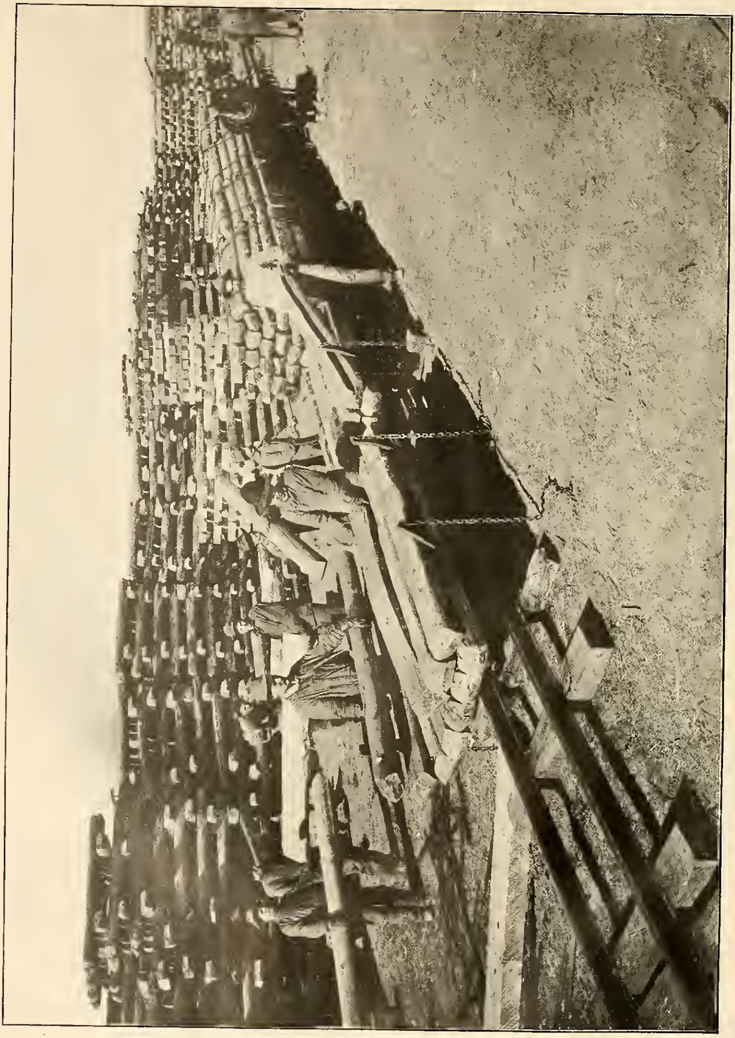

LOADING SEASONED TIES OF LODGEPOLE PINE AT SHERIDAN, WYO.

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF FORESTRY—BULLETIN No. 41
GIFFORD PINCHOT, Forester.

SEASONING OF TIMBER.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Forestry,
Washington, D. C., February 6, 1903.

Sir: I have the honor to transmit herewith a report entitled "Seasoning of Timber," by Dr. Hermann von Schrenk, pathologist in charge of the Mississippi Valley Laboratory, Bureau of Plant Industry, assisted by Reynolds Hill, agent, Bureau of Forestry, and to recommend its publication as Bulletin No. 41, Bureau of Forestry. The illustrations (of which there are eighteen full-page plates and sixteen text figures) are believed to be necessary to a full understanding of the text by the reader.

Respectfully,

Gifford Pinchot,
Forester.

Hon. James Wilson, *Secretary.*

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SEASONING OF TIMBER.

I. INTRODUCTION.

In a recent report on the general subject of timber preservation [a] it was pointed out that there were a number of problems in connection with this subject requiring further investigation. These problems related to various stages in the preservation of timber, the preparation of timber for treatment, methods of treatment, and the final disposition of treated timber. The present bulletin is the first of a series which it is intended to issue from time to time, and deals with the preliminary seasoning which precedes the actual chemical treatment.

In the report referred to, it was pointed out that one of the problems requiring further investigation was the length of life of any given timber as affected by seasoning. Although it has been known for a long time—and the fact is daily in practical evidence—that there is a marked difference in the length of life of seasoned and of unseasoned timber, the consumers of lumber have shown very little interest in the seasoning of timber except for the purpose of doing away with the evils which result from checking, warping, and shrinking. For this purpose both kiln drying and air seasoning are largely in use. Kiln drying, which dries the wood at a uniformly rapid rate by heating it in inclosed rooms, has become a part of the car-building industry and of the manufacture of furniture, vehicles, tools, and many other articles in ordinary use. Without it the construction of the finished product would often be impossible. Nevertheless, much unseasoned or imperfectly seasoned lumber is used in car construction, as is evidenced by subsequent shrinkage and warping.

Complaints are daily made by railroad managers that their freight cars twist and warp out of shape more than they did years ago. The explanation for this is probably to be found in the tremendous development in recent years of the industries which require lumber for building purposes. The manufacturer of structural lumber is so hard pressed for lumber that he is forced to send out a poor product, which the consumer is willing to take in that condition rather than to wait several weeks or months for thoroughly seasoned material. As a result, properly seasoned wood commands a high price, and in some cases can not be obtained at all. Wood seasoned out of doors, which by many is supposed to be much superior to kiln-dried timber, is

[a] The Decay of Timber, and Methods of Preventing It. By Hermann von Schrenk. (Bull. 14, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1902.)

becoming very scarce indeed, as the demand for any kind of wood is so great that it is thought not to pay to hold timber for the time necessary to season it properly.

How long this state of affairs is going to last it is difficult to say, but it is believed that a reaction will come when the consumer learns that in the long run it does not pay to use poorly prepared material. Such a condition has now arisen in connection with another phase of the seasoning of timber. As already said, it is a commonly accepted fact that dry timber will not decay nearly so fast as wet timber. Nevertheless, the immense superiority of seasoned over unseasoned wood for all purposes where resistance to decay is necessary has not been sufficiently recognized. In the times when wood of all kinds was both plentiful and cheap it mattered little in most cases how long it lasted. Wood used for furniture, flooring, car construction, etc., usually got some chance to dry out after it was placed in use. The wood which was exposed to decaying influences was generally selected from those woods which, whatever their other qualities might be, would resist decay longest. At first ties were made wholly of White Oak, and, judging from recently compiled data, this wood alone was used for many years. It lasted longer than other timber, and was hard as well. The service which it gave was an ample return on the invested cost, and no one thought at that time that it was at all necessary to devise means for lengthening that service. Ties were cut in any way and at any time, and were laid sometimes two days after cutting, sometimes not for six months or a year, during which time they may have lain in the woods, in a ditch full of water, or piled haphazard.

To-day conditions have changed, so that the White Oak can no longer be used economically to the same extent as in former years. Inferior timber with less lasting qualities has beer pressed into service, not only for ties, but for fence posts, bridge material, piles, etc. Although haphazard methods of cutting and subsequent use are still much in vogue, there are many signs that both lumbermen and consumers are awakening to the fact that such carelessness and wasteful methods of handling structural timber will no longer do, and must give way to more exact and economical methods. The reason why many timber merchants and consumers are still using the older methods is perhaps because of long custom, and because they have not yet learned that, though the saving to be obtained by the application of good methods has at all times been appreciable, now, when timber is more valuable, a much greater saving is possible. The increased cost is really very slight, and is many times exceeded by the value of the increased service which can be secured.

In the following pages a discussion of the principles applying to the seasoning of wood is presented, together with some preliminary results of tests made during the past year. It is thought advisable to publish these results at this time, because the preliminary figures obtained are so suggestive that they may prove of value even in their present incomplete form. It is to be understood, however, that the experiments described are merely the first of a large series, some of which are now under way, and which it is hoped will be carried on continuously for as many years as may be necessary to obtain sufficient data to make the conclusions reached perfectly accurate.

II. DISTRIBUTION OF WATER IN TIMBER.

As seasoning means essentially the more or less rapid evaporation of water from wood, it will be necessary to discuss at the very outset where water is found in wood, and its local and seasonal distribution in a tree.

LOCAL DISTRIBUTION OF WATER IN WOOD AND TREE.

A concise description of the distribution of water in wood was presented in an earlier bulletin of this Bureau, and as it covers the matter fully, it is quoted in full here:[a]

Water may occur in wood in three conditions: (1) It forms the greater part (over 90 per cent) of the protoplasmic contents of the living cells; (2) it saturates the walls of all cells; and (3) it entirely or at least partly fills the cavities of the lifeless cells, fibers, and vessels; in the sapwood of pine it occurs in all three forms; in the heartwood only in the second form, it merely saturates the walls. Of 100 pounds of water associated with 100 pounds of dry-wood substance taken from 200 pounds of fresh sapwood of White Pine, about 35 pounds are needed to saturate the cell walls, less than 5 pounds are contained in living cells, and the remaining 60 pounds partly fill the cavities of the wood fibers. This latter forms the sap as ordinarily understood. It is water brought from the soil, containing small quantities of mineral salts, and in certain species (Maple, Birch, etc.), it also contains at certain times a small percentage of sugar and other organic matter. These organic substances are the dissolved reserve food, stored during winter in the pith rays, etc., of the wood and bark; generally but a mere trace of them is to be found. From this it appears that the solids contained in the sap, such as albumen, gum, sugar, etc., can not exercise the influence on the strength of the wood which is so commonly claimed for them.

The wood next to the bark contains the most water. In the species which do not form heartwood the decrease toward the pith is gradual, but where this is formed the change from a more moist to a drier condition is usually quite abrupt at the sapwood limit. In Longleaf Pine, the wood of the outer 1 inch of a disk may contain 50 per cent of water, that of the next, or second inch, only 35 per cent, and that of the heartwood only 20 per cent. In such a tree the amount of water in any one section varies with the amount of sapwood, and is therefore greater for the upper than the lower cuts, greater for the limbs than stems, and greatest of all in the roots.

Different trees, even of the same kind and from the same place, differ as to the amount of water they contain. A thrifty tree contains more water than a stunted one, and a young tree more than an old one, while the wood of all trees varies in its moisture relations with the season of the year.

SEASONAL DISTRIBUTION.

It is generally supposed that trees contain less water in winter than in summer. This is evidenced by the popular saying that "the sap is down in the winter." This is probably not always the case. Some trees

[a] Timber. By Filibert Roth. (Bull. 10, Division of Forestry, U. S. Dept. of Agriculture, 1895.)

contain as much water in winter as in summer, if not more. The average weight of Lodgepole Pine ties of the same size cut at Bozeman, Mont., in June, 1902, was 157 pounds; in July, 144 pounds; in August, 150 pounds; in September, 157 pounds; in October, 164 pounds. It is probable that this increase would keep up throughout the winter.

Of the varying amounts of water in the trees of one region during the same period of different years, little or nothing is known. It is hoped that the tests now in progress will give some indications in that direction.

III. RELATION OF WATER TO THE DECAY OF TIMBER.

The intimate relation existing between the presence of water in wood and the rate at which wood decays requires a brief reference to the causes of wood decay. A full account of the factors which bring about decay has recently been published,[a] and those interested are referred to that publication for details. It will be sufficient at this point to say that low forms of plant life called fungi grow in wood, and by so doing disintegrate and dissolve portions of the wood fiber. As a result of this, the wood changes in its physical properties and is called decayed. When the fungus has extracted a sufficient amount of material, it forms, on the outside of the wood, fruiting bodies known as punks or toadstools, containing spores, which are blown about and infect sound wood. Pl. II shows a Red Fir railroad tie in position, with the fruiting body of one of the most common of these wood-destroying fungi (*Lentinus lepideus*) growing out from one side. The ballast has been partly scraped away to show the whole fungus. Fig. 2 shows the fungus on a larger scale. White, filmy fungus threads grow through the mass of sandy ballast and spread to adjacent ties.

The conditions necessary for the growth and development of wood-destroying fungi are (1) water, (2) air, (3) organic food materials, and (4) a certain amount of heat. The wood fiber and the organic substances found in the living cells of sapwood, such as albuminous substances, starch, sugar, and oils, form the food supply necessary to start the growth of the fungus threads. A further requirement is oxygen; no growth will take place under water or in the ground at depths of 2 feet or more, the depth varying with the character of the soil. The best examples of this necessity for oxygen can be found in the way in which fence posts and telegraph or telephone poles decay at points just at or just below the surface of the ground, where there is a balance between the supply of air and of water.

For practical purposes water is the most important factor. Without water no fungus growth, and consequently no decay, is possible. "Dry rot," a form of decay in which the wood turns to a dry, brittle,

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[a] The Decay of Timber, and Methods of Preventing It. By Hermann von Schrenk. (Bull. 14, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1902.)

FIG. 1.—FRUITING BODY OF FUNGUS ON TIE IN POSITION.

FIG. 2.—A NEAR VIEW OF FIG. 1.

WOOD-DESTROYING FUNGUS (LENTINUS LEPIDUS) ON RED-FIR TIE, SOUTH DAKOTA.

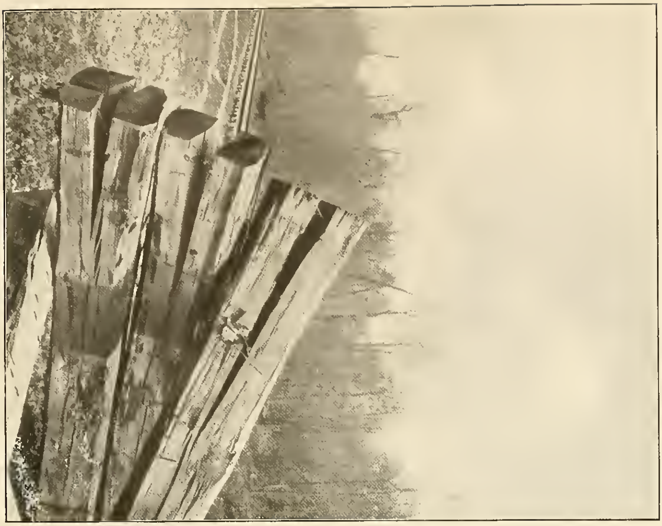

FIG. 1.—WHITE-OAK TIES SEASO. [illegible] TOO FAST.

FIG. 2.—PILE OF POORLY SEASONED CAR LUMBER.

charcoal-like substance, is commonly supposed to take place without any water. Such is not the case, however. The atmospheric moisture is sufficient to permit growth of the dry-rot fungus even if no moisture is contained in the wood. Too much water will prevent fungus growth, because it shuts off the air supply. The amount of water necessary to permit the growth of fungi is very small. Wood freshly cut contains more than enough at all seasons of the year to support fungus growth.

From the foregoing it will be clear that the removal of water from timber brings about a condition which during its continuance does not allow of the growth of wood-destroying fungi. In other words, *dry* wood will not rot or decay.

IV. WHAT SEASONING IS.

DIFFERENCE BETWEEN SEASONED AND UNSEASONED TIMBER.

Seasoning is ordinarily understood to mean drying. When exposed to the sun and air the water in green wood rapidly evaporates. The rate of evaporation will depend on the kind of wood, the shape of the timber, and the conditions under which the wood is placed. Pieces of wood completely surrounded by air, exposed to the wind and the sun, and protected by a roof from rain and snow, will dry out very rapidly; while wood packed close together, so as to exclude the air, or left in the shade and exposed to rain and snow, will probably dry out very slowly.

But seasoning implies other changes besides the evaporation of water. Although we have as yet only a vague conception as to the exact nature of the difference between seasoned and unseasoned wood, it is very probable that one of these consists in changes in the albuminous substances in the wood fiber, and possibly also in the tannins, resins, and other incrusting substances. Whether the change in these substances is merely a drying out, or whether it consists in a partial decomposition, is as yet undetermined. That the change during the seasoning process is a profound one there can be no doubt, because experience has shown again and again that seasoned wood fiber is very much more permeable, both for liquids and gases, than the living, unseasoned fiber. One can picture the albuminous substance as forming a coating which dries out and possibly disintegrates when the wood dries. The drying out may result in considerable shrinkage, which may make the wood fiber more porous. It is also possible that there are oxydizing influences at work within these substances, which result in their disintegration.

Whatever the exact nature of the changes may be, one can say without hesitation that exposure to the wind and air brings about changes in the wood which are of such a nature that the wood becomes drier and more permeable. When seasoned by exposure to live steam, similar changes may take place. The water leaves the wood in the form of steam, while the organic compounds in the walls probably coagulate or disintegrate under the high temperature.

MANNER OF EVAPORATION OF WATER.

The evaporation of water from timber takes place largely through the ends, i. e., in the direction of the longitudinal axis of the wood fibers. The evaporation from the other surfaces takes place very slowly out of doors; with greater rapidity in a kiln. The rate of evaporation differs both with the kind of timber and its shape. Thin boards and beams dry faster than thicker ones; sapwood dries faster than heartwood, and pine more rapidly than oak. Tests made during the past summer showed little difference in the rate of evaporation in sawed and hewn ties, the results, however, not being conclusive. Air-drying out of doors takes from two months to a year, the time depending on the kind of timber and the climate. No data have been obtained as to the rate of evaporation out of doors. This is one of the questions now under investigation.

After wood has reached an air-dry condition it absorbs water in small quantities after a rain, or during damp weather, much of which is immediately lost again when a few warm, dry days follow. In this way wood exposed to the weather will continue to absorb water and lose it for indefinite periods. When soaked in water, seasoned timber absorbs water rapidly.[a] This at first enters into the wood through the cell walls. When these are soaked the water will fill the cell lumen, so that if constantly submerged the wood may become completely filled with water. The following figures show the gain in weight by absorption of several coniferous woods, air-dry at the start, expressed in per cent of the kiln-dry weight:

TABLE I.—*Absorption of water by dry wood.*

	White Pine.	Red Cedar.	Hemlock.	Tamarack.
Air dried	108	109	111	108
Kiln-dried	100	100	100	100
In water 1 day	135	120	133	129
In water 2 days	147	126	144	136
In water 3 days	154	132	149	142
In water 4 days	162	137	154	147
In water 5 days	165	140	158	150
In water 7 days	176	143	164	156
In water 9 days	179	147	168	157
In water 11 days	184	149	173	159
In water 14 days	187	150	176	159
In water 17 days	192	152	176	161
In water 25 days	198	155	180	161
In water 30 days	207	158	186	166

[a] See tables given by S. M. Rowe: The Preservation of Timber (souvenir edition). Chicago, 1900.

It will be noted that almost half of the increase in weight came during the first two days of soaking. The woods were kiln-dried after a long air seasoning. A similar test was made with pieces of the same woods which had not been kiln-dried; the only difference found was that they absorbed water more readily during the first few days. Fig. 1 gives an indication of the rate at which air-dried wood will absorb water when submerged and lose it again when exposed to the air and sun. A number of absolutely air-dry blocks were kept submerged in water for five days. The gain in weight was noted from day to day.

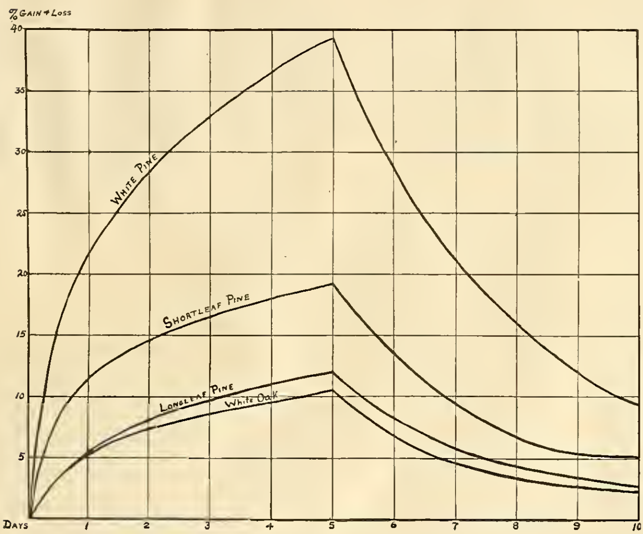

FIG. 1.—Diagram showing absorption and loss of water by dry wood.

After five days the same blocks were placed out of doors, exposed to sun and wind. The curves show the rate of absorption up to the sixth day, and the corresponding rate of loss thereafter.

While this series of curves will, of course, hold only for the particular conditions under which this test was made, especially as regards drying, it nevertheless indicates how rapidly dry wood will absorb water and lose it again. It shows likewise that light, porous wood will absorb more water in a given period than heavier and denser wood.

V. SEASONING AND PRESERVATIVE TREATMENT.

SEASONING AND THE LEACHING OF SALTS.

Where timber is chemically treated with salts dissolved in water, it will be absolutely necessary to season it after the treating process, for two reasons: First, to prevent the rapid leaching out of the salts pressed into the wood; second, to prevent subsequent decay. The practice, unfortunately in vogue in many cases, of placing timber treated with a water solution in positions where it comes in contact with water, can not be condemned too strongly. In the case of ties, the leaching out of salts takes place with startling rapidity when they are laid immediately after treatment.

The manner in which salts soluble in water leach out, and the relation of seasoning to this, is illustrated in a diagrammatic manner by figs. 2 to 6. Let us suppose for the sake of illustration that a piece of pine wood is treated with a 20 per cent solution of

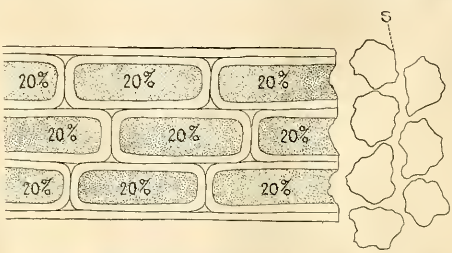

Fig. 2.—Manner in which soluble salts leach out from treated timber.

zinc chlorid. In consequence the cell openings are filled with this solution for some distance into the wood. Fig. 2 represents several series of wood cells, very much shortened for the sake of bringing them into the diagram. The dotted areas indicate water or watery solution of zinc chlorid. Let us assume that these cells are situated at the end of a tie, and that the ballast of sand touches them. The rounded masses marked *s* represent the sand grains, with air spaces between them. Immediately after treatment the cells are filled with the 20 per cent solution of zinc chlorid, and the spaces between the ballast particles are filled with air. Several days later a rain storm fills these air spaces with water. We then have pure water touching directly a 20 per cent solution of zinc chlorid. It is a well-known law of solutions that solutions of different densities tend to mix until a solution of medium density is formed. Shortly after the rain storm, therefore, the 20 per cent solution of zinc chlorid in the outer wood cells will have been reduced, let us say, to a 10 per cent solution, and

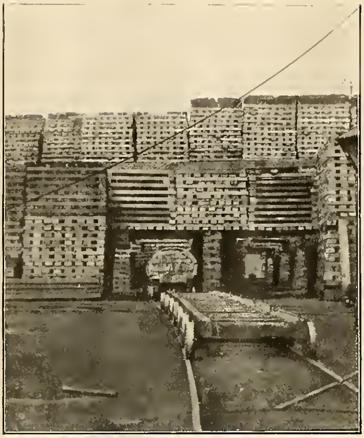

FIG. 1.—SCOTCH PINE TIES SEASONING, GREAT WESTERN RAILWAY, ENGLAND.

FIG. 2.—PILING BALTIC PINE ON THE GREAT WESTERN RAILWAY, ENGLAND.

FIG. 3.—TIES ARRIVING IN CANAL BOATS, GREAT WESTERN RAILWAY, ENGLAND.

FIG. 4.—ANOTHER VIEW OF FIG. 2.

PILING PINE ON THE GREAT WESTERN RAILWAY, ENGLAND.

FIG. 1.—TIE YARD, SHERIDAN, WYO., APRIL, 1902—SOLID PILES.

FIG. 2.—TIE YARD, SHERIDAN, WYO., SEPTEMBER, 1902—OPEN PILES.

the pure water in the ballast has become a 10 per cent solution of zinc chlorid (fig. 3). There has been, in other words, a transfer of some of the zinc salt from the wood into the ballast. When the rain stops, all the water in the spaces between the sand grains runs off into the lower strata of the ballast. Meanwhile a process of equalization has been going on among the various wood cells, which began as soon as some of the salt left the outermost cells. Fig. 4 shows in a diagrammatic

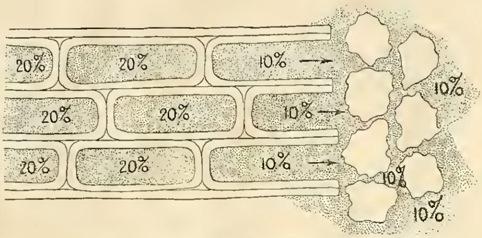

FIG. 3.—Manner in which soluble salts leach out from treated timber.

way what this process is. Some of the zinc chlorid in the second tier of wood cells passes through the walls into the outermost cells, and this continues until the solutions in the two series are practically of equal strength, i. e., about 15 per cent. In the same way the third tier of cells loses some of its salt to the second, the fourth to the third, and so on. This practically amounts to a gradual traveling of the zinc salt outward in the tie toward the end. The next rain storm will

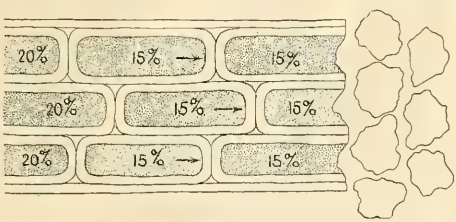

FIG. 4.—Manner in which soluble salts leach out from treated timber.

reduce the 15 per cent solution in the outer wood cells to a 7.5 per cent solution, which will again be strengthened from the inner cells. Thus the zinc chlorid gradually leaves the wood until none is left. This gradual traveling outward of the zinc chlorid goes on with varying rapidity, depending on the amount of water in the ballast, the frequency with which the water is renewed, and its temperature.

In the case of seasoned wood something very different takes place. When the wood dries the zinc salt is deposited in crystalline form in the wood cells and walls as shown in fig. 5. When the rain water fills the spaces between the sand grains, as represented in fig. 6, it passes into the outer wood cells and dissolves some of the zinc salt there. This passes out just as it did in the first case, except that in this instance the water must first of all dissolve the zinc chlorid, which in the former instance was already in solution. Only a portion of the salt is thus dissolved. Moreover, the water does not penetrate very far, for the air in the cell

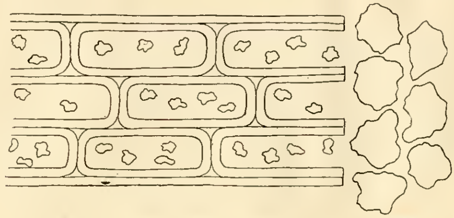

FIG. 5.—Manner in which soluble salts leach out from treated timber.

cavities forms a considerable obstacle to its entrance. When the rain ceases the water in the outer cells evaporates, leaving some of the salt in the cells. After this evaporation there is no transfer of zinc salt from the inner wood cells toward the outer cells. This is a matter of great importance, for it means that the salt injected remains for a much longer period in the seasoned than in the unseasoned wood. Subsequent rain storms do not materially change the conditions, for with every one only the outer cells are apt to have salt leached out from their cavities.

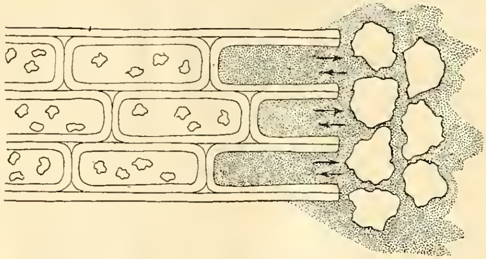

FIG. 6.—Manner in which soluble salts leach out from treated timber.

The cells shown in figs. 2 to 6 might represent wood cells from any part of a tie. In practice the leaching out of salts usually takes place first in the middle of the tie, and around the spike and under the rail or tie plates. The water collects in the spike holes or in any crack or check in the tie, and the conditions described are thereby produced. Ends of fibers are exposed in the spike hole and in every crack, or wherever the wood fibers are torn or broken.

A crude test was made with several Lodgepole Pine ties for the purpose of giving at least a partial indication of the different rates at which zinc chlorid leaches out from treated ties with and without seasoning after treatment. Two ties were taken—one which had dried for three months, the other fresh from the treating cylinder. The calculated amount of zinc chlorid in each was about 24 ounces. After twenty-four hours soaking it was found that the seasoned tie had lost 3 ounces of zinc chlorid (calculated from the amount of zinc chlorid in the water), while the newly treated tie had lost 5.5 ounces, or almost twice as much. Stating these figures in another way, the seasoned tie had lost in twenty-four hours about one-eighth of the salt injected, and the freshly treated tie about one-fourth of its salt.

A test which gives more reliable figures was conducted as follows: A number of Lodgepole Pine ties were treated with zinc chlorid, and the amount of salt absorbed was determined by weighing the tie before and after treatment. The ties were then sawed in half. One-half of each tie was placed in water for twenty-four hours, at the end of which period the amount of salt leached out was determined and the half ties allowed to dry for twenty-four hours, after which they were again submerged. This process was kept up for several days. The second half of each tie dried until air-dry, and was then alternately submerged and dried just as the first halves had been, the amounts of salts leached out being determined after every leaching. The following table shows the results obtained:

TABLE II.—*Leaching of zinc chlorid.*

FRESHLY TREATED LODGEPOLE PINE (12 HALF TIES).

Number of tie.	Grains leached in 24-hour periods.					
	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.
1	720	247	270	150	168	161
2	500	378	210	187	120	131
3	600	405	380	307	285	262
4	330	324	323	140	210	187
5	375	255	290	209	153	120
6	500	255	360	437	405	310
7	370	126	250	125	255	202
8	680	250	350	212	210	237
9	937	570	412	292	170	220
10	630	307	290	210	159	225
11	650	345	291	214	220	205
12	735	360	250	236	107	157
Average	585	318	306	226	205	201

TABLE II.—*Leaching of zinc chlorid*—Continued.

SEASONED LODGEPOLE PINE (12 HALF TIES).

Number of tie.	Grains leached in 24-hour periods.					
	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.
1	555	500	69	92	125	62
2	460	337	127	67	60	31
3	439	365	197	131	100	45
4	1,250	300	212	150	156	62
5	620	157	82	92	120	57
6	675	472	236	147	162	80
7	512	350	140	81	137	57
8	770	332	200	105	137	78
9	805	390	117	150	86	87
10	675	260	127	90	123	55
11	800	405	250	150	150	92
12	562	360	92	57	115	45
Average	677	352	154	109	122	62

It will be noted that the first two columns show an even larger amount of leaching from the dry than from the seasoned ties. This was probably due to numerous small checks caused by rapid drying, which exposed a larger surface to the action of the water. Later determinations, however, show a very marked falling off in the amount of leaching from the dry ties compared with the freshly treated ones. This is exactly what ought to have taken place according to the theory of leaching set forth above. The salt which leached out from the dry ties at first came from the outside of the wood. When it was removed the leaching was materially reduced, because there was no chance for the salts within the tie to move toward the outside. These tables are still incomplete. Completed tables will be published in a succeeding bulletin.

Attention is here called to the results obtained in seasoning Lodgepole Pine ties after treatment, given on page 38. It will be sufficient to say at this point that ties treated in June, 1902, lost 24 to 26 per cent of their weight after seasoning three weeks.

Lodgepole Pine fence posts, treated with zinc chlorid June 2, 1902, and then piled in an open pile to season, lost water in the next sixty-five days as shown in the table on the following page.

FIG. 1.—TIE CHOPPER MAKING TWO STRAIGHT FACES ON THE STICK.

FIG. 2.—PEELING THE BARK FROM THE LODGEPOLE PINE.

MAKING A TIE OUT OF LODGEPOLE PINE TIMBER, BOZEMAN, MONT

FIG. 1.—LODGEPOLE-PINE FOREST WITH TIE TIMBER CUT OUT.

FIG. 2.—CUTTING OF TIES IN THE WOODS.

TABLE III.—*Lodgepole Pine fence posts—Evaporation of water after treatment with zinc chlorid.*

[Thirty-nine posts. Treated June 2, 1902.]

	Weight of 39 posts.	Average weight per post.	Gain (+) or loss (−) in weight per post.	Per cent of gain (+) or loss (−).
	Pounds.	*Pounds.*	*Pounds.*	
Before treating	2,575	66.03	....	....
1 hour after treating	4,660	119.48	+53.45	+80.94
1 day after treating	4,450	114.10	− 8.38	−10.06
2 days after treating	4,325	110.90	− 8.58	−16.05
3 days after treating	4,190	107.43	−12.05	−22.54
5 days after treating	4,055	103.97	−15.51	−29.02
7 days after treating	3,860	98.97	−20.51	−36.37
10 days after treating	3,657	93.77	−25.75	−48.10
15 days after treating	3,488	89.43	−30.05	−56.22
23 days after treating	3,295	84.50	−34.98	−65.44
31 days after treating	3,162	81.08	−38.40	−71.83
35 days after treating	3,072	78.77	−40.71	−76.16
42 days after treating	2,996	76.82	−42.66	−79.81
50 days after treating	2,900	74.36	−45.12	−84.41
55 days after treating	2,844	72.92	−46.56	−87.11
61 days after treatiug	2,780	71.29	−48.19	−90.16
65 days after treating	2,716	69.64	−49.48	−92.57

It will be seen that in the two months about 93 per cent of the water injected into the posts by the treatment evaporated, leaving practically dry zinc chlorid in the wood cells. Most of these posts were set in Nebraska and Wyoming, together with some untreated posts. Six are still piled and will be placed in the ground in a Southern State during the winter of 1902–3.

SEASONING AND THE PROCESSES OF PRESERVATION.

The question of the relation of the water content of timber to the various treating processes has so far received but little attention in this country. The subject is one of the greatest importance, for much of the ultimate success of most forms of timber treatment depends upon the amount of water in the wood before treatment. Mr. O. Chanute and others have repeatedly urged the absolute necessity for thorough seasoning of timber before treatment with zinc chlorid. The success of timber treatment depends upon a series of factors entirely apart from the mere impregnation of the wood with one substance or another, and the sooner it is realized that the actual treatment is only one small part in the operations tending to obtain increased length of life, the better it will be.

The object of timber treatment is to get certain chemical compounds into the wood with as much thoroughness as possible. Because of its peculiar structure, wood will not allow of the penetration of liquids into its mass as does a sponge. The solution must work its way into the wood fibers through walls of wood substance. If a water solution is used for the impregnating material, it ought to fill every cell and permeate every wall, at least in the sapwood. The most successful method for timber treatment (excepting the boiling process) so far used consists in pressing the solution into the wood. If the wood cells and the walls are already full of water, it is easy to see that there will be great difficulty in making the water already in place give way to the solution. When walls and cell cavities are free from water the process of absorption of a solution is facilitated by the readiness with which the capillary forces operative in wood fiber aid the absorption. Nor is this all. Seasoning not only brings about a reduction in the amount of water, but also results in the partial disintegration of the albuminous substances which offer more or less resistance to the entrance of solutions. The steaming of wood before the injection of the solution can never replace seasoning as a means of preparation for treatment, for at best it does no more than drive off part of the water.

When the substance used is ordinary creosote or tar oil, the matter of seasoning is still more important. At the present time there are several plants in operation where green or watersoaked wood is steamed in a cylinder for varying lengths of time and then treated with tar oil, which is run in after the formation of a vacuum. The reason given for this method of operation is that just as effective a penetration of the tar oil is secured at a lower cost, since the timber does not have to be held until it is seasoned. An extended discussion of this subject is reserved for another report. It is enough to say now that tar oil and water do not mix, and that a porous medium entirely or partially filled with water will not become so thoroughly penetrated as one which is dry. Dry wood fiber absorbs tar oil with great readiness, as anyone can prove who will pour tar oil into the ends of two pieces of wood, one dry and one moist. To the claim frequently made that wood when steamed is absolutely dry, one may answer that such is indeed true when the temperature is raised sufficiently high to reach to the very center of the piece of wood treated, but such temperatures are frequently so high that the wood fiber itself is materially injured.

The experience of the European railroads and other consumers of treated timbers is so very conclusive that it seems almost needless to contend for a careful seasoning of timber before treatment. The great objection made against it is the time required. The risk taken when timber is held, as well as the interest on the investment, is sometimes considerable; but it is believed that the tests already made and those in progress will serve to show that in the long run the saving from better service far exceeds the cost.

Another consideration of decided importance is the time required for the treatment. No definite data are yet at hand which will admit of a fair comparison, but it is a matter of experience that the length of time necessary to treat seasoned wood with any of the ordinary preservatives is very much shorter than for unseasoned. Careful tests are now in progress with Lodgepole Pine, and similar tests will be made with other timbers this year.

If, therefore, we take into consideration the greater thoroughness with which timber can be treated after ample seasoning, as well as the larger amount which can be treated in a given time, it would appear that any treatment which does not accurately specify that all wood must be thoroughly seasoned before treatment with zinc chlorid, tar oil, or both, or any combination which contains salts, should be regarded with disfavor. It is claimed for several processes, notably for the Hasselmann and the electrical treatments, that green wood can be treated as well as seasoned wood. Should this prove true, the objections made to the ordinary methods of treatment would not apply to them.

VI. ADVANTAGES OF SEASONING.

Two most important advantages of seasoning have already been made apparent:

(1) Seasoned timber lasts much longer than unseasoned. Since the decay of timber is due to the attacks of wood-destroying fungi, and since the most important condition of the growth of these fungi is water, anything which lessens the amount of water in wood aids in its preservation.

(2) In the case of treated timber, seasoning before treatment greatly increases the effectiveness of the ordinary methods of treatment, and seasoning after treatment prevents the rapid leaching out of salts introduced to preserve the timber.

Additional advantages of seasoning are:

SAVING IN FREIGHT.

Few persons realize how much water green wood contains, or how much it will lose in a comparatively short time. Experiments along this line with Lodgepole Pine, White Oak, and Chestnut gave results which were a surprise, not only to the companies owning the timber, but also to the writer. Freight charges vary much in different parts of the country; but a decrease of 35 to 40 per cent in weight is important enough to deserve everywhere serious consideration from those in charge of timber operations. When timber is shipped long distances over several roads, as is coming to be more and more the case, the saving in freight will make a material difference in the cost of ties, bridge materials, etc., irrespective of any other advantages of seasoning.

USE OF CHEAP TIMBERS.

One of the questions which is engaging the attention of all large consumers of timber is the possibility of substituting low-grade timbers for those of a higher grade now in use. High and low grade are of course relative terms; a timber which is called low grade to-day may a few years hence be classed as high grade. Such a change has taken place in the past in the case of White Oak. From the point of view of the railroads the question of high or low grade is primarily a question of the durability, or "length of life," of different kinds of timber for their particular needs—as ties, fence posts, and telegraph and telephone poles. This, however, is complicated by the effect on prices of the general market demand. The price for a hewn White Oak tie in southern Illinois, delivered on the right of way, is 35 cents. But White Oak timber will bring twice this price, and frequently more, for boards, staves, etc. This discrepancy in prices is bound to increase with the increasing use of White Oak timber in the form of lumber, and with increasing scarcity. It is very obvious that it is a poor business policy for anyone owning timber to sell it for ties when he can get more for it in the form of lumber. Consequently the railroads must pay more and more for their ties, or find a substitute for White Oak in some cheaper material. In former years an investment of from 20 to 30 cents was amply repaid by the five to seven years' service ordinarily obtained from White Oak ties in the North. Such service will not pay for an investment of 50 to 75 cents. It is very evident to most railroad men that some change will have to be brought about, and in fact such a change is actually taking place now.

A further consideration lies in the interest of other industries which depend on a constant supply of White Oak. The manufacturer of tight barrels, for instance, must have White Oak, and can not substitute the porous Red Oak. If the railroads continue to use White Oak for ties, they are cutting off a supply which will seriously affect such industries. If White Oak were the only available material for ties, this consideration would have no weight; but such is not the case. In the regions which now contribute most largely to the White Oak supply, a number of inferior oaks are found in even greater abundance, and it will probably be only a short time before most railroad companies will learn that these timbers can be used just as well as White Oak. In a number of recent contracts, lumber contractors have been allowed the option of furnishing Red Oak "properly treated" in place of White Oak.

The same facts hold true for other classes of timber. During the past year the Lodgepole Pine of the Northwest has been substituted for the higher grade Bull Pine. It is believed that the time is not far distant when the Longleaf Pine will no longer be used for ties, particularly in Mississippi, Louisiana, and Texas, for its value in the form of lumber is already so high that any marked increase will bring about a situation very much like that which now obtains in the case of White Oak. The Shortleaf and Loblolly pines will then find a use for which they can be prepared at a cost low enough to permit of their economical employment.

FIG. 1.—DRAGGING TIES TO THE FLUME.

FIG. 2.—TIE PILES AT THE FLUME.

FIG. 1.—THROWING TIES INTO THE FLUME.

FIG. 2.—TIES READY FOR THE FLUME.

FIG. 1.—TIE FLUME.

FIG. 2.—ANOTHER VIEW OF FLUME.

FIG. 1.—END OF FLUME AT RAILROAD TRACK.

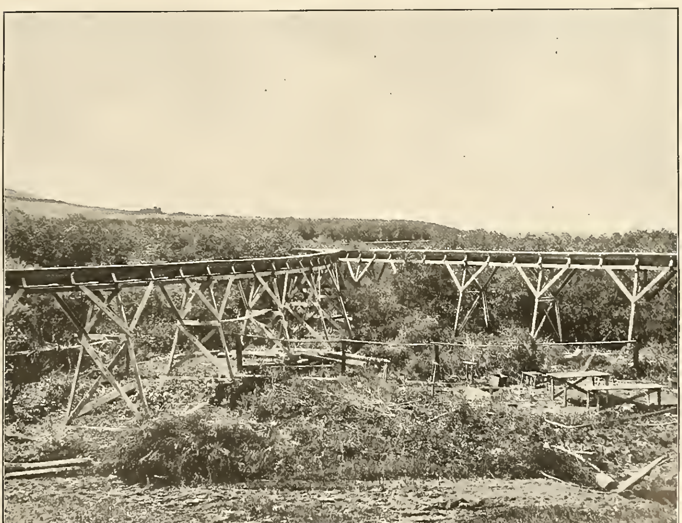

FIG. 2.—ANOTHER VIEW OF SAME.

One of the first questions to arise when we consider the substitution of Red and Swamp Oak for White Oak, Loblolly Pine for Longleaf Pine, or Hemlock and Tamarack for oak and pine, is, What shall be done to these timbers so as to get the maximum value out of the investment? The crux of the situation is the comparative lasting powers of the various timbers. That which applies to ties holds true also for telephone and telegraph poles, fence posts, bridge material, etc.; in short, for all timbers which are exposed to decay. It is believed that, by proper treatment, timbers which otherwise could not be used for the purposes specified above can be made to serve longer than the untreated timbers in use up to the present time.

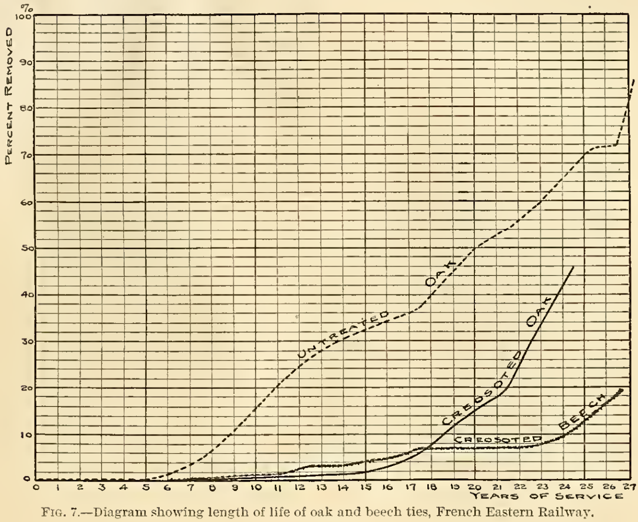

FIG. 7.—Diagram showing length of life of oak and beech ties, French Eastern Railway.

The relative ease with which so-called high and low grade timbers can be treated is another matter requiring consideration. As a rule, high-grade timbers—Longleaf Pine or White Oak, for instance—are very much denser than the lower grades, such as Loblolly Pine or Red Oak. The latter generally have a higher percentage of sapwood, which can be penetrated by a treating fluid very much more readily than heartwood. On account of this greater porosity it is very much more economical to treat a porous wood thoroughly with a good preservative than to treat a more expensive denser wood with a cheaper preservative. The cheap and porous wood well treated will outlast the other in every instance. Fig. 7 shows this graphically. The short-lived, porous Beech, which ordinarily lasts but four to five years, has outlasted the Oak several times over. It would be a great waste, therefore, to attempt the treatment of White Oak or Longleaf Pine when better results will be obtained by using Loblolly Pine or Red Oak.

One of the first steps in the process of making short-lived timbers fit for treatment consists in a proper seasoning. More benefit will result from taking care of the short-lived timbers than from similar treatment of those with longer life. The former are frequently short lived because of their greater porosity, which may mean a higher water content, and which always means a greater power of absorbing and holding water. The economical substitution of cheap for high-priced timbers is impossible without proper seasoning. The loss from the shortened term of service of unseasoned timber is very much greater in the case of porous than of the denser kinds, which are much less permeable by water, and consequently offer greater resistance to decay. Susceptibility to decay in timber is a consequence both of relatively high porosity, which may mean a high water content, and always means a greater absorptive power, and of a large percentage of sapwood, which furnishes, by its stores of organic matter, food for wood-destroying fungi. Seasoning greatly lengthens its life, because it rids it as far as possible of its water and brings about a disintegration of much of the organic matter, in both ways lessening the chances for destruction of the wood by its fungus enemies. Seasoning is therefore of the first importance for the utilization of cheap timbers hitherto regarded as short-lived.

PREVENTION OF CHECKING AND SPLITTING.

Under present methods much timber is rendered unfit for use by improper seasoning. Pl. III furnishes a good example of this. Green timber, particularly when cut in the fall or winter, contains a large amount of water. When exposed to the sun and wind the water will evaporate more rapidly from the outer than from the inner parts of a log, and more rapidly from the ends than from the sides. As the water evaporates, the wood shrinks, and when the shrinkage is not fairly uniform the wood cracks. When wet wood is piled in the sun, as were the ties and timbers shown on Pl. III, evaporation goes on with such unevenness that the timbers split and crack so badly as to become absolutely useless. Such uneven drying can be prevented by careful piling. A very large number of ties and timbers split from this cause are thrown out of use every year, and it is time that more attention were given to prevent this waste.

In Europe many railroads use S irons, which are driven into the ends of timbers in danger of splitting, and effect a great saving. Fig. 8 shows such an iron,[a] and fig. 9 its manner of application.

[a] Reprinted from Bull. 14, Bureau of Plant Industry, U. S. Department of Agriculture, 1902.

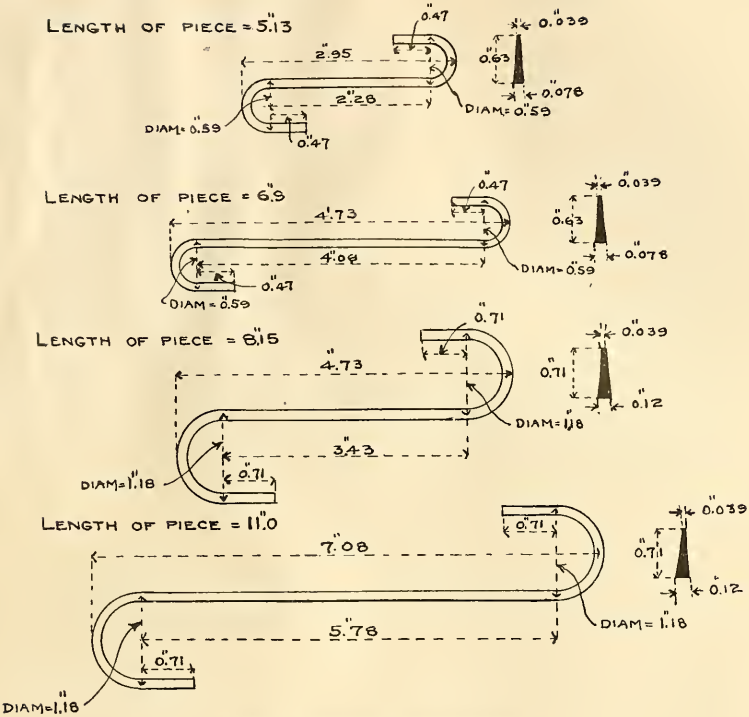

FIG. 8.—"S" irons used to prevent checking.

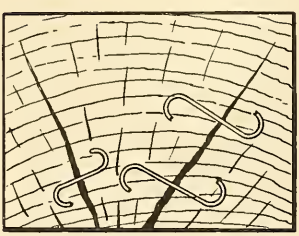

FIG. 9.—Method of applying "S" irons to prevent checking.

VI. HOW TIMBER IS SEASONED.

KILN DRYING.

As kiln drying is employed mostly to prevent the warping and checking of wood, and only rarely to prevent decay, it is not necessary to dwell at length upon this method of seasoning. In the Southern States it is often used to prevent the development of the blue fungus during the spring, when the percentage of moisture in the air is very great.

SEASONING IN OTHER COUNTRIES.

Seasoning of timber has been carried on in a practical way for many years in Europe. Most of the European railroads season their ties for many months before they treat them. The tie piles of the Great

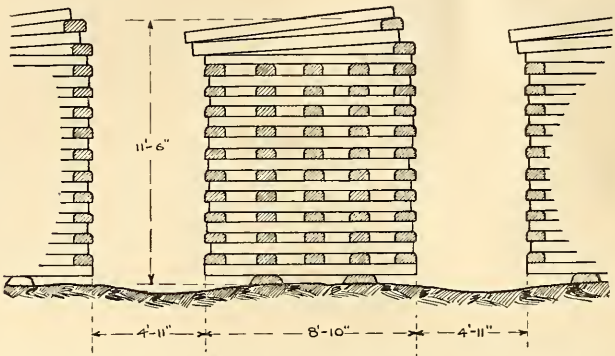

Fig. 10.—Pile of ties on French Eastern Railway. (Reprint from Bull. 14, Bureau of Plant Industry, U. S. Department of Agriculture, 1902.)

Western Railway of England (Pl. IV) are a novel sight to the American observer. The ties are piled by means of a donkey engine, and remain in piles for from five to twelve months. The Baltic Pine used by this road is very moist when it arrives; but in the high, open piles it dries out very rapidly, and when finally seasoned it absorbs in a few hours the tar oil with which it is treated. The French Eastern Railway piles its ties in open piles (fig. 10) 3.50 meters (11.4 feet) high, 2.7 meters (8.8 feet) wide, and 2.7 to 20 meters (8.8 to 65.6 feet) long. The piles are 1.5 meters (about 5 feet) apart. The ties are spaced with intervals of 0.1 meter (4 inches) between ties, except that the top tiers are inclined, as shown in the figure, to shed rain water. At Amagne some 400,000 untreated and treated ties can be placed. Oak ties are allowed to remain in piles for from fifteen to twenty months; Beech ties, six months. The French engineers assert that a good uniform

FIG. 1.—LANDING PLATFORM, BOZEMAN, MONT.

FIG. 2.—ANOTHER VIEW OF LANDING PLATFORM.

FIG. 1.—LODGEPOLE PINE—SOLID PILE.

FIG. 2.—LODGEPOLE PINE—HALF-OPEN PILE.

treatment with tar oil can not be obtained even with air-dry ties, which they therefore dry in a kiln before treatment for from sixty to eighty hours at a temperature beginning at 35° C. and gradually brought to 75° C. A complete description of the method of kiln-drying will be found in the Appendix.

The following table shows the importance of kiln-drying to secure the most perfect removal of water:

TABLE IV.—*Loss of weight by out-of-door seasoning and kiln drying—French Eastern Railway.*

Kind of timber.	Average weight per tie.			Average weight per cubic meter.			Loss in weight in per cent of original weight.	
	At arrival.	After air seasoning.	After kiln drying.	At arrival.	After air seasoning.	After kiln drying.	After air seasoning.	After kiln drying.
	Kilos.	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Per cent.*	*Per cent.*
Oak (18 months air drying; 144 hours in dry kiln; size of tie, 0.09 cubic meters)	89	74.8	72.5	0.99	0.831	0.805	16	18.7
Beech (6 months air drying; 72 hours in dry kiln; size of tie, 0.097 cubic meters)	95	71.0	67.9	.98	.733	.70	25	28.5

It appears from this table that the kiln drying removes 3 to 4 per cent additional water from the wood after the out-of-door seasoning.

Further advantages of the French method of kiln drying are specified as follows:

But the kiln drying is not only for the purpose of completing the open-air seasoning. It also assures a perfectly uniform preparation at all seasons of the year, and sometimes with woods which could not be left long enough to dry in the yards. Further, as the kiln-dried woods are hot when they enter the cylinders, the heavy oil which comes into contact with them there, is kept always fluid and at a nearly even temperature, and consequently penetrates them so much the deeper.[a]

Fig. 11 shows the average variation in weight per cubic meter, i. e., the specific gravity, from month to month, as determined by engineers of the French Eastern Railway. The ties were piled as described, during the winter, from two to three months after being cut.

The practice on other European roads differs considerably with the kind of timber used and the time of felling. In some cases, as in that of the Hungarian State Railways, the bark is stripped from newly felled trees and the trunks stacked in the woods for one to two years: other roads stack only three or four months. New Zealand railroads

[a] Note sur la preparation des traverses à la compagnie des chemins de fer de l'Est. M. V. Dufaux. Extract from Rev. Generale d. Chemins de Fer., Jan. and Mar., 1898, p. 19.

report no stacking at all. In Australia the Australian Southern Railroad specifies that wood cut in winter must have its bark removed, while that cut in summer can at once be cut up.

The loss of weight by evaporation in Hungary is shown by the following quotation:

> The Austro-Hungarian State Railway has observed that wood when felled contains 40 per cent of water; five months subsequently it contains about 30 to 35 per cent; and after it has been stored a year it contains about 20 to 25 per cent. (International Railway Congress. Question VIII, p. 11. Paris, 1900.)

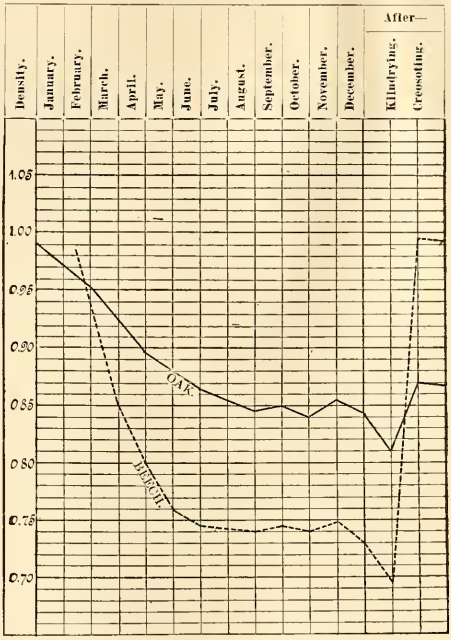

FIG. 11.—Diagram showing average loss in weight by seasoning of oak and beech timber during one year, French Eastern Railway.

In Russia oak ties are stacked from three to six months. Treatment sometimes follows and sometimes not, some lines having found that the increased length of life of a thoroughly seasoned oak tie treated with zinc chlorid does not pay for the additional cost. Their oak is so superior to our best American oaks that their practice affords no criterion for us.

In general, all railroad ties, bridge materials, telegraph poles, fence posts, etc., are commonly seasoned in Europe, and to some extent in other countries. The time of seasoning varies from several months to two years.

SEASONING BY STEAMING.

Where time is so important as it is in business affairs to-day, it is often a serious matter to hold timber for from four to six months before using it. In addition to the loss of interest on the capital invested there is also constant danger from fire. Any method by which timber could be seasoned rapidly and economically would be of great value. Reference has been already made to the use of live steam for this purpose. In a number of timber-treating plants in this country green or water-soaked wood is steamed for several hours to prepare it for the injection of chemicals. Steaming is also used to some extent with material for furniture manufacture. Steaming is said to coagulate the albuminous substances present in wood, thus rendering the walls of the wood fibers more permeable. That such is its effect there can be no doubt, for these coagulated albuminous substances make up a large proportion of the solid parts of the so-called "sap" which remains in the retorts after steaming. This "sap" is water driven out of the wood by the expansion of the air within it and by the entering water vapor, and it holds in solution and suspension the albuminous substances referred to, various tannin bodies, resins, oils, etc. Steamed wood certainly ought to last longer than unsteamed, and where it is necessary to secure partially seasoned wood the steaming may do. It is, however, at best a makeshift, and unless modified materially it can never replace open-air seasoning, supplemented possibly by kiln-drying. There is danger of injury to the wood fibers from too high a temperature. There may be absolutely no harm in prolonged steaming at high temperature, but in the present incomplete state of our knowledge it is better to be on the safe side. It has been pointed out that the steaming process after all does not remove all water unless the temperature is very high. The use of the vacuum pump does not materially improve matters, for it is not possible to maintain a sufficiently high temperature in a cylinder in which enough of a vacuum exists to insure the complete removal of all water.

A recent publication refers to the extensive use of steam seasoning in Australia. No details, however, have as yet been obtainable.

SEASONING BY IMMERSION IN WATER.

It is an old saying that wood put into water shortly after it is felled, and left in water for a year or more, will be perfectly seasoned after a short subsequent exposure to the air. For this reason river men maintain that timber is made better by rafting. Herzenstein says:[a]

Floating the timber down rivers helps to wash out the sap, and hence must be considered as favorable to its preservation, the more so as it enables it to absorb more preservative.

Wood which has been buried in swamps is eagerly sought after by carpenters and joiners, because it has lost all tendency to warp and twist. When first taken from the swamp the long-immersed logs are very much heavier than water, but they dry with great rapidity. A Cypress log from the Mississippi Delta, which two men could barely handle at the time it was taken out some years ago, has dried out so much since then that to-day one man can lift it with ease. White Cedar telephone and telegraph poles are said to remain floating in the water of the Great Lakes sometimes for several years before they are set in lines and to last better than freshly cut poles.

It is very probable that immersion for long periods in water does materially hasten subsequent seasoning. The tannins, resins, albuminous materials, etc., which are deposited in the cell walls of the fibers of green wood, and which prevent rapid evaporation of the water, undergo changes when under water, probably due to the action of bacteria which can live without air, and in the course of time many of these substances are leached out of the wood. The cells thereby become more and more permeable to water, and when the wood is finally brought into the air the water escapes very rapidly and very evenly. Herzenstein's statement that wood prepared by immersion and subsequent drying will absorb more preservative, and that with greater rapidity, is certainly borne out by experience in this country.

SEASONING BY BOILING IN OIL.

It is sometimes claimed that all seasoning preparatory to treatment with a substance like tar oil might be done away with by putting the green wood into a cylinder with the oil and heating to 225° F., thus driving the water off in the form of steam, after which the tar oil would readily penetrate into the wood. This is the basis of the so-called "Curtiss process" of timber treatment. Without going into any discussion of this method of creosoting, it may be said that the same objection made for steaming holds here. In order to get a temperature of 212° F. in the center of the treated wood the outside temperature would have to be raised so high that the strength of the wood might be seriously injured.

A company on the Pacific coast which treats Red Fir piling asserts that it avoids this danger by leaving the green timber in the tar oil at a temperature which never exceeds 225° F. for from five to twelve hours, until there is no further evidence of water vapor coming out of

[a] Bull. Internat. Railway Congress. Question VIII. Paris, 1900, p. 10.

the wood. The tar oil is then run out, and a vacuum is created for about an hour, after which the oil is run in again and is kept in the cylinders under 100 pounds pressure for from ten to twelve hours, until the required amount of absorption has been reached (about 12 pounds per cubic foot).

OUT-OF-DOOR SEASONING.

The most effective seasoning is without doubt that obtained by the uniform, slow drying which takes place in properly constructed piles outdoors, under exposure to the winds and the sun. Lumber has always been seasoned in this way, which is still the best and cheapest for ordinary purposes. The methods in use have been determined by long experience, and are probably as good as they could be made for present conditions. But the same care has not up to this time been given to the seasoning of such classes of timber as ties, bridge material, posts, telegraph and telephone poles, etc. These have sometimes been piled more or less intelligently, but in the majority of cases their value has been too low to make it seem worth while to pile with reference to anything beyond convenience in handling. A discussion as to possible methods is given in the following chapters.

VIII. PLAN FOR SEASONING TESTS.

In the foregoing chapters an attempt has been made to present a general view of the seasoning of timber—what it is, how it works, and what its advantages are. Although the general facts are a matter of common knowledge, there are scarcely any exact data in existence concerning some of the most important phases of the subject. This is particularly true of timber in the form of railroad ties and telephone and telegraph poles. The first step necessary toward working out the most practical and economical methods of using timber for test purposes must be a careful study of all the processes involved in seasoning. To this end a series of tests on a uniform plan has been inaugurated, applicable both to the kinds of timber now in use and to kinds which may come into use in the future. It ought to be emphasized, however, that to secure reliable data it will be necessary to carry on these tests for a number of years, with a large number of pieces of many different kinds of timber, and in different parts of the country. The reason for this is that the variability in the physical characteristics of timber, even of the same kind, is so great that figures obtained from a small number of pieces are very apt to be entirely unreliable. A glance at some of the figures in the tables given below will show this. In the case of different kinds of timber, or of different timbers of the same kind grown under different climatic conditions or seasoned in different years, the same thing is true in still greater degree.

In determining the amount of seasoning, some standard of measurement had to be taken. As the loss in weight due to the evaporation of water forms the largest part of the seasoning process, it was decided to adopt the test of the loss of weight as furnishing the nearest approach to an absolute register of the degree of seasoning which can be given numerical expression.

The specific questions which it is proposed to investigate in the series of seasoning tests which has been inaugurated are:

(1) The variation in character and weight of wood, and in the rate at which the wood loses water, among trees of the same species grown under the same conditions and of the same age—that is, individual variation in seasoning.

(2) The variation in the water content of the same timber in different months, and the length of time necessary to dry it properly at different seasons—that is, seasonal variation in seasoning. This inquiry will have the important result that it will settle the question of the best time to cut timber.

(3) The variation in the amount of water in different parts of the same tree, or regional variation. Top wood is generally believed not to be so good as butt wood, and much of it is therefore rejected. Ties and posts from the tops and bottoms of a large number of trees will be tested to determine the amounts of water in both parts, and the rate at which they will season.

(4) The effect of bark on seasoning. Although it is universally known that bark will retard and almost prevent seasoning, unbarked ties and piles are nevertheless sometimes used. A test will be made to show exactly to what extent this shortens the length of life of timber.

(5) The rate of seasoning of sawed, hewn, and planed timber. At present more hewn than sawed timber is in use; but as sawing is cheaper, it is probable that this condition will soon be reversed. It is important to know whether there is any material difference in the rate of seasoning between sawed and hewn timber. The saw cuts many wood fibers so as to expose their open ends, and it is conceivable that the rate of water evaporation may be influenced somewhat by this fact. Then again, the rough surface of sawed timber may retard evaporation. It is therefore proposed to compare the rate with that of planed timber.

(6) Great practical value is expected to attach to a series of experiments intended to answer the question how ties, poles, and other timbers should be piled to season them in the shortest possible time.

(7) Getting timber into immediate use counts for so much nowadays that it is very important to know just how long treated timber must be held to secure the thorough drying on which much of the efficacy of treatment depends. It is proposed to make accurate tests in various parts of the country to determine the shortest period during which treated timber should be held, and what method or methods of piling will bring about the most rapid results.

IX. SEASONING TESTS WITH LODGEPOLE PINE.

Lodgepole Pine (*Pinus murrayana*) is one of a number of inferior timbers growing in the Northwest which are coming into use. This tree is found in large quantities in the mountains of Wyoming, Montana, and northern Idaho. It is very tall and slender. Its diameter 4 feet above the ground does not average more than 14 inches, and rarely exceeds 20 inches. At an altitude of about 6,000 feet, where it reaches its best development, it has a remarkably long, straight trunk, with a very slight taper. This characteristic makes it a good tree for ties. In the future it may be used also for telephone and telegraph poles.

The wood of Lodgepole Pine contains a very large percentage of sapwood. It is light, soft, and straight grained, and can be worked easily. In drying it checks badly, even when the drying is slow, but the checks are small and rarely extend far into the wood. "The specific gravity of absolutely dry wood is 0.4096, a cubic foot weighing 25.53 pounds."[a] The wood contains a large percentage of water. It is a very short-lived timber, and for this reason has been but little used until lately.

TESTS AT BOZEMAN, MONT.

In April, 1902, experiments were begun in cooperation with the Burlington and Missouri River Railroad in Nebraska, and with Mr. Walter Cooper, of Bozeman, Mont., to determine whether it would pay to season Lodgepole Pine timber. It was believed that with proper care and treatment Lodgepole Pine could be made to last almost as long as Bull Pine timber, and certainly longer than has hitherto been supposed. The experiments are still in progress, and will be continued until sufficient data have been obtained to warrant definite conclusions. A description of the tests is given below. It is preceded by an account of how the ties are made, since a knowledge of these operations is essential to a complete understanding of what happens to the timber afterwards.

MAKING AND DELIVERY OF TIES.

The forest from which the ties were cut grows on a range of mountains at the east end of the Gallatin Valley in Montana, at an elevation of about 6,500 feet. Most of the timber cut stood in a basin at the head of Bear Creek, near Bozeman, and was a fair stand of Lodgepole Pine as it grows in Montana and Idaho. (Pl. VII.)

From three to five pole ties are obtained from a single tree under 14 inches in diameter, breasthigh. Many of the trees are fire scarred at the base, causing a brown rot to set in which makes it necessary to cut off butt logs from 4 to 10 feet in length. Trees larger than 14 inches in diameter, breasthigh, are usually cut into logs, which are trans-

[a] Sargent, C. S., in Silva of North America, XI, 93, 1897.

ported to sawmills, of which there are two in operation on the tract where the test ties were cut. The ties are mostly hewn, 8 feet long, 6 inches thick, and with two 8-inch hewn faces. In order to get a tie of these dimensions, the chopper must have a stick of timber at least 9 inches in diameter at the small end. Much larger ties are often cut, some reaching a width of from 12 to 14 inches at one end. As soon as the tree is felled, the chopper, standing on the timber, makes two straight faces (Pl. VI, fig. 1); he then cuts the tree into 8-foot lengths, allowing 3 inches for the cut. Finally the ties are peeled with a tie peeler. (Pl. VI, fig. 2.) A skillful man can make from 40 to 50 ties per day in good timber. After the ties are made they usually remain in the woods for several weeks before they are dragged out with chains (Pl. VIII, fig. 1), or skidded out on go-devils to the flume, where they are piled, ready for shipment (Pl. VIII, fig. 2, and Pl. IX).

The ties used in the seasoning tests were taken indiscriminately from the general run of ties in the woods. The only difference made in handling them was in skidding them out immediately after cutting, before there was any chance for them to dry. On arriving at the flume each tie was numbered and weighed.

The timber land operated on in the summer of 1902 is about 9 miles from the railroad track and about 1,800 feet above it. Early in the year a flume was built (Pls. IX and X), extending through the timber to the railroad, where a landing was constructed, reached by a siding from the main line (Pls. XI and XII). The flume is about 9 miles long, with an average fall of 200 feet per mile. The water used for floating the timber is obtained from a creek and from a storage reservoir.

It was suggested that drying the ties in the woods would be useless, since they were to be put into the flume afterwards, where they would absorb as much water as they had lost. A test was therefore made to learn how much water dry ties would absorb. A number of ties cut sixty days before, and fairly well seasoned, showed an average weight of 116.61 pounds per tie. To float the 9 miles required about forty-eight minutes. At the end of their journey the average weight was 117.41 pounds, a total gain per tie of only 0.8 pound. Ties in the same seasoned state as these, after immersion in a stream for one hour, showed a gain in weight of 2 per cent, but two hours after they were taken from the water they had returned to their original weight. The tests showed that the amount of water absorbed in the fluming process may be disregarded.

The ties are inspected at the landing, and are then shipped to the timber-treating plant at Sheridan, Wyo.

PILING OF TIES.

Piling tests were made with Lodgepole Pine to learn exactly the rate of water evaporation from the ties under varying conditions and at

FIG. 1.—BEFORE TREATMENT.

FIG. 2.—AFTER TREATMENT.

LODGEPOLE PINE, OPEN-CRIB PILE.

FIG. 1.—TRIANGULAR TIE PILES.

FIG. 2.—LODGEPOLE PINE PILED TO TEST INFLUENCE OF PREVAILING WINDS ON DRYING.

FIG. 1.—OAK PILES, SHOWING LOWEST TIER ON THE GROUND—A POOR METHOD.

FIG. 2.—OAK PILES, SHOWING LOWEST TIER ON THE GROUND—A POOR METHOD.

different seasons of the year. Ties placed in piles of different forms were weighed every two weeks, and the results tabulated. Although timber is known to dry most rapidly when exposed on all sides to the sun and air, close piling was tried as well as open, to show the difference in the length of time required for seasoning and in the rate at which water is lost. In all the piles the lowest layer rested on two bottom ties. About 50 ties went into each pile, and the piles were reversed at each weighing, the top ties of the old pile going to the bottom of the new.

The forms of piles were:

(1) A solid pile, 9 ties each way with no space between. (Pl. XIII, fig. 1.) This method of piling has been largely in vogue, and is still used to some extent by many railroads in this country. It affords very little chance for the circulation of air.

(2) A half-open pile, in which the ties were piled 7 each way, with about 4 inches left between. (Pl. XIII, fig. 2.)

(3) An open pile, or open-crib pile, in which the air circulated freely on all sides of the ties, which were piled in alternate layers, 7 one way and 2 the other. (Pl. XIV.) The piles at Bozeman were built to such a height that men could easily place the ties in position from the ground. At Sheridan, Wyo., it was possible to build much higher open piles (Pls. I and V) because the ties were unloaded from cars. Plate XIV, figs. 1 and 2, show in addition to the open crib method of piling the difference in color between treated and untreated timber. Treatment darkens the color so much that it is possible to distinguish at a glance between the two.

(4) Treated ties were piled also in a form which gives even more air and sun exposure (Pl. XV, fig. 1), viz, a triangular pile, so constructed that no two ties touched at more than one point, and no tie rested entirely on the ground. Where there is plenty of room, as there generally is along the right of way, this form of pile is more rapidly made than the others.

In the diagrams the various forms of piles are designated as follows:

I. Solid pile, 9 by 9 ties.
II. Half-open pile, 7 by 7 ties.
III. Open-crib pile, 7 by 2 ties.
IV. Triangular pile.

WIND DIRECTION.

To test the possible influence of prevailing winds, the open faces of some of the piles were built facing east and west, and of others north and south. (Pl. XV, fig. 2.) One point never lost sight of was to find a method of piling which would give the most rapid results at the least cost. A discussion of the results obtained is presented on p. 34.

INTERVALS OF CUTTINGS.

As one of the objects of the seasoning tests was to determine the monthly variation in the water content of timber, arrangements were made to test ties cut at intervals of one month. This is still going on. About 100 ties are taken every month and piled in the open-crib form, which gives the most rapid results.

PRELIMINARY RESULTS OF SEASONING TESTS.

The following tables present the results of the tests made with Lodgepole Pine timber for the first five months. Although it is perhaps too early to draw definite conclusions, it is believed that the data already obtained have sufficient significance to justify their publication now. They are arranged in two series, of which the first gives the weights of water lost in pounds and in percentages of the original weights of the ties; the second, the loss in weight in terms of specific gravity. A graphical presentation of this second series is given by curves (fig. 12), which will be extended when the weighing tests have been carried on for another six months.

Table V presents the results of tests made with ties which had been in solid piles in the yards at Sheridan for about two months. After the first weighing these ties were piled in three different ways—9 by 9, 7 by 7, and 7 by 2. The table shows the rate at which they lost weight subsequently.

TABLE V.—*Rate of evaporation from partially seasoned ties, Lodgepole Pine, Sheridan, Wyo.*

Date of weighing.	Solid pile, 9 by 9 (60 ties).			Half-open pile, 7 by 7 (65 ties).			Open-crib pile, 7 by 2 (60 ties).		
	Weight per tie.	Loss per tie.	Per cent of loss.	Weight per tie.	Loss per tie.	Per cent of loss.	Weight per tie.	Loss per tie.	Per cent of loss.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	
June 18	111.93	....	....	96.80	....	....	112.90	....	....
July 10	109	2.93	2.61	94.10	2.70	2.80	109.43	3.47	3.07
July 25	107.15	4.78	4.27	92.52	4.28	4.42	107.56	5.34	4.73
August 11	105.05	6.88	6.14	90.75	6.50	6.25	105.47	7.43	6.58
September 11	102.97	8.96	8	89.11	7.69	7.94	103.27	9.63	8.53
October 10	103.42	8.51	7.60	89.61	7.19	7.43	103.68	9.22	8.21

These ties were almost dry when piled; nevertheless they lost considerably more water in the open-crib pile than in the solid pile.

One factor which was not anticipated when the weighing tests were started must be taken into consideration in all the preliminary figures here presented. The experimental solid piles were placed out on the open plain, and as a result of the consequent free circulation of air the rate of drying was much more rapid than it would have been in a yard. When solid piles are placed side by side and many together, the air can not circulate between the timbers. In all future tests conditions will be more nearly like the actual conditions in a tie yard. The open-crib piles allow full air circulation even when piled closely, so that the rate of drying shown for such test piles is probably more nearly correct.

TABLE VI.—*Rate of seasoning of Lodgepole Pine, green ties.*

Date of weighing.	Solid pile (50 ties).			Open-crib pile (50 ties).		
	Weight per tie.	Loss per tie.	Per cent of loss.	Weight per tie.	Loss per tie.	Per cent of loss.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*	
June 9	152.75	....	....	155.39	....	....
June 30	130.93	21.82	14.28	108.06	47.33	30.45
July 15	114.77	37.98	24.86	99.30	56.09	36.09
August 13	104.24	48.51	31.75	95.71	59.68	38.46
September 10	101.33	51.42	33.66	93.44	61.95	39.86

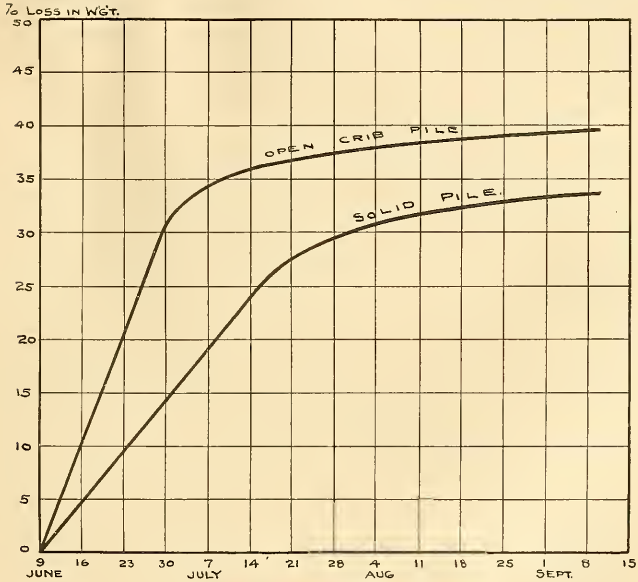

FIG. 12.—Diagram showing rate of drying of green ties.

Table VI shows the rate of drying of green ties, piled in solid and open-crib piles. The results are regarded as sufficiently marked to warrant recommending the use of the open-crib pile whenever possible. The curves in fig. 12 are a graphic presentation of the figures given in Table VI.

A study of these figures and curves shows that after three weeks the ties piled in open-crib form lost more than twice as much water as those in the solid pile. The great advantage which the open-crib form has over the other is the rapidity with which seasoning takes place during the first few weeks. It is probable that the relative positions of the curves of loss will be changed slightly when more timbers are weighed, but the general result will not be altered materially.

SEASONING AFTER TREATMENT WITH ZINC CHLORID.

Timber treated with a water solution of a salt is, like green timber, full of water. The results of a test to show the comparative rate of drying of treated Lodgepole Pine timber piled in the several forms of piles made at Sheridan are shown in Table VII and fig. 13. The first weighing was made the day after treatment.

TABLE VII.—*Rate of seasoning of Lodgepole Pine ties treated with zinc chlorid.*

Date of weighing.	Solid pile, 9 by 9 (60 ties).			Half-open pile, 7 by 7 (59 ties).			Open-crib pile, 7 by 2 (60 ties).			Triangular pile (33 ties).		
	Weight per tie.	Loss per tie.	Per cent of loss.	Weight per tie.	Loss per tie.	Per cent of loss.	Weight per tie.	Loss per tie.	Per cent of loss.	Weight per tie.	Loss per tie.	Per cent of loss.
	Lbs.	*Lbs.*		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	
June 17	163.87	......	......	174.44	......	......	172.10	......	......	165.94	......	......
July 11	123.13	40.74	24.86	127.80	46.64	26.16	122.80	49.30	28.64	118.66	47.28	28.49
July 25	114.43	49.43	30.16	119.30	55.14	31.03	115.27	56.83	33.02	111.73	54.21	32.67
Aug. 11	108.50	55.36	33.78	112.84	61.60	35.31	109.70	62.40	36.25	106.54	59.40	35.85
Aug. 25	105.67	58.19	35.51	110.04	64.40	36.92	106.80	65.30	37.94	103.58	62.36	37.58
Sept. 25	103.43	60.43	36.89	107.40	67.04	38.43	104.30	67.80	39.40	102.33	63.61	38.33
Oct. 25	102.36	61.59	37.54	106.05	68.39	39.20	102.86	69.24	40.23	100.03	65.91	39.66

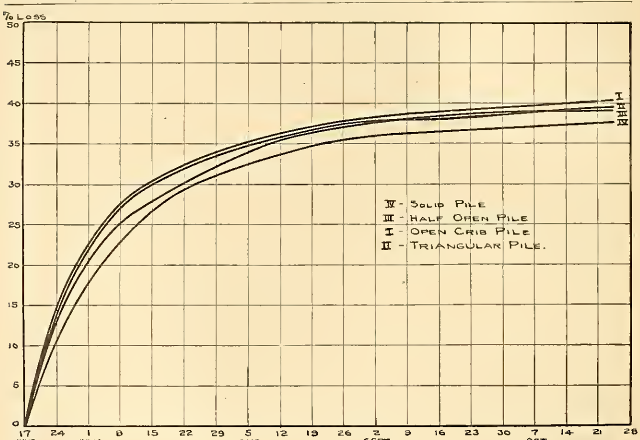

FIG. 13.—Diagram showing rate of seasoning of Lodgepole Pine ties treated with zinc chlorid.

The chief conclusions to be drawn from this test are that on the open plains in summer there is little difference in the rate of evaporation from the differently built piles, and that in all of them most of the water evaporates during the first six weeks. Accordingly, ties left for six to eight weeks along the right of way may be laid in the track at the end of that time. This conclusion will hold as yet only for Wyoming and for the summer months. Great emphasis is to be put upon this point, for it is more than probable that in other climates this relation will be very different. A test under the most adverse conditions is now in progress in southern Texas, where timber dries very slowly.

INDIVIDUAL VARIATION IN SEASONING.

The striking difference between pieces of timber from different trees of the same kind, even when grown in the same locality, is nowhere shown more conclusively than in the amount of water contained in the wood and the rate at which it evaporates. This great variability emphasizes the necessity for extended tests. Averages made from small numbers of weighings are likely to be altogether misleading, and ought never to be taken as a basis for any final conclusion. It is to be understood that all the figures given in the tables of this bulletin are merely tentative and subject to modification as fuller results become available.

The ties whose weights are shown in Table VIII and fig. 14 were cut in June, 1902, at Bozeman, Mont. They were first weighed June 25, the day after they were made. Table VIII gives the successive weights per tie, the actual loss in weight, and the percentage of the original weight lost. Fig. 14 shows the loss in weight of ties Nos. 25, 13, and 33, representing a mean and two extremes. The great variation shown is probably due to the fact that the ties came from trees of different ages and from both tops and butts. To see the great extremes between which 50 pieces will vary, one need only glance at the following figures, showing weights of 50 ties arranged in a series from the lowest to the highest. It is evident from this showing that the variation in 50 pieces is so large that a very much larger number of individual weights should be taken to furnish data for thoroughly trustworthy conclusions. Further tests are being made with from 200 to 500 pieces.

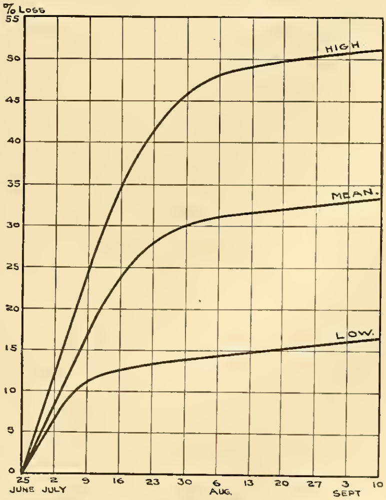

FIG. 14.—Diagram showing loss of weight of 3 ties, a mean and two extremes.

TABLE VIII.—*Lodgepole Pine ties, Bozeman, Mont., 1902.*

[Ties piled 7 by 2.]

Tie No.	June 25.	July 10.			August 10.			September 10.		
	Weight.	Weight.	Loss.	Per cent of loss.	Weight.	Loss.	Per cent of loss.	Weight.	Loss.	Per cent of loss.
	Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	
1......	227.5	185.5	42.0	18.46	129.5	98.0	43.08	126.0	101.5	44.61
2......	202.5	175.0	27.5	13.58	125.5	77.0	38.02	118.0	84.5	41.73
3......	182.0	146.5	35.5	19.50	100.0	82.0	45.05	95.0	87.0	47.80
4......	147.0	125.5	21.5	14.62	113.0	34.0	23.13	110.5	36.5	24.89
5......	211.0	172.0	39.0	18.48	130.0	81.0	38.39	120.5	90.5	42.75
6......	162.0	130.0	32.0	19.76	108.0	54.0	33.33	105.5	56.5	34.87
7......	203.0	166.5	36.5	17.98	156.0	47.0	23.15	151.5	51.5	25.13
8......	132.5	110.0	22.5	16.98	100.5	32.0	24.15	99.0	33.5	25.28
9......	190.5	159 5	31.0	16.27	148.0	42.5	22.30	145.0	45.5	23.88
10......	154.0	110.5	43.5	28.24	88.0	66.0	42.85	86.0	58.0	37.66
11......	174.0	133.0	41.0	23.56	93.5	80.5	46.29	90.5	83.5	47.99
12......	164.0	133.0	31.0	18.90	95.5	68.5	41.79	91.0	73.0	44.51
13......	154.0	126.5	27.5	17.86	106.0	48.0	31.17	102.5	51.5	33.44
14......	146.0	110.5	35.5	24.31	94.0	52.0	35.61	91.5	54.5	37.33
15......	139.5	102.0	37.5	26.88	93.0	46.5	33.33	90.5	49.0	35.12
16......	146.5	96.5	50.0	34.13	67.5	79.0	53.92	64.5	82.0	55.97
17......	148.5	118.5	30.0	20.20	106.0	42.5	28.61	104.0	44.5	30.00
18......	151.5	125.5	26.0	17.22	110.0	41.5	27.39	108.0	43.5	28.71
19......	176.5	130.5	46.0	26.06	100.0	76.5	43.34	97.0	79.5	45.04
20......	165.0	129.0	36.0	21.81	115.0	50.0	33.33	112.0	53.0	32.12
21......	120.5	105.0	15.5	12.86	101.0	19.5	16.17	98.5	22.0	18.25
22......	156.0	113.5	42.5	27.24	90.5	65.5	41.98	88.0	68.0	43.59
23......	146.5	117.0	29.5	20.13	87.0	59.5	40.61	84.5	62.0	42.32
24......	149.0	106.0	43.0	28.85	96.0	53.0	35.56	93.5	55.5	37.25
25......	181.0	161.0	20.0	11.04	154.0	27.0	14.91	151.0	30.0	16.57
26......	133.0	99.5	33.5	25.20	88.5	44.5	23.44	86.0	47.0	35.34
27......	128.0	92.0	36.0	28.12	80.0	48.0	37.47	77.0	51.0	39.84
28......	184.0	132.5	51.5	27.98	90.0	94.0	51.08	84.5	99.5	54.07
29......	134.0	103.5	30.5	22.74	84.5	49.5	36.92	82.0	52.0	38.80
30......	135.5	98.5	37.0	27.28	72.0	63.5	46.80	70.0	65.5	48.34
31......	193.0	153.0	40.0	20.72	111.0	82.0	42.50	105.5	87.5	45.34
32......	162.0	129.5	32.5	20.04	101.5	60.5	37.32	97.5	64.5	39.81
33......	187.0	139.0	48.0	25.66	96.0	91.0	48.66	91.5	95.5	51.07
34......	126.0	89.0	37.0	29.38	79.0	47.0	37.28	77.5	48.5	38.49
35......	159.0	117.5	31.5	19.80	96.0	63.0	39.60	93.5	65.5	41.19
36......	154.5	121.0	33.5	21.64	112.5	42.0	27.17	110.0	44.5	28.80
37......	177.0	156.0	21.0	11.87	144.0	33.0	18.63	140.0	37.0	20.90
38......	154.5	120.5	34.0	22.00	111.0	43.5	28.16	108.0	46.5	30.09
39......	133.0	105.0	28.0	21.05	96.5	36.5	27.43	94.0	39.0	29.32
40......	182.5	134.5	48.0	20.86	116.5	66.0	36.18	113.5	69.0	37.80
41......	87.5	83.5	4.0	4.57	80.0	7.5	8.57	78.0	9.5	10.85
42......	194.5	142.0	52.5	27.00	122.0	72.5	37.21	119.0	75.5	38.81
43......	141.0	102.5	38.5	27.30	90.5	50.5	35.80	89.5	51.5	36.52
44......	168.5	118.0	50.5	29.98	108.0	60.5	35.90	105.5	63.0	37.39
45......	132.5	106.0	26.5	20.00	100.0	32.5	24.54	97.0	35.5	26.71
46......	97.5	70.0	27.5	28.22	66.5	31.0	31.80	64.5	33.0	33.84
47......	130.5	82.0	48.5	27.17	74.5	56.0	42.83	71.5	59.0	45.21
48......	147.0	108.0	39.0	26.52	92.5	55.5	37.72	89.5	57.5	39.11
49......	90.0	84.0	6.0	6.67	81.0	9.0	10.00	79.0	11.0	12.22
50......	126.0	106.5	19.5	15.47	102.0	24.0	19.05	100.0	26.0	20.63
Average..	....	....	....	21.40	....	....	33.78	....	....	35.54

VARIATION BY MONTHS.

It has been shown in a general way that timber will season more slowly in winter than in summer, and also that the water content during various months varies, but no definite data are as yet at hand. To secure such data for Lodgepole Pine the series of tests of ties cut monthly, already described, was inaugurated. Later on these ties will be treated, and the relation between seasonal cutting and timber treatment determined. The relation between seasonal cutting and lasting powers will also be investigated.

In Table IX the results so far obtained with ties cut in June, July, August, and September, of 1902, are given in the form of general averages. The piles were 7 by 2, and were reversed from top to bottom at each weighing.

TABLE IX.—*Lodgepole Pine, Bozeman, Mont., 1902.*

Date of weighing.	No. of ties.	Weight per tie.	Loss in pounds.	Percentage loss.
JUNE CUTTING.				
1902.				
June 25	147	156.62	....	....
July 10	147	123.22	33.40	21.30
August 10	147	103.72	52.90	33.77
September 10	147	100.66	55.96	35.73
JULY CUTTING.				
July 20	270	144.28	....	....
July 25	90	129.90	14.34	9.94
August 8	270	108.99	35.29	24.46
August 28	90	105.08	39.16	27.15
September 10	270	103.23	41.05	28.26
AUGUST CUTTING.				
August 25	100	149.83	....	....
September 10	100	119.91	29.92	19.96
September 25	100	115.35	34.48	23.01
October 25	100	113.21	36.62	24.44
November 25	100	114.02	35.81	23.90
SEPTEMBER CUTTING.				
September 25	100	157.33	....	....
October 5	100	153.02	4.31	2.74
October 25	100	125.04	32.29	20.52
November 25	100	120.31	37.02	23.53

It is yet too early to draw any definite conclusions from these tables. They indicate, however, a decided variation in the weight of green ties cut in different months, and a still more striking variation in the rapidity with which seasoning takes place in summer and in fall.

Fig. 15 shows graphically the loss of water in percentages of the original weights. Although the curves are plotted with but four or five points, they are fairly correct.

The great deviation of the September curve requires explanation. Just after the ties had been cut and weighed there was a heavy snowfall, which covered the ties for a week or more. During this time they did not dry out at all. As soon as the snow melted they began to dry rapidly, as shown by the sudden rise in the curve. The dotted line indicates the path which the curve would have followed had no disturbing factor caused a deviation from the norm of the other months.

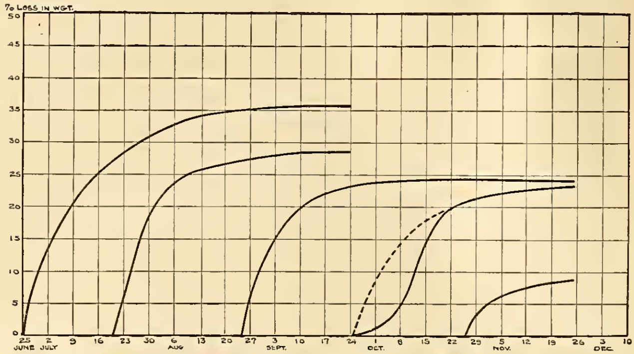

FIG. 15.—Diagram showing percentage loss of water of Lodgepole Pine timber during various months, Bozeman, Mont., 1902.

In the spring the drying out of timber cut in October and November will take place more rapidly, and the depressed curves will probably rise to the same height as the first curve.

Fig. 16 shows the changes in specific gravity of the same timber. The specific gravity of absolutely dry Lodgepole Pine is 0.409, so that the June-cut timber has almost reached a dry condition (0.446).

COST OF PILING.

The practicability of piling in open-crib form depends entirely on the additional cost. Careful records kept at the Sheridan tie plant showed that it takes no longer to pile ties in open-crib form than in solid piles. The men who did the piling were paid by the piece, so it was possible to keep an exact record. All that is called for is a little

FIG 1.—OAK PILES, SHOWING METHOD OF BUILDING A ROOF.

FIG. 2.—ANOTHER METHOD OF ROOF BUILDING.

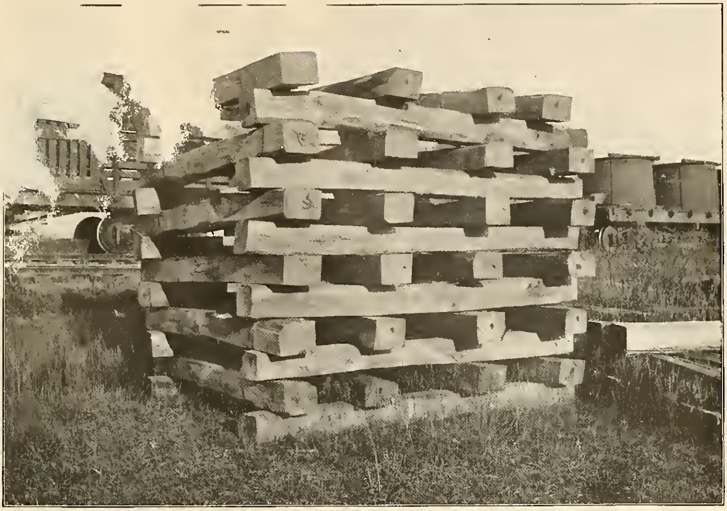

FIG. 1.—OPEN-CRIB OAK PILE, SOUTHERN ILLINOIS.

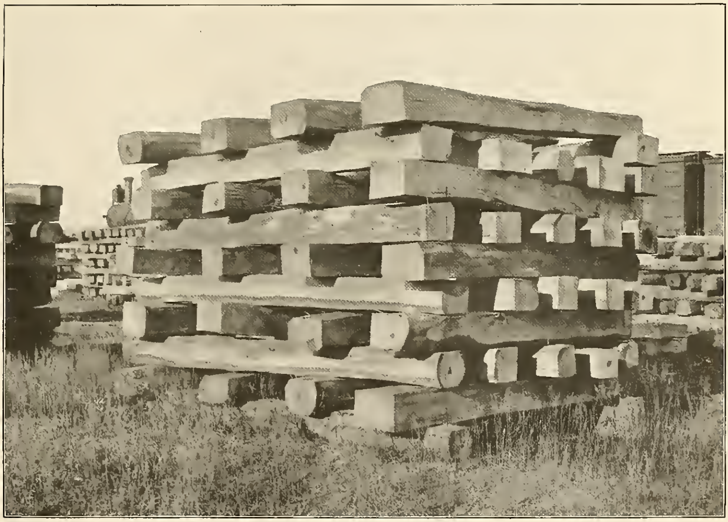

FIG. 2.—ANOTHER OPEN-CRIB PILE.

more care. The only difference in cost is the increased yard room necessary. Where land is cheap, this will not amount to much; where a treating plant is in the neighborhood of a city, it will be necessary to build high piles, or to use half-open piles. The amount of yard room for storing both untreated and treated ties ought to be one of the most important considerations in determining the location of a timber treating plant. Timber piled in high open piles (Pl. I) can be loaded upon the small cars which carry the ties into the treating cyl-

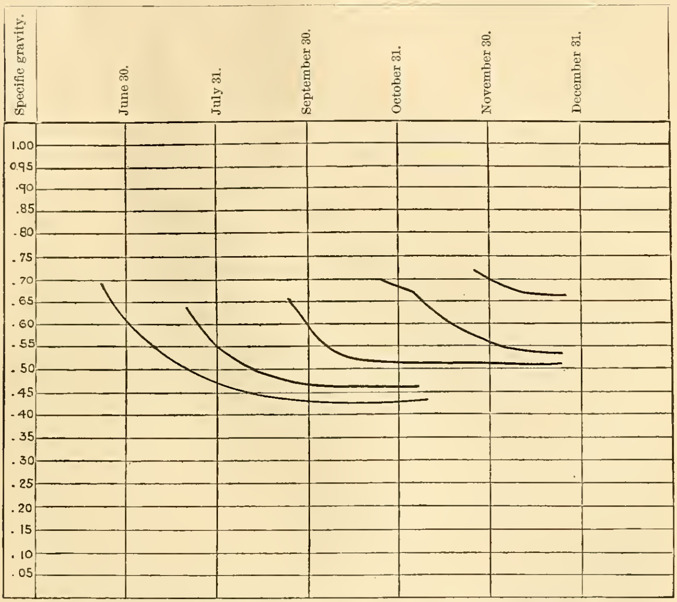

FIG. 16.—Diagram showing specific gravity of Lodgepole Pine timber cut during successive months.

inder with as much ease as from high solid piles. The timbers must be thrown down in both cases, and in this respect there is no difference between open and solid piles.

Experience shows beyond doubt that open piling pays with Lodgepole Pine. It will probably pay also in the case of oaks and other timbers which are to be treated, for, even with expensive storage land, the gain from better treatment will be great enough to warrant the expense.

X. SEASONING OF OAK TIMBER.

For several months seasoning experiments with White Oak timber have been under way, in cooperation with the Baltimore and Ohio Southwestern Railroad, at various points in southern Illinois, Indiana, and Ohio. The plan of these tests was the same as that for Lodgepole Pine. Oak ties were obtained as soon as possible after they were cut from the tree. These were piled in various ways, as shown in Pls. XVI to XVIII. Particular attention is called to the two piles shown on Pl. XVI, illustrating a method still too frequently employed, by which green ties are piled with the lowest tier of ties resting directly on the ground. In the upper figure this lowest tier is almost buried in the weeds and grass, and it is evident that these ties have little or no chance to dry out. The better method of using two ties to support the lowest tier is shown in the piles on Pls. XVII and XVIII.

The two forms of piles shown on Pl. XVIII give the most air. They do not differ materially except as to the spacing. Pl. XVII represents an experiment made to test whether it would be possible to use the method commonly employed in France, of making the uppermost tier serve as a roof. The ties are placed close together, and are given a slope by placing a tie under one end. The lower figure shows a double roof, with the ties so placed that the upper tier covers the spaces in the lower tier. In a region where the annual rainfall is high, it is very probable that the seasoning of the whole pile will advance more rapidly when the ties are in this form than in a pile not covered. The top tier can always dry out rapidly, even when wet, as it is so exposed to the sun and air. During the very heavy rains in the middle of December the ties under such a roof remained almost entirely dry.

Some preliminary results of experiments with White Oak ties which had been cut for some time, showing the rate at which seasoning is taking place in the different forms of piles, are presented in the following table. Only the first and last weights are given, with the average loss per tie and the percentage of loss. These weighings were conducted at Fairfield, Ill., on the Baltimore and Ohio Southwestern Railroad. The differences, though not as great as they would have been had the ties been green, are sufficiently striking to warrant advocating the open form of piling.

Table X.—*Preliminary weights of White Oak.*

OPEN-CRIB PILE, 7 BY 2.

Date of weighing.	Number of ties.	Weight per tie.	Loss per tie.	Per cent of loss.
		Pounds.	*Pounds.*	
August 7	75	166.47		
October 27	75	148.13	18.34	11.02

TABLE X.—*Preliminary weights of White Oak*—Continued.

HALF-OPEN PILE.

Date of weighing.	Number of ties.	Weight per tie.	Loss per tie.	Per cent of loss.
August 11	101	155.62		
October 28	101	147.35	8.27	5.31

SOLID PILE.

Date of weighing.	Number of ties.	Weight per tie.	Loss per tie.	Per cent of loss.
August 11	85	175.81		
October 28	85	166.94	8.87	5.04

In about two and a half months the open pile lost more than twice as much as the solid pile. There was no additional cost in building these White Oak piles in the same manner as the Lodgepole Pine. Eventually there may be a small increased cost of handling, but the gain outweighs the cost many times.

XI. TESTS WITH TELEPHONE POLES.

Tests have been made from time to time in this country to determine the practicability of preserving telephone and telegraph poles. Various preservatives have been applied to the whole poles, and in one instance methods of butt treatment were tried. The results have not always been satisfactory, particularly when creosote or tar oil have been used. This in most cases was no doubt due to the use of poor methods and a poor quality of creosote.

Economical treatment of telephone or telegraph poles is very much more difficult than of ties or bridge timbers. The latter are exposed to decaying influences throughout their whole mass, while a pole is generally liable to rot only around the point where it enters the ground. Except in such climates as southern Texas and Louisiana, therefore, where timber exposed to the air rots rapidly, treatment of the whole pole is a great waste. Then again, ties and timbers can be taken without great cost to and from some central preserving plant. This is frequently impossible with poles, especially when they are obtained locally; the freight charges would be so great that it would be cheaper to get new poles. In Europe, however, where the first cost of poles is very great, and where treated poles last twenty-five to thirty years, it pays to treat the whole pole. Those treated with tar oil in 1871 for the Prussian postal service are still in use in a line north of Berlin, and in good condition. The Swiss Government treats its poles with copper sulphate, after the old Boucherie process.

With the increased cost of poles in this country, it has become a matter of considerable moment to find some efficient and economical method of lengthening their lasting power. To this end some tests were started during the past summer. Before describing them it may be well to consider how poles give out, and what the conditions are which favor their decay.

DECAY OF POLES.

Poles set in the ground usually decay at or or just below the surface of the ground. The reason for this will be plain when one remembers that two of the conditions necessary for the growth of the wood-destroying fungi are air and water. Above the ground the poles dry out in a short time, and remain dry; they therefore rarely decay in this part.[a] Below the surface of the ground there is so little oxygen that the fungi can not grow; hence this part also does not rot readily. Poles standing in water are in the same class with those in the ground. Below the surface of the water no rot takes place because of the absence of air. Decay is at the surface of the water or a little above. The same thing is true of piles. The reason why poles give out first at or just below the surface is that both air and water are found there in sufficient quantities to permit the wood-destroying fungi to grow.

PLANS FOR PREVENTING DECAY OF POLES.

As has been pointed out above, decay can be prevented either by keeping the wood dry or by chemical treatment. In the case of poles, if one can keep the butt dry the length of life of the pole will be considerably extended. The ease with which this can be done will vary with the soil conditions. In a heavy clay, where water stands for days, it will be more difficult to establish drainage than in a sandy soil. In experimenting with pole treatment two lines of work have been started, one in seasoning poles, the other in treating the butts of poles. In the present bulletin we are concerned only with the seasoning tests. These have been going on since July near Mount Arlington, N. J., in cooperation with the American Telephone and Telegraph Company. Chestnut poles are being cut in northern New Jersey for a long-distance line from Providence, R. I., to Philadelphia, and from these fifty 30-foot poles are taken every month for the seasoning experiment. They are weighed one or two days after they are cut, and are then piled on a side hill, two poles on the ground and the remainder across them. An air space of about 16 to 20 inches is thus left under the pile. The poles are weighed every month. Incidentally, careful measurements of the circumference are made at three points. It is yet too early to give any definite account of results, but the poles cut in August had lost 6.98 per cent of their first weight by October 28.

While the average loss per pole in weight has not been very great

[a] An exception to this must be made for regions where during spring and summer the air holds enough moisture to keep the tops wet. Where this is the case the top will decay likewise.

so far, it must be remembered that the summer just past was a very wet one in New Jersey, and that the rate of evaporation was influenced considerably thereby. The weighing of the separate lots is to be continued until the poles have reached an air-dry condition. Poles are to be cut every month throughout the year, so that figures corresponding to the weights obtained from ties will be available. The seasoned poles will be set in some line together with unseasoned poles, to determine the difference in length of life. All poles are marked with nails indicating the month and year during which they were cut.

Similar seasoning tests for poles in other parts of the country have been arranged for, and will be started as soon as possible.

XII. PLANS FOR FUTURE WORK.[a]

Arrangements are practically complete for carrying on further seasoning tests, as follows:

SEASONING OF OAK TIMBERS.

Two series of tests have been arranged to determine the comparative rate of seasoning and the best methods to season various kinds of oak. The tests will be mainly of White Oak, Red Oak, Water Oak, Black Oak, and such other oaks as occur in any quantity in the Mississippi Valley. They are made in cooperation with the St. Louis and San Francisco Railroad Company at several points in southwest Missouri and northwest Arkansas, and with the Illinois Central Railroad Company and the Ayer & Lord Tie Company at several points in northern Mississippi, western Kentucky, and Tennessee. The tests with the Baltimore and Ohio Southwestern are being continued and will be enlarged.

A determination of the length of time required for thorough seasoning is most necessary for successful chemical treatment of the inferior oak timbers.

SEASONING OF PINE IN THE SOUTHERN STATES.

In the Southern States it is difficult to keep green timber in the woods or in piles for any length of time, because of the rapidity with which wood-destroying fungi attack it, particularly during warm weather. It may prove that the piling methods found so successful in the North will not give satisfactory results in the South, and that some form of kiln drying may have to be resorted to in order to get seasoned timber for treatment. An extensive experiment has been started in southern Texas, in cooperation with the Santa Fe Railroad and the Kirby Lumber Company, for the purpose of testing (among other things) the rate of seasoning of ties. Two kinds of pine are to be tried, the Loblolly and the Shortleaf. Both sawed and hewn ties are to be used, and the experiment is to be as exhaustive as that in progress

[a] April 15, 1903: The tests with oak and Southern pine have now been in operation three months.

with Lodgepole Pine. A similar experiment will be made in Arizona with the Mountain Pine, and another in northern Georgia and South Carolina with the Longleaf Pine.

SEASONING OF GUM TIMBER.

The vast quantities of Red Gum and Tupelo in the Central and Southern States has led to repeated inquires as to their fitness for structural lumber, etc. A number of gum ties are now being cut by the Southern Pacific Railway, which will be piled and tested with the pine in Texas.

PACIFIC COAST TESTS.

On the Pacific Coast a number of timbers which were formerly ignored are coming into general use. Piling tests are being arranged for Western Hemlock and the various species of fir. In southern California tests are being conducted with the Eucalyptus, to determine its fitness for ties and poles.

XIII. CONCLUSIONS AND RECOMMENDATIONS.

Timber seasoning is a practical method for increasing the length of life of both untreated and treated timber. At the same time it forms the most important preliminary step to successful chemical treatment. The cost of seasoning is insignificant, while the returns amount to a considerable sum in the end. With the increased cost and scarcity of timber, every step leading toward a more economic use of our supply ought to receive attention.

It is perhaps too soon to draw final conclusions, but the following general recommendations can be confidently made.

(1) Green timber should be piled in as open piles as possible as soon as it is cut, and so kept until it is air dry. In the case of ties the 7 by 2 form of pile is the best. No timber should be treated until it is air dry.

(2) Timber treated with a preservative dissolved in water should be piled after treatment for several months at least to allow the water pressed into the wood with the salt to evaporate. Under no circumstances should timber freshly treated with a water solution be exposed to weathering influences.

APPENDIX.

METHOD OF KILN DRYING IN USE BY THE FRENCH EASTERN RAILWAY.

The French Eastern Railway maintains at Amagne a plant for completing the drying of its ties after they have been seasoned in the open air, which consists of four kilns. These are structures about 50 feet long by 46 feet wide and contain two pairs of hot-air galleries, each pair of which is provided with an independent furnace and can be operated as a separate kiln. Between them is the supporting wall of the other two furnaces, each with its own chimney. The galleries are formed of vertical walls about 6 feet 4 inches apart, surmounted by a small circular arch with a radius of 3 feet 2 inches. To diminish the loss of heat, the arches are covered with a bed of concrete about 8 inches deep over the keystone. Little trams, loaded with ties, travel the whole length of the galleries upon a tramway 3 feet wide, which, to make the cars roll easily, has a grade of 1 inch for 5 yards.

The masonry supporting wall of the two furnaces for each kiln is about 16 feet long and 11 feet wide by 8½ feet high. It is strengthened with rails arranged in vertical trusses, strongly joined at their upper ends.

In escaping from the fire box of the furnaces the products of combustion rise to enter the uppermost of five horizontal rows of longitudinal conduits, five conduits to the row. From this they pass down again by circulating successively through the other four rows. The cross section of each conduit is about 10⅝ by 4⅓ inches. These conduits are inclosed in hollow brick sheating, through the passages in which a current of air is drawn in a direction counter to that taken by the smoke. To this ascending air the smoke loses all its heat, and is finally discharged into some pipes under the furnaces, communicating with sheet-iron chimneys about 40 feet high, placed inside accessory brick chimneys 26 feet high.

The air enters, at first cold, from the outside into a lower chamber of the furnace, and becomes gradually heated in its upward progress. It is at last discharged into a hot-air chamber which occupies all the upper part of the kiln. From this it is carried down to the galleries in which the ties are dried by four vertical pipes, having a cross section of 18 by 18 inches. Two pipes open into each gallery, at the end of which the trams bearing the ties pass out after the drying has been completed.

In passing through the galleries in a direction opposite to that in which the ties progress, the air becomes cooled, little by little, from contact with the wood. At the farther end it descends to be discharged into the accessory chimneys, in which a draft is created by a small fire box at the base.

The opening and closing of all the hot-air pipes is regulated by means of registers. The smoke conduits may be easily cleaned by lifting the plates or plugs which close them at one end.

Turntables at the entrance and the exit of the galleries enable the loaded trams to be started on their journey through, and at the end removed again to undergo treatment with tar oil in cylinders which receive one car at a time. Each tram carries about 40 ties, slightly separated from each other, so that all the faces may be in direct contact with the bot air in the galleries of the dry rooms and with the tar oil in the cylinders. The four kilns in all contain 16 galleries, with a capacity of 5 trams each, in all 80 small trams. It is thus possible to dry about 3,200 ties at one time. With an annual output of 400,000 ties, seventy-two hours would be allowed for the average drying period.

The temperature of the galleries is at the maximum 30° to 35° C. at the entrance, and 70° to 80° C. at the delivery. As the trams are taken from the cylinders one at a time, the drying is progressive, and the wood, for this reason, is less liable to split or warp.

The temperature is regulated according to the state of the weather and the condition of the wood.

The material used for heating the dry room is composed of a mixture of small coal, cinders from locomotives, trimmings from shoe machines, and all the trash and chips from the wood yard. To turn out 400,000 ties the furnaces of the four dry rooms consumed about 200 tons of fine coal and 250 tons of the trimmings and wood trash, making 450 tons of the mixed fuel. This mixture develops a sufficient heat and offers the additional advantage of not wearing out the fire boxes by a too intense heat. The accessory fire places put at the bases of the chimneys burn briquets exclusively. For the output indicated above the eight accessory fires burned 50 tons of briquets. The expense for fuel is about one-fifth of a cent for each tie.

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