

STUDIES OF THE DOUBLE-DIFFUSION PROCESS OF  
TREATING WOOD. --THE TREATMENT OF FENCE POSTS  
BY PARTIAL IMMERSION IN BARRELS

By

R. H. BAECHLER, Chemist



NOT FOR PUBLICATION

UNITED STATES DEPARTMENT OF AGRICULTURE  
FOREST SERVICE  
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Madison, Wisconsin

In Cooperation with the University of Wisconsin

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Introduction

This report covers some simple experiments designed to explore the possibility of applying the double-diffusion treatment of wood to fence posts by standing them upright in barrels.

Experimental work on double-diffusion treatments was suspended at the start of the war and resumed with these experiments in the spring of 1945 when it was found possible to devote some time to non-military problems. The status of the project at the time of its postwar renewal will be briefly reviewed,

Laboratory experiments had been conducted in 1939-40 on a 2-stage diffusion treatment of wood for the purpose of introducing soluble salts that would react to deposit relatively insoluble toxic materials in wood, thereby impregnating it with relatively nonleaching preservatives without using pressure equipment or heat. At the start of these experiments, one vital question concerned the rate of diffusion of the second salt which, as it diffused into the

outer layers or the wood, would be precipitated by the first salt so that diffusion pressure to force it deeper would be lacking until an amount of the second salt chemically in excess of the first salt could be built up. It was feared that this progressive reduction in the diffusion pressure of the second salt, along with the mechanical interference of the precipitate which would increase the required mean distance of molecular migration for a given penetration, might retard the ingress of the second salt to such an extent that an impracticably long time might be required for the second stage of the treatment.

It was found that when sections of green fence posts 15 inches long were successively immersed for several days in strong solutions of salts capable of forming a precipitate, good absorption and fairly good distributions of the two salts were obtained so that the deposition of the precipitate was not necessarily confined to the outer layers of the wood.

Leaching tests were made on blocks in which copper arsenate, copper chromate, nickel arsenate, nickel chromate, and magnesium ammonium arsenate had been deposited. Analysis of blocks before and after leaching showed the loss of precipitated chemical to be slow while laboratory decay tests on the leached blocks indicated considerable resistance to attack by wood-destroying fungi. It was then decided to follow these laboratory experiments with service tests to compare the effectiveness of these precipitates under actual use

conditions with the effectiveness of standard commercial preservatives applied by other means.

In the spring of 1941, 100 Southern pine fence posts were treated in tanks on the Harrison Experimental Forest with copper sulfate, followed by sodium arsenate after which the posts were placed in the test fence containing posts treated with various commercial preservatives and other materials under test. Even though these posts were the first to be treated in this manner and were not treated under optimum conditions, the test should give reliable indications regarding the practical value and feasibility of this method of treatment. The condition of these experimental posts at the time of their inspection in December 1945 is shown in table ZM66800F.

Late in 1941 some green 2 by 4 stakes were treated with copper sulfate plus sodium chromate and were installed in 1942 in the stake-test area on the Harrison Forest along with stakes treated with copper sulfate plus sodium arsenate. The condition of these stakes at the time of inspection in December 1945 is shown in table M67328F. These tests should afford a comparison of the effectiveness of these two combinations of chemicals. They will not necessarily yield a direct comparison of the protection that may be given to larger sized wood since sodium chromate and sodium arsenate diffuse through wood at different rates.

Condition of round southern yellow pine experimental fence posts on the Harrison Experimental Forest, Buxton, Mississippi, after about 1 1/2 years to 9 years' service

Unretreated December, 1951

Preservative	Fence posts (feet)	Absorption of preservative		Condition of posts		Condition of posts		Total removed	
		Mean	Standard deviation	Resealable but showing some	Resealable	Decay and termites attack	Decay and termites attack		
		lb/ft <sup>2</sup>	%	Number	Percent	Number	Percent	Percent	
Borax-boric acid (50-50 mixture)	98 Salt	0.64	1.32	10	10.2	13	13.3	24	24.5
Beta naphthol, 5% (by weight) in oil mixture	99 Solution	5.9	110.0	21	21.2	9	9.1	18	18.2
Calcium	96 Salt	.75	1.05	87	90.6	3	3.1	—	—
Chromated zinc chloride	99 Salt	.37	1.33	61	61.6	10	10.1	—	—
Coal-tar	99 Oil	1.6	19.2	65	65.8	8	8.1	—	—
Coal-tar creosote, Grade 1	98 Oil	1.9	6.6	60	61.2	6	6.1	—	—
Coal-tar creosote, 50% used crank-case oil, 50% (by volume)	100 Mixture	1.6	14.8	95	95.0	5	5.0	—	—
Coal-tar creosote, 10% used crank-case oil, 90% (by volume)	100 Mixture	1.2	13.2	82	82.0	1	1.0	—	—
Crank-case oil (used)	100 Oil	2.5	16.8	16	16.0	18	18.0	—	—
Lignite coal-tar creosote	98 Oil	1.1	11.6	59	60.2	11	11.2	—	—
Mercuric chloride	100 Salt	.05	.15	90	90.0	—	—	—	—
Mo-B-I	100 Oil	1.3	13.6	43	43.0	15	15.0	—	—
Omosear	97 Salt	—	—	80	80.5	11	11.2	—	—
P.D.A. (nonylchloroarsine) 0.5% in gas oil (by weight)	98 Solution	4.1	111.0	33	33.7	11	11.2	—	—
Pentachlorophenol, 4.85% (by weight) in used crank-case oil	99 Solution	2.9	9.5	67	67.0	2	2.0	—	—
Pentachlorophenol, 3.05% (by weight) in used crank-case oil	99 Solution	3.1	111.4	64	64.0	2	2.0	—	—
Sodium dichromate	98 Salt	.96	1.14	39	39.6	4	4.1	—	—
Sodium chromate	99 Salt	.70	1.19	39	39.6	4	4.1	—	—
Thamith	100 Salt	.20	.47	70	70.0	2	2.0	—	—
Tetrahydrophenol, 2.9% (by weight) in used crank-case oil	98 Solution	1.2	13.1	31	31.1	19	19.4	—	—
Tetrahydrophenol, 4.8% (by weight) in used crank-case oil	99 Solution	3.5	9.4	96	97.0	3	3.0	—	—
Water-gas tar	99 Oil	1.2	19.0	63	63.0	9	9.1	—	—
Zinc chloride	100 Salt	.67	1.11	96	96.0	2	2.0	—	—
Zinc-meta-arsenite	98 Salt	.25	.54	96	96.0	2	2.0	—	—
Unretreated posts (set February 1947)	65	—	—	—	—	—	—	—	—
Unretreated posts (set November and December 1950)	33	—	—	—	—	—	—	—	—
(CUM) (set May 1941)	100 Salt	—	—	96	96.0	1	1.0	—	—
ompiastic-groundline treatment (set Feb. 1941)	100 Mixture	—	—	84	84.0	3	3.0	—	—

Note: All preservatives, except copper subacetate-arsenate, mercuric chloride, chromated zinc chloride, and zinc-meta-arsenite, were applied by pressure, the oils by the brush method, and the salts by the full immersion method. The amount of preservative applied is given in the table. The percentage of posts in each group are listed in the table. The percentage of posts in each group are listed in the table. The percentage of posts in each group are listed in the table.

Prepared by J.M.H. Date 1-16-56  
Approved by E.A.H. Date 1-14-56

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Condition of southern pine stakes treated with copper arsenate and copper chromate by the double diffusion process.  
 Stakes set at Harrison Experimental Forest, Saucier, Mississippi.  
 Size of stakes - 2 by 4 (approximate) by 18 inches.

Date of inspection - December 1945

Date installed - February 1942

Treatment	Calculated absorption of chemical <sup>1</sup>		No. in test	Condition of stakes		Decayed and termites	Destroyed by termites	Decay and termites
	Copper as Cu SO <sub>4</sub>	Arsenic as Na <sub>2</sub> CrO <sub>4</sub>		Good	Attacked by			
	lb. per lb. cu. ft.	lb. per lb. cu. ft.		Decay	Decay and termites	Number:Percent	Number:Percent	Number:Percent
6 days' soaking in copper sulphate sol. (10.6% Cu SO <sub>4</sub> ) and 6 days' soaking in sodium arsenate sol. (9.8% Na <sub>2</sub> HAsO <sub>4</sub> )	0.66	0.59	10	100.0	--	10	100.0	--
6 days' soaking in copper sulphate sol. (10.6% Cu SO <sub>4</sub> ) and 12 days' soaking in sodium arsenate sol. (9.8% Na <sub>2</sub> HAsO <sub>4</sub> )	.66	.75	10	100.0	--	10	100.0	--
6 days' soaking in copper sulphate sol. (10.6% Cu SO <sub>4</sub> ) and 12 days' soaking in sodium chromate sol. (11.8% Na <sub>2</sub> CrO <sub>4</sub> )	.66	2.58	10	100.0	--	10	100.0	--
3 days' soaking in copper sulphate sol. (10.6% Cu SO <sub>4</sub> ) and 6 days' soaking in sodium arsenate sol. (Na <sub>2</sub> HAsO <sub>4</sub> -9.8%)	.88	.55	10	100.0	--	10	100.0	--
3 days' soaking in copper sulphate sol. (10.6% Cu SO <sub>4</sub> ) and 6 days' soaking in sodium chromate sol. (11.8% Na <sub>2</sub> CrO <sub>4</sub> )	.88	1.57	10	100.0	--	10	100.0	--
3 days' soaking in copper sulphate sol. (5.5% Cu SO <sub>4</sub> ) and 6 days' soaking in sodium arsenate sol. (4.9% Na <sub>2</sub> HAsO <sub>4</sub> )	.31	.17	10	100.0	--	10	100.0	--
3 days' soaking in copper sulphate sol. (5.5% Cu SO <sub>4</sub> ) and 6 days' soaking in sodium chromate sol. (5.9% Na <sub>2</sub> CrO <sub>4</sub> )	.31	.50	10	90.0	10.0	9	90.0	10.0
Untreated			10 <sup>2</sup>	--	--	--	--	80.0

<sup>1</sup>Absorptions based on chemical analyses made on two stakes treated in each charge with those placed in test.

<sup>2</sup>Average life - 1.9 years.

Prepared by W.I.H. Date 1.18.46  
 Approved by J.A.B. Date 2.18.46

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It was planned to start service tests on wood treated with other combinations of chemicals but, as has been stated, this investigation was interrupted by the more immediate importance of military problems

The essential theoretical advantages and disadvantages of this method of treating wood have been pointed out in conferences and in scattered memoranda but may be repeated here for convenience. It should be borne in mind that the following is largely speculative. The effectiveness of these precipitates in actual service remains to be determined and if they should fail in this all-important respect, other features of the method will be of no significance.

Some of the advantages which this method of treatment appears to offer are:

1. The equipment required is simple; consequently, it is possible to minimize transportation costs attending the centralizing of sufficient wood to keep down the unit overhead charge for equipment. This particular feature is of special importance in the treatment of wood that is produced and used at a considerable distance from a pressure treating plant. Fence posts constitute an outstanding example since the producer and consumer of fence posts are frequently the same so that treatment near the site of production and use is especially desirable.

2. The cost of transporting the treating materials to the site of treatment is low because the solvent used is

water, while the active ingredients are solids that may be shipped in cheap nonreturnable containers.

3. Because of the relatively low cost of the chemicals and the permanence and high toxicity of the precipitates, an initial absorption low in pounds per cubic foot and therefore low in cost may be expected to give long life to wood even when exposed to leaching conditions. (This presupposes the possibility of obtaining good distribution of low absorption, something which has not yet been accomplished.)

4. The treated wood is clean, odorless, and very likely paintable.

Established methods of treatment possess one or more of the foregoing advantages; none possesses all of them.

Some of the disadvantages of the treatment are:

1. Green wood is required and prompt treatment after cutting is not always convenient.

2. Considerable time is required which may be relatively unimportant in the treatment of a cheap form of wood such as fence posts, but would be important in the treatment of lumber, poles, etc.

3. The results seem to be less subject to control and therefore less uniform than those obtained by pressure treatment.

4. No mechanical protection against weathering and retardation of checking is obtained, which would be especially disadvantageous in the treatment of cross ties.

5. The excess of soluble salt would increase electrical conductivity which is of importance in telephone and power line poles,

6. some combinations involve a decoded hazard during the treating period to any but a careful operator and also to livestock.

7. Some combinations would be corrosive to iron fastenings if the second stage of the treatment were inadequate.

8. As compared with a simple diffusion treatment with a single salt, this method requires an additional handling of the wood and additional investment in a second container and solution.

To sum up these advantages and disadvantages, it may be said that the method offers a possible solution to certain problems in wood preservation. Whether or not it will contribute toward their solution will depend largely upon the service life of wood so treated. Speculations concerning its ultimate application are quite futile until the results of service tests are available. Until then the use of the method in practice should be discouraged.

It may be seen that, for economic reasons, the method appears more promising for some forms of wood than for others, Its advantages and disadvantages point to the treatment of fence posts as a likely field of usefulness. This fact, combined with the cheapness of fence posts as test material and with the fact that an urgent need exists for an economical

treatment for fence posts, explains the almost exclusive use of fence posts in the experimental treatments made to date.

It was recognized early that a comprehensive study of this method of treatment would be extremely time consuming and costly. This is due in large measure to the fact that tedious time-consuming chemical analyses are required to follow the results of the treatment. In studying a treatment in which the entire liquid moves without change into dry wood, the absorption may be obtained by merely weighing the test pieces before and after treatment, while distribution may be observed visually from borings or by splitting samples.

In research on the double-diffusion method, a study of the absorption of the two salts requires their determination by chemical analysis of a composite sample<sup>1</sup>, while reliable data on distribution can be obtained only by analyzing different parts of a treated piece. The variability of wood demands analyses of replicate pieces from the same treatment. These analyses are so time consuming that this phase of the work dominates the planning and constitutes the bottleneck in the progress of the investigation.

Not only is this investigation of such nature that the collection of data is slow, but it is surprisingly complex when one considers how simply the method may be described.

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<sup>1</sup>An effort is now being made to reduce this work by analyzing the treating solution before and after treatment.

The questions to be answered fall into two groups; namely, those concerning the composition of the preservative, and those concerning the means of introducing it into wood.

The properties desired in the chemicals to be used are: ability to form a precipitate of high effectiveness and permanence, low cost, sufficiently high volatility and rate of diffusion so that the amount of wood that can be treated in a pair of containers in a given time is as large as possible, freedom from health hazard, and freedom from corrosion problems. Unfortunately, of the various combinations of chemicals that appear to be adapted to this method, none is outstanding in all of these properties. Each possesses some theoretical advantages over the others so that an intelligent selection can be made only by balancing effectiveness against other properties.

A comprehensive study of any new preservative or group of preservatives requires service tests in different regions so as to include areas of high, low and intermediate decay hazard, presence and absence of termites, varied leaching conditions, as well as soils of different chemical nature. The precipitates under consideration are no exception to this rule. While all are classed as "insoluble", the difference in their solubilities is relatively very large. All are soluble in dilute acids so that their service lives will be affected by the pH of the soil. A high concentration of carbonates in natural water might lead to the gradual formation

of a nontoxic carbonate of whichever heavy metal is involved in the treatment.

These precipitates likewise may be expected to follow the general rule that wood preservative do not act by remote control so that not only must they be applied in adequate amounts, but they must be properly distributed. When attention is directed to this phase of the investigation, its scope grows tremendously. Each chemical has its characteristic rate of diffusion. The absorption and distribution of any two starting chemicals are influenced by a large number of factors. The wood itself--its size, shape, species, moisture content, percentage of sapwood, prevalence and size of knots, amount and nature of extractives, rate of growth, season of year when cut, whether barked or unbarked--all these may be expected to affect both absorption and distribution. An absorption obtained by a given set of conditions may also be obtained by decreasing the concentration of the treating solution and increasing the time, but the distribution will be different. If good distribution is obtained for a given absorption it cannot be taken for granted that satisfactory distribution will accompany a greatly decreased absorption. Temperature affects the mobility of all ions in solution; it also affects the maximum concentrations of treating solutions that may be used. The completeness of immersion of the wood is important. Final distribution is further affected by seasoning conditions such as rate of seasoning and the position of the wood.

The ideal distribution at which to aim will certainly vary with climatic conditions. In relatively dry areas in which only the part of the post below ground is subject to decay, it would be most economical to govern conditions so that as much of the chemical as possible is retained in the lower part of the post. In other areas, protection of the top is needed and establishing the conditions that would provide the most economical distribution would require considerable work. Some measures to provide protection of the tops might be needed in partial immersion treatments.

Mention may be made of a further uncertainty regarding the possibilities of this method which, while not of a technical nature, affects the relative importance of some technical questions. There is considerable reason to doubt whether a method of treating fence posts, no matter how simple and effective, would ever be used by a large number of farmers. Its use in cooperative treating centers or by small local commercial operators might be more practical. In such event, certain properties of chemicals, e.g., hazard to livestock during the treating period would decrease in importance while others such as throughput of equipment would assume increased importance.

From the foregoing it may be seen that a large amount of work would be required to bring the double-diffusion method to a state approaching perfection. It would be difficult to justify so expensive an investigation without more convincing evidence of its promise than is afforded by

the results of laboratory experiments. It was therefore decided, for the present, to confine the study of treating conditions to exploratory tests that would indicate approximate treating schedules for obtaining absorption within the range of commercial treatments with salt preservatives. Test material could then be prepared by these schedules and, despite the lack of perfection in such treatments, the results of exposure tests should show whether or not the method merits an intensive investigation and also which of the combination or combinations of chemicals should be used in such investigation.

Another reason for giving our first attention to questions regarding the nature and amount of chemicals to be recommended is that years of exposure are required in the collection of such data. On the other hand, studies of the conditions required to obtain desired treatments do not involve an intervening delay other than a relatively short seasoning period. Should the time arrive when this method may be recommended, a study of treating conditions might be subjected to "forced draft" whereby considerable data could be collected within a year.

However, a too rigid observance of this general principle of postponing studies of treating conditions would be inadvisable. An exception should be made whenever a question arises concerning a detail which profoundly affects the economy of the method in time and money. Thus, preliminary studies are indicated bearing on the possibility of

substituting barrels in place of tanks and also of dispensing with the debarking of fence posts. The findings of such preliminary studies should be applied in the preparation of material for exposure tests.

It has been pointed out that this method might be found useful in the treatment of forms of wood other than fence posts, especially in areas that are unfavorably situated with respect to pressure treating facilities. Telephone poles and bridge timbers may be mentioned as examples. The cleanliness of the treated wood combined with the expected resistance of the treatment to leaching suggests its application to highway posts that are to be painted and also to building lumber that is to be used under conditions that favor leaching as well as attack by decay and termites. The treatment of veneers for such conditions might be considered. However, there seems to be no need for any early investigations along these lines. If the results of field tests on fence posts are favorable, the treatment may safely be recommended for any form of wood in which good absorption and distribution can be obtained. A study of the treatment of various forms of wood may be incorporated in the detailed study of treating condition, since no great loss of time will be occasioned by deferring the accumulation of such information until the need for it has been demonstrated.

### Scope of Present Experiments

Prior to the experiments to be described herein, all double-diffusion treatments had been made by completely immersing the wood in both the first and second baths. This is probably the best possible means of applying such treatment when the effectiveness of the treatment is considered to the exclusion of other factors. However, it obviously requires tanks large enough to completely contain the wood and, under certain conditions, the initial cost of the tanks would act as a strong deterrent against the adoption of the method. Thus, in the treatment of fence posts (for which the process seems especially well adapted), two tanks, each large enough to hold from 10 to 20 fence posts, could not be purchased very cheaply as a general rule and their cost when prorated over the number of posts that might be treated in them during their service lives would add a significant amount to the unit cost of the treatment.

For this reason it was decided to investigate the possibility of treating posts by standing them upright in solutions contained in barrels which are generally much cheaper than tanks on the basis of a given capacity. The treatment of the emergent part of the post would then depend upon longitudinal diffusion of the chemicals.

Such treatment would be expected to result in a gradient in the concentration of total chemical from the bottom to the top of the post. Whether or not this gradient could be

satisfactorily controlled by conditions of treatment and seasoning or by the position of the post during seasoning was one of the questions to be answered.

Another uncertainty regarding this method of treatment which has already been referred to concerned the rate of diffusion of the second salt into the wood. It had been found that this retardation of the diffusion of the second salt may be counterbalanced in complete-immersion treatments by extending the steeping time in the second bath approximately 50 percent over that of the first bath. Increasing the concentration of the second solution may be resorted to if the volubility of that particular chemical permits. It was feared that in partial-immersion treatments, with the greater distance to be traversed by the second salt, an objectionably long time in the second bath might be required.

A complete precipitation of the first salt in the upper part of the post may or may not be necessary from the standpoint of permanance; in moderately dry areas the leaching of chemical from the upper part of the post would certainly be slow. However, if the first salt to be introduced were a copper salt it would need to be more or less completely precipitated to avoid the corrosive action of soluble copper salts on fencing wire and staples. On the other hand, if the first salt were a nickel salt accompanied by a small amount of sodium dichromate, the corrosion hazard would probably be negligible.

The only full-length fence posts treated heretofore by the double-diffusion process had been treated by copper sulfate plus sodium arsenate. As has been stated these treatments were made by complete immersion. The same salts at approximately the same concentrations were chosen for the present exploratory experiments which, however, were limited chiefly to the first step of the process, only six posts being treated with both salts.

It was originally planned to treat only jack pine and lodgepole pine but a few posts of other species that were readily available were given single-diffusion treatments for rough comparison. A few dry posts were treated with green posts of the same species to show differences in results obtained

### Experimental

#### Series I--Single-diffusion Treatment with Copper Sulfate

This preliminary series was run in order to get some idea of the time that would be required to introduce into the points an amount of copper sulfate equivalent to 1 percent of the dry weight of the wood.

It may be admitted parenthetically that the absorption aimed at is at present largely a matter of guesswork. A 1 percent absorption is within the range of absorption commonly used in commercial treatments with water-borne preservatives, since along with an equivalent amount of

sodium arsenate this absorption would constitute about six-tenths pound total chemical per cubic foot of pine. Certain factors point to the need of heavier absorption in the double-diffusion treatment, for example: loss uniform distribution is obtained than in pressure treated wood; the concentration gradient whereby the outer parts of the wood are heavily treated is undesirable from the standpoint of accelerating leaching; the areas surrounding the checks that ultimately form receive only an average amount of salt, while the area beyond a check may receive none. Other factors indicate the contrary, viz (1) the compounds produced are highly toxic so that unless they are poorly distributed they should give protection even when present in low concentration and (2) they are relatively insoluble so that a large initial reserve to compensate for ultimate leaching need not be introduced. Which of these opposing theories is correct can be determined only by service tests; the answers will, of course, be of prime importance in comparing the final economy of this method of treatment with other methods.

The jack pine and red oak posts used in these experiments were cut about 40 miles north of Madison on April 4, 1945. They were brought to the Laboratory by truck on the following day and were stored in the cold room. The posts were not very uniform in size, varying from 2-1/2 inches to 5-1/2 inches top diameter and also varying considerably in the width of the sapwood band and in the abundance of knots.

However, they were considered suitable for these exploratory treatments. They were out 7-1/2 foot long.

The posts were debarked just before treatment and about 6 inches were out from the butt end to assure a fresh surface. Three of the pine posts were incised by hand around the part corresponding to the groundline. Three pine and three oak posts were placed in a kiln to be seasoned before treatment.

The posts in this series may be divided into the following groups with three posts in each group: (1) and (2) green jack pine; (3) same as (1) and (2), but incised at the groundline; (4) kiln-dried jack pine; (5) green red oak; (6) kiln-dried red oak. A single green aspen and an air-dried spruce were included. Groups (4) and (6) were treated several weeks later than the rest but, as nearly as possible, the same conditions were maintained.

The treatment of the green posts was begun on April 6, 1945, two days after the posts were out. They were stood upright in a 12.8 percent solution (initial concentration) of copper sulfate in a wooden barrel. The level of the liquid was within a few inches of the top of the barrel and accordingly the posts stood in about 27 inches of solution. The solution was unheated and although no accurate record of the temperature was kept it was believed to average about 450-50° F.

A blue coloration was soon seen to be creeping up the sides of the Posts. After 24 hours the color extended in a

streaked pattern roughly half-way up the pine posts and to the top of the oak posts. Knots interrupted the continuity of the color.

One post from each group was removed after 1 day, one after 3 days and the other after 7 days.

The treated posts were exposed to one of two different sets of seasoning conditions to get some idea of the effect of retardation of seasoning on the final distribution of the chemical. To this end series (1), (3) and (5) were kept in the 90 percent humidity room for 2 weeks after treatment and then air seasoned; the posts were stood butt up in both stages. Series (2), (4) and (6) were set outside, some butt up and some butt down, immediately after treatment.

On June 2, while the treated posts were air seasoning, 15 green lodgepole pine posts were received by express from the Forest Service, Missoula, Montana. They were 9 feet long so that a foot could be sawed from each end before treatment leaving a 7-foot post. They had been end-coated to retard drying and moisture discs 1 foot from the ends of five different posts showed 58 to 70 percent moisture. They were quite uniform in size (4 to 5 inches in top diameter) and in rate of growth and width of sapwood. They were treated under conditions similar to the jack pine posts but not all of the variations could be repeated because of the small number of posts. They were air seasoned after treatment. Of three posts treated 5 days, one was placed butt up to season, one butt down and one was laid horizontally.

After the treated posts were well seasoned they were sawed in half lengthwise and observed for penetration. This could be readily observed without the aid of any spray to intensify the color of the copper salt but those to be photographed were sprayed with a 5 percent solution of potassium ferrocyanide to produce the red copper ferrocyanide which photographs better than the sulfate.

As a general rule there was complete sapwood penetration of the green posts that were treated 3 days or more. Some pine posts treated 1 day showed complete sapwood penetration although lighter at the top; others showed complete penetration at the groundline but only about 1/4 inch at the top. The absorption seemed heavier in the springwood than in the summerwood. There was little or no penetration of the heartwood in oak; there was some longitudinal penetration of the heartwood of jack pine and also lodgepole pine. The single green aspen post, which was practically all sapwood and was treated 7 days, showed penetration practically to the center but there were streaks of untreated wood even near the outside.

The posts that were seasoned before treatment showed practically no penetration above the liquid line. In some cases, especially the single dry spruce post, a small amount of chemical crept upward along checks. The end diffusion into dry pine sapwood varied from a few inches to about 1-1/2 feet; it was poorer in dry oak than in dry pine and somewhat better in the lone dry spruce.

No effect of incising was revealed since the incisions did not penetrate the heartwood and the penetration of pine sapwood was generally good without incision. A few posts peeled only to the groundline seemed to treat slightly slower than completely peeled posts.

The effect of the position of the posts during seasoning was likewise difficult to discern. It seemed that, as a rule, the posts that had stood butt up during seasoning showed the more uniform penetration, but the difference was not as marked as had been expected and it would take a larger number of posts to show whether or not the improvement in distribution is sufficient to recommend avoidance of the more convenient flat piling. Other investigators have reported considerable improvement in distribution of preservative as a result of seasoning with the butt up.

The posts that were placed outside immediately after treatment showed somewhat inferior distribution in comparison with these that were kept in the 90 percent room 2 weeks after treatment.

Figures 1 and 2 show typical penetrations obtained under different conditions.

In order to determine the total absorption of chemical by each post, 2-inch discs were cut according to the following diagram:

Figure 1 --Green and dry posts treated by partial  
Immersion in copper sulfate solution

- 4 - Green jack pine treated 1 day
- 5 - Green jack pine treated 3 days
- 6 - Green jack pine treated 7 days
- 18 - Kiln-dried red oak treated 7 days
- 21 - Kiln-dried jack pine treated 7 days
- 26 - Air-dried spruce treated 7 days



4

5

6

18

21

26

M 64059 F

Figure 2.--Green posts treated by partial Immersion  
in copper sulfate solution

- 18 - Green lodgepole pine treated 7 days
- 6 - Green jack pine treated 7 days
- 9 - Green jack pine (incised treated 7 days
- 12 - Green jack pine (half peeled)  
treated 7 days
- 15 - Green red oak treated 7 days
- 25 - Green aspen treated 7 days



18

6

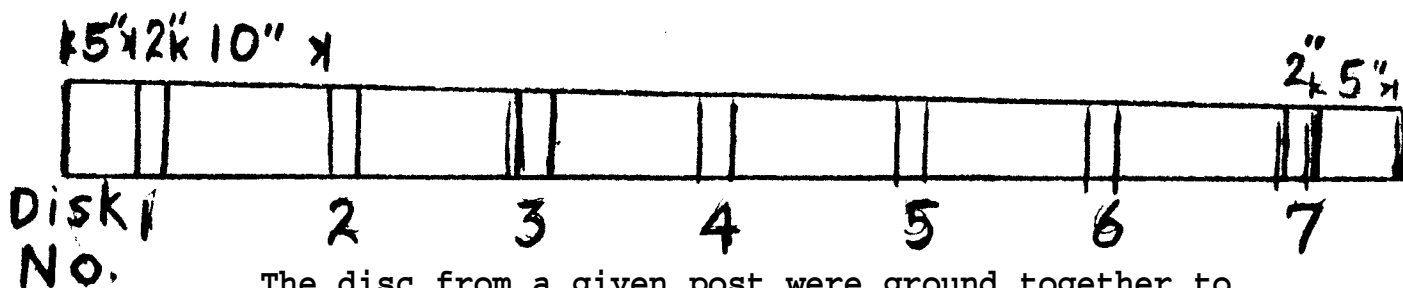
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12

15

25

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The disc from a given post were ground together to form a composite sample which was analyzed by the method of Baechler and Servais (Proc. AWPA 1942, page 19). The results are given in table 1. The absorption given are on the basis of anhydrous chemical in oven-dried wood plus chemical.

It will be seen that in the case of the green jack pine, lodgepole pine, red oak or aspen peats the absorption obtained even in 1 day were in excess of the 1 percent that was desired. They are considerably above the absorptions obtained in the complete immersion of Southern pine posts treated in 1941. (The latter were not treated under the most favorable conditions; several days elapsed between the time of cutting and peeling and the start of the treatment during

Table 1,

Post No.	Description	Steeping time	Method of seasoning	CuSO <sub>4</sub> absorbed based on dry treated wood
		Days		Percent
1	Green jack pine	1	2 weeks at 90 percent relative humidity, then air dried	2.19
2	Green jack pine	3	2 weeks at 90 percent relative humidity, then air dried	3.08
3	Green jack pine	7	2 weeks at 90 percent relative humidity, then air dried	8.45
4	Green jack pine	1	Air dried	2.65
5	Green jack pine	3	Air dried	5.06
6	Green jack pine	7	Air dried	11.30
7	Incised green jack pine	1	2 weeks at 90 percent relative humidity, then air dried	3.11
8	Incised green jack pine	3	2 weeks at 90 percent relative humidity, then air dried	7.13
9	Incised green jack pine	7	2 weeks at 90 percent relative humidity, then air dried	10.07
13	Green oak	1	2 weeks at 90 percent relative humidity, then air dried	1.21
14	Green oak	3	2 weeks at 90 percent relative humidity, then air dried	1.72
15	Green oak	7	2 weeks at 90 percent relative humidity, then air dried	2.85
16	Kiln-dried oak	1	Air dried	.37
17	Kiln-dried oak	3	Air dried	.14
18	Kiln-dried oak	7	Air dried	.23
19	Kiln-dried pine	1	Air dried	.11
20	Kiln-dried pine	3	Air dried	.67
21	Kiln-dried pine	7	Air dried	.80
25	Green aspen	7	Air dried	6.14
26	Dry spruce	7	Air dried	.35
L1	Green lodgepole	3	Air dried butt up	5.30
L2	Green lodgepole	5	Air dried butt up	8.07
L3	Green lodgepole	5	Air dried butt down	6.28
L4	Green lodgepole	5	Air dried horizontal	7.06
L8	Green lodgepole	7	Air dried butt up	5.96
L9	Kiln-dried lodgepole pine	7	Air dried butt up	.27

which considerable resin exuded to the surface. The detail of cutting a few inches from the ends was inadvertently overlooked.) The absorption desired could be obtained by 1 day's steeping in a weaker solution. Weakening the solution further so that several days are required light prove to be advisable from the standpoint of distribution.

In the case of kiln-dried oak and lodgepole pine, inadequate absorption were obtained by steeping for 7 days. The kiln-dried jack pine with its wider band of sapwood, showed an absorption in 7 days that was not far from satisfactory. As was stated elsewhere the distribution in dry wood was quite inferior to that obtained in green wood.

It should be emphasised here that, in view of the wide differences in size and sapwood content between posts of the same species, the number treated was not sufficient to give accurate average values for the absorptions to be expected under given conditions. Also the values on total absorptions do not show the relative treatability of the sapwood of different species.

The use of the term diffusion in its looser sense to designate spontaneous spreading to confusing in this case since it covers three separate phenomena, one of which is diffusion in its restricted sense. It might be desirable therefore to adopt some general term other than diffusion to designate this type of treatment.

The ingress of chemical into wood treated in the manner described may be regarded as a composite of at least three distinct phenomena, namely:

(1) True diffusion of the solute from the surrounding solution into free water contained in the wood. This movement is due to the osmotic pressure of the solute. During seasoning movement of solute continues from areas of high to areas of low concentration.

(2) Capillary rise of the solution through interconnected spaces within the wood in response to the evaporation of moisture from the top.

(3) The creep of solution up the side of the wood, followed by subsequent radial diffusion of the solute.

No attempt will be made here to discuss theoretical aspects of the different types of movement of chemical into a green fence post standing partially immersed in an aqueous solution. Their relative importance will no doubt vary for different species, for different conditions of treatment, and in 2-stage treatments, depending upon whether the first or second chemical is under consideration. The subject is obviously very involved and a study of corresponding complexity would be needed to clarify it.

Series II--Double-diffusion Treatments with Copper Sulfate  
Plus Sodium Arsenate

It was recognized that it would be desirable to defer double-diffusion treatments until the data on the absorption obtained in the preliminary series were available, It would then be possible to introduce desired amounts of copper sulfate into posts and study the movement of sodium arsenate

into such posts. It was believed however, that if a few preliminary double-diffusion treatments were made at this time the results would be of value even though subsequent analyses showed that the absorptions of copper sulfate were far from that desired. Accordingly, these jack pine and three lodgepole pine posts were removed from the treatments described in Series I and given varied treatments in sodium arsenate. The three jack pine posts were transferred to a 12.5 percent sodium arsenate solution after 4 days' steeping in the 12.8 percent copper sulfate solution. They were removed from the sodium arsenate solution after 5, 8 and 12 days, respectively. The three lodgepole pine posts were steeped in the copper sulfate solution for 5 days and then in the sodium arsenate solution for 5, 7 and 10 days. The six posts were air seasoned standing butt up. They were then sectioned in the same manner as the posts in Series I, but the grindings from the discs were not mixed to form a composite sample for each post. Instead the two bottom discs (taken 0.5 and 1.5 feet from the butt end) were combined to form the bottom sample for each post while the remaining discs were ground together to form the top sample. The results of the analyses are given in table 2.

The generally higher copper content of the upper part of a post as compared with the bottom is surprising. The increase in the percentage of sapwood going from the bottom of the post to the top is believed to be the chief reason

Table 2.

Post No.	Species	Time in $\text{CuSO}_4$	Absorbed $\text{CuSO}_4$ based on dry treated wood	Time in $\text{Na}_2\text{H AsO}_4$	Absorbed $\text{Na}_2\text{H AsO}_4$ based on dry treated wood
		Days	Percent	Days	Percent
22	Jack pine	4	T <sup>1</sup> - 7.00 B - 5.16	5	T - 0.03 B - 2.26
23	Jack pine	4	T - 5.98 B - 3.88	8	T - .42 B - 2.10
24	Jack pine	4	T - 4.50 B - 4.96	12	T - .81 B - 4.00
15	Lodgepole pine	5	T - 4.83 B - 3.98	5	T - .05 B - 1.17
16	Lodgepole pine	5	T - 6.61 B - 3.73	7	T - .15 B - 2.67
17	Lodgepole pine	5	T - 7.27 B - 4.03	10	T - .31 B - 3.60

<sup>1</sup>  
- T = Top  
B = Bottom

although gravitational flow of solution within the post during seasoning could be a contributing factor. The question is of practical as well as theoretical interest and deserves some study.

The ratio of the combining weights of copper sulfate and disodium arsenate is 1:1.17. It is apparent that the absorption of the two salts obtained in these experiments are decidedly out of balance. The lack of balance should be regarded as an excess of copper rather than a deficiency of arsenate. This heavy absorption of copper might be the explanation for the poor distribution of the arsenate since in all cases the amount of copper in the lower part of the post was more than enough to precipitate the arsenate and thus render it immobile.

It is apparent that further experimentation will be necessary to get some idea of the time required to introduce about 1 percent of sodium arsenate into wood containing about 1 percent of copper sulfate. To establish the most effective distribution of two salts for different climatic conditions and to determine the conditions for obtaining such treatment would involve a tremendous amount of work which should not be undertaken unless field tests of the comparative effectiveness of different combinations of chemicals that appear to be adapted to this method of treatment show this particular combination to merit such study.

## Summary

When green, peeled, jack pine or lodgepole pine fence posts are stood upright in a barrel containing a 12.8 percent solution of copper sulfate, the absorption of chemical seems to be more rapid than when green Southern pine posts are completely immersed in such solution. In 1 day's steeping, the absorption is of the order of that specified in commercial pressure treatments with salt preservatives. Under favorable conditions practically complete penetration of sapwood may be obtained in 3 days or less of steeping; if the posts are inverted and stood upright during seasoning the final concentration of chemical is usually higher in the top half than in the bottom half when high absorptions are obtained. The penetration of the heartwood is generally slight. The absorption obtained in kiln-dried posts is much less, although in 7 days an adequate absorption of chemical may be obtained with nearly all of the chemical remaining in the lower part of the post. When double-diffusion treatments involving copper sulfate and sodium arsenate are made in barrels by a schedule resulting in a heavy absorption of copper sulfate, the ratio of the time required for the second bath to the time of the first bath appears to be greater than in complete immersion treatments. Under these conditions the movement up the post of the second chemical is extremely slow. Data are lacking on the movement of the second chemical into wood containing small to moderate amounts of the first chemical.