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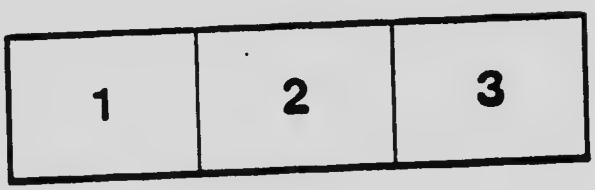
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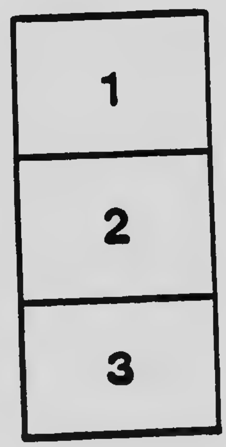
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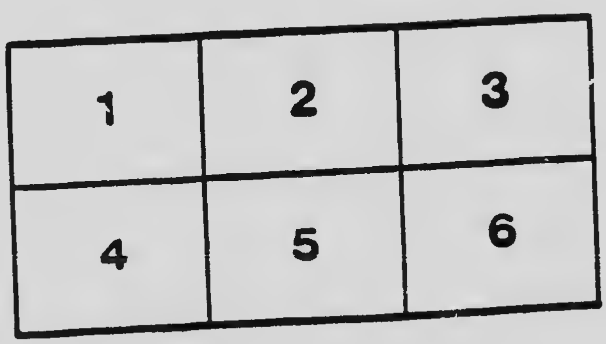
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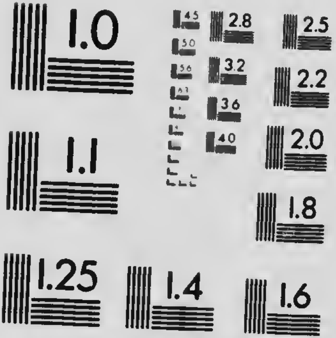

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HON. ARTHUR MEIGHEN, Minister; W. W. CORY, Deputy Minister

FORESTRY BRANCH—BULLETIN No. 67

R. H. CAMPBELL, Director of Forestry

Creosote Treatment of Jack Pine and Eastern Hemlock for Cross-ties

OTTAWA
J. DE LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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BY

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J. A. CODERRE, B.A., F.E.

Contribution from Forest Products Laboratories of Canada

J. S. BATES, Chem. E., Ph.D., Superintendent

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PRINTER TO THE KING'S MOST EXCELLENT MAJESTY

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CREOSOTE TREATMENT OF JACK PINE AND EASTERN HEMLOCK FOR CROSS-TIES

INTRODUCTION

The rapidly decreasing supplies of the more durable tie woods, the rising cost of tie material and the serious drain upon the forest resources of Eastern Canada which results from the large quantity of timber annually cut for tie purposes have directed the serious attention, both of the railways and of those interested in the maintenance of the timber wealth of the country, to preservative treatment as a means of lengthening the life of ties in service.

Decay and mechanical wear are the causes of the removal of ties from track and while mechanical wear is a factor of great importance in this connection the primary cause of failure in the great majority of cases is decay. By means of efficient preservative treatment decay can be prevented or very greatly retarded and consequently the life of the tie in service can be increased.

In connection with mechanical wear the question of heaving of track and the consequent shimming, which necessitates the frequent drawing and re-driving of spikes, has frequently been brought forward as a serious objection to the use of treated ties in Eastern Canada. It has been claimed that where shimming is done ties are often spike-killed before they fail from decay and that preservative treatment under these circumstances would be merely a waste of money. A point of the greatest importance is that heaving does not necessarily entail shimming. Shimming is only necessitated at certain points where unsatisfactory drainage conditions, combined with the presence in the sub-grade of heavy clay or other soil with high water-holding capacity, cause unequal heaving of a marked character which renders the track unsafe. These points are practically the same every year and are therefore in most cases known beforehand from previous experience. Only a relatively small proportion of the total number of ties in track is subject to shimming. Further, trouble from this source is being gradually eliminated owing to improvements in drainage.

Prior to the war the number of ties annually purchased by Canadian railways for renewals and new construction was from nineteen to twenty millions. The cessation of work on new construction brought about by the war has materially reduced the consumption during the past few years. For renewals alone however from eight to ten millions are required yearly.

It is believed that treated ties were first used in Canada about 1906. Since that date a small number have been used each year, this number, however, never exceeding 10 per cent of the annual consumption. A large proportion of these have been imported from the United States in the treated condition.

The first commercial treating plant in Eastern Canada was erected in 1911. There are now three such plants in Eastern Canada located at Trenton, Ont., Fort Frances, Ont., and Sydney, N.S., respectively, and three in Western Canada, located at Transcona (Winnipeg, Man.), Vancouver, B.C., and North Vancouver, B.C.

The principal native timbers used for tie purposes in Eastern Canada at the present time are in order of importance: jack pine (*Pinus Banksiana*, Lam.); eastern cedar (*Thuja occidentalis*, L.); eastern hemlock (*Tsuga canadensis* (L.); Carr.); tamarack (*Larix laricina* (Du Roi) Koch) and the several species of eastern spruce (*Picea* sp.). In addition smaller amounts of hardwoods are used, the most important being birch, maple and beech.

The question of the more extensive utilization of hardwoods for tie purposes is occupying a great deal of attention at the present time. Considerable quantities of hardwoods are to be found on lands from which the coniferous growth has been removed by logging or on which it has been destroyed by fires, the hardwood growth then replacing the former stand. Hardwoods, on account of their relatively high mechanical strength, make very good ties provided they are properly handled in seasoning and receive a suitable preservative treatment. The latter, on account of rapid decay of hardwoods in exposed service, is absolutely necessary. The problem of the utilization of hardwoods for tie purposes in Canada presents several difficulties, however, and while it is possible that the use of hardwood ties on a large scale may be a development of the future, the softwoods are of much greater importance at the present time.

Of the coniferous tie timbers, western cedar ranks highest in regard to natural durability and lowest as regards mechanical qualities. It is therefore questionable whether it would be economical to treat ties of this wood for main track service under Canadian conditions. In regard to tamarack, the available supply is small and is rapidly being exhausted, much of the timber now cut being obtained from dead trees. The ravages of the larch sawfly largely account for this state of affairs. With regard to jack pine, hemlock, and the spruces there is no doubt that an efficient preservative treatment would result in considerable financial saving to the railways. Further, when it is considered that jack pine and hemlock together constitute over 50 per cent of the total number of ties annually used in Eastern Canada in ordinary years, the reduction of the drain on forest resources which could be brought about by materially increasing the life of these ties is of considerable importance to the country at large. In view of the above it was decided to devote attention to the treatment of jack pine and hemlock before dealing with other woods.

Little or no reliable information is available as to the adaptability of Canadian jack pine and hemlock to creosote treatment. The lack of such information might lead to unsatisfactory results from treated ties of these species which could be avoided if such information was available. The object of the investigation therefore was to determine how these woods would respond to creosote treatment, what depth of penetration could be obtained and, if necessary, to work out an efficient and economical method of impregnating each. Creosote oil was selected as the preservative because it is the most widely used and most generally efficient material at present employed for the preservation of railway ties both on this continent and in European countries.

The investigation was carried out at the experimental treating plant of the Forest Products Laboratories of Canada, maintained by the Forestry Branch of the Department of the Interior at McGill University, Montreal. This plant is equipped with all the necessary apparatus for the preservative treatment of timber on a small scale by processes within the present limits of commercial practicability.

The laboratories desire to express their thanks to several Canadian railroads and also to the Canada Creosoting Company for rendering valuable assistance in the securing of information and experimental material.

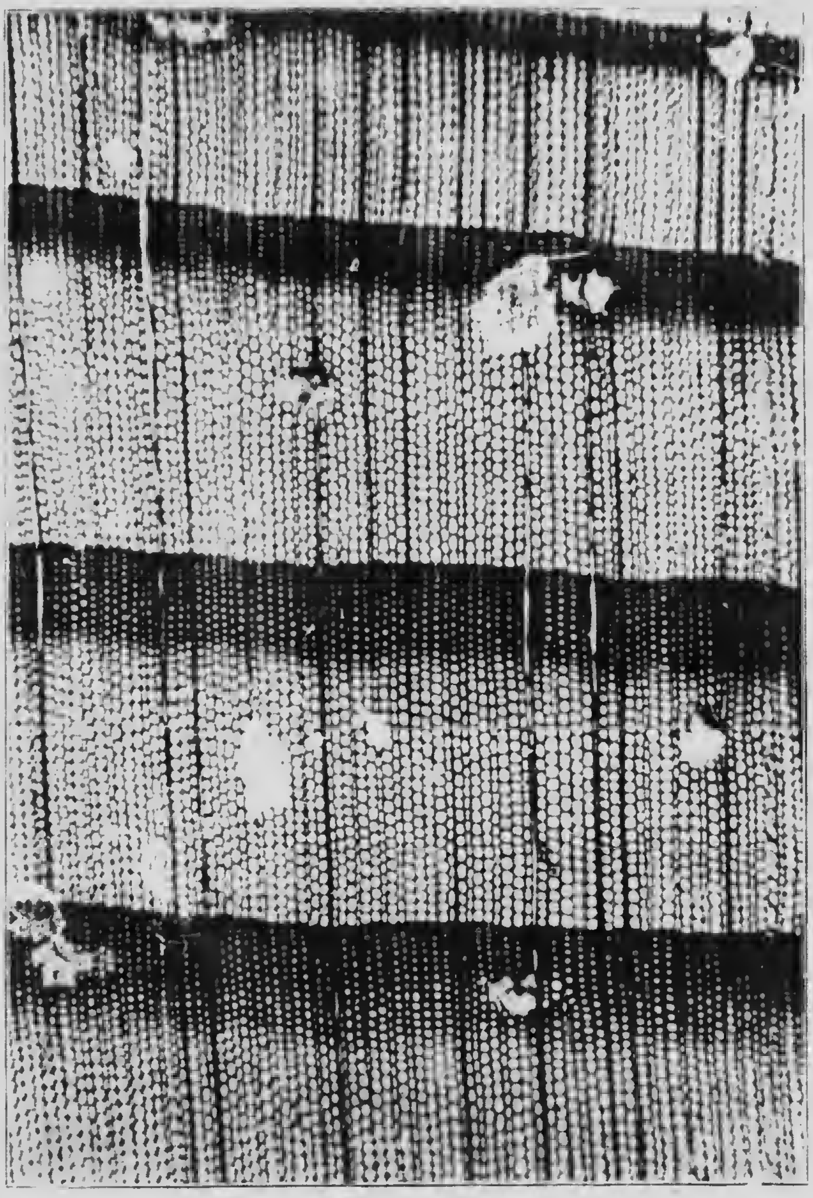
CHARACTERISTICS OF JACK PINE AND HEMLOCK

Structure

These two species are representative of two different classes of structure occurring in our coniferous timbers. The outstanding point of difference between these two classes is that in the one (to which jack pine belongs) the wood is normally traversed by vertical and horizontal resin canals while in the other (which includes hemlock) these are normally absent. (See Plates 1 and 2.) The presence of resin canals in a wood usually facilitates penetration of the preservative in treatment to some extent.

The extent to which penetration is facilitated however varies greatly even in the different species in which resin canals normally occur, being apparently dependent on the

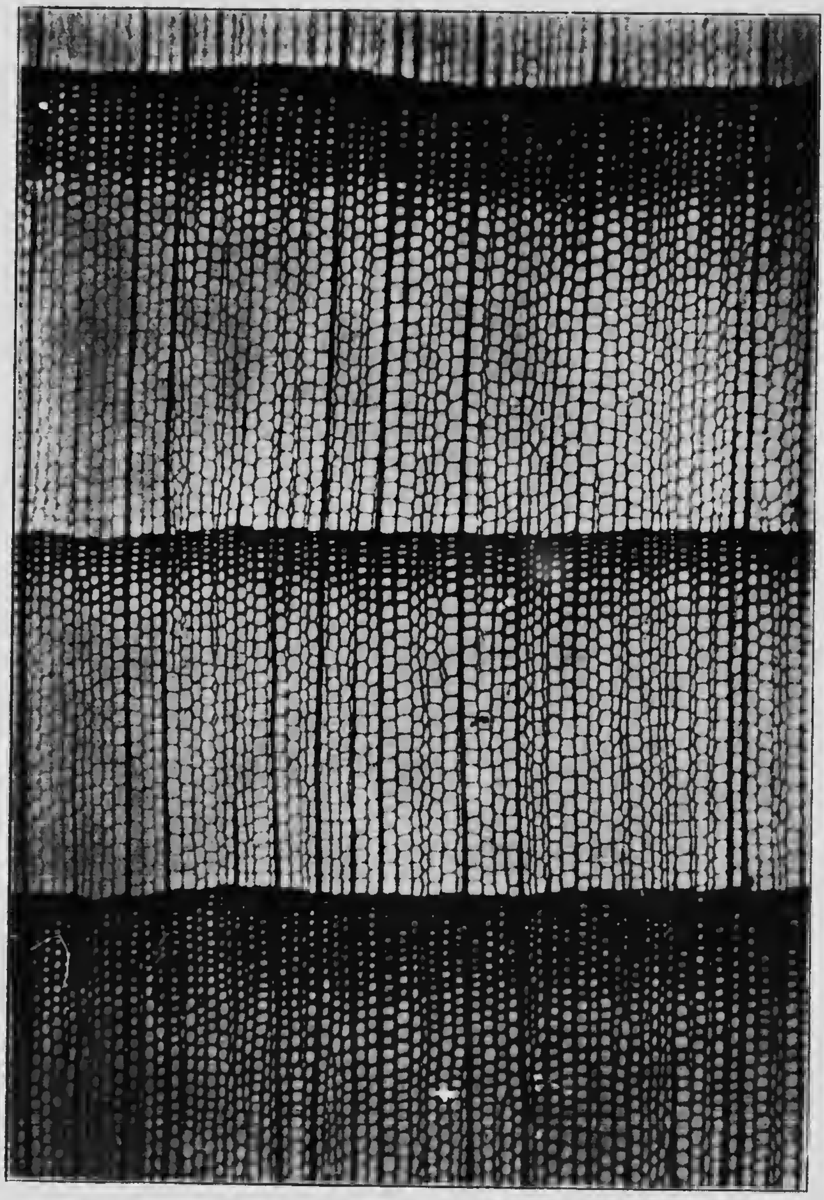
Plate I



Cross-section of jack pine wood magnified fifty times. Note resin canals (large openings).

size and relative frequency of the canals, on the presence or absence of constrictions, tyloses, and resin therein and on the character of the surrounding tissue. Further, some coniferous woods without resin systems have been found more easily penetrable than others with resin systems. It is probable that the resin canals in jack pine facilitate penetration appreciably.

Plate II



Cross-section of eastern hemlock wood magnified fifty times. Note absence of resin canals.

STRENGTH

The most important strength functions of a wood for tie purposes are compression perpendicular to grain, compression parallel to grain, hardness, static bending and

TABLE I.—Comparative strength values for various coniferous tie timbers used in Eastern Canada[1].

Species.	Seasoning.	Rings per inch.	Proportion of summer-wood.	Specific gravity, based on weight when oven dry, and on volume when tested.	Specific gravity, based on weight when oven dry, and on volume when oven dry.	Weight per cubic foot, as tested.	Moisture content, based on weight of wood when oven dry.	Static Bending. Fibre stress at elastic limit, per square inch.	Static Bending. Modulus of rupture per square inch.	Static Bending. Modulus of elasticity per square inch.	Static Bending. Work in bending per cubic inch of specimen. To elastic limit	Static Bending. Work in bending per cubic inch of specimen. To maximum load.
			per cent.			lb.	per cent.	lb.	lb.	1,000 lb.	inch-lb.	inch-lb.
Pine, jack	Green.	7	30	0·39	0·46	50	105	3,000	5,400	920	0·55	5·9
Cedar, white	Green.	23	36	0·29	0·32	28	55	2,600	4,200	640	0·60	5·7
Hemlock, eastern	Green.	20	34	0·38	0·44	48	105	4,200	6,700	1,120	0·88	6·8
Tamarack	Green.	20	38	0·49	0·56	47	52	4,200	7,200	1,240	0·84	7·2
Spruce, red	Green.	17	27	0·38	0·41	34	43	3,400	5,700	1,180	0·56	6·1
Spruce, white	Green.	14	27	0·36	0·43	33	46	3,300	5,400	980	0·66	5·7

Species.	Impact Bending. Fibre stress at elastic limit, per square inch.	Impact Bending. Work in bending to elastic limit, per cubic inch of specimen.	Impact Bending. Height of drop of 50-pound hammer causing complete failure of specimen.	Compression parallel to grain. Compressive stress at elastic limit, per square inch.	Compression parallel to grain. Crushing strength at maximum load, per square inch.	Compression perpendicular to grain. Compressive stress at elastic limit, per square inch.	Hardness. Load required to imbed a 0·444-inch sphere of steel to one-half its diameter. Radial surface.	Hardness. Tangential surface	Hardness. End surface.
	lb.	inch-lb.	inches.	lb.	lb.	lb.	lb.	lb.	lb.
Pine, jack	7,800	3·3	30	2,250	2,580	380	370		380
Cedar, white	5,300	2·0	15	1,420	1,990	230	230		320
Hemlock, eastern	7,900	2·8	20	2,710	3,270	500	410		510
Tamarack	7,800	2·7	28	3,010	3,480	480	380		400
Spruce, red	7,200	2·3	18	2,360	2,740	350	350		420
Spruce, white	6,800	2·0	20	2,280	2,380	270	280		300

1 "Mechanical Properties of Woods grown in the United States," by J. A. Newlin and T. R. C. Wilson, United States Department of Agriculture Bul. 556.

impact bending. The strength of jack pine and hemlock in these functions is stated in Table 1, the values for some other species commonly used for ties being included for comparison.

Durability

Reliable data as to the relative durability of Canadian commercial timbers are at present lacking. Hemlock however is amongst the least durable of our coniferous woods in exposed service, jack pine being somewhat more resistant to decay. For tie purposes in main track the average life of some coniferous species, as reported to these laboratories by several Canadian railroads, is stated in Table 2.

Table 2—Average life of untreated ties in main track service in Eastern Canada

Species.	Life in Years
White cedar	11 +
Jack pine	7
Tamarack	7
Hemlock	6

EXPERIMENTAL MATERIAL

Timber

The investigation was started with 160 ties of both species and of Canadian growth. The exact origin of this material is somewhat doubtful but it was selected from shipments of ordinary commercial ties originating in Ontario and Quebec and about to be used for replacements. After a considerable amount of work had been done it was found that, owing to lack of uniformity in the experimental material due to checks, shakes, incipient decay, sapwood per cent, knots, moisture content, etc., interpretation of results was obscured to such an extent that reliable conclusions as to the penetration obtainable by different processes could not be reached. Test pieces, also of Canadian growth were then employed. These were carefully selected so as to be sound, strictly heartwood, free from large knots, shakes, checks and other defects, comparable as to rate of growth and of an average moisture content similar to that of the tie material. Heartwood was selected because it was found in preliminary tests to be more difficult to impregnate with creosote oil than was sapwood. These test pieces were found highly satisfactory as they permitted all the work to be carried out on material of a relatively uniform character, facilitated interpretation of results, allowed a much larger number of units per cylinder charge and, consequently, enabled more reliable conclusions as to penetration obtainable by different processes to be drawn from the work. Throughout the remainder of the investigation such test pieces were exclusively used and all results reported herein are based on the same. It should be noted that heartwood in test pieces of this character differs in no respect from heartwood on the faces of ties of the same species and consequently there is no reason whatever why the average results obtained, as regards penetration, in a large number of test pieces should not apply to ties.

Preservative

The preservative used was a coal tar creosote oil employed commercially for the treatment of railway ties. The specific gravity at 60° C. was 1·041. Distilled by the United States Forest Service method it yielded the following fractions:—

Temperature Interval.	Per cent.
0° – 205° C.	17·21
205° – 255° C.	36·30
255° – 295° C.	11·76
295° – 320° C.	7·35
Residue and loss	27·38

EXPERIMENTAL METHODS

Each cylinder charge consisted of about twenty test pieces. Moisture content (based on oven-dry weight), volume, and absorption of preservative per cubic foot were determined for each individual test piece. Penetration was determined by sawing the test pieces lengthwise into four parts after treatment as indicated in Fig. 1. The

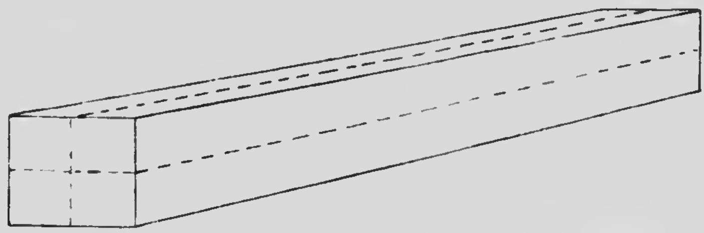


FIG. 1—Method of sawing test piece, after treatment, to inspect penetration.

freshly sawn surfaces of each quarter were then planed and penetration estimated. The most characteristic quarter was then retained for reference purposes and photographing. This procedure permits of a very accurate estimation of the penetration from all surfaces of the test piece.

EXPERIMENTAL DATA, PART I

PENETRABILITY OF JACK PINE AND EASTERN HEMLOCK

JACK PINE

A considerable number of charges of jack pine, each consisting of about twenty pieces 4 or 5 feet by 4 inches by 4 inches, were first treated by various processes in commercial use. It was found, early in the work, that jack pine was very readily penetrable by creosote oil and that satisfactory penetration could be secured by several processes in common commercial use even when the moisture content of the outer layers of the wood was as high as 32 per cent on an oven-dry basis. The approximate weight per cubic foot of jack pine containing various percentages of moisture is shown in Fig. 2. Jack pine material weighing approximately 35 pounds per cubic foot was found to be in good condition for creosote treatment.[1]

Typical results as to penetration obtained in jack pine, using pressure periods ranging from half an hour to two hours are stated in Tables 3, 4 and 5. In the treatments, the results of which are reported in these tables, temperature of the creosote during treatment was approximately 185° F.; maximum pressure was 175 pounds per square inch and was reached in about 40 minutes. A final vacuum of 26 inches was maintained for 15 minutes.

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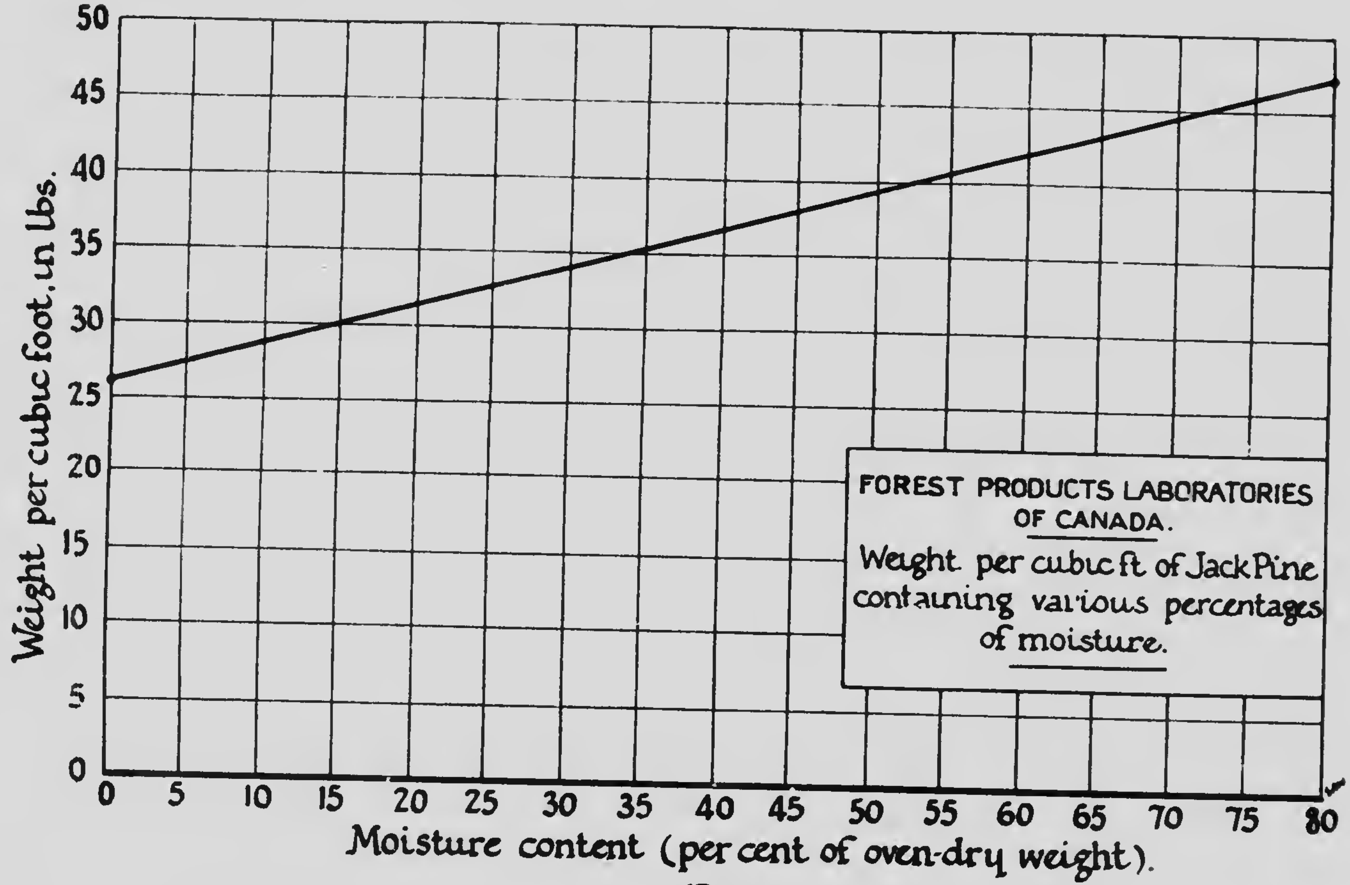
[1] A seasoning study, with the object of ascertaining the seasoning period necessary to dry both jack pine and hemlock of Canadian growth to treatable condition, is now proceeding.



FOREST PRODUCTS LABORATORIES OF CANADA.
Weight per cubic ft. of Jack Pine containing various percentages of moisture.
Weight per cubic foot, in lbs.
0
5
10
15
20
25
30
35
40
45
50
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Moisture content (per cent of oven-dry weight).

Fig. 2.

TABLE 3—Results obtained in the treatment of jack pine test pieces, using a half-hour pressure period.

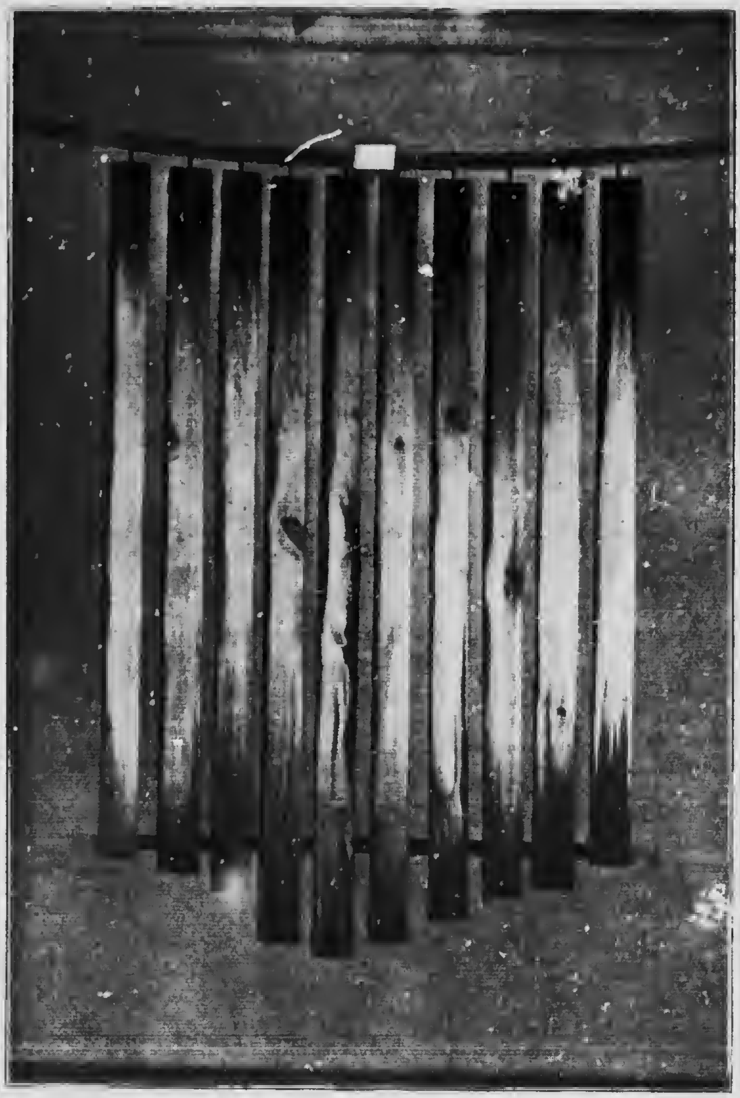
Unit No.	Average Moisture Content (% of oven-dry wt.)	[1]Absorption, per cu. ft.	Penetration (Heartwood.)
		lb.	
112a	42·0	12·2	Unsatisfactory ; erratic ; estimated average $\frac{1}{4}$ inch. (See plate 3.)
113a	38·9	11·4	
114a	36·2	13·4	
115a	39·0	7·8	
116a	26·8	12·5	
117a	33·6	11·6	
118a	26·6	9·8	
119a	45·0	8·1	
120a	59·6	9·7	
121a	38·9	10·7	
122a	36·9	11·0	
123a	32·1	7·9	
124a	29·5	8·6	
125a	46·2	9·3	
126a	43·6	8·7	
127a	41·4	8·8	
128a	32·0	11·7	
129a	32·2	8·1	
130a	38·5	10·0	
131a	34·7	9·2	
Average	37·7	10·0	

[1] Absorption per cubic foot in pieces of the size treated is, of course, higher than would occur in the same kind of timber of tie size treated by the same process. Penetration in the heartwood, however, would be the same in both cases.

TABLE 4—Results obtained in the treatment of jack pine test pieces, using a one-hour pressure period.

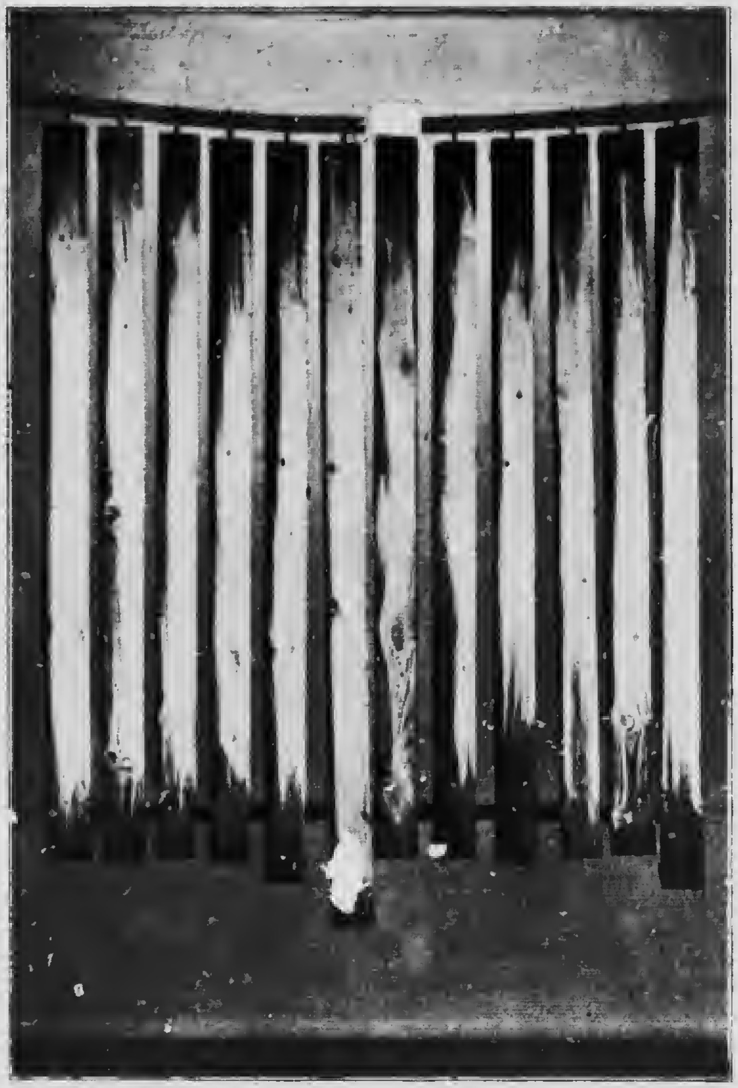
Unit No.	Average Moisture Content (% of oven-dry wt.)	Absorption per cu. ft.	Penetration (Heartwood).
		lb.	
132b	34·0	10·5	Unsatisfactory; erratic; estimated average $\frac{3}{8}$ inch. (See plate 4.)
133b	30·5	10·1	
134b	32·2	10·0	
135b	31·5	9·1	
136b	41·0	6·5	
137b	42·2	9·3	
138b	44·1	7·5	
139b	29·5	12·7	
140b	32·0	9·3	
141b	34·8	8·4	
142b	36·7	10·4	
143b	52·6	6·8	
144b	43·1	9·3	
145b	25·0	11·5	
146b	33·1	10·0	
147b	26·7	11·5	
148b	38·0	13·2	
149b	36·2	8·6	
150b	38·7	9·0	
151b	41·2	10·0	
Average	36·1	9·7	

Plate III



Penetration obtained in jack pine heartwood using a half-hour pressure period (about one-twelfth actual size). See Table 2.

Plate IV



Penetration obtained in jack pine heartwood, using a 1 hour pressure period (about one-twelfth actual size). See Table 4.

TABLE 5.—Results obtained in the treatment of jack pine test pieces, using a two-hour pressure period.

Unit No.	Average Moisture Content (% of oven-dry wt.)	Absorption per cu. ft.	Penetration (Heartwood.)
		lb.	
132a	34·0	11·4	Fairly satisfactory; somewhat erratic; estimated average ⅝ inch. (See plate 5.)
133a	30·5	14·8	
134a	32·2	11·0	
135a	31·5	8·2	
136a	41·0	12·7	
137a	42·2	13·0	
138a	44·1	16·0	
139a	29·5	18·4	
140a	32·0	12·4	
141a	34·8	13·1	
142a	36·7	11·8	
143a	52·6	15·4	
144a	43·1	13·9	
145a	25·0	17·2	
146a	33·1	13·7	
147a	26·7	15·0	
148a	38·0	18·9	
149a	36·2	13·4	
150a	38·7	10·7	
151a	41·2	11·2	
Average	36·1	13·6	

Comparing the results stated in Tables 3, 4 and 5 it may be noted that, in material of approximately equal moisture content, satisfactory penetration was not secured with pressure periods of half an hour or one hour, but that with a two-hour period reasonably satisfactory penetration was obtained. It is concluded that jack pine, seasoned to about the stage indicated, can be satisfactorily creosoted under the conditions stated when a pressure period of not less than two hours is used. Further tests, in which other pressure periods were used, confirmed the above conclusion.

HEMLOCK

To ascertain the results obtainable in hemlock when creosoted by the usual methods a large number of charges, each consisting of about twenty test pieces, were treated by various processes in common commercial use. The penetration obtained was extremely poor and decidedly erratic except in occasional pieces in which individual peculiarities probably rendered the wood much more easily penetrable. The attempt was then made to secure satisfactory penetration by means of severe treatments in which pressure periods up to 12 hours, temperatures up to 225°F., and pressures up to 200 pounds per square inch were employed. These treatments considerably increased absorption per cubic foot but still failed to give a satisfactory penetration. The increased absorption was due mainly to greater end penetration. It was found that the test pieces were treated practically to refusal in less than 6 hours.

The employment of pressures exceeding 200 pounds per square inch is not feasible in the ordinary commercial plant, and it was concluded from the results that raising the temperature a further 25° or 50° F. would not appreciably increase penetration. It was therefore concluded that there was nothing to be gained by further tests along these lines.

Typical results obtained by treating for 6 hours at 225° F. and 200 pounds per square inch (maximum pressure being reached in 45 minutes), followed by a vacuum of 26 inches for 15 minutes, are shown in Table 6.

Plate V

Penetration obtained in jack pine heartwood using a 2-hour pressure period (about one twelfth actual size). See Table 5.

TABLE 6.—Results obtained in the treatment of hemlock test pieces, using a six-hour pressure period.

Unit No.	Average Moisture Content. (% of oven-dry wt.)	Absorption per cu. ft.	Penetration (Heartwood).
		lb.	
56b	20·2	26·3	Quite unsatisfactory; estimated average slightly over ¼-inch.
57b	20·2	22·4	
58b	28·4	25·9	
59b	19·2	28·2	
60b	20·0	20·4	
61b	19·0	18·9	
62b	19·6	27·2	
63b	22·1	29·4	
64b	17·7	29·0	
65b	19·8	11·3	
66b	19·4	21·7	
67b	19·7	23·3	
68b	19·5	29·3	
69b	19·0	16·0	
70b	19·1	22·5	
71b	23·8	19·6	
72b	17·7	15·5	
73b	19·1	24·6	
74b	19·7	28·8	
75b	19·4	21·6	
Average	20·2	23·2	

Other treatments were tried in which prolonged preliminary steaming, preliminary vacuum, or preliminary soaking in hot preservative were resorted to. An extensive investigation along these lines still failed to yield the desired results, penetration remaining decidedly poor. In view of this fact it is unnecessary to go into all the details of the tests made. Some general statements in this connection however may be of interest. The material used was air-dry or approximately air-dry in all cases.

The effect of preliminary steaming at 20 pounds per square inch with saturated steam for periods ranging from two to twelve hours, followed by vacuum of 26 inches for one-half to two hours, was investigated. It was found that steaming at 20 pounds per square inch, even for two hours, retarded penetration of the preservative from the outer surfaces and apparently caused serious damage to the wood; that lengthening the steaming period appeared to cause increased damage and further retarded penetration. While steaming may render possible the securing of a satisfactory absorption per cubic foot, it appears that such absorption is secured only at the cost of serious damage to the wood.

The effect of a preliminary vacuum of 26 inches for periods ranging from one to five hours was investigated. It was found that preliminary vacuum tended to increase absorption per cubic foot but that any increase in penetration was so slight as to be inappreciable.

For the purpose of raising the temperature of the wood for some distance from the surface to a point sufficiently high to prevent the oil from congealing as it penetrated into the wood, treatments were made in which the test pieces were soaked in creosote oil at a temperature of 190° F. and at atmospheric pressure for several hours prior to applying higher pressure. This procedure failed to yield satisfactory results in regard to penetration.

EXPERIMENTAL DATA, PART II

Treatment of Jack Pine and Eastern Hemlock Prepared by Special Method

HEMLOCK

No satisfactory method of impregnating hemlock having been found, it was considered advisable at this point to approach the problem in an entirely different way. Trial was therefore made of the effect of making small holes in the surface of the timber before impregnation, with the idea of facilitating penetration and distribution of pr[illegible]ative. This principle, while it is a revolutionary one in wood preservation, is not entirely new. There is some doubt as to just where and when it originated. It is believed that the first developments worth mentioning in this connection occurred in Austria prior to 1911. The process was there used in the treatment of poles.

Plate VI

Side view of one of the knife-like projections used in the experimental incising machine (about actual size).

Some developments along this line subsequently occurred both in Germany and on the Pacific coast of America and attention has also been occasionally drawn to the method in technical periodicals in recent years. Preliminary trials of the process in this investigatio[illegible] to a recognition of its possibilities and attention was therefore concentrate[illegible] development.

After a large number of tests with an experimental machine it was found that by far the best results were obtained by producing in the surfaces of the timber incisions of a special character by means of projections of a knife-like form in contradistinction to those of a circular, rectangular or other form in cross-section. (See Plate 6.) The incisions used were relatively long and very narrow and were so made that the disturbance to the fibres of the wood was very slight and so that the incisions closed up after treatment and were barely noticeable. (See Plate 7.) The arrangement or spacing of the incisions was found to be of great importance. Suitable arrangement permits of uniform distribution of the preservative throughout the treated zone in a relatively short period.

Plate VII

Fig. 1 Fig. 2

Fig. 1.—View showing incisions before treatment of the timber (actual size).
Fig. 2.—View showing incisions after treatment (actual size). The incisions have closed up so as to be difficult to distinguish.

These incisions, as distinct from round or other holes or perforations, present to the direct action of the preservative a much larger surface for penetration across than with the grain, thus somewhat compensating for the fact that wood is much more easily penetrable with than across the grain, and enabling a much more uniform distribution of preservative to be obtained than can usually be secured in ordinary practice. It was also found that by incising timber in this way every unit in a charge showed satisfactory penetration.

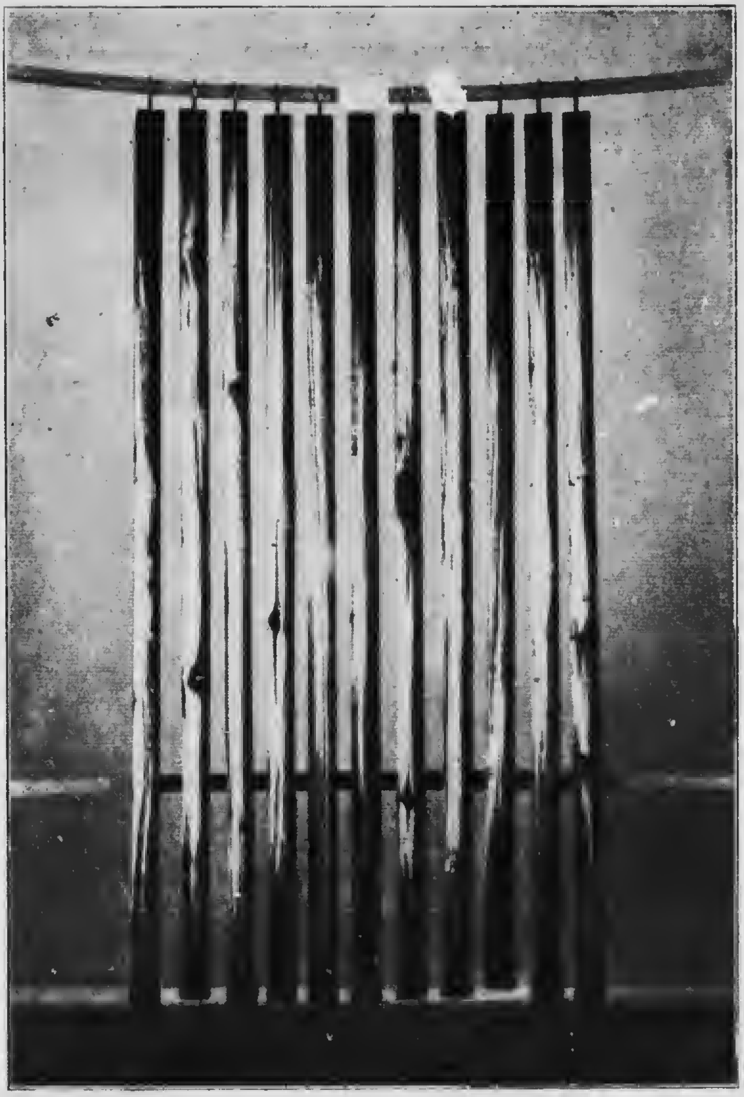
Tests made to determine the effect of incising on strength indicated that with the type and arrangement of projections used the reduction in strength was so slight as to be negligible.

A number of charges of hemlock were treated after incising. It was found that highly satisfactory penetration could be secured in air-dry material with a pressure period of about two hours' duration. Typical results obtained in the treatment of incised hemlock with an oil temperature of 185° F. and a pressure of 175 pounds per square inch (maximum being reached in 45 minutes) followed by a vacuum of 26 inches for 15 minutes, are shown in Table 7.

TABLE 7. Results obtained in the treatment of incised hemlock test pieces, using a two-hour pressure period.

Test No.	Moisture Content (% of oven-dry wt.)	Absorption per cu. ft.	Penetration (Heartwood).
		lb.	
95b	19.2	14.6	Very uniform; estimated average [illegible] inch (See plate 8.)
96b	18.5	18.1	
97b	20.4	18.0	
98b	19.5	24.6	
99b	17.5	20.8	
100b	16.8	25.0	
101b	18.2	13.4	
102b	20.2	16.3	
103b	20.4	24.8	
104b	18.2	25.0	
105b	18.8	15.5	
106b	18.7	19.0	
107b	20.0	14.8	
108b	19.1	15.7	
109b	19.2	16.2	
110b	17.5	17.8	
111b	17.5	22.1	
Average	18.8	18.9	

Plate VIII



Penetration obtained in incised hemlock heartwood, using a 2-hour pressure period (about one-twelfth actual size). See Table 7.

JACK PINE

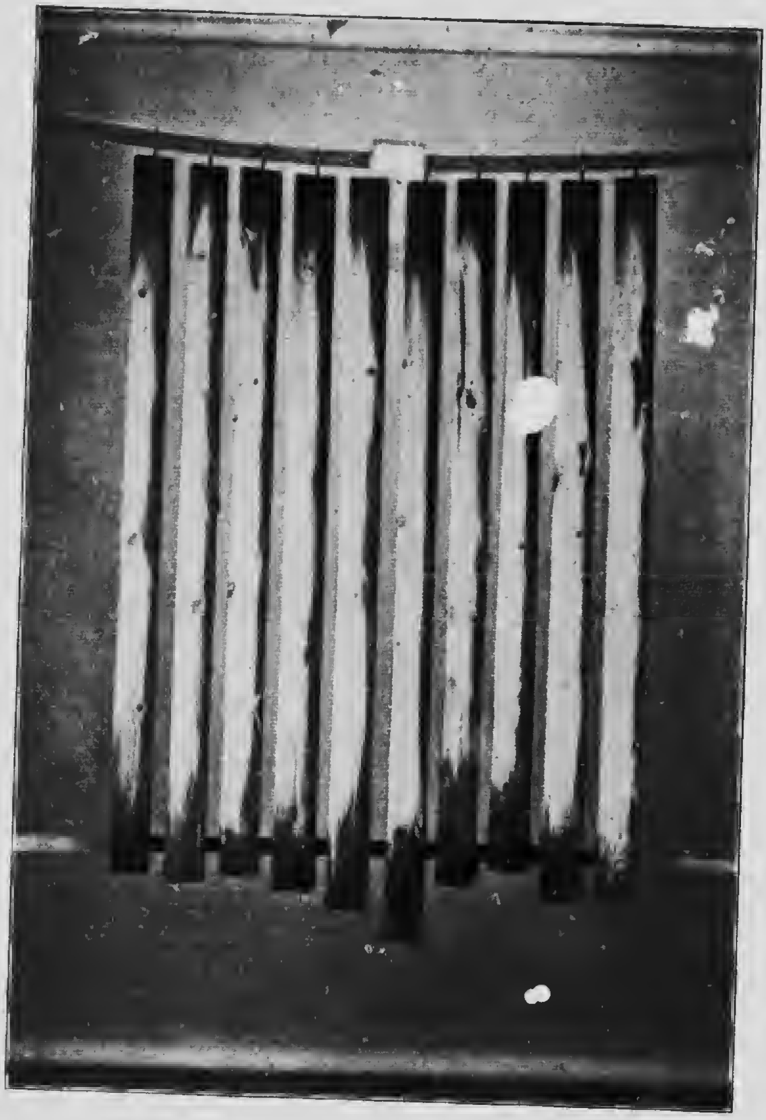
In view of the results described above on hemlock it was considered desirable to investigate the effect of incisions in the treatment of jack pine. After treating a number of charges consisting of incised test pieces it was found that with similar material in both cases a somewhat deeper and much more uniform penetration than was secured with a two-hour pressure period in wood without incisions was obtained with a half-hour pressure period in incised timber, the details of treatment being other ..se identical. Typical results obtained in the treatment of incised jack pine with an oil temperature of 185° F. and a pressure of 175 pounds per square inch (maximum being reached in about 40 minutes) followed by a vacuum of 26 inches for 15 minutes, are shown in Table 8.

TABLE 8.—Results obtained in the treatment of incised jack pine test pieces, using a half-hour pressure period.

Unit No.	Average Moisture Content (% of oven-dry wt.)	Absorption per cu. ft.	Penetration (Heartwood.)
		lb.	
112b	12·0	11·2	Excellent ; very uniform ; estimated average [illegible] inch. (See plate 5.)
113b	38·9	12·1	
114b	36·2	15·3	
115b	39·0	9·9	
116b	26·8	10·6	
117b	33·[illegible]	12·0	
118b	26·6	13·0	
119b	47·0	9·0	
120b	59·6	9·2	
121b	38·9	10·8	
122b	36·9	13·4	
123b	32·1	10·4	
124b	29·5	11·6	
125b	46·2	11·9	
126b	43·6	9·2	
127b	41·4	9·5	
128b	32·0	10·1	
129b	32·2	. .	
130b	48·5	10·4	
131b	34·7	13·2	
Average	38·2	11·2	

The outstanding results of the investigation are briefly presented in Table 9.

Plate IX



Penetration obtained in incised jack pine heartwood, using a half-hour pressure period (about one-twelfth actual size). See Table 8.

TABLE 9.—Typical results obtained in treating Jack Pine and Eastern Hemlock with and without incisions.

Species.	*Dimensions of Test Pieces.	Number of Pieces per Charge.	Moisture Content (% of oven-dry weight).	†Details of Treatment.			Penetration (side.) — (Heartwood.)	‡Absorption per cu. ft.	Treatment in General.	Remarks.
				Temp. of Preservative	Pressure	Duration of Pressure Period.				
				°F	lb. per sq. in.	hrs.		lb.		
Hemlock	4 in. x 5 in. x 5 ft	20	20·2	200	200	6	Extremely erratic; average ¼ in.	23·2	Quite unsatisfactory.	Not incised.
"	" "	20	18·8	185	175	2	Very uniform: average ¾ in.	18·8	Excellent	Incised.
Jack pine	4 in. x 4 in. x 4 ft.	20	36·1	185	175	2	Somewhat erratic; average ⅝ in	15·7	Fairly good.	Not incised.
"	" "	20	38·2	185	175	½	Very uniform, average ¾ in.	11·2	Excellent	Incised.

* All test pieces free from defects and strictly heartwood, winter cut and similar (within the same species) as to rate of growth and condition of seasoning.
† In all cases maximum pressure was reached in 10-45 minutes and a final vacuum of 26 ins. was drawn for 15 minutes.
‡ The absorption per cubic foot in pieces of the size treated is, of course, much higher than would occur in sound timber of tie size treated by the same process. Penetration, however, would be the same in both cases.
The absorption per cubic foot in actual ties will be determined when the ties now being used in the seasoning study become available for treatment. (See footnote p. 9.)

CONCLUSIONS

(1) Satisfactory penetration of creosote oil can be secured in jack pine heartwood, even when not thoroughly air-dry, by several processes in common commercial use.

(2) By means of the incision method[1] satisfactory penetration can be secured in jack pine heartwood, even when not thoroughly air-dry, in a considerably shorter time and with less preservative per cubic foot than when treated unincised. Further, the penetration is much more uniform in the incised timber.

(3) It does not appear possible to secure a satisfactory penetration of creosote oil in eastern hemlock heartwood, even when air-dry, by processes in common commercial use.

(4) Air-dry eastern hemlock heartwood can be impregnated with creosote oil in a thoroughly satisfactory and economical manner by means of the incision method.

(5) Incising timber causes a slight reduction in its strength. This reduction, however, is so slight as to be negligible for all practical purposes and is amply justified on account of the better protection given to the timber, in treatment, as a result of incising.

(6) A thorough trial of the incision method on a commercial scale is desirable, especially as results similar to those reported above would almost without doubt be secured in a number of other species in addition to jack pine and eastern hemlock.

[1] Patents applied for.

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