatest source of danger in storage sheds lies in placing the lumber too close to the ground, and several instances have been noted where widespread infections of some of the worst building fungi in the country have been prevalent in the foundation timbers and stored lumber in contact with them (Pl. X, figs. 1 and 3). Many of the sheds over low ground have drainage canals beneath to carry away excess water, and in some instances, where the pitch of the ground is not sufficient, stagnant water may accumulate over long periods. This may cause high humidities, approaching saturation, which permit the white cottony mycelium of wood-destroying fungi to develop rapidly over the surface of the timber. In general, it has been the experience of the writer that moisture conditions around the foundations of storage sheds are often very favorable to decay.

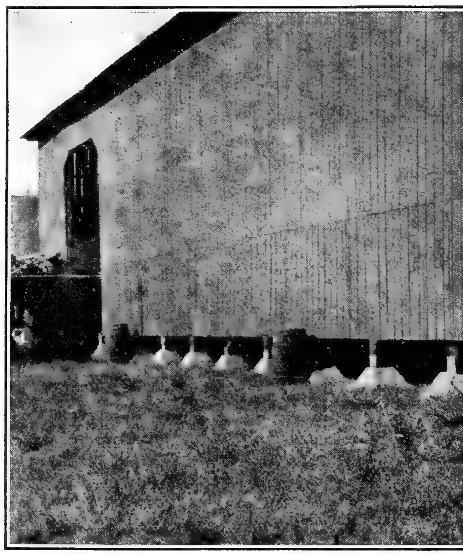


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FIG. 6.—Large storage shed at Laurel, Miss., set on concrete piers, high off the ground, with ample ventilation from all sides. This is the best type of construction.

Leaky roofs at times become a source of trouble. A few instances have come to the writer's attention where comparatively small leaks have caused a considerable amount of visible, material decay in the upper parts of lumber piles. However, when we realize that in many cases the infection, on account of the short time in storage, does not have the opportunity to cause marked deterioration, but still is present in an incipient stage ready to progress farther when placed under moist conditions, we can readily see the serious consequences which may ultimately accrue.

CONDITION OF STORAGE YARDS AT MILLS.

GENERAL SANITATION.

The vital necessity, viewed from the standpoint of decay, for absolute cleanliness around lumberyards is perhaps not fully appreciated by most lumbermen. The question of fire hazard, however, has led most mills to take certain steps in this direction which are of very great importance. These steps have usually assumed the form of keeping grass and weeds down, particularly in the dry season, and of removing rotten débris to a considerable extent.

A broad survey of the lumber industry shows some instances where absolutely no attention is given to yard sanitation (fig. 7) and also a few other instances where the yards are sodded and handled like a well-kept lawn (fig. 8). The great majority, however, fall between these extremes. As a rule, grass and weeds are kept under fairly good control either by mowing or by pasturing. In most instances some rotting débris is scattered about. The factor of location often plays an important part in sanitation, for on swampy land the lessened fire danger tends to encourage carelessness.

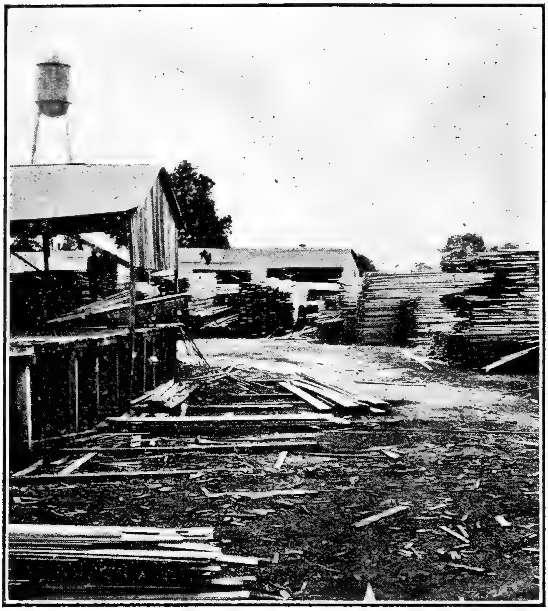

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FIG. 7.—A small, very insanitary mill in Louisiana. The conditions at this mill are a disgrace to the lumber industry. Note the rotten, dilapidated tramway, the lumber stacks placed within 2 to 4 inches of the ground, and the débris scattered about and breeding infection.

Any decaying timber which has been allowed to accumulate about the yards should be collected and burned. The mere carting of such débris to a convenient near-by pile (Pl. III, fig. 1; text fig. 9) is not sufficient, for the fungi will continue to thrive in such material for long periods and to produce fruit bodies which will liberate millions upon millions of spores into

P73F

FIG. 8.—The well-kept grounds of a high-class longleaf-pine mill in Louisiana. Practically all the lumber is run through the dry kiln and stored in large sheds, thus eliminating the problem of storage rots.

the air to infect whatever sound lumber may be in the vicinity. The writer has seen scores of instances where small piles of rotting débris have been scattered about lumberyards and even at times piled directly against sound lumber (fig. 10). Very frequently this débris consists of old ties (fig. 11) or timbers from the tramway platforms. In other cases it may be yard stock which has rotted in storage and has been left in situ or carted a few rods and discarded just beyond the confines of the yard. One such mill yard was visited where several hundred thousand feet of pine and hardwood lumber had been thrown into an adjoining rice swamp in close proximity to and extending for nearly a mile along a row of lumber stacks (see fig. 9). In this same yard it was also commonly noted that sound lumber fresh from the saw was piled upon the bases of old lumber piles which were thoroughly rotted (fig. 12).

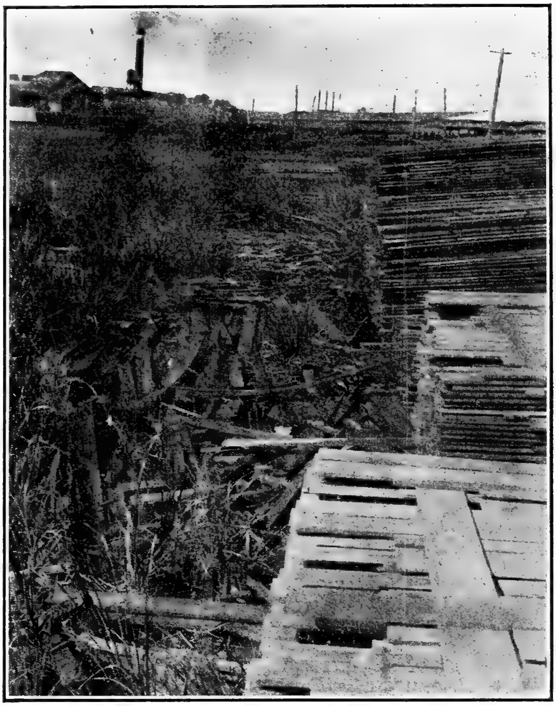

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FIG. 9.—Pine and hardwood lumber which has rotted in storage in the yard shown in figure 11. Instead of burning the débris it was thrown into an adjoining rice swamp. Fungi developing on this débris will again infect the sound lumber.

Also in this yard, as well as in a yard in Mississippi, vines were allowed to grow up over some of the lumber piles (fig. 13). This is, of course, highly objectionable, since such vegetation tends to collect moisture and impedes ventilation.

Such conditions as these are bound to be a serious menace to the effective storage of lumber.

TRAMWAYS AND RAILWAYS.

Practically all sawmills have a more or less extensive tramway or railway system for the distribution of lumber from the mill to the yard and other units of the plant (fig. 14). It is quite the universal condition that these structures harbor multitudes of various wood-rotting fungi, which cast off innumerable viable spores to be carried about by air currents to sound lumber. The elevated position of these fruit bodies on high tramways gives much greater facility to the wide distribution of their spores.

Since the tramways require large amounts of timber in their construction, the use of wood preservatives in protecting them from decay is worth careful consideration. This would effect a direct saving both by prolonging the life of the timber and by preventing the development of the fungous fruit bodies.

Fig. 10.—Partially rotted hardwood boards piled against a lumber stack. Infection will spread by contact to the sound lumber.

In only one part of the tramway structure is decay secondary to other deteriorating factors, and this is in the planking. Where the trucks or "buggies" operate constantly, the wear at the center very often nicely balances the decay at the ends, but even here, from the standpoint of sanitation alone, a light preservative treatment sufficient to immunize the timber so that fungous fruit bodies can not develop is strongly recommended.

The initial cost of constructing extensive tramways from 10 to 25 feet high reaches a considerable figure, even at the actual mill cost of the timber. In the upkeep of these structures replacements are necessary as rapidly as the timbers fail, the resulting maintenance charges being a considerable item of expense. In none of the mills visited had thorough wood preservative treatments been applied. Partial attempts were noted in several instances, where brush treatments, usually of some patented coal-tar compound, had been applied at the joints. Ordinarily it is the more widely advertised trade products which reach the attention of millmen. The cheaper preservatives appear to be little known. In the opinion of the writer, thorough preservative treatments would effect an ultimate saving in maintenance charges, a considerable part of the cost of application being offset by the use of cheaper grades of timber, which when treated properly will last longer than the highest grade of natural wood available.

In very few lumberyards are the railway ties preserved in any way. In most cases they consist of inferior timber which readily decays. Many fruit bodies of dangerous fungi are usually present (Pl. III, fig. 2), so that it is important from the standpoint of sanitation to remove this source of infection by the application of wood preservatives, such as creosote or zinc chlorid. A track in which the ties are creosoted is shown in figure 15.

P76F

FIG. 11.—A highly insanitary mill yard in South Carolina. Hundreds of thousands of feet of stored lumber have rotted in this yard as a result of these conditions. All this rotten débris should be removed and burned.

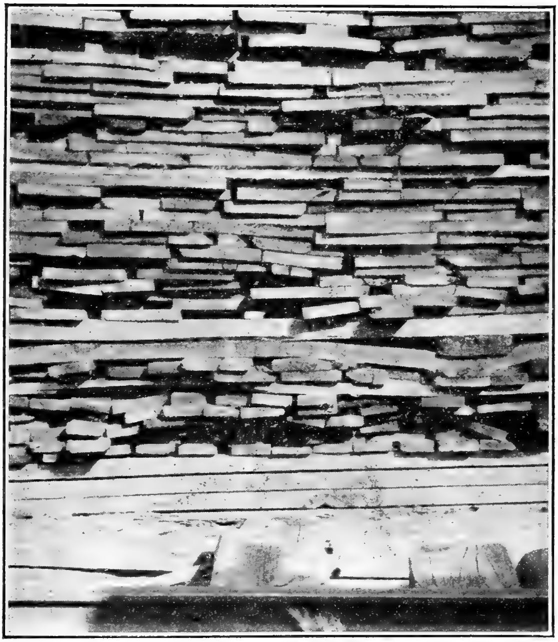
FOUNDATIONS.

Probably no other factor involved in the storage of lumber in yards is open to more criticism from the sanitation standpoint than the foundations to the piles (figs. 16 and 34). Almost invariably these timbers are severely infected and often abundantly supplied with sporulating fruit bodies of serious wood-rotting fungi (Pl. III, figs. 3 and 4).

Various types of foundations are in use. The most primitive and most insanitary type consists in laying planks directly on the ground and stacking the lumber upon them. This procedure occurs at only a few of the smaller mills. A few of the mills make use of built-up plank foundations (Pl. III, fig. 3), but the more usual method is to use 6 by 8 or 8 by 10 stringers, blocked up to a height of

1 to 2 feet (fig. 16) or set on short posts. A few of the best mills make use of concrete piers for this purpose. The latter type of foundation would be greatly improved by the use of stringers treated with a wood preservative.

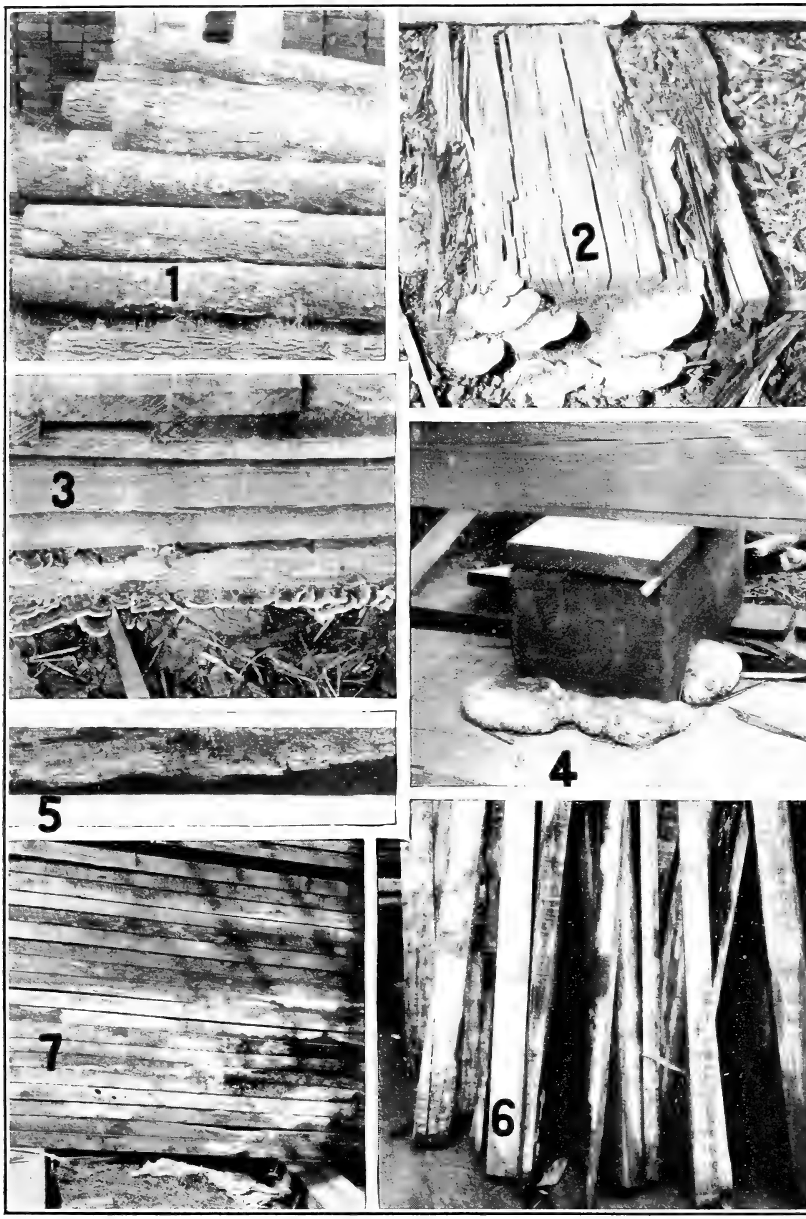
The dangers arising from partially rotted foundations are evident, as has been seen from the earlier discussion of the activities of wood-destroying fungi. Where wood blocks are used to support the skids, fungi often progress directly from the moist soil upward, in this way frequently infecting the skids, thus adding the possibility of direct mycelial infection to that of spore infection. The infected skids themselves are dangerous, since the fungous mycelium can progress directly from them to the bottom of the lumber piles (Pl. IV, fig. 3; text fig. 17). Once started, and the weather conditions being warm and moist, such infections may pass through an entire stack. In considering the menace of infected skids, we must also not lose sight of the fact that such timbers are a prolific source of fruit bodies (Pl. III, fig. 3) with their many spores, to be borne up into the lumber piles either directly by the wind or by convection currents which occur in relatively still air. The proof of this latter form of air currents is often before us in the form of rising mists or fogs.



P77F

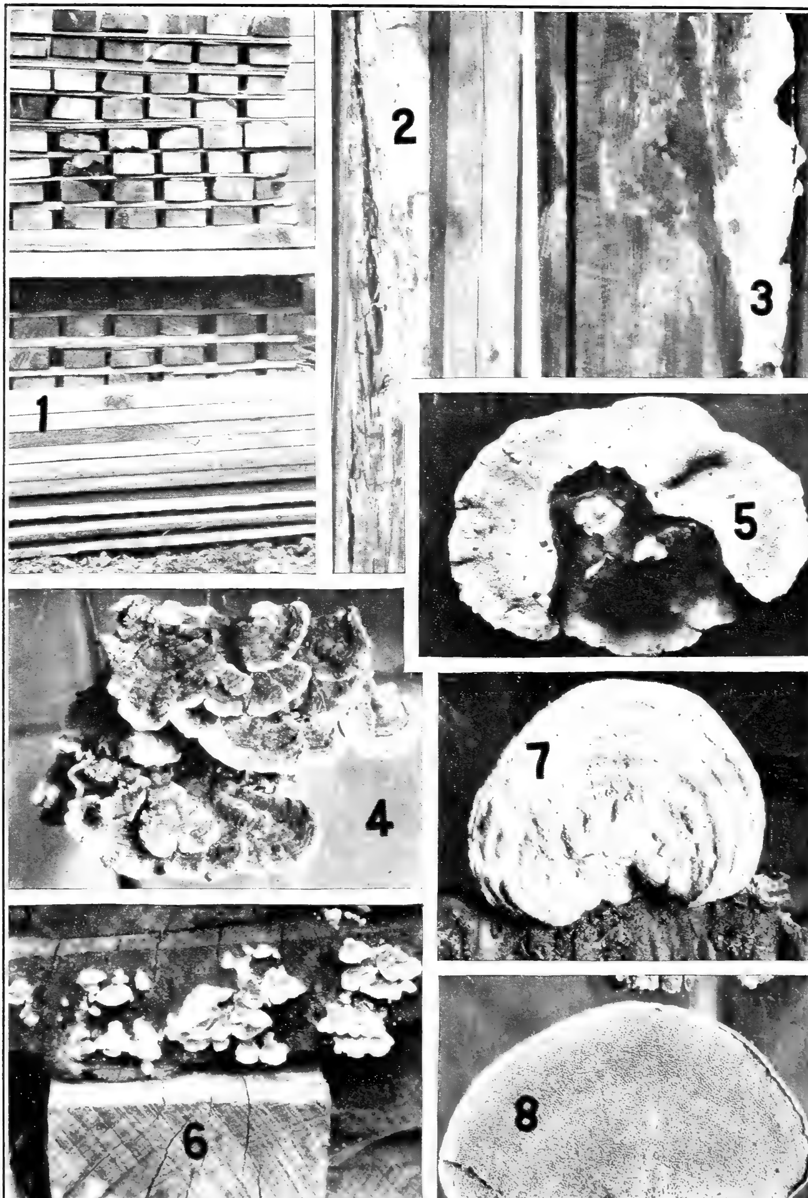
FIG. 12.—Rotten base of an old hardwood stack upon which sound lumber has been piled. This is a most insanitary practice, as fungous infection will be spread both by the contact of the diseased with the sound lumber and indirectly by the production of fruit bodies and spores, the latter blowing about, reaching sound material, and germinating to produce new infections.

The first requisite in building foundations is to get them well off the ground, so as to allow ample ventilation beneath, which will dry out the timbers themselves as well as the soil below. A height of at least 24 inches from the top of the skids to the surface of the ground should be adhered to.



LUMBER SANITATION: WOOD-ROTTING FUNGI.—III.

FIG. 1.—A pile of rejected hardwood logs which should have been removed or destroyed and not left to breed fungi (fruit bodies of 6 or 7 different organisms were identified from this pile). FIG. 2.—*Lenzites berkeleyi* fruiting on a hardwood tie. FIG. 3.—Hardwood pile foundations severely infected with *Polystictus versicolor*. FIG. 4.—*Daedalea quercina* fruiting around a foundation block in a Pennsylvania storage yard. FIG. 5.—A badly infected piling stick in use at a Florida mill. FIG. 6.—A group of infected piling sticks at a Tennessee hardwood mill. FIG. 7.—Pile of 3-inch hard pine planks badly infected with *Peniophora gigantea* (a very common condition at Portland, Me.; the fungus is introduced from the South and develops rapidly in close piles).



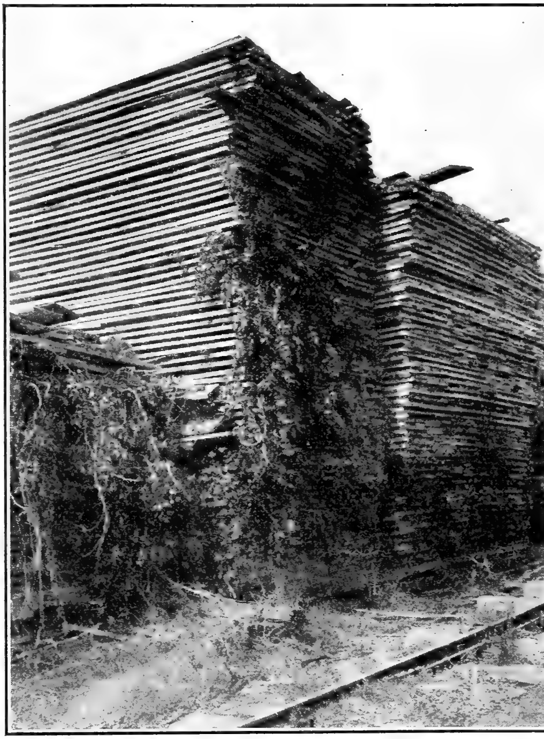
LUMBER SANITATION: WOOD-ROTTING FUNGI.—IV.

FIG. 1.—Shortleaf pine which has rotted during 10 months' storage in a retail yard at New Orleans. FIG. 2.—A structural pine timber which lay on the ground until severely rotted and was then thrown up into a pile of sound lumber. FIG. 3.—Mycelium of a wood-destroying fungus on the face of pine boards just uncovered in breaking down a pile (at a height of 6 to 8 boards from the bottom, but probably has gone much higher). FIGS. 4 to 6.—*Polystictus versicolor:* 4, Upper surface; 5, lower surface; 6, plant growing on the end of a hardwood board in a lumber pile. FIGS. 7 and 8.—*Polystictus hirsutus:* 7, Upper surface; 8, lower surface.

The use of untreated wood blocking, particularly on low, moist ground, should be discouraged, as such material invariably harbors fungi.

The most desirable practice, and one which would be free from all objections, is the use of concrete or brick piers, preferably the former, and skid timbers treated with some preservative. Such skids, about 24 inches high, treated with creosote, are now in use at the Forest Products Laboratory (fig. 18).

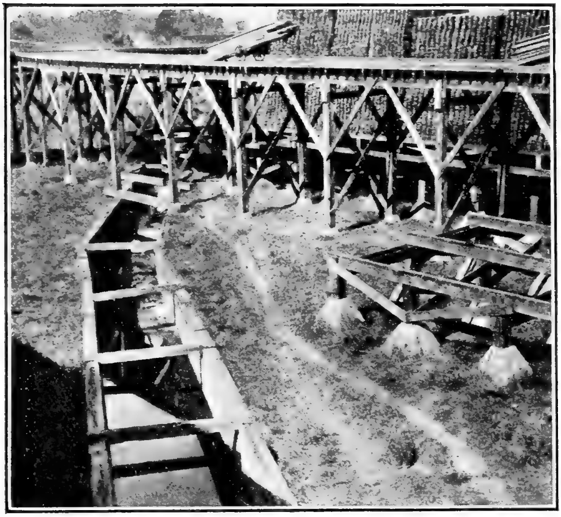
Foundations with concrete piers and untreated skids are at present in use in a number of yards and have given entire satisfaction. At one Mississippi mill (figs. 14 and 19) unfavorable conditions of low ground have been mainly overcome by good drainage, careful attention to the removal of débris, and the use of concrete foundations well off the ground. A description of the foundations and their cost may be of interest.



P78F

FIG. 13.—Vines growing over lumber piles. From a pathological standpoint this condition should be condemned, because the dense foliage prevents the lumber from rapidly drying out after rains, thus promoting decay.

The foundations were placed and the tramways rebuilt between 1908 and 1910, after a number of years of unsatisfactory experience with wood, at a reported cost of about $30,000 for a mill having an annual cut around 60,000,000 feet of pine a year. In the two years preceding the placing of the concrete foundations and the rebuilding of the tramways, the annual charge for material and labor in the upkeep of the yard was $18,000 and $17,000, respectively. Following the equipment of the yard with concrete foundation piers and concrete footings for the tramway posts, this charge was materially reduced. The present maintenance cost as reported by the company,



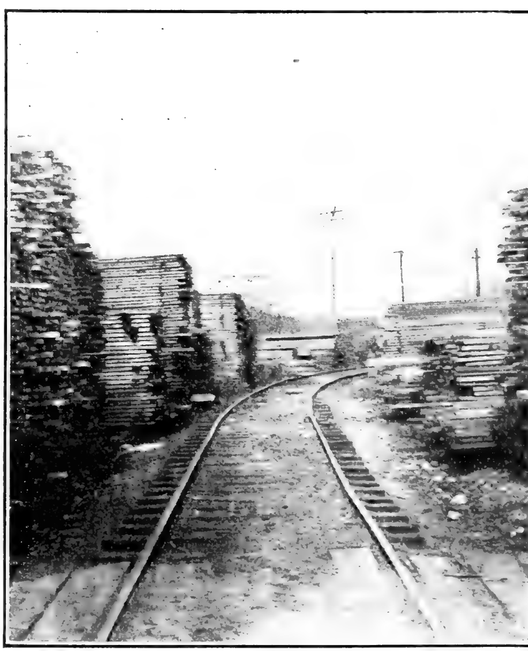
P79F

FIG. 14.—General view of a mill yard in Mississippi, showing concrete pile foundations and tramway footings. The ditch assists materially in draining the yard. No débris is allowed to accumulate. The stacks are high off the ground and amply ventilated beneath. The tramway and pile foundation timbers would be improved by a preservative treatment with creosote.

based on a consumption of 600,000 feet of timber a year at a value of $12 per 1,000 feet b. m., is $7,200, or 12 cents per thousand of mill cut. The timber used consists of pine heart seconds having an average life of 5 to 6 years and a maximum life of 8 to 10 years for material not in contact with the ground; pile foundations and tramway footings average 4 to 5 years.

In addition to the direct saving in maintenance charges, we must also keep in mind the advantage gained in preventing deterioration in the stored lumber itself, due to improved sanitation. While this item is very difficult to estimate, the company believes it a very appreciable asset of its storage practice.

The approved type of concrete foundation pier now in use by this company is of the form illustrated in figure 20, consisting of a base block 3 feet square, tapering upward and cast in position. Upon this base block is cast the top block, 2 feet square and also taper-



P135F

FIG. 15.—A clean, sanitary retail yard, having concrete foundations throughout and creosoted ties in the railroad track.

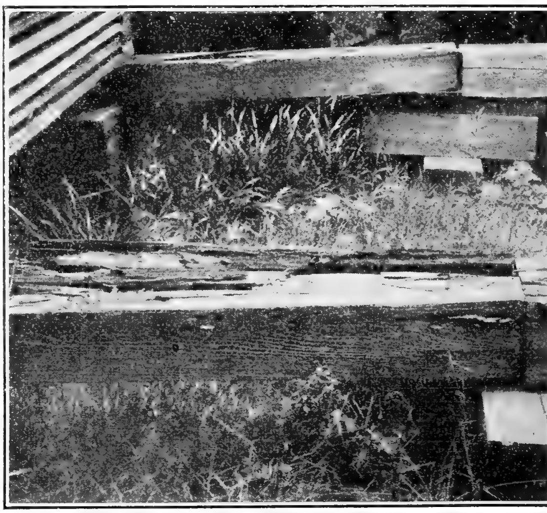
ing upward, being 1 foot square at the top, which gives a good bearing surface for the horizontal wooden skids or for the vertical posts where it is necessary to elevate the skids to a height consistent with the height of the tramways.

A concrete mixture of 1–2½–5 is used, at a cost for labor and material of $5 per cubic yard, or an average cost of about $5 per pier.

The foundations follow the slightly varying contour of the ground. To compensate for the more marked differences in soil elevation the skid timbers are frequently blocked up to an approximately level condition by the use of short sections of pine posts treated at the ends with a tar or cresote preparation.

There are two advantages in casting the piers in two pieces: (1) The reduction in weight of the individual blocks when it becomes necessary to shift them about the yard, and (2) the greater ease of alignment when erecting the skids.

All the skids are well off the ground at heights never less than 18 to 24 inches and frequently 36 inches and over. The lumber is not piled directly on the wooden skid timbers, but rests on a 1-inch pine strip, usually about 3 inches wide, to give a smaller bearing surface. This method is not uncommonly employed in various yards. It is of distinct advantage where lumber is piled on infected skids, and if the dry strips are freshly laid for each pile they materially assist in reducing infections in the base of the stack.

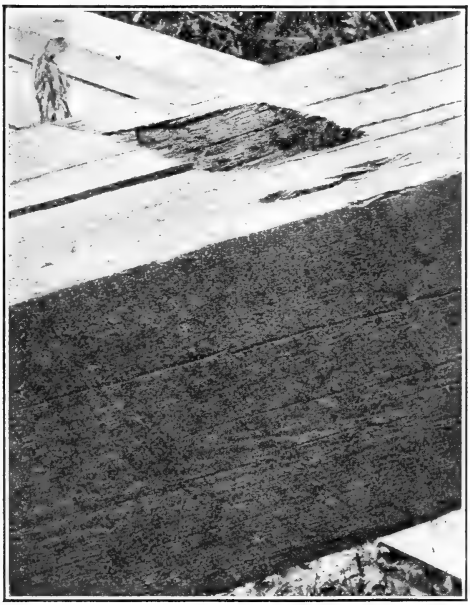


P80F

FIG. 16.—Thoroughly rotted pine skids in a mill yard in Texas. Such decayed foundation timbers are very common. Fungous infection can pass directly from these timbers to the lumber piled on them. Creosote would have prevented this condition.

In direct contrast to these concrete foundations with ample ventilation beneath, one frequently meets with the type illustrated in figure 21. The one figured is built of 2-inch pecky cypress planks about 14 feet long, resting directly on the ground. The amount of lumber used was computed for one of the squares and totaled approximately 585 feet b. m. While pecky cypress is often used in the South for foundations of this type, in many other cases either nondurable hardwoods or the cheaper grades of pine are used. Decay is often serious in such foundations. There is very little chance for ventilation, and this often leads to storage rots in the base of the piles.

The open type of foundation is always much the better from a pathological standpoint. In certain of the Gulf cities, where municipalities in cooperation with the United States Public Health Service are making strong efforts to get rid of rats to safeguard against the bubonic plague, certain ordinances have been passed requiring structures to be raised at least 12 inches from the ground and left open beneath. This requirement will react very favorably upon lumber storage, for the first necessity is to get the timber off the ground, with ample ventilation beneath. Figure 22 illustrates the method of elevating the skids employed in a retail lumberyard at Mobile, Ala., which has only recently occupied the premises.



P81F

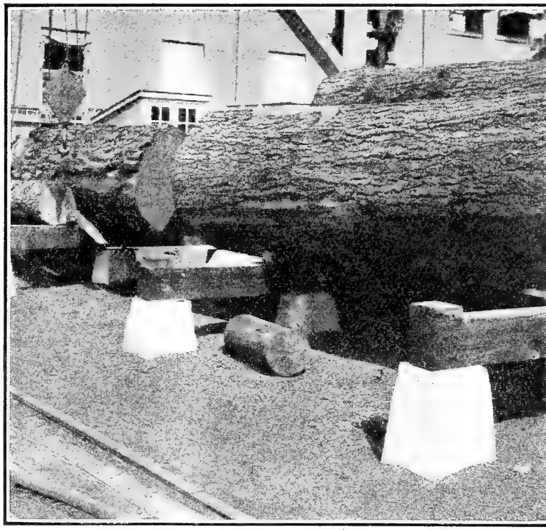
FIG. 17.—A 12 by 12 inch hard-pine timber, showing a rotten hole in the face which lay in contact with infected skids.

Timber foundations are frequently the cause of considerable trouble on account of decay failure under heavy loads, thus allowing the piles to topple over or to crush to the ground, where they have every opportunity to rot. Figure 23 shows two such piles at a South Carolina mill. Rot in foundation timbers is extremely common and, in fact, has been encountered in practically every yard examined where timbers are employed for this purpose.

PILING STICKS.

Practically all yards in which the lumber is "stuck" fail to appreciate the necessity of keeping the sticks free from infection. The strong tendency is to scatter them about on the ground wherever they happened to fall when the previous piles were taken down (fig. 24). In a very few yards attempts are made to improve the appearance of the premises by gathering the sticks endwise into conical piles or by stacking them carefully on the ground beneath the skids (fig. 25).

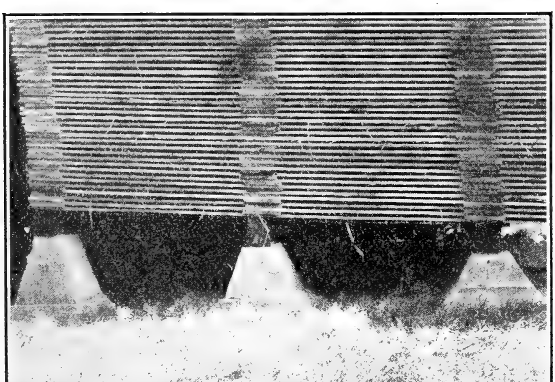
This question of the sanitary handling of the piling sticks is of very great significance, particularly in regions of high humidity, where every precaution must be taken to safeguard stored lumber. Plate III, figures 5 and 6, shows such infected sticks found in Florida and Tennessee lumberyards, where several species of wood-destroying fungi were frequently noted in the piles.



P82F

FIG. 18.—Pile foundations consisting of creosoted timbers resting on concrete piers in use at the Forest Products Laboratory, Madison, Wis. This is a very satisfactory type of foundation.

When one keeps in mind the fact that the soil in and about lumberyards often becomes, in the course of time, thoroughly intermixed with sawdust and partially decomposed woody matter which offers a fertile field for the development of wood-destroying fungi, the necessity of keeping all sound material out of contact with it becomes very evident. In cases where sawdust and bark or wood débris are used to produce artificial fills the danger is further increased. Such filling materials are not infrequently used.



P83F

FIG. 19.—Concrete foundations with untreated skid timbers in general use in a mill yard at Laurel, Miss. Only two rows of piers are used for stock 14 feet or less in length.

Such situations introduce the further question as to what material should be used for filling in low portions of the yards. While the material used will necessarily be governed largely by local conditions, it is the opinion of the writer that clean clay or sandy soil will serve the purpose admirably. While sandy soil allows fungi to spread within it more rapidly than clay, it offers the advantage of rapid seepage, and where the surface is amply ventilated no difficulty should be experienced. (Pl. X, figs 1 and 3.)

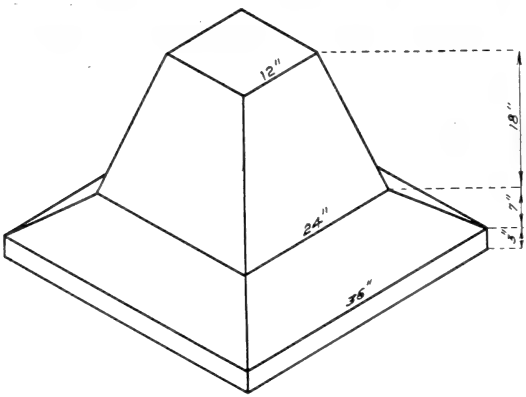


Fig. 20.—Sketch of a concrete foundation pier in use in a mill yard in Mississippi. It is cast in two sections, for convenience in aligning and moving about the yard.

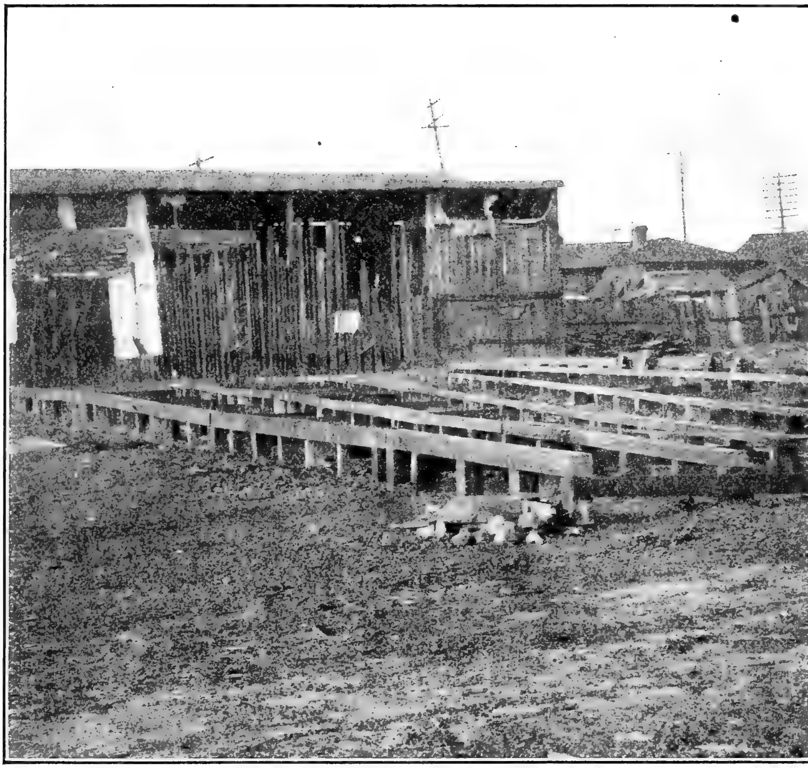
The principal need is to have the yards so laid out that surface water will not accumulate. Ordinary ashes are not considsidered a good filling or surfacing material, since they absorb moisture readily and hold it tenaciously, particularly when they are in a finely pulverized condition. Less finely divided material, such as coarse cinders, gravel, or slag, is better adapted on account of the rapid seepage. Moreover, wood-destroying fungi appear to grow through ashes quite readily when they are in a moist condition. In fact, the writer has a record of one case where fungi developed luxuriantly in a pile of ashes in the open when exposed to prolonged rainy weather. (Pl. IX, fig. 3.)

P84F

Fig. 21.—Pecky cypress foundations in use at a mill in South Carolina. Each large square contains from 500 to 600 board feet. This type of construction does not allow sufficient ventilation beneath the piles.

METHODS OF STACKING LUMBER.

Lumber piled in the open must be allowed ventilation around the individual pieces, and this is usually arranged for in storage practice. In some instances, however, this necessity is ignored in certain retail yards where it is the custom to dispose of the stock within very short periods, say, two or three months. In some of the northern retail yards along the Atlantic coast, where southern pine comes in by boat in a comparatively green condition, this practice often leads to severe fungous infections throughout entire piles. This infection undoubtedly gets a good start in the hold of the vessel during transit and propagates further when close piled in congested lumberyards. Such a pile of diseased pine is



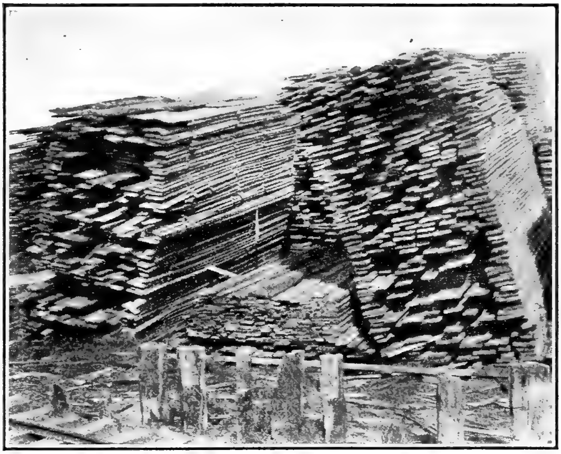
P85F

FIG. 22.—Foundations at Mobile, Ala., built to conform to an ordinance requiring all structures to be raised at least 12 inches off the ground and left open underneath.

shown in Plate III, figure 7, where the infection extends up high into the stack.

It is not the intention in the present bulletin to enter into a discussion of detailed methods of stacking lumber. The primary concern, from the standpoint of sanitation, is to dry the lumber as rapidly as possible and maintain it in this condition. However, other considerations, such as checking and warping, must be taken into account in many instances. The humidity or dryness of the climate will be of great weight in determining the proper amount of ventilation to give the best results from all standpoints.

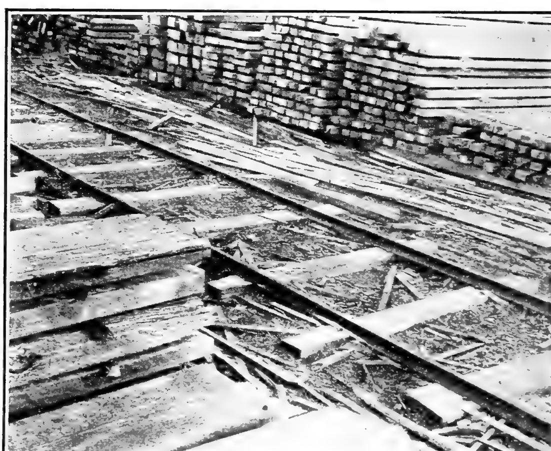
Certain general considerations, however, apply to practically all cases. The method of using special narrow cross sticks is probably in greatest use, and this offers certain advantages when the sticks are handled in a sanitary manner. In the first place, the strips are kept in an air-dry condition, which offers considerable advantage over green material; in the second place, the strips, being narrow, do not offer a bearing surface more than 1 to 4 inches wide. A distinct advantage would also accrue with the use of sticks cut from highly durable material; for instance, resinous heart pine or resistant hardwoods, such as white oak and heart red gum.



P86F

Fig. 23.—Foundations which have failed through decay, permitting the piles to topple over. This would have been prevented by the use of a good preservative.

The second general method of piling lumber consists in using the narrower widths of the lumber itself for crossing strips (fig. 26). The wider boards ordinarily offer too much of a bearing surface for good air circulation. At one of the Arkansas mills visited it was customary in the earlier days to use the regular run of lumber up to 12 inches wide as crossers, but this practice was discontinued on account of the serious loss from decay. The manager of the mill informed the writer that considerable rot would occur in 8 to 12 inch stock



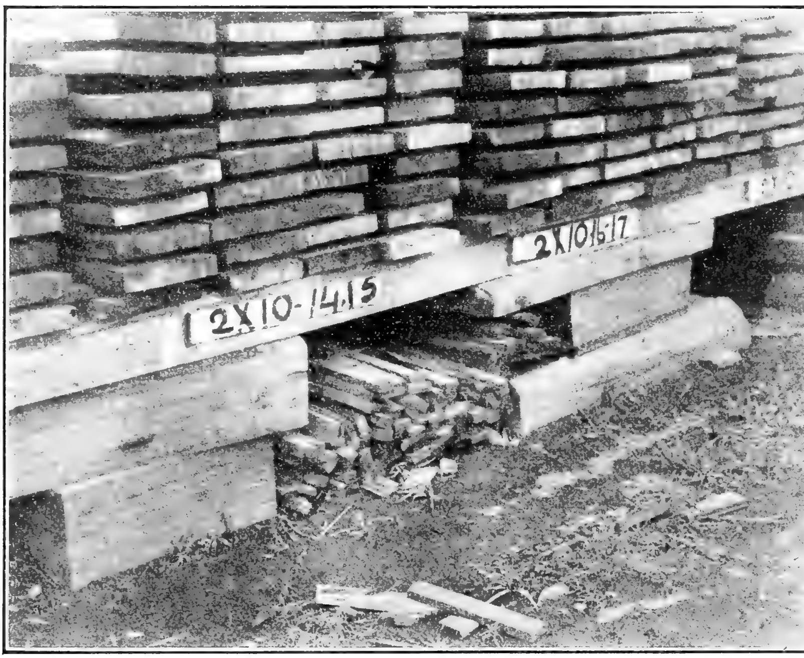
P87F

Fig. 24.—Piling sticks lying on the ground at a mill in South Carolina, showing the insanitary method of handling them. Such sticks lying for only a week or two in contact with fungus-infected ground may themselves become seriously infected, and decay may in turn pass on to the lumber stacks.

within a year under such conditions. The present practice is to use strips 4 inches wide and 1 inch thick of air-dry No. 2 pine. This method has proved entirely satisfactory.

In laying sticks careful attention should be paid to placing the successive strips vertically one above the other. If they are placed hit or miss, certain ones may fall in the span of the next tier below, thus producing much unnecessary warping of the lumber, due to the pressure of the overlying layers.

In all cases of flat piling of green lumber care should be taken to leave a space of at least half an inch between the edges of the stock. This gives a vertical air circulation, which is particularly effective.

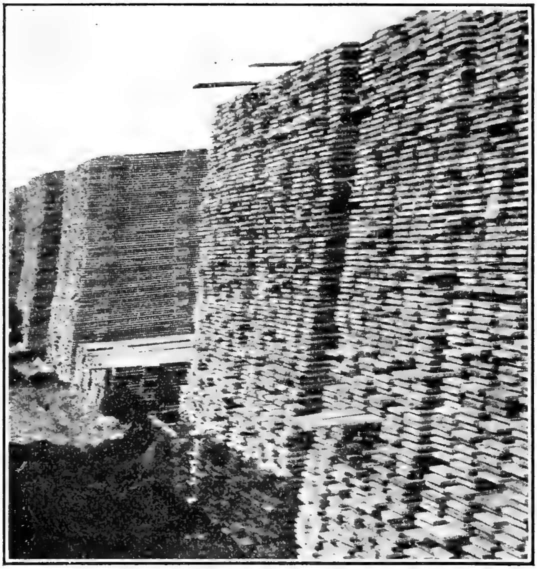


P88F

FIG. 25.—Piling sticks placed on wet ground beneath the skids. In order to keep them free from infection, such sticks should never be placed in contact with the soil.

Two other methods of piling 2 to 3 inch stock are used to some extent with good results. The edge piling of 2 by 4's (fig. 27), sticking the pieces in the usual way, has given good results at several mills where flat piling produced an appreciable amount of deterioration. The method of flat piling without the use of sticks, occasionally employed with 2 by 6's, in which horizontal circulation is provided for by leaving wide spaces between the edges of the stock (fig. 28), would not appear to offer as good opportunities for drying lumber in a moist climate as the more usual method which makes use of sticks.

Besides the proper sticking and lateral spacing of lumber, a central flue one board wide running vertically through the middle of the pile is often of decided advantage. Many millmen recognize this as good practice, but few of them consider they have sufficient yard space to carry out the method consistently.



P89F

FIG. 26.—Lumber piled in even lengths in a southern mill yard. The crossing strips consist of the narrower widths of lumber.

Another factor which enters into the storage of lumber is the piling of stock in even or approximately uniform lengths (see fig. 26). A few mills consider that such preliminary sorting is feasible from an economic standpoint, on account of the greater facility with which such stock can be billed out. From a pathological standpoint the practice is highly commendable. Uneven lengths allow rains to beat in, and also offer convenient and favorable lodging places for fungous spores. Likewise, marked disparities in length permit considerable warping of the ends, which often project out several feet from the main body of the pile. Figure 29 shows this condition in an exaggerated form. To protect the ends of the lumber from beating rains as far as possible, the cross strips should be placed at least flush with the ends, both in front and behind.

P90F

FIG. 27.—Edge-piled 2 by 4 pine at an Arkansas mill. This method of piling permits better vertical air circulation and consequently more rapid drying and less danger from decay during storage.

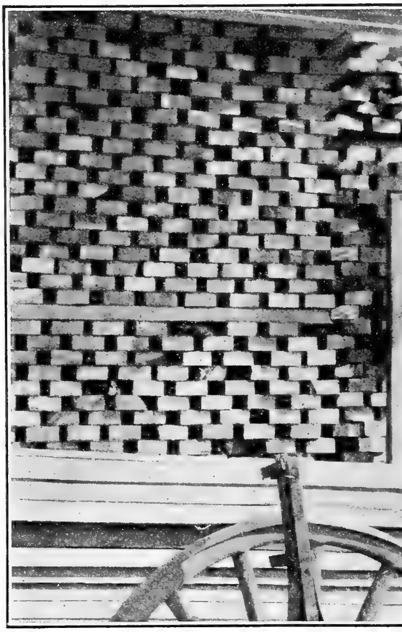
There still remains the question of roofing the piles. The commonly accepted pitch for lumber piles is 1 inch to the foot, and with a loose roof of lapped boards the greater part of the rainfall will drain away. The roofs must necessarily extend somewhat beyond the piles, in order to carry the drip clear of the stack at the rear. Roofing the piles should never be omitted, as the protection afforded against rain is of undoubted value and the operation itself adds very little to the cost of piling.

HANDLING TIMBER AT RETAIL YARDS.

The storage problems involved at retail yards are somewhat different from those at mills, although they may be discussed under exactly similar heads.

LOCATION OF YARDS WITH REFERENCE TO DECAY.

As a first observation, we may say in general that retail or wholesale yards, as opposed to yards in connection with a sawmill, have the advantage of a higher and drier location, which, in turn, should make sanitation measures easier to practice. The necessity of locating on streams or bodies of water is not ordinarily a prime consideration, but rather the location on or near a railway line and as convenient as possible to the actual consumer. Naturally, in the seaport towns, where much of the lumber comes in by boat, the most favorable location from the standpoint of transportation is along the water front, but in inland towns, where the shipment of lumber is by rail, the other factors of accessibility to the local market and the price of land play the important part.



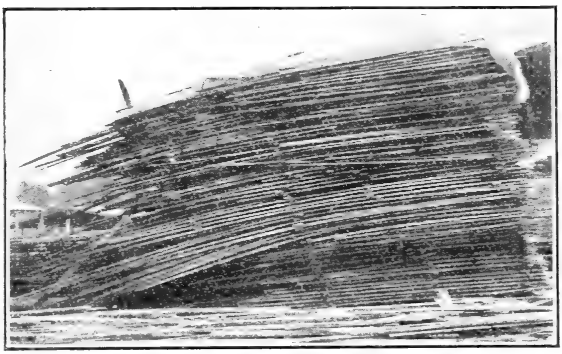
P91F

Fig. 28. — Two-inch stock piled without sticks, a method rarely used in the yards visited. Not used, as far as observed, with stock less than 6 inches wide.

This general advantage of location, however, is often considerably offset by the necessity for close piling, without adequate ventilation either between the piles or through them, due to the higher cost of land. When this is coupled with the fact that much of the product has been in storage elsewhere for varying periods, sometimes a year or more, it can readily be seen why decay is rather frequently encountered in the retail yard.

The salvation of the retail dealers usually lies in disposing of their stock rapidly. Most of them aim to turn it at least three or four times a year, for they recognize that long storage will prove disastrous. Timber showing deterioration through decay is not difficult to find in most retail yards. However, this is very often only in the incipient stage and is not readily noticed by the casual observer. Yards which dress the lumber just before filling orders can in this way supply to the trade clean-looking lumber, but this does not always imply freedom from fungous infection. The opinion seems to be prevalent among many lumber dealers that the mere brightening of the lumber by running through the planer serves to remove all objection to infected stock. This is far from the fact, however. It merely gives it a better sale appearance, and the danger to the ultimate user still remains. The adage that "beauty is only skin deep" applies to such infected stock with particular force.

While perhaps the majority of lumber dealers have merely overlooked the full significance to the building trades of the dangers which lurk in diseased stock and are trying in every way to satisfy their trade and meet competition, there still remain a considerable number who do not look into the future but are content to get the stock off their own hands without any care as to the service which it will give the consumer. This is a thoroughly mistaken policy, for the lumberman should in every way strive to increase the value of his product. In the first place, it is good business policy, and, second, there remains the question of moral and legal responsibility.



P92F

Fig. 29.—A stack of pine lumber of uneven lengths. Note the irregular distribution of the piling sticks and the consequent warping and twisting of the boards.

STORAGE SHEDS.

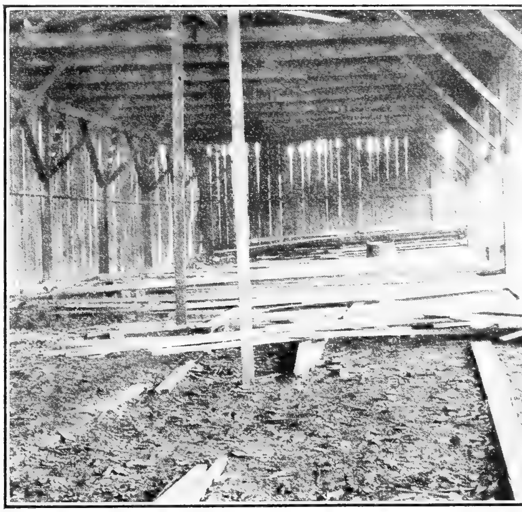
In many retail yards shed conditions are very poor. The closed type of shed is in the minority. Since lumber under cover is as a rule piled closely in bins, the need for ample ventilation beneath and a tight roof above is imperative. All the decay observed in lumber sheds is directly traceable to one or the other of these factors; mainly, however, that of improper ventilation. It has frequently been the custom merely to lay a narrow timber sill directly on the ground, or at best within a very few inches of it, to serve for the foundation (fig. 30). The best practice, however, has been to place the sills on brick or concrete piers not less than 18 to 24 inches high, running the siding of the shed only to the bottom of the sills, so as to allow a free circulation of air regardless of the direction of the wind. Such a construction is represented in figure 31.

Another defect of the open shed which has been frequently noted is the strong tendency to allow the ends of the longer stock to project beyond the eaves (fig. 32). Very few sheds are equipped with gutters (fig. 31), and the drip during rains may run back along the projecting pieces well into the center of the piles. When once wetted the close piles will retain this moisture for long periods, during which a serious outbreak of decay may be initiated.

A few cases of severe outbreaks in retail lumber sheds will be described and illustrated later.

YARDS.

On account of very limited storage space, nearly all retail yards fail to observe the proper spacing of lumber to insure ample ventilation. The general tendency is to pile altogether too close to the ground for safety, and in many instances the lumber is not spaced as well in the piles as it should be (fig. 33). The principal danger lies in the foundations, which are very often seriously infected with rot (fig. 34) or are not adequately constructed to insure proper ventilation. The danger in allowing lumber to come in contact with the soil is evident in figure 35. As the question of foundations in mill yards was discussed in considerable detail earlier in this publication and since the fundamental considerations apply with equal force to retail yards, only certain features which serve to connect these fundamentals with the direct problems of the retail yard will be added here.



P93F

FIG. 30.—An old, dilapidated shed on the Mobile River in which the lumber is too close to the ground. Many severe cases of rot have developed under just such conditions.

Many retail lumber yards use solid or latticed foundations of built-up plank running parallel to the alleys (figs. 36 and 37); others resort to wood blocking for the support of the skids. The use of concrete is very limited, but has given complete satisfaction wherever introduced. It is usually laid down as solid foundations parallel to the alleys. In one yard at Birmingham, Ala., the foundations were 8 to 10 inches high, 6 inches thick at the top, and placed in triple parallel rows spaced 7 feet apart (fig. 38). The advantage of reinforcing the concrete is well shown in figure 39.

Somewhat higher foundations than these are to be preferred in many situations, but in this yard, where every precaution was taken to keep the ground free from all infected débris, and where the drainage was excellent, this height has proved satisfactory.

Piers have the advantage over a solid wall in permitting better ventilation, but piers also involve the use of wooden skids, which if not treated with a good preservative may more than offset the advantage gained in better ventilation.

The careless handling of crossing sticks and lumber in retail yards is just as evident as in mill yards. The general practice in many of the yards visited is to throw sticks about on the ground when the stacks are torn down, and there they often remain until they are needed again. This insanitary practice needs no further comment. A comparison of the yard shown in figure 40, where the lumber is scattered about promiscuously on the ground, with the yard shown in figure 15, where concrete foundations and treated ties are in use and all débris is carefully collected into a wagon (fig. 41) and hauled away, may be of interest in this connection.

P95F

FIG. 31.—A retail shed in Tennessee, well roofed, provided with gutters, and set on brick piers with ample ventilation beneath from all sides.

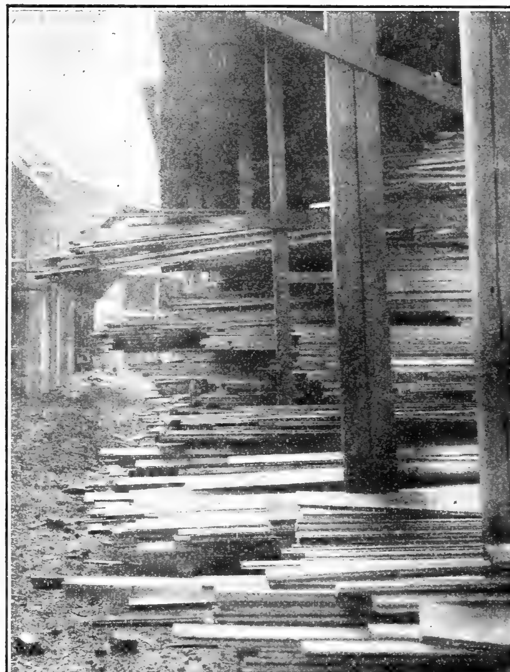
FUNGI WHICH ROT STORED LUMBER.

A considerable number of different species of wood-destroying fungi have been encountered in lumberyards. These, of course, are more frequently found fruiting on the foundations, tramway timbers, and ties than on the stored lumber, but this is only a question of the time which the timbers have been in the yard. The fact that elevated tramway posts and girders will rot in the South in a few years is proof conclusive that lumber stored in the open will also rot if it becomes necessary to hold it in storage too long. In the Gulf States low-grade lumber stored in the ordinary manner will show considerable deterioration within a year. Plate IV, figure 1, shows a small pile of shortleaf pine seriously rotted after a period of only 10 months in a retail yard at New Orleans; in fact, the owner of this yard suffered so much loss from decay in the less durable grades of pine that he has discontinued handling them.

Fungi are in evidence in lumberyards in the vegetative stage (moldlike growths; Pl. II, fig. 1, and Pl. IV, figs. 2 and 3) and in the fruiting stage. Almost any species occurring in a given region may occasionally be introduced into storage yards, but the great majority of the specimens found fruiting fall within a comparatively few species.

One of the common forms, *Polystictus versicolor* (L.) Fr., is shown in Plate IV, figures 4, 5, and 6, growing both from the ends of stored hardwood lumber and from built-up plank foundations (Pl. III, fig. 3). This organism is profusely distributed throughout the entire United States and is more destructive to hardwood timber than any other fungus.

Other members of this genus, such as *Polystictus hirsutus* (Schräd.) Fr. (Pl. IV, figs. 7 and 8), *P. pargamenus* Fr. (Pl. V, figs. 1 and 2), and *P. abietinus* Fr. (Pl. V, figs. 3 and 4) are likely to be found in most lumberyards throughout the United States, occasionally fruiting on stored lumber, but more often causing sap rots of tramway timbers, foundations, and ties. The last species grows on coniferous timber almost exclusively; the other two on hardwood timber.



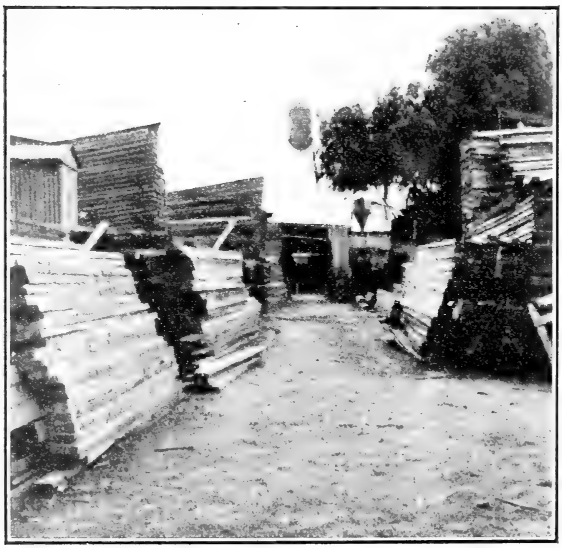
P94F

FIG. 32.—A retail shed in Alabama in which the lumber projects beyond the eaves, thus catching the drip from rains. This condition favors decay when the water runs back along the boards into the piles.

Among other members of the true pore fungi may be mentioned *Polyporus adustus* (Willd.) Fr. (Pl. V, figs. 5 and 6), which is usually thin, tough, and leathery, creamy above and smoky below; *P. sanguineus* (L.) Fr. (Pl. VI, fig. 4), of a bright red throughout, shiny above, rather thin and shelflike, which is found abundantly throughout the South on hardwood timbers; and *P. gilvus* Schw. (Pl. VI, figs. 2 and 3), a firm, comparatively thin, rather rigid species, yellowish within and reddish brown without as it ages.

In the northeastern United States one occasionally finds on oak or chestnut timbers the heavy, tough, corky fruit bodies of *Daedalea quercina* (L.) Pers. (Pl. VI, fig. 1). When the plant develops normally it forms large and sinuous pores, but in lumberyards it more often appears as abortive clay-colored cushions (Pl. III, fig. 4). It is one of the few fungi which attack white oak and chestnut.

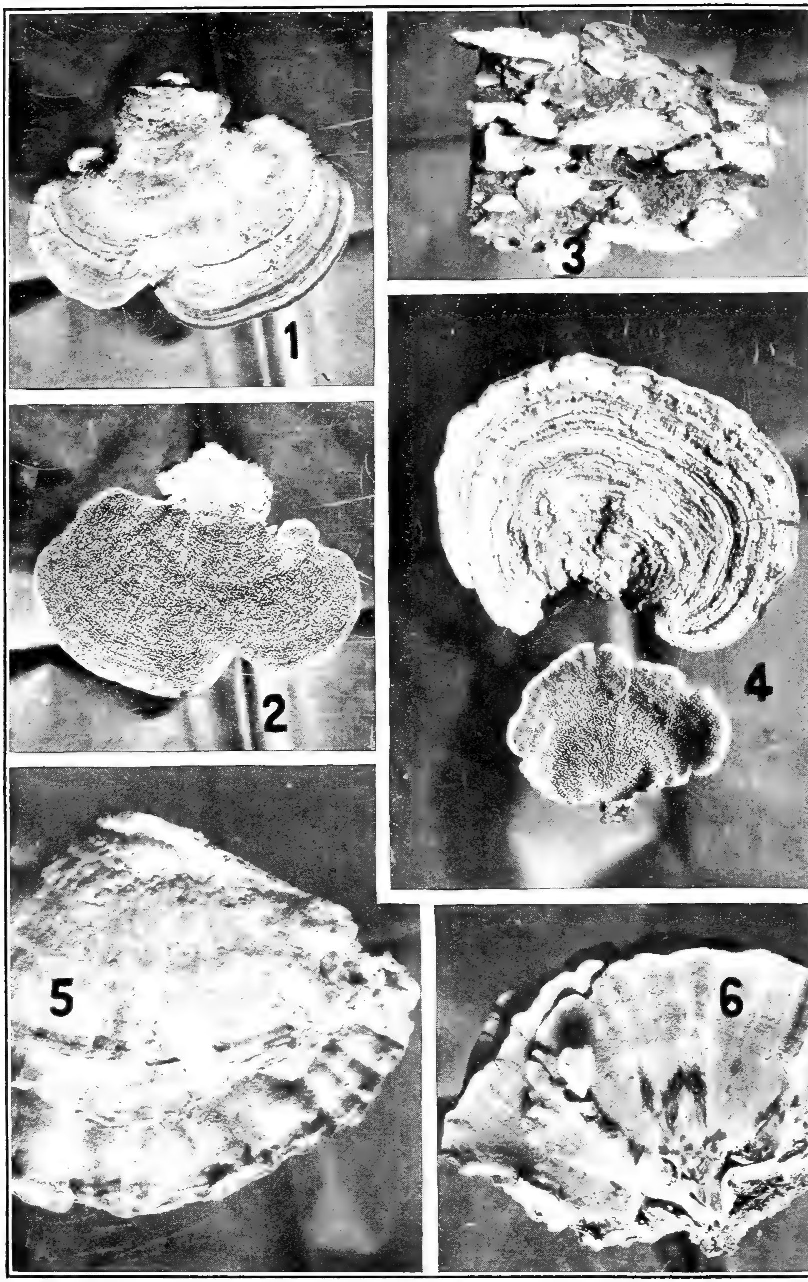
Another destructive group of fungi is represented by the genus Lenzites. Among the brown species there are three principal ones to be feared: *Lenzites sepiaria* (Wulf.) Fr. (Pl. VI, figs. 5 and 6), *L. berkeleyi* Sacc. (Pl. VI, fig. 7), and *L. trabea* (Pers.) Fr. (Pl. VII, fig. 1). The first two constitute the most serious enemies of coniferous structural timber in the United States. The last species rots both the heartwood and sapwood of many different kinds of hardwoods. All three are brown throughout and leathery to corky in texture. In some fruit bodies the under surface may consist of distinct gills; in others, the gills may more or less run together to form sinuous to subcircular pores, easily visible to the naked eye.



P96F

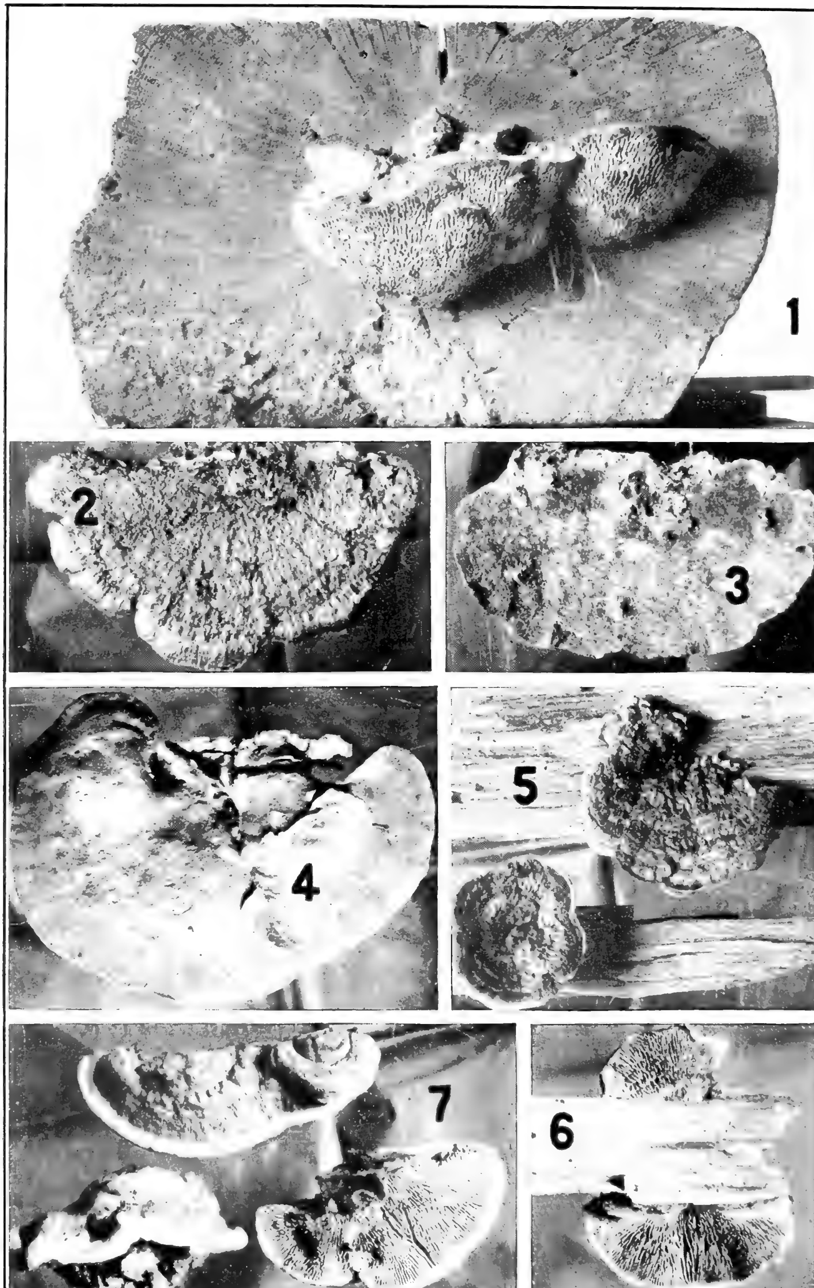
FIG. 33.—A very congested retail yard at New Orleans, La., showing lumber temporarily placed on the ground in solid piles. This is a bad practice, because under such conditions decay may start in a very short time.

Another species, *Lenzites betulina* (L.) Fr. (Pl. VII, figs. 2 and 3), of a general creamy color, with an upper surface frequently banded with shades of yellow, orange, and brown, occurs on hardwood timber throughout the United States. It has commonly been noted in lumberyards on timbers used in various structures. In one large mill yard where oak was largely used for planking the elevated tramways, this species, in conjunction with *Polystictus versicolor*, suc-



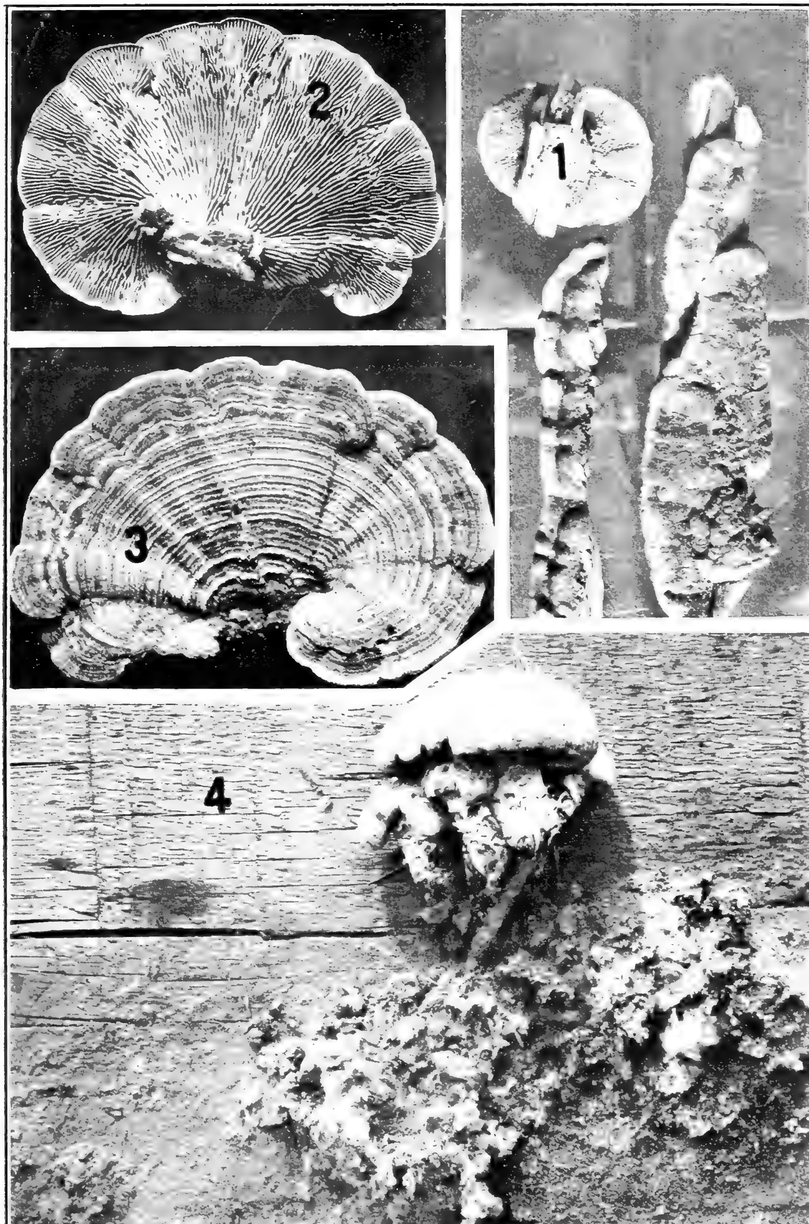
LUMBER SANITATION: WOOD-ROTTING FUNGI.—V.

FIGS. 1 and 2.—*Polystictus pargamenus:* 1, Upper surface; 2, lower surface. FIGS. 3 and 4.—*Polystictus abietinus:* 3, Typical form from a pine log; 4, plants showing upper and lower surfaces. FIGS. 5 and 6.—*Polyporus adustus:* 5, Upper surface; 6, lower surface.



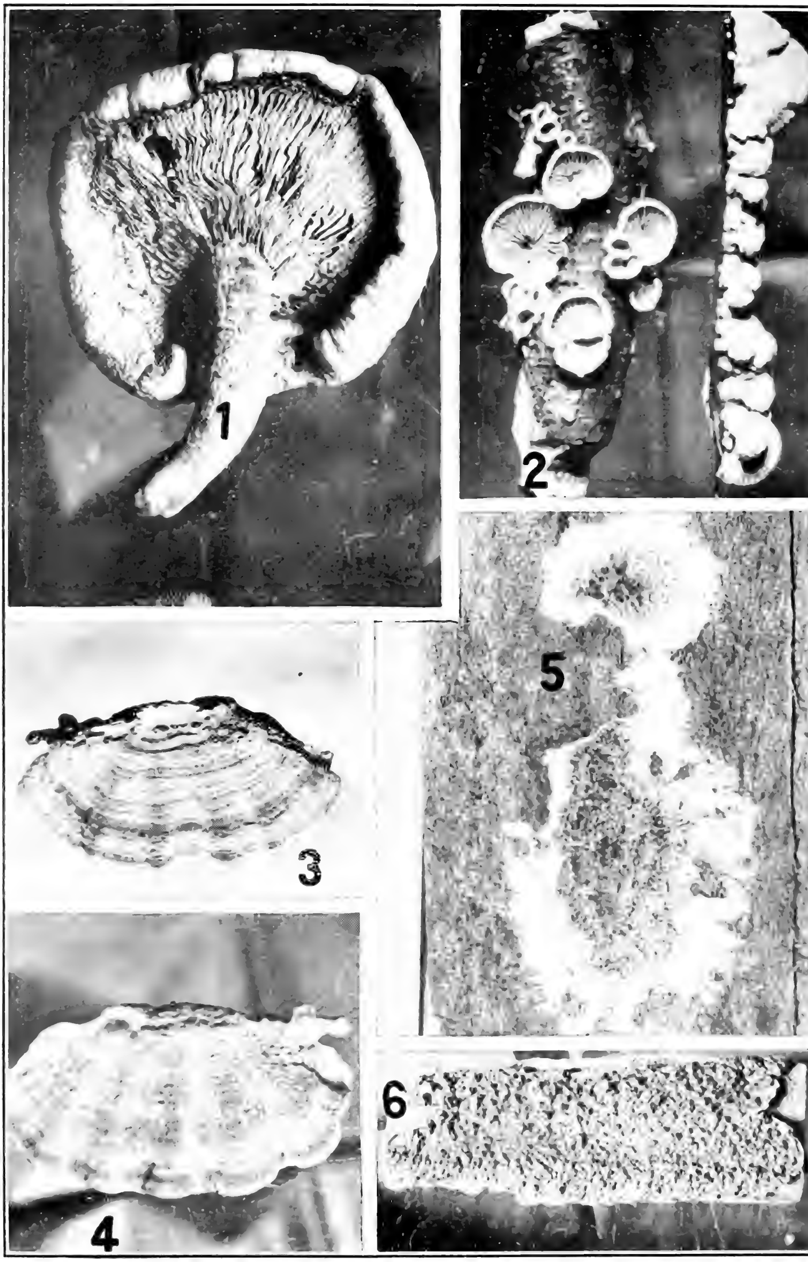
LUMBER SANITATION: WOOD-ROTTING FUNGI.—VI.

FIG. 1.—*Daedalea quercina* growing on an oak tie. FIGS. 2 and 3.—*Polyporus gilvus:* 2, Upper surface; 3, lower surface. FIG. 4.—*Polyporus sanguineus*, upper surface. FIGS. 5 and 6.—*Lenzites sepiaria:* 5, Upper surface; 6, lower surface. FIG. 7.—*Lenzites berkeleyi*, upper and lower surfaces.



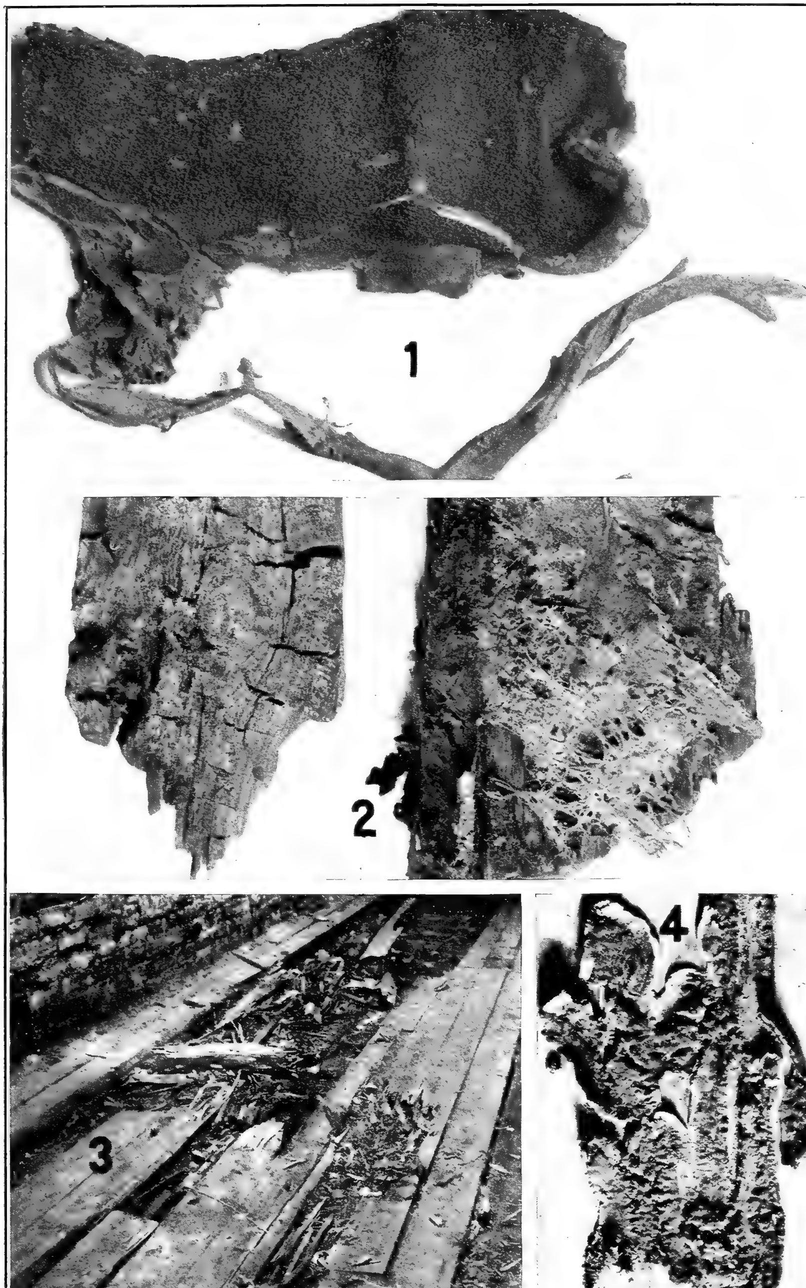
LUMBER SANITATION: WOOD-ROTTING FUNGI.—VII.

FIG. 1.—*Lenzites trabea*, upper and lower surfaces. FIGS. 2 and 3.—*Lenzites betulina:* 2, Lower surface; 3, upper surface. FIG. 4.—*Lentinus lepideus*, typical form on railway ties.



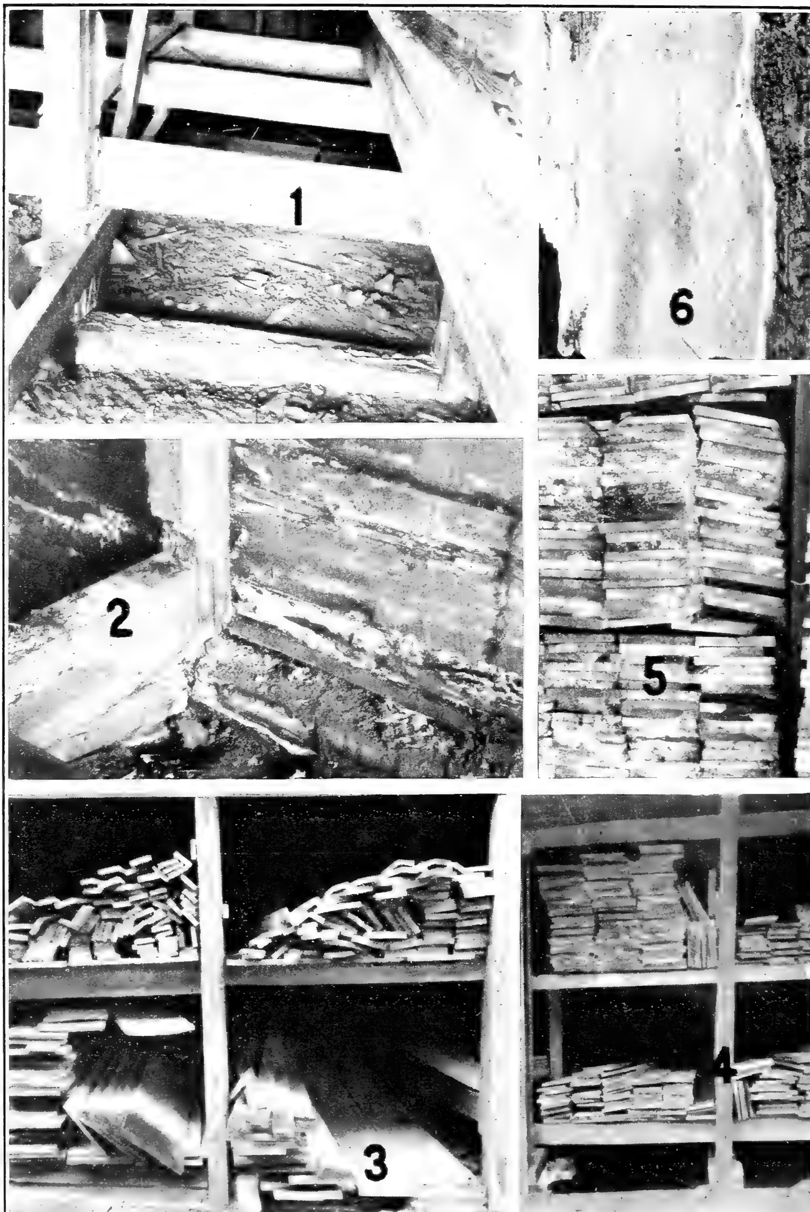
LUMBER SANITATION: WOOD-ROTTING FUNGI.—VIII.

FIG. 1.—*Lentinus lepideus*, under surface. FIG. 2.—*Schizophyllum commune*, upper and lower surfaces. FIGS. 3 and 4.—*Stereum fasciatum:* 3, Upper surface; 4, lower surface. FIGS. 5 and 6.—*Coniophora puteana:* 5, Smooth form growing on spruce sheeting in a mine; 6, warted form from a mine.



LUMBER SANITATION: WOOD-ROTTING FUNGI.—IX.

FIGS. 1 and 2.—*Merulius lachrymans:* 1, A well-developed fruit body with porous moisture-conducting strand (from a residence in Pennsylvania); 2, mycelium growing over the surface of the rotten wood. FIGS. 3 and 4.—An unidentified fungus in a Mississippi cotton warehouse; 3, flooring rotted by the organism; 4, fruit bodies developing on other parts of the floor. (This is the same species illustrated in Plate X, figures 1 and 2.)

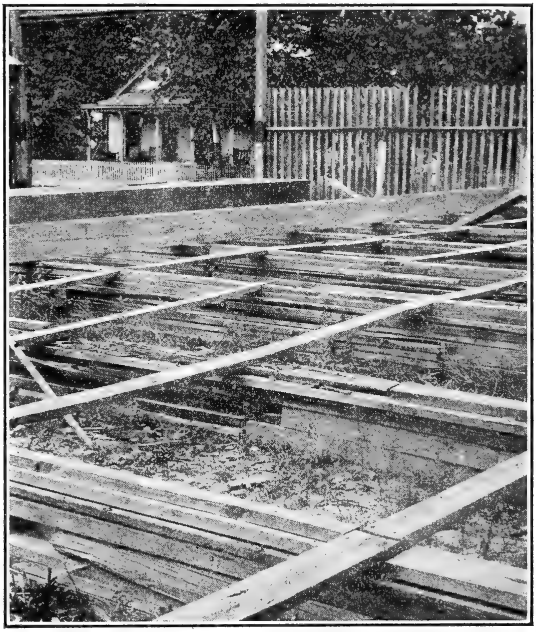


LUMBER SANITATION: WOOD-ROTTING FUNGI.—X.

FIGS. 1 to 4.—A severe infection of an unidentified fungus in an Alabama lumber yard: 1, Open shed where the fungus has progressed upward to the second bin, 5 feet from the ground; 2, corner of closed shed on the same premises where rolls of tarred roofing paper resting on the floor (not shown in the picture) were severely rotted at the ends; 3, the shed shown in figure 1, showing how the infection started by piling too close to the ground over a cinder fill; 4, the same shed after the lower bins had been raised in an effort to control the spread of the rot. FIGS. 5 and 6.—*Peniophora gigantea:* 5, Intermixed with molds and developing on moist pine shingles in a close pile in a Tennessee retail yard (growth, which an antiseptic dip at the mill would have prevented, had started during transit); 6, the mature stage growing on a pine log.

ceeded in rotting the planks at practically the same rate at which they wore down mechanically.

Of the true gill fungi may be mentioned two species—*Schizophyllum commune* Fr. (Pl. VIII, fig. 2) and *Lentinus lepideus* Fr. (Pl. VII, fig. 4, and Pl. VIII, fig. 1). The former occurs everywhere in the United States on both coniferous and hardwood timber. It is white to grayish, very thin and flexible, woolly above, and has very distinct gills below, which are split longitudinally at the edge and each half curled over, much as a dandelion stem curls when split. It is a comparatively small fungus, usually not projecting out more than 1 or 1½ inches. At times it is attached at the center of the back and then presents a circular outline with the gills radiating from a common center. When dry it is much curled and inrolled, but during rainy weather it readily revives and appears fresh and expanded again. Fortunately, it deteriorates wood but slightly and need occasion no fear among lumber users.



P97F

FIG. 34.—Built-up pine foundations in a retail yard in Tennessee. Many of the foundation timbers are seriously decayed and infection may pass to timbers piled in contact with them. Figure 17 shows what happened to a structural timber placed on a foundation in this yard similar to these.

Lentinus lepideus Fr. is a fungus of the "toadstool" type, with a circular, broadly convex, scaly cap, and a stout, fibrous, central or eccentric stem. It is white throughout, except for the brownish scales on the upper side of the caps and on the stem. The under side is provided with coarse gills, which become considerably toothed and split as the plant ages.

This fungus is a very rapid grower and primarily attacks timber in contact with the soil. It rots pine railway ties very rapidly, growing through sandy soil from one stick to another. Serious outbreaks of the fungus in pine warehouse floors have been reported several times, and it should be carefully guarded against in lumber storage yards.

Of the fungi having a smooth under surface, two species are common enemies of structural timber—*Stereum fasciatum* Schw. (Pl. VIII, figs. 3 and 4) and *S. lobatum* Knze. These fungi are too much alike for the layman to attempt to distinguish between them. They are very thin and flexible, the individual shelves often growing one above the other. The general color is grayish to creamy.

Among the incrusting forms three deserve particular attention, viz, *Merulius lachrymans* (Wulf.) Fr., *Coniophora puteana* (Schum.) Fr. (=*C. cerebella* (Pers.) Schröt.), and *Peniophora gigantea* (Fr.) Mass. The first two species are notoriously dangerous and have been found in a number of lumberyards extending from Massachusetts to the Gulf of Mexico. They are also the most frequently reported of all fungi occurring in buildings, and also the most destructive.

P98F

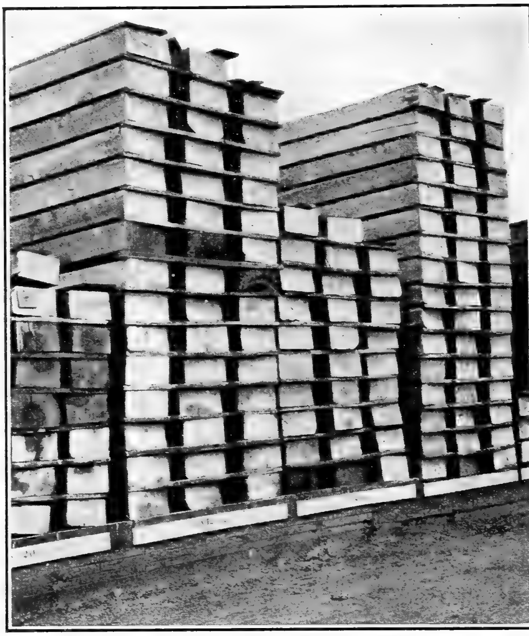
FIG. 35.—Projecting ends of lumber which have decayed by coming in contact with the ground.

Merulius lachrymans (Pl. II, figs. 1, 2, and 6, and Pl. IX, figs. 1 and 2) is a soft, subgelatinous fungus, forming a brown, crumpled growth with a white, fluffy margin over the surface of timber. As it develops it produces dirty gray to brownish minutely porous strands, which serve for the conduction of water, thus enabling the fungus to spread rapidly over comparatively dry substrata. For this reason it has been frequently termed the "dry-rot fungus." On account of its destructiveness to buildings in Europe it also goes under the German name "Hausschwamm." It rots coniferous timber for the most part.

Coniophora puteana (Pl. VIII, figs. 5 and 6) resembles *Merulius lachrymans* in color and general habit of growth. It is less gelatinous, however, and produces no porous strands. In some situations it produces a smooth, very thin, membranaceous layer on the surface of timber; at other times the surface is quite warted or convolute. The danger from the fungus is enhanced by its ability to rot hardwood as well as coniferous timber.

The fact that we are dealing here with two fungi which are known to be widely distributed in lumberyards in the United States, not only in the region covered by this study, but also along the Pacific coast, coupled with our knowledge of the rather common occurrence and seriousness of the same organisms in buildings throughout the same range, is a cause for grave concern on the part of both lumbermen and builders.

Both fungi can readily be introduced into buildings by means of diseased lumber, and it is very probable that at least some of the outbreaks in comparatively new buildings which have come to the attention of the writer can be attributed to this source.

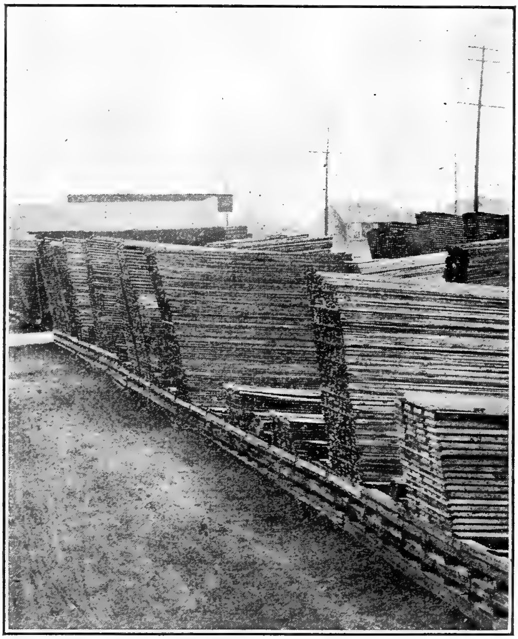


P99F

Fig. 36.—The solid type of built-up plank foundation. This permits air circulation beneath the piles in only one direction. The ends of the stock have been painted to prevent checking.

Besides *Merulius lachrymans* and *Coniophora cerebella* the writer has twice encountered another organism of much the same habit of growth and destructiveness. This organism, the identity of which has not yet been determined, was first found in a retail lumberyard in Alabama and later in a cotton warehouse in Mississippi. The owner of the lumberyard had appealed to the writer for assistance in eradicating a very serious infection, so a careful inspection was made at the first opportunity and the organism was found in great abundance in all three of the open storage sheds, where it had destroyed many of the foundation timbers and also passed upward into the stored lumber (Pl. X, figs. 1–4). The first serious infection noted in this yard occurred six years ago, when two carloads of 6 by 6 pine timbers piled in the open yard were so badly decayed to a height of 6 to 8 feet in the piles as to be rendered useless for building purposes. This material was at once disposed of for firewood. Three years later a further outbreak occurred in two of the open storage sheds and in an addition attached to the small office building. During 1913 a serious infection was also found in a third open shed

According to the owners, the immediate loss of this yard in stock and repairs up to October, 1914, was estimated to be between $1,000 and $2,000. This represents, however, only the actual loss to the company in lumber, figured at wholesale prices, and labor necessary in making repairs. The potential danger to the consumer using such stock, even though but very slightly infected, would amount to very much more than this sum, for a single stick introduced into each of a number of new buildings would occasion an incalculable amount of damage if such timbers happened to be placed in a moist situation favorable for the further development and spread of the fungus.



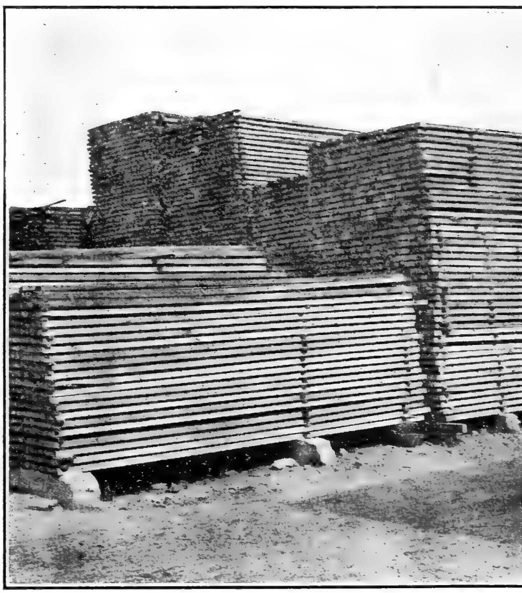
P100F

FIG. 37.—The latticed type of built-up plank foundations. This is an improvement over the solid type, as it allows better ventilation beneath the piles.

As soon as the infections were noted as serious, the company attempted eradication and control measures. In the office building the spread of the fungus has been checked by proper ventilation, and in the sheds the same methods are being applied by removing the cinder fills beneath them and raising the foundations to a height of 18 to 24 inches, placing the sills on brick piers. In future repairs the writer has suggested the application of either mercuric chlorid or some creosote compound to the new timbers.

One member of the company so firmly believed that the cinders used for filling about the yard had been highly favorable to the development and spread of the infection that orders were given to remove all of them from beneath the sheds. While it is possible that the infection may have been introduced by means of the cinders, the rapid growth of the fungus was mainly due to poor ventilation. Cinders have been used by a considerable number of other yards with complete satisfaction. Ashes, however, are not to be recommended. There are records in German literature where ashes used for filling between floors to deaden them have been the source of fungous outbreaks. The case of a cotton warehouse investigated by the writer, where pine flooring laid on flat 2 by 6's resting on ashes was very quickly rotted out by this same fungus (Pl. IX, figs. 3 and 4), likewise offers circumstantial evidence.

The remaining fungus which needs consideration is *Peniophora gigantea* (Fr.) Mass. (Pl. X, figs. 5 and 6). This is a white to pale creamy moldlike growth when immature. When mature it forms a waxy incrustation on the surface of the timber, closely adherent when fresh, but when dry tending to become hard and horny and to curl up at the free edges. This organism is widely distributed, mainly on pine timber, throughout the southern pine belt, and also occurs on conifers in the Rocky Mountain region. In the South it is frequently found in the woods, whence it readily passes to stored lumber. Many lumberyards have been abundantly infected with it ever since they started in business; so long, in fact, that to sever the attachment would be like losing an old acquaintance. From the southern yards it has been introduced northward and is very conspicuous at certain points along the North Atlantic coast (Pl. III, fig. 7). The timber reaches these points mainly by boat. Close storage of the green or partially dried stock in the hold of a vessel during an ocean voyage of perhaps several weeks usually permits a vigorous development of the fungus. As a result of this, infections are so abundant in some of the North Atlantic yards that one would have difficulty in finding any clean material whatever.



P101F

FIG. 38.—Concrete foundations in the retail yard in Alabama shown in figure 15.

It is fortunate that the organism does not approach in destructiveness such forms as have been previously described, else many lumberyards would be doomed immediately. It is a wood-destroying fungus, however, which limits its action to the sapwood. Although the deterioration is comparatively slow, it does weaken the timber to a considerable extent and should be guarded against along with the more dangerous fungi.

WOOD PRESERVATIVES IN THE LUMBERYARD.

Aside from the advisability of preserving permanent structures in the lumberyard by the use of antiseptics applied to or injected into the wood, the question of preserving the lumber itself from incipient infection until it reaches the consumer is one which merits careful thought. During the past decade the use of soda (sodium carbonate or bicarbonate) dips to prevent blue stain has become general throughout the southern pine belt. Within the writer's own experience, sawmill men who in 1909 scoffed at such a measure had within three or four years fallen in with the procession and were enthusiastic advocates of it. As yet the idea of dipping the lumber to prevent infection from true wood-rotting fungi has not been considered by the lumbermen. The soda dip is not sufficient to accomplish the desired end, so we must look elsewhere for a suitable preservative. Mercuric chlorid is a hazardous thing to use on general stock, on account of its extremely poisonous nature, but is very efficient and safe enough for special purposes. Zinc chlorid is objectionable mainly on account of its capacity to attract moisture. Of the remaining colorless salts in use for wood preservation sodium fluorid or some colorless salt of hydrofluoric acid would probably meet the needs of the situation very well. Sodium fluorid is highly toxic to fungi, but can be handled by workmen with no danger of poisoning. It is colorless, easily soluble, and can be handled in any way that the soda dip can. It is more effective than soda and so could readily be substituted for it, thus protecting against both the blue stain and the wood-rotting fungi by a single treatment.

P102F

FIG. 39.—Broken foundations, a result brought about by not reinforcing the concrete. The company later embedded some old 20-pound steel rails in the concrete near the top.

This whole feature of dipping lumber in this way to keep it in a clean condition for the consumer must necessarily involve the close cooperation of millmen, wholesale men, and retailers. The millman may feel indifferent to the proposition, claiming that the deterioration in his yard is not sufficient to warrant it. But this is not merely a mill problem; it is a lumber problem which involves the entire industry and the cooperation of all its members. Even though the mill operator may not in many cases suffer personal monetary loss, still he is often a contributing factor in the losses borne by the retailer and consumer, for incipient decay originating in mill yards and passed over to retail yards may during the later period of storage progress rapidly.

The added cost of treatment would be insignificant in comparison with the benefit derived, and if the lumber trade would take the trouble to explain the benefits to the consumer the slight additional expense would in all probability readily be met by him. Even though it should not be deemed feasible to add the cost of treatment to the finished product, the direct saving accruing to the lumber dealer himself should warrant the expense. It is imperative that something be done by the lumberman to put his product on a more favorable competing basis with other structural materials if he is to safeguard the lumber business for the future.

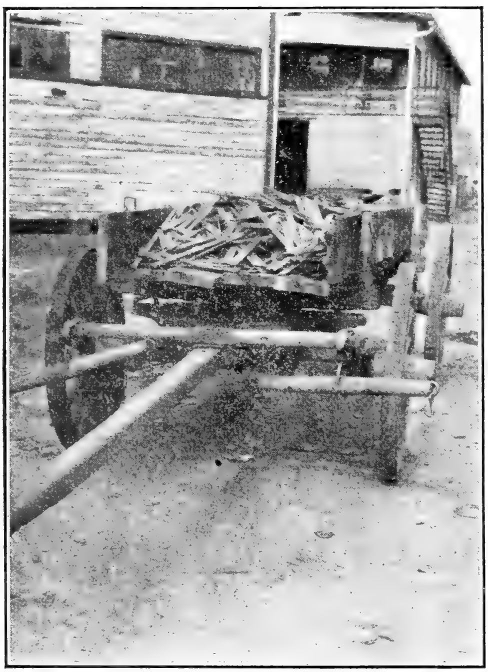
P104F

Fig. 40.—A southern retail yard, showing a most insanitary way of handling lumber. Structural timbers should never be thrown promiscuously about on the ground in this manner to become infected with wood-destroying fungi.

Another line of endeavor which would reflect favorably on the whole industry is for the lumber dealer to carry in stock, or at least be in a position to produce on order, timber thoroughly treated for construction purposes by certain of the well-known preservative processes. The wood-preserving industry to-day is primarily conducted for the benefit of the heavy consumer. The builder who may need only small quantities of treated stock to place where decay is most likely to occur in his structure is usually unable to obtain it except at prohibitive cost.

The preservative treatment of timber is no magic process and involves no heavy expenditures for necessary apparatus, especially in connection with the simpler methods of treatment. The kyanizing process consists merely in the immersion of the timber in an open wood or concrete tank containing a solution of mercuric chlorid. Any of the other water-soluble salts could be applied in the same way. Creosotes and carbolineums can also be applied in this manner. While in many cases the amount of preservative which can be injected in this way would not be sufficient to fully protect timber in direct contact with the ground, in most cases where treatment is indicated in buildings it would be sufficient. Such treatments could be carried out by any one at any point, and the local treatment of timber would probably be cheaper than when done at a distant centralized plant. In the East, such a local method of treatment is being carried out by at least two lumber dealers within the writer's acquaintance.

If treated timber were put on the local markets as a standardized product, as readily available to the man who needs 100 feet as to him who uses it by the 100,000 feet, the favorable results experienced by the public in the use of the treated product would in the course of a few years create a demand and be a stepping stone toward a more profitable lumber industry.



P106F

FIG. 41.—Wagon loaded with fragments of lumber to be hauled away. This is the highly commendable practice by which one lumber company keeps its yard clear of débris.

BRANDING STRUCTURAL TIMBER.

The discussion now leads us to a consideration of the advantages of branding timber in order to safeguard both the reputable timber producer and the consumer. Such a practice is of particular value in the case of dimension timbers where a standardized uniform product, graded particularly on strength and durability, must be supplied. It is customary at the present time to so brand longleaf pine for export, but the practice is very little followed for the interior trade. Some few retailers stencil their name or brand on certain stock, but this is with them more a matter of advertising than a guaranty of quality, and this must necessarily be the case until a standard and succinct set of grading rules is put into practice by all dealers.

Branding not only puts the company's guaranty of quality behind the product, but indicates as well the kind of timber supplied. Thus, for example, an operator in Douglas fir and western white pine in Idaho could not then possibly confuse his product with southern pine or eastern pine when it reaches the eastern market. For the architect it is very essential to know that the kind of timber he receives accords with the specifications.

The biggest and most enduring reputations in any line of industrial activity are based on the best type of service. When the lumberman who has the highest desire for good service throws his product promiscuously on the market with the lower grade materials, he is at the same time throwing away an industrial asset of no doubtful value. This will become more and more the case as the building public wakes up to the dangers lurking in the use of inferior or fungus-infected timber.

The timber of the United States is a national asset in which the citizens have a certain vested interest which calls for the best utilization possible. The lumberman as guardian of these interests certainly owes to the public no less than his best efforts to convert the forest into a finished product which shall ultimately reach the consumer in prime condition.

CONCLUSIONS.

Improvement of lumber storage conditions can be brought about by modifying present insanitary practices along the following lines:

(1) Strong efforts should be made to store the product on well-drained ground, removed from the possible dangers of floods, high tides, and standing water.

(2) All rotting débris scattered about yards should be collected and burned, no matter whether it be decayed foundation and tramway timbers or stored lumber which has become infected. In the case of yards already filled in to considerable depths with sawdust and other woody débris the situation can be improved by a heavy surfacing with soil, slag, or similar material.

(3) More attention should be given to the foundations of lumber piles in order to insure freedom from decay and better ventilation beneath the stacks. In humid regions the stock should not be piled less than 18 to 24 inches from the ground. Wood blocking used in direct contact with wet ground should be protected by the application of creosote or other antiseptic oils or else replaced by concrete, brick, or other durable materials. Treated horizontal skid timbers would also be highly advantageous, for stock should never be piled in direct contact with diseased timber.

(4) Instead of throwing the "stickers" about on the ground, to become infected, they should be handled carefully and when not in use piled on sound foundations and kept dry as far as possible. If resinous pine or the heartwood of such durable species as white oak or red gum be employed, the danger of possible infection will be greatly decreased.

(5) In most regions lumber should not be close piled in the open, but should be "stuck" with crossers at least 1 inch thick. Lateral spacing is also very desirable. Roofing the piles should not be neglected.

(6) In storage sheds the necessity for piling higher from the ground is very apparent in many cases. The same remedies apply here as for pile foundations in the open. The sheds should be tightly roofed and the siding should not be run down below the bottom of the foundation sills. Free air circulation should be allowed from all sides beneath the inclosure. Only thoroughly dry stock should be stored in close piles under cover.

(7) Should fungous outbreaks occur in storage sheds not constructed to meet sanitary needs the infected foundation timbers should all be torn out and replaced with wood soaked in an antiseptic solution or by concrete or brick. In all cases the new foundations should be so constructed as to keep the lumber well off the ground, and the soil and timber immediately adjoining the infected area should be sprayed or painted with an antiseptic solution of a water-soluble salt, like sodium fluorid, mercuric chlorid, zinc chlorid, or copper sulphate.

Stock which has become infected should never be sold for permanent construction purposes. The placing of such infected stock in buildings may lead to disastrous results, for which the dealer may be held responsible.

(8) The dipping of yard stock in a water solution of sodium fluorid appears advisable from the standpoint of preventing blue stain and incipient infection with wood-destroying fungi during storage.

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