AN INTRODUCTION TO MODERN CHEMICAL WOOD PRESERVATION

by

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A Thesis
Presented to the Faculty
of the
School of Forestry
Oregon State College

In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science

June 1938

Approved:

Professor of Forestry
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INTRODUCTION

In the field of wood preservation—a field yet young and undeveloped—there is much room for research and development. Although much has been done in this field already in the way of treating timbers and wooden construction material, we can safely say that the surface of this industry has barely been scratched. Timber, since earliest times, has been the most readily available, easily-worked and adaptable structural material. The superiority of wood as a building material is quite generally recognized, but the fact that it has always been easily obtainable, at rather low cost, has resulted in the layman's losing sight of the real reasons why wood has stood the tests of time and competition. Its lightness, strength, low cost, inherent natural durability when properly used, and its unlimited supply, are recognized as outstanding qualities. Thoroughly seasoned wood is as strong, pound for pound, as mild steel. It is an efficient insulator against heat and cold. It will stand abuse without becoming unsightly—for example, the quality of edge-grain Southern pine to withstand abrasive wear is well known. The flexibility of wood allows the architect freedom of design; the natural grain of most species supplies its own decorative effect.
The disadvantage which is most commonly cited against wood can, by the use of effective preservatives, properly applied, be readily eliminated. That disadvantage is its susceptibility to the attacks of termites, decay, and molds. Once it has been properly protected against these destroyers, wood becomes an ideal building material. Because the preservation of wood is such an important factor in the industry today, it has been selected as the topic for this study.

The competition offered by wood-substitute industries has acted as an additional inspiration in this work in the last few years, and because of the necessity of finding a suitable wood-preservative that may be used under all conditions, the last few years have seen quite an increase in the activity within this field, until now the future of the industry is well established with unlimited possibilities arising from the use of well-preserved wood.

HISTORY OF WOOD PRESERVATION

Since time immemorial, man has attempted to protect his structures from destruction by their natural enemies, and in the case of wooden structures—since by far the great majority of buildings are of wood—there are several kinds of scavenging agencies which attack dead and down timber. The most active and important of these are:

a. On land and in fresh water, various types of fungi
which feed by attacking and disintegrating the wood fibers. The result is known as "decay."

b. On land, also, termites (sometimes called white ants), which destroy the timber to provide a home and at the same time use the fiber as food.

c. In sea water, many types of low order worms and bugs, generally known as toredos and limnoria, respectively.

Some early attempts in the field of wood preservation to combat these enemies of wood consisted of merely char-ring the wood or painting and smearing the wood with some coating, such as bitumen, etc. Very little is known of the processes used in the preservation of wood previous to 1717, when directions were given to the British Admiralty to boil and dry treenails of ships before they were used. Although no substance was added to the water, some sterilizing ef-fect was thought to have been brought about by this process.

In 1737 a British experimenter, Emerson, obtained a patent on a process of saturating timber with boiled oil, mixed with toxic substances. The process appears to have been little used, although it formed the first patent on any method of wood preservation.

In 1740 a Reid proposed to arrest decay by means of certain vegetable acid, probably pyrolignaceous acid. This method consisted merely of simple immersion of the wood to be treated in the substance.
Dr. Hales, also an Englishman, in 1756, after some experimental work in the field, recommended that planks at the water line of ships be soaked in linseed oil, to prevent the rotting effect of alternate wetting and drying. American shipbuilders used to hollow out the tops of their masts in the form of cups or basins; bore holes from the ends a considerable distance down the mast and pour oils of various kinds into these holes. They were then covered over with lead and the oil soaked down through the vessels into the interior of the timber.

In 1769 Jackson, who was a London chemist, with a view to decay prevention, obtained permission to prepare some timber to be used at the government shipyards, by immersing it in a solution of salt, water, lime, muriate of soda and potash, but the result of this treatment was that the wood was rendered more perishable than if it had been left alone. Later, Jackson prepared a more successful mixture, which was of secret composition. This substance looked like glue and it is suspected that it contained slaked lime thinned with a weak solution of glue for mopping the timbers of the ships.

Shortly after Jackson's experiments, a Lewis advocated the preservation of timber by placing it surrounded by some pounded lime, in spaces, "below the surface of the earth." The action was obtained probably from the dampness of the earth and was quite similar to some of the salt treatments.
used today. Around this period, from 1768 to 1773, the practice prevailed of saturating ships with common salt. Ships so treated were free from dry rot, but the treatment resulted in the rapid corrosion of iron parts.

About 1780, marcasite, a metallic, bronze-yellow, brittle iron disulphide (FeS₂), termed by the miners "mundic", which was found in great quantities in Devonshire and Cornwall, was used in a state of fusion to prevent dry rot in construction work. Although this was supposed to have been used a good deal no definite results are recorded.

In 1796, Dr. Hales proposed to creosote treenails of ships for the same reason they were merely boiled in water earlier. This was the first recorded use of creosote as a wood preservative, and it may be noted that this event took place 42 years before Bethell's patented pressure process for creosoting wood.

In 1800, when the Society of Arts Buildings in the Adelphi, London, were being attacked by dry rot, a Dr. Higgins examined the timbers and caused some to be removed and be replaced with new. Those not removed were scraped and washed by a solution of caustic ammonia. He believed that by burning the surface of the wood with this solution the growth of the fungi could be prevented.

In 1815, Wade filled the pores of timbers with alumine or selemite. The assumption that this would prevent rot was based on the fact that alum is fire retardant, but it
worked just the other way and the rot action was increased. In the same year, Mr. Wade tried the impregnation of timbers with resinous and oleaginous matter, preferring linseed oil to whale oil, or with common resin dissolved in a mixture of caustic alkali. Also recommended impregnation with copper sulphate, zinc, and iron, rejecting deliquescent salts because they are corrosive to iron.

The results of various experiments made on wood by William Chapman were published in 1817. He had tried the treating of wood with lime, soap, alkaline, and mineral salts. He recommended a solution of one pound of copper sulphate in four gallons of rainwater, and mopped on hot over affected parts.

As was the case with many of the experiments made before this time, Chapman's experiments provided for the treatment of the timbers after infection had set in rather than before it had obtained a foothold. One reason for this type of experimental work was the fact that to determine a good preventative takes much more time than the determination of a good cure, although a much more concentrated treatment is needed to cure. About this time, however, the work began to be more complete and the experimenters worked for the development of timbers completely rot-free from the time of installation.
In 1822, Oxford took out a patent for an improved method of treating wood, wherein a proportion of lead oxide, carbonate of lime, and carbon of purified coal tar were ground, mixed with oil of tar, and applied in thick coating to the timbers to be preserved. The chief advantage of this type of treatment was that it kept the fungi away from the wood by the thick coating, rather than combatting rot with the toxic materials in the substance.

On March 31, 1832, Kyan patented a process for the treatment of wood to prevent dry rot known as the corrosive sublimate process. The wood was immersed in a tank, left there for a week, then removed and dried. The treatment was not uniform and contradictory reports were given as to its success. The use of the pressure tank gave better results, and in this innovation Kyan antedated John Bethell. Later the highly successful pressure creosoting process, known as Kyanizing, was evolved. This process rendered the wood rather brittle, but in the main it was the best process evolved so far and was quite popular for some time. A Kyanizing plant was first installed at Lowell, Mass., in 1848.

We now arrive at the modern creosoting process which was brought to perfection by John Bethell. Bethell's process of creosoting, or injection of heavy oil of tar, was first patented July 11, 1838. Of this process this
is written: "It consists of impregnating the wood throughout with oil of tars, and other bituminous matters, containing creosote, and also with pyrolignite of iron, which holds more creosote in solution than any other watery menstruum. The creosote should be thick and rich in napthalene." (36) Although this process of creosoting is fundamentally the same as it was when it was patented, several new patents have been taken out on changes in it.

The first creosoting plant in the United States was established in Somerset, Mass., by the Old Colony Railroad for the treatment of ties in 1865, and the preservation of timber secured its early American development in the railroad industry, first to realize the value of timber treatment.

The use of other chemicals for the preservation of wood developed in much the same manner as the development of the creosoting process, and today there are many ways in which wood is treated for the prevention of rot and stain.

At the present time, after much preliminary experimentation of comparatively little value has been completed along with over a century of very important and basic work, the economic advantages of the use of a preservative have been clearly and positively established. Certain of the problems concerning the various methods of impregnating the wood have been solved, but because of the demand for a clean, economical, fire-proof, and easily-applied
chemical wood preservative, there is yet much to be done in this field. Probably the greatest difficulty to be encountered in the development of a preservative today is the problem of fireproofing the wood. Although many of the other defects have already been almost overcome by the use of a preservative of some sort or another, few have been developed which are very effective in reducing the inflammability of the wood, and it is on this work that much of the research is being done today.

The use of materials for preserving woods has grown until now great quantities are used in this industry. The following is a list of the chemicals used in the United States in 1936: (7)

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<th>Chemical</th>
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<td>Creosote</td>
<td>(gal) 154,712,999</td>
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<td>Petroleum—admixture for ties with creo.&quot;</td>
<td>22,624,318</td>
</tr>
<tr>
<td>Zinc chloride</td>
<td>(lbs.) 4,127,886</td>
</tr>
<tr>
<td>Miscellaneous salts</td>
<td>(lbs.) 1,804,976</td>
</tr>
<tr>
<td>Miscellaneous liquids</td>
<td>(gal.) 4,485</td>
</tr>
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Along with the growth of the industry, the number of plants for treating wood has increased steadily since the installation of the first one in 1848. In 1874 a creosoting plant was installed at West Pascagoula, Miss., and by 1904 approximately 30 plants were operating in the United States. In 1909 there were 80 and the industry grew until in 1936 there were over 200 treating plants, of which over half were pressure-treating plants.
PRESERVATIVES USED AND THEIR IMPORTANCE

In the discussion of the preservatives used in wood preservation today, some mention must be made of the reasons for which wood is preserved, in order that the reader may get a clear picture of the "why" behind the various types of research that have been done in this field over the last few years. Some of the most important reasons that wood is treated are:

a. To increase the length of the life of the wood by reducing the decay and rot that naturally infect the various types of wood when used in certain situations, and also for the prevention of attack by termites. By proper treatment with a good preservative, the life of the wood may often be increased almost indefinitely.

b. To make the wood more fire resistant. Although untreated wood will ignite at a fairly low temperature, it will not buckle under heat nearly as soon as iron or steel members; consequently if the wood can be treated so as to increase the kindling temperature and make combustion much slower or eliminate it altogether, the superiority of wood over steel for construction work may easily be seen. This point has been one of the stumbling blocks in the path of progress in many of the wood preservatives experimented with to date, and much is being
at present to overcome this defect of so many of the preservatives used now.
c. To decrease the maintenance cost of the structure.
d. To increase the use of the less durable woods for construction work where formerly there was no use because of the susceptibility to attack.

As may be easily seen from the reasons why we treat wood, the qualities desirable in a good wood preservative are such that the defects mentioned will not be able to survive in the treated product. Some of the most important of these are:

a. Preservative value or toxicity. The strength of the preservative is important because it must effectively combat all forms of fungi, insects, and destroying organisms that may attack the wood.
b. Permanency. The preservative must not only be toxic to organisms when it is first applied to the wood, but it must be able to remain toxic in the treated wood for many years. The leachability and volatility are important factors to be studied in determining the permanence of a good preservative.
c. Economy. If the cost of using an effective preservative exceeds the cost of replacing the timbers every two or three years, naturally it will not pay to use it. Therefore the initial cost of
the preservative plus the cost of treating the wood with it must be low.

d. Ease of application. One of the large factors involved in the expense of treating wood is the time it takes to effectively administer the substance; so a simple treatment with deep and rapid penetration is hoped for in this field. Some fairly efficient methods have already been found that have been used in several cases, but as yet no sure method for the small-quantity user has been determined.

e. Fire retardance. This is the most important quality in some situations, and is the greatest need in preservatives on the market today.

There are other minor reasons for treating wood and qualifications desirable in wood preservatives, such as water repellence, non-toxicity to the wood itself, cleanliness, and non-corrosiveness, etc., but these generally cover the qualifications of an effective wood preservative.

In order that a complete understanding of the process of wood preservation may be had, and a knowledge of why it is so hard to place a new preservative before the public and meet with approval, a consideration of the necessary experimental work necessary to establish a good preservative will be made.
In the first place, in the last few years several preservatives have been placed on the market with claims made as to their effectiveness while in reality, in many cases, they were little more effective than a water-bath treatment. Because of this, many of the commercial users of preserved wood are naturally rather skeptical about adopting a new preservative for the product.

Above this, there is the long series of laboratory tests necessary to establish the preservative. The great difficulty in determining the effectiveness of a preservative substance is the fact that in many cases laboratory tests of various sorts have been made proving the substance good in experimental work but after it is put to test in the field it has been found not to be effective at all. Because of this, only long field tests can actually prove a preservative.

One of the first laboratory tests to be made on a new preservative is its toxicity to fungi, and while conditions in the laboratory may as nearly as possible be like field conditions, the results can not be very definite or conclusive. They are, however, useful in comparing the various preservatives to each other by comparing the results of the various tests. These are made by exposing samples of the treated wood under suitable conditions to the different types of fungi growths and determining the extent to which the wood is attacked by the fungi.
Probably the next important laboratory test to be made is the toxicity of the proposed preservative to termites, which form a growing enemy of wooden structures. The results of laboratory tests, because of the various conditions under which termites are able to work, are not generally as definite as those obtained in fungi tests. Also, because the termites are forced to live in captivity, they do not act quite the same as when working under field conditions. Some pioneering work has been done in termite control in California and some investigations carried on in Connecticut, but the results, although interesting, are too new to be applied very much in practice without more experience behind them.

For wood that may be in contact with the soil or with water, the next laboratory test to be made of the preservative is the resistance to leaching. In this test, the samples are soaked in water and an analysis made of the water, but although the tests are good for comparing the holding ability of the various woods and to a limited extent the comparative characteristics of the preservative, the conditions are so much different from many actual field conditions that field tests are also necessary. In actual housework construction, the tests may be more severe than are actually met with in the field, but unless the work is actually placed where it is likely to be used, there is small possibility of obtaining good results without field
tests. Because many chemicals that have been tried in this work must at least be partially soluble to kill the attacking organisms, it is difficult to get one that will stand up under conditions where water is in contact with the wood in use.

Some of the other laboratory tests that must be made are concerned with the volatility of the wood preservative or its resistance to evaporation, its chemical stability over a period of time comparable to the use of the treated product, whether or not the preservative is corrosive to metal work, its fire-retardant qualities, and whether or not it is toxic to man, along with many others. These all, with the exception of one or two, have to do with the chemical make-up of the substance; consequently the tests made are generally of a chemical nature.

Although extensive laboratory tests may be made on the various preservatives proposed to be used, the final and most important test to be made is the serviceability of the chemical in the field under true conditions. Some chemical may show up well in the laboratory and when used in the field it may give way in a very short while. Hence, it is only by the complete field tests that the effectiveness of the chemical or chemicals proposed to be used may be determined.

The number of substances that have been experimented with as possible wood preservatives is countless, but in
the tests made in the last hundred years in whatever part of the world, there have been several preservatives that have shown more possibility than the others. These preservatives fall into four general classes:

a. Preservatives of an oily nature, like creosote, which are relatively insoluble in water (the protective action obtained in some of the heavier oily preservatives does not result strictly from a chemical effect but rather from the fact that the heavy oil keeps fungi and insects away from the wood).

b. Preservatives which are salts injected into the wood in the form of water solutions.

c. Preservatives in which the toxic constituent is carried in some volatile solvent other than water.

d. Preservatives sold under trade names as commercial or proprietary preservatives.

The methods of treating the wood with the various kinds of preservatives vary from a pointed coating or simple immersion to pressure treatment in closed tanks involving several hundred pounds pressure per square inch. Some processes have even advocated the treatment of the wood with one substance and then treatment again with another, the theory being that an insoluble compound would be formed in the wood when the two compounds united. With the various kinds of preservatives and methods of treatment have also
come the combinations of various classes, such as the combination of creosote with zinc chloride, with the hope of overcoming the defects of both and benefiting from the good qualities of the two.

OILY PRESERVATIVES

Coal-tar Creosote

Coal-tar creosote is a black or brownish oil made by distilling coal produced by high-temperature carbonization of bituminous coal; it consists principally of liquid and solid aromatic hydrocarbons and contains appreciable quantities of tar acids and tar bases; it is heavier than water; and it has a continuous boiling range of at least 125°C beginning at about 200°C. The first fractions collected in tar distillation are the light oils, the residue is pitch, and in between the two comes the portion that is saved for wood-preserving purposes, and hence, the quality of the creosote oil depends on the quality of the distillation process and the degree to which the distillation process is carried. For general outside work in which the preservative creosote is often heavier than for smaller materials, the variations in the quality of the creosote do not affect the wood-preserving qualities, but in certain of the thinner oils and in cases where it is wished to combine the creosote with some other substance, the quality should be good.

Coal-tar creosote, in spite of its disadvantages, is the most important and most generally used of the modern
wood preservatives. Some of its main advantages, which help make it the best present preservative for general outdoor construction work, are:

a. Its high toxicity, which makes it extremely poisonous to wood-destroying fungi and insects.
b. Its permanence, due to its relative insolubility in water and its low volatility, which is present under the most varied use and conditions.
c. Its ease of application.
d. Its general availability.
e. Its relatively low cost, which varies with the grade of creosote used and the method by which it is applied to the wood, but in general runs from about twenty to forty dollars per thousand feet of wood treated.
f. The ease with which the depth of penetration may be determined.

One of the main disadvantages cited against creosoted timbers include their inflammability when freshly treated. After some months, however, after the volatile parts of the oil disappear from near the surface of the wood and the surface is more or less set, it is claimed to be but little easier to ignite than untreated wood. Probably the inflammability of the wood is no higher after a period of years than untreated wood which decayed for the same time. The extent to which creosoted wood should be regarded as
as a fire hazard has never been satisfactorily determined, but in general, because of the nature of creosote itself, it is used in situations in which the fire hazard is small, such as in sills and timbers in contact with the soil, while some other preservatives are generally better in small members where there is some risk of fire.

By experimentation in the last few years, some of the disadvantages of the creosoting processes have been greatly reduced, but in the regular treatment some of the disadvantages are still the discoloration of the wood caused by the treatment, the disagreeable odor, and the soiling of clothes, etc., when in contact with the fresh creosote. Foodstuffs that are sensitive to odors should not be stored near creosoted wood, and hence, the use of creosote in preserving the wood in dwellings is objectionable in certain cases. Workmen sometimes object to the use of creosoted wood because it sometimes burns the skin of the face and hands, causing an injury similar to sunburn. However, there need be no fear that creosoted timber has a serious effect on the health of workmen handling or working near it, or on the health of the occupants of buildings in which treated material has been used. The odor is greatly reduced after treatment a short time so creosoted timbers may safely be used in sills and even subflooring with little danger of the odor becoming noticeable.

Another disadvantage of creosoted lumber is the "sweating" which results in hot climates. This has long been a
problem in lumber that it was desired to paint over and for many years no solution was found. In the last few years, however, a mixture of half creosote and half petroleum oil has been used and has been found quite satisfactory to paint over. (37)

Creosote is also corrosive to some things, such as the rubber on electric cables, etc., but this is overcome by the use of the metal outer covering on the wires. In situations where the cable may not be protected by metal, some other method has to be used, but this factor is relatively small in most places where creosoted timbers are used.

The nature of creosote requires that deep penetration be obtained in order that the maximum amount of protection will result. That long-lived timbers are obtained by proper treatment with creosote is well known to all who have ever come in contact with work of this type. A good example of the long life of this treatment is the case of a series of telegraph poles in Virginia. These were in the ground where previously it was next to impossible to prevent termite attacks, and when they were removed after being in the ground for twenty-five years they were only slightly attacked, and the only places were inside of the seasoning checks which were present when the poles were put in place. Many other cases are on record in which the timbers or poles lasted twenty-five or thirty years or even longer, and are still sound, or were sound when removed or were still in the ground but their use discontinued.
The use of creosote as a general-purpose preservative is well established, and will probably be the most important method of preserving timbers for some time to come, both because of its initial low cost and because of its low maintenance cost.

**Water-gas-tar Creosote**

Water-gas-tar creosote is obtained from petroleum oil as a by-product in the manufacture of water gas. It is produced by distillation from water-gas tar. This creosote is defined as any and all distillate oils from such tars boiling between 200° and 400° C. While water-gas tar and the creosote produced from it are not considered so generally effective as coal-tar creosote, service test records indicate that they have good preservative properties. For all general purposes, wood that has been deeply penetrated with water-gas-tar creosote will have satisfactory resistance to decay. Aside from slightly lower toxicity, the advantages and disadvantages of water-gas-tar creosote are generally similar to those of the coal-tar product.

**Coal tars**

Coal tars of various sorts are, in general, unsuitable for wood preservatives when used alone because their relatively high viscosity makes it difficult to obtain satisfactory penetrations. Also, they are less poisonous to wood-destroying fungi than the creosotes. Although some tests have been made with coal tars, in general, they have demonstrated that surface coatings of tar are of little use.
Petroleum Oils

Crude petroleum, "topped petroleum", fuel oil, and waste crank-case oil are frequently suggested as possible wood preservatives and many experiments have been made with them. Experience has shown that they do not generally possess toxic properties to make them suitable as wood preservatives when used alone. However, they have been used in mixture with other preservatives and have given fair results. Occasionally even good results have apparently been obtained, but in many instances complete failure has resulted; so they cannot generally be relied upon as very consistent in their preserving properties or effects.

Creosote-coal-tar Solutions

Coal tar is extensively employed in solution with coal-tar creosote for the treatment of ties and to some extent for other classes of timber. The coal tar solutions are used principally in the eastern and southern states. Mixtures of coal tar and creosote commonly contain about 20% of tar by volume although some having as much as forty to fifty percent of tar by volume are used. The practice of mixing various substances together with the hope of obtaining the good qualities of the individual substances has been tried in many cases, and this is how this particular mixture was originated.

Coal-tar Creosote and Water-gas-tar Mixtures

The practice of using water-gas tar in place of coal tar in creosote mixtures for the treatment of various kinds
of material but more particularly for ties has been going on for some time. This forms a fairly toxic preservative that meets the needs of many general preservation problems. The proportion of water-gas tar used in such mixtures has varied over a wide range, depending upon the quality of tar and other factors.

**Coal-tar Creosote and Petroleum Mixtures**

Mixtures of coal-tar creosote and petroleum are widely used in the western and Rocky Mountain states. This use so far has been principally for the treatment of railroad ties. These mixtures in general contain from thirty to sixty percent of petroleum by volume, but more often the proportion is about fifty percent. Since the toxicity of the petroleum mixtures is furnished by the creosote it is highly important that for this purpose the creosote does not run too high in residue above 355° F.

In certain types of construction a solution of creosote with an admixture of petroleum may be desirable, and because of the high toxicity of the creosote the mixture will still retain its preservative properties. There are three advantages claimed for pressure treatments with the creosote-petroleum mixtures. These are:

a. Reduction of the initial cost because of reduction of the amount of creosote, which is the more expensive of the two items.

b. Improving of the distribution of the creosote in the timber because of the lower viscosity of the heated petroleum oil.
c. Reduction of the tendency of the timber to check due to field seasoning.

The reason that the use of creosote-petroleum mixtures for wood preserving has been limited to such fields as cross ties is that in these the mechanical life of the treated timber is less than would be the added life expectancy of full creosote treatment. In such cases it proves very economical.

In the use of timbers for mine-tunnel construction, this type of treatment for the preservation of the wood would probably prove more costly than the initial treatment with the pure creosote, because the labor cost of installing timber under ground is several times more than on the surface; also the short life of untreated or poorly-treated timbers in mines makes this labor cost an important factor in the economies resulting from the use of timbers properly treated to give long and satisfactory service.

The use of petroleum mixtures with creosote have come to the front in the last few years as a means of overcoming the disadvantage that creosoted material could not be painted over, and has proved quite good in some uses.

As has been previously mentioned, the chief disadvantages of a creosote treatment are the discoloration of the wood and the disagreeable odor and handling conditions for situations in which the treated wood is used for finishing material. Although the long service records and almost universal use of this preservative in the various kinds of
construction work indicate that creosote is the only preservative effective against the attack of marine borers and under certain other conditions, in many situations there is a desire or even a need for a so-called "clean" preservative, or one which does not alter appreciably the appearance and other surface characteristics of the original wood. In most cases, clean treatment implies a product which differs little from the untreated wood with respect to color, odor, general characteristics, cleanliness and paintability. Usually the requisites of such treatment are met by the use of preservative salts in aqueous solutions. Treatments with solutions of toxic materials in colorless oils may also satisfy these requirements, and at present, although they are of minor commercial importance, there is considerable experimental work being done with this type of preservative. Dry creosote treatments conform to some of these conditions, although they cannot be considered as genuinely clean.

WATER-BORNE PRESERVATIVES

**Zinc Chloride**

The first of the so-called "clean" preservatives to be considered will be zinc chloride, because it is the water-soluble preservative most extensively used in the United States.

The metal, zinc, forms many salts, among the most soluble of which is the chloride (ZnCl₂). The salts of zinc
are prepared by treating zinc or zinc oxide with the appropriate acid. To produce zinc chloride, an excess of hydrochloric acid is used. The resulting solution is evaporated to dryness, and the residue is fused to remove the last traces of water. Zinc chloride may also be formed by heating the metal in chlorine gas, and producing it directly. The most common method, the one first mentioned, gives a chloride that contains some oxychloride and is grayish-white, waxy, and extremely hygroscopic. Besides being soluble in water, it is caustic, disinfectant, and antiseptic. One of the uses of zinc chloride, aside from the preservation of wood, is to clean the surfaces of metals before soldering. This use depends upon the ability of the zinc chloride to dissolve the oxides of the other metals, and hence, results in one of the disadvantages of this compound when used as a wood preservative—the corrosion of metal parts in the construction. However, in many situations, the use of zinc chloride is well established and very satisfactory results are obtained.

Another great disadvantage—probably the greatest prohibitive factor to the use of zinc chloride as a wood preservative—is its solubility in water. This is a favorable factor in applying the compound to the wood, but it will leach out equally as easy. This makes it unsuitable as a preservative for pilings, etc., where there is contact with the water. As in many of the water-borne preservatives in use today, the water that is injected with it temporarily
adds considerably to the weight of the wood, and in order to avoid shrinkage troubles it must be dried out before the wood is used in buildings.

The use of zinc chloride as a wood preservative was first patented by Sir William Burnett in 1838. Since that time, the combination of many substances with zinc and with zinc chloride has been tried with the idea of overcoming the leaching of the straight zinc chloride, and some have been quite successful. However, much preservative work is still done with the pure zinc chloride, and in dry situations it is a very effective preservative.

When injected into wood in the usual quantity (about 1/2 to 1 pound of dry zinc chloride per cubic foot of wood) this salt has a slight effect in reducing inflammability. In quantities of several pounds of zinc chloride per cubic foot of wood the inflammability of the wood is reduced materially.

Zinc-chloride-treated wood, properly dried after treatment, is finding increasing use in the construction of buildings where the high relative humidity favors the rapid decay of the roofs. The facts that the net weight of the wood (after seasoning) is not greatly increased by the treatment and that the treated wood is clean and paintable and to some extent fire resistant, favor its use in such places. Zinc chloride has given better results in the field than many other compounds which tested better in the laboratory, but in high concentrations, as well as acting on
the various kinds of metals, it has a tendency to act on the wood itself.

Since the first introduction of zinc chloride as a wood preservative in 1838 there have been tried other substances as well for this work, and in combination with other substances there have been one or two quite favorable compounds found; however, the great majority of this type of treatment done today is still done with straight zinc chloride or with chromated zinc chloride. These preservatives are used chiefly in situations where there is little moisture.

**Chromated Zinc Chloride**

The use of a compound made up of chromium, zinc, and chlorine as a wood preservative is advocated because the corrosive quality of straight zinc chloride is eliminated. It is claimed that chromated zinc chloride will improve the physical and mechanical properties of lumber over a period of years in several ways, and it is well suited for house construction, mine timbers, factory roofs, wharf floor systems and super-structures, fire curtains, board walks, stadium seats, and many other uses not particularly suited to the oily preservatives. The use of salt-treated lumber for factory floors, laid over a creosoted subfloor or joist system is becoming more popular because this gives the advantages of having the creosoted material underneath where there is likely to be more moisture and the salt-treated lumber in the building where the odor of
of the creosoted lumber might be disagreeable to the users of the building.

The Grasselli Chemicals Department of the E. I. Dupont de Nemours and Co., which is one of the larger manufacturers of chromated zinc chloride for wood preservative uses, claims the following advantages for this product: decay resistance, termite repellence, fire troubles cut down to a minimum, clean treatment, odorless, paintable, improved surface hardness, increases the resistance to abrasion, free from harmful poisonous compounds, non-corrosive to hardware, readily fabricated, and economical.

The use of chromated zinc chloride as a wood preservative is the result of extended research undertaken by various members of the wood-treating industry and has been studied from all phases of the wood-preservation uses. It is now recognized as one of the better methods of salt treatment in use today. The use of the chromium in the compound helps to retard fire as well as the other factors because it makes the compound slow to ignite. The fire-retardant properties of zinc chloride and other commodities useful for this purpose have been accurately studied by the Forest Products Laboratory at Madison, Wisconsin, and compare favorably with diammonium phosphate which is recognized as one of the leading fire-retardant salts in use today.

The action of the chromium in the preservative tends to reduce the corrosive quality of the straight zinc chloride
and thus make the preservative much better for uses where nails or metal parts are involved in the construction of the building or woodwork. The use of chromium in the compound does not reduce the toxicity of the zinc chloride enough that it is not able to carry on the work of preserving the wood by killing the fungi and keeping out the termites.

Although the leachability of the chromated zinc chloride is not quite as high as that of straight zinc chloride, it is supposed to leave, after exposure to certain degrees of moisture, materials of enough toxicity to effectively combat fungi growth and development.

The claim that surface hardness and greater resistance to abrasion are good characteristics of lumber treated with chromated zinc chloride, which properties adapt it particularly well for uses including loading platforms, warehouse floors, and other purposes imposing excessive mechanical wear, is borne out by the accompanying graph, which indicates substantially higher resistance for the treated panel in contrast with a comparable untreated specimen.

(Graph on P 31)

(Furnished by Grasselli Chemicals Co.)
Although the use of chromated zinc chloride as a wood preservative is not as extensive as creosote, it is quite important in the industry today, and for uses where there is little or no moisture makes a very effective preservative. Even in some cases it has been proved fairly effective when in contact with moderate amounts of moisture.

**Carbolineums**

Although carbolineum is not strictly a salt treatment, it will be mentioned here because it is the name given to
a mixture of zinc chloride and oil. The product is a dark brown greasy compound composed of zinc chloride and anthracene oil, and was formerly used considerably as a wood preservative, but today is being replaced by some of the more modern of the clean preservatives.

**Sodium Fluoride**

Sodium fluoride (NaF), in mixture with other materials, has been used to a considerable extent in Europe for preserving wood, especially mine timbers. The compound itself is colorless, soluble, and in practice has been found quite effective in $3\frac{1}{2}$ to $4\%$ solutions, which makes the actual amount of compound necessary to be used quite small. In the United States it has been used alone experimentally in railway ties and in mine ties and timbers since 1914, and has also been used to some extent commercially in the treatment of factory roof timbers. The evidence thus far available indicates that it is an excellent wood preservative. It is quite high in toxicity, but is not as soluble after in the wood as zinc chloride, since the maximum strength of solution is about $4\%$. For the most part its advantages and disadvantages are similar to those of zinc chloride. The chief disadvantage is its relatively high price, which in recent years has been roughly one and one-half times that of zinc chloride. If it could be obtained at a price that would compare more favorably with zinc chloride it would undoubtedly be more extensively used in this country for treating wood. Sodium fluoride is not
harmful to man so is safe to handle, and it may be painted over, which makes it desirable as a preservative for inside finish work. As yet, it is little used, but it shows promise in this type of work. It is at present a valuable ingredient in several proprietary or patented preservatives, some of which are finding considerable use in the treatment of building lumber and structural timber.

Arsenic

Arsenic in various forms, either alone or mixed with other substances, has been used as a wood preservative for a number of years, and a considerable quantity of poles, ties, and other material treated with it is now in service. It is still too early to tell how effective the various forms and combinations of arsenic will be but some of them have given promising results thus far.

Mercuric Chloride

Mercuric chloride (HgCl₂) or corrosive sublimate was first employed for preserving wood in 1705, and its use was again reported in 1767. It was mercuric chloride that was involved in the process known as Kyanizing, patented by Kyan in 1832, and although the process is essentially the same today as he used it, there have been some changes made in it. The first commercial treating plant in the United States, built in 1848, used this preservative and is today using the same method. The compound is generally applied in about 1% solutions. The use of mercuric
chloride in the United States, however, has not greatly increased in all this time. Undoubtedly it is effective in prolonging the life of wood, but its relatively high price, its extremely poisonous character, and its corrosiveness to metal have militated against it. Although it is still used to an appreciable extent in Europe, either alone or mixed with sodium fluoride, it will probably never be extensively used in the United States.

**Copper Sulphate**

Copper sulphate, which has been used in Europe as a wood preservative for many years, is known to be effective in retarding decay. However, it is no more effective than zinc chloride or sodium fluoride, and has no especial advantages over them. The chief disadvantage of this preservative is the fact that it attacks iron and steel and therefore can not be used in ordinary treating equipment. Like other similar preparations, it must be handled in a wood tank or vat. It has never been used extensively in the United States for preserving wood.

**Sodium Chloride**

The use of sodium chloride (NaCl) or ordinary table salt as a wood preservative has been tried along with other types of preservatives, and has been found to be fairly effective. This compound has been used in the last few years somewhat as an aid in seasoning wood, especially large timbers, without checking, and at the same time it lends certain preservative properties to the wood. In the
use of wood piles and other members in contact with sea water it has been found that most of the damage to the wood is done by certain low order bugs and worms, and that the salt effectively keeps out fungi of the ordinary type, thus making this a fairly effective preservative for dry construction work of the ordinary type. However, it lacks the toxicity of some of the other preservatives.

The next few compounds or mixtures mentioned have been tried in various situations as possible wood preservatives, but because of certain characteristics have not been adopted very widely.

**Arsenic Trioxide and the Arsenites**

The use of arsenic trioxide with sodium arsenite gives good treatment for insects. These compounds are quite toxic and probably the cheapest of the inorganic compounds. As yet, the results with this type of treatment have been good against some types of wood destroyers, but have not been found to be very effective against termites. However, for certain situations, this type of preservative shows promise of being quite suitable.

**Boric Acid and Borax**

These compounds have been used as preservatives in tests conducted by the Bell Telephone Laboratories, and their results rate them as a little inferior to zinc chloride as preservatives. The cost, however, is low, and the compounds are not very toxic to higher animals, but the
compounds contain certain qualities affecting their use, such as the alkalinity and consequent poor paint-holding ability, which make them undesirable for general preservative work.

**Cadmium Salts**

The salts of cadmium have been experimented with, the view in mind being preservation of wood, and they are possibly more effective against termites than zinc salts, but as yet they are too expensive to be used merely for decay protection in construction woods.

**Nickel Chloride**

This chloride is less toxic to man than copper sulphate and is less corrosive to steel. The chloride of nickel is preferred to the sulphates as they do not have the tendency to weaken the wood after impregnation. This compound is relatively cheap, but has not found widespread use because others are more effective in combatting the combination of wood destroyers.

**Sodium Chromate and Sodium Dichromate**

The chromates of sodium have been experimented with in limited amounts as possible wood preservatives, and have been found to be very toxic to fungi of various kinds, but at the same time also toxic to man. However, they are probably next to arsenic trioxide for low cost per unit of toxicity so in the future may be used with other substances for preserving woods. In these compounds, the
chromium tends to reduce the toxicity of the compound to man, and to some extent is supposed to reduce the tendency of the preservative to leach out of the wood.

**Thallium Sulphate**

The sulphate of thallium has been used in experimental work and has been found to be effective against insects, but like some of the other salt treatments, is too costly to be used for mere decay protection.

**OIL-SOLUBLE PRESERVATIVES**

The use of a preservative toxic chemical that could be carried in some volatile, non-aqueous solvent is the most recent phase of the wood preserving industry. This type of preservative has resulted from the demand for a preservative that may be applied without swelling or distorting the wood, and also one which may be painted over as well as being fairly cheap to purchase and apply to the wood. The principle of this type of preservation process is the dissolving of some highly toxic chemical in some volatile, cheap solvent, and in some of the experiments work has been done with concentrations as low as three to five percent by weight, which makes the amount of chemical small.

The use of a preservative process of this nature is especially convenient because the preservative may be applied without pressure, thus cutting down on the cost of application. Another advantage of this means is that in
many of these preservatives there is no need for kiln drying of the stock before the preservative is applied. It might seem that woods treated with substances as volatile as those used to administer the toxic chemicals would be extremely inflammable, but in reality after the solvent has had time to evaporate, the inflammability of the wood is little higher than untreated wood. This type of wood treatment shows much promise in the field of wood preservation, and because of the ease of application to the material will probably gain in use in the next few years.

One of the most progressive organizations working with the oil-carried preservatives is the Western Pine Association in Portland, Oregon, in which Dr. Hubert is in charge of the chemical research. In the last two years especially, they have been doing much experimentation with this type of preservative for the protection of pine mill work in which there is a need for preservatives that maintain their toxicity and at the same time do not allow the wood to shrink or swell excessively with weather conditions. In this work, they have almost completely eliminated the water-carried preservatives in favor of this new kind.

One of the greatest difficulties yet encountered in this research is the determination of a chemical toxic to the six kinds of decay organisms and the ten kinds of stain organisms in the pine sash work, but the chemicals
used in the research carried on by the Western Pine Association have been placed in solutions mostly of petroleum oils of various kinds. These oils are colorless and do not stain the wood; they are very solvent to most of the wood-preserving chemicals; the ease with which these carriers pass into the wood makes it necessary to have only a short soaking process and also these oils do not swell the wood to a very great degree. Another point in favor of the petroleum oils is the fact that it is easy to evaporate them out of the wood after the chemicals have been satisfactorily impregnated.

**Pentachlorphenol**

The compound, pentachlorphenol, of the permatol series, is a good wood preservative, and at present prices runs about 18 to 20 cents a gallon. At this price, it costs about 9 cents for the chemical and labor to treat one sash, which is quite reasonable protection. This compound does not volatilize easily so has lasting qualities, and it may be painted over so is especially suitable for sash work and interior finish. After it is impregnated in the wood, it still remains soluble enough to kill the fungi, but is not soluble enough to leach out under ordinary conditions.

**Tetrachlorphenol.**

Tetrachlorphenol is a fairly cheap chemical preservative and gives good toxic action against decay in woods. A mixture of tetrachlorphenol in gas oil is about equal in
toxicity to creosote, and is a little cheaper. This compound is new in the field of wood preservation, and is clean, paintable, and quite resistant to leaching; it has a slightly stronger odor than pentachlorphenol, but otherwise is about the same.

**Dinitrochlorobenzene**

The compound, dinitrochlorobenzene, is a fairly cheap method of preserving wood, but as yet has not been used very much. Tests already conducted with it indicate that probably it is better as a clean treatment for wood than as an oil-mixed treatment.

**Beta Naphthol**

The treatment of wood that is used in automobile bodies and in window sash in certain localities has been practiced to a limited extent with the compound, beta naphthol, and fair results have been obtained. This compound is very soluble in volatile petroleum distillates, and hence, is easily applied to the wood with this substance as a carrier. Under certain conditions in use the treated wood turns slightly reddish in color, which may be a disadvantage in certain cases, but for general work this is not especially objectionable.

**Orthophenylphenol**

The use of orthophenylphenol as a wood preservative has been tried also, and results obtained very similar to those from beta naphthol. The compound is very much like
beta naphthol, and shows about the same promise. At present, the price is approximately the same for these two compounds.

**Naphthalene**

Experimentation has been carried on with naphthalene as a wood preservative, and this substance has been found to be inherently very toxic. It exists alone as a white solid crystalline hydrocarbon compound ($C_{10}H_8$), and is found naturally as a mineral. It is also obtained from coal-tar by a process of distillation. Naphthalene is produced by the action of intense heat on certain of the carbon compounds. It is not very soluble, but in certain gas solutions it becomes quite usable.

Other oil-soluble compounds have been experimented with in the field of wood preservation, but the aforementioned are the most important and have shown the most promise in this line.

**PROPRIETARY PRESERVATIVES**

In the last few years, especially, many preservatives have been sold under trade names of various kinds. Some of them are ordinary coal-tar creosote or coal-tar creosote that has been modified slightly by the removal of some of the solid fractions. Others have had the lighter fractions removed, giving them a higher boiling point than the ordinary run of creosote. In the main, preservatives thus made
from coal-tar creosote are good preservatives and may be used with assurance. Whether or not is is economical to do so depends upon their convenience and their cost as compared with coal-tar creosote, zinc chloride, or some other accepted preservative.

Other proprietary preservatives contain wood-tar products or other oils. Their value is not so well established, but no doubt some of them are quite effective.

In a group (3) are preservatives injected in water solutions. Whether or not these are good depends upon the material of which they are composed. A few, containing arsenic or sodium fluoride, appear to be giving promising results. Before buying a preservative of this kind the purchaser should insist upon knowing its ingredients and their proportions; important in the use of preservatives is a knowledge of what is in them, and by knowing this, often much unnecessary and sometimes even costly expense may be saved.

A fourth group of proprietary preservatives has been developed to provide a treatment that will not swell the wood or require long drying, but it will leave the wood clean, paintable, and odorless. Such preservatives have a considerable field of usefulness in the treatment of flooring, furniture, and millwork exposed to termite attack, window sash and frames, automobile woodwork, usually in the frame and body, and miscellaneous lumber for
various other purposes. The user of such preservatives should insist upon knowing the nature and amount of the effective chemicals in the mixture. The literature advertising some of the proprietary preservatives not infrequently contains extravagant claims as to their properties and their effectiveness. Obviously such claims should be greatly discounted. There are, however, a few proprietary preservatives for general use which have shown themselves to be quite satisfactory, and give promise in this field.

Wolman Salts

In the class of proprietary preservatives, Wolman Salts probably are the most important, and the use of this salt as a means of preserving wood is increasing all the time. The use of Wolman Salts has been carried on in Europe for about twenty-five years. A German chemist, Dr. Wolman, first worked with the preservative, and it was named for him. However, in America, the patent was not taken out until May 8, 1934; so the preservative is quite new in this country as compared to some of the other American methods of preservation.

About Wolman Salts as a wood preservative, the Forest Products Laboratory issued a bulletin in November, 1935, as follows:

"The term Wolman Salts, as used at the present time, includes two principal wood preservatives, Triolithy and Tanalith, developed and patented by Dr. K. H. Wolman of Germany. Triolith consists of sodium fluoride, sodium
chromate, and dinitrophenol, and the company controlling the use of Wolman Salts in the United States recommends this salt for decay prevention where protection against termites is not considered of primary importance. Tanalith, which the company recommends for protection against both decay and termites, contains a substantial quantity of sodium arsenate which is substituted for part of the sodium fluoride. The present formulas differ from those in use prior to 1932 in that the amount of sodium fluoride in each formula has been decreased and the amount of sodium chromate substantially increased, for the purpose of reducing the tendency to leach out of the wood when exposed to wet conditions. The change is considered by the company to be a definite improvement.

"Wolman salts are injected in water solution by the full-cell process. It is recommended by the company that the absorption should be not less than 3/10 of a pound of dry salt per cubic foot of wood for use outdoors or in wet places, and not less than 1/4 pound of dry salt for wood to be used in drier places, such as buildings. The company also recommends that the solution for any treatment should be of such strength that practically refusal treatment will be required to secure the specified absorption of dry salt. This is to insure the best possible penetration of the preservative.

"Accelerated tests are useful and give interesting information but they sometimes give contradictory or incomplete information that may be very misleading if the attempt is made to apply the result to commercial-sized material in actual service. The only sure test of the value of a preservative is the results it gives in actual use. A long time is required to accumulate enough data on any preservative to permit positive conclusions as to its value. Observations must be made on many different installations under different service conditions and on different forms of timber because the service life secured from any preservative will vary considerably as these factors vary. A few early failures of treated wood in service do not necessarily mean that the preservative is ineffective. It may have been applied improperly or in inadequate quantity or the conditions of service may have been abnormally severe. On the other hand, successful performance for a few years or in a few cases is not adequate evidence of high effectiveness. The results from a large number of installations must be considered together before the true picture is obtained. The accumulation of service data from Wolmanized timber in the United States is still far from sufficient to establish the degree of effectiveness to be expected from these salts. Efforts are constantly being made,
however, to accumulate service records on Wolmanized ma-
terial (as well as on material treated with other preser-
vatives) so that intelligent evaluation may be made as
soon as possible.

"There is no reason to believe that Wolman salts,
in the quantities ordinarily injected, make the wood sig-
nificantly fire resistant. Small quantities of even the
best known fireproofing chemicals have very little effect
in retarding fire. As with other inorganic salt preser-
vatives, however, such slight effect as Wolman salts may
have on inflammability is in the direction of decreasing,
rather than increasing it" (55)

An unbiased opinion as to the characteristics of this
preservative shows that it undoubtedly has qualities very
necessary to a good wood preservative and that it is quite
effective in this line.

The use of Wolman Salts is claimed to aid greatly in
the bringing back of the wood-type construction for garden
walls, stucco covered buildings, and the like, as would
any practicable wood preservative, instead of iron or steel
which gained prominence when untreated lumber in these sit-
uations gave way quickly because of decay, termites, etc.
The Wolmanized treatment is clean and non-bleeding, and is
especially useful in house construction. The danger spots
of houses valued between about $6000 and $16000 may be pro-
tected from decay and termites by the use of Wolmanized
lumber for a cost about equal to one percent of the value
of the house. This makes a very effective means of preser-
ving the wood and the cost is relatively cheap. This pre-
servative is also recommended to be used for sheathing
up to the window sills where the walls are watered fre-
quently, such as the wall behind a flower garden, etc.
The make-up of Wolman salts is a fluoride-phenol-chrome-arsenic combination, and individually these substances included in the salts have high toxicity ratings. The substances sodium fluoride and dinitro-phenol are about the highest in toxicity of common preservatives, and at high temperatures are quite soluble, although the solubility is low enough at low temperatures so the net solubility of the salts at ordinary temperature is between four and four-and-a-half percent. Also, the salts have a tendency to make the wood slow to absorb or give off moisture after impregnation with the salts is completed.

Wolman salts are claimed to be neither acid nor alkaline in action and neutral in the presence of iron and other metals commonly used as nails, etc., so the salts are not corrosive. Chromium salts in the compound prevents oxidation so the wood is preserved from weathering and keeps elastic like new wood.

A report by the Pittsburgh, Penn., Testing Laboratory in 1933 gives some of the results of an investigation made to determine the effectiveness of Wolman Salts against the attack of decay and termites. As regards decay, the laboratory was of the opinion that Wolman Salts, when properly used as a wood preservative treatment, will protect wood so treated by preventing or inhibiting decay. This conclusion of the laboratory was based upon the following:

"(a) The reliably reported successful use of Wolman
Salts in central Europe.

(b) The fact that no traces of decay were found in installations examined by us in the United States. These included installations up to eight years of age.

(c) The fact that decay of Wolmanized wood examined by us in the tropics has been almost negligible, installations up to nine years of age being examined.

(d) The finding of Wolman Salts in the heart as well as outer sections of specimens of Wolmanized wood, that had been in service for various periods of time up to nine years." (56)

Further investigation of the laboratory regarding the resistance against termites of the treated wood resulted in their concluding that the use of Tanalith properly is quite effective against attack by termites. This conclusion was based on the following:

"(a) The fact that no evidence of termite attack upon Wolmanized wood was found in the installations examined in the United States by us.

(b) The fact that we failed to find or learn of a single case of termite attack upon Wolmanized wood in the survey in central America, of the Standard Fruit and Steamship Company's properties. This company has used 35,000,000 feet of Wolmanized lumber there during the last nine years.
(c) The finding of Wolman salts by chemical analysis in all parts of specimens of Wolmanized wood taken after exposure to severe conditions in the tropics for various lengths of time up to nine years." (56) 

The use of Wolman salts in Germany is probably more widespread than in this country, because of the discovery of it there, and it is used in railroad ties, a use not yet much tried here. Wolmanized ties were used in Germany and Denmark as early as 1911, and have a good record there, but this treatment has not as yet enough time behind it in this country to give any very definite conclusions. There are, however, several railroads in this country employing Wolmanized timber for their construction.

Although Oregon state specifications for highway construction have always called for the use of creosoted timbers, several states have used Wolmanized lumber and timbers in their highway construction with apparently good results. Undoubtedly, if all claims are upheld by experience, the use of Wolman salts will increase even more in the next few years than it has in the last few.

Permatol

In answer to the demand for a suitable preservative for sash, door and millwork, the Western Pine Association in Portland, Oregon, conducted some experimental work, and from a list of twenty-five new compounds following a long series of tests in which new laboratory methods were
used, selected this new preservative, Permatol. There are three preservatives in this classification known as Permatol, and they have two outstanding properties: they have high toxic values and possess a high degree of permanence (represented in the experimental work by resistance to volatilization and to leaching by water) and are easy to handle and apply. The following are the Permatol formulas recommended for use on finished and semi-finished wood products:

**Permatol A**

- (1) Pentachlorphenol 5 lbs.
- (2) Pine oil or other solvents 1 gal.
- (3) Spreader 1 1/4 gal.
- (4) Penetrant 10 3/4 gal.

**Permatol B**

- (1) Pentachlorphenol 2 1/2 lbs.
- (la) Tetrachlorphenol 2 1/2 lbs.
- (2), (3), (4) same as in Permatol A

**Permatol C**

- (1) Tetrachlorphenol 5 lbs.
- (2), (3), (4) same as in Permatol A

The Western Pine Association, which contributed this information to the industry for use without royalty or license restrictions, recommend Permatol C for use in climates or situations where termites are a serious menace, since this toxic chemical has shown considerable
resistance to these insects in the International Termite Exposure Tests so far conducted by federal agencies.

This association has conducted some more recent tests and found three additional toxic chemicals which appear to qualify as sash preservatives. They say that two of these are still too costly to use commercially, but the third, 2-chlororthophenylphenol, has recently been reduced in price. It is also included in the Permatol series.

Permatol D
(1) 2-chlororthophenylphenol 5 lbs.
(2), (3), (4) same as in Permatol A (8)

Because of the ease of treating lumber with the Permatol preservatives, these will probably become more popular, although at present the bath treatment takes slightly longer soaking period, with not so much preliminary steaming and soaking. The total cost is cheaper by this method of treatment.

The company which has the Permatol "A" concentrate for sale is: A. D. Chapman and Co., Inc., 7 South Dearborn St., Chicago, Illinois. The Permatol "D" concentrate may be obtained from the Dow Chemical Co., Midland, Mich.

Osmose Preserving Agents

The Osmose Corporation of America produces three paste-form preservatives, which when applied to woods for preservatives are claimed to be highly toxic, permanent, deep penetrants, non-poisonous to man, non-leaching, and
leave the wood surface clean, odorless, and paintable. One of the advantages claimed for these preservatives is that they are as effective for old standing poles and structures as for green wood. The three products are:

- **Osmolit**, which preservative is recommended for general preservation needs, and for deep penetration into the wood. This compound consists of a solution of sodium fluoride, dinitrophenol, and gum arabic.

- **Osmotite**, which preservative has a strong fiber fixation point and is recommended for samples of high moisture content. The compound is the same as Osmolit with potassium bichromate added to reduce leaching.

- **Osmosar**, which is recommended for termite infested areas and has the same general characteristics as Osmotite, but has sodium arsenate added for termite resistance.

These preservatives have not been used extensively as yet, but undoubtedly have some good qualities desirable in a good wood preservative.

**Cheminite**

Cheminite is a fairly new preservative, as compared to some of the other substances, perfected by Dr. Gordon of Berkeley, California, and is primarily of copper sulphate \((\text{CuSO}_4)\). It is more resistant to leaching than ordinary copper sulphate preservatives because of the way it is made. It colors the wood greenish, and this may be
undesirable under certain conditions, but the surface of
the wood is smooth and odorless, and may be painted.

**Mineralized-cell treatment.**

While not especially advertised as a proprietary
preservative, the preservative used by the Mineralized
Cell Treating Co., of Portland, Oregon, is a toxic agent
in this classification. This treating fluid consists
of a mixture of copper, arsenic, and zinc salts, to which
are added certain precipitating agents which combine with
the sugars and acids of the wood to form solids in the cell
walls. In this type of treatment only the sapwood of the
poles is impregnated. This preservative is found to be
quite effective against many of the common fungi. (34)

**Z. M. A.**

The Z. M. A. compound has been worked out by the
Western Union Telegraph Co., as a preservative for treat-
ing poles by pressure treatment for their lines. It
is not recommended for marine work as it is most effect-
ive in reasonably dry situations. The compound, known
as zinc meta-arsenate, consists of about ninety-five per-
cent arsenic plus zinc oxide (ZnO), acetic acid, and wa-
ter, the latter two mentioned evaporating out after treat-
ment and the substance becomes solid, Zn(AsO₂)₂. This
preservative has given good results in a series of field
tests conducted by the Western Union, and is in use on
some of their lines.
Aczol

The preservative, Aczol, was the result of experimentation in Europe to find a suitable means of preserving wood, and consists of a solution of ammonia, copper, zinc, and phenol. It has been used successfully in solutions of a concentration of about 6% for dry work and concentrations of 10 to 12% for marine work. As yet, however, this process is not used much in this country.

Anaconda Wood Preservatives

The Anaconda Wood Preservatives are in two forms commercially, paste and dust. This is offered as a cheap preservative that may be used to treat poles and structures in place. Although soluble, the solubility of these substances is quite slow, and they will penetrate deeply, offering toxic resistance to decay. The preservative is composed of salts of arsenic, lead, zinc, and copper.

Ter-pa-fied Solution

The Lumber Processing Company manufactures a wood preservative that has passed the Bureau of Standards in Washington, D. C., which is claimed to be resistant to termites and fire. It has been used somewhat in the termite infested regions of California, Mexico, and Hawaii. One advantage is that wall board may be treated without reducing the insulating or sound deadening properties of the material, and the solution may be applied to the material to be treated by pressure, brushing, or spraying treatment. The company has a commercial lumber treating
plant at Richmond, California. It is claimed that the pressure-treated material is highly resistant to fire, dry rot, and insects, is permanently protected, is not very leachable, and is odorless. (39)

**Miscellaneous**

Two preservatives which are produced commercially for the prevention of stains in lumber but not so much for permanent protection against decay are Lignasin and Dowicide. These are recommended for the dipping treatment of freshly-cut lumber on the green chain for the prevention of blue stain, and are quite effective. Among the other various compounds or mixtures that have been used for preservative purposes, especially for the prevention of decay and stain, although not all produced commercially or even used much at present are formaldehyde, ammonium arsenous trioxide, copper oxychloride, amyl salicylate, butyl cresolate, butyl phenolate, and some more complex compounds such as some of the various mercury compounds produced by the Grasselli Chemicals Co., after a period of experimental work, and ethyl mercury chloride for sap-stain treatment in the south. The experimental work in this line resulted from the public demand for new-looking lumber, and was used especially in the air-dried pine lumber, but the good results obtained there gave the solution to many other stain problems in all parts of the industry. Competition now is making it an obligation
of the mill man rather than the user to treat the lumber so the buyers will be pleased with the product.

One method of preserving wood that has not as yet been mentioned because of the nature of the treatment is a new German method of wood petrification. This method consists of the impregnation of a stony substance in the cells of the wood which results in a wider range of use for the product. There is a weight increase in the wood of about 20%. The hardness of the wood is increased, and the wood remains constant during moisture changes. This process makes it possible to use green lumber prematurely in house construction. The woods may be colored to suit the taste by the addition of color pigment to the substance. In conjunction with this petrification process the chemical wood preservatives are added to the substance to prevent the attacks of fungi and termites, thus giving a hard construction material that is resistant to the common enemies of ordinary untreated wood.

Although many different types of preservatives in this class have been tried, there is still room for good preservative methods in the field, and although any new preservatives that are discovered will probably be similar in chemical constitution to some already in use, there is always the possibility that some entirely new and efficient compound will be found for this purpose.
METHODS OF APPLYING WOOD PRESERVATIVES

There are, in general, two classifications of the methods of treating woods with the preservatives. These are: (1) Pressure treatment and (2) Non-pressure treatment. These will be considered briefly under each of these classifications in that order.

PRESSURE TREATMENTS

In order for wood preservatives to be effective, they must penetrate well into the wood. Surface applications by brush, spray or dipping are not effective, because the penetration obtained is slight and the penetrated shell soon is broken through by subsequent checks or abrasions. The untreated wood beneath the surface then is exposed to decay or insect attack, and the prime reason for the treatment is defeated.

To overcome these defects of treatment, pressure processes for applying the preservatives are employed. This is the most effective method of treating wood with preservatives. There are a number of pressure processes, all of which employ the same general principle but differ in the details of application. The timber to be treated is loaded on tram cars which are run into a large steel cylinder. After the cylinder door is closed and bolted shut, preservative is admitted and pressure applied until the required absorption has been obtained.

The American Wood Preservers' Association has set up a certain standard treating practice to be followed
in treating the wood which insures the best type of treatment possible.

**Bethell Process**

In making treatments with the Bethell process, or full cell process—so called because the treatment leaves the cell cavities full of preservative—a preliminary vacuum is first applied to remove as much air as practicable from the wood cells. The preservative is then admitted without admitting air. After the cylinder is filled with preservative, pressure is applied until the required absorption is obtained. A final vacuum is commonly applied immediately after the cylinder has been emptied of preservative to free the charge of dripping preservative.

When the timber is given a preliminary steaming and vacuum treatment the preservative is admitted at the end of the vacuum period following steaming. In case the charge has received a preliminary treatment by the Boulton or boiling-under-vacuum process the unfilled space at the top of the cylinder is filled with preservative and pressure is applied as soon as this conditioning process has been completed.

Generally, the treatments recommended for various types of construction are as follows:

a. Marine construction.

   1. Piling—a minimum of 12 pounds creosote per cubic foot, full-cell treatment. (For semitropical and tropical waters, 14 and 16 lbs.)
2. Lumber in contact with sea water, a minimum of 12 pounds creosote per cubic foot, full-cell treatment.

3. Other lumber—if less than 5" in thickness, ten pounds creosote, empty-cell treatment; if over 5" in thickness, 8 pounds creosote empty-cell treatment.

b. Inland Construction.

1. Piling—a minimum of 8 pounds creosote per cubic foot, empty-cell treatment.

2. Lumber (as a3 above)

3. Ties—a minimum of 8 pounds, 45% creosote and 55% petroleum mixture per cubic foot, empty-cell process.

4. Poles (telephone and power transmission)

   8 pounds creosote per cubic foot, empty-cell treatment.

For zinc chloride:

Lumber

1. Zinc chloride, minimum 1 pound dry salt per cubic foot.

2. Chromated Zinc Chloride, minimum 3/4 pound dry salt per cubic foot.

It is impossible to remove all of the air from the wood cells regardless of the method of treatment employed. For this reason even under the most favorable conditions, there is some unfilled air space in the cell cavities of
the treated wood after impregnation by the so-called "full-cell" process.

The Bethell process was patented in 1838, and has been the most important method to date of treating wood with creosote, although the same general method is used to treat woods with certain inorganic salts, etc. It is one of the most effective methods of impregnating wood with solution, and if properly used, deep penetration may be obtained. While not exactly like the Bethell process, much the same method is used in the application of Wolman salts.

**Burnett Process**

The Burnett process of preserving wood follows the same procedure as does the Bethell process, but the chemical preservative used in it is zinc chloride. It has been used extensively in the industry and is quite effective. This is also a full-cell process of treating wood with preservative. In either of these two processes, or in almost any treating process the wood may or may not be fabricated before treatment with preservatives, and in some types of heavy timbers it is recommended that the timbers be incised before treatment. The process of incising consists of running the timbers through a machine which separates the fibers in the outer layers of wood so the preservative may penetrate more deeply into the wood in a shorter time. (See figure on next page).
Fig. 2. Machine for incising sawn railroad ties and construction timbers.
Fig. 3. Eagle Harbor Plant of the West Coast Wood Preserving Company

Fig. 4. West Seattle Plant of the West Coast Wood Preserving Company
Fig. 5. Front view of the 6-cylinder treating equipment of the Eagle Harbor plant of the West Coast Wood Preserving Company, showing transfer table for charging retorts in the foreground. Retorts are 7½ feet in diameter by 132 ft. long.

Boulton Process

The original process for seasoning or conditioning timber by boiling in creosote, under vacuum, is known as the Boulton process, and was patented by S. B. Boulton in England in 1879, and in the United States in 1881. This method or some modification of it is now commonly used in conditioning green Douglas fir for treatment and to an increasing extent for certain other species, such as red oak, etc.

This process speeds up the conditioning period necessary before treating the wood by some approved pressure process, and is essentially as follows: The treating
cylinder is filled with hot preservative oil so that all timbers are covered. The oil is then kept heated while the vacuum is applied. The oil serves to keep the wood hot while the vacuum lowers the boiling point of the water in the wood and causes part of it to evaporate. The evaporated moisture and some of the accompanying vapors from the oil pass through a condenser and the rate of accompanying vapors from the oil pass through a condenser and the rate of accumulation of condensed moisture is a measure of the progress of the conditioning treatment.

Temperatures used in this process vary from 180° to 240° F, depending on the nature of the product to be treated. Generally a low vacuum is used at the start of the process and gradually increased as the moisture evaporation progresses but some plants apply the vacuum as rapidly as possible.

When an empty-cell treatment is specified the cylinder is emptied of preservative after the conditioning period and air at atmospheric pressure or higher is admitted as desired. The preservative treatment is then applied as for air-seasoned material. In treating by the full-cell process, the cylinder is filled after the conditioning is completed and pressure is applied at once. Some preservative is absorbed during the conditioning period, depending on the kind of timber treated, amount of sapwood and heartwood, and other variables.
Although the Boulton process or a modification of it has been employed on the Pacific coast for a long time, it is only within recent years that the process has begun to be used in other parts of the United States for species other than Douglas fir. Unseasoned red oak, which is severely checked by the steam-and-vacuum treatment, has shown but little checking when conditioned by the Boulton method and the results thus far obtained from the treated wood in service appear to be very satisfactory. Green beech and Southern yellow pine have also been treated by the Boulton process.

**Lowry Process**

The Lowry process, which is of the empty-cell-process type, is a fairly common method of treating wood by pressure. The empty-cell process consists of forcing preservative into the wood cells when they are filled with air. When the preservative pressure is released, the confined air, which is under pressure, drives out part of the preservative absorbed during treatment, leaving a lower net absorption than would be obtained with the full-cell process. Good treatment depends very largely on the depth of penetration and the latter is, in a general way, proportional to the gross absorption. The cells of treated wood are necessarily partly filled with preservative after treatment by the so-called "empty-cell process". The difference between full-cell and empty-cell wood
treatment, therefore, is merely a difference in the degree to which the cell cavities are left filled after the treatment is completed.

In the Lowry process, sometimes called the "empty-cell-process without initial air", the preservative is admitted to the treating cylinder at atmospheric pressure. Then the cylinder is filled, pressure is applied and the preservative is forced into the wood against the air originally in the cell cavities. After the required absorption is completed, pressure is released and the air under pressure in the wood forces out part of the preservative absorbed during the pressure period. This makes it possible, with a limited net retention, to inject a greater amount of preservative into the wood and obtain deeper penetration than with the full-cell process. The Lowry process is convenient to use in any pressure-treating plant, since no additional equipment is required.

**Rueping Process**

The principal difference between the Lowry empty-cell process and the Rueping process is that the latter employs air pressure above atmospheric. In the Rueping process, air is forced into the treating cylinder before the preservative is admitted. The air pressure is then maintained while the cylinder is filled with preservative, thus leaving the wood cells more or less impregnated with air under pressure. In resistant woods this air pressure
may penetrate only a short distance from the surface, while in wood that is fairly pervious to the penetration of air and liquids, such as the sapwood of many species, an air pressure is built up in all of the penetrable portion. In the application of this process the preservative is usually admitted from an equalizing tank (Rueping tank) and the air in the treating cylinder interchanges with the preservative in this tank. In some plants not equipped with a Rueping tank the preservative is pumped into the treating cylinder against the air pressure and sufficient air is released during the filling period to keep the pressure constant. Impregnation of the wood is obtained by applying a preservative pressure sufficiently high to force preservative into the timber against the initial air pressure in the wood cells. This process is also called the "empty-cell process with initial air."

**Boucherie Process**

The Boucherie process of treating timbers was developed in France about 1840 for use in treating fresh round poles with water-borne toxic inorganic salts. Only freshly cut poles or piles can be treated by this system, because it depends for its impregnation upon the ability of the preservative to travel through the sapwood of the pole. By the original system of treatment, poles treated by the Boucherie process had been limited to conditions of exposure not in contact with fresh running or marine waters; however, new developments have made it possible to treat
the wood better so more universal use of the product may be obtained. The treating operation of the original process consisted essentially of the following steps:

a. The poles or piles with the bark intact were placed horizontally on skids. The butts were then capped with a sealed fitting.

b. The caps were connected by hose to an elevated tank containing the water-borne preservative or a low pressure pump. The static head of the elevated tank, or the pump at low pressure, slowly forced the preservative through the timber from the large end to the small end or to a predetermined point.

c. The poles after treatment were peeled, trimmed, and properly air seasoned before being used. As the treatment only penetrated the sapwood, carefully-controlled air seasoning was necessary in order to avoid excessive checking through the penetrated zone. Such checking would expose the untreated interior to wood-destroying organisms.

Although the Boucherie process was quite effective for certain conditions, unless the wood to be treated was of straight grain and few defects there was always the possibility of some parts of the wood remaining untreated. A recently-introduced process in the Pacific Coast states is much the same as the Boucherie process in plan
and mechanical application, but it is supposed to be more effective because of better methods of handling the material and the higher pressures obtained.

Fig. 6. Scene at the government Boucherie treating plant at Soro, Denmark. The preservative solution is conducted from the tank in the high tower through the small header pipe shown parallel to the ground in Fig. 7 (next page) and distributed through rubber hose pipes to the chambers at the butt ends of the poles formed by the wooden blocks and packing as shown in Fig. 8 (next page). The pressure caused by the height of the solution tank forces the preservative through the poles lengthwise, and treatment of the entire sapwood is complete in 10 to 12 days. (Courtesy 1927 Proceedings, American Wood-Preservers' Association, from material presented by the West Coast Wood Preserving Company, Seattle, Wn.)
Mineralized Cell Treating Process

The Mineralized cell treating process was devised by the Mineralized Cell Wood Preserving Co., of Portland, Oregon, and is quite similar to the Boucherie process. This process impregnates the sapwood of the pole or piling with a toxic agent, introduced by pressure from the butt end, through a rubber cap tightly fitted to the pole. The chemical is forced into the wood at a pressure of from
twelve to fifteen pounds per square inch. For this process, green timber is preferred, since the cell walls of the sapwood are still in a live condition and the penetration of the toxic agent is rapid. Also in the preservative are precipitating agents which combine with the sugars and acids of the wood to form solids in the cell walls.

This process requires no heavy permanent plant equipment, according to the company. They have a portable apparatus, with the tanks and mixing facilities all mounted on a motor truck chassis. A steam plant for supplying hot water for mixing chemicals is also carried on the truck. All the piping, tubing and caps are stored in lockers on the truck when not in use. The truck chassis carries copper storage tanks which hold the treating fluid. A small air compressor is used to maintain pressure on the tanks. The caps are of rubber, and by this method, much like the old Boucherie process, full penetration of sapwood in straight timbers may be obtained.

Considerable interest in the process is being shown by representatives of public service companies, engineers, and building contractors. (34)

Fig. 9, on next page, shows the portable treating plant of the Mineralized Cell Treating Co., used in a demonstration of the process at Portland, Oregon.
Fig. 9. (Main distribution line is suspended overhead, from which taps are run to each individual pole.

Hasselmann Treatment

The Hasselmann process of treating wood is of German origin, and by a pressure boiling process it administers the preservative (as originally used it consisted of copper sulphate, iron sulphate, aluminum sulphate, and kainit, all in solution) to the timbers. Scotch pine, spruce, and fir used in wet work, such as in mine shafts, have long service when treated by this method. The method tried to overcome the leachability of the usual salt preservatives by pressure treatment. (16)
Ferrell Process

The Ferrell process is of American origin, and it injects salts of various kinds into the wood through the ends by pressure treatments. By two treatments it causes the union of salts within the wood, thus forming insoluble compounds. The method, however, is quite costly, because the material has to be treated twice, and also because each piece must be handled individually for each treatment. (16)

A. C. W. Process

In this process, the wood is placed in a tank and steamed for periods varying according to the size and type of material to be treated. It is then creosoted with an air pressure of approximately 15 pounds per square inch, which escapes out the top of the tank as the creosote is injected. When the tank is full of creosote, the pressure is run up to about 100 pounds per square inch, after which the creosote is removed. When the creosote has drained sufficiently, the air pressure is again run up to about 60 or 70 pounds per square inch to drive the oil into the wood to greater depth and to secure the desired uniformity of treatment.

The Creo-resinate Process

The creo-resinate process is quite similar to the Bethell process of treating wood, except that it uses dry heat rather than steam for heating. In this process,
50 to 75% creosote in a creosote-resin mixture is applied to the wood for preservative. So far this process has been used exclusively for paving blocks.

**The Wellhouse Process**

This process is designed to counteract the solubility of zinc chloride. It consists of a 1/2% solution of glue and zinc chloride treated to the wood after which tannin is forced into the wood as a separate treatment. In the wood the tannin and glue form "leatheroid" to keep out the moisture and the zinc chloride acts against fungi and termites. This process, because of the double treatment, is necessarily quite costly.

**Allardyce Process**

This is another process designed to do away with the solubility of the zinc chloride. It combines zinc chloride and creosote, which also helps cut down the cost of the creosote. It also is a double process, in which the zinc chloride is applied to the wood in a 2 or 3% solution by a process similar to the Burnett process, followed by a creosote treatment in which the creosote primarily remains on the outside to protect the zinc chloride from leaching.

**Card Process**

In the Card process the zinc chloride and creosote are combined in one treatment consisting of 15 to 20% of creosote and the remainder a 3 to 5% solution of zinc.
chloride. First the timber is steamed and a vacuum drawn. The preservative mixture is then run into the pressure tank and the treatment carried on in the ordinary manner. Because of the difficulty of keeping zinc chloride and creosote evenly mixed in solution, the two elements of the process are kept in a mechanical mixture with a centrifugal pump; so the wood is treated with the right proportions of each.

NON-PRESSURE TREATMENTS

Because of the nature of wood and the preservatives used, it is impossible to obtain as efficient protection of the wood from decay and termites by non-pressure methods. However, in certain situations this type of treatment may be sufficiently effective to preserve the wood. In some of the newer solvent-borne preservatives it is possible to obtain fair penetration by dipping, and in the future there will probably be more use made of the method because of the lower cost of treating equipment necessary.

Hot-and-cold-bath Treatment

In this method probably almost as good penetration may be obtained as with a pressure treatment in sap pine, but in some woods it is not quite as good. The wood is heated in an open tank of preservative for several hours and then it is cooled, either in the same vat or is placed in a vat of cold preservative. The preliminary heating drives out the air; the cooling draws in the preservative.
Steeping Process (Kyanizing)

The steeping process is probably next to the one just mentioned in effectiveness. The seasoned timber is soaked in a cold solution of water-soluble salt, generally for a period of one day for each inch of thickness. The original process of Kyanizing, patented in 1832 by John Kyan, was like this; the solution used was of corrosive sublimate or mercuric chloride. Some other processes in this class have used zinc chloride solution and also sodium fluoride.

Oven Process

This process is quite similar to the hot-and-cold-bath treatment except that the wood is first heated in an oven or kiln and then immersed in the cold preservative. In case the preservative is metal-corroding, wooden vats are used for dipping tanks.

Empty-cell Non-pressure Process

This method depends for the pressure to force the preservative out of the cell cavities on changes in temperature of the various relative levels in from the outside of the piece to the center. It is not used very extensively at present.

Senilization Process

This process is of French origin, and the impregnation is done by electrodes in solutions of creo-resinate of soda after which magnesium sulphate is used. Although not used very much at present, the cost of this process is small. (16)
Emulsion Treatment

In this treatment, which is an open-bath treatment, resin is dissolved in tar oil and a strong solution of soda lye or sodium hydroxide is added. It is not used very extensively. (16)

Miscellaneous Methods

Among the other methods of non-pressure treatments used today are simple dipping treatments, brush treatments, spray treatments, and painting treatments. These methods are necessarily much less effective than pressure treatments, but are used for certain types of preservation.

Low-pressure Process

Although this is actually a combination of pressure and non-pressure treatments, it will be considered here because of the nature of the process. It was designed by the Forest Service to combine the advantages of the two types mentioned. The first part consists of a hot bath for some time to drive out the air. Next the timber is immersed in a cold bath, but a moderate pressure is applied to speed up the absorption of the preservative by the wood. This is a fairly cheap, simple, and efficient method, not involving the costly equipment needed to apply higher pressures to the wood.

Forest Service Inner Tube Treatment

This method of treating posts and small timbers was originated by the Forest Service for the purpose of giving
a cheap preservative method to farmers and other users of these items who desire to treat only a few and may be some distance from a commercial preserving plant. It consists of placing a cap of old inner tube about the top of the post, which is placed at an angle of about 45° from the vertical, into which is placed the preservative to be used. This is allowed to soak down through the cells of the wood to the other end. This is a cheap method of applying the preservative, and although it takes longer than the pressure processes, it is quite suitable for situations present on farms, etc. It is a much better method of treating if used on wood before it is fully seasoned because of the ease with which the preservative travels through the wet cells as compared to the dry ones.

**SOME USES OF CHEMICALLY-PRESERVED WOOD AND THE FUTURE OF THE INDUSTRY**

In all fields of construction work there is opportunity to use wood, and when suitably preserved to prevent the attacks of fungi, borers, and termites, it can compare favorably with any other construction material.

Creosoted woods find use in heavy dock construction, highway bridges, railroad bridges, cross ties, poles, foundation piling, highway guard rail posts, wood-stave pipe and tanks, culverts, water flumes, mine timbers, and house foundation work. The salt treatments and new
oil-borne preservatives are sometimes used in many of the aforementioned uses, but because of their cleanliness, paintability and lack of odor, they are also used in interior finish work, floors, factory roofs, furniture, and many others. In fact, there are few places where wood is used as a construction material where it is not improved by being treated with some suitable preservative, and as time goes on there will probably be more and more preserved wood used in construction work.

As was previously mentioned, the surface of the wood-preserving industry has just barely been scratched. Although there have been many quite suitable wood preservatives worked out to meet the present day demands, there is still opportunity for new developments in treating practices and substances. There is a demand at present for a preservative work which is fire retardant, and experimental work is being done on this now. New methods of treatment are being developed to make the product cheaper to the user as the demand for preserved lumber increases, and new preservatives—some good and some bad—are being developed to meet the demand of this rapidly-growing industry.


54. West Coast Lumberman. Wolman Salts Gaining Favor as a Wood Preservative. Dec. 1935


58. Also literature and bulletins furnished through the courtesy of the following:
   b. Crossett-Western Company 
      Wauna, Oregon and Portland, Oregon.
   c. Canada Creosoting Company, Limited. 
      North Vancouver, Canada.
d. E. I. DuPont de Nemours and Company.
    Wilmington, Delaware.

e. Eppinger and Russell Company.
    New York City, New York.

    Rockford, Illinois.

g. Forest Products Laboratory.
    Madison, Wisconsin. (By Ernest Bateman)

h. West Coast Wood Preserving Company.
    Seattle, Washington.

i. Wood Preserving Corporation.
    Pittsburgh, Pa.