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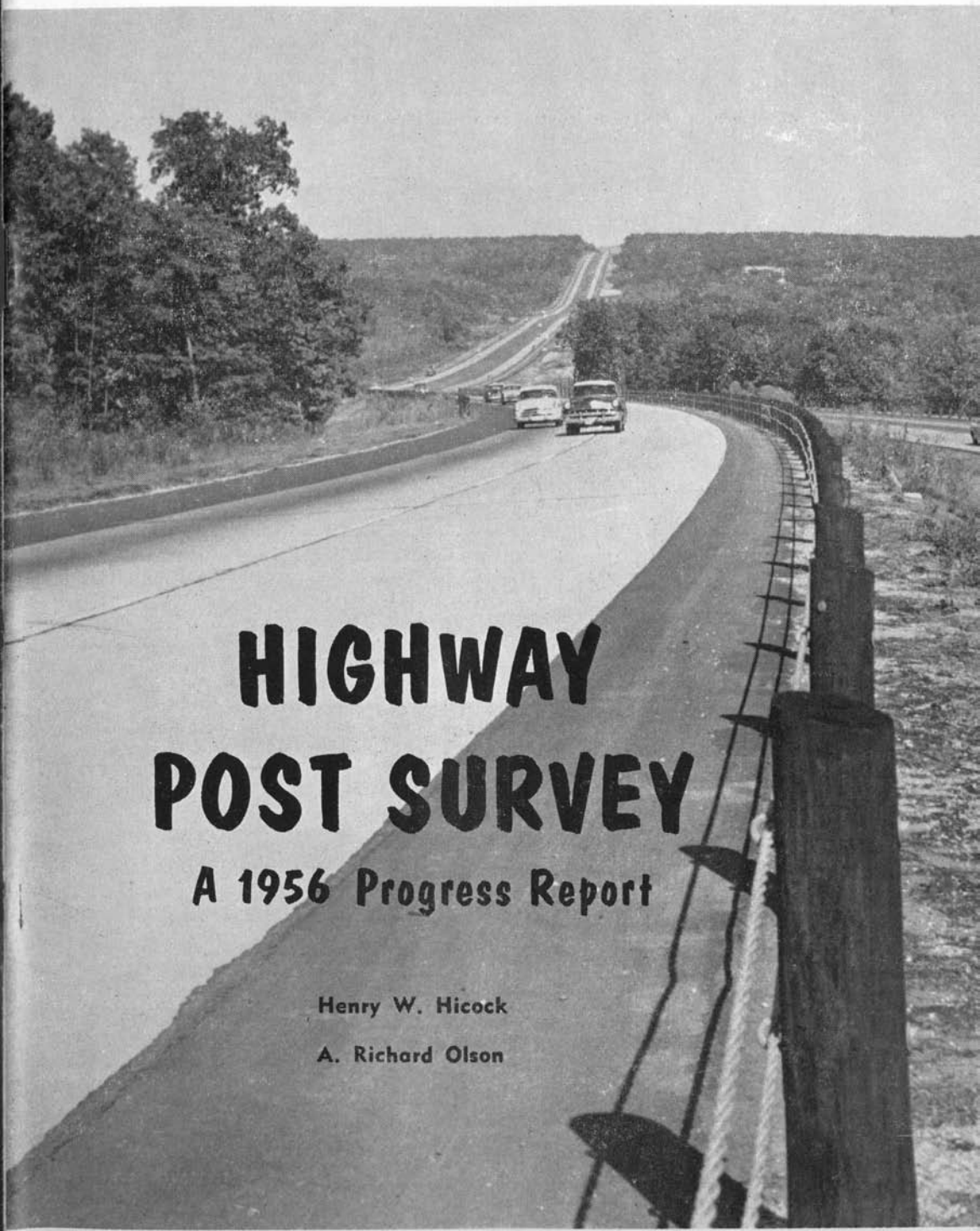

HIGHWAY POST SURVEY

A 1956 Progress Report

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THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION • NEW HAVEN

CONTENTS

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Under a cooperative agreement between this Station and the Connecticut State Highway Department a study of the service life of wood posts used in highway fencing was begun in 1940, and since that time a total of some 8,500 posts have been under observation, not all at the same time. Most of these posts were set on the shoulders of the road and bore two galvanized woven steel cables fastened to the posts with eyebolts; a few were used to support woven wire along the boundaries of adjacent property. They were 7 feet long for cable or 8 feet long for wire and were set to a depth of 3½ feet. With one exception, all posts were in the round and all posts had received preservative treatment in the manner later described.

The objectives of the study were first, to provide the Highway Department with data for use in setting up specifications for wood posts, and second, to gather information on preservative treatment when a large number of posts was involved. Because the posts were scattered over many miles of highway at widely separated locations it was not considered feasible to make inspections oftener than once every 5 years. Furthermore, this wide dispersal and infrequency of inspection sometimes made it impossible to determine precisely the reason for removal where posts had been replaced between inspections. This was anticipated and the general plan specified that any method of treatment or preservative be represented by 100 or more posts. This plan was followed with a few minor exceptions, as shown in Table 1 and Table 2.

The project started in 1940 with the tagging and inspection of some 4,800 posts which had been set between 1933 and 1935 and the tagging without inspection of some 3,300 posts set in 1939 and 1940. Reinspections were made in 1945, 1950, and 1955. These included all posts mentioned above on which observations had not been terminated (see Tables) and also some 400 posts set after 1940.

Inspection was done by excavating to a depth of 12 inches and carefully examining the exposed part of the post with the aid of a strong thin-bladed probe and a light hammer. The authors have found that light hammer blows can be used to detect zones of interior decay which can then be explored by the probe. No attempt was made to examine the part of the post below the excavation since experience had indicated that, in a very high percentage of cases, deterioration at the ground line will be more advanced than at levels more than 12 inches below that point.

Mimeographed reports for use by the cooperating departments were prepared after each inspection but were not available for general distribution until 1954. At that time the results of the 1950 and all previous inspections were incorpor-

ated in a bulletin[1] of this Station. This report includes the results of the 1955 inspection and is consequently a supplement to that bulletin. This report, however, includes certain items not previously reported, and omits data on species formerly classified as "miscellaneous."

Insofar as possible, record keeping conformed to procedure established by the U. S. Forest Products Laboratory. This consisted of considering the post as divided into two parts:

A. *The Butt* — that part of the post extending from 6 inches above ground to the bottom.

B. *The Top* — that part of the post more than 6 inches above ground.

The condition of butts and tops was then classified as follows:

1. Butt good *BG* — no evidence of decay.[2] Serviceable *S*.[3]
2. Butt partially decayed *BPD* — decay present but so limited that an effective diameter of 6 inches or more of sound wood still remained at ground line. Serviceable *S*.
3. Butt decayed *BD* — decay present to such an extent that the effective diameter of sound wood at ground line was less than 6 inches. Unserviceable *U*.
4. Top good *TG* — no evidence of decay. Serviceable *S*.
5. Top partially decayed *TPD* — decay present but so limited that an effective diameter of 6 inches or more of sound wood still remained at and below the top cable bolt. Serviceable *S*.
6. Top decayed *TD* — decay present to such an extent that the effective diameter of sound wood was less than 6 inches at and below the top cable bolt. Unserviceable *U*.

The condition of tops and butts of posts, treated by the methods and preservatives described below, is classified in Table 1. The percentages under the several headings are based on the number of posts found at the time of inspection, not on the number originally set.

Table 2 classifies the same posts as "serviceable" or "unserviceable" as indicated in the specifications given above. In Table 2, however, the percentages are based on the number of posts originally set, less those known to have been removed in relocation of highways or similar operations and, consequently, present a better basis for estimating losses from all causes than do the data in Table 1.

It may be well to note at this point that the criteria for judging the condition of the tops and butts of posts and for determining whether a post was serviceable or unserviceable were far more rigid than would be used to define the condition of farm and other types of posts in situations where human life is not at stake. Moreover, Connecticut highway specifications state that the minimum diameter of a post must be 6 inches. By implication this would mean that a post must have a minimum effective diameter of 6 inches at all times.

Types of Treatment

Treatment under pressure

Red and southern yellow pine posts were purchased through commercial channels under a specification which called for a retention of 6 lbs. of grade 1 A. W. P. A. coal tar creosote per cubic foot. All posts were framed to final size and bored for eyebolts prior to treatment.

The hardwood posts were purchased untreated by the Highway Department, which had them custom-treated in 8-foot lengths. Creosote specifications were the same as for the pines. Specifications for Wolman salt treatment are not available but presumably were standard for this material. All hardwood posts pressure-treated with creosote were framed to final length of 7 feet and bored for eyebolts *after* treatment. The cut tops were given a brush coat of creosote after setting.

Open-tank treatment with Grade 1 A. W. P. A. coal tar creosote

(1) Treatment of butts only was performed by the State Forestry Department on specifications of the Highway Department which stipulated that the top 2½ feet of the post should not be treated because this would interfere with the application of white paint for visibility. Treatment was by immersing the lower 4 feet of the posts in creosote. Hot bath temperatures of 215°F. were maintained for 4 to 6 hours. Some of the posts were subjected to a cold bath of 4 to 16 hours duration; others were not. Some of the poor results in service may have been due to omission of the cold bath but the rapid spread of decay from the untreated tops so complicated the situation that it was impossible to estimate the effectiveness of treatment with and without cold bath. Practically all maple and birch posts were incised from 18 inches below to 6 inches above ground line.

These posts showed an appreciable amount of decay in the tops in from 5 to 7 years. It was decided, therefore, to give full-length open-tank treatment to some 300 posts for camparison. Treatment was done in the same equipment as butt-treated posts; details are given in the next section.

(2) Full-length open-tank treatment followed essentially the same pattern as for open-tank treatment of butts only. It was accomplished by first immersing one end of the post in hot creosote for several hours and then reversing the posts in the tank to give a similar treatment to the other end. No posts were incised; all posts were framed to final dimensions but not bored before treatment. Bore holes were later treated with creosote.

Dip treatment to butts only

Dip treatment to butts only was accomplished by immersing the lower 4 feet of the posts in hot coke oven tar for 1 minute. The posts were treated by the Highway Department at one of its maintenance yards.

Brush treatment to butts only

Brush treatment to butts only was either with a high-grade brushing creosote or with a tar known as 8-13. Of the posts brushed with 8-13 tar, the locust posts were in the round; all others were rejected tie stock, slabbed on two sides. They were treated by highway maintenance crews on the job just before setting.

Cold-soaking

These posts were purchased from a Connecticut supplier who cold-soaked them fully immersed in a 5 per cent solution of pentachlorophenol in furnace oil. Soaking was for 48 to 96 hours. Some checks on the posts treated by

[1] Bulletin 581, Preservation of Wood by Simple Methods, by Henry W. Hicock and A. Richard Olson.

[2] The term decay, as here used, includes deterioration caused by fungi and insects. Only very occasional damage by termites and ants was found and is not separated from defects caused by decay.

[3] Letters in italic type appear as abbreviated column headings in Tables 1 and 2.

TABLE 1

Treatment, Preservative and Species	Number of Posts	After 5-7 Years Service						Number of Posts	After 10-12 Years Service						Number of Posts	After 15-17 Years Service					
		BUTT			TOP				BUTT			TOP				BUTT			TOP		
		BG	BPD	BD	TG	TPD	TD		BG	BPD	BD	TG	TPD	TD		BG	BPD	BD	TG	TPD	TD
		Per cent			Per cent				Per cent			Per cent				Per cent			Per cent		
Pressure, Creosote (1)																					
White Oak	249	98.8	1.2	0.0	100.0	0.0	0.0	245	91.4	5.7	2.9	88.6	11.0	0.4	242	83.1	10.7	6.2	83.5	12.0	4.5
Red Oak	520	99.0	1.0	0.0	100.0	0.0	0.0	512	88.9	8.8	2.3	81.1	18.7	0.2	502	71.1	18.1	10.8	74.1	17.1	8.8
Maple	68	92.6	5.9	1.5	100.0	0.0	0.0	68	54.4	27.9	17.7	100.0	0.0	0.0	63	42.9	14.3	42.8	84.1	14.3	1.6
Birch	42	97.6	2.4	0.0	100.0	0.0	0.0	42	81.0	19.0	0.0	100.0	0.0	0.0	42	50.0	28.6	21.4	92.7	7.3	0.0
Red Pine	549	100.0	0.0	0.0	100.0	0.0	0.0	526	100.0	0.0	0.0	100.0	0.0	0.0	521	99.6	0.4	0.0	100.0	0.0	0.0
Southern Yellow Pine	482	100.0	0.0	0.0	100.0	0.0	0.0	472	98.7	0.9	0.4	100.0	0.0	0.0	460	94.8	2.6	2.6	99.1	0.9	0.0
Total	1910							1865							1830						
Pressure, Wolman Salts (1)																					
Oak	386	0.0	100.0	0.0	100.0	0.0	0.0	386	0.0	95.3	4.7	99.5	0.5	0.0	379	0.0	73.9	26.1	98.7	1.3	0.0
Maple	9	0.0	100.0	0.0	100.0	0.0	0.0	9	0.0	100.0	0.0	100.0	0.0	0.0	9	0.0	88.9	11.1	88.9	11.1	0.0
Total	395							395							388						
Open Tank, Butts Only, Creosote (2)																					
White Oak	400	98.5	1.2	0.3	43.0	47.2	9.8	384	86.2	4.9	8.9	21.1	49.0	29.9	329	77.8	15.2	7.0	10.0	53.2	36.8T
Red Oak	1264	98.7	0.5	0.8	42.0	48.2	9.8	1188	74.1	15.4	10.5	9.8	37.4	52.8	814	49.8	32.8	17.4	2.8	31.2	66.0T
Maple	1293	98.7	0.9	0.4	67.9	23.2	8.9	1208	66.1	11.7	22.2	24.8	28.0	47.2	807	46.1	19.1	34.8	6.2	31.2	62.6T
Birch	304	100.0	0.0	0.0	70.4	16.8	12.8	284	70.2	16.3	13.5	18.8	23.0	58.2	198	45.5	22.7	31.8	5.1	24.7	70.2T
Pitch Pine	361	97.8	0.5	1.7	72.0	16.6	11.4	346	73.7	7.8	18.5	30.9	38.7	30.4	297	24.9	18.9	56.2	6.4	36.0	57.6T
Total	3622							3410							2445						
Open Tank, Full Length, Creosote (1)																					
Oak	195	99.5	0.5	0.0	100.0	0.0	0.0	194	99.5	0.5	0.0	86.6	13.4	0.0	192	90.6	6.8	2.6	63.5	30.2	6.3
Maple	51	98.0	0.0	2.0	100.0	0.0	0.0	43	86.0	4.7	9.3	90.7	9.3	0.0	43	60.5	16.3	23.2	90.7	7.0	2.3
Birch	53	100.0	0.0	0.0	100.0	0.0	0.0	52	98.0	0.0	2.0	100.0	0.0	0.0	52	92.3	3.9	3.8	100.0	0.0	0.0
Total	299							289							287						
Cold Soaking, Pentachlorophenol (3)																					
Red Pine	413	98.8	1.2	0.0	91.0	9.0	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Barrel Method, Zinc Chloride (4)																					
Red Pine	56	87.5	8.9	3.6	100.0	0.0	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Butts Brushed, Creosote (2)																					
White Oak	415	6.0	6.0	88.0	49.4	42.2	8.4	359	0.0	4.2	95.8	7.5	52.4	40.1	193	0.0	6.2	93.8	4.1	45.6	50.3T
Red Oak	32	3.1	0.0	96.9	37.5	50.0	12.5	31	0.0	6.4	93.6	6.4	45.2	48.4	16	0.0	0.0	100.0	12.5	18.7	68.8T
White Cedar	660	43.6	23.5	32.9	93.9	6.1	0.0	647	9.7	38.7	51.6	61.2	36.0	2.8	617	8.8	33.7	57.5	37.0	57.7	5.3T
Black Locust	75	100.0	0.0	0.0	69.4	29.3	1.3	75	4.0	96.0	0.0	64.0	34.7	1.3	75	1.3	96.0	2.7	46.7	53.3	0.0T
Total	1182							1112							901						
Butts Brushed, 8-13 Tar (1)																					
Oak	78	0.0	12.8	87.2	15.4	79.5	5.1	16	0.0	6.2	93.8	18.7	56.3	25.0T	.....	.....	.....	.....	.....	.....	.....
Pitch Pine	32	3.1	15.6	81.3	18.7	25.0	56.3T	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Black Locust	357	7.3	92.7	0.0	99.2	0.8	0.0	338	0.0	99.7	0.3	83.7	16.3	0.0	256	0.0	98.0	2.0	77.0	23.0	0.0
Total	467							354													
Butts Dipped, Hot Coke-Oven Tar (1)																					
White Oak	82	0.0	45.1	54.9	52.4	47.6	0.0	71	0.0	19.7	80.3	1.4	69.0	29.6T	.....	.....	.....	.....	.....	.....	.....
Red Oak	150	0.0	40.7	59.3	38.0	59.3	2.7	79	0.0	7.6	92.4	0.0	39.2	60.8T	.....	.....	.....	.....	.....	.....	.....
Total	232							150							6107						
Grand Total	8576							7575													

(1) Set 1939-40. (2) Set 1933-35. (3) Set 1951. (4) Set 1948.

T = Tests terminated.

this supplier indicated that his treatment resulted in absorptions of 7 to 9 lbs. of solution per cubic foot and penetrations at midpoint of 1½ inches or more.

Barrel method

These posts were purchased from another Connecticut supplier who had treated them in an unseasoned condition with a 33⅓ per cent solution of zinc chloride by immersing one end in a barrel or tank. After sufficient solution to provide 1 lb. of dry salt for each cubic foot of wood in the post had been taken up, the posts were stood in a vertical position with the intake end up for 90 days or more to equalize the distribution of salt within the post. Framing and boring was done after treatment.

Results of Treatment

Pressure with creosote

After 15 to 17 years of service both red and southern yellow pine posts were in excellent condition with less than 3 per cent of failures from decay.

After the same length of time the condition of the hardwoods was less satisfactory. The ring-porous oaks were in better shape on the whole that the diffuse-porous maple and birch. White oak was better than red oak, as might be expected from the relative durability of the heartwood of the two species (Table 2). Considering the tops and butts separately (Table 1) the tops of the oaks showed a higher incidence of decay than those of maple and birch. The butts of the oaks, on the other hand, were in better condition than the butts of maple and birch. It is believed that this reversal can be accounted for as follows:

When treated full-length with creosote or an oil-soluble preservative, such as pentachlorophenol, by any method, maple and birch posts tend to absorb an excessive amount of preservative near the extreme ends. Penetration at the mid-point of the post, on the other hand, is often extremely shallow. Under the same conditions oak posts tend to get a complete sapwood penetration over their entire length with relatively little heartwood penetration. Shallow penetration at mid-point (ground line) could be responsible for the greater amount of decay in the butts of maple and birch posts than in the butts of oak posts. Conversely, since about a foot was removed from all posts *after* treatment, it seems reasonable to believe that the heavy absorption near the ends of maple and birch posts could make their tops more resistant to decay than the tops of oak posts on which cutting exposed a large surface of untreated heartwood. The cut ends of the oak posts showed much more severe checking than those of maple and birch posts and, if such checking occurred after cutting, exposing untreated wood, brush treatment of the cut surfaces could not be expected to afford adequate protection over a period as long as 15 years.

Pressure with Wolman salts

After 10 years of service, the butts of a high percentage of the posts were listed as "partially decayed" because a thin layer of wood on the outer surface had become soft and crumbly. This wood was dark brown in color but did not have the appearance of wood decayed by fungi. This layer seldom exceeded more than ⅜ inch in thickness and beneath it the change to sound, firm wood was abrupt. The writers attribute this condition, in part

TABLE 2

Treatment, Preservative and Species	Number of Posts Set	After 5-7 Years S* Percent	After 5-7 Years U* Percent	After 10-12 Years S* Percent	After 10-12 Years U* Percent	After 15-17 Years S* Percent	After 15-17 Years U* Percent
Pressure, Creosote (1)							
White Oak	249	100.0	0.0	96.7	3.3	88.9	11.1
Red Oak	520	100.0	0.0	97.7	2.3	85.5	14.5
Maple	68	98.5	1.5	82.4	17.6	54.5	45.5
Birch	42	100.0	0.0	100.0	0.0	78.6	21.4
Red Pine	549	100.0	0.0	100.0	0.0	100.0	0.0
Southern Yellow Pine	482	100.0	0.0	99.6	0.4	97.4	2.6
Total	1910						
Pressure, Wolman Salts (1)							
Oak	386	100.0	0.0	95.3	4.7	73.9	26.1
Maple	9	100.0	0.0	100.0	0.0	88.9	11.1
Total	395						
Open Tank, Butts Only, Creosote (2)							
White Oak	400	90.0	10.0	67.1	32.9	54.2	45.8T
Red Oak	1264	89.6	10.4	43.4	56.6	26.0	74.0T
Maple	1293	91.0	9.0	45.7	54.3	24.8	75.2T
Birch	304	87.2	12.8	39.1	60.9	20.7	79.3T
Pitch Pine	361	88.1	11.9	60.9	39.1	24.2	75.8T
Total	3622						
Open Tank, Full Length, Creosote (1)							
Oak	195	100.0	0.0	100.0	0.0	91.8	8.2
Maple	51	98.0	2.0	90.7	9.3	76.7	23.3
Birch	53	100.0	0.0	98.1	1.9	96.2	3.8
Total	299						
Cold Soaking, Pentachlorophenol (3)							
Red Pine	413	100.0	0.0	.....	.....	.....	.....
Barrel Method, Zinc Chloride (4)							
Red Pine	56	96.4	3.6	.....	.....	.....	.....
Butts Brushed, Creosote (2)							
White Oak	415	11.3	88.7	3.1	96.9	2.4	97.6T
Red Oak	32	3.1	96.9	1.4	98.6	0.0	100.0T
White Cedar	660	67.1	32.9	47.3	52.7	39.7	60.3T
Black Locust	75	98.7	1.3	98.7	1.3	97.3	2.7T
Total	1182						
Butts Brushed, 8-13 (1)							
Oak	78	11.5	88.5	2.6	97.4T	.....	.....
Pitch Pine	32	9.4	90.6	0.0	100.0T	.....	.....
Black Locust	357	100.0	0.0	99.7	0.3	98.0	2.0
Total	467						
Butts Dipped, Hot Coke-Oven Tar (1)							
White Oak	82	43.9	56.1	15.4	84.6T	.....	.....
Red Oak	150	39.3	60.7	3.7	96.3T	.....	.....
Total	232						
Grand Total	8576						

(1) Set 1939-40. (2) Set 1933-35. (3) Set 1951. (4) Set 1948.
* S = serviceable; U = unserviceable or missing.
T = Tests terminated.

at least, to chemical rather than organic attack. By the 15th year the layer had increased in thickness and apparently had exposed untreated wood so that up to 20 per cent of the posts showed interior decay and had become unserviceable. None of the tops have shown this type of deterioration. A somewhat similar condition has been observed elsewhere on posts in service which were treated with zinc chloride. In general, the condition of hardwoods treated under pressure with Wolman salts compared favorably with the same woods given a 6-lb. treatment with creosote under pressure.

Open-tank treatment of butts only with creosote

At the end of 5 years, the butts of all posts were in nearly perfect condition but about 10 per cent had become unserviceable due to decay in the untreated tops. After 10 years between 30 and 60 per cent of the posts had become unserviceable because of decay in the tops whereas only 9 to 22 per cent of the butts had become unserviceable. It was evident at this time that some of the decay in the butts was within the treated shell and had worked down the interior of the posts to this point from the decayed tops. At the end of 15 years, top failures had increased to 35 to 70 per cent and observations were discontinued. Posts that had become unserviceable through failure of the butts amounted to 7 to 56 per cent. Observations on this lot of posts indicate quite clearly that, in this region, posts of non-durable woods should be given a full-length treatment to afford an approximately equal degree of serviceability to tops and butts.

Full-length open-tank treatment with creosote

Although factors of treatment and subsequent handling were sufficiently different to make strict comparisons impossible, those posts given a full-length open-tank treatment with creosote compare favorably with posts of the same woods given a 6-lb. pressure treatment with the same preservative.

Cold-soaking with pentachlorophenol

This lot of posts had been in service only 5 years at the time of the 1955 inspection when all were found in serviceable condition. Some 10 per cent of the posts were listed as partially decayed. The deterioration was in the form of small spots or long narrow streaks on one side of the post only, extending inward for ¼ inch or less. From the pattern exhibited it appeared that there may have been local areas where the wood did not take treatment. The elongated areas may have been insufficiently seasoned where two posts were in very close contact throughout their length in the seasoning piles. Similarly, cross-piling could have resulted in unseasoned spots, one above the other, where one side of a post was in spot contact with several others at right angles to it. Essentially the same pattern could result if water were allowed to accumulate in the bottom of the tank. These points are postulated to indicate that it may be necessary to pay close attention to details both prior to and during the cold-soaking process.

Barrel method with zinc chloride

Approximately 100 posts treated by this method were set in 1948. In 1954 the entire lot was replaced by pressure-

treated posts. Of the original lot of 100, 44 were lost in the process of replacement or were used at some unknown location. The 56 that were found had been reset at a new location shortly after removal from the previous site. Of these 4 per cent, or 2 posts, had become unserviceable through decay in the butts. These observations are quite in accord with experimental data taken by this Station on other posts treated by this method and preservative which indicate a high percentage of posts are in a serviceable condition after 10 years or more of service.

Superficial treatments by brushing or dipping

These treatments, which were applied only to the butts of posts by brushing on, or dipping the posts in, creosote, 8-13 tar, or coke-oven tar, did not permit the preservative to penetrate the wood to any extent. The results with all woods, except locust, were very unsatisfactory and will be discussed by species groups, when several species behaved similarly, or by species.

Oaks and Pitch Pine. The butts of from 50 to 90 per cent of the posts had become unserviceable within 5 years and from 80 to 95 per cent in 10 years. For these species superficial treatments offer little protection and are hardly worth the cost of application. Early decay in the inadequately protected sapwood created a soggy, rotting mass surrounding the heartwood at or near ground line and, without question, promoted rapid decay in the heartwood. White oak heartwood, which normally is quite durable, was badly decayed within 5 years but was in better condition than the heartwood of red oak and pitch pine, which have little natural durability. Progress of decay in the untreated tops followed essentially the same pattern as for the untreated tops of posts butt-treated by the open-tank method.

White Cedar. This wood has from 1 to 1½ inches of non-durable sapwood surrounding a quite durable heartwood. Superficial treatments offered little protection to the sapwood which, as in oak and pitch pine, became a soggy mass at or near ground line. This meant a reduction of the effective diameter of these posts of from 2 to 3 inches. This is an important consideration because the wood of white cedar is extremely low in all strength properties. The rate of decay in the sapwood of the butts of white cedar lagged somewhat behind that in oak and pitch pine but was still high enough to demonstrate the ineffectiveness of superficial treatments. The untreated tops of white cedar posts were in good condition after 15 years, and such decay as was present in the tops had apparently worked up from below.

Black Locust. The sapwood on these posts in general did not exceed ¼ inch in thickness. In the butts this had begun to show some signs of decay within 5 years and at the end of 15 years was entirely decayed; on nearly all posts the heartwood beneath has remained intact throughout the entire period. Whether the superficial treatment of the butts had any effect is questionable. It may have delayed decay of the sapwood by a few years.

At the first inspection the tops of some of the posts were marked "partially decayed" because of what appeared to be decay at branch junctions. This has increased to some extent with

time but, even after 15 years, it had not become extensive enough to warrant classifying any of the posts as unserviceable because of decay in the tops.

Summary and Conclusions

(1) Superficial treatments by brushing with, or brief immersion in, a preservative provide inadequate protection against decay in posts of non-durable woods. They may be justified for woods with highly durable heartwood, such as black locust or red cedar, to afford a few years of additional life to the sapwood, which should not be more than ½ inch thick.

(2) In northeastern United States, posts of non-durable woods should be given a full-length treatment to provide a reasonably uniform service life to tops and butts.

(3) The best results were obtained when creosote was applied under pressure to red and southern yellow pine posts at the rate of 6 lbs. per cubic foot. It seems probable that equally good results could be obtained by similarly treating any hard pine with a thick sapwood. Current highway specifications, calling for an 8-lb. per cubic foot treatment with creosote, should be even more effective.

(4) Treatment of hardwoods with creosote under pressure at the rate of 6 lbs. per cubic foot was much less satisfactory than for pine; in fact, such treatment did not appear to be as effective as a makeshift open-tank treatment of the same woods, although it was not possible to make wholly valid comparisons of the two procedures. It would appear that research and experimentation into the susceptibility of the various hardwoods to treatment in the round is needed before they can be recommended without qualification for heavy duty use.

(5) Although hardwood posts treated with Wolman salts under pressure compared favorably with the same woods given a 6-lb. pressure treatment with creosote, the somewhat peculiar pattern of deterioration in Wolman-treated posts indicates that further study is needed to determine if the treating solution itself, or some of its components, can also cause deterioration.

(6) The condition, after 15 years, of hardwood posts given a full-length open-tank treatment with creosote indicates that this type of treatment is deserving of consideration, especially where there is a strong differential between the delivered price of posts so treated and posts which must be taken to better equipped central plants and hence be subject to high transportation costs.

(7) Posts treated by any method should be fully framed and bored *prior* to treatment.