UNIVERSITY OF TORONTO

THE PRESERVATION

OF

STRUCTURAL TIMBER

McGraw-Hill Book Company

Electrical World The Engineering and Mining Journal

Engineering Record Engineering News

Railway Age Gazette American Machinist

THE PRESERVATION

OF

STRUCTURAL TIMBER

BY

HOWARD F. WEISS

DIBECTOR, FOREST PRODUCTS LABORATORY, U. 8. FOREST SERVICE

HONORARY MEMBER, AMERICAN WOOD PRESERVERS' ASSOCIATION

SECOND EDITION

REVISED AND ENLARGED

McGRAW-HILL BOOK COMPANY, INC. 239 WEST 39TH STREET. NEW YORK

LONDON: HILL PUBLISHING CO., LTD. 6 & 8 BOUVERIE ST., E. C. 1916

COPYRIGHT, 1914, 1916, BY THE

MCGRAW-HILL BOOK COMPANY, INC. 799095

TttE MAPI, K I K K H S YORK PA

FATHER AND MOTHER

THIS BOOK IS AFFECTIONATELY DEDICATED

PREFACE TO SECOND EDITION

In revising this book, much new data on the durability of treated and untreated timber have been added. Recent progress in the art of rendering wood fire-resistant has also enabled the author to strengthen the information on this subject. The author wishes to thank Miss Eloise Gerry, Mr. George B. Hunt and Mr. Clyde H. Teesdale for valuable suggestions in revising the text.

H. F. W.

MADISON, WISCONSIN,

February 1, 1916.

PREFACE TO FIRST EDITION The wood-preservation industry is one of those which is aid- ing in the great movement for efficiency in operation and in the conservation of our natural resources. Practically unknown in our country but a half century ago, its growth, especially in the last decade, has been exceedingly rapid until there are now nearly 100 plants in operation turning out over 125,000,000 cubic feet of treated wood annually. Too much credit for this splendid development cannot be given to men who like Dr. Hermann von Schrenk have by their ability, knowledge, and persistence brought the importance of preserving wood to the attention of the American people and successfully accomplished a mass of practical results. There is every reason to believe that the growth of the industry has by no means reached its climax, for there are thousands of feet of structural timber used each year that are not being treated but which should and eventually will be. In an industry which has grown so rapidly and is unique in that a long time must elapse before the efficiency of many of its processes are known, it is but natural that many perplexing problems should arise. The wood preservation industry certainly has its just share of them, and although splendid progress has been made, much yet remains to be learned; in fact, accurate knowledge is just in its infancy. The whole art is permeated with contradictory evidence and opinions so that it is exceedingly difficult for the layman seeking advice to become other than confused. During the past nine years it has been my good fortune to be thrown in personal contact with many of these problems and to study them over our entire country. While so doing, the need for a book on the subject has been repeatedly called to my attention, for while there are excellent works on given phases of wood preservation, none apparently systematically covers the subject in its broad aspect. It has been necessary to consult a large number of separate publications to secure such data a process most tedious and unsatisfactory in this day of straight-line operation. Furthermore, it is thought a textbook on timber preservation will be of help to students in forestry and engineering schools, where a knowledge of wood utilization is desirable and often necessary.

In the following pages, taken largely from lecture notes prepared by the author for the civil engineering students at the University of Wisconsin, it has been the aim to present reliable information of fundamental importance. It is hoped that they will be found of value and use to engineers, foresters, lumbermen, students and all those interested in this subject and that this effort may assist in raising still higher the enviable position already held by the wood-preserving industry.

The author certainly wishes to acknowledge his indebtedness to the U. S. Forest Service, from the publications and illustrations of which he has very heavily drawn; to his friends engaged in commercially treating timber, especially Mr. F. J. Angier, Mr. Carl G. Crawford, and Mr. J. B. Card, whose generous assistance has added much to this book; and to various associations and societies from whose proceedings data have been taken.

H. F. W.

MADISON, WISCONSIN,

October 1, 1914.

CONTENTS

PAGE

CHAPTER I

INTRODUCTION 1

Definition of wood preservation Importance of wood preservation as an American industry Present standing of the wood preserving industry in the United States Conserving our timber supply Effect of wood preservation on forest management History of wood preservation in Egypt, Europe, United States.

CHAPTER II

FACTORS WHICH CAUSE THE DETERIORATION OF STRUCTURAL TIMBER.

Discussion of their relative importance Decay Insects The pole borer Marine borers Xylotrya, Nausitoria and Teredo The Phola Mechanical abrasion Fire Minor factors Alkaline soils Birds Sap stain.

CHAPTER III

THE EFFECT OF THE STRUCTURE OF WOOD UPON ITS INJECTION WITH PRESERVATIVES Effect of density upon absorption Absorption by the cell walls The effect of sapwood and heartwood upon injection The effect of summerwood and springwood upon injection The effect of vessels or "pores" on the treatment of wood The effect of tyloses on the treatment of wood The effect of resin ducts on the treatment of wood The effect of pits upon injection The effect of cell slits upon penetration The effect of the chemical composition of the cell wall upon absorption.

CHAPTER IV

THE PREPARATION OF TIMBER FOR ITS PRESERVATIVE TREATMENT .

The cutting season Peeling timber Seasoning timber Open-air seasoning Hot-air seasoning Seasoning in saturated steam Seasoning in superheated steam Seasoning in oil Soaking timber in water preparatory to seasoning it.

CHAPTER V

PROCESSES USED IN PROTECTING WOOD FROM DECAY

Superficial processes Charring Brush treatments Dipping Impregnation processes Non-pressure processes Kyanizing process Open-tank processes Seeley process Giussani process Pressure processes Bethell (Full-cell Creosote) process Boiling process Buehler process A. C. W. process Lowry process Rueping process Burnett process Rutgers process Card process Wellhouse process Allardyce process.

CHAPTER VI

PRESERVATIVES USED IN PROTECTING WOOD FROM DECAY

Properties of efficient preservatives Water-soluble preservatives Copper sulphate Mercuric chloride Sodium fluoride Zinc chloride Crude oils Creosotes Coal-tar creosote Water-gas- tar creosote Wood-tar creosote Mixed coal-tar creosotes Source of tars Distillation of creosote from tars Paints and stains.

CHAPTER VII

THE CONSTRUCTION AND OPERATION OF WOOD PRESERVING PLANTS.

Open-tank plants Pressure plants The retort house Retorts (cylinders) Retort thermometer Retort gauges Anchors and "turtles" Retort coils Guard rails Retort doors Retort lag- ging The pump house or room The machine shop or room The boiler house Yard Loading dock Methods of transferring material in the yard Cylinder cars Measuring, mixing, working, and storage tanks Gauges and scales Piping Shower baths Inspector's laboratory Fire protection Lighting equipment Sawmill and block equipment Tie boring and adzing machines The operation of pressure plants The effect of the vacuum The effect of air pressure The effect of pressure on the preservative Some common errors and difficulties in operating pressure plants Difficulty of measuring volume of charge Expansion of creosote Expansion of cylinder Compression of the oil and wood "Kickback " of preservative Expansion of wood Extent of possible errors Purity of the preservative Pollution of streams Inspection of treatments Cost of pressure plants.

CHAPTER VIII

PROLONGING THE LIFE OF CROSS TIES FROM DECAY AND ABRASION.

Selection of species Hewed versus sawed ties Bearing afforded tie-plates and rails Uniformity in volume Waste of material Form of cross-ties Stacking ties for seasoning Grouping ties to secure uniform treatment Species of wood Proportion of sapwood Moisture content Cutting season Conditions of growth Protection from abrasion Tie-plates Spikes Adzing and boring ties The selection of processes for treating ties Cost of treating ties Economy in treating ties Need for test tracks.

CHAPTER IX

PROLONGING THE LIFE OF POLES AND CROSS ARMS FROM DECAY AND INSECTS Poles Selection of species Manufacture of poles Methods of seasoning Methods of treatment and their selection setting in crushed stone or concrete Charring Brush treatments Open tank butt treatments Entire impregnation Boucherie process Kyan process Re-enforcing decayed poles Cost of treatment Economy of treatment. Crosss Arms Selection of species The manufacture of cross arms Methods of seasoning Methods of treatment and their selection Cost of treatment Economy of treatment.

CHAPTER X

PROLONGING THE LIFE OF FENCE POSTS FROM DECAY

Selection of species Method and time of cutting posts Method of seasoning Methods of treatment and their selection Setting posts in stones Setting posts upside down Charring the butt Dipping in crude oil and charring Diagonal holes filled with preservative Brush treatments Dipping treatments Impregnation treatments Pitch streaks Cost of treatment Economy of treatment.

CHAPTER XI

PROLONGING THE LIFE OF PILING AND BOATS FROM DECAY AND MARINE

BORERS Selection of species The manufacture of piling Methods of seasoning Methods of treatment and their selection Bark left on piles Plank coating Nail coating Metal coating Burlap coatings Cement casings Electrolysis Impregnation with coal-tar creosote Cost of treating piling Economy of treatments The preservative treatment of wooden boats.

CHAPTER XII

PROLONGING THE LIFE OF MINE TIMBERS Selection of species The manufacture of mine timbers Methods of seasoning Methods of treatment and their selection, mine ties, mine props, square sets, lagging The treatment of mine timbers in relation to fire Cost of treatments Economy of treatments.

CHAPTER XIII

PROLONGING THE LIFE OP PAVING BLOCKS Progress of wood paving Selection of species The manufacture of paving blocks Methods of treatment Troubles experienced with wood block paving Slipperiness Exudation of oil Expansion of the blocks Method of laying wood blocks Cost of treatment Advantages of wood block pavements Wood blocks for barns, factories, etc.

CHAPTER XIV

PROLONGING THE LIFE OF SHINGLES Selection of species Methods of treating shingles, against decay, against fire Cost of treating shingles.

CHAPTER XV

PROLONGING THE LIFE OF LUMBER AND LOGS Methods of treating lumber for rough construction Methods of treating lumber for buildings, greenhouses and cars Methods of preserving logs from decay Methods of treating log cabins and rustic furniture.

CHAPTER XVI

THE PROTECTION OF TIMBER FROM FIRE The theory of rendering wood fire retardant Superficial processes Impregnation processes Chemicals used Commercial treatment Tests to determine the inflammability of timber: shaving test, crib test, spot test, electric furnace Cost of rendering wood non-combustible The effect of zinc chloride and creosote on the inflammability of wood.

CHAPTER XVII

THE PROTECTION OF WOOD FROM MINOR DESTRUCTIVE AGENTS . Alkaline soils Birds Sap stain Sand storms.

CHAPTER XVIII

THE STRENGTH AND ELECTROLYSIS OF TREATED TIMBER The effect of air seasoning on the strength of wood The effect of steaming on the strength of wood The effect of boiling wood in creosote upon its strength The effect of preservatives on the strength of wood, creosote, zinc chloride, crude oil The effect of temperature on the strength of wood The effect of pressure on the strength of wood The effect of various treatments on the strength of wood The electrical resistance of wood treated with creosote and zinc chloride.

CHAPTER XIX

THE USE OP SUBSTITUTES FOR TREATED TIMBER Substitutes for wood ties Substitutes for wood poles Substitutes for wood piling Substitutes for wood posts Substitutes for wood mine timbers Substitutes for wood bridges Substitutes for wood in buildings and cars Substitutes for wood shingles Substitutes for wood conduits and pipes.

CHAPTER XX

APPENDICES

Minor wood preserving processes Thilmany process, B-M process, Goltra process, Hasselmann process, Creo-resinate process Robbins process, Powell process, Creoaire process, Vulcanizing process, Cresol-calcium process.Patented, proprietary, and minor wood preservatives used in the United States Cresol calcium, S. P. F. Carbolineum, Avenarius Carbolineum, C. A. Wood Preserver, Timberasphalt, Preservol, Copperized oil, sodium silicate, Spirittine, B. M. Preservative, water-gas-tar creosote, Holzhelfer, wood creosote, sodium fluoride, Aczol, Sapwood Antiseptic, N. S. Special, Imperial Wood Preservative, Kreodone, Locustine, Creoline. List of manufacturers of zinc chloride in the United States List of manufacturers of creosote in the United States List of wood preserving plants in the United States List of fireproofing plants

in the United States The amount of wood preservatives used in the United States The amount of timber treated in the United States List of companies in the United States equipped to build wood-preserving plants Specifications for the analysis of creosote adopted by, the American Railway Engineering Association, the National Electric Light Association, the United States Forest Service Method for determining the amount of moisture in creosote and creosoted wood The durability of American timbers List of U. S. patents in wood preservation Method of analyzing zinc chloride Records on the life of timbers, mine timbers, paving blocks, poles, cross-ties Treated wood block for factory flooring and miscellaneous uses Strength of cross-ties The Davis spot test Toxicity to fungi of certain of the more important preservatives Investigation of the relative inflammability of untreated and treated siding and shingles Investigation of the relative inflammability of unpainted and painted shingles and siding.

INDEX.

LIST OF PLATES

Frontispiece. Wood Preservation Section of the Forest Products Laboratory maintained by the U. S. Forest Service in co-operation with the University of Wisconsin, Madison, Wis Frontis.

8-9

Fig. A. A stand of young lodgepole pine in Idaho.

Fig. B. Egyptian coffin dating from the XII dynasty (2000-1788

B. C.). The only restorations are three cleats on the bottom of the

coffin, otherwise it is in almost perfect preservation.

Fig. C. Lentinus lepideus.

Fig. D. Lenizites sepiaria.

PLATE II 18-19

Fig. A. A red oak tie attacked by a wood destroying fungus (Stereum fasciatum, Schw.).

Fig. B. (1) The pole borer: male and female beetles. (2) Young larvae.

Fig. C. Gallery of the pole borer.

Fig. D. Mines of the pole borer near the surface of the ground.

PLATE III

Fig. A. Cedar ties badly damaged by rail cutting. Upper section shows tie without plate, lower section shows tie plate was too small. Fig. B. Poles destroyed by a sleet storm in Maryland, 1904. Fig. C. Results of a fire at the Arlington Manufacturing Company's mill, Arlington, N. J. In rebuilding, wood beams were used throughout.

PLATE IV

Fig. A. Longleaf pine boards piled solidly after one month's exposure to sap stain fungi. Boards on left, untreated; boards on right dipped in a weak solution of mercuric chloride. Note absence of stain.

Fig. B. Cross section through red oak a "ring porous" wood.

Fig. C. Cross-section through beech a "diffuse porous" wood.

Note pores scattered through entire width of annual ring. X50.

Fig. D. Cross-section through spruce a "non-porous" wood.

Note absence of pores. Larger openings are "resin ducts." X50.

Fig. E. Cross-section through Black Jack oak. Note pores clogged with "Tyloses." Compare with red oak.

Fig. F. Radial section through pine. Note bordered pits or "eyes," also how fibers fit into one another. Vertical cells on extreme left are medullary or "pith ray" cells. XI 50.

THE PRESERVATION OF STRUCTURAL TIMBER

CHAPTER I

INTRODUCTION Definition of Wood Preservation. Wood preservation may be defined as the art of protecting structural timber from decay. This is the common acceptance of the term. When considered in its broadest aspect, however, it includes much more than this, since decay is but one factor causing the destruction of wood. It is in its broadest sense that the subject is discussed in this treatise, because it is believed that the practice of protecting from deterioration will broaden as wood increases in value. In order to adequately treat the subject, wood preservation will be defined as the art of protecting structural timber from deterioration by destructive agents. The more common of these are decay, insects, marine borers, mechanical abrasion, and fire. It should be noted that the definition does not include the protection of trees, as the methods of doing this are entirely distinct from those practised in protecting wood cut from the trees after they have been felled. This distinction should be kept clearly in mind. Importance of Wood Preservation as an American Industry. In an undeveloped country destined for civilization, extensive forests are an obstruction which must be removed, because they occupy land needed for agriculture. As long as a country is heavily timbered, conservative methods of utilizing the timber will rarely be practised. This condition prevailed in the United States during its early history but exists no longer. Scientific methods of managing forests as well as efficient methods of utilizing the timber cut from them, are now being practised. Both, however, are still in their infancy but they are undergoing a rapid application. These economic changes are excellently reflected in the United States in the development of the wood preserving industry.

THE PRESERVATION OF STRUCTURAL TIMBER Present Standing of the Wood Preserving Industry in the United States. There are now about 100 wood preserving plants in active operation in the United States representing a capitalization of over $11,000,000 and turning out products worth about $35,000,000 per year. These plants use annually over 100,000,000 gallons of creosote costing over $7,000,000 and over 28,000,000 pounds of zinc chloride costing about $1,500,000. In addition, about 4,000,000 gallons of various other preservatives are annually consumed representing a value of perhaps $1,500,000. The total amount of wood treated approximates 175,000,000 cubic feet per year, which is equivalent to the amount of wood produced annually by about 14,000,000 acres of average American forest. Since present methods of lumbering waste about 50 percent of the wood grown, the amount of wood now annually treated represents a protection given to the annual output of approximately 28,000,000 acres of timberland. To the above should be added several millions of dollars spent each year in protecting timber from mechanical destruction and about a quarter of a million protecting wood against fire. Conserving our Timber Supply. A natural result of the increasing practice of preserving wood is to decrease the drain on our forests and hence help to conserve our supply of timber. This is offset in part by the growth of the country, demanding more raw materials, so that no accurate estimate on the extent to which wood preservation will ultimately decrease the demand for structural timber to be used for replacements can be given. The author attempted such an estimate in 1909 for the National Conservation Commission. Certain modifications now appear advisable, although the estimate as then given has not been materially changed. This revised estimate is given in Table 1. It attempts to show to what extent the demand on our forests can be decreased if all timber placed in situations where it is liable to deterioration were treated in some approved manner. For example, we now use each year about 100,000,000 cross-ties to replace those which have worn out through decay, wear, and other causes. If these ties were given an efficient preservative treatment, their life could be prolonged and in a few years the demand for ties would decrease to about 42,000,000 annually instead of 100,000,000 as at present. Of course this neglects the ever increasing demand for ties due to new construction. Estimating along these lines, it appears that the application of efficient protective measures to structural timber would decrease the drain on our forests by almost 7,000,000,000 board feet annually, were all such timber which is liable to deterioration protected.

TABLE 1. ESTIMATED DECREASE IN THE ANNUAL CUT OF TIMBER WHICH

WOULD RESULT WERE ALL TIMBER WHICH is SUBJECT

TO DETERIORATION PROPERLY PROTECTED

Class

Estimated average

life in years

Estimated annual

replacements

Estimated

saving in

annual cut

resulting

from proper

protection

(number)

Total

annual

saving

(M B M)

Untreated

Treated

Untreated

(number)

Treated

(number)

Ties

7

17

100,000,000

41,200,000

58,800,000

2,000,000

Poles

13

26

2,500,000

1,250,000

1,250,000

150,000

Posts

8

24

500,000,000

165,000,000

335,000,000

2,000,000

Piling

3

20

1,000,000

150,000

850,000

100,000

Mine props.

3

15

70,000,000

14,000,000

56,000,000

275,000

Shingles.. . .

20

35

l.OOO 6

600 6

400 5

400

Lumber. . . .

8

20

3,000,000''

l,200,000 b

1.800.000 6

1,800,000

Total

6,725,000

o- cubic feet. 6=M B M.

That this shrinkage in the amount of timber cut from forests

due to the extended use of preservative treatment is not only a

logical but a real outgrowth is shown in part by the experience of

France. Although the French forests have been severely culled,

they still furnish about 3,000,000 ties annually. Approximately

2,500,000 are used each year for renewals, which number has been

steadily diminishing in spite of the fact that the total mileage of

the country has been increasing. 1 The practice of preservative

treatment in our country has been too recent to make its influence

on forest demands as yet apparent but that similar results will be

experienced cannot be doubted.

Effect of Wood Preservation on Forest Management. En-

tirely apart from the problem of husbanding our forest resources

is the effect of treating timber on the practice of managing our

forests. By giving durability to woods which do not naturally

possess it, the practice of wood preservation will in many cases

1 H. Matheiu, Revue Ge'ne'rale des Chemins de Fer, August, 1887.

4 THE PRESERVATION OF STRUCTURAL TIMBER

govern the manner in which certain forests will be composed and

managed.

Forestry teaches that trees grow according to denned onto- and

phylogeneric laws, like all other forms of life, and if these laws

are violated, destruction will inevitably follow. A layman, for

example, may not understand why a young tulip tree will not

grow in his dense maple grove.

The utilization of various kinds of timber has shown that some

combine more valuable properties for man's purposes than

others. A study of these properties has been brought about

chiefly through dire necessity. Starting with the cream, man

has been forced to the milk. The gums, for instance, classed as

"tree weeds" a few years ago, are now eagerly sought and util-

ized. As a result of these two conditions, namely, the knowledge

of the laws of tree growth and the inherent superiority of certain

woods for commercial purposes, selected types of forests have been

evolved. In other words, man endeavors to eliminate the unde-

sirable species and foster the growth of those best fitted to his

needs. The mixed pine and beech forests of Germany may be

cited as an illustration. We have not reached this stage in the

United States, but with the ever increasing intensity of forest

management, nature's combinations will be eradicated, and in

their place will be developed man's idea of the Society of the Se-

lect. Nature's law which decrees, "Since no two organisms are

alike, one must be better adapted to its surroundings than the

other, and the less adapted must sooner or later perish," will be

changed to read: "Since no two organisms are alike, one must be

better adapted to man's needs than the other, and the less adapted

must sooner or later perish." This is an illustration from Forest

Ecology, which depicts man's disturbing influence in modifying

various forms of life to best meet his requirements. Thus the

American forests of the future will be radically different in kind as

well as in degree from those now existing. Of the forty odd

species of commercial trees now found in the Appalachians, it is

safe to state that not more than one-fourth will persist. Certain

trees, like the hemlock, will become commercially extinct, simply

because it will not pay to grow them. This is not a view into

the distant future; the careful selection of species is already

common practice in Europe, and even now is being actively

applied in our country.

As stated, the commercial extinction of certain American

INTRODUCTION 5

trees and the restriction of others is inevitable, and will be

brought about because they lack certain specific qualities.

These are of two kinds:

1. Sylvical the abundance and vitality of the seed; the re-

sistance of the young plants to insects, fire, and animals; their

adaptability to their environment; their rate of growth, etc., and

2. Commercial the size, strength, weight and beauty of the

wood, its ease of workmanship, and its durability.

Of all these properties, durability is one of great practical mo-

ment and of direct bearing on this treatise. No method is

known whereby all kinds of wood can be satisfactorily treated

with preservatives. Fortunately, however, the species best

adapted to treatment are among the most abundant, and possess

certain sylvical and commercial properties which give them a

decided advantage over others. These properties briefly are:

The vitality and prolificacy of the seed, rapidity of growth, and

high percentage of sapwood. The following species may be

classed in this group: Bull, lodgepole, loblolly, shortleaf, jack

and scrub pines; cottonwood, red and scarlet oaks, silver and red

maples; white birch; buckeye; black and cotton gums. All of

these, with the possible exception of the bull and shortleaf pines

and cottonwood, are commonly classed as " inferior" species.

When a timbered area is cut or burned over, these are the com-

mercial species which usually first come in to reforest it. It

should be noted that their rate of growth soon culminates. None

of them are long lived, and none of them have durable wood.

The inherent characteristics of these trees are such as to render a

forest composed of them easy to propagate and manage.

Wood preservation thus affects the composition of certain

forests as the forests of the future will be grown for specific pur-

poses. White oak will be as rarely used for cross-ties as black

walnut now is for fence rails. Future stands of timber will often

be composed of those species whose wood without the application

of a chemical treatment would have such a limited demand that

they could not be grown at a profit.

Suppose that an individual or company has a tract of denuded

land upon which it is decided to grow timber. Should slow or

rapid growing species be planted? Which will pay better? Al-

most invariably the wood of the former is more durable than

that of the latter, but if figured on the basis of annual financial

profit, the advantages are usually in favor of the latter. An

6 THE PRESERVATION OF STRUCTURAL TIMBER

example may be cited: Loblolly pine in an index stand on a 70-

year rotation will yield about 33,000 feet B.M. per acre; longleaf

pine under similar conditions, on a 120-year rotation, will yield

about 25,000 feet B.M. Assuming the value of the land and the

cost of planting at $10 per acre, taxes 3 cents, fire protection

and management 2 cents per year, and interest 4 percent,

the total cost of growing the loblolly at the felling period will be

$174 and the longleaf $1244 per acre. The future stumpage

price of these species can only be predicted, but at the time the

trees were cut, suppose the value to be $8 per thousand feet B.M.

for loblolly and $13 for longleaf, or an advance in present prices

of over 300 percent for loblolly and 400 percent for longleaf.

The value of the crops per acre will then be respectively $264

and $325, or a total profit of $90 for the loblolly and a deficit of

$919 for the longleaf. Longleaf, in order to produce a profit

equal to the loblolly, would have to be worth about $54 per

thousand feet stumpage. At such a price it would be commerci-

ally prohibitive. In other words, longleaf pine can be grown only

at a loss.

In order to take a most favorable view of a question like the

above, let us assume that the land is worth only $1 an acre and

that the same yield will be obtained by natural reforestation.

Hence, there will be no cost for planting. Moreover, we will

assume no charge for protection. The cost of the crops per acre

will then be $26.50 for loblolly and $192.90 for longleaf, or net

profits respectively of $237 and $132 with an excess of $105 per

acre for loblolly pine. Similar examples would be found to exist

if other of our slow growing and more durable woods were com-

pared with those listed in the so-called "inferior" group.

Exceptions, of course, occur, notably with such species as

black locust, catalpa, osage orange, chestnut, and eucalypts,

which combine durability with rapidity of growth. But these

trees are of small size or poor form or are subject to insect or

fungus attack or are decidedly limited in distribution. Whenever

these species can be profitably grown their extension should by all

means be encouraged, because they combine many of those quali-

ties in strong demand and their subsequent treatment with

preservatives is not a necessity. That the use to which its

products will be put often controls the composition of a forest is

further shown in this country by the plantations of various rail-

roads. The Pennsylvania, for example, has planted large areas

INTRODUCTION 7

to so-called " treatment woods/' such as red oak in place of the

slower growing white oak and other more durable woods mentioned

above. The U. S. Forest Service is managing certain of its

lodgepole pine forests for the direct purpose of producing cross-

ties. Without preservation, it would not pay to use this pine for

ties because of its rapid decay. (See Plate I, Fig. A.)

Wood preservation enables trees removed in thinning the forest

to be put to a higher use than for fuel and by so doing permits

thinnings to be more systematically and effectively made.

If a forest plantation is started with 1200 trees to the acre, it is

safe to assume that not more than 17 percent or a total of 204

will remain for the final crop. Those removed will have been cut

in the several thinnings when the trees were yet immature, in

order to give room for the more thrifty trees. The revenue

derived from such thinnings is usually figured on the fuel value of

the wood. Such small trees, however, if cut for posts or even

poles, and treated, will have their value appreciably augmented,

so that thinnings can be made to yield a larger income. Sup-

pose the plantation is loblolly pine and the first thinning is made

at 20 years, 600 trees per acre being removed. These will be

about 3 inches in diameter and 20 feet high, hence too small to

be used advantageously even for fuel. The first thinning will

therefore represent a direct apparent loss, which, however, will

be recovered by the accelerated growth of the remaining trees.

The second thinning will be made at 40 years, and 400 trees will

be removed. These will have reached a diameter of 8 inches and

a height of 45 feet. If cut for fuel, they would yield about 13

cords worth about $1 per cord stumpage. If cut into posts, how-

ever, they would yield about 1600 worth at 2 cents each stump-

age a total of $32. Posts of this species, or more generally of

inferior species, are worth little unless treated, but when treated

their durability may equal or excell that of the more costly

varieties, so that it will often prove cheaper to use them. In-

creased profit derived from thinnings will enable them to be more

systematically and carefully made and thus the application of a

more intensive system of forest management is made possible.

The practicability of a forest working plan depends very largely

and in some cases entirely upon direct financial returns, and in

any case, if the plan can be made to produce such returns, it

will enable forest principles to be more readily applied.

Other things being equal, conservative lumbering pivots upon

8 THE PRESERVATION OF STRUCTURAL TIMBER

the value of the top logs. Change this value and you change the

system of marketing. Wood preservation enables the top and

inferior logs to be used to better advantage than if left in the woods

to rot or sawed into lumber. By raising their value, it intensi-

fies the utilization of timber and fosters its more conservative use.

Thus the top logs of such trees as the yellow poplar, black walnut,

maple, birch, etc., possess so little value that they are often left

in the woods to rot, or when sawed into lumber are frequently

sold at a loss. For example, the value of lumber cut from

yellow birch logs in the Adirondacks in 1904, 14 inches or less in

diameter, was $9.37 per thousand. The cost of stumpage, log-

ging, and manufacturing was at the lowest figure $10.50 per thou-

sand. The operators therefore lost $1.13 per thousand on all

such logs removed. For beech the loss amounted to $1.80 per

thousand feet B.M. If these logs had been cut into railroad ties,

they would, at $5 per thousand stumpage and 15 cents each for

logging and manufacture, have cost about 32 cents each and sold

for 45 cents each, or a net profit of about $3.90 per thousand feet

B.M. Untreated ties of this species have little use on account

of their rapid decay. Some lumber companies have already

realized the important part wood preservation is playing in their

operations and are now manufacturing their logs which are in-

ferior for lumber into ties. An effective system of forest manage-

ment will recognize this and will change the manner of harvest-

ing the timber so as to get greater returns from it.

Wood preservation accelerates the removal of fire-killed and

dead timber and enables areas so denuded to be more speedily

reforested and placed upon a profitable basis. Dead timber,

whether standing or down, decreases in value each year and land

encumbered with it can be likened to capital stock earning no

dividend but compelled to pay annuities. There are thousands

of acres of just such land in the United States. It is often im-

practicable to use such dead trees for lumber because of their

extensive checks, the stained condition of the wood, or holes

bored by insects. Furthermore, on account of rapid decay, the

wood may not be usable even for ties, mine props, etc. If

treated with preservatives much of this timber can be marketed.

Tests made by the author on fire-killed lodgepole pine in Idaho

proved it was in ideal condition for preservative treatment.

When cut for such purposes its stumpage value in comparison

with its former fuel value was raised about 60 percent.

PLATE I

FIG. A. A stand of young Lodgepole pine in Idaho. (Forest Service photo.)

FIG. B. Egyptian coffin dating from the XII dynasty (2000-1788 B. C.).

The only restorations are three cleats on the bottom of the coffin, otherwise

it is in almost perfect preservation. (Photo through courtesy of the Metro-

politan Museum of Art, New York.)

(Facing page 8.)

PLATE I

FIG. C. Lentinus lepideus. (Forest Service photo.)

FIG, D. Lenizites sepiaria. (Photo through courtesy of C. J. Humphrey.)

INTRODUCTION 9

History of Wood Preservation. Egypt. The earliest records

of the artificial preservation of organic bodies are found in Egyp-

tian history. The skill shown by the Egyptians in enbalming

bodies proves that they carried the art to a high state of perfec-

tion. Apparently the wooden coffins in which the bodies were

placed were given no special treatment, so that their durability

can be accounted for only by the exclusion from the wood of

sufficient moisture to allow the growth of wood-destroying

organisms. As sycamore was largely used in the construction

of these coffins, this furnishes excellent proof of the durability

of wood when it can be kept dry; in fact, in such a condition its

life is indefinite. (See Plate I, Fig. B.)

Such was not the case, however, in the preservation of the bod-

ies. It is definitely known that these were impregnated with

antiseptics, although the exact manner in which this was done is

still a matter of conjecture. From the writings of Herodotus

it appears that the bodies were first steeped in natrum (a natural

substance found in the briny lakes near Cairo and composed

principally of sodium sesqui-carbonate, sodium chloride, and so-

dium sulphate) for about 2 months, after which they were sub-

jected to a bituminous preparation, perhaps by boiling or baking

in an oven. Pettigrew extracted the preservatives from the heart

of a mummy which had been in a perfect state of preservation

for over 3000 years, and the heart at once putrified. Petti-

grew's experiments show that the mummies prepared in natrum

alone were not as well preserved as those in which solid resins or

bitumens were found.

Europe. The quantities of wood used by the early Greeks

and Romans in their buildings and bridges caused them to meet

squarely the problems of preserving it from decay. Thus among

the first attempts were the placing of stone blocks under wooden

pillars to keep away soil and vegetation. The tops were also

capped in this manner and it is thought that these early practices

are the origin of the base and capital of our modern stone pillars.

The antiseptic value of essential oils was also well understood,

these being obtained from the olive tree and from various cedars

and junipers growing along the Mediterranean. The practice

was to either rub these oils over the surface of the wood to be pre-

served, or to bore numerous small holes in the wood and pour oil

into them. In this manner the magnificent statue of Jupiter by

Phideas and the famous statue of Diana were preserved. Pliny

10 THE PRESERVATION OF STRUCTURAL TIMBER

asserts that the oils not only retarded decay but kept the wood

free from insect attacks. It was common practice among the

Romans and hut dwellers of the Baltic to char their timbers

which were used for piling before placing them permanently in

their structures. This method of preserving wood is used even

to the present day.

It was perhaps the rapid decay of timber in the British warships

that gave wood preservation its first great impetus. It is re-

ported that 40 acres of oak forest were required to construct a 70-

gun ship and that the great prevalence of rot in the vessels as-

sumed the proportions of a national calamity. 1 M. Paulet in his

book entitled, "Conservation des Bois," enumerates 173 proc-

esses or methods that were tried, most of which proved unsuccess-

ful. About this time Holland was also wrestling with the pres-

ervation of the timbers used in the construction of her dykes and

marine structures. Later came the development of the steam

engine and birth of the locomotive, which brought a new drain on

the forest, principally for cross-ties, so that some method of

preserving wood became a positive necessity. It was during

the first quarter of the 19th century that modern methods of

injecting wood may be considered as beginning, although the

most successful attempts did not come until a few years later.

It is interesting to note that the most efficient preservatives were

used several years before patents were taken out on them, or

even before their use was commercialized. Thus mercuric

chloride was used by Homberg in 1705 and by De Boissieu in

1767, although it is with Kyan's name that the salt is best known,

he having taken a patent on its use in England in 1832. Even

to the present, its use is commonly called "Kyanizing." So it is

with copper sulphate, recommended by De Boissieu and Borde-

nave in 1767 and best known as "Margaryizing," although

Margary's patent was not granted until 1837. Chloride of zinc

was recommended by Thomas Wade in 1815 and by Boucherie

in 1837 but its use is referred to as "Burnettizing" from the pat-

ents of Sir William Burnett in 1838. Franz Moll took out a

patent in 1836 for injecting wood in closed iron vessels with oils

of coal-tar but the practical introduction is attributed to John

Bethell, whose patent is dated 1838 and whose name is now fam-

ous in the art of preserving timber. It is reported that Bethell's

1 The Preservation of Timber by the Use of Antiseptics." Samuel B.

Boulton, 1885.

INTRODUCTION 11

process required the timber to be in an air-seasoned condition

before the preserving oils were injected. The treatment of green

timber with creosote by first using steam followed by a vacuum

prior to impregnation with the oil is attributed to Hayford. 1

The marked success met with by the use of the preservatives

mentioned gave a pronounced impetus to the wood-preserving

industry throughout Europe. Later, progress was directed more

to perfecting the use of these preservatives than in attempting to

introduce new ones. Thus it was found that zinc chloride had a

tendency to leach from wood, and to overcome this objection as

well as give added effectiveness to the treatment, Julius Rutgers

introduced in Germany about 1874 a method of treating ties

with a mixture of zinc chloride and creosote. This method has

met with considerable favor in Germany and is now one of the

leading processes in use in that country. The excellent results

secured with coal-tar creosote have always caused this pre-

servative to be held in very high repute. Its comparatively

high cost led Max Reuping to take out a patent in Germany in

1902 on a process of impregnating it into wood, and subsequently

withdrawing a part of it so that the total amount of oil actually

consumed was greatly reduced. This process named after the

inventor, has also met with pronounced success in European

countries. Several other methods of treating wood have lately

been exploited in Europe but few of them have met with the suc-

cess of the Burnettizing and Bethell processes.

Wood preservation is now practised in all the leading European

countries. In England creosoting appears most popular, while

in Germany both creosote and zinc chloride are extensively used.

The same is true of France, where appreciable quantities of poles

are still impregnated with copper sulphate. Not only ties and

poles but vast quantities of mine timbers, paving blocks, piles,

posts, vineyard sticks and lumber are now annually treated, so

that the industry may be considered as permanently established

and an engineering necessity. Figures on the amount of wood

treated in Europe are not available, but it is reported that about

16,000,000 ties are annually preserved and that the total number

of plants in operation is about 70. It appears, therefore, that

the plants in Europe have on the average a much smaller capacity

than those in our country.

United States. The commercial application of wood preserva-

1 Reprint, Journal of Franklin Institute, 1878.

12 THE PRESERVATION OF STRUCTURAL TIMBER

tion in our country first became of practical importance in 1848,

when a Kyanizing plant was built at Lowell, Mass. A great

many tests, however, had been carried on in a more or less

primitive way previous to this. For example, Kyanized chestnut

ties were laid near Baltimore in 1838 by the Northern Central

Railroad. The Lowell plant was built primarily for the treat-

ment of timbers used in the locks and canals on the Merrimac

River. It operated the Kyanizing process for 2 years, and then

substituted the zinc chloride method, but in 1862 the officials,

becoming dissatisfied with these treatments, reverted to Kyaniz-

ing, and since this date the plant has been in more or less con-

tinuous operation.

In 1856, the Vermont Central Railroad erected a Burnettizing

plant for the treatment of bridge timbers and ties, but it was

abandoned after being in operation 4 years. About this time

the Chicago, Rock Island and Pacific, the Boston and Albany and

Erie Railroads built plants for the treatment of timber with zinc

chloride. All these plants met with but partial success, princi-

pally because of the then abundant supply of timber and the high

cost and inexperience in handling treated timbers. Operators

could not accustom themselves to the delay which timber treat-

ments entailed; consequently few plants treated their timber for

a sufficient period to enable it to be properly impregnated with

the preservative. In 1863 the Philadelphia, Washington and

Baltimore Railroad, and in 1867 the Philadelphia and Reading

Railroad built Burnettizing timber-treating plants, but both had

a short life due to the unsatisfactory results secured. In 1865,

the Old Colony Railroad erected a plant at Somerset, Mass., for

the treatment of bridge timbers with creosote. This, apparently,

represents the first practical attempt to use this material in the

United States. The work was done with a rush and in a careless

manner, much of the timber being trimmed after it was treated.

In spite of this, the work was considered a success.

In 1867, Professor Seeley of New York obtained a patent for

treating timber without the use of pressure. He erected treat-

ing plants in New York, Chicago, and at the St. Clair Flats in

Michigan. His claim was that green timber could be treated

just as effectively as seasoned timber. This, however, accounts

in a large measure for Seeley's failure. His process was neverthe-

less adopted by the Government for its work at the St. Clair Flats

in the construction of dikes, etc., along its canal, and by the

INTRODUCTION 13

Chicago, Rock Island and Pacific and the Chicago, Burlington

and Quincy Railroads. At the World's Fair in St. Louis in 1904,

von Schrenk revived this "open tank" process, and its use was

later on made the subject of careful study by the U. S. Forest

Service, until there are now several plants in operation in this

country.

About the time Seeley's process was being promoted, Mr. L. S.

Robbins introduced a method in which he impregnated timbers

with vapors of creosote. This process was extensively adver-

tised and local companies were formed in New York, New Jersey,

Pennsylvania, Massachusetts, Connecticut, and California with

large capital. It failed, however, in practically all cases, espe-

cially where it was used in marine construction. Mr. C. B. Sears,

engineer in charge of the government works in California, states

"that it failed absolutely to protect the timber from the Teredo,

which was not more than 2 months longer in attacking it than

the untreated timber, and when once in, its action seemed to

be more rapid."

About 1870 Mr. Thilmany treated a great many ties with

copper sulphate and barium chloride for the Wabash, Pennsyl-

vania and Ohio, Lake Shore and Michigan Southern, Cleveland

and Pittsburg, and Baltimore and Ohio railroads, but the process

met with the fate of most of its predecessors and it was eventually

abandoned.

In 1872, it is reported, Mr. George H. Fletcher boiled some

paving blocks in dead oil of coal-tar and laid them in the yard of

the New Orleans Gas Light Company. They absorbed about 20

pounds of oil per cubic foot and when inspected 30 years after-

ward were thoroughly sound.

Modern timber processes may be considered as beginning in

this country in 1875, when a creosote plant was erected at West

Pascagoula, Miss., for the treatment of timbers used by the Louis-

ville and Nashville Railroad. This plant is still in operation and

has met with marked success in its work. In 1878 Eppinger and

Russell operated their creosote plant in Long Island City, N. Y.

In 1879 the New Orleans and North Eastern Railroad built

a similar plant primarily to treat the timbers used in the bridge

across Lake Ponchartrain. From this period on the wood-

preserving industry has permanently grown, the Wyckoff Pipe

and Creosoting Company erecting a plant in 1881, the Colman

Creosoting Company in 1884, the Santa Fe Railway Company in

14 THE PRESERVATION OF STRUCTURAL TIMBER

1885, the Chicago Tie Preserving Company in 1886, etc., until

at the present time there are now about 90 plants in operation

scattered all over the United States and treating annually over

125,000,000 cu. ft. of wood. (For complete list see Appendix.)

It is interesting to note that the first successful attempts in

timber preservation in this country were not made on account of

scarcity of timber, but because of the high cost of replacing it after

it had deteriorated. For example, the timber-treating plant

built by the New Orleans and North Eastern Railroad was erected

to treat the timbers used in constructing the Lake Ponchartrain

bridge, as these, without treatment, would not last more than

3 or 4 years due to rapid decay and attack by borers.

Although treated in 1875, many of these timbers are still sound

and in service. Some method of preserving the wood was there-

fore an absolute necessity to the railroad company in order to

maintain this bridge. Similar conditions prevailed in other

places along the Atlantic Coast and in mines, but the gradual

depletion of our forests and rise in the value of lumber has given

a further impetus to the growth of the industry so that there are

now but few places in the United States where wood preservation

will not pay.

CHAPTER II

FACTORS WHICH CAUSE THE DETERIORATION OF

STRUCTURAL TIMBER

Discussion of Their Relative Importance. Timber placed in

service is subject to deterioration from many causes, and its

strength eventually becomes so weakened that it must be re-

moved and replaced with sound timber or some other material.

The chief factors which cause such deterioration are decay,

insects, marine borers, mechanical abrasion, and fire. Others of

less extent are alkaline soils, birds, and sand storms. Our

country is so vast and its development has been so rapid, that it

is absolutely impossible at this time to even estimate with any

degree of accuracy the relative importance of the above factors

responsible for the deterioration of structural timbers. In the

absence of statistics, it seems very probable, however, that decay

is by far the most important, as enormous quantities of wood rot

annually. Next in rank to decay, perhaps, comes mechanical

destruction, such as the railcutting of ties; then in gradually de-

creasing amounts, fire, insects, and marine borers. We will dis-

cuss in this chapter the manner in which these destructive agents

work, as it will aid in understanding the protective measures

taken to overcome them.

Decay. On this subject volumes have been written, and it

seems strange that even at the present time the cause of decay

is a matter little understood by many timber treating engineers. \*

For this reason it is felt desirable to review the more essential

facts that are known in the hope that they may clearly fix the

basic principles of fungous growth. The prevailing theory about

1840 as to the cause for decay in timber was molded by the

opinion of the great chemist Liebig. Liebig taught that the proc-

ess of fermentation in certain fluids and the putrefying or decay

of organized bodies, animal and vegetable, were caused by a

species of slow combustion to which he applied the term "erema-

causis;" that it required for its ordinary development the pres-

1 See Proceedings American Wood Preservers' Association, 1912.

15

16 THE PRESERVATION OF STRUCTURAL TIMBER

ence of moisture and atmospheric air; that its action was pro-

voked by oxygen and its method of action was by a communica-

tion of motion by the atoms of the affected ferment to the atoms

of the body affected. He denied that fermentation, putrefaction,

and decomposition were caused by fungi, parasites or infusoria,

although these organisms might sometimes be present during

the process. 1

With the introduction of the microscope and the consequent

intensive study on the minute forms of life, the theory of Liebig

gradually became shattered. The bodies of mammoths pre-

served in ice through countless ages, the fragments of wooden

piles which have endured undecayed for centuries when driven

deeply below the surface of water, all confirm the experiments of

Pasteur and Tyndall and prove the exclusion of germs prevents

decay. Specimens are on exhibition of a sound wooden pile

known as the remains of a bridge (destroyed by fire) which was

constructed by Charlemagne across the Rhine; of pieces of piles

in the foundation of the bridge across the Medway at Rochester,

which was destroyed by Simon de Montfort in 1264. Thousands

of exact laboratory tests have established beyond all peradven-

ture, that the true cause of decay in timber are low forms of

plants called fungi and bacteria. The action of bacteria in de-

caying wood is not clearly known even to this day, but there is

little reason to doubt but what the same methods used in com-

bating fungi will prove equally as effective in combating them.

Only a comparatively small percentage of fungi and bacteria

have the ability to decay wood and a great many will not even

grow on wood. Of those which do grow on wood it is customary

to divide them, in a discussion of this kind, into " harmful" or

wood destroying and " harmless" fungi. All fungi are forms of

plants which are parasitic, that is, they are de-pendent on other

plants for their existence. They all lack " chlorophyll," a sub-

stance which gives plants their green color and which is instru-

mental in taking the gases from the air and transforming them

into plant substance.

Fungi reproduce in two ways, (1) sexually, by means of minute

" spores" which can be likened to tiny seeds, and (2) asexually,

by means of "mycelia" which can be likened to minute roots.

The spores are blown about by the wind like very fine particles

1 S. B. Boulton, The Preservation of Timber by the Use of Antisep-

tics, 1885.

DETERIORATION OF STRUCTURAL TIMBER 17

of dust, and when they alight on wood, start to germinate and

send their fine mycelia into the wood gradually decaying it.

If these mycelia come in contact with sound wood, as for example,

when a piece of decayed wood touches a piece of sound wood, they

grow into the sound wood and will ultimately decay it. In this

way, decay is also spread. Some fungi have the ability to send

their mycelia over materials which they will not attack, in their

search for wood. Thus if two pieces are separated a foot or

more apart, the mycelia from the decayed piece may reach out

over this space and attack the sound piece. This characteristic

is common in the so-called "house fungus." By the secretion

of little understood chemicals by these mycelia, the wood fiber

is dissolved and its substance serves as food for the fungus.

These chemicals are termed " enzymes " or "ferments." Since

fungi vary greatly in their capacity to secrete ferments, we have

the key to their widely varying action upon timber. It is only

those fungi which attack cellulose and lignin vigorously that

effect the durability of timber to any serious degree. Give them

a favorable temperature and proper moisture and air supply and

the destruction proceeds rapidly.

Fungi may be classified in regard to the form and habit of

growth of the "mushrooms" technically called "fruiting bodies."

Based on these characters, the "harmful" or wood destroying

fungi may be divided into three classes :

1. Fleshy forms of the "mushroom" types which have a dis-

tinct stem, a more or less circular cap with plates or "gills" on

the under side. This class contains few destructive forms. (See

Plate I, Fig. C.)

2. Fungi which are tough, corky or woody and which have no

stem, but are attached to the wood by the side of their rough

semicircular caps. (See Plate I, Fig. D.) The under surface is

provided with pores of various outlines, circular, angular, or

sinuous. Frequently the caps grow in clusters, one above the

other. This class contains many destructive kinds.

3. Fungi similar to those in class (2), but whose under surface

is smooth and not differentiated with pores or plates. (See Plate

II, Fig. A.)

The "harmless" fungi are comparatively few. There are

several species similar to those described in class (1) which grow

on wood after it has reached an advanced stage of decay. Another

form (Schizophyllum commune) having a wide distribution is

18 THE PRESERVATION OF STRUCTURAL TIMBER

small, white, thin, leathery, and flexible, and has a bracket-like

appearance. It frequently occurs on sound oak or pine and lives

mostly on the sugars and starches in the wood. Other fungi

which are white, green, brown or black and commonly called

" molds" also belong to the " harmless" group. They produce

the stain in wood but do not injure its strength to any appreciable

extent. l

Insects. The deterioration of timber through insect attack

is greatly underestimated in this country. This matter has

been made the subject of a special investigation by the U. S.

Bureau of Entomology and it is estimated that the annual loss

from this cause amounts to $100,000,000. 2 Round timber with

the bark on, such as poles, posts, mine props, saw logs, etc.,

is particularly subject to attack by round-headed borers, timber

worms, and ambrosia beetles. Frequently the insects continue

the work in the unseasoned and even dry lumber cut from logs

which had been previously infested. Their prolonged activities

in mine timbers are well known; also in cabins, and rustic furni-

ture. Hickory hoops and poles are often rendered worthless by

borers and beetles. Stave and shingle bolts, handle or wagon

stock, and pulpwood are peculiarly subject to attack. Although

termites are not usually associated with the destruction of timber

in this country, nevertheless they cause considerable damage to

poles and construction timbers used in buildings, sometimes

completely destroying them. Many of the insects not only feed

on the wood but burrow into it for their protection or breeding

grounds. This, of course, weakens the wood and allows channels

through which water and the spores of destructive fungi can

enter. Each species of insect has its own peculiar method of at-

tack so that it is not possible in a treatise of this kind to describe

all of them. Two rather typical examples will, however, be

given: The " powder-post insect" which bores into dry wood

and the "pole borer" which attacks poles and similar products.

The Powder-post Insects. 3 "The adults or winged forms of this class

of insects are small, slender or stout, brownish to nearly black beetles,

1 For a scientific discussion of the destruction of cellulose by fungi and bac-

teria, the reader is referred to Bulletin 266 of the U. S. Bureau of Plant In-

dustry, by McBeth and Scales.

2 Circular 129, U. S. Bureau of Entomology, A. D. Hopkins, 1910.

3 Circular 55, U. S. Division of Entomology, by A. D. Hopkins.

PLATE II

FiG. A. A red-oak tie attacked by a wood destroying fungus (Stereum fas-

ciatum, Schw.). (Photo through courtesy of C. J. Humphrey.)

I

I

FIG. B. (l)The pole borer, male and female beetles. (2) Young larvae.

(Circular 134, U. S. Bur. Entomology.)

(Facing page 18.)

FLATE II

FIG. C. Gallery of the pole borer. FIG. D. Mines of the pole

borer near the surface of the

ground.

Work of the pole borer (Parandra brunnea Fab.) in an untreated chestnut

pole. (Circular 134, U. S. Bur. of Entomology.)

DETERIORATION OF STRUCTURAL TIMBER 19

which upon emerging from the wood where they breed and pass the win-

ter, fly or crawl about in search of suitable wood material in which to

deposit their eggs.

The different species vary in their habits and life history, from the egg

to the adult, but in general that of the true powder-post beetles is as

follows: The winter is passed in the wood. The eggs are deposited under

normal conditions soon after activity commences in the spring, while

in storehouses and buildings kept warm and dry they may continue their

activity through the year and deposit eggs much earlier. The minute

white "worm" or grub (the second stage of the insect known as the

larva), upon hatching from the egg, proceeds to burrow in and through

the wood in all directions, feeding and growing as it proceeds, until it has

attained its full growth. It then excavates a cell at the end of its burrow,

in which it transforms to a semidormant stage (the pupa, or third stage

in the insect's life), remaining thus until the legs and wings have fully

developed, when it bores its way out and appears as the matured adult or

beetle (the fourth stage), to mate and repeat the life process. Under

normal conditions, so far as is positively known, there is probably only

one generation annually.

Each female deposits many eggs, and many females oviposit on or in a

single piece of wood, so that the combined work of their numerous pro-

geny, borrowing through the wood in quest of food for their development,

results in the complete destruction of the interior wood fiber and its con-

version into a mass of fine powder. If the first attack and the first

generation do not accomplish this destruction, subsequent generations

will follow in the same wood until nothing of the solid fiber is left but a

thin outer shell."

The Pole Borer. 1 This insect (Parandra brunnea Fab.), is an

elongated, creamy- white, wrinkled, round-headed grub or larva.

(See Plate II, Fig. B-2.) It hatches from an egg deposited by an

elongate, mahogany-brown, shiny, flattened, winged beetle, from

two-fifths to four-fifths of an inch in length. (See Plate II, Fig. B-l.)

It appears that the eggs are deposited from August to October in the

outer layers of the wood of the pole near the surf ace of the ground.

The young borers, upon hatching, excavate shallow galleries in

the sapwood, then enter the heartwood, the mines being gradually

enlarged as they develop. As they proceed they closely pack

the fine boring dust behind them. This peculiar semidigested

boring dust, which is characteristic of their work, is reddish to

dunnish yellow in color and has a clay-like consistency. The

burrows eventually end in a broad chamber, the entrance to which

1 Circular 134, U. S. Bureau of Entomology, by T. E. Snyder.

20 THE PRESERVATION OF STRUCTURAL TIMBER

is plugged with excelsior-like fibers of wood. Here is formed the

resting stage, or pupa, which transforms to the adult beetle.

Often all stages, from very young grubs only about one-fourth

inch long to full-grown grubs over 1 inch long, pupae, and adults

in all stages to maturity are present in the same pole. Adults

have been found flying from July to September.

The insect attacks poles that are perfectly sound, but will work

where the wood is decayed ; it will not, however, work in wood that

is "sobby" (wet rot), or in very "doty" (punky) wood. It

has not yet been determined just how soon the borers enter the

poles after they have been set in the ground. However, poles

that had been standing only 4 or 5 years contained larvae and

adults of this borer in the heartwood, and poles that had been

set in the ground for only 2 years contained young larvae in

the outer layers of the wood.

The presence of the borers in injurious numbers can be de-

termined only by removing the earth from about the base of the

pole; the large holes made when the adults come out are found

near the line of contact with the soil. Often large, coarse borings

of wood fiber project from these exit holes. Sometimes the old

dead parent adults are found on the exterior of the poles under-

ground. During August the young adults may be found in

shallow depressions on the exterior of poles below the ground

surface.

Marine Borers. In many places along both the Atlantic and

Pacific coasts timber used for piles in wharfs and other marine

structures is attacked by marine wood borers. There are many

kinds of such borers but those which occur in our waters can be

classed into three genera of mollusks, Xylotrya, Nausitoria, and

Teredo, commonly known as "shipworms," and two of crus-

taceans, Limnoria, Chelura, commonly called "wood lice."

The activities of the shipworms were known to the ancient

Romans, who sheathed their ships against them. Clement

Adams in the reign of Edward VI notes that upon the squadron

sent out to discover the Northeast Passage "they cover a piece

of the keels of the shippe with their sheets of leade, for they had

heard that in certaine partes of the ocean a kinde of wormes is

bredde, which many times pearceth and eateth through the

strongest oake that is." 1

i "Hakluyt's Voyages," Vol. II, p. 241.

DETERIORATION OF STRUCTURAL TIMBER 21

Xylotrya, Nausitoria, and Teredo 1 in structure and mode of

life are very much alike. Hence for all practical purposes a

description of the work of Xylotrya will be sufficient (see Fig.

1). The average diameter of an egg is less than 1/500 inch, and

a single worm may lay 100 million in a season. When the egg

hatches, the embryo swims around for about a month and the

exposed surface of the wood is then attacked by countless thou-

sands of them which immediately begin to bore. The hole by

which it enters is minute, but beneath the surface the burrow is

soon enlarged to accommodate the rapidly growing body. The

burrow extends usually in a longitudinal direction and follows

a very irregular, tangled course.

There is some controversy as to the method by which boring

is accomplished. It is possible that the body is held rigidly by

FIG. 1. Xylotrya or ship worm.

an extensile sucker-like foot, ordinarily incased within the two

shell valves (Fig. 1, a), and that the two valves revolve around

this, cutting the wood away with fine, hard, tooth-like protuber-

ances. It is possible on the other hand that the muscular ring

near the posterior end of the body (Fig. 1, b) is pressed firmly

against the walls of the burrow, and that the whole body, including

the shell valves and foot, revolves slightly in both directions, the

shell valves doing the cutting. It is probable, however, that the

boring is done by a united action of the valves and foot. The

posterior muscular end is probably the only portion of the body

held rigid. The valves revolve slightly, cutting into the wood,

partially in front and partially on the sides. At the same time

1 Circular 128, U. S. Forest Service, "Preservation of Piling against Mar-

ine Borers," by C. S. Smith, 1908.

22 THE PRESERVATION OF STRUCTURAL TIMBER

the foot, either by the secretion of an acid substance, or of

spicules used as a grinding medium, assists in breaking down the

wood fibers directly in front of the advancing mollusk. The

hardest knots are penetrated with ease, but the softer parts of the

wood are preferred. As the body grows it secretes a calcareous

substance to form a hard lining around the burrow. This is

thicker in soft, porous woods than in those which are hard and

dense.

At the posterior end of the body, just below the muscular ring,

are two siphons, or tubes (Fig. 1, c). Through the shorter one

the fine borings are ejected with the excreta; through the longer

one water and food are taken in. The food consists wholly of

infusoria, and is not obtained from the wood itself. The sole

object of boring into the wood is to secure a place of shelter.

Xylotrya rapidly attains maturity. High temperatures pro-

mote quick work and hasten bodily development. The size

attained by the adult depends upon the species, the locality, and

the obstacles to excavation. In rare cases a length of 6 feet, with

a diameter of over 1 inch, is said to be attained. Other species

seldom attain a length of over 5 inches or a diameter of over

1/4 inch.

The portion of the pile commonly attacked is that between

mean tide-water mark and a point about 4 feet below low water,

though sometimes it extends downward as far as the pressure

of the water will permit. The entrance holes do not indicate the

extent of attack, as the entrance may be at mean tide-water

mark and the active boring head several feet above. On the

other hand, part of the excavation may be below the mud line,

though the entrance is never so situated. More than half of the

weight of the structure may be removed without any visible signs

of deterioration upon the surface. When the worm is dead, the

minute entrance holes often become filled with mud or debris,

so that it is impossible to discover the true condition of the pile

without chopping into it.

The Pholas is primarily a marine stone borer but certain species

will attack wood. In form it resembles a long clam. In boring

it braces its open shell against the sides of its excavation, while its

long sucking foot emerges and rubs the surface of the stone or

wood. Particles of sand are operated between the foot and the

stone or wood, thus grinding the excavation. Granite, marble,

or any kind of stone seems to be attacked. Fortunately, its

DETERIORATION OF STRUCTURAL TIMBER 23

ravages on wood are not as extensive as the Xylotrya and

Teredo.

Undoubtedly all shipworms thrive best under the influence of

heat, though some can endure a relatively low temperature.

Certain species have been reported from as far north as Eastport,

Me. Since warm water increases their activity and permits

them to continue their attacks throughout the greater portion

of the year, shipworms are most destructive from Chesapeake

Bay south to Florida, on the Gulf of Mexico, and along the entire

Pacific coast.

The shipworm may be present in some waters, yet absent in

others near by. This is usually due to a difference in the water.

Xylotrya appears to be able to endure the brackish water of the

inner New York Harbor, while Teredo cannot live there, though

it is present in the ocean just outside. The shipworm is very

active on the north Pacific Coast, yet it is absent about the mouth

of the Columbia River, where the amount of salt in the ocean is

influenced by the inflow of fresh water. The effect of water

conditions was also noticed in Holland during certain years in

which the worms were unusually destructive. Little rain fell

during those years, and the small amount of river water brought

to the coast was thought to have allowed the ocean to become

more saline about the mouths of these streams. Analyses show

that there is a variation in the proportion of salt present in the

waters of the coast during the dry and the rainy seasons.

Observations along Chesapeake Bay and the Gulf of Mexico

indicate the species found there will thrive in waters with a saline

density indicated by a specific gravity of from 1.0054 to absolute

saturation, 1.0333; that they thrive in temperatures of from

55 F. to the highest found along our coasts; that they work in

absolutely clear and in very turbid water; that they seldom work

to a depth of over 30 feet; and that the worst attack is usually in

the very salty, warm, clear waters.

The length of time required to destroy an average, barked un-

protected pine pile in different localities is shown in the following

table:

From this table it will be seen that the average life of an un-

treated pine pile on the Atlantic coast south from Chesapeake

Bay and along the entire Pacific coast is but from 1 to 3

years.

24

THE PRESERVATION OF STRUCTURAL TIMBER

.

Length of life

reported

Average

Minimum

Colon, Panama

9 months 1 year

Norfolk, Va..

5 years

1 year

Newport News, Va

2 years . . .

Hampton Roads

11/2 years

St Andrews, Fla

2-3 years

Pensacola, Fla.

2-3 years

1 year

Fort Morgan, Ala

1 year

West Pascagoula, Miss

2-3 years ....

1 year

Texas City, Tex.

1 year

29 days

Galveston Tex

11/2 years

5 months

Aransas Pass, Tex

1 year .

3 months

Puget Sound

1 year

Klawak, Alaska

3 years

18-20 months

Limnoria. Of the crustacean borers, Limnoria, or the "wood

louse/' is one of great importance (Fig. 2). It is gregarious in its

habits, and is about the size of a grain of rice. The wood in

which it tunnels furnishes both food and shel-

ter. Boring is done with very sharp man-

dibles. The little galleries excavated are about

1/2 inch long and only slightly larger in dia-

meter than the borer. The galleries extend

inward radially, side by side, in countless

numbers, so that the wood partitions between

them are very thin and are soon destroyed by

wave action, thus exposing a fresh wood sur-

face to attack. Boring is carried on at the

rate of about 1/2 inch per year. Soft and

hard woods are both destroyed, but soft woods

much more quickly. If possible, knots, dense

summerwood, and other obstructions are

avoided. The attack is usually centered upon

a limited zone above and below low-water

mark. Hence where the tide is great the

surface exposed to attack is large.

Limnoria is reported by the U. S. Fish Commission as occurring

rarely at a depth of 40 feet. It has a wider temperature range

than Xylotrya, but requires pure salt water and cannot exist

in dirty or fresh water. It is found along the Atlantic

coast from Florida to Nova Scotia. It occurs sparingly in Long

Island Sound, is quite abundant along the coast of Massachusetts

FIG. 2. Limnoria.

DETERIORATION OF STRUCTURAL TIMBER 25

and in the Bay of Fundy. It also does great damage along the

whole Gulf of Mexico, on the north Pacific coast around Puget

Sound, and in the Straits of San Juan de Fuca. Recent exami-

nations of marine timbers show the Sphaeroma to be very de-

structive along the Atlantic and Gulf Coasts.

All the woods commonly used for piling are subject to the at-

tacks of marine borers. Some doubt has been expressed whether

borers attack certain species which are not indigenous to this

country and some native woods that have an extremely porous

structure. Examples of the first class are certain eucalypts, and

of the second class, palms and palmettos. From investigation it

is clear that species of the first class are not immune from attack,

and that those of the second, although practically immune, are

found in such small quantities and are so lacking in the require-

ments of structural timbers that the fact is not important. Hard-

ness is no barrier to attack, although boring is probably slow in

dense woods like ebony, eucalyptus, etc. Whenever partial or

complete immunity is reported, it is perhaps largely due to local

conditions rather than to the kind of wood.

Mechanical Abrasion. Wood placed in service is often de-

stroyed solely from mechanical causes, and when these cannot be

mitigated or eliminated, the protection of such wood from decay

is frequently inadvisable. Of the various forms of structural

timbers, cross-ties are most subject to serious mechanical wear,

and the loss from this cause is estimated at 15 percent of the total

number of ties annually destroyed. Wood paving blocks, piling,

arid planking used in piers, timbers in cars, and all forms of

vehicles, mine props, etc., are subject to mechanical deterioration.

In many cases no protection can be afforded the timber from such

loss, as, for example, occurs in mine props subject to "squeeze."

It frequently happens, however, that the wood can be protected

by coating its surface with some hard substance such as iron on

those portions where the abrasion occurs. At times, protection is

afforded by coating the permanent timbers with timbers that are

only temporary and whose function it is to absorb shock and stand

all wear.

Fire. The action of intense heat on wood is so well understood

that little or no comment is necessary. Combustion, of course,

occurs, the wood being decomposed into carbon dioxide, water

vapor, and ash, so that its original properties are completely

changed. Wood which is wet or is in a green condition is much

more difficult to ignite than wood which is dry, because the

26 THE PRESERVATION OF STRUCTURAL TIMBER

water it contains must be converted into steam. Consequently,

wood containing high percentages of water is less liable to injury

from fire than wood which is dry: Most structural timbers, how-

ever, particularly those used in buildings where they are protected

from the weather, are sufficiently dry so that they can easily be

ignited. The fire losses in the United States are enormous,

reaching a sum estimated at $215,000,000 a year. Of course, the

value of the timber actually destroyed is but a small percentage

of this amount, most of it being for labor of construction and

for other materials and products. There is no doubt but what

this loss can be very materially reduced, as is shown by condi-

tions abroad, but to secure most successful results it is felt that

the building itself should not only be fire-retardant but that as

many of its contents as possible should also be made to resist

the flames, and the general public educated to exercise caution.

Minor Factors. In addition to the factors just discussed, there

are a number of others of minor importance which destroy or

injure wood. The chief of these are alkaline soils, birds, sapstain

and sand storms.

Alkaline Soils. In many portions of the United States, par-

ticularly in the West, vast areas of soil are more or less alkaline.

Generally speaking, two kinds of alkaline soils are recognized,

" black" and "white" alkali. Black alkali is sodium carbonate

while the white is sodium sulphate and other sodium salts. It

has been repeatedly claimed that wood in contact with such soil

will be rapidly attacked and soon become worthless. Pieces of

wood flumes, poles, and ties have been received that were claimed

to have been destroyed by the soil. In all cases examined the

specimens showed the presence of wood-destroying fungi. For

example: Mr. A. 0. Campbell, Assistant Engineer of the Oregon

Short Line Railroad Company, submitted for analysis in 1908

several samples of ties, ballast, and soil which he took from a

portion of the line known as the Lucin Cutt-off between Ogden

and Lucin, Utah. These ties had completely deteriorated in

about 8 years. A chemical analysis showed the water-

soluble materials washed from the ballast and soil in which the

ties were placed contained about 6 percent of sodium carbon-

ate. A microscopic examination of the wood, however, showed

it to be full of fungus mycelia. It is thought that the amount

of alkali in most alkaline soils is too small to seriously affect the

strength of wood in contact with it, but that under certain condi-

PLATE III

FIG. A. Cedar ties badly damaged by rail cutting. Upper section

shows tie without plate, lower section shows tie plate was too small. (Forest

Service photo.)

(Facing page 26.)

PLATE III

FIG. B. Poles destroyed by a sleet storm in Maryland, 1904. (Forest

Service photo.)

FIG. C. Results of a fire at the Arlington Manufacturing Company's

Mill, Arlington, N. J. In rebuilding, wood beams were used throughout.

(Photo courtesy of the Boston Mfg. Mutual Fire Ins. Co.)

DETERIORATION OF STRUCTURAL TIMBER 27

tions of warm temperature and abundant moisture, chemical

action between the alkali and the wood might occur and deteriora-

tion result in time. As the chemical action of these alkalies

upon wood even under the most favorable conditions is but slight,

as is indicated by tests to reduce wood to pulp, most of the trouble

that has been experienced can be attributed to decay.

Birds. Woodpeckers are the only birds which are charged

with the destruction of structural timber. Telephone and

telegraph poles seem to be the chief forms attacked, although

at times they will drill holes into dwellings. In 1906, the

author made a count in Louisiana of a number of telegraph poles

attacked by woodpeckers. 1 Out of 268 poles, 110 or 41 percent

had been bored into. In southern Indiana another examination

was made of two pole lines near Greenwood. In one, which

extended north, 21 percent of 89 poles examined had been

attacked, and in the other, which ran south, out of 58 poles only

29 percent were uninjured.

The woodpeckers which are most injurious are the ant-eating

woodpecker (Melanerpes formicivorous) , the gold-fronted wood-

pecker (Centurus aurifrons), and the red-headed woodpecker

(Melanerpes anthrocephalus) , this latter species being the one

common in our northern states. The poles are attacked by the

birds chiefly for the insects contained in them or for nesting sites.

In some cases, however, particularly with the ant-eating wood-

pecker, they are used as a storehouse for food. These birds will

frequently fly for miles with an acorn in their bill, drill a hole in a

pole, and insert the acorn in it, to be used later for food.

Woodpeckers usually attack a pole near its top, although at

times they may bore within a few feet of the ground. Some

observations made on a telegraph line paralleling a railroad in

Tennessee showed that those poles which were imbedded in hill

tops above the level of the track were the ones most seriously

attacked, while those which were in the valleys so that their

tops were not higher than the level of the track were seldom at-

tacked. The number of holes in a pole may vary from one to a

dozen or more, although these larger numbers are not common.

The size of the hole varies from about 1/2 inch to 3

inches in diameter. When used for nesting sites, the birds may

1 Some observations on the attack of poles by woodpeckers. H. F. Weiss,

Engineering News, January, 1911.

28

THE PRESERVATION OF STRUCTURAL TIMBER

hollow out a pocket 6 or 10 inches in diameter and a foot or more

in depth.

The question of interest to telephone engineers is to just what

extent such poles are weakened. It has been found from measure-

ments that a 30-foot northern white cedar pole tapers approxi-

mately as follows :

Circumference (inches)

43

37

36

34

32

29

27

24..

Distance from butt (feet)

5

6

10

15

20

25

..30

Assuming the pole a cantilever beam loaded at one end, it is

found that it may be hollowed to the extent shown in Fig. 3

without decreasing its strength. For

example, at 10 feet from the ground if

only 2 inches of the outer shell are

left, the pole will be approximately as

strong as though it were solid. If,

however, the attack is less than 4 feet

from the ground, the pole will be

weakened. This illustration neglects

the damage done by the entrance into

the pole or the subsequent decay which

may follow, and assumes that the bird

builds its nest exactly in the center.

On the other hand, it assumes that

the pole has a uniform moisture con-

tent throughout its length and that

the outer fibers of wood at the ground

line are sound.

FIG. 3,-Diagramshow- The American Telephone and Tele-

ing the extent to which a graph Company made a few tests in

1908 near Zanesville > Ohio > to deter -

mine the effect of woodpecker attacks

on the strength of poles. These tests were made by fastening

a rope around the top of the pole and pulling with a block and

tackle to which a dynamometer was attached. In nine out of

12345

Radius ol Pole, Inches

DETERIORATION OF STRUCTURAL TIMBER

29

twelve cases the poles broke at the ground line and not at the

points attacked by the birds. It appears, therefore, that the

destruction of poles by birds is but very slight and, considering

the good which they do in destroying insects, is no justifica-

tion for killing them.

Sap Stain. When freshly cut sap lumber is piled in the open air

to season it frequently becomes discolored in a few days. This

discoloration is not due to weathering but to the growth of certain

fungi which live upon the materials in the sapwood cells. Wood

thus attacked is considered defective and its value is frequently

reduced from 50 cents to $2 per 1000 feet board measure. Perhaps

one-fourth of the annual mill cut of the United States is attacked,

the most severe damage being in the South. Any locality where

warm damp air surrounds the lumber is favorable to the produc-

tion of stain. Estimates for the whole country place the annual

loss from sap stain at about eight million dollars.

It is commonly held that lumber attacked by stain is decayed

and hence reduced in strength. This decay apparently is very

slight, because the fungi which produce the stain do not attack

the wood substance to any appreciable extent but rather live

upon the materials stored in the cells of the wood. Carefully

conducted tests on stained and unstained wood were made by

the Forest Products Laboratory at Madison, Wis., the results

of which are shown in Table 2.

TABLE 2. SUMMARY OF TESTS SHOWING THE STRENGTH OF SAP-STAINED

WOOD 1 .

Strength in static bending

Species

Mois-

ture per-

cent at

Condition

F.S. at

EL.

(pounds

M. of R.

(pounds

M. of E.

(1000

pounds

Res. to

M.L.

(pounds

Hard-

ness

time of

test

per

square

inch)

per

square

inch)

per

square

inch)

per

cubic

inch)

total

load

pounds

Shortleaf pine...

17.7

Unstained

6,295

10,040

1,559

9.6

857

9.5

do

7,729

13,736

1,792

9.8

954

8.7

Stained

8,902

14,081

1,883

9.4

852

Longleaf pine. . . .

17.6

Unstained

7,322

11,679

1,785

8.5

772

7.32

do

10,932

16,759

2,187

11.97

910

7.34

Stained

11,295

17,858

2,374

11.77

883

They show that for the same moisture content the heavily stained

shortleaf pine was slightly weaker, less tough, and showed less

surface hardness than the unstained. In the longleaf pine, which

Circular 192, U. S. Forest Service, "The Prevention of Sap Stain in

Lumber," by Howard F. Weiss and Charles T. Barnum.

30 THE PRESERVATION OF STRUCTURAL TIMBER

was only slightly stained, the differences in strength, toughness,

and hardness between stained and unstained boards were too

slight to be noticed. Immense numbers of minute spores soon

form on the freshly cut sapwood and are blown by the wind like

dust until they alight on other wood, when they start to germ-

inate. It is chiefly in this way that the stain is spread and be-

cause of the enormous numbers of spores produced, lumber

cut during the warmer months has little chance of drying without

being attacked. So far, then, as this cause is concerned, we may

consider sap stain as analogous to decay, but the results as shown

above are decidedly different.

CHAPTER III

THE EFFECT OF THE STRUCTURE OF WOOD UPON ITS

INJECTION WITH PRESERVATIVES

The Effect of Density upon Absorption. It is well known that

the structure of wood has a very pronounced effect upon the

manner in which preservatives can be injected into it, so that

all kinds of wood cannot be handled in the same way and uni-

form results secured. It is the purpose of this chapter to show

the effect of the various structures so far as they are known upon

the diffusion of the preservatives, without going into a detailed

discussion of wood formation and composition.

For our purposes we may consider wood as being composed

of a mass of small, hollow fibers or cells of various sizes and

forms more or less closely packed together. The materials of

which they are composed are chiefly cellulose and lignin. These

substances, in themselves, are heavier than water, so that, were

the cells solid, the wood would sink in water. The weight or

density of wood is largely dependent upon the amount of air

space in the various cells and it is this confined air which gives

wood its buoyancy. Thus in woods like ebony or hickory the

cells are dense and the air spaces small so that a cubic foot of

such wood contains a large percentage of solid wood substance.

In other varieties like white pine or cedar the cells have larger

air spaces and there is a smaller percentage of solid wood sub-

stance so that the wood is light and will readily float in water.

Painstaking research has shown that the density of wood sub-

stance irrespective of species is practically the same, being

about 1.55 specific gravity, or about 97 pounds per cubic foot.

It would appear that woods which are light in weight and

hence have considerable air space would absorb preservatives

more readily than woods which are heavy. Such, however, is

not the case, hence the ability of wood to absorb preservative

cannot be judged from its density or weight. In other words,

the resistance of wood to injection with preservatives has little to do

31

32 THE PRESERVATION OF STRUCTURAL TIMBER

with the dry weight of the wood. This is an important fact on

which many writers and engineers have been lead astray. Under

identical conditions of test white spruce heartwood which weighed

oven-dry 25 pounds per cubic foot absorbed only 6 pounds of

creosote per cubic foot, while heart longleaf pine weighing 39

pounds absorbed 13 pounds of the oil. Numerous other ex-

amples could be given which prove this beyond all reasonable

doubt. There seems, however, to be a rather direct relation

between density and absorption in wood of the same species.

Thus red oak, for example, which is comparatively light in

weight, will absorb more preservative than red oak which is

heavy. The difference is not great and has little practical sig-

nificance. Similar observations have been made on maple. 1

Whether or not the relationship will hold for all species cannot

be stated. As the dry weight of certain woods depends on the

rate at which the woods have grown, a relationship between

absorption and rate of growth can be said to exist, although this

is not strongly defined.

Absorption by the Cell Walls. It has been held that the cell

walls of wood do not absorb creosote, hence the amount of this

oil which can be impregnated into wood depends upon the amount

of air space which the wood contains. This claim is not strictly

true. Tests made at the Forest Products Laboratory show that

the cell walls are capable of absorbing creosote although the

amount is very small and of little significance in practical opera-

tions. 2 In these tests a number of pieces of hard maple, yew and

hemlock, 2 3/4 X 3/4 X 1/8 inch were dried in an oven at 212 F. for

24 hours then placed in a desiccator and weighed when cold to

the nearest 0.001 gram. The volume of each piece was then deter-

mined by displacement and the specimens impregnated with

water-free creosote for 1 hour under a pressure of 250 pounds

per square inch and temperature of 175 F. The volumes of the

pieces after treatment were then determined and compared with

the volumes at the same temperatures before treatment.

The average increases in volume resulting from the treatments

of the three species in percent of the volumes before treatment

were:

1 Bulletin 126, U. S. Forest Service, "Experiments in the Preservative

Treatment of Red Oak and Hard Maple Cross-ties." F. M. Bond, 1913.

2 Circular 200, U. S. Forest Service, "The Absorption of Creosote by the

Cell Walls of Wood/' by C. H. Teesdale.

THE EFFECT OF THE STRUCTURE OF WOOD

33

Percent

Yew, heartwood 6.81

Yew, sapwood 10.70

Hemlock, heartwood 7.30

Hard maple, heartwood 8.14

The Effect of Sapwood and Heartwood upon Injection. The

sapwood is commonly defined as that portion of the tree in which

the wood cells are alive and perform vital functions. It always

occurs immediately under the bark and can usually be distinguished

from the heartwood by the lighter color. The width of the sap-

wood varies considerably in the different kinds of wood, being

very narrow in such varieties as chestnut or black locust and wide

in others like loblolly pine and red gum. This difference has a

very direct bearing on the treatment of wood, because the sap-

wood of all species can be readily impregnated with preservatives.

In some varieties the sapwood is easy to inject while the heart-

wood is practically impenetrable. This is typified by the red gum

and Douglas fir. In other woods like hemlock, there is little

difference between the resistance to penetration offered by the

sap and heartwood. These differences are often very marked, as

is shown in Table 3. The specimens of wood were selected from

various species, dried to the same degree of moisture, and all

impregnated at the same time in a treating cylinder at the

Forest Products Laboratory by the full-cell creosote process.

TABLE 3. THE ABSORPTION OF COAL-TAR CREOSOTE BY THE HEART-WOOD

AND SAPWOOD OF VARIOUS WOODS GIVEN EXACTLY THE

SAME TREATMENT. (SIZE OF SPECIMENS 2 X 2 X 12

INCHES; Six IN EACH TEST)

Kind of wood

Average absorption of creosote, pounds

per cubic foot

Heartwood

Sapwood

Douglas fir

4.38

14.46

West, yellow pine

16.14

28.74

Longleaf pine

12.90

34.20

Lodgepole pine

12.84

31.56

Eastern hemlock

17.28

18.78

Alpine fir

3.66

4.14

White spruce

6.42

8.22

34 THE PRESERVATION OF STRUCTURAL TIMBER

The reason why sapwood as a rule is more permeable to the

passage of preservatives is not definitely known. So far as

the size, shape and strength of the cells are concerned there is

little difference between those in the sapwood and those in the

heartwood. It is quite likely, therefore, that the reason must

be looked for in changes which occur in the composition of the

cell walls when they are transformed into heartwood cells, or

in the cell contents or in the character of the pits in the cell

walls which become changed in position and more or less per-

manently set. Much further work remains to be done before the

true cause is determined.

The Effect of Summerwood and Springwood upon Injection.

All of the commercially important American woods grow by

adding a successive layer of wood with each successive year of

life. These layers are concentric and are called " annual rings."

Normally, one such annual ring or layer is produced each year,

so by counting the number of such rings from the center to the

outside of a piece of wood, the number of years it took to grow

the wood can be directly determined. In most varieties of trees

there is a vast difference between the character of the wood

in the annual ring formed in the spring and that formed in the

summer. The former is called "springwood," the latter " summer-

wood." Thus in longleaf pine, for example, the cells in the

springwood have much thinner walls than those in the summer-

wood. This of course makes the springwood much lighter and

weaker than the summerwood and causes the banded appearance

so noticeable in edge or " comb-grained " yellow pine lumber. In

other coniferous woods like white spruce the difference in the cells

of the spring and summerwood is not so pronounced and hence

such wood is much more uniform. The same differences occur in

certain hardwoods like oak, ash, etc., where many of the cells in

the springwood are so large as to be called "pores" or "vessels."

In other hardwoods like the maple, beech, birch, etc., the dif-

ference between the spring and summerwood is slight and hence

these woods possess greater uniformity. In all woods which have

no marked difference in the spring and summerwood the injec-

tion of preservatives is fairly uniform throughout the entire annual

ring. The beech, maples, firs, spruces, etc., fall in this class.

(See Plate IV, Fig. D.) Great irregularity in penetration and

absorption occurs in the other types of wood. Thus in longleaf

pine, red oak, ash, etc., the treatment will often appear in bands

PLATE IV

FIG. A. Longleaf pine boards after one month's exposure in a solid pile

to sap stain fungi. Boards on left untreated; boards on right dipped in a

weak solution of mercuric chloride. Note absence of stain. (Forest Service

photo.)

Fig. B. Cross section through red oak a "ring porous" wood. Note

arrangement of pores mostly in the spring wood. Note also clearness of

pores. X50. (Forest Service photo.)

(Facing page 34.)

PLATE IV

FIG. C. Cross section through beech a "diffuse porous" wood. Note

pores scattered through entire width of annual ring. X50. (Forest Service

photo.)

FIG. D. Cross section through spruce a

absence of pores. Larger openings are

Service photo.)

nonporous" wood. Note

resin ducts." X 50. (Forest

FIG. E. Cross section through black jack oak. Note pores clogged with

"tyloses." Compare with red oak. X 50. (Forest Service photo.)

Ki<;. F. Radial section through pine. Note bordered pits or "eyes,"

also how fibers fit into one another. Vertical cells on extreme left are med-

ullary or "pith ray" cells. X 150. (Forest Service photo.)

THE EFFECT OF THE STRUCTURE OF WOOD 35

(in a cross section view) or streaks (in a radial view) . This is

because the spring and summerwood offer different resistances to

the passage of the preservative. In red oak and ash most of the

preservative will be found in the springwood, while in longleaf

pine most of it occurs in the dense summerwood. The exact

reasons why these differences occur will be described further

on. It follows, therefore, that the rate at which certain woods

grow affects very appreciably the uniformity of the treatment

secured. When the tree grows rapidly, the annual rings are

comparatively wide, hence the bands of heavy and light treated

wood are pronounced. (See Plate V, Fig. A.) When growth has

been slow these rings are narrower and the bands are much

less pronounced. (See Plate V, Fig. B.) In general, therefore, the

species which have pronounced differences in the spring and sum-

merwood have a much greater irregularity in the treatment of

the annual rings than those which are of a more uniform

stucture, especially when of rapid growth. It is largely because

of these differences that the number of rings per inch allowed

in certain classes of material, such as paving blocks, is specified.

The Effect of Vessels or "Pores" on the Treatment of Wood.

All varieties of American " hardwoods" possess elongated ele-

ments called "vessels ".or " pores." These are characteristic of

hardwoods and form a reliable means of distinguishing such

woods from the "conifers" in which the vessels are entirely ab-

sent. These pores occur in two ways: first, scattered through

the annual rings, and second, as bands of "rings" in the spring-

wood of the annual ring. Because of this difference the hard-

woods are commonly classified as diffuse porous (maple, birch,

beech, etc.) and ring porous (oak, ash, hickory, etc.). These

pores, which may be likened to capillary tubes, are easily filled

with preservative and offer ready channels for conducting the

preservative into the wood. 1 Thus in red oak the pores are so

long that it is possible to blow through a piece of this wood 4

feet or more in length. It can be easily understood, therefore,

why such woods readily absorb preservatives and why the char-

acter of the treatment secured depends so much upon the ar-

rangement of the pores.

> The Effect of Tyloses on the Treatment of Wood. It frequently

happens that the vessels described above are clogged with a cell

1 When the pores are filled with "tyloses" this statement does not hold.

See discussion under "ty loses."

36 THE PRESERVATION OF STRUCTURAL TIMBER

growth which prevents the passage of air or liquids through them.

This growth is characteristic of certain kinds of wood like white

oak and black locust and renders them practically impervious to

absorption. It is caused by cells, called "tyloses," growing into

the vessels. (See Plate IV, Fig. E.) These may occur even in the

sapwood and when they are present the vessels cannot be pene-

trated. In some kinds of wood like white oak, tyloses are uni-

form throughout, only a few vessels being without them. In

other varieties, like black oak, tyloses occur irregularly through

the wood. Thus in certain parts of a stick the vessels may be

few and the preservative will readily enter, while in another part

the tyloses may fill the vessels and absolutely prevent any

entrance of the preservative. In such cases a very irregular

diffusion of the preservative naturally occurs. It is difficult to

tell the extent to which the tyloses occur in these woods except

by a careful microscopic or hand lens examination. From a

large number of microscopic examinations of various American

woods it is possible to class them into three groups depending

upon the presence or absence of tyloses. 1

Group 1 Tyloses absent the maples, birches, blue beech,

flowering dogwood, holly, silverbell, black and water gums, black

and red cherry, basswood, persimmon, honey locust.

Group 2 Tyloses few yellow buckeye, white beech, red gum

(sap), yellow poplar, magnolias, sycamore, black cottonwood,

eucalyptus (blue gum), white and Oregon ashes, and the elms.

Group 3 Tyloses abundant large tooth aspen, hardy catalpa,

desert willow, green, pumpkin and blue ash, mockernut, water

pignut, shellbark, bitternut, nutmeg and shagbark hickories,

butternut, black walnut, red mulberry, blackjack, white, Garry,

overcup, valley, burr, cow, post and swamp white oaks, black

locust, and osage orange.

Tyloses were also found very scatteringly in the pines, but in no

other conifers examined.

The Effect of Resin Ducts on the Treatment of Wood. As

mentioned above, conifers do not possess vessels or pores. Some

of them do, however, have a structure which, so far as a penetra-

tion with preservatives is concerned, functions like pores. This

structure is called a " resin duct," and as the name implies, it is

a duct or " pore " usually producing and containing resin. Except

when the ducts are clogged with resin or some other obstruction,

1 From examinations by Eloise Gerry, U. S. Forest Products Laboratory.

PLATE V

showing rapid growth, also note sharp transition of Spring wood and

Bummerwood.

FIG. B. Cross sections through two long leafpine stringers. Note

narrow rings especially in sapwood, showing slow growth. (Forest Service

photo.)

(Facing page 36.)

PLATE V

I I Mt

tt if M lift I

p \*

""1 \_ l M 1 1 t i

\*\*\*\*'\*

i t i

FIG. C. Cross section through the summerwood of larch (greatly magni-

fied) showing slits in cell walls. (Forest Service photo.)

FIG. D. Showing ease with which chestnut peels in the spring. (Author's

photo.)

THE EFFECT OF THE STRUCTURE OF WOOD 37

they afford channels for the ready penetration of the preserva-

tive. Some experiments have been made at the U. S. Forest

Products Laboratory to determine the effect of resin in the

ducts upon the entrance of coal-tar creosote. It was found that

such resin, particularly when it is old, has a very marked effect

in retarding the entrance of the oil. When the test blocks of

wood were first extracted with a resin solvent and then dried, the

creosote entered the wood very easily.

The position of the resin ducts in the wood affects very materi-

ally the character of the treatment. Thus, in longleaf pine the

resin ducts are largely in the summerwood. This tends to make

the summerwood more penetrable than the springwood even

though it is much denser. Some exacting tests have been made

by C. H. Teesdale to secure definite information on this point.

Pieces of the summerwood of loblolly pine which had a specific

gravity of 0.95 and pieces of springwood cut from the same speci-

mens which had a specific gravity of 0.39 were impregnated at

the same time with coal-tar creosote. The summerwood ab-

sorbed 1.8 times as much creosote as the springwood. There is

little doubt but what the resin ducts had much to do with this

difference and it is largely because of them that longleaf pine

paving blocks often show a " banded" treatment. In redwood

the cells occur mostly in the springwood and in this species a

better absorption and penetration of preservative is secured in

the springwood than in the summerwood.

The resin ducts also occur in certain species in the medullary

or pith rays. These are layers of cells which radiate from the

circumference of the tree to the center. In all coniferous woods

which possess such ducts, good radial penetration of the preserva-

tive is secured (from the outside toward the center). This fact

is of considerable importance commercially because in order to

secure good treatments, especially in round timbers like poles or

piles, it is essential to peel all of the bark off them; otherwise

the ends of the ducts will be plugged by the bark and little or

no penetration at that point secured. It is believed that care-

lessness in peeling such woods is one cause of the rapid destruc-

tion of creosoted piling, as it leaves streaks of untreated wood

extending to the interior of the stick and thus affords avenues of

attack by marine borers. Pieces of wood 2 X 4 X 25 inches

were impregnated by Teesdale with coal-tar creosote under

identical conditions. Those which contained radial resin ducts

38 THE PRESERVATION OF STRUCTURAL TIMBER

were penetrated radially from one-fourth to three-fourths as

far as they were longitudinally. In those woods which had

no radial ducts, the radial penetration varied from one-

twentieth to one one-hundred twentieth of the longitudinal

penetration. All of the pines, larches, and spruces belong to the

former class, while the hemlocks belong to the latter.

The Effect of Pits upon Injection. The penetration of pre-

servatives in woods containing vessels and resin ducts can largely

be explained by their presence. In certain woods, however,

where neither of these are present or where they are restricted,

the manner in which penetration

occurs is not easy of explanation.

According to Bailey, 1 " whenever pre-

servatives are injected rapidly into

green or seasoned wood, the pene-

tration takes place primarily through

the cavities of the cells, and the pre-

servatives pass from one cell to an-

other through the bordered pits."

These bordered pits may be likened

FIG. 4 . -Diagrammatic to microscopic " valves " occurring in

drawing of pit membrane the walls of the cells. (See Plate IV,

?\* F "> When the cells function a\*

in sapwood, the passage of liquids

through the pits is more or less controlled by the "torus,"

which is a thickening of the middle portion of the cell wall.

When the cells are inactive, as in heartwood, the torus ceases to

move and frequently becomes fastened to the pit, thus more or

less effectively closing the opening to the passage of liquids.

Bailey further states that the membranes of the bordered pits

are not always entire but possess numerous minute perforations

(Fig. 4). "In green wood the bordered pits and membranes are

very permeable to aqueous solutions, but are comparatively

impervious to undissolved gases and to oils. This is due to

capillary or surface tension phenomena and the valve-like action

of the torus." The experiments of this investigator throw much

valuable light upon the perplexing problem of the penetration of

wood and account for some of the results secured in its treatment.

l "The Preservative Treatment of Wood," by Irving W. Bailey, Harvard

School of Forestry, 1913.

THE EFFECT OF THE STRUCTURE OF WOOD 39

The Effect of Cell Slits upon Penetration. Experiments con-

ducted by Tiemann of the U. S. Forest Products 'Laboratory 1

show that the walls of wood cells frequently slit open in drying.

These slits as a rule are more discernible in thick-walled cells

than in thin- walled cells. (See Plate V, Fig. C.) Their presence

has been advanced by Tiemann and the author as a possible means

of aiding certain liquids to penetrate wood substance, because they

furnish points of weakness in the cell wall.

The Effect of the Chemical Composition of the Cell Wall

upon Absorption. All the phenomena noted above relate to the

physical structure of wood in relation to its absorption of liquids.

In addition to them, it is probable, although by no means proven

as yet, that the composition of the cell walls in various woods

exerts a strong influence upon the manner in which they absorb

preservatives. Thus, when the walls are reenforced by subse-

quent deposits of wood substance, it is quite likely that a dif-

ferent effect is produced than where no such thickening occurs.

In addition, the chemical composition of the various layers may

be different, as well as the character of the materials deposited

upon them. Their combined action, therefore, in retarding

oils and water solutions may be a variable one, and hence the

character of the absorbtion and penetration obtained may also

vary. To just what extent this is true is not known. This

problem still furnishes a fertile field for original research.

It can be seen from the above discussion that the manner in

which preservatives penetrate wood is very complex. No single

factor in itself entirely explains it, so it can be accounted for only

by taking several or all of them into consideration.

1 Bulletin 120, American Railway Engineering Association, 1911.

CHAPTER IV

THE PREPARATION OF TIMBER FOR ITS PRESERVA-

TIVE TREATMENT

The Cutting Season. There has been much discussion con-

cerning the effect of cutting timber in various seasons upon its

durability. The consensus of opinion gives preference to winter.

This is undoubtedly correct in that timber cut at this period

is more liable to be in better condition than that cut at any other

season. In so far as the contents of the wood cells are con-

cerned, timber cut in winter, as a rule, contains its largest per-

centage of organic materials, such as starch, these being stored

in the cells as available plant food for the next spring. These

organic materials are also readily attacked by wood-destroy-

ing organisms so that a given amount of winter cut wood, other

things being equal, contains more food material for these de-

structive agents than wood cut at other times of the year.

On the other hand, wood cut in winter is least subject to im-

mediate insect and fungous attack because, during winter, insect

and fungous activities are at a minimum. Moreover, freshly

cut wood is less able to offer resistance to the attacks of these

agents than thoroughly seasoned wood.

Aside from danger from insect and fungous attack, the problem

of seasoning is also of great moment, and, as will be shown later

on, wood cut during spring, summer, and early autumn dries

much more rapidly than wood cut in winter. This rapid drying,

unless it is properly safeguarded, will often cause green timber to

check and split, thus not only weakening the wood but also

exposing more of its surface to attack.

The season of cutting also has a marked effect upon the

reproductive power of the forest, especially if the forest is com-

posed of species that sprout from the stump, like most of our

hardwoods. Sprouts from winter cut stumps are usually much

more vigorous and thrifty than those from stumps cut at other

seasons; in fact, the sprouting capacity of stumps can often be

killed by cutting timber in summer or early fall.

40

THE PREPARATION OF TIMBER 41

Contrary to popular belief timber cut in winter often con-

tains as much water and at times, more water, than timber cut

at other periods. The common expressions that in winter the

"sap is down" and in summer "up" account for this fallacy,

whereas in reality it is only dormant, so that if the tree is in-

jured in this period the sap does not readily exude from it. The

author made some careful tests along these lines when cutting

chestnut timber for poles in Maryland, and found that those cut

in winter actually contained more water than those cut in

summer.

Generally speaking, it is easiest to remove felled timber from

the forests in winter because of climatic and labor conditions,

although in the South, where no marked changes occur, this of

course is not true. In certain northern states, as in cedar opera-

tions in the Lake Region, it is almost impossible to log except in

winter. Furthermore, the large amount of timber cut by farmers

is felled by them during the winter months because they are not

then engaged in caring for their food crops.

Peeling Timber. Practically all preservative processes require

the complete removal of bark before the wood can be successfully

treated. Generally, the best time to remove the bark is im-

mediately after the tree is felled. In sawed products the bark

usually is removed at the mill in slabbing the log. Bark can be re-

moved most easily in the spring (see Plate V, Fig. D), but adheres

tenaciously to the wood when cut at other periods. It is com-

paratively easy for this reason to tell timber cut in the spring.

The early removal of the bark lessens the weight of the product,

decreases the danger from insect and fungous attack, and causes

the wood to dry more rapidly. Because of the great resistance

of bark to penetration by liquids, it is essential to carefully and

completely remove it, if good results in treatment are to be

secured. This is particularly true for those woods which are

penetrated readily in a radial direction, as the pines. For species

like the tamarack, spruce, etc., whose radial penetration is small,

this precaution is not so essential. The author has seen pine pil-

ing impregnated with 18 pounds of creasote to the cubic foot that

had absolutely no penetration of the oil under strips of bark less

than 1/16 inch in thickness. (See Plate VI , Fig . A . ) The inner bark

or "skin' l is particularly resistant, and it is believed that its presence

is at times one cause contributing to the rapid failure of those

treated piles which are destroyed after a few years' service. Too

42 THE PRESERVATION OF STRUCTURAL TIMBER

often the treating engineer counts on the bark becoming loose

during the treatment in the cylinder, and although this frequently

occurs, nevertheless it often adheres firmly to the wood and thus

results in poor workmanship.

It sometimes happens that better treatments can be secured

by seasoning wood with the bark on, rather than with the

bark off. This was true in some tests made by the Chicago

and Northwestern Railroad on hemlock and tamarack ties at

Escanaba, Mich. It appeared that the ties peeled immediately

after cutting seasoned so rapidly that the outer layers of the

wood hardened and became much more resistant to the absorption

of the preservative than those in which the bark was removed

just before the ties were run into the treating cylinder. This,

however, is an exception to general practice.

Generally, bark is removed by hand, the only tools being

a spud, draw knife, or axe. There is a good opportunity for the

invention of some machine that will economically and satisfactor-

ily remove bark and thus decrease the labor involved in present

methods.

Seasoning Timber. Wood in all living trees contains water.

The amount of water thus contained varies with the kind of wood,

the conditions under which it grew, and the season. It fre-

quently happens that in the sapwood, and sometimes in the heart-

wood, the weight of the water is more than the weight of the wood

substance itself. Thus the gums when dried may weigh less

than half their weight at the time of cutting. In general,

as soon as timber is cut it begins to lose the water it contains.

This loss of water is called " seasoning." In addition to the loss

of water, other changes occur, such as a fixation or transformation

of organic and inorganic materials stored in the wood, and an

apparent " oxidation" of the wood substance. The objects of

seasoning are, in brief:

1. To prevent injury by insects and decay before the timber is

placed in service.

2. To increase the durability of timber in service.

3. To prevent shrinking and checking of the wood in service.

4. To increase the strength of the wood.

5. To decrease the weight of the wood and hence reduce shipping

charges.

6. To prepare the wood for its injection with preservatives and

for other industrial uses.

THE PREPARATION OF TIMBER 43

It is well known that if wood can be kept dry it will not decay.

House furniture, for example, under ordinary conditions of use

will, so far as decay is concerned, last indefinitely. It is solely

because of their protection from moisture that the wooden coffins

used by the Egyptians have been preserved to us. Water in

wood is an absolute requirement for decay. Wood which can

be kept dry will never decay. Just how much water in wood is

necessary in order to meet the requirements of wood-destroying -

fungi is not known, but from a few tests which the author has

made it appears that it is in general more than 20 percent.

It has almost unanimously been held that seasoned wood

placed in conditions of service where it is subject to decay wil-

last longer than unseasoned wood. While this is sometimes

true, nevertheless the importance which has been attached

to air seasoning as a means in itself of prolonging the life of wood

has probably been exaggerated. Authentic records on posts,

poles, ties, and mine timbers kept by the Forest Service indicate

that there is little or no difference in their durability whether

they were placed green or air seasoned.

If green timber is used for construction purposes, it will almost

invariably lose water and hence check, shrink, and warp more or

less severely. In order to avoid such defects, it is policy to use

seasoned wood in place of green in all classes of construction

where they prove objectionable. Furthermore, wood which

has been seasoned prior to injection with perservative is far less

liable to check on the surface and thus expose the untreated

wood.

The effect of water in wood upon its strength is discussed in

Chapter XVIII. The decrease in weight due to seasoning is so

large as to warrant holding the timber until seasoned before ship-

ment is made. This fact is now so well recognized that it has be-

come common practice, but on account of unfavorable conditions

surrounding the seasoning of wood at the place where it is cut, the

shipment of green material is sometimes imperative. A single

carload of 30-foot chestnut poles if shipped seasoned rather than

green would save at least 150 pounds of freight per pole, or,

counting 50 poles per car, a total of 7500 pounds. This saving

even on short hauls often more than pays for the cost of seasoning

the poles and holding them in storage awaiting shipment. What

is true for poles is true even to a greater extent for smaller

products because they season more thoroughly.

44 THE PRESERVATION OF STRUCTURAL TIMBER

It is in the preparation of wood for injection with preservatives

that seasoning plays a very important part, as it is quite essential

to remove some or most of the water from the wood before the

preservative can be injected.

Water may be considered as existing in wood in two forms: (1)

as "free water" in the cell cavities and (2) as "confined water"

in the cell walls. When wood begins to season it is the free

water which is first lost. Wood can lose all of this free water

without its strength being affected. Just as soon, however, as

water starts to leave the cell walls the strength of wood begins

to increase very rapidly, and checking, warping, and splitting are

liable to occur. The point where this occurs has been called by

Tiemann the "fiber-saturation point." It varies in the different

species but in general ranges from 25 to 30 per cent moisture.

When the free water has left the wood, the wood of course con-

tains a larger air space or volume which can later be occupied by a

preservative like creosote. This may be illustrated as follows:

Assume the oven-dry weight of shortleaf pine is 32 pounds per

cubic foot, that solid wood substance weighs 97 pounds per

cubic foot, that green shortleaf pine contains 21 pounds of water

per cubic foot; then about two-thirds of a cubic foot of green

pine would be wood substance and water, leaving about one-

third of the volume air space. If, now, all the free water were

removed, almost two-thirds of the cubic foot of wood would be

air space capable of occupancy by the preservative.

Aside from the loss of water which takes place in seasoning,

other changes occur. The bordered pits become more or less

ruptured, or changed in position, so that passage of liquids

through them is facilitated or retarded. Furthermore, the wood

cells frequently check as well as the surface of the wood. As a

result of these changes which occur in seasoning wood, practically

all processes now call for some kind of a seasoning treatment

before the preservative is injected. The chief exception occurs

in the Boucherizing process, which is at present of no com-

mercial importance in the United States. Five methods of

seasoning wood are now practised : Open-air seasoning, seasoning

in hot air, seasoning in saturated and superheated steam, and

seasoning in oil.

Open-air Seasoning. Open-air seasoning, as the term implies,

consists simply in piling the timber out of doors where it is

exposed to the atmosphere. When its moisture content reaches

THE PREPARATION OF TIMBER 45

an equilibrium with the atmospheric moisture, the wood is said

to be "air seasoned. " It can thus be seen that the amount of

water in air-seasoned wood varies considerably. Thin pieces of

wood 2 inches or less in thickness in our northern climates,

when air seasoned, contain about 10 to 15 percent of water.

Thicker pieces like poles, ties, etc., are, under the same

conditions, "air seasoned" when they contain 25 to 35 percent of

water. Some Douglas fir bridge stringers 8 inches X 16 inches

in cross section contained over 25 percent of moisture after being

exposed to the atmosphere for 2 years.

The open-air seasoning of wood is the method most commonly

practised in the United States to prepare it for injection with

preservatives. It is cheap, safe to operate, and very efficient.

The chief objections to it are the long length of time the wood

must be held before it seasons, thus tying up capital in wood

and yardage, and dangers from fire, insects, and decay while

stored during the seasoning period. In some parts of our

country where the climate is warm and damp it is impossible to

air-season certain woods without having them attacked by

incipient decay. Other objections to air seasoning are an inability

to fill "rush orders" and injury from checking, although this

latter objection can be largely overcome by proper methods of

piling.

To most efficiently season wood in the open air, it is necessary

to subject it to a free circulation of air. Stagnant air is very

prone to foster decay. The seasoning yards should, therefore,

be in situations exposed to the sun and wind. All of the timber

should be raised off the ground and should be piled as openly as

possible without producing too rapid drying, which might result

in serious checking or splitting. Another precaution is to keep

the yard free from water, vegetation, and decaying wood.

The rate at which wood seasons depends upon many factors,

chief of which is the time of the year. Spring and summer are

in general the two periods when most rapid seasoning occurs.

More detailed information for the various forest products is given

in the following pages under the discussion of these products.

When wood has once air seasoned, any water which it might ab-

sorb from rains, for example, is quickly lost. Air-seasoned poles

tested by the author absorbed 15 pounds of water during a

thunderstorm but lost all of it within 24 hours after the rain

stopped. It is by no means necessary to season wood until it

46 THE PRESERVATION OF STRUCTURAL TIMBER

has lost all its free water before it is in satisfactory condition

for treatment. Large products such as ties and poles may have,

when " air-seasoned," an average of 30 percent of water, but

the distribution of this water may vary from 5 to 10 percent

in the outer layers of wood as a minimum to 40 or 50 percent in

the inner layers as a maximum. If a tie or pole is of such a

nature (as is customary) that its interior cannot be treated

even if it is dry, little or no advantage is gained in attempting

to hold it until this condition of uniform dryness is reached.

The object, therefore, in open-air seasoning should be to cut

the period of drying as short as possible without decreasing the

penetration of the preservative. No fixed time can be given

for this, as it depends on too many variables which must be

worked out for the conditions at each plant.

Hot-air Seasoning. By " hot-air seasoning" is meant kiln

drying the wood. This method is now only practised in the

United States on certain kinds of lumber and small manu-

factured products. It is rarely if ever used for large products

such as piles, poles, and ties. In Europe, however, the method

is sometimes employed, especially as a final drying for timber

already partly seasoned in the open air. It is felt that the

method will not become common practice in our country be-

cause equally as good if not better results can be secured in

shorter time and at less expense by other means. The method

employed in hot-air or kiln drying consists in placing the wood

in a retort or kiln, where the air is usually heated by means of

steam coils. Circulation of the air is provided for in various

ways, either by blowers, or by cooling the air on the sides of

the kiln, or by drawing in air through vents in the bottom of

the kiln and permitting the hot air to escape through vents

in the top. Such treatment results in removing the water from

the wood in much shorter time than open-air seasoning and in

addition warms the wood for the entrance of the preservative.

Wood so heated is, however, liable to check and warp seriously

or case-harden, thus becoming weak and brash. For the treat-

ment of small products of comparatively high value, this method

gives very satisfactory results, but for dimension stock or products

it has little to commend it.

Seasoning in Saturated Steam. Next to open-air seasoning,

seasoning in saturated steam is in most extensive use in the

United States as a means of drying wood for the injection of

THE PREPARATION OF TIMBER 47

preservatives. When properly done this method gives quick

and satisfactory results. Its chief advantages are the ease,

quickness, and comparative cheapness with which the water

can be drawn from the wood, the warming of the wood prior

to its impregnation, and the sterilizing of the wood. When

this method is practised a large storage capacity for wood and

a large stock on hand are not necessary. Furthermore, "rush

orders" can be taken care of and dangers peculiar to open-air

seasoning are avoided. If steamed at too high temperatures

or for too long a period, considerable injury may result to the

strength of the wood. Steaming wood, in itself, does not re-

move water from the wood. On the other hand, it may add

water, as shown in Table 34. In practice, to remove the water

a vacuum is drawn. This lowers the boiling point of water

and materially hastens the rate at which it leaves the wood.

Structural timbers, when seasoned for the injection of pre-

servatives by the use of saturated steam, are loaded on cylinder

cars or "buggies" and run into the treating cylinder, which is

then closed and live steam admitted. The pressures used are

about 20 to 40 pounds per square inch. The wood is kept in

the steam bath for various periods, depending upon the judg-

ment of the operator, and the kind and form of timber he is

heating. It ranges from about 2 to 3 hours for ties to 10 hours

or even more for piling. Common practice in the South is to

steam pine 1 hour for each inch in thickness of the timber. Tests

made at the U. S. Forest Products Laboratory indicate that

5 to 8 hours are required to heat ties to the center by this method.

After the steam bath a vacuum of 24 to 26 inches is drawn in the

cylinder by means of a pump, and at the end of this period the

wood is ready for injection with the preservative. The length

of time the vacuum is held varies greatly, but is usually from

1/2 to 2 hours. Nothing is gained by holding it after the wood

has once reached a temperature below the boiling point of water.

Seasoning in Superheated Steam. It will be noted that

seasoning in saturated steam necessitates a vacuum in order to

remove the water from the wood. With superheated steam

this is not necessary, as it is capable of absorbing the water

vapor driven off from the wood as fast as it is formed. Some

of the early wood-preserving plants were equipped with super-

heaters, but on account of the unskilled labor generally em-

ployed, much timber was destroyed by being heated at too high

48 THE PRESERVATION OF STRUCTURAL TIMBER

temperatures and moreover upkeep charges were high. It was

largely due to such repeated losses that the use of superheated

steam in timber-treating plants fell into disrepute, until its use

has now been practically abandoned.

Seasoning in Oil. As with superheated steam, seasoning in

oil does not require a vacuum in order to remove the water from

the wood. After the wood is run into the treating cylinder and

the doors closed, creosote oil is admitted until the cylinder is

almost full and all the wood is submerged. Steam is then

passed through coils in the bottom of the cylinder and the oil

raised in temperature to about 220 F. This gradually vaporizes

the water in the wood and the water and certain oil vapors are

passed through condensers where the oil can be separated from

the water by allowing it to settle. The bath in hot oil is con-

tinued, until, in the opinion of the operator, most of the water

in the wood has been removed. Some operators continue the

seasoning in oil until the amount of water condensed does not

exceed one-sixth of a pound per cubic foot of wood per hour.

The cylinder is then filled with oil and the preservative injected

under pressure. At the present time this method of seasoning

is practically confined to certain plants on the Pacific Coast,

where it is claimed to give very good results, especially with

refractory woods like the Douglas fir. In addition to season-

ing the timber, this method also warms it for the reception of

the preservative. It appears that this process may cause the

wood to check microscopically and hence reduce its strength.

An improvement in this process has recently been developed.

It consists in boiling the timbers in creosote under a vacuum.

This, of course, enables the water in the wood to be removed at

lower temperatures than if boiled under atmospheric pressure.

Tests made on Douglas fir timbers treated by this new method

show but little or no decrease in strength over untreated timbers.

This, however, is discussed at length in Chapter XVIII.

Soaking Timber in Water Preparatory to Seasoning It. If

freshly cut timber is soaked in water some of the soluble con-

stituents which it contains will be leached from the wood. The

wood cells will, therefore, contain a larger percentage of air space

so that resistance to absorption of preservative after the wood has

been seasoned will be decreased. In order to make this difference

one of any appreciable amount, it is necessary to soak the timber

for long periods of time. In addition to rendering the wood more

THE PRESERVATION OF STRUCTURAL TIMBER 49

permeable to preservatives, it also causes the wood to season

with accelerated rapidity after it is removed from the water.

Short periods of soaking varying from 2 weeks to 2 months are

productive of little or no beneficial results. This method has

been tried on poles and ties, and although they lost weight very

rapidly when first removed from the water, nevertheless they

failed in the long run to show any appreciable decrease in weight

over similar timber not soaked. Furthermore, the amount of

preservative which they absorbed in excess of that absorbed by

timber unsoaked was so small (about 1/2 of 1 percent) as to be of

no practical value. Unless a treating plant is so situated that

it can afford to hold timber in storage for long periods prior to its

impregnation, or unless water soaking can be conducted (as in

rafting timber) at a very small or no extra cost, it appears that

water soaking as a means of preparing wood for treatment is not

justified by the results secured.

CHAPTER V

PROCESSES USED IN PROTECTING WOOD FROM DECAY

Although a great many processes have been and are practised

in protecting timber from decay, they may be logically divided

into two rather distinct groups, based upon the character of the

protection given. These may be termed the superficial and the

impregnation processes.

Superficial Processes. By superficial processes is meant those

processes of treatment which aim to protect the wood by simply

giving it a surface protection. Since in sound timber decay can

occur only from external attack, it is agreed that if the surface

of the wood is rendered resistant to the attack of wood-destroy-

ing fungi, the entire timber will remain sound. This contention

is without doubt correct, and when the surface of a timber is so

preserved and the surface protection is completely maintained,

the timber may be made to last indefinitely. Unfortunately,

timbers so treated are very apt to have the protective coating

broken, either through abrasion or checking. When this happens

the untreated interior is at once subject to attack, and the

effect of the protecting shell may be completely destroyed. In

this condition, the timber may be very dangerous, as it gives

the appearance of being sound although it may be entirely de-

cayed in the interior, and hence escape detection. The writer

has seen mine timbers painted with a preservative that appeared

on outward inspection to be perfectly sound, but when bored

into, were found to be little more than hollow columns because

the wood beneath the surface had entirely rotted. Furthermore,

it is not always possible to detect incipient decay in wood to be

treated. In fact, this is often impossible without a microscopic

examination, which is, of course; impracticable in practice. If

such wood is given a superficial treatment, the incipient decay

in the interior is liable to continue its growth and thus the

soundness of the wood will eventually be destroyed. These

objections can be levied against all superficial processes.

On the other hand, it is often impossible to treat wood in any

50

PROTECTING WOOD FROM DECAY 51

other way because of excessive cost. Superficial processes

are of special usefulness when only a small quantity of wood is to

be treated. They are cheap, easily conducted, and under

ordinary conditions, efficient. When the surface of the wood

is not subject to injury by abrasion or checking they succeed in

greatly prolonging the life of the wood.

Charring. Charring is one of the oldest methods of pro-

tecting timber from decay that has been practised. The wood is

held over a fire until the outer fibers are charred. This process

practically surrounds the wood with a layer of charcoal which is

not attacked by wood-destroying fungi. The heat, furthermore,

destructively distills a portion of the wood and forms products

which may be toxic to fungi. The depth to which the wood

is usually charred varies from about 1/8 to 1/2 inch. Much more

effective results can be secured by charring seasoned wood rather

than green wood, as the latter will dry out on exposure and de-

velop surface checks, which will break the continuity of the

charred surface and thus expose the untreated interior. When

air-seasoned wood is properly charred its life is increased. The

treatment is very cheap and easily applied. It has a disadvantage,

however, in that it completely destroys the strength of the

outer fibers of wood and so weakens the wood. Furthermore,

the beneficial effects secured from it are seldom of much

consequence.

Brush Treatments. Brush treatments are more extensively

practised than any other of the superficial processes. (See Plate

VI, Fig. B.) As the term implies, they consist in painting the

preservative on the surface of the wood with a brush. A large

variety of preservatives are applied in this manner, such as calci-

mine, wood preserving oils, paints, etc. Best results are secured

by treating only air-seasoned wood, thus avoiding danger of

subsequent checking. Moreover, the preservative will penetrate

dry wood better than green. With certain preservatives, such

as creosote, most beneficial results are obtained by heating them

to 180 or 200 F. before they are painted onto the wood, as they

penetrate more deeply when applied hot. The penetration,

however, seldom exceeds 1/4 inch and is generally much less.

Brush treatments can be easily applied, are cheap and con-

venient. In using them care should be taken to coat all checks,

cracks, and joints thoroughly with the preservative. The pre-

servative should not be applied when the wood is frozen and

52 THE PRESERVATION OF STRUCTURAL TIMBER

wet. If an efficient preservative is used and properly applied

and the wood after treatment is protected from abrasion, very

satisfactory results can be expected. Unless these precautions

are exercised, the treatment may do no good whatever, but may

actually result in harm. Thus, unseasoned telephone poles have

been examined which were coated with ordinary paint and

which had decayed quicker than similar poles set unpainted.

In this case the poles checked after they were treated, allow-

ing fungi to enter, while the paint formed an almost imper-

vious coating which kept the wood moist and hence in a very

favorable condition for rapid decay.

Dipping. In view of the difficulty of working the preservative

into checks and cracks, dipping gives more effective results than

brush treating. To dip wood, however, it is necessary to have

some form of tank which will hold the preservative and which is

large enough to allow the wood to be submerged. This method

of treatment is particularly adapted to small products such as

shingles and posts. The same precautions mentioned under

brush treatments apply with equal force to dipping treatments.

On account of the greater certainty with which the entire surface

of the wood can be treated, dipping is safer to use than brush

treating and, in general, yields better results.

Impregnation Processes. All impregnation processes aim not

only to protect the surface of the wood from attack but also to

force the preservative deeply into the wood. Thus, should the

surface of the wood become broken, the fibers beneath the

surface containing the preservative will still offer a strong

resistance to decay. For this reason all impregnation processes

are, as a rule, more efficient than superficial processes.

The depth to which the preservatives will penetrate depends on

many factors, chief of which are the kind and condition of the

wood, the character of the treatment, and the kind of pre-

servative used. Resistant woods like heart Douglas fir or white

oak may, under similar conditions, only receive a superficial

treatment.

By far the largest quantity of wood treated in the United

States is impregnated. Impregnation processes are much more

expensive than superficial processes and require more or less

elaborate apparatus. In connection with large operations,

however, they are unquestionably the better ones to use and the

results secured by them are the best obtainable. For purposes

PLATE VI

FIG. A. Sections of creosoted piling showing effect of thin strips of bark

adhering to the wood. (Photo through courtesy Southern R. R.)

FIG. B. Brush treating poles. (Forest Service photo.)

(Facing page 52.)

PLATE VI

FIG. C. An open tank plant for treating the butts of poles California.

(Forest Service photo.)

FIG. D. Wood preserving plant of the C. B. & Q. R. R., Galesburg, 111.

(TTnrpst. Sprvip.fi

PROTECTING WOOD FROM DECAY 53

of discussion, impregnation processes may be divided into two

classes, (1) nonpressure processes, or those using no " artificial"

but only atmospheric pressure, and (2) pressure processes, or

those using " artificial" or pressures greater than atmospheric.

Nonpressure Processes. These processes either rely upon

the absorptive properties of the wood for the penetration to be

secured, or upon the pressure of the atmosphere to force the

preservative into the wood. Heavy apparatus to withstand pres-

sures is therefore unnecessary and this fact enables plants

operating on this basis to be built at lower cost than those operating

on high pressures. This is one of the chief advantages claimed

for this method of treatment. The apparatus may be an open

vessel such as a barrel or a vat, or a cylindrical retort of metal

similar in form to those used in the pressure processes. For the

treatment of small quantities of timber, or when salts markedly

corrosive to iron are used, or when only a portion of the timber

is to be treated, the rest being left untreated, these processes

give very satisfactory results. As a rule the penetrations and

absorptions obtained with them are not as deep or as uniform as

those obtained in the pressure treatments, although, at times,

equally as good results in this respect are secured. The time

of treatment is also generally longer and the flexibility and con-

trol of the plant less than with pressure processes.

Kyanizing Process. This process has been in use since 1832

when it was patented in England by John H. Kyan. It was

employed in the United States as early as 1840 and is claimed to

be the oldest method of treating timber now practised in our

country. The process consists in steeping timber in a solution

of bichloride of mercury at atmospheric temperature and pres-

sure. At Portsmouth, N. H., and Lowell, Mass., the treating

apparatus consists of solid granite tanks laid in Portland cement

and coated on the inside with tar applied hot. The wood to be

treated is piled in the tanks with laths between each layer so as

to allow the free circulation of the solution, which is afterward

pumped into the tanks. The strength of the solution is usually

about 1 percent. The timber is kept submerged for various

lengths of time but a rough estimate is to steep it 1 day plus a

day for each inch in thickness. Thus 2-inch plank is steeped 3

days, 6-inch timber 7 days, etc. The depth to which the

solution penetrates varies largely with the kind of wood treated

but ranges from about 1/10 to 1/4 inch. The extremely poison-

54 THE PRESERVATION OF STRUCTURAL TIMBER

ous nature of mercuric chloride makes it imperative to handle it

with caution. Its corrosive action, moreover, makes its use

impracticable in iron or steel vessels unless specially prepared.

Like all treatments employing a water-soluble salt, it cannot be

used to best advantage if the timber is to be set in wet situations,

because the solution will leach from the wood. When the

treated wood is placed in fairly dry situations, very good results

have been reported. There is also a liability of the salt gradually

crystallizing on the surface of the wood where it may prove

dangerous to animals should they lick it. Although large quanti-

ties of timber have been treated by this process, its use in this

country has never been very extensive. This is perhaps largely

due to its extremely poisonous character and the comparatively

long time it takes to treat the wood. Cases are on record where

it is reported that spruce posts, Kyanized, have remained service-

able for over 50 years, and hemlock ties for over 13 years.

Open-tank Process. Under this heading we will consider

several processes which are very similar so far as the principles

of treatment are concerned. They are the Seeley, Giussani,

and nonpressure processes. All of these processes differ in prin-

ciple from the Kyanizing process, in that they aim to employ the

pressure of the atmosphere in forcing the preservative into the

wood. (See Plate VI, Fig. C.) Green or air seasoned wood may be

used. It is first placed in a bath of hot oil and held for vari-

ous periods, the object being to drive a part of the air, sap, and

water out of the wood and thus bring the wood cells into a rarified

condition. The heated timber is then quickly submerged in a

cool preservative, whereupon a rapid contraction of the air and

water vapor in the wood occurs, thus " drawing in" the

preservative.

Professor Seeley of New York is reported the first to make

use of this principle on a commercial scale, he having secured

patents on it in 1868. Seeley used creosote oil and claimed to

treat either green or seasoned wood. (See Chapter I for

further discussion.)

About 1898 Tomasco Giussani invented a similar process

in Italy which he claimed made possible the impregnation of

timber with dead oil of tar alone, with salt solutions alone,

or combinations of the two. Open tanks are used and the process

is a continuous one. The timber either green or seasoned is

carried by a conveyor to the first tank, which contains heavy

PROTECTING WOOD FROM DECAY 55

creosote oil heated to about 280 F., where it is kept submerged

until ebullition ceases (a period of from 1 to 4 hours).

It is then conveyed mechanically to another open tank con-

taining cold creosote oil or zinc chloride or any other preserv-

ing salt until the desired absorption has been obtained (a period

of from 2 to 3 hours), after which the treatment is finished

and the timber is mechanically removed from the treating vats.

This process was demonstrated at the St. Louis Exposition in

1904 where it was awarded a Grand Prize. Two plants operating

on this process are located in Rome and Milan, Italy, but so far

as the author knows, it is not practised in the United States. By

this method of treatment deep penetrations of the preservative

are possible, which, in certain timbers like loblolly pine ties,

may extend to the center. In plants operating on this basis the

diffusion and absorption of the preservative cannot be as practi-

cally controlled as in pressure plants, but for a low initial cost of

installation they are efficient.

In 1904 the U. S. Bureau of Forestry (now the Forest Service)

conducted an extensive series of tests with what is called the

"open-tank" process at the St. Louis Exposition. 1 This method

of treatment has since been extensively tested by the Forest

Service with a view to perfecting it and evolving a process which

could be efficiently used by the small consumer. It secured its

name from the character of the apparatus in which the treatments

are made, these being open tanks of any convenient size and shape.

Later experiments lead to the use of closed tanks or cylinders for

certain treatments and the term " nonpressure " was employed

to designate the process carried on in them. In principle, there-

fore, it differs in nowise from any of the " open-tank" processes.

In open-tank treatments the Forest Service recommends only the

use of air-seasoned wood. This is subjected to a bath in hot

creosote, but temperatures above 250 F. are not recommended

as they are liable to injure the wood. The wood is then either

allowed to remain in the hot oil, which is gradually cooled, or

else changed to a tank containing cool oil, or cool oil is pumped

into the tank containing the timber after the hot oil has been re-

moved. The process is adapted to the use of various preserva-

tives such as creosote, crude oil, zinc chloride, etc. Very good

penetrations are secured, in fact these compare favorably with

Circular 101, "The Open-tank Treatment of Timber," by Carl G.

Crawford, Washington, D. C.

56 THE PRESERVATION OF STRUCTURAL TIMBER

those secured in pressure processes. This process is admirably

adapted to the treatment of poles and posts where only a portion

of the stick is to be treated. Plants operating on this basis are

comparatively cheap. It is possible to control fairly accurately

the character of the penetration and absorption, especially in

woods which lend themselves readily to treatment, like sap pine.

For example, if a deep penetration is desired with a comparatively

small absorption of oil, the timber should be left in cool oil for only

a short period after it is removed from the hot bath. Another

way is to re-treat the wood after it has been treated in cool oil.

This tends to drive out a part of the oil in the wood provided it

is removed from this second hot bath while it is still hot. If

a heavy absorption is desired, the wood should be heated

thoroughly and then submerged in cool oil until the temperature

of the wood has reached that of the oil.

If it is desired to impregnate the wood with a water-soluble

salt like zinc chloride, this may be done by boiling the wood in

the solution (which, however, is very apt to weaken it) and then

allowing it to cool, or by boiling the wood in oil for a short

time and then submerging it in a solution of the salt. In this

way a deep penetration of the salt can, at times, be secured,

while the outer portion of the wood will have an added protection

due to the small amount of oil which it contains.

The length of time required to treat wood by the open tank

method is very variable, but a hot bath of 1 to 3 hours

followed by a cool bath of the same or a longer period is usually

sufficient. A number of open-tank plants are now in operation

in the United States, chiefly by farmers and mine and telephone

companies.

Pressure Processes. All processes so classed rely upon the

use of pressures above atmospheric in order to force the pre-

servative into the wood. (See Plate VI, Fig. D.) In general, best

results are secured by such treatment, although it is by no

means possible to satisfactorily penetrate all woods even with

the use of high pressures.

Bethell (Full-cell Creosote) Process. This process is named

after John Bethell who took out patents in England in 1838.

It is commonly referred to in our country as the " full-cell

process." Either green or seasoned timber can be treated by

this process, creosote oil (dead oil of coal-tar) being the pre-

servative used. The timber to be treated is loaded upon steel

PROTECTING WOOD FROM DECAY 57

cars or " buggies, " which are run into horizontal steel cylinders

usually 7 feet in diameter by 132 feet long. Their length, how-

ever, varies from about 50 to 180 feet and diameter from 6 to 9

feet. If the timber is green, it is subjected to a bath of live steam

for several hours, after which a vacuum is drawn by means of

pumps. This also is held for one or more hours according to the

judgment of the operator. If the timber is air seasoned, the

steam bath is generally omitted. Creosote oil is then run or

pumped into the cylinder and a pressure of 100 to 180 pounds

applied until the gauges show the desired amount of oil has been

forced into the wood. The excess oil is then drained from the

treating cylinder and the timber is allowed to drip for a short

period, after which the process is ended and the charge is removed.

Many treating engineers draw a vacuum in the cylinder after

the excess oil has drained from it, as this tends to hasten the

drip and dry the timber. The Bethell or full-cell process is

considered the standard process of treating timber with creosote,

and the most effective results in prolonging the life of wood

have been secured by it. On account of the relatively large

amount of oil which the ties absorb, the process is, however,

the most expensive and for this reason several modifications

have been made.

Boiling Process. This process was patented in the United

States by W. G. Curtis and John D. Isaacs and the patent

number was reissued November 1, 1895. It is used almost

exclusively on the Pacific Coast, largely for the treatment of

Douglas fir. Either green or seasoned wood can be treated,

although the former is at present in more extended use. The

wood is run into cylinders as in the Bethell process and im-

mersed in creosote oil heated at the start to about 160 F. A

space of about 10 inches is left clear from the top of the oil to

the top of the treating cylinder. The oil is heated by means of

steam coils in the bottom of the cylinder and the temperature

gradually raised to about 225 F. The vapors of oil and water

passing over are condensed in a surface condenser. The oil is

kept at a temperature of about 225 F. until the rate of evapora-

tion does not exceed about 1/6 of a pound of water per cubic

foot of wood in the charge per hour; this being to drive the sap

and water out of the wood. The treating cylinder is then

filled with creosote oil at a pressure of 5 pounds per square

inch, the temperature falling to about 200 F. The pressure

58 THE PRESERVATION OF STRUCTURAL TIMBER

pump is then started and held at about 150 pounds per square

inch until the gauges show the desired amount of oil has been

forced into the timber. After injection, the pressure is slowly

released through an overflow pipe, the excess oil drawn from the

cylinders, and the charge removed. In treating dry sawn

timber, temperatures above 214 F. and pressures over 120

pounds per square inch are not recommended by the advocates

of this process. It can thus be seen that the boiling process

resembles the Bethell process except for the preliminary treat-

ment which the timber is given. (See page 48 for improvement

in this process.)

The Buehler Process. Walter Buehler secured two patents

in the United States on September 22, 1908 (Nos. 899237 and

899480) on the process which bears his name. Either green

or seasoned timber can be treated, the preservative being

creosote oil. The process is not at present in extended use.

Green or water-soaked timber is treated as follows. It is run

into the treating cylinder as in the Bethell process and im-

mersed in creosote heated to a temperature of not less than

140 F., the cylinder being completely filled with oil. The

temperature of the oil in the cylinder is kept gradually rising

as fast as the condensation will permit until it reaches between

220 and 260 F. It is then held to maintain a Tegular and

constant temperature within the cylinder. During this season-

ing period the gauge on the cylinder should show a pressure of

not more than 5 pounds. The maximum temperature is

maintained until the condensation in the hot well shows the

interior of the wood "to be sufficiently dry/' when the steam

in the coils is released and the cylinder filled with creosote, the

temperature being lowered to about 200 F., when the pressure

pump is started and the oil is forced into the wood until the

desired amount has been absorbed. The cylinder is then

drained of excess oil and an air pressure of 15 to 25 pounds per

square inch is applied and held to penetrate all of the wood.

This completes the process.

For air-seasoned timber, a vacuum of at least 20 inches is

drawn after the wood is placed in the cylinder, and held for at

least 20 minutes. Creosote is then admitted and pressure ap-

plied with the force pump until the proper amount of oil has

been injected. The excess oil is then drained from the cylinder

and an air pressure of 15 to 25 pounds is maintained until the

PROTECTING WOOD FROM DECAY 59

maximum pressure remains constant for at least 15 minutes, after

which the treated timber is removed from the cylinder.

Tests made by the author showed that air pressures applied

to wood freshly impregnated with creosote forced much of the

creosote out of the wood after these pressures were released and

greatly prolonged the time it took the timber to drip.

The A. C. W. Process. In the A. C. W. process, so called

after the American Creosote Works in Louisiana in which it is

practised, after the timber has been subjected to a preliminary

seasoning of live steam, and after a vacuum has been drawn, air

is forced into the cylinder until a pressure of about 15 pounds is

obtained. Creosote is then admitted, the air pressure being

still maintained to prevent excessive or unequal absorption of

the oil while the cylinder is being filled. The surplus air is al-

lowed to escape through a pop valve at the top of the cylinder.

When the cylinder is full of oil a pressure of 100 pounds or more is

applied with a pump until the proper amount of the creosote has

been forced into the timber. The oil is then run from the treating

cylinder and an air pressure of 60 to 80 pounds applied. This

is introduced to drive the oil into the wood to a greater depth

and to secure greater uniformity of treatment.

The process is not in general use and is practically confined to

the plant operated by the American Creosote Works.

The Lowry Process. This process is covered in the United

States by Patent No. 831450, issued to C. B. Lowry under date of

September 18, 1906.

Air-seasoned timber is loaded on tram cars and placed within

the treating cylinder. The cylinder is then filled from the

charging tank with creosote oil at a temperature not to ex-

ceed 200 F. The main line is then closed and oil from the

charging tank is forced by pressure pumps into the retort

until the timber has taken oil to the point of refusal, or a

predetermined amount. The pressure and temperature within

the retort are controlled so as to give a maximum penetration

of the oil. The pressure is then released and the free oil in

the retort is drained off. A vacuum of sufficient degree and

duration is then drawn in the retort to recover that portion

of the free oil in the timber above the specified amount. The

recovered oil is then drained off from the retort and the charge

is withdrawn. The Lowry process may be termed an " empty-

cell" process in that it aims to secure a deep penetration of

60 THE PRESERVATION OF STRUCTURAL TIMBER

creosote without consuming as much of it as the Bethell or full-

cell process. At the present time the process is in very extended

use in the United States, particularly in treating cross-ties, eleven

plants now operating under its patent.

Rueping Process. This is also termed an "empty-cell"

process in that the object sought is a deep penetration of creosote

with a comparatively small consumption of the oil. It was

patented in the United States on September 23, 1902, the issue

being to Messrs. Halsberg & Co., M. B. H., of Germany. The

timber to be treated should preferably be air-seasoned. Green

or partially seasoned wood is subjected to a steam and vacuum

bath similar to that given in the Bethell process before the treat-

ment is begun. After the timber has been placed in the treating

cylinder, compressed air is admitted frequently from an overhead

tank and held until the wood is filled with compressed air. Creo-

sote is then admitted under a slightly higher pressure, the air in

the cylinder gradually escaping. When the cylinder is filled

with creosote the pressure on the oil is raised to about 150 or

more pounds and held until no more oil can be forced into the

wood. The cylinder is then drained of oil and a final vacuum

drawn to increase the expansive force of the air in the timber and

to dry the wood as quickly as possible. The length of time the

compressed air is held, the pressure of the compressed air, the

length and pressure of the oil period, and the length of the final

vacuum all vary with the kind of timber under treatment.

When they are properly adjusted, penetrations as deep as those

secured in the Bethell process are obtained, in some cases with

one-half or less the consumption of oil. Rueping-treated timber

has a tendency to drip much longer than timber treated without

the use of compressed air, and the rate of evaporation of the

creosote from it is also likely to be greater. The process is now

in extended use in both the United States and Europe.

Burnett Process. William Burnett patented this method of

treatment in England in 1838 and it has been in constant use

since. It is commonly referrred to as the standard process

using a water-soluble salt, chloride of zinc. The method of

treatment is exactly analogous to the Bethell process, the only

essential difference being in the character of the preservative.

As a general rule, water solutions can be forced into wood deeper

than oils, so that under any given set of conditions slightly better

penetrations are secured from the use of zinc chloride than from

PROTECTING WOOD FROM DECAY 61

creosote. The Burnett treatment is in extensive use in the

United States and Europe, where it has given excellent results

in prolonging the life of timber not set in very wet conditions.

On account of the soluble nature of the salt, several methods

have been employed to retard its leaching action, some of which

are now extensively practised.

Rutgers Process. The objections to the comparatively high

cost of creosote and the teachability of zinc chloride are both

partially overcome by the Rutgers process, invented by Julius

Rutgers in Germany about 1874. Rutgers handles the timber to

be treated in much the same way as is done in the Bethell pro-

cess, but employs a mixture of zinc chloride and creosote as his

preservative. The zinc chloride is generally in a 3 to 5 percent

solution and comprises about 80 percent of the mixture. To this

a comparatively low-gravity creosote free from naphthalene is

added by means of a jet of steam or air or other suitable mixing

device. The timber thus treated contains both creosote and zinc

chloride injected simultaneously. While the process is not

practised in the United States, it has found extensive use in

Germany, where it is reported to give marked satisfaction,

particularly in the treatment of cross-ties.

Card Process. The principle of injecting timber simultaneously

with zinc chloride and creosote was adopted by J. B. Card, to

whom a patent was granted in the United States on March 20,

1906. Card's process differs essentially from that of Rutgers in

the manner of keeping the solution mixed. He uses about 80 per-

cent of zinc solution to 20 percent of creosote, the strength of

the zinc being regulated so that approximately 1/2 pound of the

dry salt will be injected with each cubic foot of wood treated.

This solution is first mixed in the measuring tank by forcing air

through perforated pipes placed on the bottom. When the

solution is run into the treating cylinder, the agitation is continued

by means of a centrifugal pump which draws it from the top of the

retort and returns it through a perforated pipe running length-

wise in the bottom of the cylinder. The steps in the Card proc-

ess are analogous to those in the Bethell process. Air-seasoned

timber is advocated. After this is run into the cylinder a vacuum

of 22 to 26 inches is drawn for about 1 hour. The preservative

mixture is then admitted at a temperature of about 180 F. and a

pressure of about 125 pounds per square inch applied to it by

means of force pumps for 3 to 5 hours, or until the desired

62 THE PRESERVATION OF STRUCTURAL TIMBER

absorptions have been secured. During this period, the centrif-

ugal pump is kept running in the manner described above, to

agitate the solution in the cylinder. The cylinder is then drained

of excess preservative and a final vacuum drawn to assist in dry-

ing the timber, after which the charge is removed. Difficulty

may be experienced in keeping the solution uniform during treat-

ment, unless the proper conditions are maintained. Good

penetrations of both creosote and zinc chloride are secured in this

process, which is now extensively used in the United States,

particularly for the treatment of cross-ties.

Wellhouse Process. Experience with the Wellhouse or zinc-tan-

nin process began about 1881, when some ties were treated in St.

Louis, Mo. In the early 80's and 90's this method of treatment

was extensively used in the United States but at the present time

the amount of timber treated by it is comparatively small. The

chief objections to its use were apparently the many manipula-

tions required and the difficulty of satisfactorily operating them.

The timber to be treated is handled much the same as in

the Burnett process except for the manipulations of forcing the

preservative into the timber. After the timber has been placed

in the treating cylinder and seasoned, as in Burnettizing, a so-

lution of zinc chloride and glue in the proportions of 1 1/2 to 3

percent of the former to one-half of 1 percent of the latter

is forced into the wood by means of pressure pumps under a

pressure of about 125 pounds per square inch and held for 3 to 6

hours. The excess preservative is then drained from the cylinder

and a water solution of one-half of 1 percent tannin is introduced

and forced into the timber at 125 pounds pressure for about 2

hours, after which the excess tannin solution is drained from

the cylinder and the charge removed. The tannin combines with

the glue and forms a " leathery substance" which tends to plug up

the pores of the wood and retard the zinc chloride from leaching

out. The process was later modified by injecting the glue sepa-

rately, it being found that it retarded the entrance of the zinc

solution. The temperature of the treating solution as well as

the strength of the zinc chloride used was also raised.

While the mixture of glue and tannin does tend to plug the

wood cells, nevertheless, the extent to which they do this has

been exaggerated. The zinc-chloride solution not only resists

the entrance of the glue and tannin in subsequent injection, but

the air confined in the wood tends to push the plug out of the

PROTECTING WOOD FROM DECAY 63

cells due to its expansive force. Microscopic examinations of

Wellhouse-treated wood have shown that the "plug" is only a

surface coating and seldom actually extends into the timber.

While very good results have been secured from this method of

treatment, it is believed that better results could have been ob-

tained if a strong preliminary vacuum had been drawn and held

while the zinc solution was entering the cylinder. The Well-

house process is comparatively cheap, costing about 18 cents per

tie, and has succeeded in more than doubling the life of ties which

like hemlock, red oak, and gum decay very rapidly.

Allardyce Process. So called after R. L. Allardyce, who sug-

gested its use. The timber to be treated is handled much as in the

Wellhouse process except that creosote instead of glue and tannin

is used. A 4 percent zinc-chloride solution is forced into the

wood at a pressure of about 130 pounds per square inch, after

which the cylinder is drained and refilled with creosote, this be-

ing injected under a pressure of about 180 pounds per square inch

so as to form a continuous outer layer around the zinc-treated

timber. As might be expected, the penetration of the creosote is

slight. If, however, the timber is removed from the cylinder after

its injection with zinc chloride and allowed to air season, and then

re-treated with creosote, better results are obtained. The delay

thus occasioned and the increased cost of handling then become

serious objections. The Allardyce process is not in extensive

use at this time.

The author treated a number of red oak and maple ties by

reversing the Allardyce method. These were first impregnated

with 2 to 3 pounds of creosote per cubic foot, after which

the cylinder was drained and refilled with a 3 percent zinc-

chloride solution forced into the wood until 1/2 pound of the

dry salt was injected. The cylinder was drained and the

charge removed. The results secured were very similar to those

obtained in the Card process, much of the creosote being carried

further into the wood. By this manipulation, delay in treating

and increased cost of handling are avoided, but unless extreme

care is exercised the zinc-chloride solution will soon become

contaminated with the creosote, so that the amount of each con-

sumed will become a matter of speculation.

CHAPTER VI

PRESERVATIVES USED IN PROTECTING WOOD FROM

DECAY

Properties of Efficient Preservatives. Hundreds of chemicals

and compounds have been advocated and tested to preserve

wood from decay, but only a few of them possess sufficient

merit to justify their use for this purpose. As was shown in

Chapter II, decay in timber is caused by fungi and bacteria.

To preserve wood from decay it is therefore absolutely essential

to protect it from the attacks of these organisms. In brief, all

fungi and bacteria which decay wood require certain amounts

of heat, air, moisture, and food in order to live. If one or more

of these essentials can be eliminated, these organisms cannot

live and hence wood will remain sound indefinitely. The basic

problem, therefore, in any efficient preservative process is to ac-

complish this. Obviously a control of heat and air around struc-

tural timber set subject to decay is exceedingly difficult and

generally impracticable. Hence a control of the moisture in

the wood and the food of the fungus (which is the wood sub-

stance) are the two most practical lines of preventing attack.

Wood kept constantly under water is too wet to permit the fungi

to grow and will remain sound ad infinitum. Conversely, wood

kept constantly air dry or drier contains too little moisture

for fungous growth and will never decay to wit, the durability

of furniture in dwellings, etc. All successful wood preservatives,

therefore, either keep the wood comparatively dry or else poison

the wood so that the organisms attacking it are killed.

The amount of moisture in wood necessary for the growth of

wood-destroying fungi is not definitely known. It is the author's

opinion that in general it must be not less than 20 percent.

Certain fungi which have the ability of making or transporting

moisture may be able to attack wood containing a smaller

moisture content than this. It is well known that posts set in

the ground decay in or near the ground and rarely in the top.

To secure some data on the distribution of moisture in posts,

the author placed several cedar posts in the ground and took

64

PRESERVATIVES USED IN PROTECTING WOOD 65

moisture borings 2 inches deep 2 feet below ground level,

at ground level, and 3 feet above ground level, at various

periods extending over a year. That portion of the posts buried

in the ground contained in general about 30 percent moisture,

that near the ground line about 32 percent, and that near the

top less than 17 percent. If, then, wood can be impregnated

or coated with a substance that will keep it comparatively dry,

the fungi and bacteria will be unable to develop and the wood

will remain sound. This is the basic principle involved in the

use of nontoxic oils, like petroleum.

In general, most effective results in prolonging the life of timber

from decay are obtained by using some chemical which is toxic

and which thus poisons the food of the fungus. Toxic preserva-

tives differ considerably in their effectiveness against fungi.

Considerable work has been done by a number of investigators

to determine the smallest amount of preservative necessary to

inhibit fungous growth. This is called the " toxic limit." One

of the most satisfactory methods of doing this is by means of

cultures in glass dishes by what is known as the "petri-dish

method." It consists, in brief, in pouring into the sterilized

petri-dishes a solution of agar-agar of the following approximate

composition: Juice from 1 pound of beef, 25 grams of Loff-

lund's malt extract, 20 grams of agar-agar, and 1000 c.c. of dis-

tilled water. Upon this medium is placed a small mat of fungus

mycelium. The dish thus inoculated is placed in a constant

temperature oven for about 6 weeks. Various amounts of the

preservative to be tested are weighed on a chemical balance and

mixed into the culture medium. The fungus will grow readily

on low concentrations but a concentration is finally reached

above which no growth occurs. The smallest concentration

which inhibits growth is called the "toxic limit" or "toxicity"

of the preservative. A number of preservatives have been

tested in this manner by C. J. Humphrey at the U. S. Forest

Products Laboratory, the results being given in Table 4

The greater the toxicity of a preservative, the greater is its

ability to kill fungi and keep wood sound. It frequently happens,

however, that those preservatives which are most toxic are not the

ones which give best satisfaction in prolonging the life of wood,

because they may have certain inherent characteristics which

vitiate or preclude their use. Chief among these are their

permanency, and corrosion of iron.

5

66

THE PRESERVATION OF STRUCTURAL TIMBER

TABLE 4. THE TOXICITY OP VARIOUS PRESERVATIVES ARRANGED IN ORDER OP RATIO TO COAL-TAR CREOSOTE

Toxic limit (killing point)

o

1

a

+3

10 u-

IN CN >O <N O O

>o

sjiii

I

o

cfl

I

CQ

1

I

8

O O O O O O

o o

J ii

Ii

d o

O CO -CO O IO CO

tf b- -CO <\* (N CO

do jo j d d d

00 b-

o SS

d d

^ cc

Ratio to coal-tar creosote

No. 1074

10 IO

N

O 00 -CO rH CO

CO l2

liii :

,\_( ,\_( ,-( rH O ' i-H O

"-I

0000

c

CN

b b-

CO CN

' CO b- rH CO >\* 1 |<N

co d o

^ 00 ^

1 1 1

b- IO Tj< CO b-

o o o o o

<N <N C5 r-l I-H r-l O O "3 IO O

co o d

r-l

d

o o o o o

innosus

Lbs. percu.ft.

s

=

O5 CN

b- CO iN CO lO O rH Tf<

o 7 ^

+ + i

OOOOOO O O O O O O r-l

d

(N CO

: d ^ S N ^

Fomes

Percent

IO

8 - ! S

4O'O^ Tt^-^OiC

ooc^^o lOiQio 1 ^ w^c^i^ \*OCDCC ^^t>

Preservative known as

: . : . :.::::::::

: : : ::::::::::::

1 Coal-tar creosote, Fraction II, sp. gr. 1.003. . .

Sodium fluoride . .

E

"c

c

1

\* '.

d t,' ;

a " d

. H- 1 (H\*

::::::!:

: :

;.:::: TH :

-J : :

M (N

rH U3

1 s-

i .

. ex

II ^

; ; ; ; jj ;

Coal-tar creosote, Frac

Coal-tar creosote, Frac

Water-gas tar creosote,

Zinc chloride

1

^

[

1

s

s \*s ^ \* \*^ u

iJjjJ|^^}9

|

a

W

Coal-tar creosote, Frac

Copperized oil

N. S. Special

Water-gas tar creosote,

Sap wood antiseptic. . . .

PRESERVATIVES USED IN PROTECTING WOOD

67

Practically all inorganic preservatives are soluble in water,

and will, if exposed to ordinary atmospheric conditions, leach

out of wood. If they should do this at a rapid rate, the wood

will soon be left unprotected so that the fungi can attack it.

In order to be effective, therefore, such preservatives must

remain in the wood for long periods.

While organic preservatives are, as a rule, insoluble in water

many of them volatilize when exposed to the atmosphere, so

35

30

!05 C

I 25

20

II 205 to 2

30 C

40 50 60

Time of Seasoning after Treatment -Days

70

80

FIG. 5. Comparative rates at which fractions of coal-tar creosote evaporate

from wood. (Cir. 188, U. S. Forest Service.)

that the amount remaining in the treated timber may eventually

become so small as to be ineffective in further protecting the

wood from decay. This is particularly true of the lighter

fractions of coal-tar creosote, as is shown in Fig. 5, which

represents the rate at which various fractions of coal-tar creosote

and creosote evaporated from sap loblolly pine sticks 6 inches in

diameter and 24 inches long impregnated with about 18 pounds

68

THE PRESERVATION OF STRUCTURAL TIMBER

each of oil and later exposed to the atmosphere. l In this figure the

temperature represents the limits between which the distillates

were obtained from the creosote. The permanency of the

higher boiling fractions is well shown. Other tests 2 made on

timbers subjected to service for 20 or more years also show that

the higher boiling constituents are the most permanent.

TABLE 5. CORROSIVE ACTION OF THE PRESERVATIVE 3

Preservatives designated by manufac-

turer as

Loss in weight (grams) of flange steel after

immersion in preservative at 98 C. for

3 weeks

4 weeks

Coal-tar creosote . .

0.0064

0.0000

0.0389

0.0063

0.0313

0.0005

0.0807

8.2629

5.0989

1.2938

0.0243

0.2222

0.0096

0.0012

1.4636

0.6050

1.3809

3.1660

0.1256

0.0139

0.0008

0.0401

0.0467

0.0296

0.0015

0.0951

11.2350

1.5029

Coal-tar creosote Frac. 1

Coal-tar creosote Frac. 2

Coal-tar creosote Frac. 3

Coal-tar creosote Frac. 4

Coal-tar creosote Frac. 5

Averarius carbolineum

Hardwood tar

Wood creosote (Douglas fir)

Spirittine

1.07 oil

Timberasphalt

Copperized oil

Fuel oil.

0.0062

Zinc chloride

Zinc sulphate (a)

Zinc sulphate (6) by-product. . . .

B. M. preservative

Sodium fluoride

4.1746

0.1588

0.0181

Cresol calcium

(a) Equivalent to 2. 1 percent zinc-chloride solution.

(6) Equivalent to 6.2 percent zinc-chloride solution.

As nearly all wood preserving plants are built of steel cylinders,

any preservative which attacks steel cannot, of course, be used in

them. This excludes such preservatives as mercuric chloride,

copper sulphate, etc., from standard practice. A number of

tests were run at the U. S. Forest Products Laboratory to de-

termine the corrosive action on steel of various wood preserva-

tives. A strip of flange steel of the quality specified by the

1 Circular 188, U. S. Forest Service, by C. H. Teesdale. The Volatili-

zation of Various Fractions of Creosote after Their Injection into Wood.

2 See circulars 98 and 199, U. S. Forest Service.

8 "Tests to Determine the Commercial Value of Wood Preservatives,"

by H. F. Weiss, Eighth International Congress of Applied Chemistry.

PRESERVATIVES USED IN PROTECTING WOOD 69

American Society for Testing Materials, August 16, 1909, was

submerged in the preservative and heated to a constant tem-

perature of about 98 C. The preservative was changed every

week for four weeks in the case of oils; with aqueous solutions it

was changed every day for one week. The difference in the

weight of the steel before and after submersion was taken to

indicate its corrosion. All depositions on the surface of the

metal were removed as nearly as possible with a rubber " police-

man " each time the preservative was changed. At the end of

the test, where electrolytic deposition of metal had taken place,

the deposited metal was removed by acid and its amount-

determined by an analysis of the acid solution. The deposited

metal thus obtained was added to the loss of iron and this total

represented the total corrosion. The corrosive action of the

various preservatives tested is shown in Table 5. .

The odor of the preservative sometimes influences its use,

particularly if the wood is to be placed in dwellings. All inorganic

preservatives are practically odorless and hence not objectionable

on this account. Many of the organic preservatives, particularly

the " creosotes" from wood, coal, and petroleum, have strong

odors which are quite offensive. If allowed to air season thor-

oughly before being placed in position much of the odor can be

removed.

It frequently happens that it is desirable to paint wood arti-

ficially preserved. This is particularly the case with wood used

in dwellings, greenhouses, etc. Creosoted timber cannot be

painted satisfactorily with any of the lighter pigments, but

practically all of the salts are free from this objection. Two

other factors of practical significance in determining the

value of a chemical for wood preserving purposes are the effect

the preservative has on the strength of the wood treated with it,

and the ability of the preservative to penetrate the wood. If the

preservative is such as to seriously impair the strength of wood

treated with it, it will necessitate the use of larger timbers and

hence increase the cost of the structure. Moreover, if the

preservative is of such a nature that it cannot be forced into

wood, its value is considerably decreased on this account, because

it will succeed in only protecting the surface of the wood. Any

injury to the surface will therefore result in exposing the un-

treated interior. Tests to secure data on both these points were

conducted at the U. S. Forest Products Laboratory on air-

70

THE PRESERVATION OF STRUCTURAL TIMBER

seasoned hemlock. Approximately 8 pounds of the preservative

per cubic foot in the case of oils and 1/2 pound or more of

the dry salt in the case of water solutions were forced into the

wood by the Bethell process. The wood was then permitted

to air season and tested in bending on a 30,000-pound testing

machine, the strength of the treated pieces being compared with

that of the untreated. In the penetrance tests the preservative

was forced into a hole bored into the wood under a constant tem-

perature of 180 F. and pressure of 80 pounds per square inch for

30 minutes when oils were used and 3 minutes for salt solutions.

The sticks were then sawed and the depth to which the preserva-

tives entered was measured. The results of both these tests are

shown in table 6.

TABLE 6. PENETRANCE OF THE PRESERVATIVES AND THEIR EFFECT ON

THE STRENGTH OF WOOD

Preservative

designed by

manufacturer as

Penetration

Average

absorption of

preservative

Strength in per-

cent of modulus

of rupture of

untreated wood

Moisture

at test

Rad. and

tang.

Long 1

Untreated

Treated

Max.

Min.

Max.

Min.

Coal-tar creosote

S.P.F. carbolineum .. .

Avenarius Carbolin-

In.

0.28

0.37

0.17

0.03

0.08

0.10

0.02

0.22

0.10

0.25

0.10

0.10

0.13

0.05

0.10

In.

0.23

0.23

0.12

0.03

0.08

0.10

0.02

0.22

0.083

0.17

0.08

0.10

0.10

0.03

0.10

In.

6.0

6.0

6.0

0.92

3.58

6.0

0.33

6.0

6.0

6.0

6.0

6.0

6.0

0.46

6.0

In.

5.3

5.7 +

5.3 +

0.50

2.33

3.33

0.33

4.08

5.3

4.66

4.66

3.30

4.6

0.30

5.00

Lb. per

cu. ft.

8.76

8.83

8.08

6.50

2.82

9.58

5.68

8.58

0.43 2

1.11

0.96

0.46

0.50

0.99

0.20

93

6.2

%

109

98

107

108

106

101

88

82

89

103

85

82

85

6.81

6.11

5.8

4.52

6.68

5.49

7.13

3.88

5.14

5.72

5.16

6.42

5.82

9.35

5.77

9.6

6.58

9.48

7.38

8.7

Hardwood tar

Creosote (Douglas fir)

1.07 oil

Timberasphalt

Copperized oil

Zinc chloride

Zinc sulphate (by-

Zinc sulphate

Creosol calcium

B.M. preservative. . . .

Sodium silicate

Sodium fluoride

1 A penetration of 6 inches was the maximum that could be secured. The absorptions

here given have no reference to the data on penetrance.

2 Dry salt.

The effect of the preservative in the wood upon the inflamma-

bility of the wood is also an important consideration, particularly

in mines, bridges, and dwellings. This effect is described at

length in Chapter XVI.

It can be seen from this discussion that many factors aside from

cost, ease of transporting, etc., affect the practical value of a

PRESERVATIVES USED IN PROTECTING WOOD 71

preservative, and that no one preservative possesses all the re-

quirements which will make its use applicable to all conditions.

A selection is therefore imperative.

The preservatives which have most conspicuously succeeded

in fulfilling the above requirements may be logically grouped into

three classes, (1) water-soluble preservatives, (2) crude oils, and

(3) creosotes.

Water-soluble Preservatives. While a large number of water-

soluble preservatives have been tested, only a few have proven

of any practical value. Most of them are either not sufficiently

toxic against fungi or form reactions with the wood which tend

to destroy the strength of the wood. This latter is particularly

the case with iron sulphate and chemicals strongly alkaline. Of

the many water-soluble preservatives tested, copper sulphate,

mercuric chloride, sodium flouride, and zinc chloride have given

best results.

Copper Sulphate. This salt was first put to extensive use by

Margary in England about 1837. It was later used by Boucherie

in France, where it is still commonly employed in treating timber,

particularly poles. It is strongly toxic against wood-destroying

fungi. It is readily soluble in water and easily leaches from wood

treated with it. The chief objection to its use is its action on

iron, the copper being immediately deposited. It cannot, on

this account, be used in the standard type of timber-preserving

plant. It is comparatively cheap, costing about 5 to 6 cents per

pound, and when injected into wood gives good results. It is

almost as efficient as zinc chloride, poles treated with it in

Germany lasting 11.7 years as compared with similar poles treat

ed with zinc chloride which lasted 11.9 years. One desirable

quality is the ease with which the preservative can be seen in the

wood, as it stains the wood cells a distinct green. The use of this

salt is now practically confined to France. The amount of timber

treated with it in the United States is insignificant. It is believed,

however, to have distinct merit, particularly for the treatment of

green posts and poles. (See Boucherie process for further

discussion.)

Mercuric Chloride. This is the most toxic wood preservative

in use. It was first extensively employed by Kyan in England

about 1832. Extremely small quantites of this salt in wood

will absolutely kill all wood-destroying fungi. Its toxic limit is

even below that of such toxic salts and acids as potassium di-

72 THE PRESERVATION OF STRUCTURAL TIMBER

chromate, silver nitrate, hydrochloric acid, etc. It cannot be

safely tested with agar in petri dishes since it unites with the pro-

teid elements of the agar.

Magnin and Sternberg 1 conducted extensive tests with various

antiseptics upon the septic micrococcus, with the following

results :

Corrosive sublimate 1 part in 40,000 prevented development.

Copper sulphate 1 part in 400 prevented development.

Zinc chloride 1 part in 200 prevented development.

Carbolic acid 1 part in 300 prevented development.

Mercuric chloride is much less soluble in water than zinc

chloride or copper sulphate. It, unfortunately, severely attacks

iron, hence its use is debarred in modern treating plants. Al-

though it is expensive, costing about 70 cents a pound, neverthe-

less the very small quantity necessary to keep wood sound does

not by any means render its use prohibitive. On account of its

very poisonous nature, solutions of mercuric chloride must be

handled with extreme care or mercurial poisoning will result.

This salt is not in extended use at the present time in this country

but is employed by a few Kyanizing works in New England. In

India and Africa it is reported as giving very good results against

the attacks of white ants. Poles treated with it in Germany

lasted 13.7 years as against 11.9 years for zinc-treated poles.

Sodium Fluoride. The commercial application of sodium

fluoride to the preservative treatment of timber is comparatively

recent. It has been tested by Malenkovic in Austria for the

past 8 years with apparently excellent results. It is more

toxic than zinc chloride (see Table 4) and is not so readily leached

from the wood. Its corrosive action on iron is also slight, being

less than that for zinc chloride, so that it can be used in modern

timber -treating plants. Its cost is also comparatively low, being

about 5 to 7 cents per pound. No records are known

showing the use of sodium fluoride as a wood preservative in the

United States. Extensive experiments, which have thus far

yielded very satisfactory results, are now under way at the

U. S. Forest Products Laboratory and it is quite likely that this

salt may find a large commercial application in this country.2

Zinc Chloride. About 20,000,000 pounds of zinc chloride are

now used annually in the United States in treating timber an

amount which makes it by far the most extensively used water-

1 Boulton The Preservation of Timber, 1885.

2 It is now in commercial use (Feb., 1916).

PRESERVATIVES USED IN PROTECTING WOOD 73

soluble salt. It was first employed on an extensive scale by Sir

William Burnett in England about 1838 and timber is now

treated with it in all the larger European countries. Zinc chloride

is very toxic against wood-destroying fungi, offering about the

same resistance as coal-tar creosote. Its chief fault is its solu-

bility in water, which property renders it inadvisable to use

zinc-treated timbers in wet localities. In localities which are

not excessively wet, the zinc chloride will remain in the timber for

many years. Numerous cases are on record which show zinc-

treated ties have remained durable for 10 or more years, while

the untreated failed in 4 to 5 years. It appears from various

analyses which have been made that certain amounts of zinc

chloride injected into wood combine with the wood forming a

compound insoluble in water. Whether or not this combined

zinc chloride is toxic has not yet been definitely determined.

If it is not, it probably is of little or no value in preserving the

wood.

Zinc chloride will also corrode iron, although the extent to

which it does this at concentrations used in treating wood is so

small as to be of no serious moment. It is customary, however,

to figure higher depreciation on zinc-chloride plants than on

creosote plants due to its more corrosive nature.

The cost of zinc chloride is small, being about 4 or 5 cents a

pound. Moreover, the quality generally produced in this

country is of very high grade, far superior to that commonly pro-

duced abroad. Zinc chloride is purchased fused in drums of 500-

or 1000-pound capacity, or in concentrated (about 50 percent)

solution. When in high concentration the solution is basic and

will strongly attack wood, reducing it to a pulp. At dilute con-

centrations the solution is acid.

Owing to its importance as a wood preservative, the following

specification for the purchase of zinc chloride is given. It is

the one used by the U. S. Forest Products Laboratory. A

similar specification is in use by the American Railway Engineer-

ing Association.

"The fused zinc chloride must contain at least 94 percent of water-

soluble chloride of zinc and it must be slightly basic; that is, contain no

free acids. It should be practically free from soluble iron and in no case

will it have more than 0.022 percent of this element. It shall not con-

tain more than one-half of 1 percent of other inorganic impurities in-

soluble in hydrochloric acid."

74 THE PRESERVATION OF STRUCTURAL TIMBER

Although several methods have been suggested for determining

the amount of zinc chloride injected into wood, the following is

believed to be the most accurate and satisfactory. 1

The material to be analyzed is first dried in the form of discs or sec-

tions and should be a fair average. The discs are then reduced to saw-

dust and 5 grams are weighed into a 500 c.c. short-neck, round-bottom

Jena boiling flask: 50 c.c. of a previously prepared saturated solution of

potassium chlorate in concentrated nitric acid is then added in the cold

and mixed into it by a vigorous shake. A violent reaction, accompanied

by the evolution of considerable heat, immediately takes place but sub-

sides after a few minutes leaving a wine-colored solution in which parti-

cles of partly digested wood are floating. When cool, 10 c.c. of concen-

trated sulphuric acid (sp. gr. 1.8) are added and the solution again shaken.

This dissolves all the wood substance. The solution is then boiled.

More potassium chlorate-nitric acid solution is added and the solution

kept boiling until no further charring occurs on evaporation to sulphuric

acid and the solution remains a pale yellow. When cool, it is diluted

with 100 c.c. of water; 10 c.c. of dilute nitric, 10 c.c. of 2 percent ferric

chloride solution, and 1 gram of citric acid are then added, and the solu-

tion again allowed to cool. After cooling it is neutralized with ammo-

nia leaving it slightly ammoniacal. The volume is brought up to 200

c.c. and the temperature to 80 C. at titration. The standard solution of

potassium ferrocyanide is then run in from the burette until a drop of

the titrated solution when placed in the center of 1 c.c. of the glycerine

acetic acid indicator leaves a permanent greenish-blue ring. At this

point the titration is complete. Calculations are then made from the

analytical data. To calculate the results in pounds of zinc chloride per

cubic foot of wood, the specific gravity of the wood must be known to

within 0.005. Then multiply this specific gravity to 62.5 and this prod-

uct by the percentage weight of zinc chloride found by analysis to

obtain the amount of zinc chloride per cubic foot of wood.

If knowledge of the actual amount of zinc is not desired, but

simply an idea of how deeply it has penetrated, two methods are

suggested. One is to cut a section through the stick to be ex-

amined and dry it thoroughly in a drying oven heated to 100 C.

until all water has been evaporated. The wood will be turned a

deep brown wherever the zinc chloride has penetrated. A

second method is to dip the freshly cut disc of treated wood for a

few seconds in a 1 percent potassium ferrocyanide solution.

Remove the excess solution with a blotting paper and redip the

disc into a 1 percent solution of uranium acetate. On drying,

1 Method developed by Bateman, U. S. Forest Products Laboratory.

PRESERVATIVES USED IN PROTECTING WOOD 75

the untreated portion of the wood will have a dark red color while

the treated portion will be much lighter.

Crude Oils. Crude oils are not widely used in treating timber

in our country. They rely upon their ability to preserve wood

on their tendency to " waterproof " it and thus keep it too dry for

wood-destroying fungi. A promising development consists in mix-

ing toxic preservatives with crude oil, using the latter as a diluent.

The oils are all practically nontoxic, although some of them are

slightly poisonous to fungi. In order to " waterproof " the wood

it is necessary to force comparatively large quantities of the oil

into it. This makes crude-oil treated timber quite heavy and

very liable to drip oil, especially if exposed to a hot atmosphere.

Three varieties of "crude oil" are in use, viz., crude oil with a

paraffin base, crude oil with an asphaltic base, and residuum,

which is a product of petroleum distillation. All these crude

oils have a gravity less than water, whereas all creosotes are

heavier than water. Crude oils with a paraffin base are found in

large quantities in Ohio, Pennsylvania, and other states. They

are usually lighter in color and gravity than the oils with an as-

phaltic base. These latter oils occur in California and part of

Texas. Residuum, which is the heavy, rather viscous oil

remaining after the distillation of the lighter portions of the

crude oil, varies in gravity and viscosity according to the method

of manufacture. If too viscous, it cannot be made to penetrate

wood. It is best, therefore, when it contains a fairly large

percentage of lighter constituents. None of the crude oils

penetrate coniferous woods as readily as creosote. This may be

due in a large measure to their inability to dissolve the resin in the

wood as is done by creosote. The price of crude oils varies from

about 2 to 5 cents per gallon. In treating timber with crude

oil it is customary to force as much oil into the wood as it is

possible to get in an amount which varies of course with the

different woods. If 12 pounds of oil per cubic foot can be

retained in the wood, a heavy impregnation has been secured.

Creosotes. 1 Owing to their ability to preserve wood, creosotes

will be discussed in detail, as they are the most important pre-

servatives now known.

Much misunderstanding exists as to the meaning of the term

"creosote." It is defined by the Standard Dictionary as "a

colorless to yellowish oily liquid compound consisting of a mixture

1 The data given on creosotes is largely taken from Circular 206, U. S.

Forest Service "Commercial Creosotes" by Carlile P. Winslow.

76 THE PRESERVATION OF STRUCTURAL TIMBER

of phenols distilled from wood, and having a smoky odor and

burning taste. It is a powerful antiseptic and is used for the

preservation of timber, meat, etc.; called also oil of wood-tar and

oil of smoke." Allen, in his Commercial Organic Analysis,

says: "The name 'kreosot' was first applied by Reichenbach,

in 1832, to the characteristic antiseptic principle contained in

wood-tar. Carbolic acid was discovered soon after by Runge in

coal-tar, and was long confused with the wood-tar principle;

and the crude carbolic acid from coal-tar is still known as 'coal-

tar creosote.' Somewhat similar products are now obtained from

other sources, so that much confusion has arisen. The term

'creosote/ when used without qualification, ought to be under-

stood as signifying the product from wood-tar, but it is better

to describe Reichenbach's body as ' wood-tar creosote/ and em-

ploy the unqualified word 'creosote' in a generic sense as meaning

the mixed phenols and phenoloid bodies obtained from wood-tar,

coal-tar, blast-furnace tar, shale oil, bone oil, or other sources."

In its original meaning, therefore, the term "creosote" was

applied to a product obtained from wood, and the term is still

used thus in pharmacy, and refers to a refined product derived

from the destructive distillation of beech or other hardwood.

However, with the development of both the wood-preserving

and the coal-tar industries, the term "creosote oil," frequently

abbreviated to "creosote," gradually came to be applied to the

heavy distillates from coal-tar, and the use of the term has be-

come more and more extended until, at the present time, it is

commonly used in referring to the distillates heavier than water

from any tars or tar-like substances, and is even erroneously used

to cover products containing admixtures of undistilled tar or

pitch. As a result of this lax use of the word it conveys but little

to those conversant with the subject and is confusing to those

unfamiliar with commercial practice. More specific terms are

evidently needed to properly differentiate between the various

creosotes. The most useful classification from the wood pre-

server's point of view would be one based upon the merits of the

various products but lack of sufficient data renders this impossible

at this time. The most practical classification at present must

be based upon the source and method of production. The

following terms and definitions are suggested :

1. Creosote is a distillate heavier than water obtained by the

distillation of a tar or a tar-like substance.

PRESERVATIVES USED IN PROTECTING WOOD 77

2. Coal-tar creosote is a creosote derived from coal-tar pro-

duced by the destructive distillation of coal at a temperature high

enough to produce a tar consisting, for the most part, of

hydrocarbons of the aromatic series. 1

3. Oil-tar creosote 2 (water-gas tar creosote) is a creosote

derived from oil tar. This tar may be obtained from the de-

structive distillation of petroleum in a gas retort, producing

oil-gas as a main product and oil-gas tar as a by-product, or by

the cracking of gas oil in the carburetor of a water-gas plant pro-

ducing carbureted water-gas as a main product, and carbureted

water-gas tar as a by-product.

4. Wood -tar creosote is a creosote derived from a tar produced

by the destructive distillation of wood.

5. Mixed creosote is a creosote produced by mixing other

material with a given creosote, such as another creosote, pitch,

undistilled tar, or petroleum, or it may be secured by the dis-

tillation of a mixture of two or more tars on tar-like substances.

In view of the similarity between certain mixed creosotes and

creosotes obtained by the distillation of coal-tar, produced at

temperatures sufficiently low to permit the production of hydro-

carbons of the paraffin series, these latter distillates are also

classed under this heading.

Tars. Although there are a variety of tars from which creo-

sotes may be produced, the most important commercial ones may

be classified as coal-tars, oil-tars, and wood-tars. The sources

and general methods of production of these tars are as follows:

Coal-tars. The important coal-tars are derived chiefly from

two sources: The destructive distillation of bituminous coal

at high temperatures and the combined distillation and com-

bustion of bituminous coal at comparatively low temperatures.

The first, which furnishes by far the greater proportion of

1 Creosote secured from coal-tar produced at sufficiently low temperature to

permit the production of hydrocarbons of the paraffine series might also be

included under the name of coal-tar creosote, but in view of the paraffin

hydrocarbons it is classed in this publication as mixed coal-tar creosote.

2 Inasmuch as the derivatives of oil-gas tars and water-gas tars contain no

phenoloid bodies, the use of the term "creosote" in this connection might,

from a purely technical standpoint, be considered erroneous. However,

the term is used commercially at the present time in this connection, and a

careful consideration of the various definitions used in this publication

should prevent any misunderstanding.

78 THE PRESERVATION OF STRUCTURAL TIMBER

the total supply, is produced in the manufacture of coke and

gas in by-product retorts and gas-house plants. Bituminous

coal is destructively distilled at temperatures varying from

1500 F. to 3000 F., until the charge has been reduced to

coke. During the process the ammoniacal liquor and tar are

separated from the generated gases by condensation and wash-

ing. The tars naturally vary in their properties according

to the character of the coal, and of the retorts, and according

to the temperatures used. These factors in turn are largely de-

pendent upon which of the two main products, gas or coke, is

primarily desired; tar acids, however, are always present in the

tars and usually the temperatures are sufficiently high in both

cases to produce tars consisting largely of hydrocarbons of the

aromatic series.

Coal-tars produced at relatively low temperatures differ from

those produced at higher temperatures in the character of their

hydrocarbons. Since the temperatures are not high enough to

transform all of the hydrocarbons to the aromatic series, the

tars contain, to a greater or less extent, hydrocarbons of the

paraffin group. Tars secured from blast furnaces using

bituminous coal as fuel and from the Mond producer plants, where

bituminous coal is used in the manufacture of gas for power

purposes, are representative of this group. The production of

such tars, however, is not extensive in this country.

Water-gas Tars. Of the oil tars, that produced in the manu-

facture of water gas is by far the most important in its relation

to the manufacture of creosote. The method of production is, in

general, as follows: The "generator" is charged with coke or

anthracite coal, which is burned by the aid of an air blast to

a cherry red. The hot gases so formed are passed through the

"carbureter" and "superheater," which consists of vertical

cylindrical chambers filled with a checkerwork of fire brick.

After these bricks are heated to the proper temperature the

air blast is discontinued and steam is blown into the generator.

The gases formed by the contact of the steam with the hot coke

or coal pass into the carbureter, into which petroleum "gas oil"

is sprayed at the same time. This oil is partially cracked by the

high temperature of the fire brick and combines with the gases

from the generator to increase their illuminating power; the

process of cracking continues through the superheaters. The gas

is then passed to the condensers and washers, where tar is con-

PRESERVATIVES USED IN PROTECTING WOOD 79

densed and collected. This tar differs in its constituents from

coal-tar produced in the by-product coke ovens and gas retorts

both in the absence of tar acids and in the presence of hydrocar-

bons of the paraffin series; usually, however, the quantity of

paraffin hydrocarbons present is comparatively small.

Some oil-tar also is produced by the destructive distillation

of crude petroleum in the manufacture of oil gas. In tars from

this source the quantity of paraffin hydrocarbons present is

generally much greater than in that produced in the manufacture

of carbureted water gas.

Wood-tars. Wood-tar is produced in a manner somewhat

similar to that in which by-product coal-tar is formed. Wood is

destructively distilled in retorts, and charcoal is produced, together

with gas and a liquid distillate which consists largely of pyro-

ligneous acid and a product called crude tar. The tar and acid

are separated by settling and by distillation. Wood-tars are quite

different from coal-tars and contain, in particular, less of the

aromatic hydrocarbons.

Distillation of Creosote from Tars. From any or all of the

foregoing tars, either alone or in mixture, creosote may be pro-

duced. The general process of manufacture is similar in all

cases. The tar is distilled in a metal retort or still and the vapors

are condensed and collected. Those distillates which are heavier

than water form the true creosotes used in wood preservation.

The temperatures at which the creosotes are obtained vary greatly,

but generally lie between about 200 and 360 C. The actual

temperatures in each case depend largely upon the character

of the residue desired. In the United States the manufacture

of creosote from coal-tar is generally secondary to the manu-

facture of soft pitch; and in such cases the maximum tempera-

ture during the distillation is comparatively low. In Europe,

on the other hand, coal-tar is distilled largely for the production

of the coal-tar dyes, and the distillation is carried to higher tem-

peratures. The creosote, therefore, contains a relatively greater

amount of the higher boiling constituents than the American

product.

As already stated, pitch, undistilled tar, or other similar mate-

rials are frequently mixed with a creosote, and while such mixtures

are sometimes sold as creosotes, the term is improperly applied

except as it relates to the distilled product.

The complexity of the many hydrocarbons and their de-

80 THE PRESERVATION OF STRUCTURAL TIMBER

rivatives which may be produced in the destructive distillation

of coal, oil, and wood makes it impossible to state precisely the

nature of the various constituents of all creosotes. However,

they may be broadly divided into two classes, compounds of the

aromatic series and compounds of the paraffin series. The

characteristic difference between the two lies in the greater chemi-

cal activity of the former. Coal-tar creosote consists almost

wholly of aromatic compounds, and the long period of successful

use of such creosote has led to the general feeling that these con-

stituents are the more desirable.

The compounds of the aromatic series may be divided into

three groups, as follows: (1) "Light oils," which distill below

205 C. and consist largely of phenols and cresols, or tar acids;

(2) naphthalenes, which distill between approximately 205

Bituminous Goal

r

ras T

~1

ar Coke

r

ter than Water Oils I

"I

leavier Pitch

than Water

Creosote

Distillation Limits ftnd General Nature of the Aromatic Constituents

Light Oils

| Kich in Phenols

Naphthalenes

Constituents of an Anthracene Nature |

Liquid at Boom

Temp.

Solid at Room

Temp.

Liquid at Boom

Temp.

Solid at Room 1

Temp.

FIG. 6. Derivation of coal-tar creosote.

and 255 C.; and (3) constituents of an anthracene nature dis-

tilling above 255 C., which will be referred to collectively

as "anthracenes." Some or all of these are found in most

creosotes.

Of these constituents the tar acids possess the highest anti-

septic properties; they are, however, soluble in water and are

more volatile than the other constituents. The naphthalenes and

anthracenes are neither so antiseptic nor so volatile as the tar

acids and are practically insoluble in water. There is much

discussion as to the relative value of these different constituents,

but, largely as a result of experience, the presence of tar acids is

believed by many to be essential. While a large proportion of

naphthalene is sometimes advocated, particularly for the pres-

ervation of piling, a reduction in the quantity of this constituent,

PRESERVATIVES USED IN PROTECTING WOOD 81

with a corresponding increase in the amount of anthracenes, is

believed to increase the value of a creosote for general purposes.

Coal-tar Creosote. Fig. 6 1 shows graphically the derivation

and general composition of coal-tar creosote. The relative

quantity of tar acids, naphthalenes, and anthracenes will of

course vary according to the character of the tar and the tem-

peratures used during its distillation, but generally the tar acids

present will not exceed 5 percent, the naphthalenes will comprise

from 15 to 50 percent, and the anthracenes will comprise the

remainder. As previously denned, it contains practically no

paraffin hydrocarbons. The creosote as a whole is antiseptic,

insoluble in water, and somewhat volatile; it is sufficiently free

from "free carbon," and fluid enough at temperatures used in com-

mercial treating plants, to offer no great resistance to entrance

into the wood.

Tests made at the U. S. Forest Products Laboratory show the

toxic limit of coal-tar creosote to be between 0.2 and 0.4 per

cent. Very small amounts of it will therefore protect wood from

decay. In general, the lighter fractions are more toxic than the

heavier fractions. They are also far more volatile and when

injected into wood by themselves evaporate at a rapid rate

(Fig. 5). The heavier constituents of coal-tar creosote are there-

fore, in addition to being slightly toxic, of direct value in helping

to retain in the wood these lighter oils. The permanency of

the heavier oils is well illustrated by an analysis made of a pile 2

in actual service in the Gulf of Mexico for 30 years. This pile

was cut into three sections, samples from which were then ex-

tracted for creosote, with the results shown in Fig. 7.

Numerous similar examples could be cited, all of which show

that the lighter fractions of coal-tar creosote are not permanent.

While considerable heated discussion has occurred as to their

value, 3 it is the author's opinion that these lighter oils have

distinct merit in prolonging the life of timber, and if they had

been absent entirely from the creosote, it is doubtful if such long

periods of service could have been secured.

1 In Figs. 6 and 8 the term ''solid at room temperature" (20 C.) is

used in describing the condition of certain of the fractions distilled from

creosote, when, at the ordinary temperature of a room, they retained their

position in the receiving flask when vigorously shaken.

2 U. S. Forest Service Circular 199, "Quantity and Quality of Creosote

Found in Two Treated Piles after Long Service," by E. Bateman.

3 "The Preservation of Timber," by S. B. Boulton, 1885.

82

THE PRESERVATION OF STRUCTURAL TIMBER

Coal-tar creosote does not corrode iron to any appreciable

degree (see Table 5) and for this reason is admirably adapted

for use in the steel cylinders of modern timber treating plants.

When heated, the vapors arising from the oil may attack the

skin and cause a very irritating swelling and burning. This

effect is not produced on most people, but complaints have been

80

70

60

50

40

80

20

10

2(

rJ

y

^

J

</

.

/

c

>

X

^

>

X

^

X

/

Hf

s\*

X

/

^

^^

.

X

/

/

f

^

^p-t

/

I/

cf

sf

/

/

c

/

/

^

n

/

It

/

i

/

i\

/

/

-

^ 9^

f

X) 210 220 230 240 250 260 270 280 290 300 310 320 330 34

Temperature "Centigrade

Legend

Creosote taken from Section in the Mud

O Creosote taken from Section in the Water

O Creosote taken from Section above the Water.

FIG. 7. Distillation of creosote remaining in a pile after 30 years' service.

made by workers who come in contact with creosoted timber,

particularly trackmen, and several law suits have resulted. Even

the cold oil may produce such an injury. It is not, however,

serious and, with caution in handling the treated timber, even a

sensitive person can become immune to any discomfort.

The price of coal-tar creosote varies considerably and for the

past few years has been steadily rising. In large quantities the

PRESERVATIVES USED IN PROTECTING WOOD 83

average price in eastern United States is now about 6 to 9 cents

per gallon. In the West, the price is from two to three times

this amount, and, in small orders, even more. The sharp

demand for the oil, and its present limited production give little

hope that the price will lower materially in the immediate future.

Much discussion has occurred concerning the quality of

creosote best suited to the treatment of timber. Until recently

discussion has resulted in little practical value because the

demand for the oil was so great the consumer was glad to receive

most any kind he could get. Now, however, several grades of

coal-tar creosote can be obtained, but no uniformity exists as

yet as to the quality best suited to preserve wood. Most authori-

ties agree that a comparatively heavy grade is better than a light

grade. The specifications which are perhaps in most extended

use at present in the United States are the ones adopted by the

American Railway Engineering Association. They allow three

grades of oil, the specifications reading as follows :

"Grade 1 Oil. The oil used shall be the best obtainable grade of coal-

tar creosote; that is, it shall be a pure product obtained from coal gas

tar or coke oven tar and shall be free from any tar, oil or residue ob-

tained from petroleum or any other source, including coal gas tar or

coke oven tar; it shall be completely liquid at 38 C. and shall be

free from suspended matter; the specific gravity of the oil at 38 C.

shall be at least 1 . 03 when distilled by the common method that is,

using an 8 ounce retort, asbestos covered, with standard thermometer,

bulb 1 /2 inch above the surface of the oil the creosote, calculated on the

basis of the dry oil, shall give no distillate below 200 C., not more than

5 percent below 210 C., not more than 25 percent below 235 C. and the

residue above 355 C. if it exceeds 5 percent in quantity, shall be soft.

The oil shall not contain more than 3 percent water."

Grade 2 oil, which is considered "next best," is similar to the

"standard" just quoted except for the amount of fractions dis-

tilled at varying temperatures, these being "not more than 8 per-

cent below 210 C. and not more than 35 percent below 235 C."

Grade 3, which is poorer than Grade 2, differs from it only

in specific gravity and the amount of distillates at various tem-

peratures, these differences being "the specific gravity at 38 C.

shall be at least 1.025. Not more than 10 percent of the

oil shall distill below 210 C.; not more than 40 percent below

235 C."

The specification in use by the U. S. Forest Service is slightly

84 THE PRESERVATION OF STRUCTURAL TIMBER

more rigid than the above, particularly as regards the method

of analyzing the oil (see appendix) . Most of the confusion which

has occurred concerning the proper kind of creosote to use has

come through lack of definite data. Commercial motives and

an attempt on the part of certain " experts" to mystify the trade

have also added to the complexity of the situation. In all

probability, as experience grows the situation will clear and

specifications for coal-tar creosote will be drawn depending on the

use to which the oil is to be put. Until such data is available

the safest course to pursue is to demand a comparatively heavy

oil of known purity.

In treating paving blocks a heavy oil is generally used, the

idea being that it will stay in the wood and will have a marked

waterproofing effect. Thus the ''Association for Standardizing

Paving Specifications" adopted in 1911 the following grade of oil:

Coke or Anthracite

Steam and

Petroleum

ar

1

Gaa

T

r

Oils Lighter Oils Hea

than Water Water

vier than Pitch c

Creosote

General Distillation Limits of the Constituents

1 Possibly

Naphthalene

Possibly of an Anthracene Nature but Generally

containing Paraffin Hydrocarbons

Solid at Room

Temp.

C. 255 (

Liquid at Room Liquid at Room

Temp. Temp.

1. 295C. 34

Solid at Room

Temp.

C. 300

FIG. 8. Derivation of water-gas-tar creosote.

"The preservative to be used shall be a coal-tar product, free from

adulteration of any kind whatever, and shall comply with the

following requirements. (1) The specific gravity shall be not less

that 1.10 or more than 1.14, at a temperatute of 38 C. (2) Not

more than 3f percent of the oil shall be insoluble by hot continu-

ous extraction with benzol and chloroform. (3) On distillation,

which shall be made exactly as described in Bulletin 95 of the

American Railway Engineering and Maintenance of Way Associa-

tion, the distillate shall not exceed 2 percent up to 150 C. and

shall be not less than 30 or more than 40 percent up to 315 C."

It is thus apparent that the oil need not be a coal-tar " creosote"

and must contain a considerable amount of the heavier con-

PRESERVATIVES USED IN PROTECTING WOOD 85

stituents in coal-tar in order to have the gravity required. This

matter is also discussed in Chapter XIII.

Water-gas-tar Creosote. Of the oil-tar creosotes, that from

water-gas tar is practically the only one used for wood preserva-

tion. Fig. 8 illustrates its derivation and general composition.

This creosote is not more volatile nor soluble in water than coal-

tar creosote, contains no "free carbon," and offers no marked re-

sistance to entrance into the wood. In fact, water-gas-tar

creosote may be produced which on fractional distillation will

display a great similarity to coal-tar creosote. There is a dif-

ference, however, in the constituents of the two creosotes, as

shown by the difference in certain physical properties of fractions

distilled from them at equal temperatures. Furthermore, water-

gas-tar creosote is distinctive in the absence of phenols and cre-

sols, and usually in the presence of hydrocarbons of the paraffin

group; it is not so antiseptic as coal-tar creosote. Unfortunately,

quantities of this oil are mixed with coal-tar creosote, so that it is

often impossible in practice to detect its presence. While this

oil undoubtedly has considerable merit as a preservative of timber,

there is not sufficient precise data available to warrant giving it the

confidence which the coal-tar product now enjoys. Careful tests

show its toxicity to be about 3 to 4 percent as compared with coal-

tar creosote, which has a toxic limit of from 0.2 to 0.4 percent.

The most reliable tests known to the author were made by the

U. S. Forest Service in treating mine timbers (see Chapter XII)

which failed to last as long as similar timbers treated with the

coal-tar creosote.

Although it is slightly more corrosive of iron than creosote from

coal-tar, its action is so slight that its use in steel cylinders can-

not be considered objectionable on this account.

The price of water-gas-tar creosote is seldom quoted but it is

generally a cent or two a gallon less than the coal-tar product.

There is no doubt but that much of this oil is sold as a coal-tar

creosote either alone or in combination and as such commands

the same price.

The National Electric Light Association is the only association

known to the author which has framed a specification for water-

gas-tar creosote to be used in preserving wood. This specifica-

tion reads as follows :

"It shall have a specific gravity of at least 1.03 and not morethanl-08

at 38 C. There shall be not over 1 percent of residue insoluble in hot

86 THE PRESERVATION OF STRUCTURAL TIMBER

benzol. The oil shall contain not over 2 percent of water. The residue

remaining upon sulphonating a portion of the total distillate shall not

exceed 5 percent. When 200 grams of the oil are distilled in accordance

with the requirements of the specifications for the analysis of water gas

tar, dead oil or water-gas-tar creosote and the results calculated to water

free oil (a) not more than 2 percent of oil shall distill off up to 205 C.,

(6) not more than 10 percent shall distill off up to 235 C., (c) not more

than 60 percent shall distill off up to 315 C., (d) the coke residue shall not

exceed 2 percent."

The method of analysis referred to calls for a 300 c.c. side-neck

Lunge distilling flask provided with a trap. 1

Wood-tar Creosote. Of the wood-tar creosotes, that most used

in the past has been secured from resinous woods. The derivation

Resinous Woods

Liquid Distillate Charcoal

Pyroligneous Acid Crud<

Tar

Oils Lighter than Water

Turpentine

Pitch or Tar

Oils Heavier than Water.

Creosote

FIG. 9. Derivation of wood-tar creosote.

of such creosotes is illustrated in Fig. 9. Lack of authentic data

prevents even a general statement as to its constituents, but the

proportion of tar acids and volatile constituents is generally great-

er, and of naphthalene and anthracene much less, than in the coal-

tar creosotes. Wood-tar creosotes have been used to some extent

as wood preservatives for many years. They are, as a rule, not as

toxic as coal-tar creosote, their resistance being less than the

coal-tar product.

On account of the comparatively large amount of acids which

they contain, they corrode iron to a much greater extent than the

coal-tar oil and their use in this connection may be considered

objectionable. It is but fair to state, however, that this property

could be largely overcome if the acids were removed from the

oil. Their supply has been so limited and cost so comparatively

1 Report of Committee on Preservative Treatment of Poles and Cross-

Arras," National Electric Light Association, June, 1911.

PRESERVATIVES USED IN PROTECTING WOOD 87

high that little serious attention has been paid to them except

in the manufacture of certain patented products and " stains."

The rapid rise in the price of coal-tar creosote and its limited

supply have of late attracted considerable attention to the

creosotes from wood, hence it is likely their use in preserving

wood may become more general in the future.

At present these oils are rarely quoted below 12 cents per

gallon even in large quantities, so that the coal-tar product must

rise appreciably or the price of the wood-tar oils must fall

appreciably before their extensive use will occur. In addi-

tion to the tars from resinous woods, there is no good reason

why the tars from hard woods cannot be used in manufacturing

creosotes. If this is done a larger output will be possible. Just

now, no stability in composition is recognized in wood creosotes

for preserving timber and hence no general specification for them

exists.

Mixed Coal-tar Creosotes A large part of the creosote pro-

duced in this country falls into the class of mixed coal-tar

creosote. Some is made by the mixture of undistilled coal-tar,

or oil-tar, or pitch, with coal-tar creosote ; some is produced by

the partial distillation and combustion of bituminous coal at

comparatively low temperatures; and some is secured through

the manufacture of soft pitch when coal-tar and water-gas tar

are distilled in admixture. The nature of all mixed coal-tar

creosotes cannot be described, because their constituents and

relative merits as wood preservatives vary in each case accord-

ing to the materials used in their production and preparation.

Admixtures of undistilled tar or pitch containing free carbon

will, however, tend to decrease the penetrance of the creosote,

while the admixture of products which contain appreciable

amounts of constituents of the paraffin series will doubtless

affect in some measure the antiseptic properties of the creosote.

Paints and Stains. Wood which has been painted with

ordinary paint (usually a mixture of linseed oil, turpentine, and

an inorganic pigment) such as is used in decorating buildings is

partially protected from decay because it is rendered partially

waterproof. The spores of wood-destroying fungi will not

develop readily on the surface of painted wood. To secure best

results only air-seasoned wood should be painted, as green wood

will be very liable to surface check and expose the untreated

interior. Furthermore paint will not adhere as well to green

88 THE PRESERVATION OF STRUCTURAL TIMBER

timber. The layer of paint usually adheres to the surface of

the wood and has little or no penetrating power. Moreover,

it is generally porous so that certain amounts of water can pass

through it. Judged as a preservative of timber, ordinary

paint must be considered inefficient and under certain conditions

may even do the timber more harm than good, as it tends to

equalize moisture in the wood and thus render the interior more

favorable to decay.

Stains, on the other hand, penetrate the wood, although as a

rule only a slight distance from the surface. In addition, they

are generally toxic, so that fungi coming in contact with them

will be killed. The composition of stains varies greatly but they

commonly have a base of creosote either from coal-, oil-, or wood-

tars, to which is added a vegetable or mineral oil to act as a

body for the pigment they carry. Best results with stains are

secured by applying them only to thoroughly air-dry wood, and

whenever possible heating them slightly so that greater pene-

trating power is obtained. As a rule, stains are better pre-

servatives of wood than paints, and their use, particularly

for dwellings, has become very popular of late.

CHAPTER VII

THE CONSTRUCTION AND OPERATION OF WOOD

PRESERVING PLANTS

In Chapter V we described the relative merits of the open-

tank and pressure plants and the general features of their opera-

tion dependent upon the particular process selected. In this

chapter we will describe the construction of the plants, the

effect of the various mechanical manipulations used in them,

such as pressure, vacuum, etc., and the cost of building the

plants.

Open-tank Plants. Several types of open-tank plants have

been constructed. Perhaps the simplest consists in fitting an

iron pipe 3 or 4 inches in diameter, blind at one end, into a

wooden or iron barrel. A fire is then built around the pipe,

which thus heats the oil in the barrel. With wooden barrels

trouble is likely to be experienced in maintaining tight joints.

If desired 2 barrels can be joined together with one piece

of pipe about 8 feet long, and the capacity of the plant thus

doubled. Plants of this kind cost less than $5 each. (See Plate

VII, Fig. A.)

Another simple method consists in building a fire directly

under an iron barrel or tank which is mounted upon stones to

form a proper foundation and fire box. More effective results

are secured by walling the vessel with brick or stone, thus

allowing the heat to pass around the sides as well as the bottom.

The draft can also be controlled a through a small pipe. (See Plate

VII, Fig. B.) Plants of this type cost from $10 to $25 each.

In the types just described, it is difficult to control the in-

tensity of the heat. Better results can be secured if steam is

employed, this being passed through coils in the bottom of the

tank. Plate VII, Fig. C, shows such an apparatus in which the

steam is supplied by a traction engine. In order to cheapen

the cost of the tank, sheet or galvanized iron reinforced in a

wooden frame may be used in place of heavier metal. If desired

a second tank capable of submerging the entire timber in cool

89

90 THE PRESERVATION OF STRUCTURAL TIMBER

preservative can be used and the capacity of the plant thereby

increased. Such a plant including piping costs about $50.

A still more elaborate type consists in building a large rec-

tangular or cylindrical open tank of 1/4-inch or 5/16-inch iron

of various dimensions depending upon the size of the material to

be treated, and pumping the preservative into it after the wood has

been placed in position. This necessitates, in addition to the

treating tank, a good force pump, boiler, and auxiliary tanks to

hold the preservative. Plants of this kind are well adapted for

treating larger quantities of timber than would ordinarily be the

case in the plants described above, or heavier timbers such as

poles. Their cost varies, of course, with their size, but will range

from about $2000 to $6000. One similar to that shown in Plate

VI, Fig. C, cost $2500 complete.

All the plants above described are aimed to heat only a portion

of the timber, although the entire stock can in some cases be

submerged in the preservative should this be considered neces-

sary. Another type of plant for treating comparatively large

quantities of small timber such as ties and poles consists in

passing them through the hot preservative by means of an

endless chain, the length of time they are in the preservative being

controlled by the speed of the chain. Such a plant is shown in

Plate VII, Fig. D, and has been used with satisfactory results by

a traction company in New Jersey. It cost about $1600 and

has a capacity of about 1200 ties per 10-hour day. Because

of the large surface exposed, only those preservatives which

volatilize at high temperatures should be used if most economic

results are to be secured. Treatments in plants of this kind are

really nothing but prolonged dipping reatments and in this respect

differ from the Giussani process, which submerges the wood in a

subsequent bath of cool preservative by passing it through a

second tank.

Pressure Plants. Considerable quantities of timber are most

efficiently handled in pressure plants, which fact accounts for the

large number now operating in this and foreign countries. (See

Plate VI, Fig. D and Plate VIII, Fig. A.) The essential features

in all plants operating on this basis are quite similar, although

the details of construction and operation vary through wide

limits, these depending upon the opinions and experience

of their builders and the class of work the plant is to handle.

In general, the following units are characteristic of all pres-

PLATE VII

. A. A post treating plant made of two barrels and an iron pipe. (For-

est Service photo.)

FIG. B. An open tank post treating plant California. (Forest Service

photo.)

(Facing page 90.)

PLATE VII

FIG. C. An open tank post treating plant. Note heat is furnished by

steam from threshing engine. Small cylindrical tank is for butt treating in

a hot bath; rectangular tank is for a cold bath. (Forest Service photo.)

FIG. D. Open tank wood preserving plant for ties. The ties are carried

through the plant on an endless chain. (Photo through courtesy of the

Public Service Corp., Newark, N. J.)

OPERATION OF WOOD PRESERVING PLANTS

91

sure plants: (1) A retort house, (2) a pump house or

room, (3) a boiler house, (4) a machine shop or room and (5) a

yard for storing, loading, and handling the timber. Some plants

are also equipped with a sawmill for framing the timber prior to

its injection with preservatives. The arrangement of these

units in a typical plant is shown in Fig. 10. Variations, of

course, occur, especially if the plant is to operate a special process,

or only on a given kind of timber. Furthermore, the cylinders

may vary in number from 1 to 9 or more, in which case a different

arrangement of the units would be made.

Plan Showing Yard Layout

To City \V

FIG. 10. Plan showing layout of a typical wood preserving plant,

ing through courtesy of the Ry. Eng. and M. of Way.)

(Draw-

The Retort House. The retort house is built primarily to cover

and protect the treating cylinders or retorts. In best con-

struction it is made of steel, brick, or re-enforced concrete, al-

though a wooden structure may be used if minimum cost is

desired. To guard against loss of preservative due to leaks,

or accident, the floor is sometimes made of solid concrete with

appropriate drains to a sewer or underground tank, and de-

pressed so that the level of the rails in the retorts will be the same

as that of the outside tracks. It is well to so construct the build-

ing that a free ventilation can be obtained to carry off the vapors

which frequently arise during the operation and to keep the

temperature in the house from becoming oppressive to the

workmen.

Retorts (or Cylinders). These are invariably built of steel

and are cylindrical shells mounted horizontally upon concrete

piers. Their diameter varies from about 6 to 9 feet, and length

from about 50 to 180 feet. A good size is 7 feet X 132 feet.

The 7-foot diameter enables a more economic utilization of space

in the cylinder than a smaller diameter and is not too large to

92 THE PRESERVATION OF STRUCTURAL TIMBER

make the handling of the cylinder cars expensive and clumsy.

The same reasoning applies to a length of 132 feet or thereabouts.

The thickness of the metal in the retorts varies from about 5/16

to 1 inch. Good practice is to use metal of such thickness that

working pressures of 150 to 200 pounds can be safely used. In

some cases lower pressures of 100 to 125 pounds give satisfaction.

The plates of which the retorts are made are riveted with either

butt or lap j oints. For high pressures the former is the more satis-

factory. In order to completely drain the retorts a slight pitch is

given them. It is very important to have the retorts mounted

upon firm piers, or trouble from buckling is likely to occur. If

the plant is built on marshy ground the piers should be made

wide at the base and close together or mounted on piles. The

retort is perforated to admit pipes, gauges and thermometers, and

often has a small dome riveted on the top and in the middle to

act as an expansion chamber for the contained air and oil.

Retort Thermometer. The manner of placing the retort

thermometer is very important or incorrect readings of tem-

perature will result. The bulb of the thermometer should not

be too close to the shell of the retort but should be at least 2

inches from it. The thermometer preferably should be inserted

near the middle of the retort and half way up. In order to be

sure of the reading a pet cock should be inserted in the ther-

mometer plate and some oil drawn off during the treatment.

In addition to the direct-reading thermometer, recording ther-

mometers are also highly desirable, as they give a complete record

of temperature during the entire treatment and enable the

manager to get an accurate check on his men. Care should be

exercised to see that the thermometer is properly calibrated and

guarded against the men tampering with it. By ascertaining the

temperature at various points in the retort (by means of a

maximum and minimum thermometer) the thermometer inserted

in the shell can be calibrated to give the average reading in the

cylinder.

Retort Gauges. These are inserted in the retort to record the

pressures in it, whether above or below atmospheric. They may

be inserted at any convenient point in the top of the shell. If

direct reading, the gauges should be protected from injury by pre-

servative by. means of a water seal or diaphragm. The author's

experience with combination pressure and vacuum gauges has

not been satisfactory and it is believed separate gauges give better

results. Self-recording gauges are highly recommended.

PLATE VIII

FiG. A. Small wood preserving plant designed }>y the ('. S. Forest

service in co-operation with the Louisiana Creosoting Co. (Forest Service

Photo.)

FIG. B. View through a large treating cylinder. Note guard rails, steam

coils and track. International Creosoting and Construction Company.

(Facing page 92.)

PLATE VIII

FIG. C. Spider door with independent sockets. (Photo, through courtesy

of the Allis Chalmers Mfg. Co.)

FIG. D. Spider door with continuous socket support. (Photo through

courtesy of the Allis Chalmers Mfg. Co.)

FIG. E. Construction of a cast steel door. (Photo through courtesy of

the Allis Chalmers Mfg. Co.)

OPERATION OF WOOD PRESERVING PLANTS 93

Anchors and "Turtles." As the temperature of the retort

varies considerably, it is necessary to anchor the retort and also

allow for its expansion and contraction. Anchorage can best be

made at the middle. There are several methods of doing this

but embedding a channel or angle iron riveted to the retort

in a concrete pier or "tie rods" in two piers prove satisfactory.

In some plants the retorts rest in cast-iron saddles or " turtles,"

which are permitted to slide back and forth over plates embedded

in the piers, thus providing for expansion. In other cases the

turtles are made of wood. Although steel rollers are sometimes

used to permit a freer movement of the "turtles," they are not

necessary, as equally satisfactory results can be obtained by

simply permitting the expansion and contraction to take place over

flat surfaces.

Retort Coils. Steam coils placed in the bottom of the retort,

generally over its entire length in order to heat the preservative,

are a source of constant expense and trouble unless they are

properly laid, as they dilute the preservative with steam and cause

leakage of the preservative. (See Plate VIII, Fig. B.) The im-

portance of first-class construction in these coils cannot be over-

emphasized. A few plants omit the coils but as a general rule

they are necessary for best results. Common practice consists

in screwing extra heavy 1 1/4 to 2-inch pipes into extra heavy

return bends or headers. If this is done only sharp threads should

be used and no white lead or any similar material should be

permitted in order to make the joints tight. Two schemes which

appear meritorious are to use cast-iron radiators in place of coils,

these being coupled in series, or to place one steam pipe in-

side another, leaving one end free so that it can expand and

contract at will. This latter device has been found very satis-

factory in practice. In order to protect the coils from possible

injury due to derailment and from dirt off the timber, per-

forated steel plates are frequently laid over them. 1

Guard Rails. When the cylinder cars loaded with wood are run

into the treating retorts, the tendency is for them to float off the

track after the perservative is admitted. This is because the

buoyant force exerted by the wood is greater than the dead weight

of the cars. To overcome the possibility of such trouble, guard

rails are generally used. Three types of such guard rails are in

1 Mr. J. B. Card has invented a new method of heating creosote during

treatment. He has a heater outside the cylinder and circulates the oil

through it and the treating cylinder.

94 THE PRESERVATION OF STRUCTURAL TIMBER

use. In one an angle iron is bolted to the seats riveted to the

shell of the cylinder. The car with its load can float partially off

the tract equal to the distance between the top of the retort and

the top of the iron bale or hoop fastened to the car a space usually

of 1 1/2 to 3 inches. As the preservative is run from the cylinder

the car gradually settles into position on the track.

In the other two types a projecting flange is generally riveted

to the cylinder car, which slides under the guard rail and thus

prevents the car from floating, the only difference in the two

types being that in one the projecting flange is riveted on the

bottom of the car, while in the other it is on top of the frame.

Retort Doors. These may be fastened on one or both ends of the

treating cylinder, depending largely upon the ease with which

the timber can be handled in the yard. Retorts with but one

door are entirely satisfactory and in the author's opinion are

preferable to retorts with doors at both ends. When one door is

used the other end of the cylinder is closed with a dished head,

thus saving extra expense and often trouble. Retort doors are

always fitted to cast-iron or steel rims or " collars" riveted to the

shell of the cylinder. These collars are machined with a dove-

tailed groove to hold a gasket against which the " tongue" on the

door can press. Asbestos rope pounded into this groove and its

surface kept well lubricated with graphite and oil makes a very

satisfactory packing.

There are several types of doors but they may be classed

into two groups, " spider doors" and "bolt doors." The former

enable the cylinder to be opened and locked easily and quickly,

and for this reason are preferred by some. They are, however,

more expensive than bolt doors and are more liable to get out of

adjustment and cause leaks. Two kinds of spider doors are

generally used. The one shown in Plate VIII, Fig. C, has a

center screw and lever nut arranged so that each lever has an

independent connection to the frame. The type shown in Plate

VIII, Fig. D, is stronger and better constructed and so arranged

that the levers are connected to the frame by a continuous-

flange ring. Both of these types swing on hinges.

Most treating plants now use some form of bolt door, as the

small time of opening and closing is not a very important factor,

their cost is low, and their construction simple and efficient.

There are several types of bolt doors and several methods of

arranging the bolts. A good type is one constructed of solid

OPERATION OF WOOD PRESERVING PLANTS 95

cast steel, with independent Tee-bolts fastened to the cylinder

and swinging on hinges without a wheel support. This is

shown in Plate VIII, Fig. E. Doors are sometimes constructed

of a cast-steel rim to which is riveted to a dished-steel plate.

Such doors are light in weight but not as strong as those of

solid cast steel. (See Plate IX, Figs. A and B.) In some plants the

bolts are not mounted to the cylinder but simply rest in slots

so they can be removed when not in use. This is the cheapest

construction but not as good as where the bolts are fastened and

hence always in position ready for use. Bolts with an "eye"

in place of a "Tee" are also used, being fastened to a ring which

passes through the eye, which is in turn tapped to the collar on

the cylinder. This construction is very satisfactory but has an

objection in that if one bolt becomes damaged it is necessary to

remove all those fastened to the portion of the ring on which it

swings in order to make repairs. However, as such damage

occurs but seldom and as this construction is cheaper than the

independent Tee-bolts, it has very much merit in its favor.

It is very important to properly imbed the curved iron plate

or rail upon which the door wheel rolls or the door will either

jam or not rest on the wheel. Furthermore, improper founda-

tions will throw the cylinder out of alignment and render the

wheel useless.

In order to avoid hinges, doors are sometimes cast without them,

as is shown in Plate IX, Fig. C. In this case they are supported

on a small derrick or overhead track so they can be swung or

run out of the way during the transfer of the cars. Further-

more, they render it unnecessary to entirely remove the nut

as is done on some of the bolts near the hinge. However, by

proper design this objection can be remedied on the hinged

door.

Retort Lagging. Practice in regard to lagging or covering

the retorts to prevent heat losses due to radiation varies widely.

In northern plants where fuel is high and outside temperature

at times very low, several plants have covered their retorts and

tanks and secured very good results. The chief objection to

covering retorts is the expense and trouble in case of cylinder

leaks. It is common practice, however, to lag all steam pipes.

Most plants use exhaust steam to heat these various tanks and

consider the lagging of the retort unnecessary. It is the author's

opinion that lagging is desirable and if properly applied will more

96 THE PRESERVATION OF STRUCTURAL TIMBER

than pay for itself in a few years. Mr. R. W. Yarborough con-

tributed an interesting paper on this subject at the 1911 con-

vention of the Wood Preservers' Association. Mr. Yarborough

roughly estimated that about 2,000,000 B.T.Us, were lost per

hour in operating a retort 7 feet X 132 feet, which is equivalent to

the consumption of about 187 pounds of coal. With coal at $3

per ton, this represents a loss of about 30 cents per hour, or $2.40

per 8-hour day. It costs about $300 to $1200 to cover a

7 foot X 132 foot retort, depending upon the kind of lagging used.

Most any fibrous material which is a poor heat conductor can

be employed. Cheap coverings can be made according to the

following: (1) Sawdust and starch re-enforced with poultry wire,

(2) cotton seed hulls, (3) mixture in equal parts of lime, sawdust,

and asbestos, (4) sawdust, tar felt, and wood slats.

The Pump House or Room. It is highiy desirable to have the

pumping machinery as close to the retorts as possible, as this

avoids unnecessary piping and renders the operation more accur-

ate and less troublesome. (See Plate IX, Fig. D.) In best practice

this is accomplished by either building the pump house adjoining

the retort house or placing the machinery in the retort house and

separating it from the retorts by means of a fire wall or partition.

Fumes arising from the cylinders are thus confined to the retort

house. In the pump house are installed the force pumps for

moving the preservatives, vacuum pumps, compressed-air

pumps, fire pumps, and at times electrical equipment in case the

plant is to operate at night. Gauges for recording temperature,

pressure, and vacuum in the retorts are also frequently installed

here, as well as the devices for measuring the absorption and

consumption of the preservative in the retorts and measuring

tanks. The arrangement of this apparatus is one of the most

important features in designing a wood preserving plant. It is

very essential to use only high-grade machinery and then, if

funds permit, provide for duplicate units. Cheap pumps and

rigid units always result in troublesome delays and repairs, mak-

ing good work almost an impossibility. Machinery made by

any high-grade concern can, however, be used, its selection being

largely a matter of personal taste. Rubber gaskets should not

be permitted if they are likely to come in contact with creosote.

Likewise, if zinc chloride is to be used the pumping parts should

be so constructed that they will not be corroded too rapidly

and hence cause the pumps to work unsatisfactorily. It is es-

PLATE IX

Fi<;. A. The construction of the collar and door in a pressure cylinder.

Note cylinder track and guard rails. (Photo courtesy of the Allis Chalmers

Mfg. Co.)

FIG. B. Construction of a door with cast steel rim and dished plate steel

head. (Photo, through courtesy of the Allis Chalmers Mfg. Co.)

(Facing page 96.)

PLATE IX

FIG. C. Cylinder doors without hinges. Norfolk Creosoting Company

(Forest Service photo.)

FIG. D. Pump room C. B. & Q. R. R. treating plant,

gauges and control valves.

Note arrangement

OPERATION OF WOOD PRESERVING PLANTS 97

sential also to have pumps of such design that the packing and

working parts can be easily inspected and replaced. Either

wet or dry vacuum pumps may be used. If the latter, a surface

condenser will be found advantageous. Some plants have done

away entirely with force pumps in moving the preservative

and apply pressure in the retorts by using compressed air. The

author's experience with such equipment has shown it to be

highly satisfactory, as it is quick, efficient, and cleans the pipes

thoroughly. Care should be taken, however, to prevent an

emulsifying of the oil, especially if it contains much water. In

fact, it is good policy to so design the plant that the oil can be

transferred with a minimum of agitation.

According to Mr. F. J. Angier, the advantages of the air-

pumping system over the hydraulic system are: 1

"Only one tank is required for each retort, that tank serving in the

triple capacity of pressure tank, measuring tank, and drain tank.

One air pump is ample for three retorts, while one hydraulic pump is

required for each retort.

The maintenance of one air pump is much less than three hydrau-

lic pumps, and is decidedly cleaner. The air pump requires less at-

tention, and lessens the cost of packing, lubricants, valves, valve seats,

plungers, etc.

An air pump is a necessity in plants using hydraulic pumps for blowing

back solution, unless those plants are equipped with expensive under-

ground receiving tanks. In the latter case an air pump can be dispensed

with in lieu of a large oil pump for pumping solution back into the work-

ing tank. The underground receiving tank is more expensive in opera-

tion than the air pump, and no doubt this is the reason why so few plants

are thus equipped.

One air pump can be operated on two or more retorts at the same time

without deranging the gauge readings. This is not practicable with

hydraulic pumps.

Experience has taught us that it is practically impossible to maintain a

steady and constant pressure on a charge of timber with a hydraulic

pump, even though it is equipped with relief valves, while with the air

pump this is easily accomplished.

The amount of steam required to operate one air pump is not more

than would be required to operate three hydraulic pumps, but as

the exhaust steam is used for heating purposes, this feature is not so

important.

The initial cost of installing the air-pump system is a trifle more than

1 F. J. Angier, Proceedings American Wood Preservers' Ass'n., 1914.

7

98 THE PRESERVATION OF STRUCTURAL TIMBER

for the hydraulic pump system, but the maintenance is less, and in the

long run air is more economical. The following statement will give some

idea of the relative first cost, which may vary one way or the other,

depending on local conditions:

COST OF AIR-PUMP SYSTEM

One air pump (capacity 8 cubic feet of compressed air per

minute at 175 pounds gauge pressure) $1200.00

Three pressure-measuring-drain tanks 2000 . 00

Piping, valves, etc. (estimated) 400 . 00

Total cost of air-pump system $3600 . 00

COST OF HYDRAULIC PUMP SYSTEM

Three hydraulic pumps $1000 . 00

Three measuring tanks 900 . 00

Two drain tanks 400 . 00

One low-pressure air pump 500 . 00

Piping, valves, etc. (estimated) 600 . 00

Total cost of hydraulic-pump system $3400 .00

With hydraulic pumps there is more machinery to care for, more

tanks to look after, and more piping and valves to maintain. There is

also more work for the engineer, and unless everything is compactly

arranged the engineer will require an assistant. With the air pump one

man can easily look after the entire operation with greater satisfaction

and with better results."

The Machine Shop or Room. This may be an independent

building or a room adjoining the retort house, but in either case is

a very important element in a pressure preserving plant, espe-

cially if the plant is remotely situated. In addition to hammers,

chisels, wrenches, etc., it is very desirable to have a good forge,

especially for repairing cylinder cars. If the plant is large a lathe

will also be found handy. Too much attention cannot be paid to

a good pipe-fitting outfit, and only clean, sharp dies should be

permitted about the plant.

The Boiler House. As a precaution against fire, the boiler

house should be a separate building situated some distance from

the treating plant proper. There is nothing novel about the

construction of the boiler house. A common mistake, however, is

to underestimate boiler capacity, especially where steaming is

practised and low temperatures are encountered. A good ratio

is about 160 H.P. to a cylinder 7 feet in diameter X 132 feet in

length with a working pressure of 125 pounds.

OPERATION OF WOOD PRESERVING PLANTS 99

Yard. The yard arrangement is one of the most important

features of a wood preserving plant. (See Plate X, Fig. A.) To

have the yard designed in a flexible manner so any point can be

easily reached without unnecessary distance, to economize in track

equipment, to allow proper storage for the timber, and ready

means of loading and unloading it is not a problem easy of solu-

tion. Many yards are poorly designed, resulting in an unnec-

essary initial expenditure and excessive operating costs. While

the yard layout will vary considerably depending upon the re-

quirements peculiar to each plant, certain general essentials

applicable to all yards can be given.

In the first place, the yard should be level, well drained, free

from rank vegetation, and if possible covered with cinders. The

timber should be piled off the ground at least 8 inches, preferably on

creosoted stringers, with sufficient space between the piles to allow

a free circulation of air and ready inspection. No decayed wood

about the yard should be tolerated.

The track should be well constructed, with good bearing for

each tie, properly spaced, in perfect alignment, and even grades.

The rail should not be too light but should run 60 pounds or over.

To use a very light rail or old rail badly worn or pitted is poor

economy. So far as possible the track should be straight and

sharp curves avoided. A good working distance between tracks,

center to center, is 50 to 70 feet. If the plant is to handle

several forms of timber, especially piling, poles, and long dimen-

sion stock, the use of 3-rail track for standard and narrow

gauge is satisfactory and economical but liable to cause delays.

If only ties are to be treated, a narrow gauge in the yard proper

is sufficient, standard gauge being used only to tap the main

centers of distribution. The number of frogs and crossovers

should be kept to a minimum, but should allow sufficient flex-

ibility in moving trams or cars. The use of a transfer table has

been suggested by Mr. W. F. Goltra in order to keep the number

of switches to a minimum. There appears much merit in this

scheme. A yard arrangment for a tie plant is shown in Fig. 10.

Loading Dock. If the plant is to handle large numbers of ties,

a loading dock will be found very useful, especially if the plant re-

ceives mostly flat cars or gondolas and the ties are loaded by

hand. The dimensions of the loading dock will vary, of course,

with the size of the plant, but it should have an elevation at

least equal to the height of the floor in freight cars. A loading

100 THE PRESERVATION OF STRUCTURAL TIMBER

dock for ties is shown in Plate X, Fig. B. The loading dock

enables the foreman to easily keep his workmen in view.

Methods of Transferring Material in the Yard. Practice

varies and opinions differ concerning the best method of handling

timber in the yard. The tram or cylinder cars are moved in four

ways: by cables, dummy engines, electric locomotives, and by

horses or mules. For tie plants where the yard arrangement can

be simplified, electric locomotives are very satisfactory. For

general all-around work the dummy engine is satisfactory, as it

is inexpensive, flexible, and efficient. If properly handled it offers

no unusual fire risk. When labor is available, loading and un-

loading ties by hand is still best practice, especially when it can

be done by piece work. Some plants, however, use the locomo-

tive crane moving a whole buggy load of ties at a time. (See Plate

X, Fig. C .) For timbers which are too heavy to be moved by hand

the author prefers the locomotive crane to any other system, large-

ly because of its efficiency and flexibility. Stationary derricks

operated by cables are also satisfactory for heavy timbers, but

have not the radius of action of the locomotive crane. Traveling

cranes are also used by some plants but like the derrick are limited

in their territory. Furthermore, unless the structures on which

they run are properly braced and mounted on solid foundations,

they will get out of alignment and cause trouble. In a few treat-

ing plants small canals filled with water run through the yard.

The heavy timbers are rolled off skids into these canals and

floated to the retort house, where they are placed on the cylinder

cars by a traveling crane. (See Plate X, Fig. D.) A few coast plants

store their heavy timbers as rafts in water a method which of

course precludes any air seasoning.

Cylinder Cars. These are also referred to as tram cars, bolster

cars, retort cars, and " buggies. " Three general types are gener-

ally recognized: (1) a tie car of rigid construction throughout, (2)

a swivel or bolster car which has a pivot bearing to allow for long

timbers in rounding curves, and (3) a block car for holding pav-

ing blocks. Two of these types are shown in Plate XI, Fig. A, and

Fig. B. There are two essential features in the proper building of all

types, which are often sadly neglected, viz., a heavy, substantial

construction and a maximum holding capacity. On account of

the severe usage to which the cars are put, they should be made very

strong or they will soon be broken or bent and consigned either to

the repair shop or scrap heap. Especial attention should be given

PLATE X

FIG. A. Chicago and Northwestern Tic Treating Plant, Escanaba, Mich.

(Photo through courtesy C. & X. W. R. R..)

FIG. B. Tie treating plant of the Pennsylvania R. R. Xote concrete

loading dock with empty cylinder cars on top, also manner of unloading

and piling ties for air seasoning. (Photo through courtesy of the P. R. R.)

(Facing page 100.)

PLATE X

FIG. C. Unloading treated ties from cylinder buggies into gondolas

with a locomotive crane. Port Reading Creosoting Co. (Forest Service

photo.)

FIG. D. Overhead electric crane for loading timber into cylinder cars.

Gulfport Creosoting Co., Gulfport, Miss.

OPERATION OF WOOD PRESERVING PLANTS 101

to properly reenforcing the curved arms so they will not bend and

jam in the cylinder. The frame work should also be set low or

the treating capacity of the plant will be greatly decreased. A

solid iron hoop or " bail " is preferred to chains, in order to hold the

timbers on the car, and no jamming or pounding of the bails

should be tolerated. It is almost universal practice to build the

cars without couplers, the idea being to save expense, time and

space in the cylinder. Hence the cars must always be pushed

and never pulled. Some plants broke away from this practice and

used couplers on their cars so they could be pulled as well as

pushed a scheme which has been prohibited in certain states

because of danger to workmen. Block cars can be made out of

tie cars by simply placing on the tie car a perforated sheet-iron

basket with hinged doors. In some cases the cars are built

purposely for handling blocks and so designed that they can be

emptied by lifting them bodily with a locomotive crane and turn-

ing them upside down.

A good feature in the design of cylinder cars is to have loose

wheels of heavy construction fitted with roller bearings and a

fairly wide tread.

Measuring, Mixing, Working, and Storage Tanks. A meas-

uring tank is one used for measuring the absorption of pre-

servative forced into the wood. It is invariably constructed of

steel. It is considered good practice to have the diameter of these

tanks as small as possible in order to allow for an accurate reading

of the preservative and to have them accurately calibrated.

Furthermore, they should be placed as close to the retorts as

proper design will permit. Some engineers have carried this

idea as far as to place them directly over the retorts. The size

of the measuring tanks in relation to the size of the retort varies

greatly in practice. In some plants the volume of the measuring

tanks is 1 1/2 times the volume of the cylinder, in others it is less

than half the volume of the cylinder. In most plants these

tanks are built to withstand the pressure due to only the head

of the preservative, and are elevated upon stationary platforms

so that the preservative can flow from them into the retorts

by gravity. In a few plants, using compressed air, the meas-

uring tanks are mounted on the ground and built to withstand

a working pressure equal to that of the retorts. Another design

mounts the measuring tanks upon scales so that as the preservative

is pumped out of them through flexible connections the amount

102 THE PRESERVATION OF STRUCTURAL TIMBER

of preservative forced into the retorts can be read directly. All

float gauges are in this case done away with. The author prefers

the two latter designs of constructing tanks of this kind.

Mixing tanks are used for making solutions of zinc chloride.

A substantial construction is to use wood lined with lead. Con-

centrated solutions of zinc chloride are basic and will attack

wood. If tar is mixed with creosote the tanks in which this is

done are also sometimes called " mixing tanks " and are generally

built of steel.

Working tanks are intermediate in size to measuring and stor-

age tanks and are in common use. They are not used to measure

absorption but to aid the measuring tanks in rilling the retorts

with preservative. In other words, after the wood has been

placed in the retorts and the doors locked, the preservative is

run from the working tank until the retort is filled, after which

the preservative is drawn from the measuring tank. Working

tanks are usually built of steel and elevated so that the pre-

servative can run from them into the retorts by gravity. If zinc

chloride is used, the tanks are frequently built of wood, as weak

solutions of zinc chloride will attack steel. In some plants

working tanks are not used, in which case the measuring tanks

are made with larger capacity. Working tanks may have from

about 1 to 3 times the capacity of the retorts.

Storage tanks, as the name implies, are used to store the

preservative. There is no agreement as to size, this depending

upon the requirements of each plant. They are generally located

some distance from the plant proper as a matter of safety. It is

well to have the storage tanks at least sufficiently large to allow

for a month's supply when operating at full capacity. On account

of their large size, storage tanks are frequently built without a

roof, evaporation of oil being retarded by means of a water seal.

Generally the measuring and working tanks are covered.

Some plants are equipped with receiving tanks, which are

buried below ground so that the excess preservative in the retorts

can be drained into them, after which it is pumped back into the

working or measuring tanks. This enables a quick emptying of

the cylinders. When the excess preservative is pumped or

blown back from the cylinders, these tanks are unnecessary.

Because creosote congeals at low temperatures, all of the

tanks described are generally fitted with steam coils through

which exhaust or live steam may be passed. Traps should be

PLATE XI

FIG. A. Bolster Car. Used for long timbers. (Photo through courtesy

of the Allis Chalmers Mfg. Co.)

FIG. B. A tie car. (Photo through courtesy of the Allis Chalmers

Mfg. Co.)

(Facing page 102.)

PLATE XI

FIG. C. Mercury gauge for measuring the preservative in the measuring

tank. Baltimore & Ohio R. R. Tie Plant. (Photo through courtesy of

the B. &O. R. R.)

FIG. D. Wood Block treating plant of the Chicago Creosoting Co., Terre

Haute, Ind. Note vertical cylinders. (Photo through courtesy of the

Chicago Creosoting Co.)

OPERATION OF WOOD PRESERVING PLANTS 103

coupled to the exhaust ends of all these coils. Air is at times

passed through the storage tanks in order to keep the composition

of the preservative uniform.

Gauges and Scales. Many plants are still careless in their

methods of measuring absorptions of preservative. Of course, if

the plant is doing its own work, as in most railroad plants,

accurate measurements of absorption are not as essential as in

commercial plants treating on contract. However, in either

case, correct determinations are at least desirable. Several

methods of measuring absorption are in practice. The most

common is to have a float and tell-tale sliding on a vertical scale

board, the two connected by a chain or fine piano or annealed wire

which runs over pulleys. If the float, tell-tale, and pulleys are

large, operating with little friction, the scale board accurately

calibrated, the chain or wire protected from the wind, and the

preservative, if an oil, corrected for temperature expansion, this

method is simple and gives satisfactory results. Care should be

taken to agitate the preservative as little as possible in pumping

or blowing back.

When compressed air is forced into the top of the measuring

tank the total absorption may be determined by gauge glasses

or pet cock fastened to it, and a check on the total amount made

after the excess preservative has been pumped or blown back

from the retort.

If the measuring tank is mounted on a scale, the absorption

may be read directly from the scale beam in pounds. This

renders corrections for temperature expansion unnecessary in the

measuring tank. Another excellent device is to use a mercury

column set at an angle to the desired degree of sensitiveness.

(See Plate XI, Fig. C.) Readings in pounds can thus be directly

and accurately obtained. Care should be taken to keep the oil in

the gauge pipes liquid and free from air. A very good check on

the methods just described is to weigh the timber on track scales

before it goes into the retorts and immediately after it comes

out. This, doubtless, is the most accurate way of determining

absorption. It cannot be used, however, if the timber is steamed

or boiled in oil while in the retort, as such treatments change the

weight of the untreated wood. It is by no means easy to measure

accurately the amount of preservative the charge of wood is

absorbing, especially during treatment, and this is largely a

matter dependent upon the skill of the operator. A very im-

104 THE PRESERVATION OF STRUCTURAL TIMBER

portant aid in gauging absorption is to have accurate ther-

mometers in all tanks used during the treatment.

Piping. The importance of using sharp, clean threads, in mak-

ing pipe connections has already been emphasized. Too much

emphasis cannot be laid upon this detail. It is also highly

desirable to make all pipe lines especially those for trans-

ferring oil as short as possible, and to provide a system

whereby then can be completely drained, with a sump if neces-

sary. Otherwise, trouble may be experienced with the oil con-

gealing in the pipes. Another essential is to use only high-grade

gate valves with replaceable wearing parts in all lines for trans-

ferring liquid, and to pack these with material not attacked by the

preservative. A precaution against leaks or breakage is to have

duplicate valves in all important lines. As considerable dirt,

pieces, of bark, etc., fall from the timber, all lines transferring pre-

servative from the retorts should be protected with perforated

plates or screens. A "mud drum" placed below the retorts is a

good precaution. If these safeguards are not taken, the valves run

a decided risk of being either damaged or destroyed.

Shower Baths. Under best operating conditions a wood-pre-

serving plant is none too clean a place for workmen. Those

companies which have installed locker rooms and shower baths

for their men have found their investment a paying one. Since

these can be installed at small expense, they are recommended.

Inspector's Laboratory. Too frequently an inspector's or

chemical laboratory is either omitted entirely, or when an at-

tempt is made to furnish one, it is a good place to avoid. This

is bad business policy, as the most progressive companies have

discovered. While, of course, an elaborate outfit is not neces-

sary, the place should be clean, well lighted, comfortable, and

equipped with proper apparatus. In brief, the inspector's

laboratory should contain a detailed map of the plant, showing

all valves and pipe lines, with tables giving the dimensions of all

essential plant units. It should have tools, such as rules, tapes,

a brace and bit, saws, and hatchets, for studying the penetra-

tions, and standard tables for ready reference; apparatus and

chemicals for analyzing the preservative, including retorts,

flasks, beakers, pipettes, hydrometers, etc., and a chemical

balance. While not absolutely necessary, a drying oven for

studying moisture in wood and a refractometer for studying

oils will also be found helpful. Samples of wood properly iden-

OPERATION OF WOOD PRESERVING PLANTS 105

tified as to kinds and showing proper treatment will also be found

valuable. Some companies have not only equipped their plants

with such laboratories, but have furnished a small experimental

plant. Unfortunately, the press of daily routine almost in-

variably prevents the operators from carrying on experiments

in them.

Fire Protection. The best fire protection lies in proper pre-

vention through wise design and efficient operation. Under

such conditions danger from fire is very slight. However, as

added precaution and to meet underwriters' requirements, a

good fire pump is highly desirable. In addition, the water stor-

age tank can be drawn upon. Fire hydrants should also be in-

stalled in the yard and properly maintained. Some plants leave

fire lanes between the piles of timber 30 or more feet in width.

Boxes of sand protected against rain and equipped with shovels

are an excellent safety factor, as well as hand chemical extin-

guishers hung at vital points in the plant.

Lighting Equipment. As the plants are often called upon to

run at night, the dynamos should be sufficiently powerful to not

only light the plant proper but also arc lights in the yard. As a

general rule, however, loading and unloading of material should

be confined as much as possible to the daytime, leaving only the

treatments for night work.

Sawmill and Block Equipment. Several wood-preserving

plants in the United States are equipped with small sawmills to

frame their timbers before treatment. The framing of such tim-

bers before the preservative is injected is good practice, as it

insures a protection to the wood over its entire surface. In fact,

ideal practice would be to have the timber framed to the exact

dimensions required so that no cutting or boring would be re-

quired after it has been treated. There is nothing novel about the

construction or operation of these sawmills. They can be located

at any convenient place in the yard and, as a matter of safety,

some distance from the treating plant.

The manufacture of wood blocks is almost invariably done in

connection with the treating plant, the timber being received in

planks and sawed into the various sizes of blocks required.

The planks are carried by chain conveyors to the saws,

which are spaced so as to cut them into the desired depth of

block. In some plants-the saws are all arranged on the same axis

and the blocks all cut at one time. In others the planks are first

106 THE PRESERVATION OF STRUCTURAL TIMBER

cut into smaller planks, which are in turn cut into blocks, it being

claimed that this economizes in wood consumption, as knots, etc.,

can be trimmed with least waste. The blocks then fall from the

saws onto a conveyor, which either carries them to a bin, or,

preferably, direct to the cylinder cars, into which they are dumped

by gravity. A good design is to have the cylinder cars on a track

paralleling the block conveyor. As the blocks are carried along

the conveyor they can be inspected and all defective blocks re-

moved. By having small swinging gates along the side of the

conveyor, the operator can open one, using it to deflect the blocks

into the cylinder car below, and after this has been filled, close

the gate and open the next one situated further on, thus deflecting

the blocks into the second car, and so on until the entire charge

is filled. This method works very efficiently and minimizes

labor. The rate at which the blocks can be manufactured varies,

of course, upon the size and speed of the machine and depth to

which the blocks are cut. A good machine, however, should

turn out 200 square yards of 4-inch, blocks per hour.

The Chicago Creosoting Company has recently taken out pat-

ents on a new type of plant for treating paving blocks which does

away entirely with cylinder cars and enables a decreased cost in

operation. Their cylinders, which are 11 feet in diameter and 40

feet high, are built vertical, the blocks being carried on a con-

veyor and dumped automatically into the cylinder. The treat-

ment is then conducted in the usual manner, after which the

door in the bottom of the retort is opened and the blocks fall

directly into cars for shipment. (See Plate XI, Fig. D.)

Tie-boring and Adzing Machines. At present few treating

plants consider tie-boring and adzing machines as a fixed part

of their equipment. There is no doubt but what such machines

are a desirable asset to any plant which is treating large quantities

of ties, and that they will be viewed with increasing favor because

of the excellent results secured from them. These machines at

present are generally mounted upon a portable platform such as

an improvised box car and are driven by a gas engine. (See

Plate XII, Fig. A-Plate XII, Fig. B.) The rough ties are placed

on a conveyor which automatically passes the ties through the

machine, where they are adzed and bored. Other attachments

are sometimes used, such as a device for trimming the ties to exact

length, and a die or punch which brands them on the ends, this

giving the date, kind of treatment or species of wood. The ties

PLATE XII

FIG. A. Ties entering boring and adzing machine. (Photo through cour-

tesy of the Greenlee Bros. Co.)

FIG. B. Ties adzed and bored being piled on the cylinder cars ready for

treatment. (Photo through courtesy of the Greenlee Bros. Co.)

(Facing page J06.)

PLATE XII

FIG. C. Section through an oak tie showing a cut and screw spike

driven in place. Note comparative distortion of wood fibers. (Photo

through courtesy of the Spencer-Otis Co.)

OPERATION OF WOOD PRESERVING PLANTS 107

then pass down a conveyor on the opposite side of the car, where

they are piled either in stacks or directly upon cylinder cars for

treatment. The capacity of these machines varies but averages

about 3000 ties per 10-hour day. The advantages of such treat-

ment are given in greater detail in Chapter VIII. The total cost

of adzing and boring ties varies from about 1 1/4 to 2 cents each.

The Operation of Pressure Plants. The operation of pressure

wood-preserving plants varies widely, depending upon local

conditions, the opinion of the engineer in charge, and the proc-

esses used. The latter have been described in detail in Chapter V

but we will discuss here the effect of the various manipulations

more or less common to all plants. Unfortunately, the amount

of exact data available is very meager, and results are often se-

cured without knowing why; hence the success or failure of a treat-

ment depends very largely upon the experience of the operator.

The Effect of Vacuum. A vacuum may be drawn in the treat-

ing cylinder before the preservative is admitted, or after the pre-

servative has been forced into the timber, or both before and

after. When drawn before admission of preservative, it is re-

ferred to as a " preliminary vacuum." If drawn after injection

it is called a "final vacuum."

As stated in Chapter IV, a preliminary vacuum drawn imme-

diately after the timber has been steamed helps to dry the timber.

The reduced pressure in the cylinder lowers the boiling point of

water and hence hastens the rate with which it evaporates.

When a preliminary vacuum is drawn on air-seasoned wood it

also tends to slightly dry the wood and remove an appreciable

amount of air from it. If, now, the preservative is admitted to

the cylinder without breaking the vacuum, the speed with which

the cylinder fills is increased. Furthermore, the preservative

can usually be forced into the wood in a shorter time and with

less difficulty. But the most noticeable effect is the manner in

which the preservative is held in the wood after the pressure is

released (Fig. 11). It will be noticed that only a comparatively

small amount of it rebounds or drips from the timber. The

absence of large amounts of air in the wood cells is undoubtedly

the cause of this, since on the release of pressure there is not suf-

ficient expansion of this air in the wood to force out much of the

preserving fluid. In order to leave the greatest amount of

preservative in a given stick of timber, therefore, a preliminary

vacuum should be used. This fact is of prime importance in

108 THE PRESERVATION OF STRUCTURAL TIMBER

1UU

90

80

70

60

50

40

30

1 20

a

i

To 10

"3

5

ei 10

o

I 90

3 80

fc

70

60

50

40

30

20

10

I

\

\

;,

\

\

V

\

^

\

^

fo

'V

\

"--

^^,

"-

|

\

\

^

~^.

>

Hen

alo<

k

\

"^

'^^

-^

\

\

"^

^N

\*>

X

NN

\

\*->.

^

^

^^

\

^~-

-Lc

blc

ily

Pii

e

;

i

r<-0

\

I/

\_\_^

--

\*"

1 ^

\

^

\

^

^

\*^

N

^

\*

i

iVith Final Vacuum

Vithout Final Vacuum

1

V

Q\

\

\

N

I

\

k \^

\

\

\

\

\

V

\

\

\*^

^-~-

\

^..^

X.

V

\

^^i

\

v

\

^ s

\

v

-^

ap

V

f\*^

^

"\*-^S

-

\

-.

^^

,

\ (

S?

--V

^.^

E

ed

Oak

^\

^^.

-^

^

"^

^^

^

i

^

^

^i

k )

^r

X

i

^

10 20 30 40 50 60 70 80 90 100

Preliminary Cylinder Condition - Lbs. per Sq. In. (Absolute)

FIG. 11. Showing the effect of air in ties upon the amount of creosote

retained in them.

OPERATION OF WOOD PRESERVING PLANTS 109

treating timbers which are resistant to absorption or when

large absorptions are desired. The greater the intensity of the

vacuum, the better will be this result, and, if possible, at least 26

inches should be obtained. The length of time the vacuum should

be held depends chiefly upon the kind and size of timber being

treated. Porous woods like maple and red oak require a shorter

vacuum period than resistant woods like hemlock and tamarack.

Small size timbers require a shorter vacuum period than large

size. Exact periods for all species and sizes of wood are not

definitely known. Some attempts to secure data on the rate at

which a vacuum can be drawn on the interior of air-seasoned

ties were made at the U. S. Forest Products Laboratory by boring

a hole to the center of the tie and inserting a small pipe connected

with a vacuum gauge fastened to the shell of the cylinder,

and thus drawing a vacuum in the cylinder. It was found that

in the porous woods like red oak the vacuum on the inside ap-

proached that on the outside much more rapidly than in the more

resistant woods like hemlock. Of course, it is not necessary to

secure as great a vacuum in the center of timber as in the outside,

because the preservative can rarely be forced to the center, espe-

cially in large-sized sticks, but the closer this can be obtained, the

more beneficial will be the results.

To sum up the effect of a preliminary vacuum :

1. More preservative is absorbed during the filling of the cylinder than

when no preliminary vacuum is used (Fig. 12). This is especially true in

porous woods like loblolly pine.

2. It reduces the length of time pressure must be held in the cylinder in

order to secure the desired absorption. This difference is apparently very

slight in woods of moderate porosity like maple, but considerable in porous

or resistant woods like loblolly pine or hemlock (Fig. 12).

3. It reduces to a minimum the rebound or "kickback" of the preserva-

tive on the release of pressure in the cylinder (Fig. 12).

4. It reduces to a minimum the amount of drip (Fig. 12).

5. It enables very heavy absorptions to be more easily obtained.

6. It tends to produce very unequal penetrations and absorptions if only

small amounts of preservative are forced into wood and hence should not be

used in such cases.

A final vacuum produces the opposite effect of a preliminary

vacuum in that it tends to remove the preservative from the wood.

It is greatly aided in doing this if air is left in the wood or if the

wood is treated with compressed air before the preservative is

admitted. The vacuum causes this air to expand and force out

110 THE PRESERVATION OF STRUCTURAL TIMBER

OPERATION OF WOOD PRESERVING PLANTS

111

112 THE PRESERVATION OF STRUCTURAL TIMBER

the preservative. A final vacuum is drawn either to dry the

timber and thus reduce loss of preservative through drip, or to

withdraw a portion of the preservative (see description of " empty-

cell" processes), or to do both. In the tests referred to above, a

final vacuum was drawn on some of the ties and its effect in re-

covering creosote is shown in Figs. 13 and 14. In these tests

the amount of preservative recovered was about 10 percent more

than when no final vacuum was drawn, being greatest in woods

easily treated and least in those which are resistant to injection.

It should be noted that if a preliminary vacuum is used in con-

nection with a final vacuum, a very small recovery of oil is se-

cured, hence in heavy treatments both may be used to advantage.

g 80

".

h

1 70

|

a GO

"M

a

\* 50

"3

2 .40

fi

| 30

20

3 10

M

10 20 30 40 50 60 70 80 90 100

Preliminary Cylinder Conditions -Pounds per Square Inch (Absolute)

FIG. 14. Showing the effect of air in ties upon the "kickback " with creosote.

To sum up the effect of a final vacuum :

1. It dries the ties and hence reduces drip (Fig. 13).

2. It removes some of the preservative injected into the ties, although

this, in itself, is apparently not great, but may be appreciable if used in con-

nection with a preliminary or atmospheric air pressure (Figs. 13 and 15).

The Effect of Air Pressure. Air pressure is used either before

or after the preservative is forced into the wood; hence, as with

the vacuum, we have " preliminary" and "final" air pressures.

Preliminary air pressures are used to force a portion of the

preservative out of the wood and hence give an "empty cell"

OPERATION OF WOOD PRESERVING PLANTS

113

treatment. (See Rueping Process.) As would be expected, it

can be forced more easily into porous than nonporous woods.

If a preservative is forced into wood filled with compressed air

40

20

10

1 1

With Final Vacuum

Without Final Vacuum

^

^

^s

/

/ 1

tod

Oa

s

c

w

p ^

\*\*-

^s

^

^x.

^ ^

c

"

--C

20

10

^ Mape

-f-t-4-4-

10 20 30 40 50 60 70 80 90 100

Preliminary Cylinder Condition- Lbs. per Sq. In. (Absolute)

FIG. 15. Showing the effect of air in ties upon the amount of creosote

recovered by a final vacuum and drip.

and the pressure on the preservative is then released, the air in

the wood will expand and force out a part of the preservative.

Some data on the amount thus forced out is shown in Figs. 12

and 13. It will be noted that the amount of air forced out varies,

114 THE PRESERVATION OF STRUCTURAL TIMBER

up to a certain ratio, with the amount of air forced into the wood,

and that a final vacuum increases this amount (Fig. 15). It has

been noticed, however, that it takes the compressed air in wood

7

led Oak

.3

a

10 20 30 40 50 CO 70 80 90 100

Preliminary Cylinder Condition -L,bs. Per Sq. In. (Absolute)

a long time to escape several days in some cases and that this

causes either a large drip or volatilization of preservative or both.

The effect of a preliminary air pressure is, then, to :

I. Increase the amount of preservative absorbed during the filling of the

OPERATION OF WOOD PRESERVING PLANTS 115

cylinder over what is absorbed when only atmospheric pressure is used

(Fig. 16).

2. Increase the length of time pressure must be held on the preservative in

order to obtain the desired absorption. This is but slight, however, in

woods like red oak but considerable in resistant woods like hemlock (Fig.

12).

3. Increase the amount of preservative which rebounds or "kickback"

from the wood on release of pressure (Fig. 12).

4. Increase the amount of drip (Figs. 12, 13).

5. Leave a minimum amount of preservative in the wood (Fig. 14).

A "final air pressure" is seldom used. It was originally ad-

vocated to force the preservative deeper into the wood and thus

produce an " empty-cell" effect. While it tends to do this to a

slight extent, nevertheless it exerts a more pronounced action

in removing some of the preservative. This is probably due to

the fact that when pressure is released the air escapes from the

wood and carries some of the preservative with it.

The Effect of Pressure on the Preservative. In applying

pressure to a preservative in a treating cylinder three factors are

of importance: The intensity of the pressure, the duration of

the pressure, and the rate at which the pressure is applied.

In general, the higher the pressure the greater and more rapid

the penetration. On porous woods, high pressures are not neces-

sary and, in fact, often objectionable because they force the pre-

servative too rapidly into the wood and cause irregular penetra-

tions. With resistant woods, high pressures (175 pounds per

square inch or over) are also of little value because the resistance

of the wood is often so great that the application of excessive pres-

sure even 500 pounds per square inch or more is not suffi-

cient to overcome this resistance. Working pressures of from

100 to 150 pounds per square inch give most general satisfaction.

As the wood cells are minute and the channels through which

the large portion of the preservative passes are frequently micro-

scopic in size, it is necessary to allow sufficient time for the pre-

servative to diffuse through them. If the desired absorption

of preservative is secured in a short period, the penetration is

apt to be very irregular, whereas if the same absorption is ob-

tained in a longer period a more uniform distribution is generally

secured. The ideal result is to have the preservative diffused

through the wood uniformly and deeply. The application of a

lower pressure held for a longer time approaches this result better

than a high pressure held for a short time. Its chief disadvantage

116 THE PRESERVATION OF STRUCTURAL TIMBER

is a decrease in the capacity of the plant. The rate at which the

pressure is applied to the preservative is also important. If it is

applied rapidly up to the maximum, and the maximum is high,

the desired absorption will be obtained in the shortest time but

at the expense of greatest diffusion. A rapid application of

pressure with a comparatively low maximum is better practice.

If, however, the operator wants capacity, and a large rebound or

"kickback" of preservative after the pressure is released, a

rapid application of high pressure is the thing to use. The erratic

penetration due to a quick absorption may be compensated for,

in part at least, if the operator forces into the wood more pre-

servative than he intends to leave in it, and counts upon the

"kickback" to remove the surplus preservative. As has been

shown above, the condition of the air in the timber also produces

a marked effect upon the amount of preservative which rebounds

out of the wood when pressure is released.

Some Common Errors and Difficulties in Operating Pressure

Plants. Even in the best equipped and managed plants, mechan-

ical errors and difficulties in operation are almost daily encoun-

tered. Without going into the details characteristic of each proc-

ess, the following general notes may be found of service, particu-

larly to operators and inspectors.

Difficulty of Measuring Volume of Charge. The volume of

the timber in the treating cylinder could easily be determined,

irrespective of its form, by subtracting the quantity of preserva-

tive it takes to fill the cylinder when charged from that necessary

to fill it when empty, and deducting the volume of the cars, were

it not for the fact that the wood will absorb the preservative

while the cylinder is being filled. The amount absorbed varies

with the kind and condition of the wood, being greatest in the

case of porous woods air-dry and least for resistant woods when

green, but generally ranges from about 5 to 20 percent. Some

treating plants allow for this "initial absorption," and deduct

10 percent from the total amount of preservative to be forced

into the wood after pressure is applied. 1 There is no satisfactory

way of determining just what this initial absorption will be, and

it must be worked out through experience at each plant. The

1 Some treating engineers claim that blowing the preservative out of the

treating cylinder into the measuring tank also blows some of the preserva-

tive out of the wood, especially if it is porous. As shown above (see " final

air pressure"), this is quite likely to occur.

OPERATION OF WOOD PRESERVING PLANTS 117

volume of sawed timbers can usually be determined with suffi-

cient accuracy by direct calculation.

Expansion of Creosote. Creosote expands considerably when

heated, averaging about 1 percent for every 22 1/2 F. rise in

temperature. It is frequently run into the treating cylinder at

about 200 F. and its temperature invariably falls from 10 to 60

when it strikes the timber. Unless brought back to its tempera-

ture at entrance this contraction may be charged against absorp-

tion. Similar errors will be introduced in taking the final reading

of absorption when the height of the oil in the measuring tank

after the treatment has been completed is subtracted from the

height before treatment, unless the temperature at both times is

the same. It is important, therefore, to keep the temperature of

the oil as nearly constant as possible (with no greater variation

than 20 F.) ; or, if this cannot be done, to correct for tempera-

ture errors by using the proper coefficients of expansion. For

zinc treatments and others of a similar nature such corrections

need not be made.

Expansion of the Cylinder. When hot creosote enters the

comparatively cool treating cylinder it produces an expansion of

the metal, which is further augmented by an internal pressure

often as high as 175 pounds per square inch. Fora cylinder made

of 3/4-inch boiler steel, 7 feet in diameter and 132 feet in

length, this increase in volume may amount to about 18 cubic

feet, equivalent to an absorption of about 1187 pounds of

preservative.

Compression of the Oil and Wood. When pressure is ap-

plied to creosote the oil is compressed. At most, however, this

can produce only an insignificant error, since creosote under

ordinary operative conditions compresses less than one-tenth of 1

percent. The error due to the compressibility of the wood is also

insignificant. Some tests were made at the U. S. Forest Prod-

ucts Laboratory in which 20 pieces of green red oak and black

oak, 2 by 2 inches in cross section, were tested in a 100,000-

pound machine, the load being applied radially and tangentially.

The average modulus of elasticity was 50,375 pounds per square

inch. Disregarding the longitudinal dimension, the volumetric

compression due to an exterior pressure of 200 pounds per square

inch ranged from 0.51 to 1.30 percent, or an average of 0.80 per-

cent. This compression is probably much in excess of that which

takes place in practice, since when wood is submerged in a

118 THE PRESERVATION OF STRUCTURAL TIMBER

preservative fluid the pressure is applied from all directions.

Furthermore, at least a part of this pressure is transmitted to

the interior. It would seem, therefore, that the decrease in the

volume of wood undergoing treatment, due to the pressure

exerted on it, can be entirely disregarded.

" Kickback" of Preservative. When pressure is applied to a

cylinder charge, the oil, wood, and air confined in the wood are

under compression and the cylinder is under tension. If the pres-

sure is released a certain amount of the preservative will be forced

out of the cylinder, although it remains constantly full. The

amount of preservative thus forced out will be called the " kick-

back." It varies with many conditions, and unless provided

for may result in errors of measurement for absorption of from

10 to 40 percent. In the treatment of air-seasoned red oak and

maple ties at the U. S. Forest Products Laboratory by the full-

cell process it was necessary, after the desired absorption had

been reached, to allow from 20 to 30 percent for the oil which did

not remain in the ties.

To secure data on the variability of the " kickback" a careful

series of tests was run on 36 pieces of air-dry longleaf pine. These

were cut 2 inches by 4 inches by 4 feet, matched, divided into

three groups of 12 each, and treated in three different runs in a

cylinder approximately 18 inches in diameter and 4 feet long.

In all cases the drip was stopped when it amounted to less than

1/2 pound of creosote in a half-hour period. The runs were

made as follows:

Run 1. No preliminary or final vacuum was used. The

cylinder was filled with creosote in 6 minutes and the oil raised

to a temperature of 180 F. A pressure of 120 pounds per

square inch was immediately applied and held for 7 minutes.

The pressure was then released through the top of the cylinder

for 15 minutes, after which the cylinder was drained and the

wood permitted to drip for 121 minutes, when it was removed

and weighed.

Run 2. After the wood was placed in the cylinder a prelimi-

nary vacuum of 25 1/2 inches was held for 15 minutes, the total

vacuum period amounting to 22 minutes. Without breaking

the vacuum the creosote was then drawn into the cylinder, the

operation consuming 5 minutes. The temperature of the creo-

sote on entering the cylinder dropped to 125 F. It was raised

to 181 F. in 12 minutes, when a pressure of 120 pounds per

OPERATION OF WOOD PRESERVING PLANTS 119

square inch was immediately applied and held for 3 minutes.

The pressure was then released for 16 minutes through the top

of the cylinder, after which the cylinder was drained and the

wood permitted to drip for 73 minutes, when the charge was

removed and weighed.

Run 3. A preliminary air pressure of 50 pounds per square

inch was immediately applied and held for 15 minutes, after

which the oil was pumped into the cylinder against this pressure,

the operation taking about 10 minutes. The temperature of the

oil on entering the cylinder dropped to 156 F. It was then

raised to 180 F., consuming 9 minutes. During the heating

period the pressure in the cylinder varied between 55 and 70

pounds per square inch. As soon as the oil reached 180 F. a

pressure of 120 pounds per square inch was applied and held

for 78 minutes. The pressure was then released through the

top of the cylinder for 14 minutes, after which the cylinder was

drained and the wood permitted to drip for 128 minutes, when

the charge was removed and weighed.

The results of these runs are given in Table 7. It will be seen

that the "kickback" was least when a preliminary vacuum was

drawn, and greatest when the cylinder was first filled with com-

pressed air. 1 Similar results were secured on full-sized ties, as

is shown in Figs. 12 and 13.

To illustrate the possible source of error through this "kick-

back" on the release of pressure, suppose, for example, it amounts

to 20 percent, and the specifications call for a 10-pound per cubic

foot injection in cross-ties of 3.5 cubic feet each. If the "kick-

back" is disregarded and the pumps kept running until the gauges

show an injection of 10 pounds per cubic foot and the pressure is

then released, only 8 pounds per cubic foot will be left in the ties.

If, on the other hand, the "kickback" is considered, then the

pumps will be kept running until the gauges indicate an absorp-

1 When the preliminary vacuum was drawn, only 3 minutes of oil pressure

were required to force 12 . 3 pounds of oil per cubic foot into the wood, but

when the cylinder and wood were first filled with compressed air it took 78

minutes to force 12 pounds of oil per cubic foot into the wood. That the

preliminary vacuum rendered it easier to force the preservative into the

wood is therefore apparent. After the run the sticks were split and the

penetration in run 3 was found to be slightly greater than in runs 1 and 2.

Furthermore, the sticks in run 3 were treated more uniformly than in the

other runs, especially run 2, in which the penetration and absorption were

very irregular.

120 THE PRESERVATION OF STRUCTURAL TIMBER

O fl n T3 o

111;!

1 \* 1 3 s

1

imu

rpti

> t>

!-:

2j

3

s l^

E M,I

"o g

if\*

^

H 8

2

fl O5 "5 O

O O O r-I

P4

'S o o o

C 00 \* ut

o TJ< ci -^

1C I-H T<

00 00 00

. t- CO 00

tion of 12.5 pounds per cubic foot, which

on the release of pressure will leave 10

pounds per cubic foot in the ties. If

this " kick-back" is released through an

underground tank or some measuring

tank other than the one used during

treatment (and this is a common prac-

tice), the chances for error in measur-

ing the absorption are increased.

Expansion of Wood. Another pos-

sible source of error in measuring ab-

sorption is the expansion of the wood

due to raising its temperature. Assum-

ing the thermal coefficient of linear ex-

pansion of wood, 0.00001 per degree

Centigrade parallel to the fiber and

0.00006 across the fiber 1 and that the

wood is raised in temperature 60 C.

(140 F.) during treatment, then the

increase of volume in a charge of say 800

ties will be about 22 cubic feet, equiva-

lent to about 1,386 pound of creosote,

or 1.7 pounds per tie. If the wood is

raised more than 60 C. in temperature,

the volume increase will, of course, be

greater.

Extent of Possible Errors. The ex-

tent of the various errors possible in

measuring absorption may be illustrated

by the following example: Assume the

treating cylinder to be 7 feet in diameter,

132 feet long, and to hold a charge of

800 7-inch by 9-inch by 8-ft. ties; as-

sume also that 10 pounds of creosote

per cubic foot are to be injected into

and left in the ties; that a pressure of

175 Ib. per square inch is used during the

treatment; that the oil in the measuring

tank is maintained at 200 F. and is in-

1 Experiments of Glatzel and Villari : Smith-

sonian physical tables, 5th rev. ed., p. 223.

OPERATION OF WOOD PRESERVING PLANTS 121

jected into the wood at 180 F.; and that the normal tempera-

ture" of the cylinder and wood is 60 F. With all gauges work-

ing perfectly, no leaks of any kind occurring, all air out of the

cylinder when the oil pump is started, and the volume of the

ties accurately known, the following errors may take place:

Pounds

per tie

1. Chargeable to contraction in the volume of creosote 1 .85

2. Chargeable to the expansion of the cylinder due to temperature 1 . 35

3. Chargeable to the "kickback" (assumed to be 20 percent of the

absorption) 7.00

Total positive errors 10 . 20

4. Chargeable to the expansion of the wood 1.50

Total in excess of apparent absorption 8.7

Thus, out of a total specified injection of 10 pounds per cubic

foot, or 35 pounds per tie, 8.7 pounds per tie may be forced

into the cylinder, but either will not go into or not remain in the

ties, constituting a total error of about 25 percent. In plants

operating with zinc chloride, item 1 may be eliminated and item

3 will be less than that given.

Purity of the Preservative. The composition of the preserva-

tive is subject to change so that check analyses of it should be

made from time to time to see that it meets specifications.

With creosote, the chief difficulty likely to occur is with the

water content of the oil. Leaky steam coils, or snow or ice on

the wood, or water in the wood are all liable to adulterate the

oil with water. It is not necessary to remove all of the water

but large amounts (over 5 percent) are objectionable and it is

not good practice to allow for this by giving the timber a heavier

injection. Proper procedure is to remove the water. This may

be done in some cases by allowing the oil to stand for several days

in a tank, 1 when the water may be drawn from the top of the oil,

or by boiling off the water in tanks equipped with steam coils.

In either case loss of some oil is almost sure to occur.

It sometimes happens that the carbon content of the creosote

will increase as it is used over and over again, so that timber

treated with "old" oil will look much blacker than timber treated

with " fresh" oil. The author has known of inspectors refusing

1 Some engineers alternately heat and cool the oil several times before

drawing off the water.

122 THE PRESERVATION OF STRUCTURAL TIMBER

to accept treated timber because it did not look " black." Free

carbon will not penetrate wood, has no preservative value, and

detracts from the quality of the oil. About the only practical

way to guard against too large a percentage of free carbon is to

be careful in the purchase of the oil.

It is also asserted, at times, that the composition of creosote

changes because that portion of it which enters the wood and is

then redrawn carries with it some of the soluble constituents in

the wood. While there is a possibility of its doing this, careful

tests have failed thus far to show any marked changes in the oil

due to this cause.

Solutions of zinc chloride also need careful attention. Common

practice is to place a hydrometer in the solution and if it shows

correct gravity to assume the strength to be correct. This prac-

tice is subject to error because foreign substances such as other

inorganic salts or materials dissolved from the wood may change

the gravity. Some careful tests made at the U. S. Forest Prod-

ucts Laboratory have also shown that the strength of a zinc-

chloride solution may be changed by successive treatments, the

solution tending to weaken.

Pollution of Streams. Complaint has been made against some

treating plants because they polluted streams with waste oil.

This comes largely from the cylinders and steam exhausts. Of

course, no plant is going to deliberately waste preservative and

it is believed that such complaints can be entirely avoided as they

are indications of bad management. The use of a final vacuum

in drying the timber, and attention to steam coils to see that they

do not leak, will remedy much of the difficulty. All drains can

be carried to a common settling tank, where by a system of over-

flow chambers arranged in the tank practically no oil will escape.

Inspection of Treatments. Controversies between purchasers

of treated timber and operators of treating plants over the in-

spection of treatments have been no more common than in other

industries which are of comparatively new growth and where so

many factors are involved, but much needless dispute has oc-

curred because one party or the other has not been sufficiently

trained to recognize legitimate demands. Attempts to cover up

fraudulent work have, of course, been made and probably will be

as long as the industry exists, but such cases are decidedly in the

minority, for corrupt practice sooner or later becomes generally

recognized and eventually kills itself.

OPERATION OF WOOD PRESERVING PLANTS 123

Much of the trouble can be laid entirely on the purchaser, who

frequently insists upon impractical specifications and unattainable

results. It is the author's opinion that considerable freedom

should be given the operator as regards the details of the treat-

ment, and that only a few essential features need be required.

We will attempt to give here only those which are more important

and applicable to general conditions.

First, perhaps, comes the wood itself. It should be remem-

bered that wood is a product grown under a wide variety of con-

ditions and hence varies greatly in its structure. It is practically

impossible to get two pieces which are alike, and therefore speci-

fications for wood should not be too stringent. It is reasonable to

expect, however, that only sound wood be furnished. In this

connection, wood which is sap-stained should not be confused

with wood which is decayed. In specifying rings per inch, knots,

crooks, tapers, etc., care should be exercised so that the speci-

fications are reasonable and do not require the rejection of large

quantities of good material. As regards the kinds of wood, the

specifications should recognize that the same kind may go under a

variety of names; hence no chance for misunderstanding should be

left.

The composition of the preservative to be used should be clearly

stated and also its method of analysis, and the inspector should be

granted permission to take samples for analysis as often and from

whatever source he pleases. Requirements in this regard can be

made fairly rigid.

The treating operator can also be held to have his plant in

fit condition for accurate work, and if considered necessary the

inspector can measure all essential pieces of apparatus in order

to make sure the dimensions furnished are correct. Errors

in operation already described should be recognized, so that they

can be taken into account in making determinations of absorption.

As for the treatment proper, the essentials to specify are the maxi-

mum temperatures to be used and the absorption of preservative

required. This should be final absorption , or the amount of pre-

servative actually in the wood at the time it is removed from the

cylinder, free from drip. Because wood varies so, it should not

be expected that all pieces are to have the same absorption. They

may vary widely. In all cases, as deep and uniform a penetra-

tion as possible should be required, and the inspector should

124 THE PRESERVATION OF STRUCTURAL TIMBER

know what is possible before he attempts to pass judgment on the

results. A complete penetration of all sapwood should always be

secured and the specifications should be so framed as to admit

of this. Woods which vary widely in their resistance to injection

should not be treated in the same charge; neither should the

mixing of green and seasoned wood in the same run be allowed.

In all cases the difference in the height of the preservative in the

measuring tank before and after the treatment has been made

should furnish the final basis for determining the absorption

secured; or if seasoned wood is treated, the weights on the track

scales should be used. Sources of error due to friction of gauges,

differences in temperatures, etc., should be carefully considered

in determining final absorption.

The Cost of Pressure Plants. The cost of pressure plants is

exceedingly variable even for plants of the same capacity. Any

estimate, therefore, must be considered with a wide latitude.

The variations in cost are due largely to the type of buildings,

the number of processes practised, the yard layout, and local

soil and surface conditions. The author knows, for example,

of two plants with cylinders approximately 6 feet 2 inches in

diameter by 132 feet in length, equipped to treat timber by

the same methods, one of which cost $65,000 and the other

$170,000 complete.

With these variations in mind, the following estimate of a

2-cylinder plant with cylinders 7 feet in diameter by 132 feet

in length, equipped to treat by any standard process and of

first class construction, is given :

Track and grading $35,000

Retorts with all piping installed 13,000

Three 150 H.P. boilers complete 4,000

Sewers 1,500

Buildings 30,000

Pumps (compressor, vacuum, hydraulic, service) 5,000

Piping, valves, complete 7,000

Fire hydrants and equipment 3,500

Electric plant complete 4,000

Miscellaneous plant items 4,000

One 12-ton locomotive crane 4,200

One dummy engine 3,000

Cylinder cars (190) 8,500

Total.. . $122,700

OPERATION OF WOOD PRESERVING PLANTS

125

<N

co

8

1

8

00

O

co"

CO

co"

I

8

Os"

8

co"

05"

S"

!

i

203,900

2

X

2

IN"

O

O5

8

O

O5

05

o

o

+i fl

fj

8

8

1\*1

8

8

CO

8

8

8

8

3

\

8

o

i

\

8

-

d

1

g

1

J

S-

1

o"

co"

n

1

co"

!

co"

1

05\_

157,980

d

1

CO

X

1

t-

T-T

CO

1

ri

8

co

CO

CO

8

co

8

8

8

10

o

8

d

(M

S

8

CO

2

1 2

3

co

!

8

#>

9

S"

8

I

o"

co"

1

I

g

I

co"

1 1

2 S

o

(N

X

CO

i

^

>

10

g

n

g

8

g

8

8

;

8

g

^ 11

s

^

|j

oo

8

-

00

s

00

1-1

co

|

1

g

2 il-g

M fe w i

|

g

o

2

g

g

o

g

g

o

g

o

>> 'O d \*T

2

o

8

o

00

O

S

CO

^

CO

N

^

CO

N

(N

3

N

CC

a ^ "^ g

X

<M

o

IN

co

<N

5

?l

g

3

8

^

05

8

10

'X

ro

8

05

8

d

co

.

8

i

g

1

j 1 M

8

g

I

ro

71

^

J

|

w"

-.

lo

1

if

g

1

M"

1C

CO\*

s

4(5,005

l f jj|

A

i

oo

CO

~

~

\*i S

g

g

00

8

8

g

S

8

S

t! jj si 85

\*.S

co

S

\*

CO

S

N

^

)

j

2

~

^ d"S-r^|

g

i

1

1

1

CO

.J

3-

-o"

I

!

1

05

1

1

-

CO\*

1

1

K

S

8

oo"

g

^

3

S

d

8

05

S

CO

n

g

co

-r

i

8

C

111 II II

M

-f

V

i

o

S

I

8

i

d

6\*\*

|

1

3

1

S

1

g

'

g

10"

C

S

\*"

c

l "

~

2

^s

8

CO

g

g

g

g

8

g

c

I ^'"S a'l"^' 5

c

o

S

co

S

^

co

'0

S

X

sl^ila!

d

e3

1

?-, ' t! rf" a fl

of cylinders

13

a

ft

5

01

ft

1

8

|

1

1

Equivalent in thous

board feet of lumber

Creosote in gallons . . .

Water in gallons

es of track in yard. . . .

loading platform ....

3

6

09

h

1

1

C3

H

1

i

1

TJ

ig and foundations. . . .

)latform

ige is based on 75 per

oil storage is equal to

based on 60 pounds p

ire designed for workil

re arranged for either

re for transferring trar

lants are treating pili

capacity.

J Number

o'

"o

0)

cc

j!

1

1

j

E

i

t

c

^

!

i,

1

'

3

tt

j

Particula

1 Machiner

1

1 Water ta

S

rt

.

'S

V\* 1

'3

PQ

rf)

1 Excavatil

Loading j

| Tracks...

c

ce

"ct

"c

H|

126 THE PRESERVATION OF STRUCTURAL TIMBER

"S

s

8

S

i!

+3 3

fl\*S

1-s

p

I

. g i;

M "' 3.2

fl 73 O+s

'3 S \* 2-

ft g.\*--

g o -a aT

8 g

g

Itlllll

5 U i5 3-s

3 gja IH a

re fc.'S-

OPERATION OF WOOD PRESERVING PLANTS 127

Through the courtesy of the Allis-Chalmers Company, the

author is able to give Table 8, which contains estimates of the

cost of wood preserving plants of various capacities. The plants

given in the table are arranged for either the Burnett, Wellhouse,

Bethel, Rueping, Lowry, or Card process. In using this table,

variations of at least 20 percent either way can be expected.

CHAPTER VIII

PROLONGING THE LIFE OF CROSS-TIES FROM DECAY

AND ABRASION

Selection of Species. 1 At the present time, practically any

kind of tree which is large enough to make a cross-tie is used for

this purpose. The result is a great variety of ties differing

widely in their properties. It stands to reason, therefore, that

the service obtained from ties must be very erratic. The diffi-

culty now generally experienced by many American railroads to

secure adequate supplies of good ties makes it impossible to be

too stringent in specifying the kinds of wood which will be used.

If planting trees for ties becomes general, the question of proper

selection of species will be a very important one, but at the pres-

ent time this feature is recognized only in the price paid for ties

and no special selection is made.

Common practice now consists in dividing the various kinds of

ties into two groups, viz., ties to be used without preservative

treatment and ties to be treated. The former group includes

those woods which are naturally durable, the latter those which

if placed in a track untreated would decay in a few years.

The ideal tie for use without treatment is one which is not only

very resistant to decay but which is hard and will hold spikes

and resist rail cutting without serious splitting or checking. Of

our more common American woods, black locust and white oak

best meet these requirements. Redwood, cedar, and cypress

are very durable but are inferior to black locust and white oak as

regards strength.

If the tie is to be treated, the prime qualities are strength,

hardness, and permeability. Red oak, maple, birch, beech, and

elm best fulfill these conditions. A large variety of other woods

are, of course, also used, chief among which are the pines, firs,

spruces, gums, hemlocks, chestnut, and tamarack. Irrespective

of marketing conditions, the value of these woods for tie purposes

depends directly upon their ability to meet the requirements

just mentioned. In other words, a wood which is hard and por-

1 For further discussion see "Strength of Cross Ties," appendix.

128

PROLONGING THE LIFE OF CROSS-TIES 129

ous is more valuable for a " treatment tie" than a wood which

is soft and resistant to impregnation, and should therefore com-

mand a higher price. Maple, for example, is worth more for a

cross-tie than white pine or spruce because, when treated, it will

give better service.

Unfortunately, conditions are still such in our country that

many trees are cut for ties which ought to be cut for more valu-

able products such as veneer or lumber. Black walnut, cherry,

and hickory are conspicuous examples. Where these trees occur

scattered in forests or woodlots, it is often easiest to market them

in the form of ties, but whenever possible, they should not be

used for this purpose, as it results in a distinct economic loss of

valuable material.

Hewed Versus Sawed Ties. Approximately 75 percent of all

ties purchased are hewed. In the tie industry as a whole the

methods of manufacture are undergoing no general or perma-

nent changes. The probable reasons are that the railroads

obtain, either directly or indirectly through tie companies, a

large proportion of their ties from farmers and small holders of

timber who cannot afford to saw them, and also because the im-

portance of utilizing timber to the best advantage has not yet

been keenly felt. Under certain conditions the sawing of ties

may be impracticable, as when, for example, only a few trees

suitable for cross-ties are available, or when ties are cut from tops

of felled trees. In such cases it is much better to utilize the wood

by hewing it into ties than to leave it in the forest. The claim

is often made that hewed ties are more durable than sawed ties

because they shed water better. Nothing is known by the U. S.

Forest Service to substantiate this impression. Even if untreated

hewed ties should be more durable than sawed ones, this advan-

tage disappears when the ties are treated. On the other hand

there are many serious objections to the use of hewed ties, and

these will increase in importance in direct proportion to the num-

ber of ties treated with preservative. Chief among these objec-

tions are (1) unequal bearing afforded tie plates and rails, (2),

lack of uniform volume, and (3) unnecessary waste of valuable

material.

Bearing Afforded Tie Plates and Rails. The heavy tonnage

on American railroads necessitates the use of some form of tie

plate on practically all first-class construction. Hewed ties

seldom offer a uniform bearing surface to the plate or rail, and

130 THE PRESERVATION OF STRUCTURAL TIMBER

unless specially adzed before placement soon wear unevenly and

must be removed. An inspection of test ties on the Chicago

& Northwestern track showed in many cases that one edge of the

plate had cut into the tie to a depth of over 1/2 inch, while

the other edge was not even flush with the surface. With sawed

ties the bearing over the surface is more uniform and rail cutting

is considerably reduced. The introduction of tie-boring and

adzing machines is doing much to improve the bearing of plates

on the ties and should cut down mechanical wear appreciably.

Uniformity in Volume. Since tie inspectors offer no objec-

tion to, but rather favor, ties of greater dimensions than those

specified, the tie manufacturer rarely hews a large log to the

standard size. Thus the cubic content of hewed ties may vary

from that of the minimum dimensions allowed to about twice the

size specified. Practically all contracts for treating ties state

that so much preservative shall be injected per cubic foot of

wood. With hewed ties no treating plant knows accurately

what this volume is until after the ties have been treated. To

obtain the total quantity of preservative to be used, it is custom-

ary to figure that a tie will contain a certain amount of wood,

and to multiply this figure by the number of ties and the amount

of preservative to be injected per cubic foot. For example, to

figure the amount of creosote needed to treat 1000 cross-ties

6 inches by 8 inches by 8 feet with 10 pounds of oil per cubic foot,

the calculation would be 1000 X 2.67 X 10 = 26,700 pounds. If

the hewed ties average 3.2 cubic feet, though figured as of

standard size, the total amount of preservative would be the

same, viz., 26,700 pounds, but the amount per cubic foot would be

only 8.3 pounds instead of 10, as specified. Sawed ties are cut to

more exact dimensions, and errors of this kind are improbable.

Waste of Material. To hew a tie necessarily entails an enor-

mous waste of material. Based on actual field data the waste

by hewing varies from 25 to 75 percent 1 (Fig. 17). Logs 15

inches in diameter furnish, as a rule, only one hewed tie, but if

sawed they furnish two. Whenever possible the tie hewer selects

trees of about 12 or 14 inches in diameter. The waste of wood

each year in the United States from hewing ties amounts to about

285,000,000 cubic feet, a quantity equivalent to about 80 percent

of the total amount of pulpwood used in the United States in

1 U. S. Forest Service Bulletin 64, "Loblolly Pine in Eastern Texas, with

Special Reference to the Production of Cross- ties," by Raphael Zon.

PROLONGING THE LIFE OF CROSS-TIES

131

1909. This is an absolute waste, as it is not even used for fuel.

(See Plate XIII, Fig. A.)

Form of Cross-ties. Practically all of the wooden cross-ties

now used on steam railroads in the United States are rectangular

in cross section. Their size is by no means uniform, varying in

width from 6 to 10 inches, in depth from 6 to 7 inches, and in

length from 8 to 9 feet. These ties are sometimes cut either with

a saw or axe on all four sides (see Plate XIII, Fig. B), in which

case they are said to be "squared." In many cases only the top

and bottom are cut, leaving the sides the natural shape of the tree.

When thus made from small trees the ties are called "pole ties.'\*

In Europe a large number of ties are cut larger on the base than

on the top and are commonly referred to as "half-round ties."

ker Edgings

Fia. 17. Ideal economy in manufacturing a cross tie. A = tie 6 X 8

inches; B = board 7 inches wide; C. C. = boards 5 1/2 inches wide; D =

board 91/2 inches wide; E = board 71/2 inches wide; F = board 3 inches

wide. (Diagram courtesy of the Forest Service.)

Such ties are also used to a limited extent in our country. (See

Plate XIII, Fig. C.) One railroad uses a form of tie which will

economize in timber by cutting them triangular. (See Plate

XIII, Fig. D.) It is believed that the form of cross-ties, especially

as regards the distribution of the sapwood on them, is very im-

portant and an item too frequently overlooked in track con-

struction. It is just as logical to specify how ties to be treated

shall be sawed or hewed as regards their sapwood content and

its distribution, as it is to specify a difference in price due to

a difference in the kind of wood. Exceptions of course occur,

as, for example, in those ties whose heartwood treats as easily

132 THE PRESERVATION OF STRUCTURAL TIMBER

as the sapwood. Sapwood is easy to impregnate with pre-

servatives, while the heartwood is generally very resistant.

This difference in the resistance to treatment between the sap

and heartwood of the same tie is often very much greater than

the difference in treatment between two ties of widely different

varieties of wood. In certain species like the red oak, hemlock,

and the ash, this condition is not true, but in the majority of cases

it is. With most ties composed of part heart and part sapwood,

when placed in a cylinder and injected with a preservative, most,

if not practically all of the preservative will go into the sapwood

A B

D

H

a a

FIG. 18. Showing the character of the preservative treatment in ties prop-

erly and improperly manufactured.

To secure best results it is of considerable importance, therefore,

to specify how this sapwood should be distributed. The best

kind of cross-tie intended for treatment is one which has a uniform

distribution of sapwood on all surfaces (Fig. 18 C). A tie of

this kind can be very efficiently protected against decay. Un-

fortunately, only a comparatively small number of ties are of

this kind, and even those that are, are usually of low crushing

strength. By far the largest percentage of ties now used are

composed mostly of heartwood or needless sapwood, as shown in

Fig. 18 A and Fig. 18 B. When ties of this kind are treated accord-

ing to the ordinary run of specifications, practically all of the

PLATE XIII

FIG. A. Method of hewing oak ties in Tennessee. Note waste. (Forest

Service photo.)

FIG. B. Rectangular cross-ties standard form in the United States.

(Facing page 132.)

PLATE XIII

FIG. C. Standard Prussian ties of Baltic pine. (Forest Service photo.)

FIG. D. Triangular cross-ties Great Northern Ry. (Forest Service

photo.)

PROLONGING THE LIFE OF CROSS-TIES 133

preservative will go into the sapwood, leaving the heart faces with

only a superficial penetration. The greatest wear on a tie comes

on its face immediately under the rail or plate. This is the por-

tion which should have the greatest and not the least protection

against decay, as now generally occurs due to the present methods

of manufacture. If ties of the type shown in Fig. 18 A and Fig.

18 B are treated, they can unquestionably be made to absorb the

amount of preservative specified say 10 pounds per cubic foot

but most of the preservative will be in those portions of the tie

where it will do the least good. If, now, these ties were sawed

as indicated by the dotted lines in the sketch, it would be possible

to secure j ust as long a life from them with a much less consump-

tion of preservative.

For example, consider a modern treating plant having an

output of approximately 800,000 ties per year: If the ties are im-

pregnated with 10 pounds of creosote per cubic foot, the oil cost-

ing 6 cents per gallon and the ties containing approximately 3

cubic feet, the total amount of the oil used would be approxi-

mately 24,000,000 pounds. If, now, the ties had been cut as indi-

cated in the sketch, it would be possible with a consumption of

about 6 pounds of creosote per cubic foot to protect them as

effectively as with 10 pounds in the former case. This would

result in a net saving of approximately 4 pounds per cubic foot

or 12 pounds per tie, equivalent to about 9 cents per tie for cost

of preservative, or $72,000 in one year's operation.

There are other ways in which this point could be argued.

For example, if this unnecessary sapwood were removed, could

not the life of the tie be increased over what it would have been,

provided the quantity of oil injected in both cases remained the

same? A company would be justified in paying more for prop-

erly sawed ties intended for treatment than for ties which are

improperly sawed or hewed, especially when the treatment is one

using straight coal-tar creosote. It is the author's opinion that

roads using this method of treatment could very well afford to

insert another clause in their specifications for cross-ties, concern-

ing the amount and distribution of sapwood, and even go to the

extent of paying a higher price for ties in which the sapwood was

properly distributed. They would thereby save an appreciable

item in the cost of treatment. The roads which do not use

treated ties or which adhere to a zinc treatment would not be

benefited to the same degree by a requirement of this kind.

134 THE PRESERVATION OF STRUCTURAL TIMBER

Such procedure would simply be a step in advancing the increased

efficiency with which cross-ties can be utilized, with a view to

decreased cost in track maintenance and operation. The diffi-

culties in putting it into practical use would, in some cases, be

unsurmountable, but where conditions of production are such

that a requirement of this kind could be employed, it is believed

its adoption would unquestionably result in decided profit.

In Fig. 18, A, B, and C. represent the cross sections of three

ties, the shaded portion being sapwood and the white, heart-

The Effect of Form of Pile

upon

Bate of Seasoning

Solid Pile 9x9

Open Pile 7 x

16 23 30 7 14 21 28 4 11 18 25 1 8 15

June July August September

Time- Weeks

FIG. 19. Effect of the form of piling upon the rate of seasoning of lodge-

pole-pine ties.

wood. The dotted lines show how these ties could be improved

by slabbing the sides.

If impregnated with creosote, the ties would appear as in Figs.

18 D, E, and F. Note the heavy impregnation on the sides and

the very slight impregnation on the faces in Figs. 18 D and E.

Figs. 18 G and H show ties A and B slabbed on the sides and then

impregnated with creosote. Note the even distribution of the

preservative and the heavier injection on the faces than in D and

E, thereby giving greater protection to the tie where it is most

needed and at the same time consuming less of the preservative.

Stacking Ties for Seasoning. Different kinds of wood and

climate require different methods of piling. The closer the ties

PROLONGING THE LIFE OF CROSS-TIES 135

are piled the slower will be their loss in weight. In no case should

more than two ties in a pile come in contact with the ground.

The most open form is the triangular one, which can be rapidly

made and is well adapted for use along the right of way. It

should not, however, be used for many hardwoods cut in summer,

since these will check badly. Good forms of piles are the 7 by 2,

7 by 1, and 8 by 1. (See Plate XIV, Fig. A.) These are well

adapted for softwoods and for most hardwoods cut in summer.

They are easy to build and permit of free circulation of air.

When it is desired somewhat to retard the rate of drying, the 8

by 2 or the 10 by 1 form should be used, or if these are still too

open, the 7 by 7 form. An advantage of the 7 by 1, 8 by 1, 10

by 1, and similar forms is that no tie lies flat on another, thus

giving an easy run-off for rain water and a free circulation of

air. In practically no case should untreated ties be piled solidly

9 by 9, since such forms are exceedingly inefficient in regard

to seasoning and invite decay. The effect of the form of piling

upon the rate of seasoning is shown in Fig. 19.

Though the U. S. Forest Service has made many tests to de-

termine the effect of different forms of roofs on the seasoning of

ties, the data secured are not conclusive. However, a slanting

roof of ties is fairly efficient in shedding water, and when not re-

quiring too much additional labor can be employed advantage-

ously.

Ties cut from conifers are less likely to check during seasoning

than ties cut from broadleaf trees, and in consequence can be

piled more openly.

If ties are seasoning too fast they should be piled closer to-

gether (see Plate XIV, Fig. B) ; if seasoning too slowly they should

be piled more openly. Ties cut in winter can be piled more

openly without danger of checking than ties cut in summer.

The length of time ties should season before treatment will

vary primarily with the species of wood, form of pile, and period

of the year. In general, ties cut in spring and summer will be

seasoned sufficiently for treatment by the end of the following

autumn; ties cut in early spring will be seasoned sufficiently by

the following early autumn; the seasoning period varying from

about 2 to 4 months. Ties cut in autumn and winter will be

sufficiently seasoned by the end of the following spring, the period

varying from about 5 to 8 months. The periods necessary

136 THE PRESERVATION OF STRUCTURAL TIMBER

to season dense ties like the oaks will generally be from 2 to

3 months longer than those just given.

Figs. 20 and 21 illustrate these conditions; Fig. 20 representing

red gum ties which season very rapidly and Fig. 21 red oak ties

11.1

110

103

Ill I I I I I I I 1 I I I I II

Mar. Apr. May Jun. Jul. Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. t

Time-Mouths

FIG. 20. Rate of seasoning of red gum ties.

180

175

170

105

ICO

J 155

q

t 15

140

135

130

125

D

B

g

Q

i

3

\

1

l| S

<

g

\

M

\

A

1

X

\

Q

\

V'

J

H

\

\

s

\

\

,%

6.

\y

\* >c '/

\^

\

%

^

S^j

^^

^

c>

-o-

^

^

^&

u

^

^o]

2 n

>v.

^0

Ve,

\*

Mar. Apr. May Jun. Jul. Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. JuU Auj.

Time-Months

FIG. 21. Rate of seasoning of red oak ties.

which season slowly. Both figures show the accelerated drying

in the warmer months and the retarding action of winter.

Grouping Ties to Secure Uniform Treatment. The importance

of properly grouping ties before placing them in the treating

PROLONGING THE LIFE OF CROSS-TIES 137

cylinder cannot be overemphasized. If ties offering unequal

resistance to penetration are treated at the same time, those

offering the greatest resistance will take practically no pre-

servative, while the others will get it all. Consequently, if ties

so treated are placed in a roadbed, the ones heavily injected will

outlast the others and the wear on the track will not be uniform.

Furthermore, when the ties inadequately treated decay, the load

which should be borne by them will be transferred to the sound

ones, hastening their mechanical destruction. Thus much of the

preservative will be wasted, since there is no economy in pre-

serving ties from decay after they have been worn out. The

aim, therefore, should be to have the ties depreciate uniformly,

and this can largely be brought about by grouping them in such

a manner that they will receive equal amounts of the preservative

uniformly diffused. Many tie plants already realize the import-

ance of grouping, and consider the added expense more than justi-

fied by the results secured.

The chief factors which determine the ease with which ties

may be impregnated are (1) the species of wood, (2) percent of

sap and heartwood, (3) moisture content. The less important

are conditions under which seasoned, time of cutting, and con-

ditions of growth.

Species of Wood. It has been explained in Chapter III that

the species of wood differ greatly in their physical properties and

that this difference accounts in a large measure for the variable

results secured in preservative treatments.

Interesting experiments on 20,000 ties to ascertain the absorp-

tive properties were made by Mr. F. J. Angier in 1908-09 at the

treating plant of the Chicago, Burlington & Quincy Railroad,

using the zinc-creosote process. The results are summarized

in Table 9.

Class A includes ties absorbing less than 22 percent of their

volume; Class B, ties absorbing between 23 and 30 percent;

Class C, ties absorbing more than 30 percent. In all cases the

ties were kept in the cylinder until no more preservative could be

forced into them. With hardwoods, such as oak, hickory, ash,

beech, etc., the pressure was 175 pounds, but with softwoods

this was reduced to from 125 to 150 pounds per square inch. In

both cases the pressure was held for from 2 to 5 hours. No sepa-

ration of the ties was made on the basis of their proportion of sap-

wood and heartwood, but about 75 percent of them were hewed.

138 THE PRESERVATION OF STRUCTURAL TIMBER

TABLE 9. ABSORPTION OF PRESERVATIVE BY VARIOUS SPECIES OF

CROSS-TIES 1

CLASS A

Kind of wood

Number

ties used

in the tests

Absorption

percent

of volume

Number

months

seasoned

in yard

Beech

2,481

21.8

15

Oak, red

3,112

20 9

6-15

Hemlock

Oak, Din

1,364

671

20.7

19 5

8-15

10

Hickory

414

18 8

2- 8

Tamarack

Oak, white ....

2,329

731

17.1

14 2

6- 8

7

CLASS B

Hard maple

691

28 3

15

Popular. .

1,348

26 8

7- 9

Sycamore

364

26 6

7

Ash.

318

23.0

2- 6

Sweet gum

928

23

5- 9

Chestnut

345

22.6

12

CLASS C

Shortleaf pine

2,192

36 9

5- 9

White elm

872

36.6

7-15

Cypress, white. .

662

35 4

7- 8

Red elm

626

34 9

6- 9

Soft maple. . . .

599

33.1

6

Red birch

775

33

6- 9

Tupelo gum

790

30.7

8

Proportion of Sapwood. As has been stated, the sapwood of

practically all woods native to the United States readily absorbs

preservatives. The heartwood, however, is much more resistant,

so much so in some cases that no effective treatment is possible.

Two hundred maple ties thoroughly air seasoned (the moisture

content ranging from 24 to 39 percent) were treated by the full-

cell and Burnett processes at the U. S. Forest Products Labora-

tory. It was found that of the ties given a full-cell treatment,

those containing 43.7 percent sapwood absorbed 10.48 pounds of

creosote per cubic foot, while those containing 82.7 percent of

sapwood absorbed 17.40 pounds per cubic foot. In the Burnett

treatments the difference was not so pronounced. Ties contain-

ing 46.2 percent sapwood absorbed 19.7 pounds of solution,

1 Proceedings of Wood Preserver's Assn., 1911

PROLONGING THE LIFE OF CROSS-TIES

139

while those which contained 80.5 percent absorbed 22.5 pounds.

Because of this difference in the absorption by sapwood and

heartwood, ties which contain large amounts of sapwood should

be treated separately. Differences in absorption by ties of the

same species, but with varying proportions of sapwood, are

of ten greater than in the case of widely different species. If the

ties are "pole" ties, it will be found that those of certain species

almost invariably fall in the same class when graded with refer-

ence to the percent of sapwood. The grouping will be approx-

imately as shown in Table 10.

TABLE 10. CLASSIFICATION OP POLE TIES BASED ON THEIR SAPWOOD

CONTENT

Group I

Sapwood 1 inch or less in

width (less than 20 per

cent of volume of tie)

Group II

Sapwood 1 inch to 2i inches

in width (more than 20 per-

cent, but less than 50 per-

cent of volume of tie)

Group III

Sapwood over 3 inches wide

(more than 50 percent of

volume of tie)

Oaks.

Longleaf pine.

Shortleaf pine.

Douglas fir.

White pine.

Loblolly pine.

Cedar.

Hard maple.

Western yellow pine.

Chestnut.

White elm.

Cypress.

Tamarack.

Red elm.

Lodgepole pine.

Hemlock.

Tupelo gum.

Spruce.

Red gum.

Sycamore

Poplar.

Soft maple.

Red birch.

Hickory.

Ash.

Beech.

This grouping does not, however, in all cases accurately rep-

resent the relative resistance to penetration of the various

species. For example, red oak, because of its porous nature,

can readily be penetrated to the center, and thus, in spite of its

comparatively small amount of sapwood, would be grouped with

ties of a structure resembling the elms. Also, the sapwood of

soft maple, hickory, ash, and beech is more resistant to treatment

than that of the other species mentioned in Group III.

If ties are cut from logs larger than 12 to 14 inches in diameter,

as is usually the case with sawed ties, the percentage of sapwood

may range from zero to the maximum shown in the table; hence

the grouping of such ties may be different from that given. For

140 THE PRESERVATION OF STRUCTURAL TIMBER

example, shortleaf pine ties cut with little or no sapwood would

fall in Group II, hard maple without sapwood in Group I. Sap-

wood can usually be distinguished from heartwood by its differ-

ence in color, and it is as a rule easy to separate ties into groups

according to their sapwood content. Such a separation will un-

doubtedly assist in a proper grouping of ties for treatment, but

before this grouping can definitely be decided upon as the best,

considerably more experimenting will be necessary.

Moisture Content. When ties are green the cell walls and

many of the cell spaces are filled with water. To properly inject

a preservative, at least a part of this water must be removed, and

the extent to which it has been removed governs the amount of

preservative which can be injected. It is important, therefore,

that all of the ties to be treated at one time should have approxi-

mately the same moisture content. One of the most practical

ways of insuring this is to pile the ties in the yard and thoroughly

air-season them.

The conditions under which ties season effect the uniformity

of the treatment. Ties seasoned too rapidly are likely to " case-

harden," which makes them more difficult to impregnate and

affects their strength. Moreover, whether ties are seasoned with

the bark on or off affects the treatment. It is good practice to

season all ties to be treated in one charge under the same condi-

tions.

Cutting Season. The time of year the ties are cut also affects

the uniformity and degree of treatment. Several tramloads of

hemlock ties cut in the summer, fall, and winter were first air-

seasoned and then treated with zinc chloride, with the results

shown in Table 11.

TABLE 11. EFFECT OF THE SEASON OF CUTTING ON THE AB-

SORPTION OF PRESERVATIVE

Weight per cubic foot

before treatment

Average absorption of

solution per cubic foot

Summer .

Pounds

33 4

Pounds

12 9

Fall

Winter

36.2

37.3

10.0

8.9

It is probably safe to say that, aside from moisture content and

case-hardening, the effect of the time of cutting on the penetra-

tion and absorption of preservative can be neglected in commercial

PROLONGING THE LIFE OF CROSS-TIES 141

work. Good practice consists in cutting all ties in winter or late

fall whenever possible.

Conditions of Growth. The arrangement of the cells in the

same species of wood grown under different conditions may differ

to such an extent as to cause variability in the results of the treat-

ment. When that is the case, the ties should be grouped sepa-

rately. For example, a plant receiving red oak ties from the

South may find it advantageous to group them separately from

those received from the North. Moreover, ties cut from various

parts of the tree treat differently.

Although the above considerations sound very complicated,

they are not difficult of practical execution. It goes without say-

ing that the careful grouping of ties for treatment costs more

than not grouping them, but there is no doubt but what it will

far more than pay in the long run. This is particularly true for

treatments with creosote where the amount of preservative

forced into the ties is not the maximum amount they will absorb

but the amount called for by the specification. Grouping is

least essential when the ties are impregnated with a solution of

zinc chloride, which can be forced into them until there is no

more absorbed or until the point of refusal is reached.

Protection from Abrasion. It has been estimated that from

10 to 75 percent of unprotected ties fail by rail and spike cutting; 1

the former figure referring to hard, quick-decaying ties like maple,

the latter to durable, soft ties like cedar. Since the number of

treated ties is increasing annually, this percentage will also in-

crease rapidly unless improved methods of fastening rails are

generally adopted. Already the amount of preservative injected

into ties is in some cases reduced because it is claimed to be more

than is necessary to prevent decay throughout their mechanical

life. With increased mechanical life of the tie the efficiency of

the preservative treatment may also be increased.

The most practical means of reducing the mechanical de-

struction of ties are through the use of tie-plates and improved

forms of spikes.

Tie-Plates. Tie-plates are designed primarily to (1) distribute

the impact and compression of trains over the tie; and (2) absorb

the grinding action of the rail.

If the tie-plate is too light it will soon buckle, or if its bearing

surface is too small it will become embedded in the tie. In

1 Proceedings A. R. E. and M. of W. Association, Vol. 9, 1908.

142 THE PRESERVATION OF STRUCTURAL TIMBER

either case the value of the plate is reduced. It is essential, there-

fore, to use plates that are strong enough to stand the pressure

exerted on them, and that have sufficient surface area to properly

distribute the load. Failure to meet these conditions will al-

most invariably result in severe mechanical wear on the tie. This

is shown in Plate III, Fig. A.

Many forms of tie-plates are now on the market, but in general

plates may be divided into two groups: 1 (1) Pronged or ridged

plates; (2) flat plates.

In the opinion of some engineers the tie-plates should be so

firmly fastened to the tie that they really become part of it.

To secure this condition, the bottom of the plate is pronged,

ridged, or flanged. (See Plate XIV, Fig. D.) Plates of this type

were used in test ties on the Northern Pacific and Chicago and

Northwestern experimental tracks laid in cooperation with the

U. S. Forest Service. Although they have not been in service long

enough to show their real worth, the following points were observed

during recent inspections. When the plates are heavily ridged, it

takes a very heavy load to embed the ridges and bring the plates

down flush with the tie. In the Chicago and Northwestern track,

even after 2 years' service, the majority of the ridged plates were

elevated about 1/4 inch above the tie. This was due in part to

the resistance offered by the ridges to embedment in the wood

and in part to sand and gravel which collected under the plate;

also, to the fact that the traffic over this portion of the track is

now very light. After these plates become firmly embedded they

have a tendency to split open the ties, and thus not only weaken

them, but furnish catch basins for the retention of rain water.

In ties which are difficult to impregnate with preservatives, these

checks may extend beyond the zone of treated wood and thus

expose the untreated interior of the tie to decay. Another char-

1 Wooden plates have also been used experimentally, and are being tested

by the U. S. Forest Service in both the Chicago and Northwestern and

Northern Pacific tracks. The plates are made of creosoted oak and maple,

about five- eighths of an inch thick, 8 inches long, and as wide as the base of the

rail. They are inserted between the tie and the rail without any previous

adzing, the common practice abroad. The results thus far have been

that the plates split badly, and at times have become loose or displaced.

In some cases they have embedded themselves into the ties. This is shown

in Plate XIV, Fig. C. Although the tests with wooden plates have not as

yet been completed, the results thus far secured have not been satis-

factory. It is thought, however, that this is largely due to the poor

manner in which they were placed.

PLATE XIV

FIG. A. A good method of piling tics for air seasoning, Port Reading

Creosoting Co. (Forest Service photo.)

FIG. B. White-oak ties seasoned too fast. (Forest Service photo.)

(Facing paye 142 )

PLATE XIV

FIG. C. Ties "protected" with wooden plates. Note plate crushed into

tie. (Forest Service photo.)

FIG. D. Metal tie plate. (Courtesy Spencer-Otis Mfg. Co.)

PROLONGING THE LIFE OF CROSS-TIES 143

acteristic of such plates is to grind into the wood fibers, especially

of softwood ties such as loblolly pine, cedar, etc. This action

also may extend beyond the treated portions of the tie and cause

interior rot. These features are unquestionably objectionable,

and in some cases may prove of such a serious nature that they

will overbalance the good points, such as adherence to the tie

and lack of rattling, claimed for plates of this type.

The objectionable features of pronged or flanged plates are

obviated if they are made flat and so rest flush on the surface of

the tie. The chief objections to this type seem to be the rattling

noise which they make when they are not firmly held to the spikes,

and the fact that all resistance to creeping and lateral thrust

must be borne entirely by the spikes. The rattling, however,

would seem to be an excellent indication that the spikes are loose

and need attention. Just how much weight must be attached

to the second objection cannot at this time be ascertained from

the plates under observation by the U. S. Forest Service. Thus

far no creeping or widening of the gauge of the experimental track

has been noticed.

It seems, moreover, in view of the data thus far secured, that

of the various forms of tie-plates now under test, those made

of metal with a flat bearing surface, or the bearing surface only

slightly ridged, are giving better service in protecting the ties

from mechanical destruction than those made of metal heavily

flanged or pronged.

A feature which is not a present taken into account, but which

unquestionably will be, is the size of tie-plate to be used on

different kinds of wood. A softwood tie like loblolly pine is more

subject to rail cutting than a hardwood tie like oak, and con-

sequently needs a larger tie-plate for its protection. Some tests

at the U. S. Forest Products Laboratory of compressive strength

of various kinds of ties gave results as shown in Table 12 on

pages 144 and 145.

In other words, shortleaf pine is only about half as strong as

red oak and consequently needs a plate with a considerably

larger area in order properly to distribute the load.

Spikes. The practice of spiking ties to the rail has long been

recognized as capable of improvement. The spikes, especially

in softwood ties, do not hold firmly, and permit the rail to " creep "

and "pump," thus greatly shortening the life of the tie. Fur-

thermore, they tear the wood-fibers, work loose, and permit rain

144 THE PRESERVATION OF STRUCTURAL TIMBER

TABLE 12. CRUSHING STRENGTH OF CROSS-TIES IN PERCENT OF WHITE

OAK

Kind of tie

Fiber stress

at elastic

limit per-

pendicular,

to grain, Ib.

persq. in.

Fiber stress

in percent

of white oak,

or 853 Ib.

per sq. in.

Common name

Botanical name

Osage orange

Honey locust

Black locust

Toxylon pomiferum ....

Gleditsia triacanthos . . .

Robinia pseudacacia. . .

Quercus minor

2,260

1,684

1,426

1,148

1,142

1,088

1,070

1,012

997

986

938

857

853

836

828

778

742

696

607

599

578

548

531

525

518

497

491

480

456

454

451

444

433

427

408

400

358

353

351

348

265.0

197.5

167.2

134.6

133.9

127.5

125.5

118.6

116.9

115.7

110.0

100.5

100.0

98.0

97.1

91.2

87.0

81.6

71.2

70.2

67.8

64.3

62.3

61.6

60.8

58.3

57.6

56.3

53.5

53.2

52.9

52.1

50.8

50.1

47.8

46.9

42.0

41.4

41.2

40.8

Post oak

Pignut hickory

Water hickory

Shagbark hickory ....

Mockernut hickory....

Big shellbark hickory.

Bitternut hickory ....

Nutmeg hickory

Yellow oak

Hicoria glabra . .

Hicoria aquatica

Hicoria ovata

Hicoria alba

Hicoria laciniosa

Hicoria minima

Hicoria myristicaeformis

Quercus velutina

Quercus alba

White oak

Bur oak

White ash

Quercus macrocarpa ....

Fraxinus americana

Quercus rubera.

Red oak

Sugar maple

Rock elm

Acer saccharum

Ulmus

Beech

Slippery elm

Redwood

Bald cypress ....

Fagus atropunicea

Ulmus pubescens

Sequoia sempervirens . . .

Taxodium distichum.. . .

Acer rubrum

Red maple

Hackberry

Incense cedar

Hemlock

Longleaf pine

Celtis occidentalis

Libocedrus decurrens . . .

Tsuga canadensis.

Pinus palustris . . . .

Tamarack

Silver maple.

Larix lariciana

Acer saccharinum

Betula Lutea

Yellow birch

Tupelo

Black cherry

Nyssa aquatica

Prunus serotina

Platanus occidentalis.. . .

Pseudotsuga taxifolia . . .

Magnolia acuminata. . . .

Pinus echinata

Pinus resinosa

Pinus lambertiana

Ulmus americana

Pinus ponderosa

Sycamore

Douglas fir

Cucumber tree

Shortleaf pine

Red pine

Sugar pine

White elm

Western yellow pine. .

PROLONGING THE LIFE OF CROSS-TIES

145

TABLE 12. CRUSHING STRENGTH OP CROSS-TIES IN PERCENT OF WHITE

OAK. Continued.

Kinc

I of tie

Fiber stress

at elastic

limit per-

Fiber stress

in percent

of white oak

Common name

Botanical name

pendicular,

to grain, Ibs.

per sq. in.

or 853 Ib.

per sq. in.

Lodgepole pine

Pinus contorta. .

348

40 8

Red spruce

Picea rubens

345

40 5

White pine

Pinus strobus

314

36 8

Engelmann spruce . . .

Arborvitse

Largetooth aspen. . . .

White spruce

Picea engelmanni

Thuja occidentalis

Populus grandidentata .

Picea canadensis

290

288

269

262

34.0

33.8

31.5

30 7

Butternut

Juglans cinerea

258

30.3

Buckeye (yellow) ...

Basswood

Aesculus octandra

Tilia americana

210

209

24.6

24.5

Black willow

Salix nigra

193

22.6

to collect and decay to start. This necessitates a rather frequent

respiking of the rail, which often fills the tie with holes to such

an extent that it is " spiked to death" and must be removed.

It was thought that by first boring a hole into the tie and then

driving the spike into it, the fibers would not be torn and then the

spike would hold more firmly. (See Plate XII, Fig. C.) Tests

were made 1 in which ordinary 9/16-inch square spikes were driv-

en into red-oak ties previously bored with holes 3/8, 7/16, and

1/2 inches in diameter. Although the spikes were driven by an

experienced trackman, in over half the cases they failed to follow

the holes. Their resistance to pulling was thus reduced. When

no hole was bored the average force required to pull the spikes

was 8827 pounds; when bored in the manner above described

the respective forces were 8050, 8106, and 7154 pounds. In order

to overcome the objection mentioned the spikes were pointed on

four sides, and when this was done there was no difficulty what-

ever in getting them to follow the holes. Furthermore, their

resistance to vertical pull was increased and the wood-fibers

were not seriously torn. The number of pounds required to pull

spikes from red-oak ties was as follows : 2

1 By J. A. Newlin, in charge of timber tests, Forest Products Laboratory.

2 It will be noticed that the spikes driven in the first test held more firmly

than those driven in the second. For example, when no hole was bored it

took 8827 pounds to pull them in the first test and only 7613 pounds in the

10

146 THE PRESERVATION OF STRUCTURAL TIMBER

Pounds

Ordinary 9/16-inch square spikes driven without boring 7613

Ordinary 9/16-inch square spikes pointed on four sides, driven in

hole 3/8 inch in diameter 8178

Ordinary 9/16-inch square spike pointed on four sides, driven in

hole 7/16 inch in diameter 7856

Ordinary 9/16-inch square spike pointed on four sides, driven in

hole 1/2 inch in diameter 7664

When the diamond-pointed spikes were driven into the tie

without first boring holes, the ties were almost invariably split.

It appears, therefore, that they cannot be used satisfactorily

without previous boring.

Some of the ties used in these tests were treated with creosote,

others with zinc chloride, and still others were left untreated,

but no appreciable difference due to treatment was noticed.

In a few cases a heavy oil was poured into the holes and allowed

to soak for 16 hours before the spikes were driven. The resist-

ance to pull was decreased from 7644 to 6628 pounds. While no

tests were made, it is quite possible that if the holes are bored into

the ties before they are treated the resistance of the spike will be

less than if they are bored after treating. In spite of this, how-

ever, it is believed that if holes are bored at all they should be

bored before and not after treatment, since in the former case the

ties will be fully protected against rot.

While the tests described show that boring holes into ties pre-

vious to spiking them is an improvement over the common prac-

tice in this country, experience abroad leads to the conclusion

that even better results can be obtained by the use of screw

spikes. To secure data for American operating conditions,

screw spikes were used by the U. S. Forest Service in the Northern

Pacific, Chicago & Northwestern, and Chicago, Milwaukee &

St. Paul test tracks. In laying the Northern Pacific and Chicago

& Northwestern tracks no screw-spike boring or driving machine

was available, so that the holes had to be bored and the spikes in-

serted by hand. In some cases the holes were not bored deep

enough, and the point of the spike struck the base of the hole.

On further tightening the spike the threads in the wood were

destroyed. Furthermore, the holes were not in all cases bored

second. This cannot be attributed to any difference in the spikes, but to the

ties into which they were driven. Also, in the latter case the spikes were

pulled soon after they were driven. The two series of tests, therefore, are not

comparable with each other.

PROLONGING THE LIFE OF CROSS-TIES 147

vertically, so that the spikes were inserted at various angles.

When the Chicago, Milwaukee & St. Paul track was put in place,

a . screw-spike boring and driving machine was used, and the

difficulties previously encountered were done away with. The

machine drove the holes vertically and to a uniform depth, so

that the spikes all had proper alignment and clearance. In

every case the machine drove the spikes firmly into the tie.

The screw spikes used in the Northern Pacific and Chicago &

Northwestern test tracks were driven through plates which did

not reenforce the head of the spike against lateral thrust. After

3 years' service many of the these spikes were badly bent,

resulting in a widening of the track gauge. In laying the Chicago,

Milwaukee & St. Paul track, a plate with bosses for supporting

the heads of the spikes was used, which it is believed will mate-

rially increase their holding power.

In a large number of tests made at Purdue University, a part

of which were conducted by the U. S. Forest Service, 1 it was

found that screw spikes had from 1.7 to 3.8 times the strength of

the common spike against pull, and from 1.2 to 2.4 times the lat-

eral resistance of the common spike. The heads of the spikes

were not supported in these tests.

An objection raised against the use of screw spikes is that it

takes longer to insert them than to insert cut spikes, and that this

at times delays the passage of fast trains. In laying the Chicago,

Milwaukee & St. Paul test track this objection was partially

overcome by spiking every third tie throughout the rail length,

which permitted trains to pass, and afterward spiking the re-

maining ties.

A further objection to the use of screw spikes is the difficulty

of regauging the track when the rail becomes worn. It is pos-

sible that this objection may in time be overcome by altering the

design of plates used with this type of spike.

While the use of screw spikes in this country is still in its in-

fancy and final judgment cannot as yet be pronounced, it gives

promise of overcoming the objections raised against the ordinary

cut spike. If it succeeds in this it will unquestionably result in

greatly reducing the mechanical destruction of ties.

Adzing and Boring Ties. In Chapter VII it was stated that

adzing and boring ties prior to treatment was good practice, and

Progress Report of Tests on Treated Ties, by W. K. Hatt,

Purdue University, Bulletin 124, A. R. E. and M. of W. Assn.

148 THE PRESERVATION OF STRUCTURAL TIMBER

the data given above show how the holding power of spikes can

be increased by driving them through such holes. Of equal

importance is a proper bearing of the rail or plate on the tie, for

if this is not done the wear will be concentrated over a small

area and the mechanical destruction of the tie hastened. Further-

more, it is felt that the unequal bearing of rails on ties can be

held responsible, in part at least, for breaking the rail, especially

during cold weather. Adzing prior to treatment not only en-

ables the plate and rail to be firmly and uniformly fastened to the

tie, but makes it possible to at least coat with preservative that

portion of the tie most subject to wear. For these reasons

adzing and boring of ties are highly commended.

The Selection of Processes for Treating Ties. The wide

range of conditions under which cross-ties are used makes a

selection of treating processes necessary if most economic results

are to be secured. Lack of specific data on the exact value of the

various processes prevents a clear-cut decision as to which is best

for a given set of requirements.

The ideal treatment is one in which the ties fail from decay

and wear at the same time. If the failures are caused by decay,

then a more efficient preservative should be used; if, on the other

hand, the failures are caused by wear which cannot be prevented,

then a less efficient treatment should be used. It can be readily

seen that any process which puts into ties more preservative

than is necessary to protect them longer than their mechanical

life is a wasteful process, because after the ties are removed from

the track the preservative in them is useless. The proper balance

between the failure of a tie from decay and from wear is a very

difficult one to obtain with our present limited fund of data

and this complicates greatly the selection of a proper treating

process. Certain general rules can, however, be laid down which

should aid in selecting the proper process for any given condi-

tions. The most important points to consider in this connection

are: (1) kind and form of ties to be used, (2) the tonnage over the

road, (3) climatic conditions, and (4) type of track construction.

These are so closely interwoven that they must all be considered

together.

If the road is so fortunate as to run through or tap a forested

region containing strong, durable tie material, the need of a

preservative treatment is not pressing and may even be dispensed

with entirely. Thus, if ties of heart cypress, redwood, and cedar

PROLONGING THE LIFE OF CROSS-TIES 149

can be obtained at a reasonable price, no treatment other than

a protection from wear is required. However, this condition

rarely exists, so that some method of increasing the resistance

of the wood to decay becomes necessary. If the wood is refrac-

torythat is, if a preservative cannot be forced into it except

superficially as with Douglas fir, tamarack, etc., as heavy a

treatment as possible with straight creosote will probably give

most efficient results because even at best only small amounts

of the oil will be absorbed. If, however, the wood is porous and

readily absorbs preservative, then some cheaper process, like the

Burnett, Card, or empty-cell creosote is preferable. The same

is true for those ties which are cut so as to have fairly wide strips

of sapwood on one or both sides while the faces are of resistant

heartwood possessing in itself little durability.

Obviously, ties which have a heavy tonnage passing over them

are more subject to failure from wear than ties laid in a track

where the tonnage is light. In general, such ties should be given

a less efficient and expensive treatment, for if heavy injections

are made, considerable quantities of preservative will be destroyed

with the ties.

Climatic conditions must be carefully considered. Ties laid

in regions of heavy rainfall had best be treated with straight

creosote. In arid regions and where rainfall is comparatively

light, zinc-treated ties may be advantageously used.

The type of track construction has much to do with the selec-

tion of the process. In general, best construction enables the

use of the more effective and expensive treating processes. For

example, a track laid with heavy rail, heavy tie plates, screw

spikes and a firm rock ballast would call for a more costly and

effective treating process than one laid with cut spikes, dirt

ballast, and no tie plates. It should not follow that this is uni-

versally true. Suppose, for instance, that the track construction

is of the best, but that the ties are of a comparatively soft wood

like loblolly pine; it is the author's opinion that an empty-cell

process should be selected in preference to a full-cell, as it would

give an equal length of life to the tie with a much less consump-

tion of preservative, and hence the expense would be less. As

mentioned above, a decision on the selection of a proper timber-

treating process for ties can be correctly made only after all fac-

tors affecting the life of the tie have been considered. It appears,

therefore, that railroads controlling a large mileage, especially,

150 THE PRESERVATION OF STRUCTURAL TIMBER

if it traverses a wide territory, should use more than one process

in order to secure most economic returns. In the above discus-

sion, the question of initial cost has not been mentioned, as its

effect in the selection of a process is so obvious as to need no special

comment. The ideal process selected may be the cheapest

process Burnettizing, for example in so far as initial cost is

concerned. Or the ideal process may be the most expensive

full-cell creosote in which case, if the company could not afford

it, the next best rather than none at all should be selected. A

common feature is that practically all standard processes using

pressure pay if compared to the use of untreated ties, so the

problem reduces itself largely to a question of which pays best.

Cost of Treating Ties. The total cost of treating ties can be

divided into the following general items: (1) seasoning, (2) labor,

(3) fuel, (4) plant operation and maintenance, and (5) chemicals.

The majority of ties now treated in the United States are air-

seasoned prior to treatment. The cost of this varies with the

kind of wood, season of the year, and geographical location.

In general, however, seasoning charges range from about 0.50 to

1.5 cents per tie.

Labor includes all forms necessary to the treatment, such as

loading and unloading of ties in the yard, and for the tie plant

and superintendence. It also varies considerably, but ranges

from about 3 to 6 cents per tie.

Fuel is least in those plants which can use natural gas or oil and

highest in those most remote from a source of supply, but ranges

from about 1/2 to 2 cents per tie.

On account of the corrosive action of zinc chloride, the life

of a plant using that kind of a preservative is usually reckoned as

shorter than that of one using creosote; consequently, its de-

preciation is greater. If the capacity of the plant is lowered

through accident, shortage of ties, etc., the depreciation charges

per tie will be very high. The total cost of maintenance, includ-

ing this depreciation, interest on the investment, etc., will usu-

ally range from 1 to 2 cents per tie.

Practically all of the ties now treated in commercial plants in

the United States are injected with zinc chloride or with creosote,

either alone or in combination. Only a few plants use preserva-

tives like crude oil and mercuric chloride. It is customary to

inject about 1/2 pound of dry zinc chloride per cubic foot

of wood although this varies at times from one-third to two-

PROLONGING THE LIFE OF CROSS-TIES 151

thirds of a pound. This salt costs from 3 1/2 to 5 cents per

pound. Creosote costs from about 7 to 12 cents per gallon in

large quantities. It is customary in tie work to inject from 5 to

10 pounds of this oil per cubic foot.

With the above data the cost of tie treatments may be esti-

mated. It should be borne in mind, however, that the figures

given are general, and will not apply to all conditions. Using

them as a basis, however, the cost of treating a standard 7 inch

X 9 inch X 8 foot tie will be approximately as shown in

Table 13, royalties not included. It is understood that royalties

are now charged in the Rueping and Card processes, while the

Lowry process is operated under certain restrictions by the com-

pany which controls the Lowry patents. For the other proc-

esses listed in the table no royalties are required.

TABLE 13. APPROXIMATE COST OF TREATING TIES

(Tie 7 inches X 9 inches X 8 feet)

Process

Cost per tie, cents

Burnett

10-14

Wellhouse

12-16

Card

16-20

Rueping(a)

Lowry (6)

Full-cell cresote(c)

25-29

32-35

39-45

a = assuming about 6 pounds of creosote per cubic foot absorption.

b = assuming about 8 pounds of creosote per cubic foot absorption,

c = assuming about 10 pounds of creosote per cubic foot absorption.

Assuming creosote costs about 1 cent per pound and zinc chloride about

4 cents per pound.

It will be noted in this table that the cost of the preservative

used is a large percentage of the total cost of treatment. Creo-

sote, for example, greatly increases the cost of the treatment and

when it is used in comparatively large quantities 8 pounds or

over per cubic foot all other costs make but a small fraction in

the total cost of treatment. The opportunity either for an effi-

cient preservative at lower cost or for some modified method of

operation which will enable a high-priced preservative to be

better utilized than is being done in present practice is strik-

ingly apparent.

Economy in Treating Ties. There is no longer any just doubt

but what the preservative treatment of ties pays. Unfortunately,

152 THE PRESERVATION OF STRUCTURAL TIMBER

reliable records on the life of treated ties which have been in ser-

vice for long periods are too meager to enable exact estimates of

actual economy to be made, so that the financial saving is still a

matter of conjecture. Because of this condition it is not pos-

sible to state what process of treatment is most economical,

and it will take several years before any true basis for such state-

ments will be warranted. As has already been pointed out,

it is quite likely that the different methods of treatment now

practised will be found to have rather sharp limitations so that

they will not overlap and compete to such a large degree as at

present. The different kinds of ties, the different types of con-

struction, and the different geographical regions traversed by

our roads will demand different treatments.

In the meantime, the best that can be done is to use what

data is already available on treated and untreated ties in service,

and add to this our knowledge on the efficiency of the various

preservatives used, the action of wood-destroying fungi, and the

durability and susceptibility to treatment of the various woods

now used for manufacture into ties.

While the saving in money is undoubtedly the most important

feature which the railroads will consider, nevertheless it is be-

lieved that other factors should not be overlooked. If a process

showing lowest annual charges is selected, it may be it does not

prolong the life of the ties as much as some other process having

higher annual charges. This means that tie removals will be

more frequent and the roadbed will consequently be more con-

tinuously disturbed. The disadvantages are obvious. Further-

more, if the price of untreated ties shows a steady advance, the

advantage of securing as long a life as possible from them is

readily apparent.

Because of the many factors which influence the economy

resulting from treating ties and because of the uncertainty of

present data on the durability of ties, estimates on saving are

here given for only two processes the Burnett and full-cell

creosote as these represent the probable extremes, certainly in

so far as initial cost is concerned. In order to make the results

comparable, it is assumed that all ties are plated, the plates cost-

ing 25 cents per tie, and that the cost of placing the ties in the

track is 15 cents. Furthermore, all ties are subjected to the same

traffic conditions and preliminary treatment. As annual charges

best show resulting economy they are used in the following table

PROLONGING THE LIFE OF CROSS-TIES

153

W x '~\* x

H H

1^ cO

&\* M

S g

H S

H^

g W

gb

p

TJ

1

i TJ

OS \_

S3 -P ,

3

ft

a d 1 1

1

O

o

"Si

CO

"1 s \*

ooooooooooooooooo

ii

a

Ji

1

^l d

lO ^< "^ ^ O5 \*O OOOOCOC^COOOi^DC^\* '

. . . .oOOOOOOOO'-i'-iO<NO'-i<Ni-i

|

a -S

d

2 ^

ooooooooooooooooo

"^ "

"a ^

IH

\*:

1

o

^.C 3 S

u ft

ooooooooooooooooo

&

fl

S

a!

\*n ^

&

H

fi 1 3

||

a

\_=

V

75

s ii

ooooooooooooooooc

2

d

d

1

a 1

o T

S |

oooooooooooooooooooooo

1^

S3 "^ OD

\SSSSS3S3\*S9S\*S$1S

.3 |

II

-^i^

ooooooooooooooooo

E

a "

S

EH

. ^ ii

. . .

6 ft

\*>

- S

SoOOOO5O5000000t^OOt^XOiOOt^t^(X)

.

\*o

o g

s

a

\_, a

^

M S s

i

ft

s

o 'C

2

-2 M

u

4 |-

o M co-o5,M.-o 5WM o- t c^o^c,^XS,X

'C o

1 1

p 1

oooooooooooooooooooooo

03

1

V

S "3

1|

^1^1

S i i ; ! ! oe,o-QOC,e, a <<ci

S8

I -5

3

^N " S.

JH

"ft to

"S

: : : : .

m

.2 o>

\*

fil

| i : ioiOiO^^^WWWJOOQO^OiOWW

II

.. o>

1 ?

.

M&

h : : :

31

1

N

3

OQ I

p g

Sd

83

IS

g|

0) (N "! rH -l

3?

s

\*o

8

3 T3

-\*J rt

o

09

1

d

. . OJ .

jliiiljlililliiiliilii

1 Prices from

1 Prices quote

154 THE PRESERVATION OF STRUCTURAL TIMBER

and are figured on the cost of the ties in the track, the computation

being made by the following formula:

n l.0p n .0.0p

'TO^T

Where r = equivalent annual charge.

R = initial expenditure.

p = rate of interest (taken as 5 percent).

n = term of years.

It will be noted that, in general, the ties treated with creosote

show a slightly greater economy than when treated with zinc

chloride. In this connection, however, the remarks already

made concerning the selection of the treating process should be

kept in mind; that is, ties treated with zinc chloride should not

be laid in wet localities. If ties treated by this method are laid

in such regions the differences shown in the table would, of course,

be considerably greater.

It should be noted that greatest economy in treating ties comes

from those which possess little durability in an untreated condi-

tion, this amounting in certain cases to an annual saving of over

20 cents per tie per year. Least saving comes from ties which

are resistant to treatment and which do not possess a marked

natural durability. Such ties ought not to command high prices.

In fact, it is exceedingly likely that the prices now paid for ties

will be readjusted as reliable data on their serviceability is grad-

ually obtained, and more value is placed upon their intrinsic

properties. Red oak, beech, and elm, for example, will become

more and more prized as good tie woods, because of their rapid

growth, hardness, and permeability.

If the figures given in the table are found by actual experience

to be accurate, the difference in the annual saving between the

two processes compared is insignificant. This does not mean,

however, that the selection of the process is unimportant, because

other factors such as initial cost, ultimate length of service, local

climatic conditions, etc., as pointed out above, must also be taken

into consideration.

Need for Test Tracks. It is apparent from the above discus-

sion on the economy of treatment that little of definite value on

the efficiency of various processes can be determined until ac-

curate data is available. Without doubt, the best way of secur-

ing such data is to set aside certain portions of the main track,

PROLONGING THE LIFE OF CROSS-TIES 155

typifying conditions of the road, for experimental or test purposes.

Such portions of the track are called "test or experimental

tracks." In them complete records should be kept on each tie,

such as kind of wood, how treated, when and how laid, and notes

on its character of failure obtained from yearly inspections. In

addition, general data on the character of the ballast, type of

construction, tonnage over the road, etc., should be made a matter

of record. To assist in identifying the ties, each tie should have

zinc-coated dating nails driven into it at some readily accessible

point. A good place for the nails is about 1 foot inside the rail.

The old method of driving dating nails into all treated ties and

attempting to keep records on all of them has not proved success-

ful and is not recommended. Trackmen as a rule will not keep

accurate records and unless the records are accurate they are

worse than useless, as they may lead to absurd conclusions.

The direct and positive value of the data secured from test tracks

enables accurate deductions to be made of the efficiency of the

treatment and far more than justifies the cost of placing and

maintaining them.

CHAPTER IX

PROLONGING THE LIFE OF POLES AND CROSS ARMS

FROM DECAY AND INSECTS

POLES

Selection of Species. According to present usage, in order to

make a satisfactory pole, a tree must have the following general

properties: Its wood must be strong, comparatively light in

weight and durable, its taper must be gradual and well defined,

its form must be straight, and in addition its supply must be

accessible and abundant. These requirements necessarily re-

strict the number of species which can be used. For example,

of the 3,000,000 poles consumed annually in the United States,

over two-thirds are cedar and about one-seventh chestnut.

Hence, over 80 per cent .are cut from only two kinds of wood.

If the preservative treatment of poles was more generally

practised, a much larger variety of woods could be drawn upon,

since they possess all of the requisite properties save durability.

It seems apparent, therefore, that as the present supply of "pole

woods" becomes more and more exhausted the need for preserva-

tive treatment will increase. Such woods as the pines, spruces,

and firs should prove admirably adapted for poles, and they will

undoubtedly be called into use. In fact, a movement in this

direction has already taken place, and poles cut from these timbers

are now being used in several places in the West.

Insects, in addition to decay, also attack poles, thus weakening

them not only by their burrows but also by admitting channels

through which the decay can enter and spread. As the methods

which prevent decay will also prevent insect attack, the two are

discussed in common in this chapter.

Manufacture of Poles. Most of the poles used in the United

States are simply tree trunks which have been trimmed of limbs

and then peeled. Very few sawed poles are used. As has already

been pointed out (Chapter IV) the best time to cut timber is in

winter or late fall. Poles cut during this period are, however,

more difficult to peel, as the bark clings tenaciously to them,

156

PROLONGING THE LIFE OF POLES 157

whereas in spring long strips of bark can readily be torn from the

trunk. It is very important to peel all bark from that portion

of the pole to be treated; otherwise the bark will prevent a uni-

form penetration of the preservative.

The practice of dragging poles over the ground for long dis-

tances, thereby grinding off the outer layers of wood, should be

prohibited, as it not only weakens the pole but makes it more

susceptible to decay.

It is also bad practice to saw that portion of the pole which

projects above ground, leaving the butt the natural shape and

size of the tree, unless the butt is given a thorough preservative

treatment, because the sap on the butt will quickly decay and

infect the heartwood. If sawing must be done on account of

local or other requirements, it is better to saw the entire pole. As

a general proposition, however, sawing should be avoided if pos-

sible. The top of the pole should also be cut slanting unless

there is some reason why this cannot be done. If a plate or cap

is placed on the top of the pole, the wood underneath should be

at least brush treated with creosote. Whenever possible the

pole should be trimmed and bored to exact dimensions before

it is treated, in order to avoid cutting into the treated wood and

thus exposing the untreated interior.

Method of Seasoning. Common practice now pays little at-

tention to seasoning poles. (See Plate XV, Fig. A .) Poles are gen-

erally piled one on top of the other in order to occupy as little

space as possible. If the poles are not to be treated and if they

are not held too long in these piles so that decay will attack them,

no serious objection can be levied against this practice. Of

course, when piled in this manner, the rate at which they lose

water is greatly decreased and consequently they will weigh

more when shipped; hence, the cost of transportation is

increased.

If the poles are to be treated, especially by the open-tank or

brush methods, a preliminary air seasoning is highly desirable.

The best way to do this is to roll the poles on skids with suf-

ficient space between them so that the air can circulate freely.

These skids can be built of poles placed horizontally and ele-

vated a foot or more above the ground. If space permits, but

one layer of poles should be built on each skid, but if necessary,

several layers can be piled on each other. (See Plate XV, Fig. B.)

Factors other than ease of handling should be given con-

158 THE PRESERVATION OF STRUCTURAL TIMBER

sideration in selecting the seasoning yard. For example, the

ground should be fairly level, well drained, and as free from weeds

and decayed wood as possible. The poles should be exposed to

the sun and air currents so that the seasoning will be rapid.

Too rapid seasoning, however, may check the poles, in which

case they can be piled closer together. Incipient checks, which

are liable to increase in size, should be protected with "S-irons"

(Fig. 22).

The length of time poles should be seasoned varies primarily

with the time of year, the kind of wood, and climatic conditions.

FIG. 22. Method of applying "S "-irons to prevent checking.

From a large number of tests made by the U. S. Forest Service

in cooperation with the American Telephone and Telegraph

Company the following table has been compiled :

TABLE 15. APPROXIMATE TIME REQUIRED TO AIR SEASON POLES FOR

TREATMENT

Species

Region

No. of months required when poles

are cut in

Spring

Summer

Autumn

Winter

Chestnut

Maryland

Carolinas

Michigan

3

2

5

5

3

2

5

2

7

4

9

9

6

3

8

6

Southern white cedar ....

Northern white cedar. . . .

Western yellow pine

California

The above figures may be used to predict the seasoning periods

for other varieties of wood not listed, although just how accurate

they will be cannot be told except by actual trial.

Because of its comparatively large diameter, the moisture

content of an " air-seasoned " pole varies considerably. For

example, the outer portion may contain only 10 percent of moisture

PLATE XV

FIG. A. Cedar poles piled for storage, Michigan. (Forest Service photo.)

FIG. B. Poles properly piled for air seasoning, Black Forest, Germany.

(Forest Service photo.)

(Facing page 158.)

PLATE XV

FIG. C. An open tank pole treating plant. A poor design, note creosote

evaporating from tanks. (Forest Service photo.)

FIG. D. Creosoted poles for heavy construction, Hayes, England. (Forest

Service photo.)

PROLONGING THE LIFE OF POLES

159

while the interior has 40 percent or over. It is not necessary

or practicable to reduce this interior moisture very materially

for it does not seriously affect any preservative treatment which

might be given.

The effect of this moisture loss on freight shipments is very

important, especially in long hauls.

TABLE 16. SHOWING SAVING IN FREIGHT EFFECTED BY AIR-SEASONING

POLES

Size of pole

No. of

poles re-

Total de-

crease in

Saving in freight on

carload lots

Species

Length,

Top

diam-

quired for

carload of

weight due

to air

25 cent

15 cent

feet

eter,

in.

40,000

Ib.

seasoning

(pounds)

rate,

dollars

rate,

dollars

Chestnut .

30

7

43

7,700

19.25

11.55

Southern white cedar.

30

7

74

16,900

42.25

25.35

Northern white cedar.

30

\*j

91

12,800

32.00

19.20

Western red cedar ....

40

8

59

12,900

32.25

19.35

Western yellow pine. . .

40 8

46

38,400

96.00

57.60

The decrease in weight from a green to an air-dry condition

varies from about 20 to 50 percent, or 180 to 850 pounds per pole.

The decrease in shipping weight and freight charges is, of course,

in direct proportion to these percentages.

The shrinkage in the circumference of poles due to their season-

ing is insignificant, contrary to general belief. Consequently,

if a pole is measured when green, these figures can be considered

as practically unaltered by subsequent drying, since the shrinkage

will not exceed 1 percent. Exact data on shrinkage taken

from measurements on about 2000 poles of chestnut, cedar and

pine averaged from 0.3 to 0.5 percent of the green circumference

6 feet from the butt to 0.6 to 0.9 percent at the top. This is

equivalent on 30- to 40-ft. poles to about 0.1 or 0.2 inch in

the circumference of the butt and from 0.15 to 0.25 inch at

the top.

If the poles are steam seasoned, they are handled in much the

same manner as cross-ties, viz., placed in the treating cylinder

and subjected to live steam at pressures not exceeding 40 pounds

for four or more hours, after which a vacuum is applied and the

preservative injected.

Methods of Treatment and Their Selection. Because of

their large size and the high cost of handling and shipping them

and the comparatively small number assembled at one point,

160 THE PRESERVATION OF STRUCTURAL TIMBER

the treatment of poles is quite a different problem from the treat-

ment of ties. Furthermore, poles are not subject to the same

kind of deterioration as ties. That portion which projects above

ground is much less subject to decay than that in the ground,

and in temperate climates like the northern and western United

States, where the humidity and temperature are generally low,

the tops may last indefinitely. In warm, humid climates, as in

the South, a protection to the top is desirable and often as in

the case of pines necessary. Poles do not fail from mechanical

wear, so that this factor need not be considered.

Several methods of protecting the life of poles from decay and

insects the chief destructive agents are practised. These are

(1) setting the poles in crushed stone or concrete, (2) charring the

butts, (3) brush treating the butts with a wood preservative,

(4) impregnating the butts with a preservative, and (5) impreg-

nating the entire pole with a preservative.

Setting in Crushed Stone or Concrete. If the hole into which

the pole is to be placed is dug several inches wider than the pole,

crushed or small field stones can be pounded around the pole

after it is set. These will permit more or less circulation of air

around the butt and keep weeds from growing close to the pole.

In this way a partial protection is afforded which will add a year

or two to the life secured. Furthermore, the stones will tend to

protect the pole from ground fires. Sand placed in such holes

affords no protection and may even hasten decay. The author has

little evidence that poles set in concrete are materially prolonged

in service. Such concrete jackets are liable to become broken

and hence admit water. All of these methods are considered

make-shifts and should be used only when no better treatment

can be had.

Charring. Provided the poles are air seasoned, charring to a

depth of 1/4 in. from the butt to about 2 ft. above ground line

will pay for itself. It is, however, an inefficient method of treat-

ment and adds but little to the life of the pole. If charred green,

the poles are very liable to check open and decay hastened rather

than retarded. Charring, furthermore, destroys the outer fibers

of the wood and weakens the pole where strength is most needed.

Charred poles examined by the author were also readily attacked

by insects.

Brush Treatment. These should be applied to poles only

after they are air seasoned. If applied to green poles, the effec-

PROLONGING THE LIFE OF POLES 161

tiveness of the treatment will be greatly decreased. The methods

of applying brush treatments have already been described (see

Chapter V). To secure best results, particularly for poles set in

sandy soil, the entire butt and end of the pole should be coated

with the preservative and the protection should extend 1 or

2 feet above the ground line. If poles are well treated by this

method, their life can be extended from 3 to 6 years. When

no better method can be afforded, brush treatments are recom-

mended. The best preservative thus far known is coal-tar

creosote, which should be applied hot (about 160 F.) in two

coats. For reliable results secured to date the reader is re-

ferred to Fig. 31, appendix.

Open-tank Butt Treatments. If the top of the pole is not

subject to decay, a butt treatment in an open tank is the best

known. (See Plate XV, Fig. C.) (For description see open-tank

treatment, Chapter V.) A number of test poles treated in

this manner have shown excellent results (see Fig. 31 and Fig. 32,

appendix), and because the preservative is confined to the

butt of the pole where decay is most active, the method is

more economical than if the entire pole is impregnated. Un-

fortunately, in order to cut down labor and maintenance costs,

such treatments are feasible only where comparatively large

numbers of poles are assembled at one point. Furthermore, the

treatment may mean a delay in shipment, although it is felt

that this objection should be met on the part of pole consumers

by anticipating their orders in sufficient time to enable the

treatment to be made.

Coal-tar creosote to the amount of 10 pounds per cubic foot,

or more if possible, will give best results. It is possible, how-

ever, to impregnate the butts with zinc chloride or other

antiseptic salts, either alone or in combination with the creosote,

in which case a decrease in the cost of the preservative can be

made. In any event, the aim should be to treat all of the

sapwood to a height of 1 to 2 feet above ground level.

Butt treatments are now given which often amount to little

more than dipping treatments, and while they are better than

a mere brushing of the pole, they will not prove as effective as

though the preservative is driven through the sapwood. In

some cases, the surface of the pole has been perforated with small

holes in order to facilitate the entrance of the preservative and

shorten the time of treatment.

11

162 THE PRESERVATION OF STRUCTURAL TIMBER

Poles to be butt-treated are hoisted by a derrick into open tanks,

where they are stood on end. The preservative is then admitted

until the butts are submerged. If creosote or a similar oil is used,

it is heated to about 215 F\* for two or more hours, after which

it is permitted to cool, or cool oil is pumped into the tank and the

butts kept submerged until the desired absorption is obtained.

In a similar manner the poles can be treated with zinc chloride.

By running the hot oil out of the tank and admitting a zinc-

chloride solution, a combination treatment can be obtained, or

the poles can be lifted out of the hot tank and stood in a second

tank containing the solution. Table 17 gives some results

secured in butt-treating poles by the open-tank method and shows

the amount and depth to which the preservative was absorbed. 1

TABLE 17. AVERAGE ABSORPTION AND PENETRATION OF CREOSOTE

TAINED IN THE BUTT TREATMENT OF POLES BY THE

OPEN-TANK METHOD

OB-

Species

Absorp-

tion per

pole

Pene-

tration

Species

Absorp-

tion per

pole

Pene-

tration

Chestnut. . .

Pounds

21 5

Inches

3

Western yellow

Pounds

Inches

Northern white

pine

81.4

3 1

cedar

48 4

5

Lodgepole pine...

34

1

Western red cedar

39.5

0.8

Entire Impregnation. If the poles decay in the top as well as

in the butt, the entire pole should be treated. This is done by

placing them on cylinder cars and running them into a treating

cylinder. The treatment is very similar to that given ties, no

special apparatus being required except that the cars should be of

the bolster type in order to take curves. The best process is the

full-cell creosote injecting about 10 pounds of oil per cubic foot.

This method of treatment is most expensive on account of the

large amount of creosote absorbed. It should not be used if

open-tank treatments will suffice. A modified treatment has been

suggested whereby the poles are run into horizontal cylinders

mounted on pivot bearings, after which the cylinder is revolved

to a vertical position. In this way it is possible to impregnate

the butt under pressure and give the top of the pole a lighter

treatment, thus saving materially in total cost. So far as known

1 Bulletin 84, U. S. Forest Service, by Wm. H. Kempfer.

PROLONGING THE LIFE OF POLES 163

to the author, this method has not been practised thus far,

although it has much to commend it. 1

Boucherie Process. In this process, which is extensively used

in France and which has been tested in our country, the poles are

treated green and before the bark is removed. (See Plate XVI,

Fig. A.) In fact, the sooner the treatment can be given after the

trees are cut the better the results secured. A clamp is placed over

the butt of the pole, which is placed in a horizontal position;

through this clamp a hole is bored, into which a wooden plug

is inserted. The plug is connected to a hose, which in turn is

fastened to a larger hose or pipe. A barrel or other vessel filled

with copper sulphate, and elevated about 20 ft. above the pole so

as to give a static pressure, is connected by means of a hose to

this feed pipe. In this way the copper-sulphate solution runs

out of the overhead tank and forces its way into the butt of

the pole and eventually through its entire length. As soon as

the solution appears at the top end, the pole is disconnected

from the treating apparatus, after which it is peeled, trimmed,

and air seasoned. It is then ready for use.

The Boucherie process is very well adapted to the treatment

of poles in small quantities and in rough country where there is

a supply of timber suitable for poles and where the cost of trans-

porting treated poles would be prohibitive. Experiments with

this process were made by the U. S. Forest Service in California,

the time required to impregnate the various poles being given in

Table 18. 2 The poles were treated green under a pressure of

about 10 pounds. Their length was about 22 ft.

TABLE 18. TIME REQUIRED TO TREAT GREEN POLES BY THE BOUCHERIE

PROCESS

Species

Average time required to impregnate poles

Yellow pine

(Days)

3 5

White fir

Douglas fir

Incense cedar

2.9

6.2

1 9

Sugar pine

3.1

Kyan Process. This process has been used extensively in

Europe for treating poles and has given very good results. The

1 A plant to operate on this principle is now (Jan., 1916) under construc-

tion in the U. S.

2 From report by Geo. M. Hunt and C. S. Smith, of the U. S. Forest Service.

164 THE PRESERVATION OF STRUCTURAL TIMBER

manner in which the process is operated has been described in

Chapter V. Next to poles impregnated by the full-cell process,

Kyanized poles have given greatest durability. The treatment

is comparatively inexpensive when compared with the full-cell

creosote and in addition the surface of the poles is clean and

free from oily exudations. It is believed the process can be

adapted to many conditions in our country and is well worthy

of a more extended trial. While no tests which have been made

are known by the author, it is probable that a treatment with

mercuric chloride can be given poles in much the same manner

as they are now treated by the Boucherizing process, although

the uniformity of the penetration might not be as good as when

the poles are first air seasoned.

Reenforcing Decayed Poles. The expense of replacing de-

cayed poles with new ones is considerable, as all the wires must

be restrung, in addition to replacing the pole proper. For this

reason, some companies have attempted to reenforce their de-

cayed poles in an effort to prolong their life. Two methods

have been rather extensively tried, viz., reenforced stubs and re-

enforced jackets. The former consists in placing a stub buried

in the ground next to the pole and bolting or wiring the pole to

it. (See Plate XVI, Fig. B.) These stubs are often creosoted

by the brush or full-cell method. They undoubtedly increase the

strength of the decayed pole and some excellent results have been

secured as a result of this treatment.

An effective method consists in cutting all decayed wood

from the pole for some distance below and above ground. The

pole is then brush treated with a preservative like creosote, after

which steel reenforcing rods are driven into it and the whole

buried in creosote. This method is claimed to give very good

results and add materially to the strength and life of the pole.

No definite records on the added life thus secured are, however,

known to the author, but an estimated life of 8 to 10 years is

claimed. The cost of such a treatment is about $3.50 to $5 per

pole. (See Plate XVI, Fig. C.)

In some cases, after a pole has decayed, it is cut off at the

ground line, the decayed butt removed, and the pole lowered

in the same hole. This practice is common and feasible when

the length of the pole is sufficient to stand this shortening. It

is believed that better results would be secured if the sound por-

PLATE XVI

FIG. A. A Boucherie pole treating plant, Fulda, Ormany. (Forest Serv-

ice photo.)

FIG. B. Partially decayed pole reenforced with a creosoted stub. (Forest

Service photo.)

(Facing page 164.)

PLATE XVI

PROLONGING THE LIFE OF POLES

165

tion of the pole was given two coats of hot creosote before it was

lowered into the ground. As the ground about the hole is in-

fected with decay-producing fungi, the life of a pole set in such soil

will not be as great as the life of a pole set in a freshly dug hole.

Cost of Treatment. The cost of treating poles varies through

wide limits. It depends chiefly upon (1) the process used, (2)

the size of the pole, (3) the cost of the preservative, (4) the cost of

labor, and (5) the number of poles treated per day. In order to

have some general data, however, Table 19 has been compiled,

but in using it the reader is cautioned against drawing too sharp

conclusions. Creosote is assumed to cost 1 cent per pound,

labor $2 per day, the size of pole to be 30 feet, and the treatments

given as already described.

TABLE 19. ESTIMATED COST OF TREATING POLES

Kind of treatment

Amt. of preserva-

tive used per pole

(pounds)

Cost per pole

Field or crushed stone around pole

$0 00-SO 20

Charring butt

05- 15

Brush treatment (2 coats creosote)

Open-tank butt treatment creosote.

8 a

50 6

0.15- 0.30

1 00- 1 50

Entire pole treated full-cell creosote

144 C

1.70- 2.25

= about 24 square feet surface.

b = about 6 cubic feet treated.

e = about 18 cubic feet treated.

A more detailed estimate of the cost of butt-treating poles,

based on an open-tank plant having a daily capacity of 120 poles

per day or 30,000 per year (250 working days), is as follows: 1

LABOR PER DAY

1 yard foreman $4 . 00

1 plant engineer 4 . 00

1 stationary engineer 4 . 00

2 firemen, at $2 . 50 5 . 00

5 laborers, at $2 .10.00

Total $27.00

Labor charge per pole $0 . 225

FUEL PER DAY

2 tons coal, at $4 $8.00

Fuel charge per pole .067

bulletin 84, U. S. Forest Service.

166 THE PRESERVATION OF STRUCTURAL TIMBER

MAINTENANCE PER YEAR

Depreciation and repairs $500 . 00

Interest on investment in plant and preservatives 400 . 00

Total $900.00

Maintenance charge for pole $0 . 030

Seasoning charge per pole (interest on investment) . 100

Total treating charge, exclusive of preservative $0 . 422

The cost of treatment, exclusive of preservative, based on a

liberal estimate for all charges, is thus seen to be $0.422 per pole.

To this should be added the cost of the preservative, taxes on

property, and, if the treating plant is not located at a central

seasoning or distributing yard, extra shipping charges.

Economy of Treatment. Treated poles have not been in use

in this country for a sufficient period to furnish actual data on

the length of time their life has been prolonged. In Germany,

where fairly accurate information is at hand, the following results

have been secured based on about 50 years experience :

Untreated poles 7.7 years average life

Poles treated with copper sulphate 11.7 years average life

Poles treated with zinc chloride 11. 9 years average life

Poles treated with mercuric chloride 13.7 years average life

Poles treated with creosote 20 . 6 years average life

The amount of creosote injected in each case, and the exact con-

ditions under which the poles were set, are not known. We have

records in this country, however, of longleaf pine poles treated

by the full-cell creosote process and set in Virginia which are

perfectly sound after 18 years' service. Accurate records on

the durability of poles in the United States, so far as these are at

present obtainable, are given in Fig. 31 and Fig 32, appendix.

Using them and the cost of treatments given above, the econ-

omy of treatment can be approximated as in Table 20. 1

It will be noted from the estimates given in the table that poles

butt-treated with creosote by the open-tank method are the

cheapest to maintain. In this connection, however, several

factors should be kept clearly in mind. It has been assumed in

the table that the tops of the poles do not decay. While this

condition is true for a large part of our country, it must not be

universally applied. If the top is subject to decay, the full-cell

creosote process will undoubtedly be found to give lowest main-

1 The economy is much greater for large than for small poles.

PROLONGING THE LIFE OF POLES

167

tenance charges, although its initial cost of installation will re-

main highest. Another very important point is the kind of wood

used in the pole. Northern white cedar has been selected in the

table because of its uniform excellence and very extended use.

If other varieties are employed the annual charges shown in

the table will, of course, be materially changed. For example,

a loblolly pine pole will last untreated about 4 years, whereas the

northern white cedar is estimated at 14 years. When given a

butt or full-cell treatment with creosote, the difference in the

annual charges between treated and untreated loblolly pine poles

will be much greater than the differences between treated and

untreated cedar poles, because of the natural durability of the

latter. Consequently, poles possessing less natural durability

will, when treated, show greater economy in treatment than poles

possessing great natural durability. Furthermore, the lower

price at which such poles can generally be secured will frequently

make their use, when properly treated, cheaper than the more

naturally durable poles. The wide range through which these

conditions vary frustrates any attempt to arrange them in a

table that would be of practical value, hence no attempt to do so

has been made.

TABLE 20. ESTIMATED ANNUAL CHARGES OF CEDAR POLES TREATED BY

VARIOUS METHODS

Method of Treatment

Cost of

treatment

Cost of

pole set in

line

Estimated

life

Annual

charge

Untreated

9

$

7 00

Years

14

$

71

Charred at butt ....

15

7 15

15

69

Butt brush-treated

25

7 25

18

62

Boucherie ....

70

7 70

20

62

Butt treated zinc chloride (open

tank)

60

7 60

22

58

Butt treated mercuric chloride

(open tank)

90

7 90

24

^Q

Butt treated creosote (open tank).

Full-cell creosote (pressure)

1.25

2.29

8.35 1

9. 50'

30

30

0.54

0.62

Pole northern white cedar.

Life untreated = 14 years.

Cost of pole = $4.

Cost of placement = $3.

Size of pole = 30 feet.

Interest 5 percent compounded an-

nually.

1 Extra charge for increased weight due to treatment.

168 THE PRESERVATION OF STRUCTURAL TIMBER

CROSS ARMS

Selection of Species. Two kinds of wood, Douglas fir and

pine (mostly longleaf), furnish about 90 percent of the 3,500,000

cross arms used annually in the United States. Other varieties

such as oak, cypress, spruce, juniper, cedar, chestnut, and locust

are also used, but in scattering quantities. Due to the manner

in which they are placed, decay in cross arms is not nearly as

serious as decay in poles. The problem of selecting material

for cross arms is therefore largely confined to those species which

occur in sufficient quantities in one locality and thus warrant the

installation of the special machinery necessary to manufacture

cross arms at low cost. Douglas fir and longleaf pine are the

woods now most largely manufactured into lumber and occur

in enormous stands over a wide area. The intrinsic properties

desired in a cross arm are strength, freedom from warping and

checking, a comparatively light weight, and resistance to decay.

Even when the arms are to be treated, their ability to absorb the

preservative is not of prime importance, as only small quantities

of an efficient preservative are necessary in order to protect them

from decay. For greatest strength at least weight, redwood is

one of the best cross-arm materials used and it is surprising that

more redwood arms are not in service. A distinction is made

between arms cut from Douglas fir, the trade recognizing two

distinct types known as "yellow" and "red" fir. The former

is claimed to be the better arm and far more durable than the

latter, cases being on record where such arms untreated were in

service over 40 years without any signs of decay. It is probable,

however, that this long service was due to the comparatively

dry climate (Utah) in which these arms were used.

The Manufacture of Cross Arms. It is quite essential that

the wood from which cross arms are made be of straight grain

free from defects such as knots, spiral grain, checks, etc., which

tend to decrease their strength. This is especially true for that

portion of the arm at and near the middle, as failure is most

likely to occur at this portion.

It is also important to have the arm brought to exact dimen-

sions and all holes bored before any preservative treatment is

given.

Methods of Seasoning. On account of their comparatively

small size and the ease with which they can be handled, cross

PROLONGING THE LIFE OF POLES

169

arms are generally air seasoned before they are shipped or treated.

The usual precautions for the condition of the seasoning yard, as

described in Chapter VIII, hold as well for cross arms. Many

forms of piles have been tried but those which give best satisfaction

are open piles without roofs, in which the end arms in each tier

are placed with their depth vertical while the arms in between

are placed with their depth horizontal. (See Plate XVII, Fig. A.)

This allows a free circulation of air and induces rapid drying.

From a large number of measurements, the shrinkage in con-

iferous cross arms from a green to air-dry condition is of little or

no practical significance. The same holds for any changes in the

shape of the holes bored into the arms. In hardwood cross arms

these changes are much greater.

Cross arms season rapidly and reach an air-dry condition in

about 1 month. In summer this rate may even be exceeded,

while in winter or rainy weather longer periods are of course

necessary. Some experiments were made by the U. S. Forest

Service in air-seasoning loblolly pine arms, which, according to

the amount of sap wood they contained, were divided in three

charges, heartwood, sap wood, and intermediate. The manner

in which these arms seasoned is shown in Table 21. 1

TABLE 21. COMPARATIVE RATES OF SEASONING OF LOBLOLLY

HEARTWOOD, SAPWOOD, AND INTERMEDIATE CROSS ARMS

PINE

Days

seasoned

Heartwood

Sapwood | Intermediate

Weight

per arm

Weight

per cu-

bic foot

Mois-

ture

content

Weight

per

arm

Weight

per cu-

bic foot

Mois-

ture

content

Weight

per

arm

Weight

per cu-

bic foot

Mois-

ture

content

30

60

Pounds

38.8

34.2

33.9

34.3

34.2

33.9

33.6

Pounds

42.6

37.6

37.3

37.3

37.6

37.3

36.9

Percent

51.5

33.4

32.5

33.8

33.7

32.3

31.2

Pounds

52.7

34.5

32.6

32.6

32.5

32.1

31.6

Pounds

57.9

37.9

35.8

35.8

35.7

35.3

34.7

Percent

105.8

23.8

27.2

27.3

26.9

24.5

23.6

Pounds

45.8

34.8

33.3

33.4

33.4

33.0

32.5

Pounds

50.3

37.7

36.6

36.7

36.7

36.3

35.7

Percent

79.0

34.0

30.0

30.3

30.3

29.0

26.9

90

120

150

180

Methods of Treatment and Their Selection. As above stated,

cross arms are not subject to severe attack by fungi, since they are

surrounded on all sides by air and are raised a considerable dis-

tance above ground. Decay is most likely to occur at the bolt

and pin holes. It is quite essential, therefore, to have these prop-

erly protected. If the arm is of a naturally durable wood such as

white or red cedar, heart cypress, etc., no preservative treatment

1 Circular 151, U. S. Forest Service.

170 THE PRESERVATION OF STRUCTURAL TIMBER

is necessary, as the arm will unquestionably last much longer than

the pole. If, however, the wood is not so durable, such as pine,

fir, spruce, etc., a preservative treatment is desirable.

If the preservative selected is a salt, such as zinc or mercuric

chloride, objections can be raised in that it will tend to wash from

the wood, it will attack the iron spikes or bolts, and it will tend

to keep the arms more or less moist thus lowering the strength

of the arms and decreasing their resistance to the leakage of

electric current.

On the other hand, if creosote is used, it will tend to volatilize

quickly from the arms, or if large quantities are injected danger

from drip may be encountered. Cases are on record where com-

panies have been forced to replace their arms because of the dam-

age done by such dripping. Arms heavily creosoted are, more-

over, increased perceptibly in weight.

Taking all these factors into consideration, it is believed that

arms treated with about 5 to 6 pounds of creosote per cubic foot

by an empty-cell process so that no drip will occur will give

best results. In doing this, however, it is important to use a

high-grade preservative, so that loss from volatilization can be

kept to a minimum.

Dipping the arms in a tank of hot preservative such as coal-

tar creosote or carbolineum for several minutes should also give

good results. The oil will run into all checks and holes and, as

wood is most easily treated in the direction of the grain (longi-

tudinally), a good penetration will be secured at those points

which require greatest protection.

Kyanized arms are reported to have given excellent service.

The process produces clean arms and adds practically no dead

weight.

Cost of Treatment. The cost of treating cross arms is very

variable. When large quantities are handled and apparatus is

at hand for doing the work mechanically, the cost is kept at a

minimum. It has been assumed in the estimates given in Table

22 that these mechanical features have been provided.

TABLE 22. APPROXIMATE COST OF TREATING CROSS ARMS

Process used

Total cost per arm (10-pin) (cents)

Full-cell creosote

10-20

Empty-cell creosote

7-10

Dipping creosote

4- 8

Dipping carbolineum

10-30

PLATE XVII

FKJ. A. Cross arms properly piled for air seasoning. (Forest Service

photo.)

FIG. B. Creosoted cross arms just leaving the treating cylinder, Norfolk

Creosoting Co. (Forest Service photo.)

(Facing page 170.)

PLATE XVII

FIG. C. Fence posts properly piled for air seasoning. (Forest Service

photo.)

FIG. D. Untreated lodgepole pine post set four years

ground. (Forest Service photo.)

at the

PROLONGING THE LIFE OF POLES

171

Economy of Treatment. Only estimates based upon the opin-

ions of operators and our knowledge of the decay of wood can be

given in arriving at the probable economy resulting from the pre-

servative treatment of arms. No authenticated records are

known to the author of the service secured from treated arms in

actual use. It is only reasonable to expect that climatic condi-

tions will affect very materially the life of cross arms. For ex-

ample, arms in the South where the air is often warm and moist

will tend to decay much more rapidly than arms in dry or cold

climates. In fact, it is doubtful whether the treatment of arms,

other than a mere soaking in the preservative of the bolt and pin

holes and the center portion in contact with the pole, under these

latter conditions is at all feasible or necessary. As has been

stated, cases are on record of yellow fir arms which in a com-

paratively dry climate like Utah and Nevada lasted untreated

for over 40 years without any signs of decay. Of course, such

conditions cannot be expected for the greater part of our country,

so that a treatment of some sort is generally advisable.

The estimates given in Table 23 are very rough as no da,ta

could be found giving the lives of cross arms treated in the

manner suggested.

TABLE 23. ESTIMATED ANNUAL SAVING DUE TO TREATMENT OF CROSS

ARMS (INTEREST COMPOUNDED AT 5 PERCENT)

Item

Fir

Pine

Life untreated (years)

Life treated by empty-cell process (years)

Life treated by dipping process in creosote (years) ....

Life treated by dipping process in carbolineum (years)

Cost untreated in place (dollars)

Cost treated by empty-cell process in (place)

Cost treated by dipping process using creosote

Cost treated by dipping process using carbolineum . . .

Annual charges untreated

Annual charges treated by empty-cell process

Annual charges treated by dipping process (creosote) .

Annual charges treated by dipping process (carbolineum)

15.0

25.0

20.0

21.0

.50

.58

.56

.60

0.150

0.110

0.125

0.125

10.0

30.0

18.0

19.0

1.50

1.58

1.56

1.60

0.190

0.100

0.130

0.130

CHAPTER X

PROLONGING THE LIFE OF FENCE POSTS FROM

DECAY

Selection of Species. Where trees abound, fence posts are

generally made from timber easiest to cut. For this reason

practically all kinds of wood large enough to make a post are used

and a list of them would comprise nearly all species which grow

in our country. Where post timber is scarce, greater care is

taken in selecting the kinds of wood cut into posts, and in any

event the durable species are almost invariably the best ones to

use. Aside from the question of cost, which is always of first

importance, the qualities demanded of a good post wood are

durability, form, and ability to hold staples or nails. If the posts

are to be given a preservative treatment, their ability to take

treatment must also be considered.

The durability of posts is very variable even when cut from the

same kind of wood, so that any estimates on durability must be

judged with considerable latitude. Posts set in wet ground are

more durable than posts set in soil alternating wet and dry.

Posts cut from slow-grown trees are generally more durable than

posts cut from rapid-grown trees. To these variations must be

added the variations due to climatic conditions.

The best formed posts come usually from the coniferous trees

like cedar, pine, fir, etc., and fences set with them have the neat-

est appearance. Crooked posts are more liable to pull the

staples, as the wires fastened to them are not in alignment.

In general, the staple or nail-holding power of a post varies

with its dry weight. That is, posts cut from heavy woods like

locust, oak, etc., will hold staples better than posts cut from light

woods like pine and cedar.

If the posts are to be set untreated, the more heartwood they

contain the better. Consequently, split posts are generally

more durable than round posts. If, however, a preservative

treatment is to be given, round posts are preferable, as the sap-

172

PROLONGING THE LIFE OF FENCE POSTS 173

wood can be more easily impregnated than the heartwood and

a continuous layer of preserved wood will then extend continu-

ally around the post.

Method and Time of Cutting Posts. As just mentioned,

split posts containing mostly heartwood are preferable to round

posts if they are to be set untreated. So far as possible, the ends of

the posts should be cut with an axe or fine saw, especially if the

posts are of soft wood. A smooth cut enables rain water to run

off more freely and is less liable to cause top decay. A slight

bevel to the top of the post is also desirable and should be given.

If, however, the posts are subject to "frost heave," that is,

thrown out of alignment by frost, the bottoms should be pointed

so they can be reset upright in the spring and driven into the

ground with a mallet. With such posts, too great a bevel to

the top should be avoided.

It is generally conceded that the best time of the year to cut

posts is in winter or late fall, as they are at such seasons less

subject to immediate attack by fungi. Furthermore, sprouts from

winter-cut stumps are far more vigorous than sprouts from stumps

cut in spring or summer. In fact, the sprouting capacity of a

stump may sometimes be killed by summer cutting.

In all cases, whether treated or untreated, posts should be

peeled, as the bark offers practically no protection and generally

does a positive harm. All bark should be thoroughly removed

from that portion of the post to be treated with the preservative

so that the preservative can have an opportunity to penetrate

uniformly into the wood.

Method of Seasoning. Whether or not it pays to season posts

which are to be set untreated is still an open question. It

appears, however, that the seasoning adds but little to the life

of the posts and if it entails much delay or expense is not

warranted.

Of course, where a preservative treatment is to be given,

seasoning is as a rule highly advisable, as better penetrations are

secured and the protective coating is less subject to injury due to

subsequent checking. A simple and effective means of season-

ing posts is to pile them in horizontal layers, allowing sufficient

space between each ppst so that air can circulate about them.

(See Plate XVII, Fig. C .) If the posts are liable to check seriously,

as in the case of the gums and oaks, it is best to pile them

closer together and in a shady place. One or two months are

174 THE PRESERVATION OF STRUCTURAL TIMBER

generally required to produce an air-dry condition but in warm

weather two weeks may be sufficient.

Methods of Treatment and Their Selection. Farmers are the

largest consumers of posts, and most of them make their own posts.

The chief requirement for a preservative treatment is, therefore,

that it shall be one which the farmer can give himself. In some

localities where the posts are bought, a rather elaborate treat-

ment can be given and the posts sold in a treated condition. For

the most part, however, the most practical methods are those

which are simple of execution. The ones most commonly used

are described below.

Setting Posts in Stones. If stones are abundant, this method is

better than setting the posts directly into the soil. If the stones

must be hauled long distances, the method will not pay, as it

does not materially increase the life of the posts. Its chief ad-

vantage lies in that it keeps weeds and vegetation away from

the base of the post, thus prolonging its life and protecting the

post from ground fires.

Setting Posts Upside Down. This is done on the theory that

rain-water will run out of the post more readily in this position

than when set large end down. There is no evidence whatever

to substantiate this and were it not for the widespread belief

in this method it would not even be commented upon here.

An obvious objection to this method is that it places the small

end of the post in the ground and hence gives a weaker post

than if set the other way, since greater strength and resistance

are required in the butt than in the top.

Charring the Butt. Charring at best is a poor method of

treatment, since its effect is but slight. If the posts are charred

they should first be air seasoned thoroughly and charred from the

butt to about 6 inches above the ground line. The charr should

not extend more than 1/4 inch into the post. While this treat-

ment will tend to increase the durability of the post, it also

weakens it at the very point where it needs greatest strength.

However, if the charring can be done at slight expense, it will

more than pay for itself through added durability.

Dipping in Crude Oil and Charring. If the butt ends of the

posts are dipped for a few minutes in crude oil and then charred

better results than simple charring are obtained. (See Plate

XVIII, Fig. A.) This method is, however, also subject to criti-

cism in that it weakens the posts at the butt. It seems that

PROLONGING THE LIFE OF FENCE POSTS 175

burning the posts after their oil treatment tends to drive some of

the hot oil into the wood. Some experiments made along this

line by the Wyoming Experiment Station showed pitch-pine

posts to be sound after 16 years of service. It should be stated,

however, that these posts set untreated under similar con-

ditions would last at least 12 years, so that the efficacy of the

treatment is not pronounced.

Diagonal Holes Filled with Preservative. This method of

treatment consists in boring 2 or 3 holes about 1/2 inch in

diameter and 3 inches deep diagonally downward into the post

near the ground line, and pouring a preservative such as a solu-

tion of copper sulphate, mercuric chloride, kerosene, etc., into the

hole, after which it is plugged. When the preservative escapes

from the cavity, the plug is removed and more inserted. This

treatment is not recommended, first because it weakens the post,

second because the preservative does not diffuse evenly through

the post as claimed, and third because the results secured are not

sufficient to pay for the trouble and expense of the treatment.

Brush Treatments. If posts are first air seasoned and then

given two coats of a good preservative like coal-tar creosote or

carbolineum in the manner described in Chapter V, their natural

life can be increased from 3 to 6 years. The entire butt of the

post should be treated to a distance about 1 foot above the

ground line. The preservative had best be applied hot and worked

into the cracks as completely as possible. Brush treatments

when properly applied will more than pay for themselves but are

not as efficient as can be given. In the case of posts that decay

at the top, such as maple, gum, etc., it is well also to brush-treat

the top.

Dipping Treatments. These are more effective than brush

treatments, as the preservative is sure to run into all checks.

As posts can be easily handled, this method is recommended, par-

ticularly where only a few posts are to be treated. Creosote or

a similar preservative is the best obtainable for dipping treat-

ments. All that is necessary is to have the preservative hot

(about 150-180 F.) and dip the butt ends of the post in a tank

or barrel containing the oil for about 1/4 minute, after which they

can be removed. The post should be submerged to a depth of

about 1 foot above the ground line. One dipping will give good

results. Better absorptions and penetrations will be secured,

however, if the post is dipped twice, a sufficient time elapsing

176 THE PRESERVATION OF STRUCTURAL TIMBER

between treatments to allow the first to dry. Tar is not recom-

mended for either brush or dipping treatments.

Impregnation Treatments. Treatments of this kind are the

best known, although the most troublesome and expensive to

make. If the preservative selected is a salt like zinc or mercuric

chloride or copper sulphate, all that is necessary is to stand the

air-seasoned posts in a tank or vessel containing a solution of the

preservative. For zinc chloride a 6 percent solution is recom-

mended, while for copper sulphate 1.5 percent and for mercuric

chloride 0.9 percent is sufficient. If the latter salt is used great

care should be taken in handling it and keeping it away from ani-

mals because of its very poisonous nature. With copper and

mercury solutions, wooden or stone vessels or tanks should be

used, as they will attack iron. The posts should remain standing

in the preservative for about 1 week.

Better results can be secured with coal-tar creosote, but to get

most effective treatments the oil should be heated as described

in Chapter V. If but one tank is used, the oil and posts can be

heated and then allowed to cool in it. This cuts down the num-

ber of posts that can be treated per day and is called a "single-

tank treatment." If two tanks are used, one for hot oil and one

for cool oil, quicker results are secured. Such treatments are

known as " double-tank treatments." The U. S. Forest Service

has made a large number of tests in treating posts by these meth-

ods and has obtained some very satisfactory results. These are

shown in Table 24.

The treating tanks necessary to treat posts in this manner

and the method of operating them are described in Chapter V

(open-tank process).

While no tests that have been made are known to the author,

it is believed that if the posts are boiled in crude oil or any cheap

oil for 2 or 3 hours and then quickly plunged into a tank

containing a solution of zinc chloride, copper sulphate, or mer-

curic chloride at atmospheric temperature, as described above,

and left standing in this solution for 3 or 4 hours, very

good results will be secured and at a lower cost than if only coal-

tar creosote were used. It is quite likely that green posts can

be treated in this manner and good penetrations obtained, but

in such cases the length of the boiling period will probably have

to be increased somewhat. In no case should the posts be heated

above 275 F.

PROLONGING THE LIFE OF FENCE POSTS

177

TABLE 24. BEST RESULTS SECURED IN THE TREATMENT OF VARIOUS

WOODS 1

(All posts were round, peeled, and seasoned)

Species

Absorp-

tion creo-

sote per

5-inch

post

Penetration

Single-tank treatment

Double-tank

treatment

2 feet

from

butt

2 feet

from

top

Butt

Top

Hot

oil

Cold

oil

Hot Cool-

oil |ing oil

Gal.

0.4

0.6

0.6

0.6

0.4

f 0.4

\ 0.6

0.6

0.4

0.6

0.6

0.6

0.4

0.6

0.6

0.6

O.r.

0.4

0.5

0.6

0.8

0.5

0.6

0.5

0.6

0.6

0.6

In.

0.4

0.1

1.0

0.7

0.56

0.6

0.3

0.36

0.46

0.6

0.6

1.0

0.5

0.4

1.0

0.2

1.06

0.5

1.5

1.2

1.0

1.0

1.0

0.5

1.0

0.4

O.G

In.

0.05

0.4

0.3

0.1

0.1

0.3

0.3

0.3

0.2

0.3

0.1

0.5

().:{

1.0

(i i>

0.3

0.4

0.3

0.2

0.2

0.1

0.2

Hr.

5

Hr.

12

Dipped". .

Hr.

1

1

3

Hr.

i

i

i

Basswood .

Beech

Birch, river

6

}'

12

12

Cottonwood

Dipped" . .

iu :

u

i

U

Elm, slippery

Elm, white

Gum, black

Gum, cotton (tupelo) .

Gum, sweet (red)

Hickory, bitternut. . . .

Magnolia, sweet (bay)

Maple, red

Maple, sugar

6

12

i

i

i

i

i

I

6

12

Dipped". .

i

4

3

1

li

u

3

3

3

6

1

2

4

i

2

2

f

I

1

1

1

2

1

12

1

i

1

Oak red

Pine, loblolly

Pine, lodgepole

Pine, pitch

Pine, shortleaf

Poplar white

Sycamore

Tulip-tree

Willow, white c

a Dipped for 5 minutes or more.

b Width of sapwood. Penetration limited by impenetrable heart.

c Requires especially thorough seasoning.

Pitch Streaks. It is well known that pine posts which contain

large amounts of resin are more durable than pine posts which are

not resinous. This fact is taken advantage of in certain portions

of the South by peeling all of the bark off a small tree to a height

of 7 or 8 feet except for a strip about 2 inches wide, which is

sufficient to keep the tree alive for several years. The tree

thus injured covers its wound with resin, which frequently

penetrates into the wood for a half inch or more and thus

forms pitchy wood. In two or more years the tree is felled and

the post cut from it. This method is not recommended, as it

is very destructive to timber and wasteful, and the posts are

'Farmers' Bulletin 387, U. S. Department of Agriculture.

12

178 THE PRESERVATION OF STRUCTURAL TIMBER

very liable to catch on fire, if ground fires are common, because

of the pitchiness of the wood.

Cost of Treatment. Costs of treatment will be estimated

only for brush, dipping, and impregnation treatments, as the

other treatments described cost practically nothing except for

labor, which is generally supplied by the farmer himself at odd

times. If labor is included, the cost of the treatments will, of

course, depend upon the number of posts which can be treated

per day and the value the farmer puts upon his labor. In the

following calculations it is assumed that the apparatus used is

such as is described in Chapter V and that the price paid for the

chemicals is average for small quantities, viz., creosote 2 cents

per pound, zinc chloride 5 cents per pound, copper sulphate

6 cents per pound, and mercuric chloride 70 cents per pound;

these being used in the manner specified above. The total cost

of treatments per post (6-inch top 7 feet long) will then be

about as estimated in Table 25.

TABLE 25. ESTIMATED COST OF TREATING FENCE POSTS (BUTT ONLY)

Method of treatment

Total cost per

post (cents)

Brush.- treated coal-tar creosote

4-6

Dipped coal-tar creosote

5-7

Impregnated with zinc chloride, copper sulphate or

mercuric chloride

3-7

Impregnated with coal-tar creosote

12-20

If the entire post is treated the above costs will be about doubled.

Economy of Treatment. As the preservative treatment of

fence posts cut from durable wood is unnecessary, it will be

assumed that only posts having a comparatively short natural

life will be given a treatment. In order to approximate the value

of the treatments, therefore, we will take as an example posts

cut from such woods as red oak, maple, pine, etc., which decay

in about 5 years and which are worth about 5 cents each. The

cost of setting the posts will be estimated at 12 cents each. With

these assumptions and figuring interest compounded at 6 percent,

the annual cost of posts treated by the various methods will be

as shown in Table 26.

It will be noted that, if the values given in the table are approxi-

mately correct, the economy resulting from the treatment of

posts is not great. The selection of woods to be cut into posts

is perhaps of as great or even greater importance. For this

PROLONGING THE LIFE OF FENCE POSTS

179

TABLE 26. ESTIMATED ANNUAL CHARGES OF TREATED POSTS (Burr

TREATED ONLY)

Method of treatment

Life of

post

(years)

Cost of post

set in position

(cents)

Annual

charges

(cents)

Untreated

5

17

4.0

Brush treated coal-tar creosote. . .

9

22

3 2

Dipped coal-tar creosote

11

23

2 9

Impregnated with zinc chloride, copper

sulphate, or mercuric chloride. .

12

22

2 6

Impregnated with coal-tar creosote

21

33

2.8

reason, Table 27 is given to show what can be expected from

posts cut from a variety of woods. Fortunately, some reliable

data from actual experience is available on the life of untreated

posts, this data being compiled from painstaking inquiries and

researches by Mr. J. J. Crumley of the Ohio Agricultural Ex-

periment Station and published by him as Bulletin No. 219 of

that station. He examined 292 fences containing 30,160 posts

in Ohio, Indiana, Illinois, Kansas, and Texas. The results are

shown in Table 27.

TABLE 27. LIFE OF FENCE POSTS SET UNPROTECTED

Kind of wood

Average age

of fences

(years)

Percent of

sound posts at

this age

Osage orange

33 2

99

Locust (black)

25 4

82 3

Red cedar

33 2

65 3

Mulberry

23 8

74 1

White cedar.

18 4

68

Catalpa

17 5

61 8

Chestnut

12 3

71 8

Oak (mostly white)

11 8

65 2

Black ash

6.5

64.2

It can be seen at a glance that posts cut from such durable

woods as osage orange, black locust, red cedar, etc., will far out-

last nondurable posts treated by the best methods known and

will be far cheaper to use even if they cost considerably more.

The following interesting facts on the life of untreated fence

posts are brought out by Mr. Crumley's investigation:

1. "A large post usually lasts longer than a small one of the

same wood.

2. There is no difference which end is put in the ground, except

that the sounder or larger end should have the preference.

180 THE PRESERVATION OF STRUCTURAL TIMBER

3. In stiff clay soil, the posts rot principally just beneath the

top of the ground, and in a porous, sandy, or gravelly soil they

usually rot from the top of the soil all the way down.

4. In soil that is full of water all the time, posts will last

longer.

5. Timber that grows rapidly and in the open is not as good as

the same variety that grows in the woods.

6. There is some evidence that it is not a good time to cut posts

just as the tree begins to grow in early spring.

7. The wood at the center of the tree is not as good as that just

inside the sapwood. This characteristic is very common with

nearly all the varieties of timber examined, especially so with the

locust, white cedar, hardy catalpa, and the oaks."

CHAPTER XI

PROLONGING THE LIFE OF PILING AND BOATS FROM

DECAY AND MARINE BORERS

To satisfactorily treat piling and timber placed in salt water

where marine borers abound is exceedingly difficult of accomplish-

ment and the problem is quite different from that of protecting

timber from decay. As has been pointed out in Chapter II,

it matters little what the wood is, for the borers will rapidly

perforate it. The hardest woods like oak and eucalyptus are at-

tacked by them. The most resistant wood known against these

attacks is the greenheart, but even this will eventually succumb.

Of course piling driven in fresh water or in the ground is not

subject to the attack of marine borers. If such piling is kept

continuously submerged or buried, no preservative treatment is

necessary, as it will last indefinitely. If, however, parts of it

project into the air, decay will take place and some preservative

treatment is advisable. The methods described under the

treatment for poles may be considered in this connection, except

of course if the piling is in water or wet soil soluble salts should

not be used.

Selection of Species. A good pile timber should be straight,

strong, susceptible to treatment, and of moderate cost. Any

wood which has these properties can be used to advantage.

These requirements are admirably filled by our common southern

pines, the loblolly, shortleaf, longleaf, and Cuban. On the

Pacific Coast, western yellow pine and Douglas fir are available,

although the latter is objectionable on account of its resistance

to treatment by present known processes. Strange to say, two

woods which differ greatly in their mechanical properties are used

untreated for piling with apparent good results. These are the

palmetto, which is comparatively weak and " spongy," and

greenheart, which is exceedingly strong and dense. The re-

sistance of the palmetto is supposed to be due to its porous nature

and the natural adversion of the teredo to crossing vacant spaces.

The greenheart apparently has some peculiarity not at present

understood which is unattractive to the marine borers.

181

182 THE PRESERVATION OF STRUCTURAL TIMBER

If the piling is to be used in waters where attack by marine

borers is known to be very rapid, only those woods which have

a wide sap wood (about 2 inches in width) should be used, as more

preservative can be forced into them and better results thus

secured. Where attack is less severe, it seems that piling with

sapwood about 1 inch wide is preferable, as this tends to con-

centrate the oil in the outer portion to a greater extent than when

the sapwood is wide. In either case it appears that a con-

centration (heavy injection) of oil is better than diffusing the

same amount of oil more deeply through the wood a condition

quite the reverse of the protection against fungi.

The Manufacture of Piling. In making piling which is to be

treated there are two essentials which should be strictly adhered

to. First, is a complete removal of all bark from that portion

of the pile which will project above the mud line. Bark is very

resistant to penetration and if thin strips of it are left adhering

to the wood the penetration under such strips may be very slight

or none at all; consequently, no matter how well the rest of the

pile may be treated, attack will begin at these points and extend

rapidly to the interior. Many failures have occurred because

this simple rule was violated. (See Plate XVIII, Fig. B.)

The second precaution is to keep the sapwood continuous

and not cut into it so as to expose the heartwood at any point

which can be reached by the marine borers. Heartwood does not

take treatment as well as sapwood, and is always more subject

to attack no matter how well the treatment is given. As that

portion of the pile which is driven below the mud line is not

subject to attack either by decay or marine borers, and hence

will last indefinitely, it is believed that much economy in the

treatment of piling could be effected by leaving the inner bark

adhering to this portion of the pile. In this way, much less

oil would be consumed without in any way affecting the life of

the pile.

Methods of Seasoning. If the piling can be air seasoned with-

out decay, the method followed is the same as that given for air-

seasoning poles. Unfortunately, it often happens that this can

not be done, particularly in the South where the air is warm and

damp and decay is liable to occur before the pile becomes dry.

Some plants store their piling in water prior to treatment or leave

them on the ground. Both these methods may become ob-

jectionable in that they may cause marked differences in the

PLATE XVIII

FIG. A. Fence posts dipped in crude oil and then charred. Note good

condition after 12 years' service. (Photo courtesy of the Wyoming Exp.

Station.)

FIG. B. Sections of creosoted piling. Note erratic penetrations of creosote.

(Forest Service photo.)

(Facing page 182.)

PLATE XVIII

FIG. C. Pile sheathed with zinc entirely destroyed by marine borers,

Pensacola, Fla. (Forest Service photo.)

FIG. D. Piling protected with cement casings from attack by marine

borers, Pensacola, Fla. (Forest Service photo.)

POLONGING THE LIFE OF PILING AND BOATS 183

water content of the pile, which in turn is liable to result in

unequal penetrations.

When air seasoning is impossible, live steam or oil seasoning

can be used. The methods of doing this have been given in

Chapter IV. Care should be taken not to use temperatures

above 275 F., as injury to the timber is liable to occur. The

length of time the wood should be steamed or boiled varies con-

siderably, depending upon the size and " greenness" of the

wood and the amount of preservative to be injected. In general,

it is between 6 and 18 hours, although longer periods are some-

times used.

Methods of Treatment and Their Selection. Many methods

for treating piling have been tried but only a few have been found

meritorious. Only those which have been most commonly

practised are described.

Bark Left on the Piles. Bark resists the attacks of the marine

wood borers, but will adhere only a short time, after which it

loosens and falls off. If the piles are to be driven untreated,

however, the bark should be left on, except for the portion pro-

jecting above high- water level.

Plank Coating. Strips of wood nailed tightly together around

the pile will ward off attack for a short period, but their value is

only temporary.

Nail Coating. Flat-headed nails resembling upholsterers

tacks driven into the pile close together will prolong the life

of the pile. It seems that the iron rust formed by the nails is

avoided by some of the marine borers, especially the limnoria.

The method is, however, expensive and awkward and not

recommended.

Metal Coating. Sheets of zinc or copper nailed around the

pile at those points subject to borer attacks will effectively pro-

tect the pile as long as they last. (See Plate XVIII, Fig. C.)

Care should be taken, however, to make all joints tight. The

coating will corrode in time and is liable to puncture by floating

de\*bris, but this method of treatment is efficacious.

Burlap Coatings. These are made by coating the pile where it

is subject to attack with various mixtures such as coal-tar, pitch,

asphalt um, sand, etc., and wrapping the whole in several layers of

burlap. Very good results have been secured from treatment

of this kind.

184 THE PRESERVATION OF STRUCTURAL TIMBER

Cement Casings. 1 These are made in two ways, (1) with

no space between the casing and the pile, and (2) with an inter-

vening space of from 2 to 4 inches.

The first are manufactured as follows: The bark and knots are

removed and the pile driven. A jacket of iron, wood, or sewer

pipe is placed around it, and the space between jacket and pile,

which is from 2 to 4 inches wide, is filled with hydraulic cement.

(See Plate XVIII, Fig. D.) When this becomes hard, the

jacket is removed. Some jackets are so made that they can be

applied to the pile without disturbing the superstructure of the

wharf, thus making repairs to broken casings easy.

The second class is composed of cement pipes divided longitu-

dinally into two halves, which, when placed together around

the pile, are joined by a scarf joint keyed with a wooden plug

soaked in hot tar. The intervening space between pile and casing

is filled with sand. The chief advantage of this kind of casing

is the fact that broken sections can easily be replaced without

removing the superstructure of the wharf. These treatments

are very efficient.

Electrolysis. A canvas bag or curtain is placed around the

pile driven in position and an electric current passed through the

pile and the surrounding water. This liberates chlorine gas in

the salt water and kills the borers in the pile. It is necessary,

of course, to apply this treatment from time to time, since it

simply kills the borers present in the wood. The treatment is

expensive, but performs a peculiar function in being able to pro-

tect piles already set in position and undergoing attack.

Impregnation with Coal-tar Creosote. For general work,

treatments with coal-tar creosote, by either the Bethell or

Boiling process (see Chapter V for details of treatment), have

given most effective results. It is necessary, however, to inject

large quantities of the oil into the wood (18 to 24 pounds per cubic

foot) if the piles are subject to severe attack. This greatly

increases the cost of the treatment. However, piles properly

treated in this manner have been known to last for 30 years,

while untreated piles set in similar waters are completely de-

stroyed in 5 years. While this method of treatment is the best

known, it leaves much to be desired. It is, as has just been

stated, very costly. Furthermore, several cases have been called

to the author's attention where the piling so treated has not

1 Circular 128, U. S. Forest Service.

PROLONGING THE LIFE OF PILING AND BOATS 185

withstood attack, especially of the limnoria and xylotrya, and

failed in less than 8 years after it was driven. There is a

distinct need for a good preservative which can be used in

treating piling set in waters badly infected with marine borers.

(See Plate XIX, Figs. A and B.)

It seems that a more economical method of treatment than

is now practised could be devised. As has already been pointed

out, that portion of the pile driven below mud line needs no pro-

tection, yet in present methods it receives even more oil than

the rest. Furthermore, the portion of the pile above high-water

mark does not require as heavy injection as that portion in the

water. If a plant could be constructed which could be tilted

vertically after the piles are run into it, and only a portion of

the pile impregnated, it is believed much expense could be saved.

Such a plant would also be admirable for butt-treating poles

under pressure.

The selection of the process to be used in treating piles largely de-

pends upon local conditions. If the waters are comparatively free

from borers, such as in our more northern harbors on the Atlantic

Coast, or if the waters are brackish, a comparatively light treat-

ment with creosote (10 to 14 pounds per cubic foot) is sufficient.

If, however, the borers abound as at Gulfport, Miss., and San

Francisco, CaL, the heaviest impregnations should be used.

Where the piling can be protected from floating d6bris, casings

of cement or metal as described above are also effective. These

can also be placed over piling already driven into position if it is

found attack is taking place. Treatments with burlap, soaked

as already described, give good results even in waters badly

infected. So far as is at present known, heavy impregnations

with coal-tar creosote are, when all things are considered, the

most effective that can be given, and they are recommended for

all places where attack is severe.

Cost of Treating Piling. The total cost of treating piling by

the standard full-cell creosote process including the removal of

the strips of inner bark or "skin" left after the piles have been

TABLE 28. ESTIMATED COST OF TREATING PILING WITH

CREOSOTE

Item

Per cubic foot (cents)

Cost of peeling and handling at plant

1 0-2.5

Cost of preservative

16 5

Cost of treatment . . .

3.5-6.0

Total cost of treatment

21.0-25.0

186 THE PRESERVATION OF STRUCTURAL TIMBER

roughly peeled in the woods is given in Table 28, where oil is

figured at 9 cents a gallon of 8.75 pounds, the piles are steam-

seasoned, and 16 pounds of oil per cubic foot are injected.

Economy in Treating Piling. The cost of treating and driving

piling as well as the life secured from it are all so variable that

general figures are of value only as an illustration. In prepar-

ing the general estimates given in Table 29, two conditions

are illustrated, case (A) where piling is driven in salt water

where attack by marine borers is light, and case (B) where

attack is severe. In the former it is assumed that a treatment

of 16 pounds of creosote per cubic foot is given, while in the latter

22 pounds are injected. The cost of driving the piling including

the superstructure bolted to them is taken as $6 per pile, and all

piles are assumed to be 40 feet in length and to contain about

25 cubic feet each. Variations of at least 100 percent in the

estimated annual savings either way can be expected because

of the extremely varying conditions under which piling is used.

TABLE 29. ESTIMATED ECONOMY IN TREATING PiLiNQ 1

Item

Case A

Case B

Life of untreated piling years

8

3

Life of treated piling years.

25

18

Cost of untreated piling driven in place

Cost of treated piling driven in place

$8.50

$14.75

$8.50

$16.50

Annual charge untreated piling

$1.32

$3.12

Annual charge treated piling

$1.03

$1.40

Annual saving treated over untreated

$0.29

$1.72

The Preservative Treatment of Wooden Boats. If wooden

boats are used in salt water which contains marine borers, they

are very subject to attack and unless properly protected their

bottoms may be entirely destroyed in a year or less. For light

boats which can be readily hauled out of the water, repeated

coatings with copper paint will prove effective. Heavier boats

should be protected with sheet copper nailed securely to the

bottom. Barges and similar craft should have their bottoms

built of lumber heavily creosoted, 12 or more pounds per cubic

foot being injected. Even under these conditions, attack is very

liable to occur. If fresh-water moorings are accessible the borers

in the boats can be killed by anchoring the boats for a few days

in fresh water.

1 Interest compounded annually at 5 percent.

PLATE XIX

FIG. A. Sections of longleaf pine piles after 21 months' exposure to the

SK ot marine borers at Gulf port, Miss. Section to the right, untreated;

ion to the left, impregnated with a crude oil. (Forest Service photo).

(Facing page 186.)

PLATE XIX

FIG. B. Untreated pine piles completely destroyed by marine wood borers,

Santa Rosa Island, Fla. (Forest Service photo.)

PROLONGING THE LIFE OF PILING AND BOATS 187

Wood in boats not subject to attack by borers is often quickly

decayed, as the moist conditions of the air in them is very

favorable to the growth of fungi. It is a very good plan to brush-

treat with creosote or carbolineum all such joints subject to

decay. The author has had considerable experience in protecting

small fresh-water boats in this manner and has entirely eliminated

decay. Of course, the portions so treated cannot be painted,

as paint will not adhere to the creosoted wood. In barges and

boats where artistic effects are not essential, all lumber subject

to decay can be profitably creosoted by one of the empty-cell

methods. This will protect the wood from rotting without

increasing its weight very materially.

Although no cases are known of where it has been tried, it is

believed that the life of small pleasure boats subject to decay

can be materially prolonged if they are filled in the spring with a

3 percent solution of copper sulphate or a 1 percent solution of

mercuric chloride and allowed to soak in this solution for several

days before they are run into the water. These solutions should

soak into the joints and permeate the partially decayed wood,

thus killing whatever fungi might be present.

CHAPTER XII

PROLONGING THE LIFE OF MINE TIMBERS

On account of the warm damp air which exists in many mines,

timber placed in them is very subject to attack by decay and in-

sects. As the methods which will eliminate decay will also elimi-

nate insects, no differentiation in treatment is specified. It is

very common for mine timbers, a foot or more in thickness, to

become completely decayed in less than 2 years if set untreated.

The expense of resetting these timbers is great, and, furthermore,

such replacements generally interfere with the working of the

mine. This is particularly true in coal and iron mines. In

many mines the walls are of solid rock so that little timber is neces-

sary, and even this is often not subject to rapid decay. Also, in

temporary workings, where the props are either left standing or

"pulled" after the coal or ore has been removed, a preservative

treatment is unnecessary. But for permanent shafts and

gangways it is highly advisable to so treat the timbers that

greatest life can be secured from them and thus the working of

the mine will be least interfered with. Several mine com-

panies in the United States are using treated timber and have

secured excellent results. As the workings are extended deeper

and deeper, the need for a preservative treatment is found

to become more acute.

Selection of Species. It is the practice at most mines to use

any kind of wood which is available and is large enough for the

purpose desired. Preference is, of course, given to those varieties

which are most durable. This freedom in the selection of

species must be considered bad practice on the part of the mine

operator, for aside from the large expense and trouble to which

he is put in replacing the decayed timber, he is filling his mines

with the mycelia of the destructive fungi. Sanitation of timber

in such conditions is advisable if contamination is to be pre-

vented, just as it is among human beings where some are

affected with a contagious disease.

Strength, form, and durability are the inherent properties

188

PROLONGING THE LIFE OF MINE TIMBERS 189

required of a good mine timber, but if a preservative treatment is

to be given, adaptability to treatment can be substituted for

natural durability. As mine timbers, except for shafting and

"long walls/' are generally short, they are not so difficult to fur-

nish as timber for poles and piles, and consequently the mine

operator has a wider choice of species at his command. If the

timbers are to be set untreated, durable woods should be

selected for the permanent workings, such as osage orange,

black locust, white oaks, chestnut; or if strength is not so

important, the cedars, cypress, etc. The more heartwood they

have the longer will be the life secured.

When treated, the red oak, maple, birch, beech, the hard

pines, fir, elm, etc., are good woods where great strength is

required, and for workings requiring less strength most any wood

having an inch or more of sap wood can be used to advantage.

The Manufacture of Mine Timbers. In permanent workings,

whether the timbers are to be set treated or untreated, they

should be peeled before they are placed in the mine. This in

itself will increase their durability and destroy the breeding places

for many wood-destroying insects. To peel timber in the woods

or at the shipping point effects a saving in freight and in the cost

of handling. The weight of the bark usually amounts to from

6 to 15 percent of the original green weight. If the timbers are

to be treated, they should be framed to exact dimensions so that

no cutting into the treated surface will be necessary. Unless

there is some good reason to the contrary, all timbers intended

for treatment should be left round. Slabbing them only exposes

the heartwood and hence decreases the effectiveness of the

treatment.

Methods of Seasoning. When mine timbers are set untreated

there is little or no advantage gained in seasoning them before plac-

ing them in the mine. If they are to be treated, however, season-

ing is advisable, as it enables better results to be secured. Air

seasoning is recommended, unless for some local reason it can-

not be practised. Props and other round timbers can be piled

on skids in the same manner as poles (see Chapter IX). Mine

ties can be piled like railroad ties (see Chapter VIII). Lumber

and sawed stock should be piled with liberal air courses be-

tween the planks, and with as small an area as possible in contact.

The rules as given in Chapter IV for the selection and care of the

seasoning yard should be followed.

190 THE PRESERVATION OF STRUCTURAL TIMBER

The length of time necessary to air season the timbers of course

varies considerably (see Chapter IV). In general, 1 or 2

months are sufficient. Fig. 23 shows the rate at which loblolly

pine and red oak props and ties air-seasoned in Pennsylvania and

Alabama. Whenever possible, timber should be seasoned before

shipment, as a considerable saving in freight will result. If it is

not practicable to air season the timber, it can be seasoned in

steam or oil as described in Chapter IV. The length of time nec-

essary to do this will, of course, vary with each kind and form of

5

10

15

20

25

30

35

c

Description of Material

V

Curve

Species of

Timber

Porm,

Dimensions

\

v \

A o

SO

Co

Loblolly Pine

Loblolly Pine

Bed Oak

Mine Props J

Mine Ties

Mine Ties

I'bia.xlo'Lo

b'x. 5'x. 5-4"

Ig

\

N>

x

5x5x5-4"

Y

\

--^

"xx

"^^

\

s

\

\

X

\*-.

o

i

\* .

o

s^

--o

\*-\*.

\

V

"^N.

^N,

\*o-

-

-0

\

^^

' .

A

\

\

^->

-^

>

\

" >s \*

^x

\*>^

\

B

^0

^^

^

^

\*^

^,

..

^

^

1

-o

-^s

^^

^^

^

5 10 15 20 25 30 35 40 45 50 55

Days Seasoned

FIG. 23. Percentage of green weight lost by seasoning mine timbers. 1

timber and with the character of treatment desired, so that each

plant will have to work out its own best operative conditions.

The instructions already given in Chapters IV and V should be

consulted for helpful suggestions.

METHODS OF TREATMENT AND THEIR SELECTION

Mine Ties. The methods of treating mine ties do not differ in

any essential way from the treatment of cross-ties described

in Chapter VIII. If the mines are dry, treatments with zinc

chloride or any empty-cell treatment with creosote will prove

very satisfactory. On the other hand, if the ties are liable

to be wet or alternately dry and wet, heavier injections of

1 From Bulletin 107, United States Forest Service.

PROLONGING THE LIFE OF MINE TIMBERS 191

creosote are best. Ties constantly in water need no treatment

whatever.

Mine Props. Under this heading are included props, legs,

collars, and caps. The cheapest treatment consists in brush-

treating these with coal-tar creosote, and if the preservative is

applied to the ends and joints as well as the sides, several years

increase in life will be secured, so that the cost of the opera-

tion will more than pay for itself. Such treatments should,

of course, be applied to the timbers before they are placed

in the mine. If dipped, better results will be secured than

by brush-treating, as all checks will be coated with the pre-

servative.

Impregnation treatments have given by far the most satis-

factory results. Three processes are recommended, the Burnett,

the empty-cell and the full-cell creosote. If decay is not un-

usually severe and if the timbers are liable to be broken by crush

or " squeeze/' the Burnett process is recommended. Excellent

results can be secured from it. If the timbers are set in mines

where there is much moisture and where decay is very rapid,

treatments with creosote should be used, the empty-cell method

being employed for porous woods containing much sapwood, as

loblolly and shortleaf pines, etc., and the full-cell process where

the timbers are refractory and the percentage of sapwood small,

as in Douglas fir, hemlock, and hewed timbers generally. One-

half pound of zinc chloride per cubic foot is sufficient for the Bur-

nett-treated timbers. Six to 12 pounds per cubic foot is sufficiently

heavy for the creosoted timbers. All these timbers can be handled

in precisely the same manner as in treating ties.

The practice of sawing off treated mine timbers in order to

make them fit is bad. It can often be avoided by using com-

paratively short timbers and wedging them into place by means of

creosoted wedges or caps. In this manner much valuable timber

can be saved and decay greatly retarded.

Square Sets. If these are made of round timbers they can be

handled in the same manner as props. If the timbers are sawed

or hewn and are not susceptible to treatment, the full-cell creosote

treatment is recommended. Care should be taken to see that

the ends especially are well protected, and if for any reason

it is necessary to retrim these timbers after they have been

treated, such places should be brushed over with one or more

coats of creosote.

192 THE PRESERVATION OF STRUCTURAL TIMBER

Lagging. It seldom pays to treat lagging, but if the lagging is

made of sawed lumber, a treatment with zinc chloride can

profitably be given. The chief advantage in treating lagging

rests in retarding the spread of the wood-destroying fungi.

The Treatment of Mine Timbers in Relation to Fire, This is a

very important matter, as nothing should be placed in the mines

which will increase the fire hazard. All timbers treated with

zinc chloride will be more fire resistant than untreated timbers.

Furthermore, this salt tends to keep the timbers moist, and

hence under pressure they will act more like green timber, viz.,

bend considerably before they break. Much importance is

attached to this property by some mine operators, as it gives a

warning to the men in case of a crush or fall of rock or earth.

In all cases, timbers which are creosoted should first be air

seasoned for at least 1 month before they are placed in the

mines. This will enable the lighter portions of the oil to

evaporate and will decrease very materially the ease with which

the timber can be ignited. After it has once air seasoned,

creosoted timber is not easily ignited. It is possible to hang the

naked flame of a miner's torch or lamp on such timber without

injury other than a charring of the surface. If, however, the

timber once ignites, it will burn freely and, unfortunately, emit

dense cloud,s of black smoke. Fire in creosoted timber is, how-

ever, easily extinguished. The author witnessed the effect of a

fire in a mine shaft, built of half untreated and half creosoted

props, where the flames shot from the mouth of the shaft. The

fire was extinguished by smothering the shaft. An examination

made after the fire showed nearly all of the untreated props

destroyed, while those creosoted were simply charred on the

surface and still serviceable. There is little doubt, however, but

what zinc-treated timbers in mines are preferable to creosoted

timbers when judged from a fire-hazard standpoint. They are

not only fire resistant in themselves, but they do not emit odors

which may be objected to by the workmen and hence cause

anxiety among them. For further information on the inflam-

mability of timber treated with zinc chloride and creosote, the

reader is referred to Chapter XVI.

Cost of Treatments. Table 30 gives an estimated cost of

treating mine timbers. It is assumed that creosote costs 1 cent

per pound, zinc chloride 4 cents per pound, peeling and seasoning

about 1 cent per cubic foot, brush-treating about 15 cents per

PLATE XX

FIG. A. Gangway of treated mine timbers, Pottsville, Pa. (Forest Service

photo.)

FIG. B. Rank growth of fungus on mine timbers.

(Facing page 192.)

PLATE XX

FIG. C. Treated and untreated mine props. Treated prop to right set

at same time as failed untreated prop at left, Pennsylvania. (Forest

Service photo.)

FIG. D. Untreated mine props destroyed by decay and "squeeze"

Pennsylvania. (Forest Service photo.)

PROLONGING THE LIFE OF MINE TIMBER

193

set, and impregnating about 2 cents per cubic foot. A sufficiently

close estimate on the cost of treating mine ties can be secured

from a direct comparison with cross-ties already given, making

allowance, of course, for the differences in volume between the

two.

TABLE 30. ESTIMATED COST OF UNTREATED AND TREATED PINE

GANGWAY SETS

(One set consists of one 7-foot collar, one 9-foot leg, and one 10-foot leg; average

diameter of timber about 13 inches)

Amt. of pre-

Cost of

Cost of peel-

Total

Method of treatment

servative used

preserva-

ing, seasoning

set in

per set

tive

treating

mine

Ib.

$

$

$

Unpeeled

8.50

Peeled and seasoned

0.26

8.76

Brush- treated creosote

28

0.28

0.40

9.18

Empty-cell process

130

1 30

0.80

10 60

Full-cell process (Bethell)

312

3.12

0.80

12.42

Burnett process

13

0.52

0.80

9.82

In western United States the cost of treating mine timbers is

high. Some figures secured from practice in Montana in treating

square timbers are as follows: 1

Cost of untreated sets :

1127 feet B.M. squared timbers, at $20.50 per M B.M $25.36

Framing timbers 13 . 50

Cost of lagging, at $15 per M B.M 5.90

Switching and unloading charges 0.85

Cost of placing set 18 . 00

Total cost of untreated set in place $63 . 61

Cost of treatment:

Cost of treating, including interest, depreciation, fuel, and labor

charges 3 . 34

Cost of creosote, at 15.6 cents per gallon; absorption 4.5 pounds

per cubic foot 8 . 03

Loading and unloading charges 1 . 23

Total cost of treatment 12 . 60

Total cost of treated set in place 76 . 21

Ecomony of Treatments. Because of the rapidity with which

timber placed in most mines decays, the economy due to its

treatment is very striking. As stated in the opening of this chap-

1 Bulletin 107, United States Forest Service.

13

194 THE PRESERVATION OF STRUCTURAL TIMBER

ter, it is not advisable to treat all of the timber which is placed in

the mine because much of it is intended to serve only a short

period. But for permanent shafts, gangways and entries it will

almost invariably be found that a treating process of some sort is

advisable and will result in a marked economy. Fortunately,

some reliable records on the life of treated timber in mines is

available on which fairly accurate estimates of economy can be

based. (See Chapter XX, Reliable Records on the Life of Treated

Timbers.) Excluding all failures from crush and fire, which may

be nil or total, the economies that may reasonably be expected

when such woods as pine, red oak, etc,, are used are shown in

Table 31.

TABLE 31. ESTIMATED ANNUAL CHAEGES OF TREATED AND UNTREATED

MINE SETS

(interest 5 percent compounded annually)

Method of treatment

Life of

timber

(years)

Cost of

timber set

in mines

Annual

charges

Untreated

2

$8 50

$4 39

Brush-treated creosote

5

9 18

2 12

Burnett process

10

9 82

1 27

Empty-cell process

11

10.60

1.27

Full-cell process (Bethell)

15

12.42

1.19

CHAPTER XIII

PROLONGING THE LIFE OF PAVING BLOCKS

Progress of Wood Paving. "The first use of wood for paving is said

to have been in Russia, where crude blocks were laid several centuries

ago. Wood was introduced into New York City in 1835-36, and into

London in 1839. Continental Europe was slower to take it up.

During the first 30 years of wood paving in England and America

the chief consideration seems to have been the form of block. The large

and unequal interstices between the round blocks then commonly used

permitted the edges to wear off rapidly into a corduroy condition which

was uncomfortable to the traveler, and which hindered both drainage and

cleaning, thus making the pavement unsanitary and hastening its decay.

To remedy this, other forms of block were devised, many of which were

patented.

In the United States perhaps the most conspicuous of these blocks was

the 'Nicholson/ patented in 1848 and laid extensively in the 10 years

following the civil war. The block was rectangular, which gave equal

interstices; but this by no means solved the problem, and results were

no better than before. Little thought was given to the kind of wood

used, and as soft a wood as white pine was frequently laid. The blocks

were neither seasoned nor treated with chemical preservatives, and

quickly decayed. Wide joints permitted water to get under the pave-

ment, where it was absorbed by the blocks, with the result that they

swelled, so that the pavement often heaved from its foundation. Fin-

ally, the foundation was usually of untreated planks, laid directly upon

earth, so that they soon decayed, while the pavement sank into ruts

and holes.

Round blocks, mostly of cedar, were extensively laid in the Middle

West. They made neither a durable pavement nor in any way a satis-

factory one. But they were cheap and served a good purpose in tiding

fast-growing cities over a critical period. There have also been laid in

various cities pavements of oak, cypress, white pine, hemlock, Washing-

ton red cedar, cottonwood, mesquite, Osage orange, edwood, Douglas

fir, and tamarack. In nearly all these cases the blocks were untreated,

or at most dipped or boiled for a short time in tar, asphalt, or other mix-

ture of supposed preservative value, and they failed to give satisfactory

results. Untreated American red gum was tried in England, and for a

time raised great hopes, but it finally proved unsatisfactory.

195

196 THE PRESERVATION OF STRUCTURAL TIMBER

Some species of eucalyptus, especially karri (Eucalyptus diversicolor)

and jarrah (E. marginata), which are very dense, hard, Australian woods,

have been laid extensively in England. In London these woods have

shown a life of from fifteen to twenty years, but continued use has not

entirely justified the hopes first entertained for them. Their structure is

too dense to permit impregnation with chemical antiseptics, without

which they absorb water and swell. They wear much more slippery

than most native woods, and they are not immune from decay, though

because of certain antiseptic gum-resins which they contain they are

more so than any untreated native woods. In England, however, they

are still used. Jarrah blocks were laid on Twentieth Street, New York

City, in 1895, but were removed in 1904. The cost of this pavement was

about $5 per square yard, which would exclude these woods from exten-

sive use in America even should they make a better pavement than our

best creosoted native woods, which is not likely." 1

The failure of the untreated woods turned attention to blocks

artificially preserved. One of the earliest records in our country

is in the city of Galveston, Texas, which laid some creosoted pine

blocks in 1873. These blocks gave satisfactory service for 30

years, when they were destroyed by a flood. Little progress was

made in advancing the use of wood blocks until within the past

10 years, when the demand for a high-class pavement, especially

in large cities, caused a big increase in the number laid. This

growth is shown by the following table:

TABLE 32. AMOUNT OF WOOD USED ANNUALLY IN THE UNITED STATES

FOR PAVING BLOCKS

Year

Amount of wood used,

cubic feet

Year

Amount of wood used,

cubic feet"

1907

1908

1909

1910

2,874,560

1,260,020

2,994,290

4,692,453

1911

1912

1913

1914

10,145,724

7,397,095

6,844,000

7,455,000

a = divide figures given by 2.625 to convert into square yards.

Mr. George W. Tillson, Chief Engineer, Bureau of Highways

of New York City, conducted an inquiry on the comparative

value of various forms of pavements in which the opinions of

several city engineers were asked in regard to the salient points

to be considered in judging a street pavement. Mr. Tillson

summarized these opinions in his book entitled "Street Paving

1 Extract Circular 141, United States Forest Service.

PROLONGING THE LIFE OF PAVING BLOCKS

197

and Paving Materials."

given in Table 33.

The results of this investigation are

TABLE 33. COMPARATIVE VALUE OF DIFFERENT PAVEMENTS

Pavement qualities

Per-

cent-

age

Gran-

ite

Sand-

stone

As-

phalt

(sheet)

As-

phalt

(block)

Brick

Mac-

adam

Creo-

soted

wood

Cheapness (first cost) . .

Durability

14

20

4.0

20

4.0

17 5

6.5

10

6.5

14

7.0

12 5

14.0

6

4.5

14

Ease of maintenance.. .

Ease of cleaning

10

14

9.5

10.0

10.0

11.0

7.5

14

8.0

14

8.5

12 5

4.5

6

9.5

14

Low traction resistance.

Freedom from slipperi-

ness (average of con-

ditions)

14

7

8.5

5.5

9.5

7

14.0

3 5

13.5

4 5

12.5

5 5

8.0

6 5

14.0

4

Favorableness to travel

Acceptability

Sanitary quality

4

4

13

2.5

2.0

9.0

3.5

2.5

8.5

4.0

3.5

13.0

3.5

3.5

12.0

3.0

2.5

10.5

3.0

2.5

4.5

3.5

4.0

12.5

Total number of points

100

71.0

73.5

76.0

79.5

74.5

55.0

80.0

Average cost per square

yard, laid, 1905

$3.26

$3.50

$2.36

$2.29

$2.06

$0.99

$3.10

Favorableness to travel is dependent chiefly upon smoothness and freedom from dust and

mud, secondarily upon the qualities composing "Acceptability."

Acceptability includes noise, reflection of light, radiation of heat, emission of unpleasant

odors, etc. It chiefly concerns the pedestrian and the adjoining resident.

Cost per square yard includes concrete, but not excavation, curbing, etc.; except for

macadam, which is not usually laid on concrete.

Other investigators have attempted similar comparative

studies, and while no two of them agree in all respects, a high

rating is given to wood-block pavement in regard to its noise-

lessness, durability, and sanitation.

On the other hand, the pavement has been severely criticized

on account of its high initial cost and troubles experienced with

slipperiness, expansion or buckling, and the exudation of oil, or

"bleeding." From investigations which have been conducted,

it is believed that much progress has been made in overcoming

some of these objections and that before long all of them, except

perhaps high initial cost, will be eliminated.

Selection of Species. At present most of the wood blocks used

(over three-fourths of the total number) are cut from the " south-

ern yellow pine." This is rather indefinite as regards the exact

species, as the term may include the longleaf, shortleaf, Cuban,

or even loblolly pines. What is wanted, undoubtedly, is the

longleaf pine, but according to present practice there is no

certain way of telling these various pines apart except by a most

careful microscopic examination, which in commerical work is,

198 THE PRESERVATION OF STRUCTURAL TIMBER

of course, impracticable. Specifying a certain number of rings

per inch is of assistance but is by no means certain. As the

strength of wood is directly proportional to its dry weight, it is

believed that a specification coupling rings per inch with dry

weight would give the engineer more definitely what he desires.

Branding lumber at its point of production would also be of

assistance to the inspector.

In addition to the " southern yellow pine," blocks made of

Douglas fir, red gum, tamarack, larch, and Norway pine are also

used, although in comparatively small amounts.

The intrinsic properties demanded of a good block wood are

resistance to wear, uniformity in structure and freedom from

defects, adaptability to treatment, and ability to hold its shape

after treatment. These requirements coupled with a reasonably

low cost limit very materially the number of woods which can be

used. In addition to the woods already mentioned, it is believed

the following are worthy of trial : Beech, birch, black gum, maple

sycamore, tupelo, hemlock, lodgepole and western yellow pines.

They will, of course, have to be handled somewhat different

from standard practice, but some of them possess desirable

qualities for street pavements.

Blocks which are cut from a very hard wood have a tendency

to wear smooth, so that unless the pavement is sanded periodically

they may prove too slippery for satisfactory use. If some of the

woods above suggested give good service in pavements, it should

tend in certain cases to lower the initial cost of wood-block

pavements.

The Manufacture of Paving Blocks. Paving blocks are usually

cut from planks of varying lengths, about 3 1/2 to 4 inches thick,

and 6 to 10 inches wide. These are fed into the paving-block

machine, which is fitted with a series of saws so spaced as to cut

the blocks to exact depth. In this manner many blocks are cut

at one time. The capacity of the machine varies but good

machines can turn out 200 square yards of 4-inch blocks per

hour. On leaving the block machine, the blocks fall onto a

conveyor, where they are inspected and all imperfect ones

removed. The rest are carried mechanically to the treating cylin-

der or cylinder cars and dumped automatically. It is very

important that the blocks be cut to an exact depth, for if this is

not done the surface of the pavement will be uneven and its wear

greatly augmented. The prevailing depth of blocks for street

PROLONGING THE LIFE OF PAVING BLOCKS 199

work varies from 3 to 4 inches, the smaller being used for light

and the larger for heavy traffic. In Europe the practice is

to use deeper blocks than in our country. This, of course, greatly

increases the cost of the pavement but is claimed to give longer

life and greater resilience. It is believed that the question of

proper depth of the block is not given the attention to which it is

entitled. As all woods vary in strength, it is only reasonable to

cut them to different depths depending upon their strength.

Blocks are laid with the grain vertical. This subjects them to

shear parallel to the grain, which is the weakest direction in which

a load can be applied. Failure from shear is therefore great, and

many blocks have been shattered in practice because of such

failure. It is believed, therefore, that if best service is to be

secured, blocks low in shear should be cut to greater depths than

blocks which are high.

The planks from which the blocks are cut are generally air

seasoned. It is believed unnecessary to do this, in fact some-

times inadvisable. If cut from green planks, the blocks will be

treated at their maximum size, so that danger from expansion

after they are placed in a street will be lessened. Most woods

treat easiest in the direction of the grain so that the problem of

securing a good penetration in blocks only a few inches in length

is not a difficult one.

Specifications for paving blocks vary considerably. The fol-

lowing is a fair sample of what is generally required : The blocks

shall be made of prime, sound timber, and no wood averaging

less than 6 rings to the inch, measured radially from the center of

the heart shall be used or wood that is poorly manufactured and

contains loose knots, worm holes, and other defects. The blocks

shall be from 5 to 10 inches long, 3 to 4 inches in depth parallel to

the grain depending upon traffic, and 3 to 4 inches in width, pro-

vided all blocks furnished for one street are of uniform width and

depth. A variation of 1/16 inch in depth and 1/8 inch in width

will be allowed.

Methods of Treatment. Nearly all of the paving blocks

treated in the United States are impregnated with coal-tar

creosote, either alone or in mixture with tar, by the full-cell

method. 1 In a few cases, the blocks are simply dipped in oil

(creosote or carbolineum) and lately the zinc-creosote process

has been advocated for blocks used in factories and shops. A

common method consists in placing the air-seasoned blocks in a

1 Up to 1915, 250,000 square yards of blocks treated with water-gas tar

creosote were reported to the author.

200 THE PRESERVATION OF STRUCTURAL TIMBER

treating cylinder (and sometimes drawing a vacuum), after which

the oil is admitted and forced into them under a pressure of about

150 pounds per square inch until the desired amount is absorbed.

The cylinder is then drained of excess oil and a vacuum drawn for

about 1/2 hour to dry the blocks, after which they are removed

and are ready for use. This practice is modified by certain opera-

tors, who steam the blocks after they are run into the cylinder

and then pull a vacuum after the steaming period. A few opera-

tors also steam the blocks after they have been impregnated with

the oil.

The amount and kind of oil injected varies considerably. Nearly

all specifications call for a heavy grade, viz., one with a specific

gravity of at least 1.08 at 25 C. and in some cases as high as 1.12.

Many engineers allow the oil to be mixed with certain amounts of

"filtered tar" in order to bring up its gravity. Some also allow

water-gas-tar creosote to be mixed with the coal-tar creosote. The

amount of oil required is generally 16 pounds per cubic foot, al-

though this varies from 12 to 20. It can thus be seen that the

practice in treating blocks is by no means a uniform one, but dif-

fers with the opinions of the various engineers.

The Chicago Creosoting Company has recently constructed a

block plant wherein the cylinders are placed vertically. (See

Plate XI, Fig. D.) The blocks are dumped into the top of the

cylinders by a mechanical conveyor. After the desired absorp-

tion has been obtained, the excess oil is drained from the cylin-

ders, and a door in the bottom of the cylinder is opened allowing

the blocks to fall directly into cars ready for shipment. This

method does away with cylinder cars entirely and is claimed to

cut down the cost of handling.

Troubles Experienced with Wood-block Paving. It has al-

ready been stated that wood-block paving at times has serious

objections. Unfortunately, the exact cause of these difficulties

is not known at present, so that definite remedies for all conditions

cannot be prescribed. Opinions and practice differ widely. The

chief objections are slipperiness, exudation of oil, and expansion of

the blocks.

Slipperiness. In general, the harder the blocks the smoother

the pavement becomes. Blocks of softer wood give, therefore,

less trouble from slipperiness, but there is a limit to which the

softness can go, as blocks which are too soft will of course wear

rapidly.

PROLONGING THE LIFE OF PAVING BLOCKS 201

Oil and tar on the surface of the pavement also increases

slipperiness. It is believed that this cause can be largely over-

come as will be discussed below.

If our streets were sanded from time to time, as is done abroad,

the surface of the blocks would become roughened because the

sand would embed itself in the wood. This should be done

particularly in cold weather, when ice forms on the pavement.

Asphalt is also subject to the same objection in cold weather and a

similar treatment should be given it.

Exudation of Oil. This is about the most troublesome objection

raised against wood blocks. The oil and tar may at times exude

to the surface and form a thick, disagreeable mat, which sticks

to the feet of pedestrians and is generally objectionable. In

certain cities like Chicago, the trouble became so acute as to

arouse bodies of citizens into a protest against what was termed

the "black plague." Other cities like Minneapolis have for-

tunately been free from these troubles. It is probable that the

exudation of oil, commonly called " bleeding" or "weeping,"

is due to several causes, such as too heavy an impregnation, too

much pitch or tar poured into the joints, too rapid-grown blocks,

improper treatment, and too close laying of the blocks. From

observations and tests made by the author it is believed that

bleeding can be eliminated if (1) only slow-grown wood is used

for the blocks; (2) if green timber or steamed seasoned timber

is used; (3) if a strong preliminary and final vacuum is drawn

before and after the oil is injected; (4) if when tar is used the

blocks are steamed slightly after the oil is injected; (5) if the

penetrations are made complete; (6) if impregnations no greater

than 16 pounds per cubic foot are given; (7) if straight coal-tar

creosote or coal-tar creosote containing only small amounts of

carbon-free tar is injected; (8) if the blocks are not laid too close

together; (9) if excess tar or pitch is not poured between the

joints. All of these requirements can be easily met without added

cost.

Expansion of the Blocks. This is commonly called "mush-

rooming," "buckling," or "pop ups." (See Plate XXI, Fig. A.)

The true cause of it is not known except, of course, that the

blocks are under heavy pressure. If the blocks are laid very

dry and close together there will be little room for expansion and

the pavement will be very liable to buckle. It is believed that

if the blocks are well penetrated so that their tendency to absorb

202 THE PRESERVATION OF STRUCTURAL TIMBER

moisture will be decreased, are treated green or steam seasoned,

are laid fairly loose and have proper expansion joints, little or

no trouble from buckling will be experienced.

It is wasted effort to try and make the blocks nonexpansive,

for no matter how much oil is forced into them they will absorb

more or less water in time. Furthermore, the oil and wood will

expand due to rise in temperature. Best practice, therefore, is to

keep the absorption of water to a minimum by proper treatment

and to allow for expansion by carefully laying the pavement as

described above.

Method of Laying Wood Blocks. In street work, a concrete

base about 4 to 8 inches thick is first constructed, this having the

desired crown. Over this is then placed a layer of coarse sand

about 1 inch thick. The blocks are then laid on this smoothed

sand cushion, after thich they are tamped and rolled into final

position. Asphalt, grout, or hot pitch is then poured into the

joints and further worked into them with a squeegee. The

surface is then covered with sand and the pavement is ready for

use. In a few days the excess sand is removed from the pavement.

Experiments have been tried in doing away with the sand

cushion by pouring hot pitch directly over the concrete base and

embedding the blocks in it. These pavements have not been in

service sufficiently long to judge of the results.

The angle at which the blocks are laid has also been tested.

It is found that blocks laid at an angle of 671/2 with the curb

show least wear, those at 45 next, and those at 90 most.

The character of filler to be used is still an open problem.

Coal-tar pitch and asphalt seem to be preferred. The former is

objectionable in that, if not properly applied, it will ooze to the

surface. Asphalt is free from this objection but is more difficult

to work into the joints.

Expansion joints are, at times, laid not only along the curb

(about 1 inch in width on a 50-foot roadway) but crosswise.

In some cities strips of wood about 1/4 inch thick are

placed between the blocks, thus leaving joints for a better footing

of horses. This practice, however, is not common.

When wood blocks are used on certain types of bridges, they

are laid directly upon creosoted plank. This adds considerably

to the lightness of the bridge and is considered a distinct

advantage over other forms of pavement.

Cost of Treatment. The cost of treating wood paving blocks

PLATK XXI

FIG. A. A "popup," or failure in :i street laid with creosoted blocks due

to their expansion.

FIG. B. Wood block pavements grading the sand cushion and laying the

blocks, Minneapolis, Minn. (Forest Service photo.)

(Facing page 202.)

PLATE XXI

FIG. C. Working the tar filler into the joints of a newly laid wood block

pavement. (Forest Service photo.)

FIG. D. Pine beams in a building completely rotted in the end after 30

years' service, Madison, Wis.

PROLONGING THE LIFE OF PAVING BLOCKS 203

varies with the kind of oil specified, the amount to be injected, the

kind and size of the block, and other peculiarities in the specifica-

tions. If ordinary creosote is used it can be obtained for about

8 cents per gallon. Generally, however, a higher grade is re-

quired, which in some cases costs 12 to 15 cents or more per

gallon. Assuming the cost of the oil to be 1 cent per pound

and 16 pounds to be injected per cubic foot, the cost of treating a

square yard of 3 1/2-inch blocks will be about 45 to 50 cents, and

of 4-inch blocks about 52 to 57 cents. This, of course, is but a

fraction of the total cost of the pavement, which, in general,

varies from about $2.20 to $3.70 per square yard, making it one

of the most expensive pavements in use.

Advantages of Wood-block Paving. Wood-block pavements

possess some very desirable properties, the chief ones being

sanitation, durability, ease of repair, low traffic resistance, ease of

cleaning, and absence of noise. Friends of the pavement will

find many other points to extoll, but the above list may be

considered conservative.

Coal-tar creosote is a strong antiseptic, and as large quantities

of it are forced into the blocks, its presence alone tends to keep

the street in a healthy, sanitary condition.

The durability of wood blocks when properly laid is surprising.

Data collected on a test pavement in Minneapolis, where ac-

curate traffic records are kept over one of the busiest streets in

the city, show a wear of about 1/32 inch per year. The expe-

riences of several cities have shown the marked value of wood

blocks in comparison with the durability of other kinds of

pavement. There is no doubt but what the good results already

obtained could be considerably bettered if American munici-

palities only took better care of their pavements. In this respect

Europe is far ahead of us.

The ease with which wood-block pavements can be repaired

is all the more reason why better care should be taken of them.

If a depression once starts it will grow rapidly until a considerable

hollow is formed. The time to repair such failures is in their

beginning when all that is necessary is to remove a few blocks,

smooth the sand cushion, and add new ones.

The depressions caused by vehicles and horses in asphalt on

hot days is well known. This, of course, means the load is

harder to pull. Wood blocks do not have this objection and

because of their smooth surface make traffic run smooth.

204 THE PRESERVATOIN OF STRUCTURAL TIMBER

The even surface of wood-block pavements enables them to

be easily cleaned and, of course, adds to their santitation.

It is perhaps the noiselessness of wood blocks which makes

them so desirable, especially in congested business districts,

and has earned for them the title of the " silent pavement."

This quality has placed wood-block pavements in high regard

and is largely responsible for their rapid growth in our large

cities.

In all of the above, it has been assumed that the pavements

were properly laid, for if this is not done poor results are bound to

follow. There is no unusual difficulty in properly laying a wood-

block pavement.

Wood Blocks for Barns, Factories, Etc. 1 Considerable progress

has been made within the past few years in introducing wood-

block flooring in factories, car barns, ferry slips, etc., where it

has given good service. It is liked by the workmen in preference

to cement floors because of its " touch. " It is durable, easily

repaired, sanitary, and dustless. For use under such conditions

the blocks are often cut smaller and treated with less oil than

blocks intended for streets. In fact, the Rueping and Card

processes are sometimes employed, thus decreasing perceptibly

the cost of treating the blocks. The blocks are laid in much the

same manner as for street work except that the angle of the

courses is almost invariably 90.

1 For a more detailed discussion see "Treated Wood Blocks for Factory

Flooring and Miscellaneous Uses," appendix.

CHAPTER XIV

PROLONGING THE LIFE OF SHINGLES

Shingles are subject to two common forms of destruction, (1)

decay and (2) fire. If made from durable woods, the problem

of protection from decay is not serious, as shingle roofs may

easily last 25 years or more. Protection from fire is of greater

importance, especially where the houses are close together. In

congested districts the use of shingles is now almost entirely

obsolete. However, shingle roofs possess certain desirable

properties so that their use in dwellings will undoubtedly continue

to be extensive.

Selection of Species. In round numbers about 15 billion

shingles are used annually in the United States, about 75 per-

cent of which are of cedar mostly the western red cedar of

Washington. Next in rank come cypress and yellow pine, each

furnishing about 9 percent. Then redwood with 3 percent, white

pine 2 percent, and spruce 1 percent. The other species such as

chestnut, hemlock, western pine, and oak all furnish less than

1 percent. With the exception of oak and chestnut, the total

cut of which is insignificant, it will be noticed that all of the

shingles are made from coniferous woods.

The ideal shingle is one which is light in weight, durable, and

will "lay flat" without checking, warping, or splitting. Western

red cedar admirably meets these requirements. Excellent service

is also secured from cypress and redwood shingles, both of which

possess remarkable durability.

The best grades of shingles are cut only from clear timber free

from all defects. Sap wood is also excluded, since it is not very

decay resistant. If, however, the shingles are given a thorough

preservative treatment, sapwood should not be considered a

defect, and in some cases treated sapwood shingles can be obtained

at no greater cost than untreated shingles of all heartwood.

METHODS OF TREATING SHINGLES

Treating against Decay. The most common method of pro-

tecting shingles from decay is to dip them in a preservative and

205

206 THE PRESERVATION OF STRUCTURAL TIMBER

after they have dried nail them on the roof. There are several

preservatives sold on the market for this purpose under the name

of "shingle stain," which not only preserve the shingle but color it.

For best results, the shingles should be thoroughly air dry when

they are dipped and the preservative should be warm or even

hot. As a general rule, only that portion of the shingle which is

exposed is dipped, the upper or thinner portion being in this

manner covered by the treated portion of the shingle next above

it on the roof. Roofs laid in this manner are frequently given a

final coating of preservative after they are laid, in order to insure

a uniform color and the treatment of all exposed portions.

Cheaper and less efficient results are obtained if the shingles

are simply brush-treated with the preservative after they are laid.

It is doubtful if ordinary paint preserves the life of shingles; in

fact, it may hasten their decay. Paint is of value, however, in

certain cases, in that it tends to make the shingles lie flat and

hence prevent leaks.

Most efficient results in treating shingles against decay con-

sists in impregnating them with the preservative. This is

done either in open tanks or pressure plants. The absorption

of the preservative should not be so great as to unnecessarily

increase the cost of the shingles or cause them to ooze and

drip oil on hot days. An absorption of 10 pounds per bundle

is ample. In either of these processes the shingles can be

treated in the bundle, provided they are not strapped too tight

together. If the open-tank process is used the shingles should

be removed while hot; if the pressure process is used, a final

vacuum should be drawn. These manipulations are advisable in

order to dry the shingles. If treated in this manner sap shingles

can be made as resistant to decay as heart shingles, and inferior

shingle woods like hemlock and yellow pine made exceedingly

durable.

Shingles treated with creosote or the so-called shingle-stains

have a very strong odor which to many people is objectionable.

This odor, however, decreases with age and in time ceases en-

tirely. Furthermore, the rain-water off a freshly treated roof is

very liable to smell and taste of the preservative at least until the

roof has been exposed for several weeks.

Treating against Fire. Practically nothing has been done to

date in treating shingles against fire. 1 The recent agitation against

shingle roofs in certain cities, has, however, caused considerable

1 See appendix for latest information on this subject.

PROLONGING THE LIFE OF SHINGLES 207

interest in this matter and several concerns are now at work

attempting to render shingles noncombustible. Ordinary fire-

proofing compounds like ammonium chloride, ammonium phos-

phate, etc., are objectionable in that they are soluble in water and

consequently will soon be washed from the wood. It is possible,

however, that their use might be rendered practicable by paint-

ing the shingles treated in this manner with a waterproof paint

after they have been laid. A large variety of experiments are

now under way, some of which indicate hope of a satisfactory

solution of the problem, but at this writing no method that

can be called successful is known. Greatest danger from fire

is caused by the shingles curling and igniting from sparks or

brands. If the shingles are made to lie flat their liability to

catch on fire from such sources is greatly decreased. Some of the

so-called ''fireproof" paints now on the market are of value in

this respect and tests known to the author have indicated that

even ordinary paint will be found of material assistance.

Cost of Treating Shingles. If shingles are impregnated with

creosote, the cost will be about $1.25 to $1.75 per thousand. If

they are simply dipped into the creosote the cost will be about

$0.60 to $1.50 per thousand; if brush-treated with two coats after

the roof is laid, about $0.40 to $0.90 per 100 square feet. Shingle

stains which cost from about $0.40 to $1 per gallon make, of

course, a more expensive treatment, the cost of dipping per thous-

and being about $1.50 to $3. 50, and for simply brush-treating after

the roof is laid about $0.60 to $1.50 per 100 square feet.

CHAPTER XV

PROLONGING THE LIFE OF LUMBER AND LOGS

Methods of Treating Lumber for Rough Construction. An

immense quantity of structural timber is used annually in the

United States under conditions which subject it to decay. Un-

fortunately, only a small percentage is treated, so that our

depreciation losses are both rapid and large. Of course, wherever

the timber can be protected from the weather, or warm damp at-

mosphere, no artificial treatment is necessary, as it will under such

conditions last indefinitely. However, in bridges, trestles, piers,

walks, platforms, docks, etc., etc., where such timbers are used,

failure from decay is all too common. (See Plate XXI, Fig. D.)

This is particularly true if the wood comes in contact with the

soil. While it is not possible to lay down a set of instructions

which will cover all cases, certain general rules should, however,

prove of direct value to those using this class of material.

Whenever possible, all such timbers should be kept from

contact with the ground. In many cases, they can be placed

on concrete or stone piers, and by this simple treatment, their

life considerably prolonged.

The most effective treatment which can be given such timbers

is to impregnate them with coal-tar creosote. For severe cases,

the full-cell process should be used; for less severe, the empty-

cell, Card or straight zinc. From 5 to 12 pounds of oil should be

injected, depending upon local conditions. As sap wood is just

as strong as heartwood, the treatment of this kind often enables

the use of sappy timbers, which, untreated, would not be used.

Hence, specifications for the raw material can be made more

lenient and the timber can frequently be secured at a lower initial

price. All structural timbers injected with preservatives should be

framed as close to final dimensions before treatment as possible.

Next to impregnation treatments, brush treatments with a

high-grade coal-tar creosote are recommended. If these are

208

PROLONGING THE LIFE OF LUMBER AND LOGS 209

used, the wood should first be thoroughly air seasoned and dry

at the time the preservative is applied, otherwise little or no

beneficial results will be secured. Two coats are better than one,

and in all cases the oil should preferably be brushed on hot (about

150 to 175 F.)> care being taken to soak especially all joints,

bolt holes, and laps.

In timbers which decay only at the joints, the joints only need

be coated with hot creosote, the rest of the member being left

untreated. All joints made in timber which has been impreg-

nated should always be brush-coated with hot creosote if these

are framed after treatment.

Timbers treated with creosote cannot as a rule be painted, a

the paint will not adhere to them. They will, however, be turnes

a deep brown which, on prolonged exposure, will become lightd

in color. For rough construction, the oil will take the place

of paint, and in this connection also effect a saving.

Methods of Treating Lumber for Buildings, Greenhouses, and

Cars. In general lumber used in buildings, cars, etc., cannot be

creosoted because it is desirable to paint it, and as mentioned,

paint does not readily adhere to creosoted wood. In certain

cases, however, this is not necessary. For example, sills in build-

ings, beams in porches, etc., where the wood is covered, can be

profitably treated. Thus the sills and beams used in constructing

the so-called "Sanitary floors" in the South, particularly New

Orleans, are impregnated with 10 to 12 pounds of creosote per

cubic foot, and very good results obtained. Even in silos, if it is

not desired to paint them, creosoted lumber can be used to ad-

vantage provided it is permitted to air season before the silos are

filled.

When the wood is to be painted, a treatment with one of the

antiseptic salts is recommended. Zinc chloride, mercuric chloride

copper sulphate, or sodium fluoride will all give good results. As

mercuric chloride and copper sulphate cannot be used in steel

cylinders, it is necessary to soak the lumber in stone, concrete,

or wooden vats containing these preservatives. This is done as

described under the Kyanizing process. These salts have a

further disadvantage in that they will attack the steel in

carpenters' tools. Zinc chloride and sodium fluoride can be

handled as described in the Burnett process. The lumber should

then be air seasoned before it is placed in the building, after

which it can be handled like untreated lumber. Paint of all colors

14

210 THE PRESERVATION OF STRUCTURAL TIMBER

will in general adhere readily to wood treated with the salts just

mentioned, and will aid materially in holding them in the wood.

Treatments of this kind are recommended particularly for such

places as floors and columns in porches, trim around the eaves,

bench boards and sills in greenhouses, roofs in dye houses, and in

fact, all places where the wood is subject to decay, and where it is

necessary to pain it with light colored pigments. Much has been

written of "dry rot" in buildings. This can be greatly re-

tarded or prevented by the treatments described, since it is caused

by a fungus. In all cases, the lumber should be framed to as

near the exact dimension it is to have as can be done because

any subsequent cutting will expose the untreated interior and

hence shorten the life of the wood. It is believed that there is a

good field for many lumber companies to operate treating plants

for preserving wood used in building construction. By so doing,

woods which are not naturally durable could be made to compete

with the more expensive and naturally durable woods like cypress,

cedar and redwood, and would in certain cases be preferable in

that some of them possess greater strength. Treatments with

the above salts will also resist insect attack.

The life of untreated wood can be prolonged in many cases by

keeping a circulation of dry air about it. Stagnant air in

cellars or store rooms is particularly liable to start decay, and it

frequently happens that by simply improving the ventilation,

further decay can be arrested. Of course, when untreated

wood is used, sap wood is a detriment and "all heart" pieces are

always to be preferred. In certain types of flooring, creosoted

planks can first be laid and then faced with thinner planks of

untreated wood. If timber is set subject to decay, ordinary

paint will seldom arrest the decay unless all surfaces of the wood

are treated. In fact, the paint may actually hasten decay in some

instances, as for example, when only one or two surfaces are

painted and the others are left unpainted. The unpainted

surfaces will absorb moisture, while the painted surfaces will

retard it from evaporating, and thus the wood will actually have

more moisture in it and in such a condition be more susceptible

to decay. This is a common occurrence in the floors of outdoor

porches, the upper side of which is usually the only surface

painted.

It has been reported that dry rot in factories can be checked

by raising the temperature in the rooms to 120 F. or more for a

PROLONGING THE LIFE OF LUMBER AND LOGS 211

few hours. The author is unable to verify these reports but

believes the treatment well worthy of trial by those troubled

with this form of decay.

Methods of Preserving Logs from Decay. It is very difficult

to store logs with bark on them for any length of time without

their being attacked by decay. This is particularly true of logs

having much sapwood, like the gums, sycamore, maples, birch,

etc. Decay can be retarded if the ends of these logs are given one

or two coats of creosote as soon as possible after they are cut.

The same should be done wherever the bark has been broken off.

If it is simply desired to retard checking, the ends of the logs

should be coated with paint. In this way the logs can be pro-

tected at a cost of only a few cents per thousand feet of lumber.

To protect logs from insect attack, it is necessary to peel them or

soak them in water. In special cases, the methods described

below might be used.

Methods of Treating Log Cabins and Rustic Furniture. No

satisfactory method of keeping bark on wood for any appreciable

length of time is known, particularly if the bark is soaked by

rain from time to time. Fungus and insects are both very apt

to work in under the bark and cause it to fall off. 1

Damage of this kind can be largely prevented by cutting the

logs in late autumn and piling them so that they will dry as

rapidly as possible or by utilizing them immediately. Even

better, but more expensive and troublesome results can be ob-

tained by cutting the logs in the spring and stripping them in

laps of bark, which at this season peels readily. The bark can

then be soaked in a 1 percent solution of mercuric chloride

and the logs used directly. After the logs have air-dried, they

can be brush treated with one or two coats of coal-tar creosote or

carbolineum. When this has dried for several days, the bark can

then be nailed to the logs. Treatments of this kind are the

most effective known. Care should be taken in handling the

mercuric chloride solution as this is extremely poisonous, and

also in thoroughly air-seasoning the treated logs so that the

odor of oil will not prove objectionable.

Rustic furniture should be kept under cover and dry. Little

or no trouble will then be experienced with decay. Insects,

however, may attack it, as is evidenced by little mounds of saw-

dust and miniature pin holes in the bark. Sponging such

furniture thoroughly with kerosene or benzene will usually

1 The Boucherie process might have merit for preserving logs used in

cabins (see description of Boucherie process).

212 THE PRESERVATION OF STRUCTURAL TIMBER

kill the insects and stop their depredations. Or if the

holes are caused by larger wood-boring insects, carbon bisul-

phide can be injected into the holes, which should then be im-

mediately stuffed with putty, or a similar substance. The

offensive odor of the bisulphide will leave the wood in a few days.

CHAPTER XVI

THE PROTECTION OF TIMBER FROM FIRE

The use of wood as a construction material, especially in con-

gested centers as in cities, has a serious objection due to the

comparative ease with which it can be ignited and with which

it burns. The objection to its use because of this property is

rapidly growing and will undoubtedly continue to do so. The

fire losses in the United States are enormous, reaching the vast

sum of $215,000,000 per year. Of course, all of this is not due

to the use of structural wood, as the contents of even "fireproof"

buildings are inflammable and are frequently destroyed. A few

cities have already passed ordinances prohibiting the use of

natural wood in buildings over a certain number of stories in

height, and other cities have specified against the use of wooden

shingles within their more congested limits. Such action has

attracted keen attention of late to the possibility of rendering

wood noncombustible. This problem is quite different from the

problem of protecting wood from decay and has to do almost

entirely with the control of the gases driven off from wood when

heat is applied to it. If these gases can be diluted with a non-

combustible gas in proper proportions, the wood will charr and

not burn. On the other hand, if these gases can be kept from

mixing with requisite amounts of oxygen, a similar result can

be secured. In either event, the original properties of the wood

will be destroyed, so that, strictly speaking, it is practically

impossible, if not impossible, to render wood "fireproof." The

best that can be expected is to either make the wood noncom-

bustible or slow burning. The temperature at which natural

wood will ignite under ordinary conditions is about 500 F. The

temperature of a burning building is estimated at about 1700

F. The ease with which natural wood ignites, therefore, when

subjected to such high temperatures, is readily seen. As great

progress in protecting wood from fire has not been made thus far

as in protecting it from decay, and but two companies are now

in operation in this country. Progress has been considerably

213

214 THE PRESERVATION OF STRUCTURAL TIMBER

retarded by fraudulent practices on the part of defunct companies

claiming to " fireproof " wood, and by contractors who claimed

to use such wood in their construction. Furthermore, a gross

misunderstanding exists concerning the possibilities of render-

ing wood noncombustible, which has often led to the drafting of

impracticable specifications. Much work remains to be done in

perfecting present methods and in enlightening the public to

what can reasonably be expected.

The chief objections raised against the use of a fireproof ed "

wood aside from increased cost are the leachability of the

chemicals, their corrosive action on metals, their effect on the

strength of the wood, and their action on paints and varnishes.

Wood impregnated with the best known fire retardent chemicals

cannot be set in wet or damp situations or exposed to the

weather, as the chemicals will be leached from the wood. Nails,

hinges, etc., in contact with such fireproofed wood will, when it

becomes damp, be corroded. Wood treated with these chemicals

is rendered more brittle than wood not treated, although the loss

in strength can be greatly decreased by proper methods of treat-

ing and drying. For many purposes, as in trim in buildings, the

question of decreased strength should have little or no serious

consideration, as this property is not important. Due to their

hygroscopic nature, the salts are quite liable to keep the wood

moist and hence interfere with the adhesion of paint or varnish.

When not exposed to the weather or unusual dampness, " fire-

proofed wood," as it is now known, has given very satisfactory

service. It retains its resistance to fire for long periods, and, so

far as its other properties are concerned, behaves in much the

same manner as untreated wood.

The Theory of Rendering Wood Fire Retardent. Those results

which have been most successful thus far have been founded

on one or more of the following theories:

1. To cover the wood with a chemical which, like sodium

silicate, when heated will fuse over the surface and prevent a free

access of oxygen to the wood.

2. To cover the wood with a noncombustible material which,

like asbestos or metal, will prevent a free access of oxygen to the

wood and thus produce a slow distillation.

3. To impregnate the wood with a chemical which, like borax,

when heated will liberate water vapor or steam, thus diluting the

combustible gases so that their ignition cannot occur.

THE PROTECTION OF TIMBER FROM FIRE 215

4. To impregnate the wood with a chemical which, like salts

of ammonia, when heated will liberate a noncombustible gas,

thus diluting or combining with the combustible gases so that

combustion is impossible.

Owing to their manner of application, these various theories

can be classified into two groups of treatment which may be

called superficial and impregnation processes.

Superficial Processes. These consist in protecting the surface

of the wood from contact with flames. If the protective coating

is a liquid like sodium silicate, it is simply painted onto the

wood or the wood is dipped into it. Such treatments, while

effective in retarding the ease with which the wood will catch on

fire, are not conducive to best results. Other superficial proc-

esses consist in covering the exposed surface of the wood with a

noncombustible material such as asbestos or metal. Unless the

covering entirely surrounds the wood, the temperature of the

protected face may become so high as to cause the wood to

ignite. When, however, the covering entirely surrounds the

wood the protection is very efficient as burning is almost entirely

excluded and only charring is produced. As might be surmised

from its manner of application, this method of treatment has

only a limited use and is quite costly.

Impregnation Processes. These are conducted at the present

time in much the same manner as the Bethell or Burnett processes

(see description) of protecting timber from decay. They

differ from them in two respects: (1) different chemicals are

used, and (2) the wood is generally kiln-dried after the chemicals

have been forced into it, in order to remove the large amount of

water injected into it. As a general rule, only thoroughly air-

seasoned wood is treated, this usually in the form of rough sawn

lumber. The kiln drying of " fireproof ed" timber requires a

nice adjustment in that the temperatures used must not be so

high as to volatilize the chemicals injected or cause them to " pull "

toward the surface. Checking and warping must also be guarded

against. Any efficient kiln-drying process can, however, be

employed provided it is properly applied.

Chemicals Used. A large variety of chemicals have been

tested by various experimenters in the attempt to render wood

non-combustible. The more important of these chemicals thus

tried, either alone or in combination, are: Ammonium sulphate,

phosphate and chloride, zinc sulphate and chloride, borax,

216 THE PRESERVATION OF STRUCTURAL TIMBER

cresylates of mercury, lead, copper, iron, and zinc, sulphate of

iron, alum, calcium bisulphite and lime, sodium silicate, oxalic

acid, potassium and sodium carbonate. Best results have been

secured with the salts of ammonia, borax, and sodium silicate.

"Fireproofing" tests have been made at the U. S. Forest

Products laboratory on noble fir, using the following fire-retarding

agents. 1

Strength of solution

Amount dry salt injected

per cubic foot of wood

6 percent solution ammonium phosphate

1 . 7 pounds

10 percent solution ammonium sulphate

3 pounds

3 percent ammonium phosphate 1 . ,

y mixture

0.9 pound

5 percent ammonium sulphate

10 percent solution borax

1 . 5 pounds

2 5 pounds

10 percent solution ammonium chloride

2 . 9 pounds

CHEMICAL FIRE RETARDENTS 2

Sodium Carbonate. Sodium carbonate did not prove efficient

in retarding combustion (Fig. 24). It also caused a marked

weakening of the wood.

Sodium Bicarbonate. Sodium bicarbonate did not prove

efficient in retarding combustion (Fig. 24), and also caused a

marked weakening of the wood.

Oxalic Acid. Oxalic acid did not prove efficient in retarding

combustion (Fig. 24), and also caused a marked weakening of

the wood.

Borax. Borax was of considerable value in retarding com-

bustion (Fig. 24). The dotted curve (G), Fig. 24, shows the

comparison with natural wood and the other fireproofing agents

used. The points determining the position of this curve were

obtained after the piece had become charred and incandescent.

A small amount of an inflammable gas, probably carbon mon-

oxide was generated, which burned with a small blue flame on

the top of the test specimen, but only with the aid of the pilot

light.

Ammonium Chloride. Ammonium chloride proved of con-

siderable value in retarding combustion (Fig. 24). The points

determining the position of the dotted curve (F), Fig. 24, repre-

sent the same condition as was described under borax. How-

1 From Proceedings American Wood Preservers' Association, 1914, by

Robert E. Prince.

2 Subsequent tests showed ammonium phosphate and ammonium sul-

phate were the most effective chemicals in retarding the combustion of wood.

These were used in amounts shown above.

THE PROTECTION OF TIMBER FROM FIRE

217

ever, ammonium chloride is somewhat hygroscopic and its use

may be restricted for this reason.

Commercial Treatment. A number of tests were made on

pieces of red oak, treated by a commercial fireproofing company

with a solution containing ammonium phosphate and ammonium

sulphate. The strength of the solution was not known. Am-

monium phosphate and sulphate proved of considerable value in

retarding combustion.

Tests to Determine the Inflammability of Timber. Several

methods of testing the inflammability of wood have been sug-

401 1 1 I 1 1 I 1 II 1 1 1 1 1 1 1 1 1 1 ' | | | || | | | |

35-- ::!::

Noble Fir

B .

"" ~ B " -Oven Dry 1ST

;:\;;

" ~ C Treated -Oxalic Acid 211!

30 ::.:::

J~ D " Sodium Carbonate ICO

" " j

--G -Borux -ji-j

of Temperature at which Specimens

\*S L A

. . \_ were hold for 40 Minutea without

20 \f --5c \ m

[ - - 1 ; Dashed Line ehow when

15 V.-.^S

o, . - - - S \* 5 ~ ~

\* 5;

H \ j2\_

i;;^i>;-: :::::E;:::

S, 10 - -\*;-V

ntS ' ~ e-

g - : ';<

- - - s ;^x\*" : ; ^ ' '

> --"

fc 5 ij !\_5 ; \_ .

< ^MM\\Mmmm

->>- U NV : - > -

t ^^ ?4it ^^ 5=^ it

I

- i ^\_o

100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475

Temperature-Degrees Centigrade

FIG. 24. Time required to ignite natural wood and wood impregnated with

fire retardent chemicals when subjected to various temperatures.

gested. The more common of these are the shaving test, crib

test, spot test, and electric furnace.

Shaving Test. Shavings planed from the treated wood are

placed in a wire basket over a Bunsen burner. Notes are taken

on the length of time required to ignite the shavings, the character

of the burning, the length of glow, and the loss in weight due to

the burning or smoldering. This method of test is faulty in that

the wood is so finely divided that the volatile gases are readily

driven from it and conditions comparable to practice are not

duplicated. Furthermore, it is difficult to get concordant results

due to varying air currents and temperatures.

Crib Test. So called because small splints of wood about

218 THE PRESERVATION OF STRUCTURAL TIMBER

1/2 X 1/2 X 4 inches are cut from the treated wood and piled

in a crib over a Bunsen burner, the flame being permitted to

pass through them. While better than the shaving test, the

method is also open to similar criticism.

Spot Test. A flame (usually of illuminating gas) 1 is played over

the surface of a treated piece of wood. The depth to which it

charrs or burns and the character of burning or glow are noted.

The temperature of the flame may be read from a pyrometer, the

thermocouple of which is placed against the wood at point of

test. This method is much more comparable to practice and

gives good indicative results, which, however, are faulty in that

they are difficult of duplication.

Electric Furnace. This method of test gives concordant results

when small pieces of wood are treated, and enables an accurate

comparison between various treatments. It is objectionable,

however, in that the heat is applied to all sides of the test speci-

men and usually requires that the treated plank be cut into small

sizes. For laboratory work, however, this method of testing has

been found very satisfactory. The apparatus consists of a silica

tube, wrapped with nichrome ribbon. An iron tube fitted with

a mica sight is cemented below the silica tube.

The specimen of wood, after being lowered into the silica tube,

is heated at a uniform rate, by passing 24 amperes of electric

current through the nichrome ribbon. Temperature readings are

obtained from a thermocouple placed beside the specimen and

reading direct from a Hoskins pyrometer. A pilot light is used

to ignite the gases distilled from the wood. Compressed air par-

tially dehydrated by expansion is passed through the apparatus,

its intensity being indicated by a sensitive liquid manometer.

The temperature of ignition, character of combustion or glow,

and loss in weight due to the burning for a 3-minute period is

noted. After ignition the specimen is lowered into the iron tube,

where it can burn of its own heat.

Cost of Rendering Wood Noncombustible. The cost of ren-

dering wood noncombustible is in general higher than to protect it

from decay. As has been mentioned, most effective results in

fireproofing wood have been secured by injecting chemicals into

it. These are more corrosive than the common preservatives and

hence increase plant depreciation. Then, the preservatives them-

1 A plate heated electrically in place of the flame is easier of control and

gives more concordant results.

THE PROTECTION OF TIMBER FROM FIRE 219

selves are comparatively expensive. Finally, the wood, after it

has been treated, must generally be kiln-dried to avoid loss in

time and checking in seasoning. Taking the above factors into

consideration, the cost of rendering wood fire retardent is ap-

proximately as follows, when chemicals like ammonium phosphate,

costing about 8.5 cents, and ammonium sulphate, costing about

3 cents per pound, are used.

ESTIMATED COST OF RENDERING WOOD NONCOMBUSTIBLE PER M.B.M.

Cost of handling $3 . 00- $4 . 00

Plant depreciation and maintenance 1 . 00- 3 . 00

Chemicals 8.00- 12.00

Kiln-drying 2 . 00- 5 . 00

Total $14.0(}-$24.00

The lower figure of $14.00 per thousand assumes the plant in

continuous operation and the consumption of chemicals about

200 pounds per M.B.M. The upper figure of $24.00 covers opera-

tions which are not continuous and allows for a heavier injection

of the salts into the wood.

The Effect of Zinc Chloride and Creosote on the Inflammability

of Wood. Although zinc chloride is not one of the most ef-

ficient fire retarding chemicals, nevertheless wood treated with

it is much more difficult to burn than untreated wood. This

makes zinc-chloride treated timber of particular value in those

locations where decay is rapid and danger from fire important,

as for example in coal mines. Timber treated with zinc chloride

will ordinarily ignite at the same or lower temperatures as un-

treated wood but will burn far more slowly. This is due in a

large measure to the hygroscopic nature of the salt. Some tests

made in the electric furnace above described at the U. S. Forest

Products Laboratory on zinc-chloride treated hemlock gave a

temperature of ignition of 287 C. as against 320 C. for untreated

wood. Only 19 percent of the treated wood was destroyed, how-

ever, as against 29 percent of natural wood.

Much discussion has occurred concerning the inflammability

of wood treated with coal-tar creosote. This matter was also

investigated at the U. S. Forest Products Laboratory and it was

found that wood freshly treated with creosote was very inflam-

mable, but that its resistance to burning increased with its age.

This is undoubtedly due to the lighter oils volatilizing from the

220 THE PRESERVATION OF STRUCTURAL TIMBER

wood and leaving the heavier oils. When tested under the condi-

tions analogous to the zinc-treated specimens mentioned above,

freshly creosoted hemlock ignited at a temperature of 173 C. and

lost 40 percent of its weight in a 3-minute burning period. When

allowed to air-season for 90 days, the temperature of ignition rose

to 216 C. and a loss of only 27 percent in weight occurred. Many

instances showing the resistance of seasoned creosoted timber to

fire have been reported, of which the following are cited :

After the Jacksonville fire the creosoted telephone poles were

standing in good condition although the buildings all about them

had been destroyed.

The Stuyversant docks at the same place were built of un-

treated and creosoted timber. The latter was easily extinguished

while the former was completely destroyed.

In Baltimore the creosoted wood-block streets did not burn

but came through the fire better than pavements of asphalt which

melted and ran down the sewers.

The author saw a shaft of a coal mine in Pennsylvania which

had caught fire, it being timbered with untreated and creosoted

props. After the fire was extinguished by smothering the mouth

of the shaft, all the untreated props had been burned to such an

extent as to be useless while those creosoted were simply charred

and not replaced.

It appears that the creosote in timber when it does ignite burns

for a long time in much the same manner as oil does in a wick;

hence the reason why the wood itself is so slightly consumed. It

must not be construed that creosoted timber is fire resistant in the

same sense that zinc- treated timber is, but that when, thoroughly

air seasoned it burns for some time with less damage to the wood

than untreated wood.

CHAPTER XVII

THE PROTECTION OF WOOD FROM MINOR

DESTRUCTIVE AGENTS

A description of the manner in which these minor destructive

agents attack wood has been given in Chapter II. We will now

consider methods of protection.

Alkaline Soils. While it is well known that certain alkalies will

attack wood and eventually disintegrate it, there is no positive

evidence which shows that their presence in the so-called " alkali

soils " does this. It is quite likely that the alkali is not sufficiently

concentrated or heated to sufficient temperature to cause disin-

tegration. In all cases which have been examined by the author,

such as deteriorated wood from flume pipes, cross-ties or poles,

fungus was always present. It is believed, therefore, that if the

growth of the fungus is prohibited, the deterioration can be materi-

ally reduced or eliminated. In other words, the wood should be

treated for decay, the process to be selected depending upon local

conditions as already described. By so doing it is quite likely that

the effect of the alkali in the soils can be generally disregarded.

Birds. The destruction of structural timber by birds is so small

as to warrant little comment, and certainly does not justify kill-

ing them. Woodpeckers will at times drill holes into buildings

and poles, and the size of the holes and the oddity of the attack has

given rise to an exaggerated idea of the destruction done. When

buildings are attacked, they are generally more or less deserted and

usually good for nothing but birds' nests at best.

The so-called destruction in poles is apparent rather than real,

as has been shown in Chapter II, although at times the holes

drilled by the birds may cause a real damage. No good method of

preventing such attacks is known. Creosoting the poles under

pressure is of assistance, although the birds will at times attack

creosoted poles. Plugging the holes is of no value as the birds

will drill new holes. It often appears to be a matter of " life or

death," and considering the great good and little real damage that

they do, destruction caused by birds had best be charged as an

221

222 THE PRESERVATION OF STRUCTURAL TIMBER

operating expense and borne with a smile. Nesting boxes can

often be used with great satisfaction, if hung on posts, poles or

buildings, and thus prevent damage (see Plate XXIII Fig. C).

The use of such boxes has been extensively tested in the Grand

Duchy of Hesse, where in 2 years all the boxes were inhabited.

Sap Stain. To be efficient, all known methods of protecting

wood from sap stain must be applied before the stain enters

the wood. If the logs are stained before they are cut into

lumber, no satisfactory process is known for removing the stain.

Logs should therefore be cut as soon as possible after they are

felled, particularly during warm weather.

The most effective means of preventing stain is to kiln dry

the lumber immediately after it has been sawed, and then keep

it under cover. In this manner, stain can be entirely prevented.

This method, however, is generally too expensive and cumbersome

for all but the best grades of lumber.

For rough lumber, dipping in a solution of bicarbonate of

soda gives best commercial results. 1 In practice, this is done by

having the freshly cut boards carried through a tank of the soda

solution on their way to the sorting table. In this manner no

extra expense for handling is required. A 5 to 8 percent

solution is usually sufficiently strong. This should be kept warm

by means of a steam coil in the bottom of the tank, which can be

constructed of wood, iron or concrete. A few companies are now

maufacturing " soda-dipping" tanks and will furnish a complete

outfit (see Plate XXII, Fig. A) or the tanks can be constructed by

an ordinary mechanic. After the lumber has been dipped in this

manner, it should be piled with open air courses so that it will dry

rapidly.

An extended series of tests were made by the United States

Forest Service in co-operation with the Great Southern Lumber

Company at Bogalusa, La., in which pine boards were dipped in a

variety of solutions. It was found that solutions of mercuric

chloride, varying in strength from about 0.2 to 0.3 percent, were

most effective in preventing stain, but on account of their very

poisonous nature, cannot be generally recommended.

The following conclusions are drawn from these tests: 2

1. Freshly cut sap lumber when stacked in the yard to dry

should be stacked in open piles to permit a free circulation of air.

Boards so piled season in about half the time required for those

1 Sodium fluoride in 4-6 percent solutions has given excellent results ex-

perimentally (1915). The author recommends it as well worthy of trial.

2 Circular 192 United States Forest Service.

PROTECTION OF WOOD FROM DESTRUCTIVE AGENTS 223

piled in close piles. Open piles, moreover, are not so severely

attacked by insects and are more effectively protected against

sap stain.

2. In commercial work sap stain can be most effectively

prevented by dipping boards in solutions of sodium bicarbonate.

Such solutions, though they give fairly good results, leave much

to be desired. The strength of the solution should be determined

by the severity of the conditions under which the boards are

to season, but in general it will require from 5 to 10 percent.

Care should be taken that the chemical used is not mixed with

adulterants.

3. The best results in preventing sap stain were secured with

mercuric chloride solutions, but on account of their poisonous

nature they are not recommended for general use.

4. The solution made by mixing sodium carbonate and lime

was not as effective as one of sodium bicarbonate alone. More-

over, it had a greater tendency to streak the surface of the boards

with a white precipitate.

5. Solutions of magnesium chloride, calcium chloride, sodium

hydroxide, phenol, copper sulphate, and zinc chloride did not

prevent sap stain; nor did sprinkling the boards with naphthalene

flakes give satisfactory results.

6. On account of cheapness and facility in operation, it is

recommended that sap-stain solutions be applied to the boards

by machinery. If this is done, the cost of treating lumber with

solutions of sodium bicarbonate will amount to from about 7 to

10 cents per 1000 board feet.

7. The indications are that shavings planed from soda-dipped

boards do not burn as readily as those from untreated boards,

but the difference in inflammability is so slight that for com-

mercial purposes it may be neglected.

Sand Storms. The destruction of timber in the United States

by sand storms is insignificant. Far more is destroyed by wind

and sleet storms against which there is, of course, no known

method of protection except heavier and more expensive construc-

tion. In certain portions of the Southwest the wind carrying

sand at high velocity so wears away poles, stakes and posts that

renewal is sometimes necessary. (See Plate XXII, Fig. B .) About

the only practical method known of retarding such damage is to

nail planks of wood or sheets of metal to the poles and posts and

after these have been destroyed, replacing them.

CHAPTER XVIII

THE STRENGTH AND ELECTROLYSIS OF TREATED

TIMBER

The Effect of Air Seasoning on the Strength of Wood. It

has been stated in Chapter IV that a considerable amount of

water can be removed from green wood, without affecting its

strength. As soon, however, as the water begins to leave the

cell walls so that their moisture content is decreased, the strength

of the wood rapidly increases. This is shown in Fig. 25 where

the strength of wood is plotted against the amount of water it

contains. Prolonged air seasoning removes a certain amount of

water from the cell walls and hence tends to increase the strength

of wood. In large structural timbers this gain in strength due

to loss of water is generally offset by the checks which develop.

The amount of water thus removed depends upon the tempera-

ture and humidity of the surrounding air and the size and kind

of wood being seasoned. For example, it is greatest in warm

dry air (as in summer) and in thin boards (1 inch or less in thick-

ness). Material of this kind is called "air dry or seasoned"

when it contains about 8 to 12 percent of water. If dried to

lower moisture than this it is very probable that the wood will

re-absorb moisture. Air-dry lumber containing 8 to 12 percent

of moisture is therefore seasoned about 16 to 20 percent below

its fiber-saturation point and has about twice the strength of green

wood. On the other hand if the boards are larger, say 6 to 10

inches in thickness it is very likely their " air-dry " moisture will be

15 to 20 percent rather than 8 to 12 percent. Consequently

their strength will not be increased to the same degree. It is

evident, therefore, that the term "air dry" is a very variable and

arbitrary one. If now, the wood is dried in a kiln and its moisture

reduced to say 2 to 3 percent, its strength will be increased con-

siderably over what it was in an air-dry condition. Thus, other

things being equal, the more moisture there is removed from

wood, the greater will be its strength (Fig. 25). This relation

has been equated by Tiemann 1 for longleaf pine with the following

formula:

1 Bulletin 70, United States Forest Service.

224

PLATE XXII

FIG. A. Type of soda dipping tank manufactured by the Lufkin Foundry

and Machine Co.

FIG. B. Stake damaged by sand storms in southern California. Com-

pare portion in the ground with portion above ground. (Photo courtesy

of the Am. Tel. & Tel. Co.)

(Facing page 224.)

PLATE XXII

FIG. C. Section of an experimental track laid with steel ties. (Photo

courtesy of the Ry. Eng. Ass'n.)

FIG. D. A fence of concrete posts, Madison, Wis. (Photo courtesy Na-

tional Concrete Machinery Co.)

THE STRENGTH OF TREATED TIMBER

225

C = G (22.1 P 2 - 1335 P + 25,610)

where C = crushing strength in pounds per square inch

G = specific gravity of dry wood

P = percent of moisture.

On account of the wide variability in the structure of wood, the

equation is applicable only within certain limits, and will not, of

course, give the exact strength for each and every piece of wood,

but is sufficiently close for most commercial engineering problems.

I I I I I I I I I I I I I I

5 10 15 20 25 30 35 40 45 50 55 60 65 70

Moisture-Per cent of Dry Weight

~. cent of Dry "Weight

FIG. 25. Moisture-strength curves for longleaf pine, eastern spruce and

chestnut. Note fiber-saturation points.

Lowering the moisture content of wood below its fiber-satura-

tion point produces certain phenomena; the more important, so

far as strength is concerned, being shrinkage and cell slitting.

Both of these vary with the kind of wood, the degree to which

it is seasoned, and the manner in which it is seasoned. Conifers

shrink less than hardwoods, and the drier the wood the greater

15

226 THE PRESERVATION OF STRUCTURAL TIMBER

the shrinkage. Given the specific gravity of a piece of wood

its shrinkage from a green to oven-dry condition can be fairly

closely approximated from the following logarithmic equations

developed by J. A. Newlin:

Shrinkage in volume percent = 26.5 G 1 - 00

Radial shrinkage in percent = 9.5 G 1 - 00

Tangential shrinkage in percent = 16.5 G 1 - 00

where G = specific gravity.

When water leaves the cell walls it sometimes happens that

these check open and become more or less filled with microscopic

slits (Fig. C, Plate V). These slits apparently weaken the wood,

but their weakening effect by no means offsets the marked in-

crease in the strength of the wood due to its loss of water. If

wood which has once been thoroughly air-dried is resoaked in

water until it contains as much water as it originally had, its

strength will be found to be less than the original green strength.

The slitting of the walls probably has much to do with this.

From the above discussion, it can readily be seen that any

treating process which tends to keep wood dry will, provided it

does not in itself weaken the wood, tend to increase the strength

of the wood. Thus treatments with creosote tend to retard the

absorption of water and hence keep the wood in a stronger and

more resilient condition than untreated wood or wood treated

with a preservative like zinc chloride. This is of decided ad-

vantage in certain cases, as in paving blocks, and is undoubtedly

one reason why creosoted blocks have resisted wear so much

better than similar blocks laid untreated. On the other hand,

objections have been raised to the seasoning of wood, partic-

ularly in mines, where certain operators assert that they prefer

green wood to dry or partially dry as it bends more and gives

better warning of danger from rock fall.

The Effect of Steaming on the Strength of Wood. Little is

known concerning the effect of superheated steam on the strength

of wood, but from our knowledge of the effect of temperature on

wood, the rapid drying of wood and practical operative results

with superheated steam, it appears that it is very prone to

seriously weaken wood and render it brash and brittle.

Saturated steam is in common use in preparing wood for treat-

ment as has been shown in previous chapters. Saturated steam

in itself does not dry wood, but heats it so that drying is possible.

In fact, while the wood is in the steam it may actually take up

THE STRENGTH OF TREATED TIMBER

227

water, particularly if it is already partially seasoned. This is

shown in the following table:

TABLE 34. INCREASE IN WEIGHT OF LOBLOLLY-PINE TIES DUE TO

STEAMING 1

Conditions of steaming

Gain in weight per tie, due to steaming

Period

Pressure per square

inch

Green ties

Air-seasoned

ties

Hours

4

4

4

4

4

6

10

Pounds

10

20

30

40

50

20

20

Pounds

2.13

Pounds

5.1

6.9

6.3

8.1

4.3

10.8

10.7

0.62

1.12

0.62

1.00

After the wood has been heated and the steam around it removed,

the heat units stored in the wood will evaporate much of the

water it contains and produce a condition of partial dryness

or "seasoning." A vacuum applied immediately after the steam

bath will further increase the drying, since it lowers the tem-

perature at which the water will vaporize. Common practice,

therefore, is to steam the wood and then apply a vacuum. The

important items to consider, in so far as the effect of steaming

on the strength of wood is concerned, are the temperature of the

steam and the length of time it is applied to the wood. The best

data on this subject known to the author is contained in United

States Forest Service circular 39, which summarizes the results

of about 6000 tests. Due to the variability of the wood used

and the complexity of the problems, it is probable that further

tests might change some of the conclusions there drawn, but the

essential features are probably correct. In general, it appears

from these tests that steaming at high temperatures, or lower

temperatures for long periods, materially weakens the strength

of wood. The extent of the weakening will depend upon the kind

of wood, its moisture content at the time of seasoning, the

character of the wood structure such as density, rate of growth,

etc., and the manner in which the steam is applied. Disregarding

the individual effect of each of these, and lumping them all

together, the effect of the temperature of the steam and the

length of time it is applied is shown in Table 35. 2

1 Circular 39, United States Forest Service.

2 United States Forest Service Circular 39.

228 THE PRESERVATION OF STRUCTURAL TIMBER

o b

S -S

o "-^

I

si

^s&^l

H 'S

^S

to 45 '55 ft 2

III til

pif

OcO'-Hl>OO\*OGOCiCO\*-iOO'-O

iO^\*O'^>OiO'^^t < TtiO l O\*O\*OiOiO

ddddddddddddddd

OOOOOOiOO\*OOOOOOO

S

S

s

!l

6

II

11

II

11

3 c

1^3

^ "3

2 i

T>|1

<1> g c5

S ^

s-ll

s-1

2 |^

^ d ^

155

III

THE STRENGTH OF TREATED TIMBER 229

In this table the word "control" refers to the test pieces cut from

the ends of the ties which were left untreated in order to furnish a

standard of comparison. It should be noted that these pieces

were tested immediately after treatment. It was found that if

they were air seasoned after treatment and then tested they

regained a large part of their original strength. Sufficient reliable

data is not available to state accurately what is the maximum

temperature of steaming or maximum duration of steaming that

should be used. The conclusion drawn from the tests just quoted

was that "for loblolly pine the limit of safety is certainly 30

pounds for 4 hours, or 20 pounds for 6 hours." It is well known

that some of the best results secured in the treatment of wood in

this country have been obtained from timbers (longleaf pine

piling) which were steamed at higher temperatures and longer

periods than this, hence it is entirely probable, when full informa-

tion is available, that more severe steaming treatments will be

found safe and practicable.

The Effect of Boiling Wood in Creosote upon its Strength.

If wood is submerged in creosote which is heated above the

boiling point of water under atmospheric pressure only, the water

contained in the wood will be converted into steam. Unless

confined, the steam will escape and thus the water content of the

wood will be reduced. It is obvious, therefore, that boiling wood

in creosote seasons the wood and is quite a different action from

steaming wood, which as already described, is simply a means of

heating it. If, however, the wood is heated in oil under pressure,

the action should be similar to that produced by steaming it,

since the pressure will prevent the water from vaporizing.

It is well known that rapidly seasoning timber is very apt to

weaken it, because it tends to develop checks and slits. This is

particularly true of woods having a complex structure such as

the oaks, maples, etc. Without definite knowledge we should

therefore expect to find a decrease in the strength of wood boiled

in creosote, particularly if the boiling reduces the moisture in the

wood much below its fiber-saturation point. Information on

this point is meager. Some green Douglas fir bridge stringers

boiled in creosote and then impregnated with the oil showed

about 40 percent loss in strength over similar stringers untreated.

This decrease was, apparently, permanent, because a year's

seasoning after treatment showed approximately the same

results. One example does not, of course, prove that the

230 THE PRESERVATION OF STRUCTURAL TIMBER

weakening was caused by the boiling, as it may have been due

either to the heat or the oil. The shrinkage of timber boiled

in oil is very rapid and its quite possible that this rapid shrinkage

may produce injury by setting up a complex series of stresses in

the wood. Whether or not this is the case and the extent to

which it may affect the various woods is not known at the

present writing. 1

The Effect of Preservatives on the Strength of Wood. This

is a much discussed problem on which little conclusive data is

available. A number of tests have, however, been made and

from them certain deductions can be drawn. The preservatives

which have been tested are creosote, zinc chloride, and crude oil.

Creosote. It has commonly been supposed that creosote does

not enter the cell walls of wood and for this reason could have,

per se, little or no effect on the strength of wood. Careful tests

by Teesdale 2 have shown that creosote enters the cell walls and

will cause them to swell. The amount which is absorbed by the

walls in practice is, however, insignificant compared with the

total amount injected. We should expect, therefore, that

creosote has but little weakening effect on the strength of wood

treated with it. Tests made on creosoted wood, tend to sub-

stantiate this (Table 6), these being made on small clear speci-

mens impregnated with about 8 pounds of oil per cubic foot. Green

loblolly pine steamed and creosoted with about 20 pounds of oil

per cubic foot showed no loss in strength over the ties which were

simply steamed and then tested. In fact, in creosoting loblolly

pine without steaming, the creosoted wood tested higher than

the untreated wood, the process apparently having a tendency

to dry the wood. 3 Some full-sized longleaf pine bridge stringers

steamed, creosoted by the Bethel process with 12 pounds of oil per

cubic foot and then tested, showed no apparent loss in strength

over the stringers tested untreated and carefully matched with

them. It appears that when the wood is not damaged by the

process, creosote in itself will produce little or no weakening of

practical significance. There is, however, a possibility that

this will not hold for all kinds of wood but at present data to

substantiate this is not known.

Zinc Chloride. It is well known that a concentrated solution

of zinc chloride will dissolve wood. In practice, the solutions

1 See page 48 (Seasoning in Oil) for improvement in this process.

2 Circular 200, United States Forest Service.

8 Circular 39, United States Forest Service.

THE STRENGTH OF TREATED TIMBER 231

rarely exceed a strength of 6 percent and at this concentration

their action on wood is very slight. The common specification

calls for an injection of a half pound of dry zinc chloride per cubic

foot of wood. Assume the wood after treatment will season to

10 pounds of water per cubic foot and the preservative has been

diffused through it. This will give a strength of only 5 percent.

If, however, the solution only penetrates the outer fibers of the

wood and the zinc chloride concentrates itself in these fibers,

it may reach sufficient strength to do actual harm. In this

condition the wood is said to be "burnt" or " killed" and is in-

variably the result of poor workmanship. Proper treatments

use as weak solutions as possible in order to get the requisite

absorption, and thus avoid any liability to injury of the wood

fiber. Green loblolly pine treated with zinc chloride solutions

of various concentrations and then tested in static bending,

compression parallel to the grain and in impact bending, gave

the following results when air dried to about 13 percent moisture. 1

Strength of Average strength in

solution percent of steamed wood

2.5 98.0

3.5 95 . 1

5.0 91.8

10.0 91.8

The conclusions drawn from these and similar tests is that zinc

chloride when properly injected into wood will not weaken it to

any appreciable extent under static loading, but apparently tends

to render it brittle under impact, especially when strong concen-

trations are used.

Crude Oil. Crude oil when heavily injected into wood ap-

parently weakens it. Thus some loblolly pine, shortleaf pine

and red gum ties, impregnated with about 14 pounds of crude oil

per cubic foot, gave only 73, 72, and 90 percent respectively of

the strength of the same kind of ties untreated, whereas the ties

treated with creosote and zinc chloride showed no loss whatever.

The Effect of Temperature on the Strength of Wood. Heat

tends to weaken wood, cold to stiffen it. In this respect wood,

therefore, behaves like a plastic material. Tiemann 2 has made

some careful researches along these lines, and the results secured

by him have been substantiated by further tests. He has soaked

1 Circular 39, United States Forest Service.

2 Bulletin 70, United States Forest Service.

232 THE PRESERVATION OF STRUCTURAL TIMBER

pieces of longleaf pine, spruce and chestnut in water for various

periods and then tested them at various temperatures. The

general results are shown in Table 36. The tests designated

"cold" were made when the wood was at temperatures ranging

from 7 to 19 F.; those marked "warm" at 45 to 68 F. An

examination of all the results shows a decided increase in both

the strength and stiffness of the frozen pieces, excepting the

very dry wood. Of course, in treating operations the timber

is seldom frozen, although this at times occurs. On the other

hand, the temperatures in the cylinder frequently rise to 250

F. It is doubtful whether this is sufficiently high to cause in itself

any permanent weakening in the wood, so that after the timber

has again reached atmospheric temperature no weakening due

to the temperature of treatment has any practical significance.

TABLE 36. THE EFFECT OF TEMPERATURE ON THE STRENGTH OF WOOD

(Specimens about 2 X 2 X 5.75 inches>

Kind of wood

How

tested

Moisture at

test, percent

Crushing strength,

Ib. per sq. in.

Modulus of elasticity,

Ib. per sq. in.

Longleaf pine.

cold

warm

23

24

6,440

5,750

1,418,000

1,360,000

Spruce

cold

warm

27

22

4,060

3,923

894,000

753,000

Chestnut

cold

warm

68

72

3,180

2,622

708,000

553,000

The Effect of Pressure on the Strength of Wood. Pressures

used in treating timber are all far too low to cause any weakening

of the wood. A pressure of 200 pounds per square inch is about

as high as is ever held, and even this is much below the crushing

strength of our weakest commercial woods. It is quite probable

that the wood during treatment undergoes a slight decrease in

volume (less than 0.5 percent) due to the pressure used, but

that on the release of pressure this is almost wholly recovered.

The Effect of Various Treatments on the Strength of Wood.

We have now considered the individual effect of the various units

in the treatment of timber upon the strength of the timber. Let

us now consider their combined effect as shown by some tests on

treated wood. For this information we are indebted to Dr. W. K.

THE STRENGTH OF TREATED TIMBER

233

Hatt, who tested a number of ties treated by various processes at

commercial plants. In other words, no attempt was made to study

more than the added effect of all factors entering into the treat-

ment in order to ascertain whether or not the treatment decreased

the strength of the ties over similar ties untreated. The results

of these tests are shown in Table 37.

TABLE 37. SHOWING EFFECT OF TREATING TIES UPON THEIR CRUSHING

STRENGTH AND SPIKE HOLDING PowER 1

Kind of wood

Treating

process used

Crushing

strength at

elastic limit

perpendicular

to grain in

percent of un-

treated tie

Resistance to spike pulling

in percent of untreated

tie with cut spikes

Cut spikes

Screw spikes

Untreated. . .

100

100

173

Burnettized.

97

98

172

Red oak

Lowry

104

93

163

Rueping

92

93

162

Full cell....

104

101

172

Untreated.. .

100

100

215

Rueping

99

123

209

Loblolly pine ....

Lowry.

104

112

94

109

219

246

Rueping

Full cell ....

100

84

184

Crude oil... .

73

53

192

Untreated.. .

100

100

241

Short/leaf pine

Rueping

Full cell....

103

108

100

103

209

223

Crude oil... .

72

45

176

Untreated...

100

100

202

Longleaf pine. . . .

Rueping

109

100

205

Full cell ....

101

105

270

f Untreated...

100

100

228

Red gum

I Rueping

.Full cell....

97

99

102

105

222

252

( Crude oil

90

70

270

1 A part of the differences in strength here noted are due to varying

moisture contents of the ties and the fact that different ties had, of course,

to be used, it being impossible to keep these absolutely uniform.

Data taken from experiments made under the direction of Dr. W. K.

Hatt and published in the bulletins of the American Railway Engineering

Association.

234 THE PRESERVATION OF STRUCTURAL TIMBER

It will be noted that all the treatments show little or no decrease

in strength with the exception of crude oil. The increases noted

may be due to superior wood in the treated ties or to their having

dried out more than the untreated ties or to a combination of these

two. Of course, all these conclusions presuppose that the treat-

ments were properly made and are normal. Bad management on

the. part of the treating engineers would, undoubtedly, have

yielded entirely different results.

The Electrical Resistance of Wood Treated with Creosote and

Zinc Chloride. This a matter of considerable importance to

steam railroad companies in the operation of their block signals, to

electric traction companies in the return of their current, and to

telephone and hydro-electric companies in the seepage of current

carried in wires over their poles. As is usual in problems of

this kind, the opinions of operating men vary considerably, and

little agreement is found. Mr. J. T. Butterfield conducted some

interesting and valuable experiments on this problem at Purdue

University in 1910, with ties treated at commercial plants, the

following information being taken from his work:

"The resistance was measured by the method commonly used

for measuring the insulation resistance of electrical machinery,

namely, by means of a direct- current voltmeter of known resist-

ance. This method was applied in two ways. (1) The contact

surface for flow of current in the ties was a sawn surface as nearly

plane as possible. Contact pressure of 250 pounds per square

inch was applied in a Riehle Testing Machine by means of sheet-

iron pans, placed one above the other and filled between with

dry sand, by which constant surface resistance was obtained.

(2) After some of the fundamental laws were investigated, the

resistance of the various ties was compared by measuring the cur-

rent flowing between two spikes driven 20 inches apart in the

face of each tie. Then the relation of these latter tests, between

the two spikes, to the conditions obtaining in a full tie with

rails spiked thereto was investigated.

In beginning the tests the principal elements which cause the

resistance to vary were determined and investigated in the follow-

ing order:

1. Amount of moisture present.

2. Kind of wood.

3. Treatment.

4. Direction of grain.

THE STRENGTH OF TREATED TIMBER 235

5. Contact pressure

6. Temperature.

7. Amount and time of current flowing.

8. Dimensions of specimen.

Moisture. The important effect of moisture is plainly shown

by the following tables, determined by the testing-machine

method :

TEST OF RED OAK

Zinc-chloride treatment 1.7 percent

Percent moisture Ohms per cu. in.

14.4 3,370,000

17. 414,000

19.1 94,000

27.4 2,140

35.7 1,381

47. 1,310

52.2 1,100

Untreated

13.3 5,020,000

17.3 784,000

21.6 198,000

26.6 136,300

38.0 7,100

43 . 3 6,440

47.3 5,070

In order to investigate the longitudinal distribution of resistance

through a tie, a number were cut up into 6-inch lengths and the

resistance measured parallel with the grain. The results plainly

showed that there was an enormous resistance at the ends of a

tie, which may have a uniformly low resistance in the interior.

The cause for this high-end resistance was, of course, the drying

out of the ends.

KIND OF WOOD AND TREATMENT

In measuring the resistance of different woods, the method

used was that of determining the resistance between two spikes,

as described above. The ties were generally tested in the yard

and had been piled. Some were covered and were no doubt less

dry than others. Variation in resistance of untreated ties of

same species is to be accredited to moisture variation. Generally

tests of 5 treated and 15 natural ties enter into the average.

236 THE PRESERVATION OF STRUCTURAL TIMBER

LOWRY CREOSOTE PROCESS

Resistance Ratio of,

(megohms per half tie) treated to

Natural Treated natural

Red oak 0.182 0.177 0.973

RUEPING PROCESS

Loblolly pine 5.58 5.05 0.91

Shortleaf pine 2.97 1.035 0.35

Longleaf pine (very dry) 5.4 6 . 05 1.12

Red gum 0.39 0.22 0.58

Loblolly pine 1 .46 1 .41 0.96

FULL-CELL PROCESS

Loblolly pine 2 . 94 1 . 00 . 34

Shortleaf pine 3 . 41 2 . 70 . 79

Longleaf pine 1 . 80 2.2 1 . 22

Red gum 0.225 0.28 1.24

Loblolly pine 4.47 0.905 0.20

ZINC CHLORIDE PROCESS

Red oak... 0.08 0.0125 0.156

DIRECTION OF GRAIN

The direction of the grain has a decided effect upon the

resistance of wood, and as the resistance of ties was taken parallel

with the grain, little consideration was given the question aside

from the following tests:

RESISTANCE IN MEGOHMS

Radial to

3-in. cubes, Lengthwise growth to growth

Kind of wood Radial to Tangential Percent

moisture

air dried rings rings

Natural red oak 0.0175 0.12 0.15 25

Natural red oak. . 0.0175 0.041 0.07 40

CONTACT PRESSURE

The study of the effect of contact pressure on a number of

different specimens held between contacts in the testing machine

and involving the longitudinal resistance corresponding to

different loads developed the following results. As would be

expected, it was found that the resistance decreases rapidly with

increase of contact pressure.

THE STRENGTH OF TREATED TIMBER

RED OAK, ZINC CHLORIDE TREATMENT, S-IN. CUBES

Lengthwise of grain Air dried

Lb. per

Ohms

sq. in.

500.0 175

278.0 180

56.5 220

22.2 270

8.9 460

3.3 575

1.0 1550

0.0 5850

RED GUM, NATURAL, 3-iN. CUBES

Lengthwise of grain Air dried

55.5 26,400

33.3 26,800

22.2 27,700

15.5 30,350

11.0 32,700

7.9 33,000

5.5 39,400

0.0 67,000

237

TEMPERATURE

Some preliminary tests were made upon the ties to discover

the effects of temperature. The results, although not capable

of representation by a smooth curve, showed that the resistance

decreased with an increase of temperature in a nearly direct

proportion.

RED OAK

Zinc chloride treatment testing machine method. End of grain

Block =5X8X6 inch

Temperature = average of six thermometers

Temperature, Resistance,

degrees C. ohms

0.33 2500

3.65 2100

5.70 1945

7.50 1820

10.70 1560

12.20 1270

14.50 1050

16.70 910

21.00 670

22.50 623

238 THE PRESERVATION OF STRUCTURAL TIMBER

ELECTROLYTIC EFFECT

While measuring a low resistance in the testing machine with

a high voltage it was noticed that the voltmeter needle tended

to fall back rapidly if the circuit was allowed to remain closed

for a short time. This pointed to some kind of an electrolytic

effect, and some tests were therefore made in which the current

was allowed to flow for some time until the resistance became

nearly constant. Then the circuit was opened and the specimen

allowed to recover. The following are the results;

ELECTROLYTIC EFFECT

Natural red oak. 60 percent moisture

Ohms per

Time Volts

cu. in.

0.00 sec. 13.00 1010

0.15 sec 12.80 1130

0.30 sec. 12.70 1190

l.OOmin. 12.61 1248

2.00min. 12.55 1288

3 . 00 min. 12 . 50 1320

4.00min. 12.47 1340

6. 00 min. 12.41 1380

Circuit opened

7. 00 min. 12.40 1386

8. 00 min. 12.79 1140

9. 00 min. 12.86 1101

10. 00 min. 12.92 1056

11. 00 min. 12.92 1056

INFLUENCE OF VOLUME

The relation of resistance to the dimensions of the specimen

was plainly showed to vary the same as with any conducting

material.

RED OAK ZINC CHLORIDE TREATMENT

Resistance,

Length Sect,on ohmg

6 in. 3 sq. in. 9,790

9 in. 3 sq. in. 16,030

12 in. 3 sq. in. 22,500

15 in. 3 sq. in. 35,500

RED OAK NATURAL

Length 3 in. Cross section varied

Cross section, sq. in. Resistance, ohma

9 6,000

18 11,000

27 16,000

36 22,000

THE STRENGTH OF TREATED TIMBER 239

RELATION OF TESTS BETWEEN SPIKES TO ACTUAL TIE

A few tests were made with rails spiked to a whole tie, and the

resistance measured and compared to the resistance of spikes

20 inches apart.

The resistance between the rails spiked to the whole tie was

found to be about 18 times the resistance between spikes

driven 20 inches apart and 4 1/2 inches in the face of the tie.

The moisture condition of the surface of the tie was artificially

varied.

H = The percentage increase in conductivity between rail and

tie, due to rail bearing. For example, the value of H = 0.95

for oak ties is found as follows:

1 1

H = 4 - ' X 100 = 0.95 percent.

44800

CONDUCTIVITY OF TIE WITH RAILS SPIKED THERETO AS COM-

PARED WITH SPIKES ALONE

Section of 85-pound Rail Spiked to Ties at Standard Gage Distance. No.

6 is Red Oak. No. 7 is chestnut

Percent.

0.95

2.16

0.93

6.79

Condition of tie

Dry | spikes only ...

f No. 6

Ohms. H.

44,800

Dry ; with rails

Wet at rail bearing; spikes only

Wet at rail bearing; with rails

I No. 7

. f No. 6.

I No. 7.

. f No. 6.

I No. 7.

( No. 6.

9,500

44,400

9,300

43,700

9,400

43,300

Wet all over ; with rails

j

\ No. 7.

( No. 6.

8,800

27,800

Bottom of tie in wet gravel; with rail . .

Tie in moist gravel ballast; with rail

Tie in very wet ballast; with rail

Same as above; spikes only

I No. 7.

. . No. 6.

. No. 7.

. . f No. 6.

I No. 7.

. f No. 6.

7,760

10,270

4,350

6,780

3,220

7,300

I No. 7.

3,430

7.68

6.52

The resistance of the bearing between a newly spiked dry rail

and a dry red-oak tie will be found to be approximately 1 per-

cent of the total conductivity of the tie, but after the spikes

have loosened the pressure on the rail bearing is about the

240 THE PRESERVATION OF STRUCTURAL TIMBER

weight of rail per tie divided by the area of the bearing. This

is about 2 pounds per square inch. Such light pressure means

high contact resistance. Considering the further fact that the

crosswise resistance of a tie is several times its lengthwise

resistance per unit of length, and that all leakage current through

the rail bearing must pass through a considerable amount of

cross-grain resistance, the total resistance of the leakage path

between rails is very high.

CONCLUSIONS

The results obtained tend to establish the following conclusions:

Timber is ordinarily classed with the nonconductors. When

dry and well seasoned, it has a very high dielectric strength and

practically infinite resistance. When green or moist, however,

timber becomes a kind of electrolytic conductor of comparatively

low resistance. The treatment with zinc preservatives has the

simple effect of producing in the wood a stronger electrolyte and

hence a better conductor of current.

1. The resistance of timber varies directly with the length

and inversely with the cross section.

2. The resistance of timber varies almost inversely with the

amount of moisture present, between the limits of 15 and 50

percent.

3. The resistance of timber is lowest when measured along

the grain, and highest when measured tangentially to the growth

rings.

4. When treated with a soluble salt such as zinc chloride,

the resistance varies approximately inversely as the amount of

the salt present.

5. Treatment with such a soluble salt does not change the

behavior of the resistance with respect to the percent moisture

present. Only the amount of the resistance is changed.

6. The resistance of timber varies almost inversely with the

temperature between the limits of zero and 50 C.

7. The resistance of nonporous woods, such as the pines,

is higher than that of porous woods, such as the oaks and red

gum.

8. Treatment of timber by different creosote processes does

not greatly change the natural resistance of the timber.

9. Finally, all the data taken goes to establish the view that

THE STRENGTH OF TREATED TIMBER 241

the conductivity of wood is due primarily to the presence in the

pores of an electrolyte formed by an aqueous solution of the

salts found in the natural timber, or of these salts and others

artificially introduced.

Assuming the worst condition for leakage covered by the test,

i.e., red oak ties treated with zinc chloride laid in wet ballast

and with wet rail bearings, the resistance between the rails of a

block 1 mile in length would approximate 30 ohms. This

would permit a leakage current of 0.05 ampere to flow with the

battery voltage of 1.5 volts. The leakage loss would, there-

fore, be 0.075 watt, or about 30 percent of the power required to

operate the relay. This should not seriously interfere with the

operation of signals, as leakages up to 60 percent exist without

such serious interference.

It is to be regretted that determinations of resistance were not

made with wet ties or with ties and rails partially immersed in

water, as is sometimes the case in practice, for it is believed that

under such conditions the leakage .current would probably be

sufficiently large to interfere with the successful operation of

relays.

As a final conclusion, it should be noted that since the above

results show only a reduction in resistance of a tie of from 26 to

53 percent when treated with zinc chloride, depending upon the

percentage of moisture, while a change of resistance by the ratio

of 25 to 1 may be effected by varying the kind of wood, a change

of 33 to 1 by varying the pressure upon the tie sufficiently, and of

3.7 to 1 by temperature changes, it follows that the treatment of

ties with preservatives should not interfere with the operation of

signal circuits, except possibly in exceptional cases in which the

resistance of the leakage paths is abnormally low from other

causes."

From a number of inquiries, it is the experience of several

signal engineers that little or no difficulty will be experienced with

zinc treated ties if the distance between signal blocks is not too

great and if the ties are not laid green. Some of them have

shortened the distance between signals to about 1000 to 1200 feet

and report complete satisfaction. Against creosoted ties no com-

plaint on this account is made.

A number of traction companies state that the zinc-treated

ties corrode their spikes very rapidly and for this reason they are

opposed to using them. It is entirely possible that this will occur

16

242 THE PRESERVATION OF STRUCTURAL TIMBER

especially if the ties are liable to hold much moisture and are

situated a long distance from the power house. Ties which can

be kept fairly dry, and can be laid close to the power house so that

the return current will be through them, rather than away from

them, should give little trouble.

The leakage in current in poles and cross arms treated with

soluble salts should de very slight and of little or no practical

consequence since they are not counted upon for insulation,

this being taken care of by the insulators themselves. However,

it seems entirely probable that creosoted poles and arms will tend

to resist leakage more than those which are salt treated because

they will, in general, contain less moisture. As already stated,

such a difference can at most have little practical significance and

for this reason treated poles can undoubtedly be used in the same

manner as untreated poles.

CHAPTER XIX

THE USE OF SUBSTITUTES FOR TREATED TIMBER

By the term "substitute" is here meant a material which is

offered in place of wood, wood having been the standard. Thus,

although wood and asphalt are both used extensively for street

pavements, asphalt is not considered a substitue for wood but a

competitor of wood. On the other hand a concrete tie is a

61 substitute" for the wood tie. With this distinction in mind,

a clearer conception of the inroads being made by other materials

can be had. It is not intended to discuss in this chapter the

general substitution of other materials for wood but only for

treated wood. This has taken place in a wide variety of products

and, in certain instances, is making rapid headway. It is caused

by the rise in the price of timber, the demand for better con-

struction and an improvement in the manufacture of the sub-

stitutes.

Substitutes for Wood Ties. This was one of the first fields

entered and thousands of dollars have been spent in attempting to

find a satisfactory substitute for wood ties. Ties made of steel,

concrete, leather, and combinations of these materials have all

been tested both in this country and abroad. Best success has

been had with the steel ties, but their introduction has been very

slow, and the results secured from them by no means all that is re-

quired. The American Railway Engineering Association has gone

rather extensively into this problem and has made a report con-

taining much valuable data. l It states that " an improved form of

steel tie, as shown in Plate XXII, Fig. C, of the type manufac-

tured by the Carnegie Steel Co, with metal plate over the insu-

lating fiber and with the wedge clip rail fastening, seems to be

very promising." A few railroads report satisfactory experience

with the steel tie, while other companies have discarded them.

The general consensus of opinion at present seems to be that

these ties are still in the experimental stage but worthy of trial.

As a result of its studies, the American Railway Engineering

1 Bulletin 108, American Railway Engineering Association, 1909.

243

244 THE PRESERVATION OF STRUCTURAL TIMBER

Association committee concludes "that no form of reinforced

concrete tie has been made which is suitable for heavy and high-

speed traffic, but believes a properly reinforced concrete tie, with

proper fastenings, may be found economical in places where speed

is slow and where conditions are especially adverse to the life of

wood or metal." The Lake Shore & Michigan Southern Railroad

placed some "Buhrer Concrete Ties" in its track at Sandusky,

Ohio, in 1904. There were no renewals up to 1908 and all the

ties appeared in good condition. The more common experience,

however, seems to be like that of the Pennsylvania Railroad, which

placed 500 of these ties in 1903. " The concrete broke and crum-

bled and by December, 1906, all had been removed on account

of breaking." Kimball, Percival, Affleck, Chenoweth, Keefer,

Hickey and Alfred concrete ties tested by various railroads all

cracked or crumbled in 2 or 3 years although in a few cases longer

lives were secured. It appears, therefore, that a satisfactory

substitute for the treated wooden tie still remains to be found.

Substitutes for Wood Poles. Iron, concrete and glass have

been tested for poles. In cities, the iron pole has given very good

use and has very largely replaced the wood poles. However, in

the larger cities, even the iron pole has been done away with, ex-

cept for street lighting, its place being taken by conduits. Wood

poles are still used in large quantities in towns and cities and in

the country for trolley, telephone, telegraph and high power trans-

mission lines, although with the latter, steel towers furnish the

best construction. Concrete poles are largely in the experimental

stage as yet. Poles 100 feet or more in length have, however, been

constructed of reinforced concrete. On account of their great

weight, high cost, and difficulty of handling, it is doubtful whether

concrete poles will make serious inroads on wood poles for years

to come, except perhaps in isolated cases. Concrete poles have

not been in service long enough to know their merits.

Glass poles are purely an experiment and, from the results

secured thus far, success seems doubtful.

A review of past experiences shows that only in large cities has

any material been successfully substituted for wood in the manu-

facture of poles, and that no substitute which gives promise of

extended usage is in demand.

Substitutes for Wood Piling. Wrought iron, cast iron, steel

and reinforced concrete have all been used for piles. Iron in all

its forms is, of course, free from attack by the marine borers.

USE OF SUBSTITUTES FOR TREATED TIMBER 245

It corrodes, however, when driven in sea water. Wrought iron

apparently corrodes more rapidly than steel which contains

about 0.1 percent of carbon. Cast iron becomes pitted, the iron

being gradually dissolved leaving the carbon. The life of iron

piles is not known, but from tests made by various investigators,

it appears that wrought iron and steel will corrode at the rate of

about 0.40 inches per 100 years. The actual usefulness of the

pile will depend largely upon the extent to which it becomes pitted

and apparently this varies between very wide limits.

Reinforced concrete piles have been used since 1896 and large

numbers have been placed in various harbors of the world.

These piles, are attacked at times by the sea water, which

disintegrates them. Furthermore, alternate freezing and thaw-

ing have, in cases, cleaved off much of the concrete. Yet in

spite of these difficulties, concrete piles possess considerable merit

and give promise of being perfected to an extent where they will

prove free from these objections. Concrete piles have not been

used sufficiently long or driven in sufficient numbers and under

such conditions as to furnish reliable data on their probable life.

Substitutes for Wood Posts. Considerable progress has been

made in manufacturing concrete posts, and several railroads in our

country are now using large quantities of them. The cost of

making the posts varies from about 16 to 25 cents each. Nothing

is known of their life, but this is estimated by several manufac-

tures to be at least 40 years. Concrete posts are heavy, trouble-

some to make, liable to be thrown by frost heave, require careful

handling and have other ills, but in spite of them all, they

possess much merit, particularly because of their durability and

appearance, and have unquestionably come to stay and their con-

sumption will increase. (See Plate XXII, Fig. D.)

Posts are also made of cast iron, iron pipe and galvanized sheet

iron, but the number is so small as to be insignificant and prob-

ably will always remain so, except for a comparatively few

special cases.

Substitutes for Wood Mine Timbers. Concrete, masonry and

steel have all been substituted for wood mine timbers, but only

in isolated cases. Concrete mine timbers are very expensive,

their installation interferes with the working of the mine and in

some cases they are crushed before they become "set." It is

doubtful if they will come into general use. (See Plate XXIII,

Fig. A.) Iron mine "timbers" have been tested both here and in

246 THE PRESERVATION OF STRUCTURAL TIMBER

Europe. They are expensive, difficult to install, and are corroded

by the mine gases and water. Furthermore, if the mine once

starts to "cave," the iron "timbers" will fail although they will,

of course, hold a greater load than wood. In Europe a unique

method in the design of iron props has been tested. It consists

of two hollow pipes, one of which fits snugly inside the other.

Round iron balls are then placed in the lower pipe. In this man-

ner the upper pipe can be extended and held by the balls, pre-

venting further telescoping. When it is desired to remove the

prop, a plug in the lower pipe is opened and the balls allowed to

roll out. This makes a prop which can be fitted into place. Its

cost, of course, is high and in addition it is subject to most of

the objections raised against iron mine "timbers." Our largest

iron and steel company is using enormous quantities of wood in

its own mines, some of which is treated with preservatives.

Masonry, is, of course, out of the question because of its high

cost, trouble in laying, etc., except for very unusual situations,

so it doubtless will never become a serious rival to other forms

of "timbering."

Substitutes for Wood Bridge Timbers. Steel, masonry and re-

inforced concrete have almost entirely replaced wood in the

construction of permanent bridges. In addition to possessing

greater strength, such bridges are less subject to destruction by

fire. In so far as durability between steel and wood bridges is

concerned, doubt still exists in the minds of some engineers and

conflicting data have been submitted. Creosoted wood bridge

timbers are known to have existed in perfect condition for over

30 years in the South where decay is generally rapid. Appre-

hension of the gradual deterioration ("fatigue") of such timber

due to repeated impacts, does not appear well founded. Some

railroads in our country are laying creosoted bridge timbers on top

of steel members, thus adding to the elasticity of the bridge and

deadening of sound. Considerable quantities of wood are still

used on steel bridges in the form of ties, guard rails, wall plates,

etc., and in wooden bridges and trestles, but as the demand for

high grade permanent structures increases, the use of wood will

unquestionably decrease. It is likely, however, that a demand

for wood shields under steel bridges which are subject to corro-

sion from the locomotive stacks will increase, especially when the

wood is rendered noninflammable.

PLATE XXIII

FIG. A. Concrete mine props, Pennsylvania. (Forest Service photo.)

FIG. B. Indiana Tie Company's wood preserving plant, Joppa, III.

Note depressed tracks and manner of running cylinder cars on flat cars for

loading ties into box cars for shipment.

(Facing page 246.)

PLATE XXIII

FIG. C. Nest box used to protect poles and buildings from attack by

woodpeckers. (Photo courtesy Ernest Baynes.)

FIG. D. Wood dowels screwed into softwood ties as a protection against

spike cutting.

USE OF SUBSTITUTES FOR TREATED TIMBER 247

Substitutes for Wood in Buildings and Cars. As only small

quantities of treated wood are used in the construction of

buildings and cars, the substitution of other materials affects but

little the wood preserving industry.

A special committee of the American Railway Association ap-

pointed in 1912 circularized the railroads of the United States

and received reports from 247 railroad companies operating

227,754 miles of track. The object of the circular was to ascer-

tain the progress being made in introducing steel passenger cars

in place of wooden cars. The following table summarizes the

findings of this committee:

TWil

Percentages

number

Steel

Steel under-

frame

Wood

1909

1880

26.0

22.6

51.4

1910

3638

55.4

14.8

29.8

1911

1912

January, 1912

(Under construction i

3756

2660

1649

59.0

68.7

85.2

20.3

20.9

11.5

20.7

10.4

3.3

The substitution of steel for wood in freight cars is also taking

place at a rapid rate. While opinions vary widely at present, it

appears that a combination of steel and wood will be the ultimate

solution of many of the freight car problems. Similar changes

are taking place in the construction of buildings in cities where

the tendency is to reduce the fire hazard to a minimum. Steel,

concrete, and clay products have replaced wood to a very

large extent and there is little doubt but what such replace-

ment is permanent. In certain cases, however, a reaction has

set in, as it was found that many buildings supposedly " fire-

proof" were really not so when put to the test. Thus wood

floors and trim will probably remain for years to come. "Slow

burning" factory construction has also been in demand. It is

believed that " fireproofing " wood used in such buildings will do

much to remove some of the serious objections raised against

wood and that this phase of the wood-preserving industry will

grow to much larger proportions than at present.

Substitutes for Wood Shingles. There is a great variety of

roofing materials such as metal, slate, tile, asbestos, etc., now on

the market which are replacing shingles. This has been brought

about largely through the demand for fireproof construction

248 THE PRESERVATION OF STRUCTURAL TIMBER

certain cities having passed ordinances prohibiting the use of

wood shingles within their congested limits. As buildings be-

come more crowded and permanent, wood is invariably replaced.

In general, roofs built of these " substitute" materials cost more

than shingle roofs, not only for the covering itself, but for the con-

struction necessary to hold up the greater weight. It is possible

that the progress being made in "fireproofing" shingles, will do

much to retain their existence. If this one very serious objection

could be removed, wood shingles would remain in favor. They

possess certain characteristics such as cheapness, ease of repair,

light weight, adaptability to artistic design, durability, resistance

to heat transmission, etc., which are in strong demand.

Substitutes for Wood Conduits and Pipes. The use of treated

wood for these purposes is quite small, and forms but a small

percentage of the total amount. Fiber conduit, tile, brick, and

steel are all used in large quantities. Creosoted wood conduit is

very durable and has given excellent service. It is comparatively

inexpensive, easily laid and resistant to injury from settlement

of the surrounding earth. The oil will, of course, attack rubber

and under certain conditions cannot be used. Large quantities

of wood have been used in building pipes, particularly for irrigat-

ing purposes. One decided advantage seems to be a lowering in

the coefficient of friction through use a result quite the opposite

of metal, which tends to become rough and hence decrease the

quantity of water which flows through it.

CHAPTER XX

APPENDICES

Minor Wood-preserving Processes. No attempt is made to

list and describe all of the various processes which have been

advanced in this country to preserve wood from decay. To do so

would prolong this book to several volumes. Some idea of the

number of wood-preserving processes suggested can be gained

by examining the list of patents given below. But to inform those

who might wish information on this phase of wood preservation,

a number of the better-known and more interesting methods

will be briefly discussed. Some of them may eventually be

extensively practised in our country.

Thilmany Process. Patented by Thilmany in 1876, the proc-

ess consists in impregnating wood with copper sulphate (later

zinc sulphate was substituted) followed by a second injection of

barium chloride. The object was to produce a chemical reaction

giving copper chloride and barium sulphate; the latter being

insoluble in water was intended to plug the wood and prevent the

copper chloride from leaching out. The process was tested by

several railroads in this country without apparent success.

The B-M Timber-preserving Process. This process uses

a combination of zinc chloride and aluminum sulphate as

covered by patents held by Hubertumuhle of Schopfurth,

Mark, Germany. It is claimed that the aluminum sulphate is

not only an antiseptic salt, but gives a better solution to the zinc

chloride and carries this salt deeper into the wood. It is also

claimed to combine in part with the wood structure. The

solution is injected into timber much in the same manner as zinc

chloride in the Burnett process except that the temperatures are

kept somewhat lower. From analyses of treated wood made by

certain reputable chemists, it appears that better penetrations are

secured in the B-M process than in the straight Burnett process.

Some treating companies in the United States are now ready to

treat timber by this process.

249

250 THE PRESERVATION OF STRUCTURAL TIMBER

The Goltra Process. Named after W. F. Goltra of Cleveland,

Ohio. For handling ties the distinct steps in the process are:

(a) Steaming ties upon delivery at plant.

(6) Stacking ties for open-air seasoning.

(c) Machining ties.

(d) Drying and warming ties in ovens.

(e) Impregnation with antiseptic liquid.

The novel features in the process are the steaming of the ties

on delivery at the plant and then air - seasoning them; also

warming the ties in ovens before injecting the preservative. So

far as the author knows, this process is not in commercial use,

although it has been considerably agitated in the past few years.

The Hasselman Process. Patented in the United States in

1897. This process consists essentially in injecting into wood

a solution containing sulphates of iron and aluminum to which

"Kainit" is added to neutralize the free acids which may be

formed. The process was tested experimentally in Texas with

poor results. Since then certain modifications of the process

have been proposed by Barschall and some timber treated in this

manner is now under test by the United States Forest Service

with no conclusive results to date.

The Creo-Resinate Process. First practised by the United

States Wood Preserving Company, particularly for the treatment

of paving blocks. The wood is subjected to a dry heat, after

which a vacuum is drawn and the creo-resinate mixture forced

into the wood. This mixture consists of creosote (about 50

percent), 48 percent rosin, and 2 percent formaldehyde. A

subsequent treatment with a solution of lime is then given. It is

understood that the original treatment has undergone considerable

change since it was first advocated.

Robbins' Process. Practised by the Suffold Wood Pre-

serving Company of Boston about 1869. It consisted in passing

vapor of naphtha into the retort after the wood had been run into

it, the vapor being heated to about 250-300 F. This vapor

was to expel the water from the wood, coagulate the albumen,

and expand the wood pores. The temperature in the retort

was then raised to 400 F. and vapor of creosote passed into the

wood. The process was tested extensively, but failed.

Powell Process. This is an English process which has been

tested extensively abroad but is little known in our country.

It consists in boiling wood in a solution of sugar for a few hours

APPENDICES 251

and then drying it in an oven at high temperatures. It is said

to render wood resistant to ants and decay and nonabsorptive

to water. Tests known to the author indicate the process has

decided merit in overcoming the hygroscopicity of wood.

Creoaire Process. Advertised by the International Creosot-

ing & Construction Co. It consists in treating wood similar

to that employed in the full-cell creosote process, but after the

desired amount of oil is forced into the timber the cylinder is

drained of excess oil and an air pressure applied to drive the oil

further into the wood, thus producing an " empty-cell" effect.

Tests made by the author show that this method drives con-

siderable oil out of the wood and may cause " bleeding."

Vulcanizing Process. Practised by the New York Vulcaniz-

ing Company of New York City. Sometimes called " Raskins'

process." The timber is placed in the treating cylinder. Air

compressed to 150 to 200 pounds per square inch is then forced

into the wood through a water separator to remove moisture,

and heated to about 400 to 500 F. for about 8 hours. The

process rapidly removes the water from the wood and, producing

a partial distillation, is claimed to render it antiseptic. A large

number of ties have been treated by this process, some of which

gave long service.

Cresol-calcium Process. This is a Swedish process not

practised in this country except experimentally. Agents are

Blagden-Waugh & Company of London. The timber is handled

much as in Burnettizing except that the solution consists of a

mixture of milk of lime and crysilic acid resulting in calcium

crysilate. It is under test in several places in the United States

but apparently with little success.

Cecil-Williams Process. An open-circuit circulating apparatus for

emulsionizing mixtures of preservatives of different specific gravities, and

circulating all preservative fluid in the retort, for the purpose of maintain-

ing uniform temperatures in all parts of the retort during period of impreg-

nation. Patented 1916. Other patents pending.

The inventors claim: Perfect control of pressure, circulation and retort

temperature, by means of a specially constructed, mechanically operated

valve that, closing at a uniform rate of speed, gradually raises the pressure

in the retort until the maximum is attained at which point the mechanical

arrangement that drives the valve is automatically stopped. A relief valve

is located in the circulating pipe between the retort and operating tank to

prevent excessive pressure due to any increase of supply to the retort.

In operation, mixtures are constantly agitated in the operating tank by

252 THE PRESERVATION OF STRUCTURAL TIMBER

any suitable means, and while pressure is maintained, the liquid is passed

through the retort back to the operating tank in any required volume, and

all free air passes out of the retort. The process is accomplished with one

pump and is positively automatic, requiring no attention from the operator

after the pump is started except to empty retort when treatment is finished.

PATENTED, PROPRIETARY, AND MINOR WOOD PRESERVATIVES

USED IN THE UNITED STATES

A number of wood preservatives which fall under this heading are used

in the United States, few of them in any appreciable amount. Perhaps the

best known are the "carbolineums," which are used quite extensively, espe-

cially for brush-treating timber.

S. P. F. Carbolineum. Handled by Bruno-Grosche & Co. of New York

City. It is a preservative distilled from tar, which, according to the engi-

neering department of the American Telephone and Telegraph Company, is

somewhat similar on distillation to Avenarius Carbolineum. It has been

used in this country for many years and has given good results.

Avenarius Carbolineum. Made in Germany, but handled by the Carbo-

lineum Wood Preserving Company of Milwaukee, Wis., and other cities.

It is essentially a high-grade distillate of coal-tar specially manufactured

and has been used in this country for many years with good results.

C-A-wood Preserver. A foreign-made product handled in this country

by the C-A-Wood Preserver Company of St. Louis, Mo., with agencies in

other cities. Essentially a high-grade distillate of coal-tar, which has been

used in this country for many years with good results.

Timberasphalt. Sold by the Indian Refining Company of New York

City. It is an "asphaltic flux" resulting from the refining of crude oil, and

has no marked antiseptic properties, relying more on its waterproofing and

"plugging" action to preserve wood. It is one of the more recent preserva-

tives placed on the market.

Preservol. Sold by the Newbold Manufacturing Company, 135 Green-

wich Street, New York City. Said to be a " creosote" made from beech.

It has not been very extensively tested in this country.

Copperized Oil. Handled by the Copper Oil Products Company of New

York City. It is an oil containing copper. The kind of oil used and amount

of copper it contains apparently can be varied for specific requirements.

It is one of the new preservatives placed on the market.

Sodium Silicate. Made by several companies in the United States. It

does not readily penetrate wood, but has a marked tendency to decrease

the inflammability of wood.

Spirittine. Manufactured by the Spirittine Chemical Company of Wil-

mington, N. C. This is a special "creosote" made from coniferous wood,

and has been used quite extensively in the United States with good results.

B. M. Preservative. The agent in this country is Franz Workman, 31

Liberty Street, New York City. It is a mixture of zinc chloride and normal

aluminum sulphate, and has been tested experimentally on a large scale in

this country but has not been commercially practised to any appreciable

extent. It is forced into wood in much the same manner as in Burnettizing.

APPENDICES 253

Holz-Hefer. Handled by the Vaughn Paint Co. of Cleveland, Ohio, and

made in Germany. The wood is either painted with or dipped in the solu-

tion. It is a greenish-brown liquid containing zinc chloride, copper, and

creosote with a specific gravity at 60 C. of 1.113. From tests made at the

U. S. Forest Products Laboratory it appears to be much less toxic than

creosote.

Sodium Fluoride. Made by large manufacturing chemists in the United

States. Little known in this country but extensively tested abroad. Ex-

periments by the U. S. Forest Products Laboratory indicate the possibility

of using this salt to decided advantage. Further tests are necessary before

its full value is known. It is impregnated into wood as in the Burnettizing

process.

Aczol. Manufactured by J. Gerlache, Boulevard du Nord 68, Brussels,

Belgium. This is a cuprous-ammonium salt, which is not used to any ex-

tent as yet in the United States but is undergoing experiments with the

U. S. Forest Service.

Sapwood Antiseptic. Made and patented by J. W. Long, Chicago, 111.

It is a mixture of copper sulphate, sodium chloride, calcium sulphate, zinc

sulphate, and iron sulphate with water. Is now undergoing test by the

U. S. Forest Products Laboratory and elsewhere. Is claimed to prevent

sap stain as well as decay. Toxic tests show it to possess a very low resist-

ance to fungi.

Imperial Wood Preservative. This is a comparatively light gravity,

greenish-black oil, handled in St. Louis, Mo., containing a high percentage

of residue at 315 C. It is under test by the U. S. Forest Service and else-

where, and is giving results riot very unlike those obtained from coal-tar

creosote.

Kreodone This is a special wood-preserving oil made by the Republic

Creosoting Company of Indianapolis, Ind., and elsewhere and used largely

for preserving wood blocks. It is reported as giving good service.

Locustine. Manufactured by W. H. Huff, Beverly, N. J. It is reported

as being a patented compound of nonvolatile petroleum products and certain

animal and marine oils and antiseptics, which can be applied to wood either

by the brush, dipping, or impregnation processes.

Creoline. This is a very light gravity, brown oil containing much tar

acids and water. In spite of this it is giving good results in some test pole

lines set under the supervision of the U. S. Forest Service and the Bell Tele-

phone Company.

Mykantin. Mykantin is a water-soluble preservative and is manufac-

tured by Farbwerke vorm Weister Lucius & Briining. It is sold in this

country by Farbwerke Hoechst Company, 20-22 Natoma Street, San Fran-

cisco, Cal. The preservative consists of a solution of dinitrophenol in

water, which is said to be highly toxic against fungi. It is recommended

by its manufacturer especially for use in the prevention of decay in wood

used in building construction.

Montanin. Montanin is a water-soluble preservative manufactured by

the Montanin Chemical Works, Germany. It is sold by the Montanin

254 THE PRESERVATION OF STRUCTURAL TIMBER

Company, 81 Fulton Street, New York City. It is recommended by its

manufacturer especially for use in the prevention of decay in buildings.

Montanin is claimed by the manufacturers to be a very toxic preservative

and is used in solutions of 2 percent or less in water.

Lyster. Lyster wood preservative is a heavy black oil obtained from

hardwood tar. It is recommended by its maker for preserving wood used

in dwelling houses, mills, boats, bridges, wharves, telephone poles, etc.

Jodelite. Jodelite is said to be a high-boiling coal-tar product of the

nature of carbolineum, manufactured by Jos. Dee and Sons, Manchester,

England. It is recommended by the manufacturer especially for brush

and open-tank treatment of wood for prevention of decay, and also for use

against the attack of ants and termites.

Conserve. Conserve is a creosote product manufactured by Samuel

Cabot, Inc., Boston, Mass. It is recommended for protecting all kinds of

woodwork, especially shingles, ties, posts, sills, bridge, dam, and wharf

planking, etc., from decay and insects. This company also makes a variety

of shingle stains which are now widely used in this country.

Atlas Wood Preservative. This preservative is sold by the Atlas Pre-

servative Company, 95 Liberty Street, New York, and it is a water-soluble

preservative. It is said to consist of a powerful antiseptic, combined with

an alkaline solution. It is claimed to protect wood from decay and from

the attack of termites, and is also said to make wood fire retardent.

Anthrasota. Anthrasota is a high-boiling creosote product similar to

carbolineum. It is manufactured by the Barrett Manufacturing Company,

New York City. It has a specific gravity at 38 C. of about 1.11, which

especially fits it for open-tank and brush treatments.

Beechwood Creosote. Beechwood creosote is manufactured by the Lake

Superior Iron and Chemical Company, Detroit, Michigan. It is an oil

refined from hardwood tar and has toxic properties equal to if not better

than coal-tar creosote. The oil is recommended for all kinds of work where

coal-tar creosote is suitable.

Barol. Barol is said to be a carbolineum to which copper has been added.

It is manufactured by the Anthracene Wood Preserving Company and is

recommended for all kinds of work where carbolineum is used.

Letteney. Letteney is said to be a coal-tar product having the character

of a carbolineum. It is sold by the Northeastern Company of Boston,

Mass., and is used like carbolineums.

Barrett's Grade I Oil. This is a high-boiling coal-tar product and is

manufactured by the Barrett Manufacturing Company of New York City.

It is made especially for use in protecting wood from decay by the brush

and open-tank methods of treatment.

LIST OF MANUFACTURERS OF ZINC CHLORIDE IN THE

UNITED STATES

General Chemical Co., 112 W. Adams St., Chicago, 111.

Graselli Chemical Co., Cleveland, Ohio.

Sandoval Zinc Company, East St. Louis, 111.

APPENDICES

255

LIST OF MANUFACTURERS OF, OR DEALERS IN, CREOSOTE IN

THE UNITED STATES

American Conduit Company, East Chicago, Ind.

American Tar Products Company, Chicago, 111.

Armitage Manufacturing Company, Richmond, Va.

American Wood Preserving Company, Chicago, 111.

Barrett Manufacturing Company, New York, Chicago, and various offices.

Barnaday, J. R., Seattle, Wash.

Betts, C. G., Spokane, Wash.

Burton Coal and Lumber Company, Salt Lake City, Utah.

Carolina Portland Cement Co., Atlanta, Ga.

Creosote Supply Co., Chalmette, La.

Chatfield Manufacturing Co., Carthage, Ohio.

Coal-tar Products Company of New York.

Clintock & Irvine Co., Pittsburgh, Pa.

Dominion Tar and Chemical Company, Sidney, Nova Scotia.

Diem & Wing Paper Co., Cincinnati, Ohio.

Denver Gas & Electric Co., Denver, Colo.

International Creosoting & Construction Co., Galveston, Texas.

C. Lembcke & Company, New York City.

J. F. Lewis Manufacturing Co., Chicago, 111.

National Aniline & Chemical Co., New York City.

Nashville Chemical Co., Nashville, Tenn.

Pehlam Bay Chemical Co., Mount Vernon, N. Y.

Pacific Creosoting Co., Seattle, Wash.

Republic Creosoting Co., Minneapolis, Minn.

Semet-Solvay Company, Kingsley, Ala.

Southern Roofing Company, Atlanta.

United Gas Improvement Co., Philadelphia, Pa.

Utah Light & Railway Co., Ogden, Utah.

Warren Brothers, Cambridge, Mass.

Western Electric Company, Salt Lake City, Utah.

Zopher Mills, 91 Williams St., Brooklyn, N. Y.

LIST OF WOOD PRESERVING PLANTS IN THE UNITED STATES

EASTERN STATES

Location of plant

Managing company

Year

built

No.

of re-

torts

Diam.

retorts

(in.)

Length

retorts

(feet)

Long Island City, N. Y.

Eppinger & Russell Co

1878

4

72

100

Rome, N. Y

Federal Creo Co

1910

2

84

150

Bound Brook, N. J. . . .

Federal Creo. Co

1909

1

84

150

Newark, N. J

American Creosoting Co . .

1906

2

78

105

Paterson, N. J

Federal Creo. Co

1909

1

84

150

Maurer, N. J

Barber Asphalt Pav. Co

1905

4

72

115

Port Reading, N. J....

P. & R. R. R., C. R. R. of N. J.. .

1912

2

88

140

Greenwich, Pa

Penna. R. R.. . .

1910

2

72

132

Mt. Union, Pa

Penna. R. R. . .

1909

1

72

132

Bradford Jc., Pa

Pittsburgh Wd Pres Co

1911

1

84

132

Bradford, Pa

Buell, near Norfolk, Va

Buff., Roch. & Pgh. R. R

U S Wood Pres Co

1910

1907

1

2

75

78

95

150

Buell, near Norfolk.Va.

Norfolk, Va

Norfolk Creosoting Co

Atlantic Creo & Wood Preserving

1896

1905

4

1

1

1

78

78

84

78

100

105

125

62

Co

78

82

Portsmouth, Va

Green Spring, W. Va...

Wyckoff Pipe & Creo. Co

Balto. & Ohio R. R

1901

1881

1912

2

78

74

84

126

102

132

256 THE PRESERVATION OF STRUCTURAL TIMBER

SOUTHERN STATES

Location of plant

Managing company

Year

built

No.

of re-

torts

Diam.

retorts

(in.)

Length

retorts

(feet)

Gainesville, Fla

Atlantic Coast Line R. R.

1912

2

74

138

Pensacola, Fla

Southern Pav. Con. Co.

1912

1

72

90

Jacksonville, Fla

Eppinger & Russell Co.

1909

3

84

130

Hull, Fla

Charlotte Harbor and Nor. Ry.

1912

1

74

73

Macon, Ga

Co.

Central of Ga. R. R. Co

1912

2

84

116

Atlanta, Ga

Southern Wd. Pres. Co

1908

1

72

70

Ensley, Ala

Mobile, Ala

Pioneer Lum. & Creo. Co

Republic Creosoting Co

1911

1906

1

2

74

74

76

130

McAdory, Ala

Southport, near New

Tennessee Coal, Iron and Rail-

road Co.

American Creosote Wks

1909

1

1

72

84

65

172

Orleans, La.

New Orleans, La. . . .

New Orleans Wd Pr Co

1901

1888

1

1

108

72

172

125

Slidell, La

Shreveport, La

Southern Creosoting Co

Shreveport Creo. Co

1879

1902

1910

1

2

2

84

72

84

150

100

134

Winnfield, La

Louisiana Creo. Co

1906

1

72

126

Bogalusa, La

Colonial Creo. Co

1

72

80

Grenada, Miss

Ayer & Lord Tie Co

1912

1904

2

4

72

74

134

128

Gulf port, Miss

Gulfport Creo. Co

1906

2

84

120

Gautier, Miss

W. Pascagoula Creo. Wks

1876

1

72

119

Louisville, Miss

Argenta, Ark

American Creo. Wks

Ayer & Lord Tie Co

1903

1912

1907

2

1

4

72

108

74

115

172

132

Texarkana, Ark

Beaumont, Tex

Int. Creo. & Con. Co

Int. Creo. & Con. Co

1902

1892

1

1

114

72

165

125

Denison, Tex

Texarkana, Tex

'

Mo. Kan. & Tex. Ry. Co. of Texas

Nat. Lum. & Creo. Co

1897

1909

1910

1

4

2

108

72

84

140

108

132

Houston, Tex

Nat. Lum. & Creo. Co

1912

4

72

120

Houston, Tex

Somerville, Tex

Tex. &N. O. R. R. Co

A., T. & S. F. R. R

1890

1906

5

5

72

74

112

132

Hugo, Okla

American Creo. Co

1907

1915

2

2

84

84

134

121

Galveston, Tex

Guthrie, Ky

Galveston Creo. Co

L. & H. R. R. Co

1905

1913

1

2

72

84

100

133

APPENDICES

257

CENTRAL STATES

Location of plant

Managing company

Year

built

No.

of re-

torts

Diam.

retorts

(in.)

Length

retorts

(feet)

Toledo, Ohio

Federal Creo Co

1909

3

84

134

Toledo, Ohio

Jennison-Wright Co

1910

2

72

130

Orrville, Ohio

Ohio Wood Pres. Co

1912

1

84

132

Cincinnati, Ohio

Indianapolis, Ind

Terre Haute, Ind

Terre Haute, Ind

Bloomington, Ind

Columbus, Ind

Comp. Wd. Pres. Co

Republic Creo. Co

Indiana Zinc-Creo. Co

Chicago Creosoting Co

Indiana Creosoting Co

Indianapolis, Columbia <fe South-

1909

1903

1904

1912

1907

1909

1

1

2

2

1

1

72

74

72

132

84

72

76

130

120

20

134

45

Evansville, Ind

Waukegan, 111

Carbondale, 111

ern Trac. Co.

Indiana Tie Co

Chicago Creosoting Co

Ayer & Lord Tie Co

1907

1907

2

2

4

72

72

72

110

134

122

Marion, 111

Madison, 111

American Creo. Co

Kettle River Co

1902

1907

1909

4

2

4

74

84

84

132

134

135

Galesburg, 111

C., B. <k Q. R. R

1907

5

74

132

Mt. Vernon, 111

T. J. Moss Tie Co

1

74

132

Metropolis, 111

Joppa, 111

Joyce-Watkins Co

Indiana Tie Co

1899

1914

1909

1

1

2

72

72

72

117

132

110

Bay City, Mich

Escanaba, Mich

Minneapolis, Minn

Sandstone, Minn

Brainerd, Minn

Michigan Pipe Co

Chi. & N. W. Ry. Co

Republic Creosoting Co

Kettle River Co

Nor. Pac Ry

1893

1903

1905

1904

1907

1

3

2

2

2

72

72

74

72

84

42

112

130

120

134

Springfield, Mo

American Creo. Co

1907

2

84

134

Kansas City, Mo

Topeka, Kansas

Indianapolis, Ind

Reed City, Mich

American Creo. Co

Union Pacific R. R

American Creo. Co

Mich. Wood Pres. Co

1907

1909

1913

1913

2

2

2

1

84

73

64

90

134

117

134

90

17

258 THE PRESERVATION OF STRUCTURAL TIMBER

ROCKY MOUNTAIN AND PACIFIC STATES

Location of plant

Managing company

Year

built

No.

of re-

torts

Diam.

retorts

(in.)

Length

retorts

(feet)

Somers, Mont

Paradise, Mont

Butte, Mont

Sheridan, Wyo

Laramie, Wyo

Great Northern Ry. Co

Nor. Pac. Ry. Co

Anaconda Cop. Min. Co

C., B. & Q. R. R. Co

Union Pacific R. R. Co

1901

1907

1910

1899

1903

4

2

1

2

2

72

84

72

74

73

110

134

43

132

117

Kellogg, Idaho

Bunker Hill and Sullivan Mining

Co

1908

1

84

10

Tacoma, Wash

St. P. & Tacoma Lum. Co

1912

1

84

130

Yardley Wash

Western Wd Pres Co

1912

1

84

65

Lowell Wash

Puget Sd Wd Pres Co

1

1

84

72

117

83

Seattle Wash

J. M. Colman Co

1895

1912

1

72

52

Eagle Harbor, Wash. .

Pacific Creosoting Co

1884

1906

3

8

75

73

120

125

Wyeth Ore

Oregon-Washington R. R. and

1904

4

72

114

St Helens, Ore

Nav. Co.

St. Helens Creo. Co

1912

2

84

136

Latham Ore..

Southern Pac. R. R

1893

2

72

112

Burlington (near Port-

land) Ore

1912

1

72

65

Alamogordo, N. Mex.

El. Paso & S.W.R.R. Co

19C2

2

72

106

A T & S F Ry Co

1908

2

74

132

Oakland Cal

So Pacific Ry

1

72

108

So Pacific Ry

1889

1907

1

2

72

72

138

112

San Pedro, Cal

Cimarron, N. M

S. P. L. A. AS. L. R. R

Continental T. & L. Co

1908

1913

2

1

72

84

117

87

OPEN-TANK PLANTS

Location of plant

Managing company

Year

built

Lowell, Mass

Otis Allen & Son

1848

Portsmouth, N H

Otis Allen & Son

1875

Nanticoke, Pa.

Del., Lack. & West. R. R. Coal Mining

1907

New Philadelphia, Pa

Dept.

Phila. and Reading Coal and Iron Co .

1908

New Orleans, La . . . ...

Reeves Co

1910

Keokuk, Iowa ....

U. S. Wood Pres. Plant

1908

Milan, 111

U. S. Wood Pres. Plant

1908

U S Wood Pres Plant

1908

Fountain City, Wis

Cleveland Ohio

U. S. Wood Pres. Plant

City of Cleveland .

1908

1909

Lead, S. Dak

Homestake Mining Co

1908

Portland Ore

Carbolineum W. P. Co

1910

Lowell, Wash

Puget Sound W. P. Co

1895

Butte, Mont. .

Anaconda Cop. Min. Co

1909

Fresno, Cal. . . .

San Joaquin Light & Power Co

1910

San Miguel, Cal

Oakland, Cal

Newark, N. J

Mobile, Ala

San Joaquin Light & Power Co

So. Pac. Ry. Co

Public Service Corporation

Republic Creo. Co

1910

1899

1906

1912

Chicago, 111

Naugle Pole & Tie Co

1912

Minneapolis, Minn

Page & Hill Co

1911

Milwaukee Ry & Light Co

1910

Spokane, Wash

Carbolineum Heating & Paving Co. . .

1910

Priest River, Ida

Lindsley Bros

1912

Loa Angeles, Cal

Pac. Light & Power Co

1912

APPENDICES

259

LIST OF "FIREPROOFING" PLANTS IN THE UNITED STATES

New York, N. Y Standard Wood Treating Company.

New York, N. Y Electric Fireproofmg Company.

THE AMOUNT OF WOOD PRESERVATIVES USED IN THE

UNITED STATES

Creosote and zinc chloride are by far the preservatives con-

sumed in largest quantities in the United States for preserving

timber. About 3,000,000 gallons of other preservatives such as

crude oil, carbolineum, and other varieties of preservatives de-

rived from coal-tar were used in 1912. In addition, copper sul-

phate, mercuric chloride, and aluminum sulphate were also used,

the exact amounts being unknown. The consumption of creo-

sote and zinc chloride for preserving wood is shown in Table 38.

TABLE 38. THE APPROXIMATE AMOUNT OF CREOSOTE AND ZINC CHLORIDE

CONSUMED IN THE UNITED STATES 1

Years

Creosote (gallons)

Zinc chloride

(pounds) ;

all domestic

Domestic

Foreign

Total

1908

17,360,000

38,640,000

56,000,000

19,000,000

1909

13,862,000

: '.7,569,000

,51,431,000

16,215,000

1910

18,184,000

45,082,000

63,266,000

16,803,000

1911

21,511,000

51,517,000

73,027,000

16,360,000

1912

31,136,000

52,531,000

83,666,000

20,752,000

1913

41,700,167

66,673,192

108,373,359

26,466,803

1914

28,026,870

51,307,736

79,334,606

27,212,259

AMOUNT OF TIMBER TREATED IN THE UNITED STATES

The amount of timber treated annually in the United States is

shown in Table 39.

In addition to the amount shown in Table 39, a considerable

amount of wood was treated with other preservatives such as

carbolineum, crude oil, and various coal-tar products sold under

a variety of trade names, but the exact amount of which is

unknown.

American Wood Preservers' Association Proceedings, 1915.

260 THE PRESERVATION OF STRUCTURAL TIMBER

III

III

Ill

111

\* i w

2 S

J e

I 'I

O o

OS O C OS CD

8 3 S S 8

t~iOCCOcDCOOi-iC<lO>COSO b GO OS OS CO CO 00 rf

CO^HCSCSOS5OeOCOcoCSt~iCaSTt< CO d I-H I-H <N OO 1C GO

t^t^OSi-lOSiOCOOOSOCOCOCOCO COO 00 Tf OS CO CO <N

OJ"!OSCOjacOO>OSOOOS

CO OS O CO GO -H 00 CO \_

<N (N <N <N rH

\* d 1-1 00 O SO

5D CO CO (N i-l O

t~ O O5 I O \*

\*-\* CO rH CO" W 10 oj 05

\* OS I-H 00 OS Tt<

CO O CD C^ -i ^H

t>;\_ O OS ^H If- OS

58 i-H 00 i-^ CO Tf t>T

TJH t t> <C o 00

iO CO

U? d O

OS CO i ( CO 00

(N TJ\* O\* t^ CO CO

1C (N OS b- 1C

ic co o\* i> oo\* e3

1C O CO CO 00

03 OO t>\*

(N 10 TJJ\_

OS Id CO 00

SS3S

rH CN ^H

CO -^ CO OS 00 b

C<1 O CD CO (N 1C

\*". \*l M . i M .

.-lOst^TtiO^ c3 03 c3

i-H CO CM

N OS CO

10 T i>

l^ OS M T}< CO CO

oo c t- co co o o:

^Ot^|N. CJI-Ht^t^t^t^^H

OStN (M>CCOCOCCO

CO \* (N OS t>- OS O

o ic c os t^ rn ic co

\*\*\*\*"

^ M Tf< OO

lO "H rH CC

cc -" o

00\* CO\* O 00\* CO\* 1-\* 00\* CO\* 1C\* <N\* 00" 1C\* tC O\* ^H\*

MCClC COtOOOS(NCO

O 83

Itlllll

3- a <\*> a c5

Irlzil-i

'o'o'o Put

III -g

SS S O

J3.fl.fl

c c c

JI'J

,0.0 .

o o o

APPENDICES 261

About 4,000,000 feet of lumber are also given a "fireproof"

treatment each year.

LIST OF COMPANIES IN THE UNITED STATES EQUIPPED

TO BUILD WOOD-PRESERVING PLANTS

Allis-Chalmers Mfg. Co Milwaukee, Wis.

Basshor T. C. Co Baltimore, Md.

Bovaird & Seyfaud Mfg. Co Bradford, Pa.

Casey & Hedges Chattanooga, Tenn.

Chicago Bridge & Iron Co Chicago, 111.

Coeur d'Alene Iron Works Wallace, Idaho.

Cole, R. D Newan, Ga.

Erie Heating Co Chicago, 111.

Fairbanks Morse Co St. Paul, Minn.

Graves (Wm.)Tank Works East Chicago, Ind.

Gravier Tank Works Galveston, Tex.

Jacobs (S.) & Sons Birmingham, Ala.

Lockett (A.M.) & Co New Orleans, La.

Logan Iron Works Brooklyn, N. Y.

Manitowoc Engineering Works Manitowoc, Wis.

Mine-Smelter Supply Co Denver, Colo.

Mohr (John) & Sons Chicago, 111.

Moran Bros Seattle, Wash.

Morris Sherman Mfg. Co Chattanooga, Tenn.

National Boiler & Sheet Iron Works Indianapolis, Ind.

Payne & Joubert New Orleans, La.

Petroleum Iron Works Sharon, Pa.

Power & Mining Machinery Co Milwaukee, Wis.

Reeves Bros. Co Alliance, Ohio.

Struther- Wells Co Warren, Pa.

Union Iron Works San Francisco, Cal.

Vogt (Henry) Louisville, Ky.

Williamette Iron & Steel Works Portland, Ore.

SPECIFICATIONS FOR THE ANALYSIS OF CREOSOTE

A number of specifications for analyzing creosote oil have been

proposed and are in force. Perhaps the best known and the one

in most extended use is that adopted by the American Railway

Engineering Association, which reads as follows:

SPECIFICATIONS FOR ANALYSIS OF CREOSOTE OIL APPROVED

BY THE AMERICAN RAILWAY ENGINEERING ASSOCIATION

1. The sample taken for analysis shall be strictly average of the

whole bulk of oil to be tested. The oil shall be completely

262 THE PRESERVATION OF STRUCTURAL TIMBER

liquefied and well mixed before samples are taken. Whenever

possible a drip sample of not less than 2 gallons shall be taken

commencing after the oil has started to run freely. When this

cannot be done, as for instance, in large storage tanks, samples

shall be taken from various depths in the tank by means of

a tube or bottle, the number of samples depending on local

conditions.

For taking samples during the process of treatment a

sample of the oil shall be taken from the storage tank about 1

foot from the bottom of the tank before the cylinder is filled, and,

where possible, a sample directly from the cylinder during the

process of treatment. For this purpose a thermometer well

may be used.

The sample to be analyzed shall be thoroughly liquefied by

heating until no crystals adhere to a glass stirring rod, and also

well shaken, after which one-half shall be taken for analysis and

the balance reserved as check test.

2. The apparatus for distilling the creosote shall consist of a

stoppered glass retort similar to that shown in diagram having

a capacity as nearly as can be obtained of 8 ounces up to the

bend of the neck when the bottom of the retort and the mouth

of the off-take are in the same plane. A nitrogen filled mercury

thermometer of good standard make, divided into full degrees

Centigrade, shall be used in connection therewith. In order to

insure uniform results for comparative purposes, the length of

the thermometer bulb shall be one-half (1/2) inch; but in no case

shall a thermometer with a long bulb be used. The bulb of the

retort and at least two (2) in. of the neck shall be and remain

covered with a shield of heavy asbestos paper, shaped as shown

in diagram, during the entire process of distillation, so as to

prevent heat radiation, and between the bottom of the retort and

the flame of the lamp or burner two sheets of wire gauze, each

20-mesh fine, and at least 6 inches square, shall be placed.

The flame shall be protected against air currents. An ordi-

nary tin can, from which a portion of the bottom and all of the top

have been removed, placed on a support attached to the burner, as

shown in diagram, will answer the purpose.

3. Before beginning the distillation the retort shall be care-

fully weighed and exactly 100 grams of oil placed therein,

the same being weighed in the retort. The thermometer

shall be inserted in the retort with the lower end of the bulb

APPENDICES 263

1/2 inch from the surface of the oil and the condensing tube

attached to the retort by a tight cork joint. The distance be-

tween the bulb of the thermometer and the end of the condensing

tube shall not be less than 20 nor more than 24 inches, and

during the progress of the distillation the thermometer shall

remain in the position originally placed.

The distillate shall be collected in weighed bottles and all

fractions determined by weight. Reports shall be made on the

following fractions:

to 170 C. 235 to 270 C.

170 to 200 C. 270 to 315 C.

200 to 210 C. 315 to 355 C.

210 to 235 C. Residue above 355 C.

Reports shall be made on individual fractions. In making

such reports it is to be distinctly understood that these frac-

tions do not necessarily refer to individual compounds. In other

words, the fraction between 210 and 235 will not neces-

sarily be all naphthalene, but will probably contain a number of

other compounds.

The distillation shall be a continuous one, and should require

about 45 minutes.

When any measurable quantity of water is present in the oil

the distillation shall be stopped, the oil separated from the water

and returned to the retort, when the distillation shall be re-

commenced and the previous readings discarded. In obtaining

water-free oil, it is desirable to free about 300 to 600 c.c. of the oil

by using a large retort and using 100 grams of the water-free oil

for the final distillation. In the final report as to fractions,

a correction shall be made of the amount of water remaining, so

that the report may be made on the basis of dry oil.

4. In order to determine the specific gravity of any oil, simply

heat the oil in a water bath until it is completely liquid. A

glass stirring rod dipped into the liquid should show no solid

particle on the rod when the same is withdrawn from the oil.

When completely liquid, it should be stirred thoroughly and the

hydrometer cylinder filled, which has previously been warmed.

Insert a specific gravity hydrometer of good make, taking care

that the hydrometer does not touch the sides or bottom of the

cylinder when the reading is taken. This reading should prefer-

ably be taken when the oil is at 38 C. (100 F.), because

264 THE PRESERVATION OF STRUCTURAL TIMBER

at this temperature almost all oils are completely fluid.

Where contract requirements specify a specific gravity at a dif-

ferent temperature, such gravity is obtained by multiplying

0.0008 by the number of degrees Centigrade, or 0.00044 by the

number of degrees Fahrenheit, the oil is found to be above the

temperature required by the contract, and adding the product to

the observed gravity.

If it is desired to make further chemical analysis for the

determination of the low- boiling tar acids and the naphthalene,

the following method is recommended, tentatively:

"For the determination of low-boiling tar acids, the fractions

should be placed in a separating funnel, to which should be added

about 30 c.c. of the 15 percent hot sodium hydroxide solution,

vigorously shaken, and allowed to stand until the dissolved

phenols separate out and may be drawn off, after which repeat

with successive sodium hydroxide solutions 20 c.c. each time until

no phenols are left (the sodium solution comes off clear). The

phenols so obtained should be separated by the addition of a 25

percent sulphuric acid, slowly stirred in. When this reaction is

complete, the phenols so obtained should be decanted and

weighed."

The Committee on Wood Preservation of the National Electric

Light Association was not entirely satisfied with the above speci-

fications for analysis and drew up a set of its own. 1 In the opin-

ion of this committee the above specification does not fully meet

present requirements because "it is generally admitted by chem-

ists that the retort is an antiquated piece of apparatus," and fur-

thermore the test is not sufficiently stringent to detect adultera-

tions. The specification for analysis which this committee rec-

ommended reads as follows:

ANALYSIS SPECIFICATIONS (NATIONAL ELECTRIC LIGHT

ASSOCIATION)

General

"The apparatus employed in making the distillation and other

tests required under these specifications shall conform in general

to that shown on drawings Fig 26 (Fig. No. a) and Fig. 27 at-

tached to and forming a part of these specifications, except that

a five percent (5%) variation from the dimensions given is

1 Report of Committee on Preservative Treatment of Poles and Cross

Arms, National Electric Light Association, 1911.

APPENDICES

265

allowed. The distilling apparatus must be assembled as in draw-

ing Fig 28. As further defining the requirements in this re-

spect, the following description of certain parts and manner of

assembling is given:

(a) Flask. The flask required is a Lunge side neck distilling

flask, provided with a trap (Fig. 26), and having a tubular

side neck thirty centimeters (30 cm.) long placed close to the

bulb. The flask must have a capacity of three hundred cubic

Distilling Flask

FIG. 26.

upport for Flask

Thermometer

FIG. 27.

centimeters (300 c.c.) when filled to a height equal to its maximum

horizontal diameter.

(6) Thermometer. The thermometer must be made of Jena

glass and be nitrogen filled and graduated at intervals of one

millimeter (1 mm.) in single degrees Centigrade, the scale reading

to plus four hundred degrees Centigrade (+ 400 C.).

(c) Receivers. The glass receivers may be of any convenient

size and shape; the flask shown on drawing No. 27c is, however,

recommended.

266 THE PRESERVATION OF STRUCTURAL TIMBER

(d) Shield. A shield ten centimeters (10 cm.) in diameter

and eight centimeters (8 cm.) high, made of asbestos, must

be provided (Fig. 27).

(e) Support for Flask. The flask must rest on an asbestos

board one-half centimeter (0.5 cm.) in thickness by fifteen centi-

meters (15 cm.) in diameter, a hole five centimeters (5 cm.) in

diameter being cut in the center of the board. The board shall

rest on a ring stand (Fig. 28).

ASSEMBLING APPARATUS

The apparatus must be assembled as shown in figure No.

28. The thermometer passes through a cork in the top of the

FIG. 28.

flask and is so placed that the top of the bulb of the thermometer

is on a line with the bottom of the tubular outlet. The asbestos

shield is placed around the bulb of the flask and the flask mounted

on the asbestos board supported on the ring stand as shown on

drawing Fig. 28.

Distillation Test

Two hundred grams of the oil shall be used in the analysis,

this amount being weighed on a balance sensitive to one milligram

(1 mg.), in the following manner:

APPENDICES 267

The flask is first placed on the pan of the balance and weighed,

and the weight recorded. Without removing the flask, a two

hundred (200) gram weight is placed on the opposite pan of the

balance and a sufficient quantity of the oil dropped into the

flask through a long stem funnel to bring the pans into equi-

librium. The flask is then removed from the balance and set up

as in drawing Fig. 28. Care must be taken that the cork

stopper carrying the thermometer fits tightly into place. The

flask should be heated, preferably by a Bunsen or other standard

form of gas burner. The distillation shall be continuous and

at such a rate that two (2) drops of oil per second (5 c.c. per

minute) leaves the end of the tubular after the thermometer

registers two hundred and five degrees Centigrade (205 C.),

or after all of the water has been driven off. The percentage

weights of the following fractions shall be recorded:

To 205 C.

To 235 C.

To 245 C.

To 270 C.

To 315 C.

To 360 C.

DETERMINATION OF FREE CARBON

The apparatus required is as follows:

Knorr Condenser.

Knorr Flask.

C. S. & S. No. 575 Filter Papers, 15 cm. diameter.

Wire for supporting filter papers.

Ten grams of the oil should be weighed into a small beaker

and digested with C. P. toluol on a steam bath. A cylindrical

filter cup is prepared by folding two of the papers around a rod

about five-eights of an inch (5/8") in diameter. The inner

paper should be cut to fourteen centimeters (14 cm.) diameter.

Prior to using the filter papers, they should have been extracted

with benzol to render them fat free. The filter cup is dried at

one hundred (100) to one hundred and ten (110) degrees

Centigrade and weighed in a weighing bottle.

The contents of the beaker are now decanted through the

filter cup, and the beaker washed with hot toluol, passing all

washings through the cup. The filtrate should be passed through

268 THE PRESERVATION OF STRUCTURAL TIMBER

the filter a second time, the residue washed two or three times

with hot C. P. benzol and transferred to the extraction ap-

paratus, in which C. P. benzol is used as the solvent, which

solvent is vaporized by means of a steam or water bath. The

extraction is continued until the filtrate is colorless. The filter

cup is then removed, dried and weighed in the weighing bottle.

C. P. benzol followed by chloroform may be used instead of

C. P. toluol followed by C. P. benzol.

Precautions. In removing filter paper from the extraction

apparatus see that no particles of mercury find their way into the

precipitate. To prevent splashing, the filter paper should be

elevated as near to the outlet of the condenser as possible. A

good precaution is to cover the top of the filter cup with a round

cap of filter paper.

Sulphonation Test

Ten cubic centimeters (10 c.c.) of the total distillate to three

hundred and fifteen degrees Centigrade (315 C.) are placed

in a flask and warmed with four (4) to five (5) volumes of con-

centrated sulphuric acid to sixty degrees Centigrade (60 C.) and

the whole transferred to a graduated separatory funnel. The

flask is rinsed three times with small quantities of concentrated

sulphuric acid and the rinsings added to the contents of the

funnel, which is then stoppered and shaken, cautiously at first,

afterward vigorously, for at least fifteen (15) minutes and al-

lowed to stand over night. The acid is then carefully drawn

down into the graduated portion of the funnel to within two

cubic centimeters (2 c.c.) of where the unsulphonated residue

shows. If no unsulphonated residue is visible the acid should

be drawn down to two cubic centimeters (2 c.c.). In either case

the test should be carried further as follows: Add about twenty

cubic centimeters (20 c.c.) of water and allow to stand for 1/2

hour. Then draw off the water as close as possible without

drawing off any supernatant oil or emulsion, and ten cubic

centimeters (10 c.c.) of strong sulphuric acid and allow to stand

for from fifteen to twenty (15 to 20) minutes. Any unsulphonated

residue will now separate out clear and give a distinct reading.

If under two-tenths of a cubic centimeter (0.2 c.c.) it should be

drawn down into the narrow part of the funnel to just above

the stop-cock, where it can be estimated to one one-hundredth

of a cubic centimeter (0.01 c.c.) The volume of residue thus

obtained is calculated to the original oil.

APPENDICES 269

DETERMINATION OF TAR ACIDS

One hundred cubic centimeters (100 c.c.) of the total distillate

to three hundred and fifteen degrees (315 C.), to which forty

cubic centimeters (40 c.c.) of a solution of sodium hydroxide having

a specific gravity of one and fifteen hundredths (1.15) is added, is

warmed slightly and placed in a separatory funnel. The mixture

is vigorously shaken, allowed to stand until the oil and soda solu-

tions separate and the soda solution containing most of the tar

acids drawn off. A second and third extraction is then made

in the same manner, using thirty (30) and twenty (20) cubic centi-

meters of the soda solution, respectively. The three alkaline

extracts are united in a two hundred cubic centimeter (200 c.c.)

graduated cylinder and acidified with dilute sulphuric acid. The

mixture is then allowed to cool and the volume of tar acids noted.

The results shown should be calculated to the original oil.

COKE TEST

In making the coke determination, hard glass bulbs are to be

used. The test is to be carried out as follows:

Warm the bulb slightly to drive off all moisture, cool in a

desiccator and weigh. Again heat the bulb by placing it momen-

tarily in an open Bunsen flame and place the tubular side neck

underneath the surface of the oil to be tested and allow the bulb

to cool until sufficient oil is sucked in to fill the bulb about two-

thirds full. Any globules of oil sticking to the inside of the tubu-

lar should be drawn into the bulb by shaking or expelled by slight-

ly heating it, and the outer surface should be carefully wiped off

and the bulb re- weighed. This procedure will give about one gram

of oil. Cut a strip of thin asbestos paper about one-quarter inch

wide and about 1 inch long, place it around the neck of the bulb and

catch the two free ends close up to the neck with a pair of crucible

tongs. The oil should then be distilled off as in making an ordi-

nary oil distillation, starting with a very low flame and conducting

the distillation as fast as can be maintained without spurting.

When oil ceases to come over, the heat should be increased

until the highest temperature of the Bunsen flame is attained, the

whole bulb being heated red hot until evolution of gas ceases

and any carbon sticking to the outside of the tubular is completely

burned off. The bulb should then be cooled in a desiccator and

weighed and the percentage of coke residue calculated to water-

free oil.

270 THE PRESERVATION OF STRUCTURAL TIMBER

Still more refined specifications for analyzing creosote oil,

especially as regards the method of distillation and sulphonation

residues, are those in use by the U. S. Forest Service. In the

author's opinion these tests are much more exact than either of

the two just given. They are, however, more troublesome and

hence expensive to make, but where accuracy is desired, their use

is recommended.

SPECIFICATIONS FOR ANALYZING CREOSOTE USED BY THE

U. S. FOREST SERVICE 1

(Note. All temperatures referred to in the following are on

the centigrade scale.)

SPECIFIC GRAVITY OF THE WHOLE OIL

"The perfectly liquefied oil is poured into a hydrometer cylinder,

and, at a temperature of 60, the specific gravity is read with

hydrometer standardized against water at 60.

The somewhat prevalent method of determining specific

gravity with a hydrometer standardized at 15 and then calculat-

ing the results from the temperature of the determination back

to 15 is roundabout and involves the expression of the specific

gravity of creosote in the liquid condition at a temperatuie at

which the oil does not exist as a liquid. The method is illogical

and open to inaccuracies. With very rare exceptions creosotes

are all liquid at 60, and if the weight of a unit volume of the oil

at 60 is compared with the weight of a unit volume of water at 60,

a true specific gravity is obtained. . . .

FRACTIONAL DISTILLATION

The Hempel distilling flask of resistance glass is employed.

The empty flask is tared, 250 grams of melted, well-shaken oil

introduced, the platinum-wire plug and the glass beads put in

place, and a second weight taken. The thermometer is then

inserted in the flask, so that the first emergent reading is 200.

The flask is supported on an asbestos board with a slightly ir-

regular opening of very nearly the largest diameter of the flask.

A condensing tube is employed and the fractions are collected in

1 Circular 206, United States Forest Service.

APPENDICES 271

tared flasks. The distillation is run at the rate of 1 drop per

second, and fractions collected between the following tempera-

tures: Up to 170, 170-205, 205-225, 225-235, 235-245,

245-255, 255-285, 285-295, 295-305, 305-320, and if

feasible, 320-360.

The characters of the fractions and their weights are recorded

and the results plotted as a curve, in which the ordinates are per-

centages by weight and the abscissae temperatures. . . .

When the distillation has reached the 225 point, an asbestos-

board box should be placed around the distilling flask, to cover

the bulb, but leave the Hempel column exposed. Drafts upon

the distilling apparatus must be avoided.

INDEX OF REFRACTION'

The indices of refraction of the different fractions between 235

and 305 are determined at 60 in a refractometer with light

compensation. The results are plotted with temperatures as

abscissae and indices of refraction as ordinates.

"index of Refraction. The index of refraction is the ratio between the

sines of the angles of incidence and of refraction of light, expressed by the

formula ^ = -. L 5' where -~ means the index of refraction referred to

sodium light, 7 equals the angle of incidence, and R the angle of refraction.

The index of refraction varies with the temperature, but is constant for

any given oil at a stated temperature. In making measurements of the

index of refraction of the different fractions of a creosote distillation, it was

necessary to make the measurements at 60. The determinations were

made with an Abbe refractometer provided with a light compensator. By

means of this instrument the index of refraction may be read with great

accuracy, and the measurement is one of the most exact which can be

applied to such an oil.

"Sulphonation Test. In contradistinction to the hydrocarbons of the

paraffin series, those of the aromatic series react with concentrated sulphuric

acid with marked ease. The products of this reaction, in which a sulpho

group or groups replace hydrogen in the aromatic compound, are called

sulphonic acids and the process is known as sulphonation. For example,

the reaction with benzene would be C 6 H 6 + H 2 SO 4 = C 6 H 6 SO 3 H + H 2 O.

The sulphonic acids are characterized by their solubility in water. If a

fraction from the distillation of a creosote oil be treated under proper con-

ditions with concentrated sulphuric acid, it will be converted into a mixture

of sulphonic acids, which will readily dissolve in water. If, however, there

are paraffin bodies present they will not be attacked to the same degree as

1 The following explanation of the index of refraction and of the sulphona-

tion test is taken from U. S. Forest Service Circular 112:

272 THE PRESERVATION OF STRUCTURAL TIMBER

the aromatic hydrocarbons, and when the products of the sulphonation are

treated with water the paraffin components will remain as a residual oil.

In applying this test to creosote oils it has been found that the most

information is obtained by using it on the higher boiling fractions."

Specific Gravity. The specific gravities of the fractions

between 235 and 305 are determined by means of specific-

gravity bottles. These bottles are filled at 60 and the weights

referred to water at the same temperature. The results are

plotted as a curve in which the ordinates are specific gravities

at 60 and the abscissae temperatures.

Sulphonation Tests. 1 Ten cubic centimeters of the fraction of

creosote to be tested are measured into a Babcock milk bottle.

To this is added 40 c.c. of 37 times normal acid, 10 c.c. at a

time. The bottle with its contents is shaken for 2 minutes after

each addition of 10 c.c. of acid. After all the acid has been

added the bottle is kept at a constant temperature of from 98

to 100 C. for 1 hour, during which time it is shaken vigorously

every 10 minutes. At the end of an hour the bottle is re-

moved, cooled, and filled to the top of the graduation with ordi-

nary sulphuric acid, and then whirled for 5 minutes in a Babcock

separator. The unsulphonated residue is then read off from the

graduations. The reading multiplied by 2 gives percent by vol-

ume directly. (Each graduation equals one two-hundredth of a

cubic centimeter.)

In well-equipped chemical laboratories the usual steam-jacket

ovens, capable of maintaining a temperature of from 98 to 100

C., will keep the reaction mixture of the sulphuric acid and creo-

sote at the proper temperature. It frequently happens, however,

that creosotes are analyzed in a laboratory equipped only for that

purpose, and for such cases a special steam bath or oven can be

made by any tinsmith at small cost. It is essential that the

chamber be of sufficient size to completely contain (under the

cover) the Babcock bottle; otherwise the exact dimensions of the

steam bath are unimportant, and any two vessels of suitable di-

mensions, which are at hand or can most readily be obtained, may

be utilized in its construction.

Tar Acids. Fifty cubic centimeters of the creosote under analy-

sis are measured at 60 into a small distilling flask by a pipette.

The oil is distilled as completely as possible without breaking the

distilling bulb, and the distillate is caught in a short-stemmed

1 U. S. Forest Service Circular 191.

APPENDICES 273

100 c.c. separating funnel. At the end of the distillation 25

c.c. of boiling hot 15 percent sodium hydroxide are added to

the distillate and the mixture thoroughly shaken. The alkaline

extract is then drawn off into a 100 c.c. cylinder and 25 c.c.

more of hot sodium hydroxide added. After extracting with

this second portion for 5 minutes, with frequent shaking, the

solutions are allowed to separate and the alkaline extract added

to the first portion in the cylinder. A third extraction is made

with 15 c.c. of alkali. The total alkaline extract is cooled,

acidified with sulphuric acid, thoroughly shaken, brought to 60,

and the volume of supernatant oil read off.

Water. After weighing the first two fractions of a fractional

distillation they are united in a small separatory funnel and any

water which is present is separated from the oil and its amount

accurately determined. If particular accuracy is required in

the estimation of the water it may be done by the Marcusson xylol

distillation method. 1 "

METHOD FOR DETERMINING THE AMOUNT OF MOISTURE IN

CREOSOTE AND CREOSOTED WOOD

"The creosoted wood, in the form of borings, turnings, saw-

dust, or similar material, is quickly weighed and transferred to

the 250 c.c. Erlenmeyer flask, and 75 c.c. of water-saturated

xylol 2 added. The basin in which the flask is placed should

be two-thirds full of melted paraffin or of some heavy lubricat-

ing oil such as cylinder oil. The bath is heated and the distil-

lation continued until the distillate comes in clear drops. At

the end of the distillation the condenser should be rinsed with

the stream from a wash bottle containing xylol. After it has

stood for a short time, the emulsion of water and xylol separates,

giving two clear liquid layers. The mean of the readings at the

top and bottom of the meniscus, between xylol and water, gives

the volume of water, and the percentage of moisture in the

wood is obtained by multiplying the water volume by 4. There

are always small globules of water adhering to the sides of the

graduate in the portion filled with xylol. These are readily

1 Forest Service Circular 134, The Estimation of Moisture in Creosoted

Wood, A. L. Dean.

2 Water-saturated xylol is readily prepared by heating a mixture of water

and xylol with frequent shakings and subsequently removing the water in a

separatory funnel.

18

274 THE PRESERVATION OF STRUCTURAL TIMBER

scrubbed down with a piece of rubber tube on the end of a piece

of glass tubing, which is better for this purpose than the rod com-

monly used for a ''policeman."

It is important that the distillation be carried on slowly to

allow all the water in the wood to volatilize. The finer the wood

particles, the more rapid may be the distillation. If rather

coarse material is used, the distillation should not run faster than 1

drop per second.

The apparatus shown in Fig. 29 was devised for making

large numbers of moisture estimations on creosoted wood. The

FIG. 29. Apparatus for making several moisture determinations in

creosoted wood.

compaitments of the paraffin bath are larger than necessary for

the 250 c.c. flasks, but the apparatus was designed so that larger

flasks might be employed when considerable wood was to be used,

for purposes of investigation, to obtain very accurate results.

Marcusson's method is well adapted to the estimation of water

in creosote oils. The apparatus used for creosoted wood is satis-

factory for creosote, except that a wire gauze should be sub-

stitute for the paraffin bath. The 250 cubic centimeter flask

is weighed, 50 cubic centimeters of melted, well-shaken creosote

introduced, and a second weight taken. Seventy-five cubic

centimeters of water-saturated xylol are added and the mixture

distilled until the water ceases to come off. The percentage of

water is obtained by dividing the volume (cubic centimeters)

of water in the distillate by the weight (grams) of creosote. The

results are likely to run one or two-tenths of a percent too low.

APPENDICES

275

THE DURABILITY OF AMERICAN TIMBERS

The durability of timber is so exceedingly variable that any

general table is of value solely in securing an approximate idea of

the durability of one wood as compared with another and not

as an index of what the wood will actually do under all con-

ditions. For example, timber used in the South and exposed to

the weather will decay quicker than the same timber placed under

similar conditions in the North; timber cut from a given tree

may be more durable than timber cut from the same kind of

a tree which grew next to it; timber placed in one kind of soil

may be far more durable than the same timber placed in another

soil, etc. All of these variations have been discussed in the

preceding chapters. Taking all of them into consideration and

striking an average for common practice, Table 40 has been

compiled. It naturally follows that these figures are of chief

value in comparing the relative durability of one kind of

untreated wood with another, and it is believed that most of them

are approximately correct. As more authentic data is collected,

it is quite likely that changes in the estimated durability will be

necessary.

TABLE 40. THE ESTIMATED DURABILITY OF UNTREATED WOOD IN CONTACT

WITH THE SOIL

Class A. Very durable

woods.

(These woods will probably

last more than 25 years

in contact with the soil)

Class B. Durable woods.

(These woods will probably

last more than 10 years but

less than 25 years in contact

with the soil)

Class C. Nondurable woods.

(These woods will probably

last less than 10 years in

contact with the soil)

Black locust

Chestnut

Aspen

Northern white cedar

Southern white cedar

Ash

Western red cedar

Douglas fir

Beech

Cypress

Red. gum (heart)

Birch

Mulberry

White oaks

Basswood

Osage orange

Longleaf pine

Balsam

Redwood

Cottonwood

Elm

Red gum (sap)

Blue gum

Hemlock

Red oaks

Western yellow pine

Lodgepole pine

Loblolly pine

Sitka spruce

White spruce

Sycamore

Tamarack

Tupelo

276 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Henry Aitken, Darroch,

Falkirk, Scotland

Preserving timber.

352,216

Nov. 9, 1886

Hugo Akerhielm, Chicago,

111.

Improvement in compositions for

preserving wood.

185,058

Dec. 5, 1876

Augustus, Allen, Cass Co.,

Mich.

Improved method of preventing

decay in the timbers of bridges,

buildings, etc.

106,647

Aug. 23, 1870

Edw. R. Andrews, New

York, N. Y.

Composition for preserving wood.

247,234

Sept. 20, 1881

W. C. Andrews, New

York, N. Y.

Vulcanizing wood.

430,055

June 10, 1890

Philip F. Apfel, Seattle,

Wash, and Ralph L. Earn-

est, Portland, Ore.

Protecting piles against worms, etc.

883,507

Mar. 31, 1908

Oliver App, Blue Mound,

111.

Improvement in compositions for

preserving wood.

219,377

Sept. 9, 1879

R. W. Archer, Corpus

Christi, Tex.

Improvement in processes for pre-

serving wood.

153,515

July 28, 1874

McKenzie Arnn, Bristol,

Va.

Composition for coloring and pre-

serving wood.

601,767

Apr. 5, 1898

McKenzie Arnn, Bristol,

Va.

Wood preserving compound.

633,778

Sept. 26, 1890

Chas. Arnoudts, Seattle,

Wash.

Composition for preserving piles

from teredo, etc.

526,552

Sept. 25, 1894

Max Bachert, New York,

N. Y.

Apparatus for saturating wood.

666,915

Jan. 29, 1901

Max Bachert, New York,

N. Y. & D. W. O'Neil,

Newark, N. J.

Preserved wood and process of pre-

paring same.

602,713

Apr. 19, 1898

Thurman Bailey, Brid-

port, Vt.

Improvement in processes for pre-

paring wood for roofing.

125,251

Apr. 2, 1872

Jas. J. Barr, Slidell, La.

Automatic retort-cover.

857,148

June 18, 1907

Jas. R. Bate, Cincinnati,

Ohio.

Process of preserving wood.

522,284

July 3, 1894.

Frank Batter, Marshfield,

Ore.

Apparatus for preserving piles.

452,513

May 19, 1891

J. H. Bauer, Scranton, Pa.

Improvement in processes for treat-

ing sounding-boards.

149,426

Apr. 7, 1874

S. Beer, New York, N. Y.

Improved process for seasoning and

preserving wood.

73,565

Jan. 21, 1868

APPENDICES

List of U. S. Patents on Wood Preservation. Continued

277

Nane and address

inventor

Title of patent

No. of

patent

Date issued

Andries Bevier, New York,

N. Y.

Method of preserving wood.

681,032

Aug. 20, 1901

V. W. Blanchard, Brid-

port, Vt.

Improved mode of preserving wood.

94,704

Sept. 14, 1869

Guido Blenio, New York,

N. Y.

Process for fireproofing wood.

779,761

Jan. 10, 1905

A. T. Bleyley, Conception,

Mo.

Improvement in processes for pre-

serving burial cases, etc.

175,329

Mar. 28, 1876

H. H. Blodgett, Omaha,

Nebr.

Wood-preserving composition

606,702

July 5, 1898

John B. Blythe, Bordeaux,

France.

Treating railway-sleepers.

313,912

Mar. 17, 1885

John B. Blythe, Bordeaux,

France.

Apparatus for treating, seasoning

and preserving timber.

313,913

Mar. 17, 1885

John Borner, Rahway,

N. J.

Apparatus for impregnating wood.

703,522

July 1, 1902

S. B. Boulton, Cooped

Hall, County of Hertford,

England.

Treating timber with preservative

fluids.

247,602

Sept. 27, 1881

S. B. Boulton, London,

Eng.

Method of preserving timber.

360,947

Apr. 12, 1887

Edmond Bouvier, Pensa-

cola, Fla.

Improvement in solutions for pre-

serving timber.

218,659

Aug. 19, 1879

Joachim Brenner, Gain-

farn, Austria-Hungary.

Process of dyeing wood.

755,993

Mar. 29, 1904

Jas. P. Bridge, Boston,

Mass.

Improved compound for preserving

wood, leather, etc.

86,808

Feb. 9, 1869

Robert E. Bright, Gren-

ada, Miss.

Apparatus for treating timber.

887,583

May 12, 1908

H. R. Brinkerhoff, Oak-

park, 111.

Waterproofed wood and method of

making same.

686,582

Nov. 12, 1901

Albert Brisbane, New

York, N. Y.

Improvement in processes for treat-

ing wood for paving and other

purposes

155,788

Oct. 13, 1874

Wm. Brisley, and Wm. S.

Finch, Toronto, Canada

Composition for preserving wood.

359,384

Mar. 15, 1887

Chaa. Brown, Albemarle

Co., Va.

Improved process of preserving tim-

ber from decay.

83,758

Nov. 3, 1868

278 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Saml. P. Brown, Washing-

ton, D. C.

Improvement in preserving wood.

115,931

June 13, 1871

W. C. Bruson, Chicago,

111.

Compound for preserving wood.

251,346

Dec. 27, 1881

Walter Buehler, Minne-

apolis, Minn.

Preserving wood.

899,237

Sept. 22, 1908

Walter Buehler, Minne-

apolis, Minn.

Preserving wood.

899,480

Sept. 22, 1908

Wm. W. Bunnell, Thomas-

ville, Nebr.

Compound for preserving wood.

238,341

Mar. 1, 1881

Peter Grant Burns, St.

Louis, Mo.

Wood-preserving apparatus.

864,092

Aug. 20, 1907

Rudolph G. Burstenbin-

der, Hamburg, Germany

Preservation of wood.

266,092

Oct. 17, 1882

Jas. J. Byers, Gulfport,

Miss.

Wood saturating and coating

apparatus.

858,950

July 2, 1907

Saml. Cabot, Jr., Boston,

Mass.

Improvement in processes for pre-

serving wood.

184,141

Nov. 7, 1876

Saml Cabot, Brookline,

Mass.

Compound for bleaching and pre-

serving wood.

515,191

Feb. 20, 1894

Jas. Calkins, New York,

N. Y.

Improvement in preserving wood.

78,514

June 2, 1868

Jos. P. Card, St. Louis,

Mo.

Preserving wood.

254,274

Feb. 28, 1882

Jos. P. Card, St. Louis,

Mo.

Process of preserving wood.

317,440

May 5, 1885

J. P. Card, Chicago, 111.

Solution for preserving wood.

419,582

Jan. 14, 1890

Jos. B. Card, Chicago, 111.

Method of preserving wood.

815,404

Mar. 20, 1906

C. S. Chamberlain, Oak-

land, Cal.

Wood-preserving apparatus.

621,774

Mar. 21, 1899

Octave Chanute, Kansas

City, Mo.

Preserving timbered structures.

430,068

June 10, 1890

Octave Chanute, Chicago,

111.

Process of preserving wood.

688,932

Dec. 17, 1901

S. B. Chapman, Abbeville,

Ga.

Solution for preserving lumber.

764,913

July 12, 1904

APPENDICES 279

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Sydney B. Chapman, Sky-

land, N. C.

Treated wood and process of pro-

ducing the same.

839,551

Dec. 25,1906

Emile Chevigny

Composition of matter for painting

and preserving wood.

824,794

July 3, 1906

William B. Chisholm,

Charleston, S. C.

Preservation of wood.

802,680

Oct. 24, 1905

Chas. E. Clarke, Geo.

Hadley, and J. C. Clif-

ford, Buffalo, N. Y.

Improved mode of preserving wood.

67,104

July 23, 1867

E. W. Clark, Hartford,

Conn.

Improved solution for the treat-

ment of wood.

94,869

Sept. 14, 1869

Seth L. Cole, Brooklyn,

N. Y.

Improvement in preserving wood.

124,419

Mar. 12, 1872

Seth L. Cole, Brooklyn,

N. Y.

Improvement in processes of pre-

serving wood.

124,420

Mar. 12, 1872

Edw. Z. Collings, Camden,

N. J.

Apparatus for preserving wood.

310,880

Jan. 20, 1885

Edw. Z. Collings, Camden,

N. J.

Method of preserving wood.

317,730

May 12, 1885

Jos. H Connelly, Alle-

gheny, Pa.

Preserved wood.

243,062

June 21, 1881

Silas Constant, Peekskill,

N. Y. and John Smith,

Brooklyn, N. Y.

Improvement in seasoning and pre-

serving wood.

65,545

Mar. 17, 1867

Silas Constant, Peekskill,

and John Smith, Brook-

lyn, N. Y.

Improvement in seasoning and pre-

serving wood.

116,274

June 27, 1871

Geo. C. Cowles, Bay Mills,

Mich.

Undressed lumber and process of

preserving same.

746,678

Dec. 15, 1903

E. L. Cowling, Boston,

Mass.

Improvement in preserving wood.

84,733

Dec. 8, 1868

C. M. Cresson, Philadel-

phia, Pa.

Improvement in preserving wood.

79,554

July 7, 1868

C. M. Cresson, Philadel-

phia, Pa.

Improvement in seasoning and pre-

serving wood.

109,872

Dec. 6, 1870

C. M. Cresson, Philadel-

phia, Pa.

Improvement in seasoning and pre-

serving wood.

109,873

Dec 6, 1870

Wm. Cross, Brisbane,

Queensland.

Method of preserving timber.

643,762

Feb. 20, 1900

280 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

W. G. Curtis, and J. D.

Isaacs, San Francisco,

Cal.

Process of preserving timber.

545,222

Aug. 27, 1895

W. G. Curtis, and J. D.

Isaacs, San Francisco,

Cal.

Process of preserving wood.

11,515

Dec. 3, 1895

A. R. Davis, Cambridge,

Mass.

Improved process of treating wood

for covering walls.

74,056

Feb. 4, 1868

Edw. Davis, Redondo,

Cal.

Pliable-flange pile-casing.

464,960

Dec. 15, 1891

J. C. Day, Hackettstown,

N. J.

Improvement in seasoning and pre-

serving wood.

100,380

Mar. 1, 1870

J. A. De Cew, Montreal,

Can.

Wood preservative.

1,140,127

May 18, 1915

J. A. Deghuee, New York,

N. Y.

Method of preserving and water-

proofing wood.

802,739

Oct. 24, 1905

E. J. De Smedt, New

York, N. Y.

Improved composition for pre-

serving timber and wood.

100,608

Mar. 8, 1870

B. H. Detwiler and

S. G. Van Gilder, Wil-

liamsport Pa.

Improvement in preserving woods.

111,045

Jan. 17, 1871

Fred Dixon, London, Eng.

Improvement in processes for treat-

ing wood.

181,651

Aug. 29,1876

B. V. B. Dixon and J. P.

Card, St. Louis, Mo.

Preserving wood.

239,033

Mar. 22, 1881

John Dolbeer, San Fran-

cisco, Cal.

Apparatus for steaming piles.

333,204

Dec. 29, 1885

H. C. Dorr, San Francisco,

Cal.

Compound for preserving wood.

293,955

Feb. 19, 1884

C. J. Doyle, Philadelphia,

Pa.

Apparatus for preserving wood.

645,793

Mar. 20, 1900

J. A. Draper, Shaftsbury,

Vt.

Improvement in compounds for

preserving wood.

152,620

June 30, 1874

Wm. Dripps, Coatesville,

Pa.

Improved process of restoring and

preserving decaying railroad ties.

96,405

Nov. 2, 1869

P. H. Dudley, New York,

N. Y.

Apparatus for impregnating wood.

381,682

Apr. 24, 1888

P. H. Dudley, New York,

N. Y.

Preserving railway-ties.

406,566

July 9, 1889

Firmin Dufouric, New

York, N. Y.

Improvement in processes for pre-

serving wood.

150,841

May, 12 1874

APPENDICES 281

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

P. F. Dundon, San Fran-

cisco, Cal.

Timber-treating process.

753,052

Feb. 23, 1904

Chas. J. Eames, New

York, N. Y.

Improvement in processes for pre-

serving wood.

134,133

Dec. 24, 1872

Edw. Earle, Savannah, Ga.

Improvement in the mode of pre-

serving timber.

934

Sept. 20, 1838

H. F. Eckert. San Fran-

cisco, Cal.

Apparatus for preserving timber.

509,724

Nov. 28, 1893

H. L. Eddy, Geneva, N. Y.

Improved method of preserving

wood.

53,217

Mar. 13, 1866

W. E. Everette, Tacoma,

Wash.

Method of preserving wood.

801,859

Oct. 17, 1905

L. S. Fales, Monmouth

Junction, N. J.

Improvement in compounds for

preserving wood.

142,453

Sept. 2, 1873

H. W. Fawcett, Titusville,

Pa. and Thomson Mo

Gowan, Meredith, Pa.

Improvement in preserving wood.

123,009

Jan. 23, 1872

J. S. George, Ferndale,

Wash.

Injecting apparatus.

765,312

July 19, 1904

Joa. L. Ferrell, Philadelphia,

Pa.

Method of and apparatus for fire-

proofing wood, etc.

620,114

Feb. 28, 1899

Jos. L. Ferrell, Philadelphia,

Pa.

Process of impregnating wood.

694,956

Mar. 11, 1902

Jos. L. Ferrell, Philadelphia.

Pa.

Process of impregnating wood with

fireproofing preservatives, etc.

695,450

Mar. 18, 1902

Jos. L. Ferrell,

Philadelphia, Pa.

Fireproofed wood and method of

of making same.

695,678

Mar. 18, 1902

Jos. L. Ferrell,

Philadelphia, Pa.

Fireproofing compound and method

of making same.

695,679

Mar. 18, 1902

Jos. L. Ferrell,

Philadelphia, Pa.

Apparatus for impregnating wood.

716,400

Dec. 23, 1902

Jos. L. Ferrell,

Philadelphia, Pa.

Apparatus for impregnating wood.

716,401

Dec. 23, 1902

Jos. L. Ferrell,

Philadelphia, Pa.

Apparatus for impregnating wood.

727,928

May 12, 1903

Jos. L. Ferrell,

Philadelphia. Pa.

Fireproof wood, etc., and the art of

making same.

728,452

May 19, 1903

282 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Jos. L. Ferrell,

Philadelphia, Pa.

Process of fireproofing wood.

767,514

Aug. 16, 1904

Lewis Feuchtwanger,

New' York, N. Y.

Improvement in preserving wood.

123,467

Feb. 6, 1872

J. W. Fielder,

Princeton, N. J.

Improvement in apparatus for pre-

serving wood by the Robbins

Process.

115,946

June 13, 1871

Henry Flad,

St. Louis, Mo.

Method of seasoning wood.

231,783

Aug. 31, 1880

Henry Flad,

St. Louis, Mo.

Process of preserving wood.

231,784

Aug. 31, 1880

Henry Flad,

St. Louis, Mo.

Apparatus for the treatment of

timber for preserving it.

253,361

Feb. 7, 1882

Webster Flockton,

Bermondsey, Eng

Inprovement in metallic solutions

for the preservation of timber.

130

Feb. 16, 1837

H. P. Folsom, and Howard

Jones, Circleville, Ohio.

Sterilized erected pole.

837,820

Dec. 4, 1906

Henry Page Folsom and

Howard Jones,

Circleville, Ohio.

Sterilizing and preserving posts

and poles.

894,619

July 28, 1908

B. S. Foreman,

Morrison, 111.

Improvement in preserving wood,

railroad ties, etc.

43,191

June 21, 1864

B. S. Foreman,

Improvement in preserving wood,

railroad ties, etc.

4,360

May 2, 1871

E. M. Fowler,

New York, N. Y.

Improvement in preserving blocks

of wood.

112,136

Feb. 28, 1871

J. D. Francks,

Hanover, Germany.

Process for preserving wood.

231,419

Aug. 24, 1880

Chas. S. Friedman,

Philadelphia, Pa.

Method of creosoting wood.

693,697

Feb. 18, 1902

Wm. T. Garratt,

San Francisco, Cal. and

S. J. Lynch,

Santa Cruz, Cal.

Improvement in protecting wooden

piles.

215,600

May 20, 1879

Louis Cathman,

Washington, D. C.

Drying apparatus.

766,340

Aug. 2, 1904

Jas. H. Gatling,

Murfreesborough, N. C.

Improvement in treating the timber

of old field pines.

113,158

Mar. 28, 1871

APPENDICES

List of U. S. Patents on Wood Preservation. Continued

283

Name and address of

inventor

Title of patent

No. of

patent

Date issued

J. W. Geibel,

Loysburg, Pa.

Process of removing sap, etc., from

wood.

825,819

July 10, 1906

Joseph F. Geisler,

New York, N. Y.

Fireproofing and preserving wood.

560,614

May 19, 1896

Jos. F. Geisler,

New York, N. Y.

Process of fireproofing and preserv-

ing wood.

675,826

June 4, 1901

Jos. F. Geisler,

New York, N. Y.

Process of fireproofing wood.

679,739

Aug. 6, 1901

J. S. George,

Newport, Cre.

Method of preserving timber.

533,587

Feb. 5, 1895

P. H. Gerhard,

Austin, Tex.

Apparatus for treating timber.

794,605

July 11, 1905

John Knowlea and

Robert Gilbert,

London, Eng.

Method of preserving timber and

other vegetable products.

391

Sept. 21, 1837

C. C. & G. E. Gilman,

Eldora, Iowa.

Fireproofing building materials.

560,580

May 19, 1896

J. T. Gilmer,

Pensacola, Fla.

Sap and gum extractor.

858,380

July 2, 1907

J. L. Gilnxore,

Minneapolis, Minn.

Apparatus for creosoting the ends

of poles.

797,275

Aug. 15, 1905

Edw. Gold,

Vancouver, Can.

Method of protecting piles.

686,282

Nov. 12, 1901

A. P. Goodell, Detroit,

Mich.

Process of preserving wood.

1,134,044

Mar. 30, 1915

A. J. Goodwin,

New Smyrna, Fla.

Impregnating wood, etc., with

copper.

414,111

Oct. 29, 1889

Geo. Win. Gordon,

Philadelphia, Pa.

Process of preserving wood.

751,981

Feb. 9, 1904

Aug. Gotthilf,

New York, N. Y.

Improvement in the method of pro-

tecting timber from destruction by

worms, dry rot or other processes

of spontaneous decay.

232

June 14, 1837

Wm. D. Grimshaw,

New York, N. Y.

Improvement in processes and ap-

paratus for preserving and curing

wood.

218,624

Aug. 19, 1879

Gustaf Grondal,

Djursholm, Sweden.

Channel-furnace for treating wood.

245,162

Oct. 31, 1905

Hugo Gronwald,

Berlin, Germany.

Process of preserving cork.

273,645

Sept. 11, 1906

284 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Hugo Gronwald,

Berlin, Germany.

Process of preserving cork.

830,831

Sept. 11, 1906

Tomaso Guissani,

Milan, Italy.

Process of preserving wood.

707,224

Aug. 19, 1902

Tomaso Guissani,

Milan, Italy.

Apparatus for impregnating wood.

713,630

Nov. 13, 1902

Stuart Gwynn,

New York, N. Y.

Improved process of saturating

wood, cloth, paper, etc., with

paraffine.

52,788

Feb. 20, 1866

Erwin Hagen,

St. Louis, Mo.

Preserving wood.

246,762

Sept. 6, 1831

Francis Hall,

Tacoma, Wash.

Method of preserving wood.

506,493

Oct. 10, 1893

Wm. A. Hall,

New York, N. Y.

Art of coloring and fireproofing

wood.

961,123

June 14, 1910

Alex, Hamar,

Hungary, Austria.

.Improvement in preserving wood

from decay.

48,636

July 4, 1865

Alex, Hamar,

Hungary, Austria.

Improvement in preserving timber.

51,528

Dec. 12, 1865

Louis Hanson,

Wilmington, N. C.

Apparatus for preserving and creo-

soting wood.

722,505

Mar. 10, 1903

Ludvig Hansen and

Andrew Smith,

Wilmington, N. C.

Apparatus for creosoting wood.

316,961

May 5, 1885

Ludvig Hansen and

Andrew Smith,

Wilmington, N. C.

Process for preserving wood.

317,129

May 5, 1885

Ludvig Hansen and

Andrew Smith,

Wilmington, N. C.

Wood-preserving apparatus.

322,819

July 21, 1885

Thos. Hanvey,

Lancaster, N. Y.

Improvement in preparing and

preserving wood.

62,956

Mar. 19, 1867

Smith T. Harding,

Morrison, 111.

Improved compound for preserv-

ing wood.

68,069

Aug. 27, 1867

Louis Harmyer,

Cincinnati, Ohio.

Improved composition for preserv-

ing wood, metal, canvas, etc.

73,246

Jan. 14, 1868

S. E. Haskin,

Avoca, N. Y.

Method of vulcanizing wood.

399,196

Mar. 5, 1889

APPENDICES 285

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

S. E. Haskin,

Avoca, N. Y.

Process of and apparatus for vul-

canizing wood.

488,967

Dec. 27, 1892

Fritz Hasselmann,

Rapfelburg, Germany.

Method of impregnating wood.

580,488

April 13, 1897

Fritz Hasselmann,

Munich-Nymphenburg,

Ger.

Method of impregnating wood.

626,538

June 6, 1899

Hermann Haupt,

Philadelphia, Pa.

Improvement in drying, preserving,

and coloring wood or other fibrous

material.

99,186

Jan. 25, 1870

Robt. T. Havens,

Wilmington, Ohio.

Improved process for preparing

wood for boots and shoes.

54,339

May 1, 1866

Joshua R. Hayes,

Washington, D. C.

Improvement in preserving wood.

107,904

Oct. 4, 1870

Ira Hayford,

Boston, Mass.

Improvement in the process and

apparatus for treating wood.

101,012

Mar. 22, 1870

Ira Hayford,

Boston, Mass.

Improvement in processes and ap-

paratus for treating wood.

127,482

June 4, 1872

Ira Hayford,

Boston, Mass.

Improvement in apparatus and

processes for preserving wood.

194,773

Sept. 4, 1877

Wm. Hayman,

Taunton, Mass.

Improvement in compositions for

preserving wood.

110,652

Jan. 3, 1871

Theo. Wm. Heinemann,

New York, N. Y.

Improved mode of purifying, sea-

soning, and preserving wood.

76,757

Apr. 14, 1868

Theo. Wm. Heinemann,

New York, N. Y.

Improved method of seasoning and

preserving wood.

94,204

Aug. 17, 1869

T. W. Heinemann,

New York, N. Y.

Improved process and apparatus

for preserving wood.

95,474

Oct. 5, 1869

Hubert, Higgins,

Cambridge, Eng.

Apparatus for impregnating and

seasoning wood.

695,152

Mar. 11, 1902

Arthur Holmes,

Cortland, N. Y.

Improvement in preserving wood

from decay.

62,334

Feb. 26, 1876

Ira Holmes,

Moscow, N. Y.

Improvement in compounds for

preserving wood.

124,358

Mar. 5, 1872

H. L. Houghton,

Morrison, 111.

Improved composition for harden-

ing and preserving wood.

65,674

June 11, 1867

Chas. Howard,

New York, N. Y.

Process of and apparatus for satu-

rating wood.

557,271

Mar. 31, 1896

286 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Chas. Howard,

New York, N. Y.

Process for preserving wood.

899,400

Sept. 22, 1908

Wm. Howe,

Seattle, Wash.

Pile-protector.

900,929

Oct. 13, 1908

Frank A. Howig,

San Francisco, Cal.

Improvement in production of

wooden bottle-stoppers and bungs.

197,220

Nov. 20, 1877

Pierre Hugon,

Paris, France.

Improvement in apparatus for car-

bonizing wood.

48,882

July 18, 1865

D. W. Hunt,

San Francisco.Cal.

Improved machine for kyanizing

wood.

91,848

June 22, 1869

David W. Hunt,

San Francisco, Cal.

Improvement in machines for kyan-

izing wood.

6,848

Jan. 11, 1876

John Huntington,

Cleveland, Ohio.

Improvement in devices for impreg-

nating timber with antiseptic fluid.

171,135

Dec. 14, 1875

John Huntington,

Cleveland, Ohio.

Improvement in devices for impreg-

nating timber with antiseptic

fluids.

171,136

Dec. 14, 1875

Warren Iddings,

Warren, Ohio.

Preserving and hardening wood.

398,619

Feb. 26, 1889

B. A. Jeager,

Bower's Station, Pa.

Improved compound for preserving

wood.

81,172

Aug. 18, 1868

Paul Jaeger,

Esslingen, Germany.

Method of and apparatus for im-

pregnating and dyeing wood.

578,516

Mar. 9, 1897

B. H. Jenks,

Bridesburg, Pa.

Improved process for coloring wood.

55,110

May 29, 1866

B. H. Jenka,

Bridesburg, Pa.

Improved mode of treating wood

for the manufacture of carding-

engines.

55,111

May 29, 1866

B. H. Jenks,

Bridesburg, Pa.

Improved process of seasoning

wood.

58,425

Oct. 2, 1866

Joseph Jones,

New Orleans, La.

Improvement in preserving wood.

118,245

Aug. 18, 1871

Thos. Jones,

Calstock, Eng.

Improvement in processes for pre-

serving wood.

155,191

Sept. 22, 1874

Wm. H. Jones,

Rochester, N. Y.

Improvement in processes of pre-

serving wood.

132,584

Oct. 29, 1872

APPENDICES

List of U. S. Patents on Wood Preservation. Continued

287

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Chas. Karmrodt and

Nicholas Thilmany,

Bonn, Prussia.

Improvement in preserving wood.

132,584

Mar. 30, 1869

Carl Kleinschmidt,

Seattle, Wash.

Wood-preserving compound.

697,632

Apr. 15, 1902

Ernst Koepfer,

Vienna, Austria-Hungary.

Apparatus for impregnating wood.

910,546

Jan. 26, 1909

Franz L. Konrad,

Munster, Germany.

Method of fireproofing wood.

629,861

Aug. 1, 1899

H. E. Kreuter,

Dallas, Tex.

Apparatus for treating timber, rail-

way ties, etc.

249,953

Nov. 22, 1881

Rudolph Kroll,

Spearfish, So. Dak.

Wood preservation by means of

borings in timber to permit the

entrance of air.

727,975

May 12, 1903

George Kron,

Copenhagen, Denmark.

Method of producing liquid-tight

joints for impregnating wood.

256,456

April 19, 1905

Berthold Kuckuck,

Wannsee near Berlin, Ger.

Apparatus for impregnating wood

or other substances.

866,487

Sept. 17, 1907

John Howard Kyan,

Cheltenham, Eng.

Improved mode of preserving tim-

ber and other vegetable sub-

stances from decay.

800

June 23, 1838

Sylvester W. Labrot,

New Orleans, La.

Process of preserving wood.

862,488

Aug. 6, 1907

Jas. Guy La Fonte,

Indianapolis, Ind.

Improvement in treatment of wood

for corset stays, etc.

201,022

Mar. 5, 1878

Fred. E. Lampert,

San Francisco, Cal.

Coating for piles.

454,744

June 23,1891

C. S. Lawrence,

Plainfield, Wis.

Wood-preserving compound.

682,363

Sept. 10, 1901

Fred. Lear,

St. Louis, Mo.

Improvement in coloring and pre-

serving wood.

109,027

Nov. 8, 1870

Fred. Lear,

St. Louis, Mo.

Improvement in preserving, color-

ing, and seasoning wood.

116,969

July 11, 1871

Georg Friedrich Lebioda,

Boulogne-sur-Seine,

France.

Apparatus for dyeing and impreg-

nating wood.

609,442

Aug. 23, 1898

Georg Friedrich Lebioda,

Boulogne-sur-Seine,

France.

Apparatus for impregnating wood.

644,252

Feb. 27, 1900

288 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Georg Friedrich Lebioda,

Boulogne-sur-Seine,

France.

Apparatus for impregnating wood.

655,788

Aug. 14, 1900

Georg Friedrich Lebioda,

Boulogne-sur-Seine,

France.

Apparatus for impregnating wood.

689,317

Dec. 17, 1901

Georg Friedrich Lebioda,

Boul ogne-sur-Seine,

France.

Process of obtaining impregnated

wood.

729,362

May 26, 1903

Chas. T. Lee,

Boston, Mass.

Process of preserving wood.

419,858

663,234

Jan. 21, 1890

Louia L. Le Franc,

Bosc-le-Hard, France.

Manufacture of wooden stoppers.

Dec. 4, 1900

lens P. Lihme,

Cleveland, Ohio.

Preserved wood and process of pre-

paring same.

756,173

Mar. 29, 1904

John T. Lloyd,

New York, N. Y.

Vulcanizing wood.

566,591

Aug. 25, 1896

Fred. A. Lobert,

National City, Cal.

Compound for preserving timber.

546,960

Sept. 24, 1895

Rembrandt Lockwood,

Brooklyn, N. Y.

Improvement in processes of treat-

ing wood.

174,914

Mar. 21, 1876

John Thos. Logan,

Texarkana, Tex.

Process of preserving wood.

831,793

Sept. 25, 1906

J. T. Logan,

Texarkana, Tex.

Apparatus for treating the butt-

ends of logs.

836,592

Nov. 20, 1906

John Loomis,

Jeffersonville, Ind.

Solution for seasoning and pre-

serving wood.

273,861

Mar. 13, 1883

Ira Loughborough,

Pittsford, N. Y.

Apparatus for saturating railroad

ties.

533,543

Feb. 5, 1895

Cuthbert B. Lowry,

Lexington, Ky.

Wood impregnation.

831,450

Sept. 18, 1906

Cuthbert B. Lowry,

Lexington, Ky.,

Richard Bernhard,

Chicago, 111.

Means for withdrawing and con-

densing vapors.

902,097

Oct. 27, 1908

M. A. Luckenbach,

Denver, Col.

Process of treating wood to prevent

decay.

473,705

Apr. 26, 1892

Geo. A. Ludington

Akron, Ohio.

Method of vulcanizing tires in con-

tinuous lengths.

754,078

Mar. 8, 1904

APPENDICES

List of U. S. Patents on Wood Preservation. Continued

289

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Gregory Lukins,

Sweetwater, 111.

Preserving wood.

245,845

Aug. 16, 1881

Antionette Macauley,

Ft. Dodge, Iowa.

Wood-preserving compound.

778,321

Dec. 27, 1904

J. C. Mallonee,

Charleston, S. C.

Process of preserving wood.

386,999

July 31, 1888

Ernat Marmetschke,

Schopfurth near

Eberawalde, Ger.

Method of impregnating timber

and the like.

898,246

Sept. 8, 1908

J. C. Marshall,

Oakland, Cal.

Wood-preserving compound.

259,030

June 6, 1882

J. A. Mathieu,

Detroit, Mich.

Apparatus for preserving railway

ties.

332,097

Dec. 8, 1885

H. G. McGonegal.

Washington, D. C.

Improvement in apparattus for pre-

serving wood.

140,520

July 1, 1873

Jas. McKeon,

Oakland, Cal.

Process of preserving timber.

461,365

Oct. 13, 1891

John McLachlan,

Chicago, 111.

Process of solidifying wood.

575,973

Jan. 26, 1897

A. R. McNair,

New York, N. Y.

Improvement in preserving wood

from decay and mildew.

94,626

Sept. 7, 1869

Wm. K. Miller,

Canton, Ohio.

Improvement in burial cases.

57,545

Aug. 28, 1866

E. P. Morong,

Boston, Mass.

Improvement in preserving wooden

pavements.

134,479

Dec. 31, 1872

L. D. Mott,

Marshalltown, la.

Compound for preserving wood and

metal.

251,918

Jan. 3, 1882

H. G. Mullcr,

San Francisco, Cal.

Preserved wood.

236,065 Dec. 28, 1880

Peter Murray,

Seattle, Wash.

Method of preserving timber.

495,991

Apr. 25, 1893

H. C. Myers,

Cleveland, Ohio.

Method of vulcanizing wood.

537,393

Apr. 9, 1895

Robt. Newell,

Philadelphia, Pa.

Improvement in compounds for

coating wood and other articles to

render them acid proof.

140,530

June 21, 1873

B. R. Nickerson,

San Francisco, Cal.

Improvement in preserving and

hardening wood.

107,620

Sept. 20, 1870

W. W. Norman, Hunter-

ville, Mo.

Apparatus for treating wood.

1,142,611

June 8, 1915

19

290 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Wm. C. Jones,

W. J. R. Stratford,

F. B. Byrnes, and

E. J. Nixon,

Texarkana, Tex.

Process of saturating wood.

216,286

Nov. 7, 1905

Patrick O'Brien,

South Bend, Ind.

Improvement in processes for pre-

paring the surface of wood-work of

carriages.

175,621

Apr. 4, 1876

John Oliver,

Toronto, Can.

Improvement in preserving and

drying lumber.

142,347

Sept. 2, 1873

Geo. Palmer

Littlestown, Pa.

Improvement in preserving wood.

49,146

Aug. 1, 1865

Chas. W. Parker,

Genesee Fork, Pa.

Preserving posts, etc.

378,459

Feb. 28, 1888

Wm. D. Patten,

New York, N. Y.

Fireproofing compound.

802,311

Oct. 17, 1905

Jos. Paul, and

Ira Hayford,

Boston, Mass.

Improved process of treating wood

to preserve, season and give it a

better surface.

95,583

Oct. 5, 1869

Chas. Payne,

South Lambeth, Eng.

Improvement in processes for pre-

serving wood.

7,399

May 28, 1850

Wm. T. Pelton,

New York, N. Y.

Improvement in portable appa-

ratus for preserving wood.

113,338

Apr. 4, 1871

Wm. T. Pelton,

New York, N. Y.

Improvement in apparatus for

seasoning and preserving wood.

124,080

Feb. 27, 1872

Herbert Elmer Percival,

Houston, Tex.

Wood-preserving compound.

891,726

June 23, 1908

Saml. R. Percy,

New York, N. Y.

Preserving wood.

249,856

Nov. 22, 1881

Josef Pfister,

Vienna, Austria-Hungary.

Method of preserving timber.

683,792

Oct. 1, 1901

Josef Pfister,

Vienna, Austria-Hungary.

Process of staining woods.

708,069

Sept. 2, 1903

Josef Pfister,

Vienna, Austria-Hungary.

Apparatus for impregnating or

staining wood.

735,019

July 28, 1903

Geo. Phillips,

Key West, Fla.

Coating for wooden structures.

414,247

Nov. 5, 1889

Geo. Phillips,

Key West, Fla.

Process of preserving wood.

414,249

Nov. 5, 18,89

APPENDICES

List of U. S. Patents on Wood Preservation. Continued

291

Name and address of

inventor

Title of patent

No. of

patent

Date issued

A. M. Pierce,

Brooklyn, N. Y.

Process of fireproofing wood.

737,468

Aug. 25, 1903

Wm. Powell,

Liverpool, Eng.

Vulcanized wood and process of

vulcanizing same.

755,240

Mar. 22, 1904

E. L. Powell, New Orleans,

La.

Preserved timber and method of

making same.

1,151,039

Aug. 24, 1915

Theo. Pridham,

Petersham,

New So. Wales.

Coating for timber.

453,821

June 9, 1891

D. R. Prindle,

East Bethany, N. Y.

Improved process of preserving

wood and timber.

63,300

Mar. 26, 1867

Thos. N. Prudden,

San Francisco, Cal.

Method and apparatus for protect-

ing marine wooden structures.

855,588

June 4, 1907

A. D. Purinton,

Dover, N. H.

Improved composition for setting

posts, timbers, etc.

78,691

June 9, 1868

Geo. Pustkuchen,

Hoboken, N. J.

Improved apparatus for impreg-

nating wood with tar and other

materials.

64,703

May 14, 1867

Jos. W. Putman,

New Orleans, La.

Apparatus for treating wood for

preserving it.

247,947

Oct. 4, 1881

Jos. W. Putman,

New Orleans, La.

Apparatus for treating timber with

antiseptics.

266,516

Oct. 24, 1882

Jos. W. Putman,

New Orleans, La.

Compound for preserving timber.

404,302

May 28, 1889

Jos. W. Putman,

New Orleans, La.

Wood-preserving compound.

405,907

June 25, 1889

Randolph. F. Radebaugh,

Tacoma, Wash.

Process of and apparatus for treat-

ing wooden stopples.

535,770

Mar. 12, 1895

Frederick Ransome,

Ipswich, Great Britain.

Improvement in preserving timber.

55,216

May 29, 1866

John M. Reid,

Allegheny City, Pa.

Improvement in preserving wood.

154,767

Sept. 8, 1874

Peter C. Reilly,

Indianapolis, Ind.

Preserved wood and method of

making same.

901,557

Oct. 20, 1908

Peter C. Reilly,

Indianapolis, Ind.

Preserved wood.

899,904

899,905

Sept. 29, 1908

R. P. Reynolds,

Walla Walla, Wash.

Timber preservative.

792,458

July 13, 1905

H. L. Ricks,

Eureka, Cal.

Method of preserving submeged

timbers.

380,820

Apr. 10, 1888

292 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent I N ' f

| patent

Date issued

Saml. Ringgold, Fla. and

Edw. Earle,

Savannah, Ga.

Improved mode of preserving tim-

ber by boiling the same in lime-

water.

877

Aug. 6, 1838

L. S. Robbing,

New York, N. Y.

Improved process for preserving

wood.

47,132

Apr. 4, 1865

L. S. Robbins,

New York, N. Y.

Improved mode of preserving

telegraph poles.

89,345

Apr. 27, 1869

L. S. Robbins,

New York, N. Y.

Improvement in processes for pre-

serving wood.

165,768

July 20, 1875

L. S. Robbins,

Elizabeth, N. J

Improvement in processes and ap-

paratus for preserving wood or

lumber.

217,022

July 1, 1879

L. S. Robbins,

New York, N. Y.

Preserving wood.

9,512

Dec. 21, 1880

J. G. Robinson,

Brooklyn, Ala.

Fence-post.

655,638

Aug. 7, 1900

W. W. Robinson,

Ripon, Wis.

Process of preserving wood.

294,676

Mar. 4, 1884

H. N. Roge,

Edouard Poret,

Pierre Baffoy, and

Pierre Dupre,

Paris, France.

Improvement in processes of pre-

serving wood and other vegetable

matters.

191,257

May 29, 1877

Jas. Rowe,

San Francisco, Cal.

Composition for protecting piles.

440,832

Nov. 18, 1890

Sam'l. M. Rowe,

Chicago, 111.

Door mechanism for creosoting

tanks.

908,144

Dec. 29, 1908

Karl Rucker,

Zernsdorf, Ger.

Method of fireproofing wood.

691,812

Jan. 28, 1902

Max Ruping,

Charlottenburg, Ger.

Method of impregnating wood.

707,799

709,799

Sept. 23, 1902

Julius Rutgers,

Berlin, Germany.

Wood-impregnating compound and

method of making same.

662,310

Nov. 20, 1900

Emile Sabathe, and

Louis Jourdan,

Paris, France.

Improvement in impregnating

substances with preservative

material.

58,036

Sept. 11, 1866

Thos. H. Sampson

New Orleans, La.

Process of preserving lumber.

403,144

May 14, 1889

APPENDICES

List of U. S. Patents on Wood Preservation. Continued

293

Name and address of

inventor

Title of patent

v \ patent

Date issued

J. L. Samuels,

San Francisco, Cal.

Improved composition for prepar-

ing and hardening wood and pre-

serving the same.

60,794

Jan. 1, 1867

Chr. Schallberger,

Seattle, Wash.

Compound for protecting timber.

678,201

July 9, 1901

Chr. Schallberger,

Vancouver, Can.

Wood-preserving compound.

714,521

Nov. 25, 1902

Julius Schenkel,

Dortmund, Ger.

Process of impregnating wood.

655,459

Aug. 7, 1900

Julius Schenkel,

Dortmund, Ger.

Process of fireproofing wood.

647,428

Apr. 10, 1900

P. Schmidt,

Preserving wood.

4,560

June 6, 1846

Jos. Schneible,

New York, N. Y.

Method of and apparatus for sat-

urating corks.

599,798

Mar. 1, 1898

Chas. A. Seely,

New York, N. Y.

Improved method of impregnating

wood with oleaginous and saline

matters.

69,260

Sept. 24, 1867

Jos. A. Sewall,

Denver, Colo.

Process of preserving wood.

374,208

Dec. 6, 1887

A. J. Sheldon,

Buffalo, N. Y.

Improvement in preserving wood.

106,625

Aug. 23, 1870

Morris Sherman,

Chattanooga, Tenn.

Means for securing heads to boilers,

cylinders, etc.

781,371

Jan. 31, 1905

S. L. Shuffleton,

Seattle, Wash.

Method of protecting wooden piles.

676,704

June 18, 1901

J. E. Siebel,

Chicago, 111.

Improvement in depilating hides

and preserving wood.

116,638

July 4, 1871

H. V. Simpson,

London, Eng.

Fireproofing wood.

646,101

Mar. 27, 1900

H. V. Simpson,

London, Eng.

Process of fireproofing wood.

668,227

Feb. 19, 1901

Archibald J. Sinclair,

Chicago, 111.

Process of coating porous material

with asphalt.

893,391

July 14, 1908

Smith A. Skinner,

Hoosick Falls, N. Y.

Cordage and twine to be used in

binding sheaves of grain.

255,040

Mar. 14, 1882

Bat Smith

Spanish Camp, Tex.

Composition for preserving wood.

244,327

July 12, 1881

294 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Geo. B. Smith,

Philadelphia, Pa

Improvement in apparatus for pre-

serving wood.

160,846

Mar. 16, 1875

Geo. B. Smith,

Philadelphia, Pa.

Improvement in wooden shingles

made fire-proof.

199,001

Jan. 8, 1878

W. B. Smith,

La Fayette, 111.

Improved apparatus for saturating

timber.

62,295

Feb. 19, 1867

W. H. Smith,

Steubenville, Ohio.

Improvement in apparatus for in-

jecting preservative liquids into

wood.

111,784

Feb. 14, 1871

W. L. Smith,

New York, N. Y.

Apparatus for impregnating wood.

711,080

Oct. 14, 1902

P. S. Smout,

Everett, Wash.

Composition for preserving piles

and timber.

806,591

Dec. 5, 1905

Edw. Spaulding,

Brooklyn, N. Y.

Improved process for treating wood.

77,777

May 12, 1868

S. F. Spaulding,

Jerico, Conn.

Improvement in preparing veneers

for butter-boxes.

164,945

June 29, 1875

Geo. Speiz,

Dutch Kills, N. Y.

Preserving wood.

387,375

Aug. 7, 1888

Chas. F. Spicker,

New York, N. Y.

Improvement in coloring and hard-

ening wood.

3,635

June 24, 1844

I. B. Sprague,

Everett, Wash.

Process of preserving wood.

694,212

Feb. 25, 1902

Jas. D. Stanley,

Eastover, S. C.

Device for charring surface of

timber.

361,095

Apr. 12, 1887

Jas. D. Stanley,

Wilmington, N. C.

Apparatus for charring timber.

282,395

July 31, 1883

Jas. D. Stanley,

Eastover, S. C.

Device for charring logs.

361,193

(

Apr. 12, 1887

Chas. W. Stanton,

Mobile, Ala.

Apparatus for steaming wood.

735,608

Aug. 4, 1903

Adolphe Ste. Marie and

Alfred Hoffman,

Lyons, France.

Process of seasoning wood.

675,500

June 4, 1901

Jas. C. Stead,

Jersey City, N. J.

Improvement in apparatus for pre-

serving wood.

148,630

Mar. 17, 1874

L. M. Stern and Edw. M.

Kempner, Buffalo, N. Y.

Apparatus for impregnating wood.

662,104

Nov. 20, 1900

APPENDICES 295

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

F. A. Stevens,

Chicago, 111.

Improvement in apparatus for pre-

serving wood.

102,725

May 3, 1870

Chas. Stollberg,

Toledo, Ohio.

Sheet-metal sap receptacle or

vessel.

857,846

June 25, 1907

Richard Sutphen,

Freehold, N. J.

Improvement in wood-preserving

compositions.

120,009

Oct. 17, 1871

Geo. W. Swan,

San Francisco, Cal.

Improvement in the processes for

softening and toughening blocks of

wood.

142,298

Aug. 26, 1873

Wm. Taggart,

San Francisco, Cal.

Preserving piles.

261,045

July 18, 1882

A. H. Tait,

Jersey City, N. J.

Improvement in preserving wood.

115,784

June 6, 1871

Rudolf Tanczos,

Vienna, Austria-Hungary.

Fireproofing wood.

329,973

Nov. 10, 1885

Chas. Taylor, R. I. Murch-

ison, and Geo. Sharpe,

Melbourne, Victoria.

Composition for preserving timber.

391,209

Oct. 16, 1888

J. H. Taylor,

New York, N. Y.

Improved process of preventing

decay in wood.

70,761

Nov. 12, 1867

Wm. B. Taylor,

Winterpark, Fla.

Composition for preserving wood.

759,938

May 17, 1904

L. N. Teachman,

Lincoln, Nebr.

Wood-preserving composition.

277,810

May 15, 1883

Horace Thayer,

Warsaw, N. Y.

Treating wood for the manufacture

of boxes, cases, etc.

45,537

Dec. 20, 1864

Waldemar Thilmany,

Cleveland, Ohio.

Improvement in apparatus for im-

pregnating timber with antiseptics.

177,770

May 23, 1876

Waldemar Thilmany,

Cleveland, Ohio.

Improvement in processes for pre-

serving timber.

202,678

Apr. 23, 1878

Nathan H. Thomas,

New Orleans, La.

Improvement in processes for pre-

serving wood.

113,706

Apr. 11, 1871

A. B. Tripler,

New Orleans, La.

Improvement in preserving wood.

104,916

June 28, 1870

A. B. Tripler,

New Orleans, La.

Improvement in preserving wood

for railroad ties, etc.

104,917

June 28, 1870

A. B. Tripler,

Philadelphia, Pa.

Improvement in processes for pre-

serving wooden pavements from

rot.

126,592

May 7, 1872

296 THE PRESERVATION OF STRUCTURAL TIMBER

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

A. B. Tripler,

New York, N. Y.

Improvement in processes for stain-

ing wood.

207,630

Sept. 3, 1878

A. B. Tripler,

New York.N. Y.

Improvement i the art of preserv-

ing wood.

208,649

Oct. 1, 1878

Abel D. Tyler,

Worcester, Mass.

Impregnating wood.

553,547

Jan. 28, 1896

Geo. S. Valentine,

Brooklyn, N. Y.

Process of and apparatus for pre-

serving wood by impregnation to

given heights.

285,087

Sept. 18, 1883

Rose L. Valleen,

Seattle, Wash.

Wood-preserving compound.

579,101

Mar. 16, 1897

G. A. Vivien and

Paul C. Vivien,

Honfleur, France.

Improvement in compositions for

preserving wood, coating ships'

bottoms, etc.

123,801

?

J. G. Voorhees,

Aqueduct Mills, N. J.

Improvement in preserving wood.

121,141

Nov. 21, 1871

Martin Voorhees, Prince-

ton, and G. W. N. Custis,

Camden, N. J.

Improved process and apparatus for

seasoning and impregnating wood

with preservative material.

87,226

Feb. 23, 1869

John F. Walter, Jr.,

Brooklyn, N. Y.

Process of drying and seasoning

lumber.

287,351

Oct. 23, 1883

Fred J. Warren,

Newton, Mass.

Wooden block pavement.

794,758

July 18, 1905

Chas. G. Waterbury,

New York, N. Y.

Improvement in processes for hard-

ening and preserving wood.

124,402

Mar. 5, 1872

Ezra Webb,

New York, N. Y.

Improvement in preserving wood.

108,659

Oct. 25, 1870

Peter Welch,

St. Louis, Mo.

Improvement in preserving wood.

129,503

July 16, 1872

Wm. Wellhouse, & Erwin

Hagen, St. Louis, Mo.

Improvement in preserving wood.

216,589

June 17, 1879

Pelag Werni,

Philadelphia, Pa.

Improvement in compounds for

preserving wood.

164,786

June 22, 1875

S. P. Wheeler,

Bridgeport, Conn.

Improvement in the manufacture of

articles of compressed wood.

101,552

Apr. 5, 1870

S. P. Wheeler,

Bridgeport, Conn.

Improved process of treating wood.

101,553

Apr. 5, 1870

APPENDICES 297

List of U. S. Patents on Wood Preservation. Continued

Name and address of

inventor

Title of patent

No. of

patent

Date issued

Thos. B. White,

Warsaw, Mo.

Post-protector.

868,953

Oct. 22, 1907

Sidney S. Williams,

Providence, R. I.

Apparatus for use in treating wood.

904,589

Nov. 24, 1908

Sigmund Willner,

London, Eng.

Apparatus for impregnating wood.

620,627

Mar. 7, 1899

Sigmund Willner,

London, Eng.

Apparatus for impregnating wood.

676,060

June 11, 1901

Sigmund Willner,

New York, N. Y.

Apparatus for impregnating wood.

771,689

Oct. 4, 1904

Sigmund Willner,

Memphis, Tenn.

Apparatus for forcing fluids into

wood.

807,411

Dec. 12, 1905

Sigmund Willner,

Chicago, 111.

Apparatus for injecting chemicals

into logs.

896,785

Aug. 25, 1908

Jas. P. Witherow,

Pittsburg, Pa.

Process of and apparatus for vul-

canizing wood.

446,501

Feb. 17, 1891

Jas. P. Witherow,

Pittsburg, Pa.

Apparatus for vulcanizing wood.

446,500

Feb. 17, 1891

Jas. H. Young,

New, York, N. Y.

Apparatus for impregnating wood.

329,799

Nov. 3, 1885

Wm. Youngblood,

Jamaica, N. Y.

Method of preserving wood.

398,366

Feb. 19, 1889

METHOD OF ANALYZING ZINC CHLORIDE 1

Sampling. A fair average sample must be taken from one out

of every ten drums. Quickly transfer the sample to a clean, dry,

small-mouthed bottle, stopper, hermetically sealed and send to

the laboratory for test. The sample should be marked with a

number or other device, corresponding to the drum or lot from

which it was taken.

Insoluble Basic Zinc Chloride. Pulverize about 10 grams of

the fused zinc chloride by crushing between filter papers, and

quickly transfer to a weighing bottle. This operation must be

performed quickly, owing to the deliquescent nature of the sub-

stance. Weigh the bottle plus the sample, transfer the sample to

500 c.c. of water in a beaker, and weigh the bottle again; the

1 From the Proceedings of the American Wood Preservers' Association.

20

298 THE PRESERVATION OF STRUCTURAL TIMBER

weight of the sample is thus obtained by difference. Cover the

beaker and allow the solution to stand for 12 hours.

Filter through a weighed Gooch crucible into a liter flask.

Wash the residue with cold water until it is free from chlorides.

Dry the basic zinc chloride at 100 C. for about 12 hours and

weigh.

Dilute the filtrate to 1000 c.c. and mix thoroughly.

Ferric Chloride. Take 100 c.c. of the solution, boil, and pre-

cipitate the iron with ammonium hydroxide. Boil off the excess

of ammonia, filter and reject the filtrate. Dissolve the precipi-

tate off the paper with hot dilute hydrochloric acid, and reprecipi-

tate with ammonium hydroxide. Filter through the original

filter paper. Wash the ferric hydroxide 5 to 6 times with hot

water, ignite and weigh as Fe 2 0a.

Factor for metallic iron,.?.

Factor for ferric chloride, 2.032.

Soluble Zinc. Take 50 c.c. of the original solution, and add a

concentrated solution of sodium carbonate, until the solution is

slightly alkaline. Zinc is precipitated as basic carbonate.

Boil for 15 minutes. Decant through a weighed Gooch crucible

and wash by decantation three or four times. Ignite at a high

temperature and weigh as ZnO. Subtract the percentage of

ferric oxide found above.

Factor for metallic zinc, 0.8034.

Factor for zinc chloride, 1.675.

Free Acid. Dissolve 10 grams of the fused chloride in 100 c.c.

of distilled water, and test with methyl orange. If free acid is

present, which is rarely the case, determine by titration with

standard alkali. Factor, chlorine from hydrochloric acid, 0.973.

Total Soluble Chlorine. Titrate 25 c.c. of the solution with

standard silver nitrate, using potassium chromate as indicator.

Subtract the amount of chlorine equivalent to the free hydro-

chloric acid present, if any, and also the chlorine combined as

ferric chloride, and calculate the remainder to zinc chloride,

by using the factor 1.922. The amount of zinc chloride thus

obtained should check with that found from soluble zinc.

RECORDS ON THE LIFE OF TIMBERS 1

Mine Timbers. The U. S. Forest Service treated a large num-

ber of mine timbers according to various methods and placed

1 See pages 304-321 for additional records.

APPENDICES

299

them in the coal mines of the Philadelphia and Reading Coal

and Iron Company at Pottsville, Pa. Inspections were made

Description of Material

Condition of Material

Legend

WMifa Partly Decayed, Still Serviceable

I I Entirely Decayed, to be Bemoved, not Serviceable

I I Removals Due to all Causes

FIG. 30. Comparative condition of treated and untreated loblolly pine

gangway sets placed in the mines of the Philadelphia and Reading Coal

and Iron Co.

each year for 4 years with the results graphically shown in

Fig. 30. 1

Paving Blocks. In January, 1910, the American Association

1 Bulletin 107, U. S. Forest Service.

300

PRESERVATION OF STRUCTURAL TIMBER

3 .

1

"o -3

d ^

8 1

2 'ft

1 5

o "S oj

"3 S

II

I

- ^

1 1 1

'S o

INI

w S

o

a

Method

Treating

a

;>

i

c

|

! \

i

r

3

is

c

i| 1 1 1 1 | 1 5

s r : r r i .

" o "

i

i

scription of Mate

a

P

C3

ca

00

i

i

E-

1

i

C.

3 C

< S

! J

i

i

!

J

c

1

&

fcj D

) "o

1 . a - - - g : :

i = ? g

=1=1 S ,

s - H

5 - fa . S - -3

(i, - > o : :

1

1

fi

Condition

Treatment

1

J

J

5 L

I

3

Q

a

S S

BO

1

I ,. |. -

1

3 g.

o

8

o S J

'e

s u

00 S '

J w

s 2

""^

s

APPENDICES

301

of Creosoted Wood Block Paving Manufacturers sent inquiries

to various American cities to learn their experiences with wood-

block paving. The replies are summarized in Table 41.

TABLE 41. EXPERIENCE OF SOME CITIES WITH WOOD-BLOCK PAVING

City

Years of service

at last inspec-

tion.

Condition

Authority

Brooklyn

7

Good

J. C. Sheridan

New Orleans

31

Blocks good

R. E. Slade

Minneapolis

8

No repairs

E. R. Dutton

St. Louis. . .

7

Excellent

J. C. Travilla

Duluth

5

No repairs

T. F. McGilvray

Des Moines

Toledo

Detroit

4

9

5

No repairs

No repairs

No repairs

J. MacVicar

G. W. Tousori

R. H. McCormick

Grand Rapids, Mich. . .

Q

Excellent

L. W. Anderson

Poles. About 1000 chestnut poles treated in various ways

were set by the U. S. Forest Service in 1905 in cooperation with

the American Telephone and Telegraph Company in Pennsyl-

vania. The results after 5 years of service are shown in Fig. 3 1. 1

Description of Experiment,

Preservative wsed

Method

of

Character

of

Sold as

Material

where Set

Cruibed

Spirittine

Brush

Stone

Arenarius Carbolineui

^^~

^^ m

o.r, i.o 1.5 2.0

Average Loss in Circumferance at Ground Line-Inchei

FIG. 32. Condition of experimental poles in the Poughkeepsie-Newton

Square line 8 years after placement.

A similar line was set up by the U. S. Forest Service in New

Jersey in 1902. All the poles were chestnut. The results after

8 years of service are shown in Fig. 32. 2

The German government has kept record on the life of its

poles when treated by various processes, these records extending

over a period of about 50 years. The general results to date are

shown in Table 42. 3

1 Circular 198, U. S. Forest Service.

2 Circular 198, U. S. Forest Service.

8 Archiv fur Post und Telegraphic.

302 THE PRESERVATION OF STRUCTURAL TIMBER

B

31

I

00^

00 00 O CO

(N 00 rH

3

Oi 00

9s ^

co" i-T

i-T c<T

1-H O

b- TH IO CO

O5 O OS O5

O <N CO OS

CO O5 Tt< t^

(N

00

CO

OS

<N

O

iO O 00 Oi

t\* CO CO l^.

co" \*C

APPENDICES

303

Cross Ties. The reported life of cross-ties in service is given

in Table 43, which is taken from Bulletin 118 of the U. S. Forest

Service.

TABLE 43. REPORTED LIFE OF TIES IN SERVICE

Species

Laid by

How treated

Life

White oaks... .

Spruce

Duluth & Iron Range Ry. Co.

Union Ry. Co. (horse)

Untreated

Burnettized

Years

8 to 9

8 to 20

Pine (probably

f A T & S. F. Ry. Co ..

do

1(H to 15

western yel-

| T & N O Ry Co

do

10 to 11

low, longleaf,

and pinon

pines).

Baltic pine

( H. &T. C. Ry. Co

English railroads

Creosoted

do

19

8 to 18

C. R. R. of N. J

do

15|

Hemlock

C., R. I. & P. Ry. Co

Duluth & Iron Range Ry.Co.

do

Wellhouse

Burnettized

do

10 to 15

8 to 10

H

Tamarack

Beech

Pittsburg, Ft. Wayne & Chi-

cago Ry. Co.

French, German, and Aus-

trian railroads

/ C R R of N. J

Wellhouse

{Untreated

Burnettized

Creosoted

Burnettized

8.84

4 to 5

10 to 12

18 to 30

15 +

Maple

\ German railroads

I Wabash R. R .

do

do

16

5 to 6

Red oaks

1 French and German railroads

Creosoted

19 to 25

REPORTED LIFE OF TREATED TIMBERS IN THE UNITED STATES

In 1915, the author and Mr. C. H. Teesdale undertook a

compilation of records on the life of treated timbers in the United

States. Hundreds of letters of inquiry were sent asking for

reliable data on this subject. The result of this test is sum-

marized in Table 44, which is believed to be the most compre-

hensive compilation on the life of treated timber yet secured.

MOJ O5

!SS5

3

!T M 9\* <n ; ou\*n ^

^|fi.pii

;c^-T5 oo < ft-, H B

O g

1?

2 o

II

I!!

hjius

Q M+-

HUH

|

<<

rf r}< rj<

05 O5 O5

O O

IO l^ 05

"S"S

o o

s s

2

00

OOO5

(US'

43 03

e. a

-j

CD TH\_

00 CO

CO

<N

OOO

ja'S S

Is 3 3

OO O

.3

P

00 O5O '-'

304

g H

> '-6

S"-- p

.= |;|

o wSjj

2 J ^?

8-3 1^

r. f-Bi

22^ '\_' >fl

. . . Bt

\* c- 57

J^ S ^

^ : tfe

^fi ^^

(j -wtf O

i : l^s-dl

j 0^ ^W

^ ilfj;

: a ,!:

J O t-i .'"O " I

3| | fa g| i : :

o

d

CO

: : : PH"

Slightly rail cut

No record of

failures.

10 % removed in

1888; balance

removed at in-

tervals until

1885.

Average life

15.5 years.

Laid in a funnel.

Average life 20

years.

Average life 19

years.

Remainder in

good condition.

L i i

O> O> O>

i rsr

i i i

2m co "-" oJ

. (H . hi . j

S CO \*TH \*O3 \*<lJ" M

T}J

2

CD"

(N

s

c^

o

3 ^

Is

>>

\ d

s

1 :

83 :

&- ;

j Company,

It

: %

; &

I\_JJJ

= = ||:

a

o " \*\*

2 .

S21 : o

Oft

"3

: o

: '

CN

o

; a

: 1

: s

i i

^0

^e^s

CJ O Q O

8 : :

\*o- : :

C5g

O OJ

; li

i i|

6

1

al

O Z

. <

c5-. ^

8 \* : : :

: : : :

B^

fl

O5 C5 O3

O5 O5 O5 00

O i-t

d

05

05 O> O3 C5

05 05 030303

R

.22

c5 M

00

O O OO

iO O

O

C3

\*^

IS

jfJ,

I II

O O C b-

O5 O5 O5 OO

1

li

00

'? ^ 00 h-

05 05 03

00 00 00

CO CO ^H #

O5 O5 O 00

00 00 O OO

8J

^1

s s

SCN COO

i-^ t>-O

i-H 00 00 >O

Q 00'

1

I-H CN

i 1

o"

O CN

S

5 i s i

OS CO CN O

^ g

lerican Creos

No records

8

5il

W ^ \*

^^ = ^

"! 03 02

?|\*4 J^

= a\*

b 5\*

CQ S

\* a - -

j .

02 X :

r 5 : :

,0, "3

S 03

^. a ! <B o\*

ItiH'p ^?

la^i l

t. 17, 1914, to An

s due to decay.

o

o o5

^:

o

: ^ ?

3 ' a

= - |

o

CN

10.0

No record

= : :

Better of Sep

i no remova

h

1 =

oT v

\* s l

I

\*> cvo

: sl : 6 s

.id

O

s "s

a a,

a

Pine

Pine longleaf

a

3

M \*J

1. V '

^T3 ^

||Jj\_J

^

H!I

^ \* 03 .0

i -a s i

o o S w

t furnished. 1

3 10 years, wit!

tt

: =

: :

1

1 |

I I 1 a

o a

P

g

\* 5

o

^

: :

: :

3 en

& .2- 2-2\*

Q Q O 05 ^

3l

i

: : :

: : : :

: :

Creosote, coal-

tar.

: I : :

I

S

o-

. i 1

o>

I?

nformation reque

tated average lift

t" "C-0

t^ CO OO

^ CN

n \*

5 CO b- 00

O O i"" 1 C^

\*

20

305

rt 00 M O 4)

\* w s . , I

1 > ~ i .a .

w

y

S : E

^a '' M

3 38

CN ea "S. c "3 e .2

d"' naiu >5^

>> o

II

S

to

Q

-s 1

CO giO g

o ^

fc ^ -

O C5 O

\*<\* CO

oo o o o

S 8

O3 00

00 !-

i

5

\*. "tl^ilto^l |<y|N

Hod ,0jje

P \*v o5

.2 . K3<j

>. a >. : ? s 3

8 OC8 .

lO 1-1 t~

do d

? s

o

.^

& .as'^s -8" 1 --s

fc m ^'SS^S c-d - r 8

i sas-s s I|fl \*!! I l-s s .

6 g a s^ a a PU Q H^H g^; o oo a

S

I 6

11

H <N 2 -^

CD CO CO CO

S S

307

O aj oo o "oo N c^ r tf o S

Tf<

& i 1 ? : l 1 ? - K 2,-? fj

"3

aj ti^^S 06 \* - N '2 W ' "\*! .-cS^<N^^^

"\*"

M^ a^oi^Qi^ ' : ^o\* ^coK 12 n'^oi^ao'a

WW tf^o'^-a 2d| a^2^^j d^-inl

: SUg'C > s "o S : : : "

J3

; ^ \* & o w \*> ^

1 -

^||J gjge . . s . : : : .eg

C)03. K, 1 T l c3l > \*Q?COCQOCJ' 'cofl

1>

^^o-c^Ss\* Sld\_J : :

fs

'3 .... .

Is

""c3

M

o

a ;

f

II "

4\* a ...

o >

02

i

Q : Q " : : Q : : Q

H

73 ^j

<J

EH

T3 a

> i 05

m

fb -a "3

Q

g 'C '-g ^

f = : S a = : = s |

H

H

P

J-HI "

C o o ^ g

^"ti ^b^t^ b?b^b?M

vO wO KO fli s 6 s - X s 0^ (

5 d : - I i N . i:

CO COCO- ,3 : ^COiO<0<NO,5

W<q ZCOCN co<N.-iZ

H

-2 +> , a

\* r^LOOO 00O T}\*OOTjH TjHl>Tt<Tf<

0\*0 ci ^ o,-2 2

O5 O5O5O5 O5O5 O500O5 O5O5O5O5

M '"' X-U

^ r-li-H rH^Hr-l rHrH^HrH

jz

-g g-g& .g

O OO- -O >OOO OOO>O

^^^'^^ 0\*0^05

C5 ^-00 COCOCN^I^.COCNCO

M

S ^ ^\* s\* rt S.

H

n

h-5 CQ oJ.S

i

5 1

H w

^ hN-CO COCN h\*COO l: s '<CNt >

W GO

H CO

i-, >>

o SSoco oo coSt^ S^oco

< O

CN CNC^t>- OCN lOOOCN CNCOOt^

H

tf u

111 -

SiO ^ CN CN O

H

II s

I-H CO

10

h

O

H

h

. x c rt rt ,< S O .j5

44- \* o .w"o3&

J

.2

CO

d s ^ i \* \* s 3^ M .5 1^^.

fc

1

^^ ^^og I-! e C ; J5 i-i j& ^^'

KUJ 2 . | o $ ^ ^ t c 8 W 'S y

^ I^M d P w^ d d H ' ^^'s ^^'

I fc

: S i i : .| : : ^

CO

Q

tf

O

Ill's \*

: 1 S ' j ! o j r : : 1

O

H

^ r

o

: o : ; : ^ : : o

PH

1

<n

1 -

^'

1

^4 \_j a "

\*

| "

S 2

a

CQ

S 1 : -3 S S S-gl

Sow o S <Cg

H

1

^0-08

M

S^2 |

slilil

V

1 -9

"S

1 ^

o g : : : : : : : : : : :

. . : : ... ....

N N

liii -

CO t^OOC5 O-l CNCO^J\* >OCOh00

OH a"

308

|rf ^ .

J. Q. Barlow, Asst.

Chief Engineer

Southern Pacific.

\*! i -s'8 s &ls S

II I : 1". iS'kHJ\*

|s ? : iii i|a\*g \*^

^Sj g. "7 ^rl.^ ^

<i|- ^i : gw T g -a8i w ^

cJ^ P S td^ ' ^^-^^c-i^ ^hj

Estimated life

15 years.

Mifei

|-sisi-l 4112 8|3 J|S\*

i!i?i-L : I"! IP \*l2

ll^si'il? lliii Ililsil^^l

r/j- w jg^ ? ~ <j \* c ^ o \* ^m- \* a a

Part removed

for decay.

>> 2> r& d

; : i lil

E I i L i!{

1 s : : |3 |1

\*3 .

I f!

I! hill

11-1 "S ^^ s^ ^ tf

3.-2o :\* <u

fefH M O o" O OJ

1 i

05

CO (N M CO CO CO 00

O5 C5 O5 O5 O5 O5 O5

CO 00

it

o \*n u) o o o ^

g 00 00 |

1 1

^. s

^H CO CO W 1C 10 tl

os o o o t>- o t^

00 00 00 00

1

J

lw "

\*jj> O5 -f OS S 8 8

(U^ CO

ll

oB

T) >>

~

53 ~

& o

1 Ss

5 'M

3 ^l

I 1 ! ^ rf s ^

^ = ?l ! : K\*i

O M

& 1\* \*\* 3 \*os

d

O O O M O 2

'ft a c8

C^l

1

g

Q

tT

ill . . .

: =

U)

d

m

u

= :

1

: : : : : : :

S 8

00 00

00 S S S

309

h

fe

u, 3

H-l O

1 S

J S5

"^.S

3

PQ \*y

^

w

|.2-l^1 I'Sl 15-SgS

\*> .rt r^"^ IJ-^.S' C^' J .S < \*-< 0\*

3 3 2 \* S ^^ ~ ^^c 2 <

05 CO

1

2S|^5 a ~- Sg^sla\*\*

55^1-a a^l-S^s-sB^Pr

4)-\* J z;c^2 t< \_e^ ) f^ >H \*H" -3 \*\*

1 n^.^js i:-3l=! =

^rfi

JM

11

Ills

"S

3s

cS"^, S"

o

02

^aa

1"

"^ ^H

if =

IM&-8 i

SSJJo ,.

1^1-51 1-

SS^fi -5 :

ailai sS

<j J3<J ft <;\*

i, -i J. i-i -i

& -S-

II It 1^ "l^.

|x . |f 1 ll 1 : : fl

5^^ ^J^- 2 .N\*^\* 3\*

v -M i a

O O O iO

O5-\* Tf< Tj< ^-^^

| J-2 |2 2

o e o 05

22 22 222

5 8-Sg -2

o o o o

00 000

5?\*t^ > i-3 O,O ^ O

I> IO 'N TH rH C^ CO

3 !JP\*

rH rH t-l <N

Si

\* a

00 O i-H i-l

O (N CO COMi-i

ft

00 00 O5 00

o> o> o o o o^

S~TJ

1 1

gg ^ CO ^^^

"i S S t-

\*a ' :

Iff

3 S fl

| | | !

1

g

\*\* . .

to "3 o\*

|. fi . s

43

CS

\* Ss

rt <

-3

"u ^3 QJ^"

1

1

t" I " sg

jl|1

OO1 >O l>. t^DOO

1 '

0)

S 3 3

1

" I 3 3

o

:

PU

2 : : :

33 3 3 333

'S

V

S

3 3 3

3 i S S 333

HP -

8 S 8 S

rjtio o r^ oooso

O5O5 OS O5 O5OSO

310

.2 o

i

3 Hi 44 j 5

3\* i^

1\*1 Jj 1-S

~ S 1 I? II

Oil

%

:l

i

o a

o o

tO <N

O O

O ^H

GO'S W02

02 So

.\*.

1\*

o o

O 00

311

thern P

.

o r i

4iis s|5

h

\*6

i 17.\* o^ \*

\*

fttf ^

^3\*0^2; ' w ''^

J3 i\*

Q " IS \*?

. ^ o

3

^ w

M .3^ "S "^ o\*

<3

stLSM? gS'i-t

w^" ^

^OJ .- j^CQ cO-i^

C CO

1

Ml|4||a-li||i

a'S-S^^ a ^ S H-SM

^>> \*T3^ o3 a! 1 " g g >^

ShibBU^UJ

ltiifi^^;:|i=jii

S M SSd\*\* fl .SS\* s Jt.^'

g 5 -S .-a-S^2^S S '-2-S \* -2

l^l5lls^Sl.al^|^^

s

S

1 \*\*

s

ii ::

I ll

1

1

i i i

& $-,\*-\*

1

g ts| 1

1 jpw] a

P ^

i i

S '"Q? t> G .

o 1 " 1 '? "^ \*" \*^

H ".n\*" ' 8 o

2

l> CO ^ ^O ^O ^O ^

O3 OO OO O -(

g Q J-S |-2 2

2 2

CO O3 O3 O3 O3 O3 O3

"S U ^ t) . SD

00

fl\*O '\*'"' ^ O S? 05

O> Ju -4J 2 'S bi.

g ffl H> 8-.S\*\*

CO l^

IN

1C OO O O

IN <NCO CO 1-1

Sg

03

CO 03 O3O3 O3

HE <\*

o S

O COCO COCO GO M<

!>>>. t\* N. t^ O

CO C0 COCO 00 O3

H a ^ >>

< o a"

p\_i 5 s'S>~

^g 55-ge-

i I 8 1

5 " 5S 5 .gg

II

,

^00 00

g

ss ^.

r 'I ^

^

H

g

z;

\* ^

llrlr L

S3

3 fr - & ^

0-0

o

|-

(N

JO

g a

K

rt

J,

1

2

1

1. S

"\* ^

I

Qd

^H rt

H M

O

fl .

j

S w

03

PH

P^^^ CU

5

H 1

g CO

6

: : : : : : :

"3 :

5

<N

1

i :

: : : : : : :

u

HP -

O l-H

CJ CO

312

11

M <N<N ININ

O5 O505 O505

O5 O5 O5 O5 O5

00 00 0000 00 00 00!

O5 O5 O5O5 O5 O5 O5(

t-i INCO <Ni~l

CO CO CO "5

"

c

: <=: o :

: s

^= .8 1= " =

: : : g:

Is

II Is

;r s is u is

I|

CT

\* J '\* c. : c-a:

g <D ; i^ .2 \*\*

: : : c :

go

c S" 2 -c

2\*3 c= ^ !

=313 Ji \* 2\*3 \* -- 5

2=S

CB W f Qp

ij

3i c2^ ,gB ^Q-5

cgn

M

CO

t^ -O !>

L

So S ig co

<0 00

\*"\*

O "H r-t

i\*" 1

(NO rH OiN TJI

<N CO

B

S

! i.

li I, 31

1= =! li

L

v cT

.S .S.sT

aj al a

I- n i

^ Mm M

QJ''B\*H' a

^ C g : :

SS \*

I "S

|| | : | |

^

c

- - \* .

,

- fl -

- . \* .

5

1

5

a

d

: : : : :

: : 3

= = s :: =

i : : : :

S

3S

\*2

"o

\*o

\* - \* \* \*

41

5

5

S5 SS S

1 3<5

sl s s

00 O5 O \*-\* <N

<N IN CO CO CO

313

a

M a

^

u u- i

ii

S MS

move

moved

1!

o

\* ii

32 sji

i"

und

ecay

un

c

30 3 r .3 o 3 5

s-s i i-g-

SSggSgS

o o

os os

i

00 1C

CO CO

: co 2 co 2 10 co

-^ o Tjr o o do

11

1!

U

CO CO

O

CO

1 111 11

O C? 00 O iO OO

CO ^ CO CO CO

OS 05 OS 050>

CO CO 00 0000

00

t>. 00

9 6

^"COM ,j jaja

Jlf I III'

CO t^ OO OS

CO CO COCO

314

s

"

<jotf

^S-2

'H T3

slf

J.

0^

1

: 2

; Q

!

|j, ,

See Remarks

Large portion

due to losses

in storms.

cay.

All show decay

13 % removed

94 % show de-

cay.

38 % removed

4 % show decay

4% "

5 <fc "

i i iii

1 -S 1 : 1 I s -i

a 2 ^

1

s 5

Igltf

placed.

Total removals

less than 5 %.

30 7 <, shnw

i

GO

CO CO

CO CO

CO CO ^

CO CO CO CO CO COCO <!

CC

\* -fl

CO

C5 O5

O5 O5

o> 05 a

05 O5 O5 05 O O505

O 1

O)

05 a

o

> 00 00

co oo

00 00 CC

CO CO 00 00 00 0000 CC

3

IN.

i-t

CO

1C ic

o o

O5 O5

11

ill

00 00

1 1

oc

JNi

i

O5 OC

00 i\*

8 8

00 CO CC

IN <r

-1 CS

CO 00 CO ^f CO OS 'f t^

IN CN 1-1 00 COCO -^

!

< <r

3 "

CO

N. Y.-Warren

Buffalo Line.

Savannah, Ga.

N. Y.-Warren

Buffalo Line.

Savannah, Ga.

N. Y.-Warren

Buffalo Line.

g 3

1

1 .il

Savannah, Ga.

N. Y.-Warren

Buffalo Line.

Savannah, Ga.

Cal.-Stokes Mt.

Line.

Los Angeles,

Cal.

Norfolk-Wash-

ington.

Montgomery-

New Orleans.

s

s

1

&

H

\*

<N

2

1

t^t

1

1 1

1

"3 23

g 2sgi

.11^' ^ |

^lls'll 111

02 "3 OJ >'

111 =41^

^ OJ

111 '

I

(N

-i \* tN

: : : : to

: CN : : ~\*

: -H

S :

ii- n -. i

B B O

B

1 ii= 1"r

o do c. a

1= i :

1 =

V

"o

^

\* \*

^ \*

O O

o

O <-H CN CO \* C

CO N. CO g

rH (N CO-\* IO

fcO \*O O \*O \*O

CO ^ g

00 g

315

Authority

14

est Service.

::::::::::

: : :

3 :

:

1 "

M

S CO

.

||

|.

! >> I >> >>

I o; o o

: p : p : p

: : !

1

1

tion of

material

at last

inspection

11

1,

2

fe5 fex

S 5

S "8 14-8 | -g

^ ^. . 1^ 1 5 I i

26"- ^\_ S ' ^ S

\*>\*" I" 8 .\* 1 s

fexwfe5^ ^ ^&5>i^ ^5^ ^5

i-H-rtiNiN CO 5 o "5 ^5 ^

IO i-H^t 1 CO "\*^00 CO a-H 1 \*^ i 1

34%

58% show de-

cay.

All show decay

Ij

os o fcS >

o

CO

1

H-S ' S fl o

co co

2 22 2 22 2 22 2

CO CO CO

CO T^

:

p

~"\* "-3 ^

i

J

lilir

00 00

00 CO GO GO 0000 00 0000 00

00 00 CO

CO CO

|

"3.

O O)

g 3 g 3

sss

00

:

l|l

e.sj h.

IN <N

"^ " \* MT "

i-H O (N

IN iO (N

Scq

^

i-H

i i

|

Savannah, Ga.

a j S Ji el j

SSO: = -. ggO = ggO

gf l e=1

^iS- = = ^{g| = ^gi

3 > 3 > 3 >

^' W CO ^' W CQ ^' W CB

! 1=

. 3

Cal.-near Los

Angeles.

Cal.-Stokes Mt.

Line.

Cal.-near Los

Angeles.

, i,

; ;

;

jj OT5 . O

4

5

Q,

8

CO

Chestnut

Cedar, S.

.| "i . : | "i .| |

s o o ^ o o ^u o

Chestnut,

seasoned.

Chestnut

1 1

! 5i

u S- 2

1

i

AH

"of -2

: :: .-H:: CO:^H:

: M ^H

r] m r{

+d

c3 IV

:

:

Imper. wood

preserver.

g : : : : : g>

hfl

a -5 o

3:: : :: .\*j :

..S 'S, 5 :

M'- co H

Wood creosote

1 :

2

e

.2 :

6

o]

<

(

P

il|| -

S

N C0^< >O COt\* 00 O5O ^H

C^ CO ^

10 CO

g

316

i

"8 "8 . "S-e /8 .

1 2 ZZ

6 g-8 S'

"2 . 'S "2

%% $ S

8'g S S

"I

\* f Jl :

^J 63 d 60

CO <N COCq<N(N 00 CO <N n <N <N (NCOCO

O 05 O503C503 05 05 O5 05 O5 OJ O5 O5 35

eo 10 <# eo CO-\*M<

000

<N M f r. '-

I-H CO>OT}<Tti

-

2 .

5-3 g

g-a

<!0

-2 ? "5

I 1III fl

PQ OOOO O

-? .-

o

js s? E

ill

: =

00 OJ O>-<NfO \*\* V} t> t~ 00 O3 O H<

317

s s-

03 OOJ 05

(NOO O 00 00

3< t^O N 1C

^ <^tt^ O '-1

^ 4 \*

5 : | .|

1 J4|

0000

\*

J ^

f s |

o o

Q

'

5 S

Authority

14

"0 . M F . C

30.3\* ^S ,

Ills : : f i

SWg r W

fli =: |S- 5

City Engineer.

Duluth, Minn.,

City Engineer. {

Birmingham, Ala.,

City Engineer.

Springfield, Mass.,

City Engineer.

: H ^-w 1

a^

TO

M

a "

S

1

u. ^4 <"^ .-4 rt O CQ \*\*"' \*\*

: \* - a l e\*9 s; T3

i

fl <} S\* :

\*!\* ' S

Hi- 1 :

SwftJ tf

:

tS 1>\*O i

""J2

ll ^

fl S

g p S .

I ||1|| i

PI

JB

| -3 s 3

W fe " 02 fe

1 11.

Good

Excellent

"

^olc| 2

05 05 0505 OS OS

O5 OS O5 C 1

Q ~ <n-\*>

HJIrt"

CO O5 0000 GO GO

O5 00 i-l C

00 00 C-l \*H

ij .

II ii 11

1C CO CO \*

OS OS OS O\*

IB -

^T TfrH CO" tH

\* I\* 1-1

^ CO \*C OC

O5 CO CO O5

!H CO L ^

gS 2 8

Tf 00 CO CO

CO N CO

CO 1-1

a

1

1

\* ^23

A \*

? ? ' g j

S Sd Q S

^o fl .s 3 u

^3^ .2 -

NN\_\*2 OQ M

a S

-52 s

S

1 s4i s

Q S^^ S

Steelton, Pa.

Minneapolis,

Minn.

|i d \*

|\*1 <

a

(M M

<-H O ON O O

o o o

O CN CN

(N (N (N

o o o

s s a

I || S |||l|| | A

J

1 /.I ."\*1J^1 \* |

1 ! \*

jS t . .

02

S PH\*^-\* c83^-.C-M-a g g

08 S

2^ 1

I '

1 : :: - -

al :

Full cell

0)

I =

! : :

ji "

"J.

lip -

s i ii i i

I I!

O5O -i (N

N CN CM C^

318

3 Id :

ac \_-

2W ,:

ftfl"

s

II

ol\*o

8

a 8.

\*r

!! >>.

O 41

Otf

2

a "8.S "ss,

ss If 8-3

Ofe

050505 05050505050 05O505

)t-t^4 <N i-l

!S SS 88

I O CO CO ^f 00 M (N lO rt< O5 ^ <N O CO O O COCO 1-1 CN

( C^l CO T-it^t^^i-cOJ OOOi-i O >O rH O CO CN 1-1 (NO

>ooo ost^coco^N coooco 1-1 >OO<N<N coo coo5\_

r-t i-l CO N i-1 rH Tj< ' i-H M ' COOO CN

.S2 ^ o "^ ^ M "^

. "3 . . . . . I . . ^ u3 . . . o 8. o o. o g

d f \*8 .o^- o .o o.\*.,

o

p

o <

<N <

I .

o-

I

2 52

o

e8 \*""\*

S g

p p

CO IN

<u

3 s

= 1

319

Q

^ M r r r

.s { . >< . r - -g

4

! .

g

<

C 1 l .,-S SwsllH S!

M S -r S 553^ c^fl5)fl a

fesi i^ J^lf^Fl 1

^og |w gW-gw-6WSflS ^w

fe^'S g^ 1 S >,-c>> a >>3 >, 3 >, M>,

gii |G |sac|g|g|g 56

B

O.

S

teO

-^ 6

n

00

J4

1 2

: it! i s ; ;

: g-\*> g c g ; :

^ .2 3

; Hilisli :

; jgcsttaosd^ ; ;

1

T3

a>

> M\_

C 4)

ill

pja^

o-i

S

6l

lo^J

WflJjJg

3.2ll\*&

I\* l - |

w

^ ^. \*

I 11

g > "S "3 i -o

g. . . M v 1 S

O- OjOXgjO

O > O W PM O

1

CO

-2 ^ , i fl

00

g's a.\* y 2

O501GO OS 05 05 05 05 O5

Hllil-

O50005 ^H \* O O t-H 00 O5

m

(N

si

i w

10COK5 W O \* \* CO O 10

000 000000

O5 O5 O5 O5 O5 O5 O5 O5 O5 O5

.ANEOU

g

00

\*- ji"

,2 g"2

S.S \*

IP

OSpfcO I-H i-H C<5 GO O" CO\*

-\*C5 ^H rH

MISCELI

Number

j

^^' \_^TJ fl - , oj >; .

Qd^S^ ><' ^ M -S 8

?Jtl5 ^!i^. i

t"ttj I i 1 1 1 fs

mil is

New York City,

5th Ave.

1 Q.

If-Sj \*

r l

10

8

l 4 till

B - 3 -H 00 ^

1:: : : : : T^ S W

.b 111- 11

p4 fe S^fc ? \*

h.i

JSfl

III

.

J

1 n

1" 1

8. . 9

1

a

511\_J fe

cS

V

1

1

g: : : : : : : : |

o. - - ::::: 2

^

o

iip -

N N iM O\* <N CO CO

<N <N <N <N (N <N <N

d

S

320

APPENDICES

321

Fence Posts. The United States Forest Service has conducted

a large number of tests in co-operation with agricultural colleges

in the United States, in which fence posts were treated with

creosote. These posts were preserved by the open-tank process

as described in Chapters V and X, and after treatment were set

in fence lines and carefully labeled where inspections were made

annually. The last inspection made on these posts gave the

results shown in Table 45.

TABLE 45. LIFE OF CREOSOTED FENCE POSTS

Location

Kind of posts

Treatment

Years'

service

at last

inspec-

tion

Num-

ber in

test

Num-

ber

re-

moved

up to

last

inspec-

tion 1

Per-

cent

re-

moved

up to

last

inspec-

tion 1

Remarks

Ames,

Iowa.

White cedar

Black walnut

Willow

Soft maple

Ash

Box elder

Open tank

Open tank

Open tank

Open tank

Open tank

Open tank

5 and 6

6

9\*

9\*

9i

9\*

522

50

45

23

35

10

0.0

0.0

0.0

0.0

0.0

0.0

About one-third

of these in bad

condition, in

tops, although

not removed.

Z mbro

Entire post

4\*

481

3

0.6

Heights,

Mi nn

Basswood

Red oak

Entire post

Open tank,

4\*

4\*

254

59

1

0.4

0.0

inn.

Red oak

butts only.

Auburn,

Alabama.

Loblolly pine

Open tank,

entire post.

6\*

55

0.0

Left in pile 2\*

years; in ground

4 years.

Loblolly pine

Rav

-

5 to 7

5 to 7

395

145

8

27

2.0

19.0

Left in pile vari-

ous periods up

Calhoun,

Louisiana.

oay

Cypress

Sweet gum

Tupelo gum

5 to 7

5 to 7

5 to 7

70

177

81

1

2

4

2.0

1.0

5.0

to 2J years;

in ground 4J

years to 6$

years.

White oak

"

5

51

0.0

Black gum

"

5

49

0.0

Yellow poplar

"

5

51

0.0

One missing.

Scrub pine

11

5

101

0.0

College

Willow

"

5

103

0.0

Park,

Maple

"

5

50

0.0

Three missing.

Md.

Sycamore

"

5

52

0.0

Beech

"

5

51

0.0

Chestnut

"

5

50

0.0

Birch

"

5

50

0.0

Red juniper

11

5

45

0.0

Clemson

f Loblolly pine

"

5\*to6

279

37

13.2

College,

Yellow pine

"

5Jto6

167

15

9.0

S. C.

Post oak

"

5\* to 6

71

10

14.0

1 A few posts show more or less decay, but since they were not removed at the time of the

last inspection they are not recorded in these columns.

21

322 THE PRESERVATION OF STRUCTURAL TIMBER

TREATED WOOD BLOCK FOR FACTORY FLOORING AND MIS-

CELLANEOUS USES 1

In 1915, the United States Forest Products Laboratory, Madi-

son, Wisconsin, made an exhaustive inquiry to determine the

extent to which wood blocks for floors were in use in the United

States and the opinions of their owners in regard to the satisfac-

tion which the floors were giving. About 160 replies were re-

ceived to these inquiries and it is from them that the following

data are taken:

Types of Construction in Which Wood Blocks are now Used.

Wood blocks are now used in the United States in the following

types of construction:

Warehouses

Factories

Factory courts

Foundries

Machine shops

(all kinds)

Shops handling

machinery

Railroad shops

Round houses

Railway stations

Freight houses

Express rooms

Baggage rooms

Dumping platforms

Freight platforms

Loading platforms

Station platforms

Wharves and docks

Ferry boats and ap

heavy proaches

Driveways

Bridges

Post offices

Tennis courts

Barns

Stables

Slaughter houses

Wild animal cages, run-

ways, etc.

Garages

Cotton mills

Paper mills

Rubber plants

Hospitals

Laundries

Printing establishments

Hotel kitchens

Bakeries

Fire engine houses

Milk depots

Breweries

Species of Wood. Eleven of the plants reported the use of

Southern yellow or longleaf pine for this purpose. Five plants

also recommended Eastern tamarack as being satisfactory, and

the three Western plants recommended Douglas fir; black gum,

beech, Norway pine, maple, hemlock, and Western larch were

recommended by one plant each.

Several of the plants, particularly those producing the largest

quantity of this material, pointed out that the wood block floor-

ing problem naturally divides itself into two classes :

A. Blocks used in very dry situations, as in factories and warehouses.

B. Those used in alternately wet and dry, or in wet situations, as in

stable floors, docks, wharves, slaughter houses, etc., where the

blocks are exposed to the weather, to flushing with water, etc.

The treatment and method of handling the blocks differs

radically in the two cases.

1 Investigation by C. H. Teesdale, Forest Products Laboratory.

APPENDICES 323

Preservative. Eight of the 14 plants manufacturing wood

blocks reported in favor of using a distillate creosote oil. Three

plants recommended paving oil similar to that quite generally

used for wood block street paving. One recommended water-gas

tar; one carbolineum; one a mixture of half water-gas tar and half

zinc chloride solution ; and one a mixture of half water-gas tar and

half coal-tar creosote. The last-mentioned product was, however,

recommended only for wet situations, this plant recommending

creosote injected by the Rueping process for dry situations. The

concensus of opinion was to use a distillate creosote, especially

for dry situations, and a heavier paving oil for wet conditions.

Absorption of Preservative. In general, the plants were not

very specific as to the absorption of preservative that they recom-

mended for the two classes of blocks. The inference to be drawn,

however, was that comparatively light absorptions (from 5 to 8

or 10 pounds per cubic foot) would prove satisfactory for dry

situations. Heavier absorptions, ranging from 8 to 16 pounds

per cubic foot, were recommended for alternately wet and dry or

wet situations. In general, the absorption to be given would

appear to depend to a considerable extent upon the conditions

met with in each individual problem, the more severe conditions

especially as to the chance of the water coming in contact with

the blocks, requiring heavier absorptions of oil. In the case of

plants recommending paving oil and water-gas tar, heavier ab-

sorptions were specified than when creosote was recommended.

Treatment. It is evident that the use to which the blocks

would be put has a very important bearing on whether the timber

should be thoroughly dried out before treatment. Three of the

largest producers of flooring pointed out that blocks which are to

be used in inside construction, especially in factories or other

situations where the buildings will be heated in winter and where

the blocks do not often come in contact with water should be

thoroughly air dried or even kiln dried before treatment; other-

wise, if they are comparatively wet when laid they are liable to

shrink badly in the floor and become loose. However, if the

blocks are to be subject to alternately wet and dry conditions,

swelling and heaving are liable to take place if they are too dry

when laid. Not all of the plants heard from reported on whether

they would prefer to treat green or dry timber for this purpose.

However, all of the plants but one reporting on blocks for inside

construction preferred air-dry material. One plant specified

324 THE PRESERVATION OF STRUCTURAL TIMBER

either air-dry or green. The majority of the plants also pre-

ferred air-dry material for blocks in wet situations, although two

plants specified their preference for green material and three for

either green or air-dry material.

Steaming the Timber. Of 12 plants replying to this question

seven stated that the timber should not be steamed before treat-

ment, and one not if the timber is dry. One plant preferred to

steam lightly in winter, and three plants answered yes to the

question. The consensus of opinion, especially in the case of

those plants producing the larger amounts of flooring, was not

to steam the timber.

Methods of Laying. Most of the plants stated that a con-

crete base should preferably be used. Six of the plants, however,

stated that where the concrete was not practicable, treated plank

would be satisfactory. One plant stated that treated plank

foundations should always be avoided, if possible. One plant

specified sand and cement base. Practically all of the manufac-

turers agreed that expansion joints were necessary. Those who

reported, specified joints ranging from 1/2 to 2 inches and filled

with bituminous filler. Whether blocks are to be laid tight or

loose appears to depend upon the use to which they are put.

In very dry situations the preference was to have the blocks laid

as tightly as possible. For alternate wet and dry situations the

plants appear to favor comparatively loose laying. Most of

the manufacturers favored a bituminous filler. One, however,

specified cement filler, one either a dry sand or a cement grout

filler, and one sand filler.

Methods of Construction. The depth of block used varied

from 2 to 6 inches, but 3 inches was used with 56 percent of the

floors concerning which replies were received. Southern yellow

pine was used in 72 percent of the cases, while 15 percent did not

reply to the question, the remaining 13 percent being divided

between eight other species of wood.

The replies concerning the preservative used are probably not

very reliable. In certain cases it was known that water-gas tar

was used, though creosote was reported. The records were cor-

rected in all cases where the preservative used was definitely

known. The records as given show that 67 percent used creo-

sote, 12 percent used paving oil, and 8 percent water-gas tar,

while the remainder used other preservatives, or did not reply

to the question:

APPENDICES 325

The reliability of the replies as to the process used is also

probably uncertain. It is not likely that all who replied to this

question were sufficiently well informed to answer it correctly.

Thirty-eight percent did not reply, while 48 percent reported

the Bethell process and about 9 percent the Rueping process.

The absorption of preservative reported varied from 6 to 20

pounds. Nearly 60 percent did not reply to the question, but

the largest number (9.4 percent) reported 16 pounds. About

19 percent reported 12 pounds or less, and 22 percent reported

15 pounds or more.

Concrete foundation was reported in 80 percent of the replies,

the remainder being plank, dirt, tamped earth, etc., or not an-

swering the question. Seventy-one percent reported the use of

sand cushion, 12 percent cement grout cushion, and 3 percent

bituminous cushions. Bituminous fillers were reported by 44

percent, and sand by 25 percent. Thirty-nine percent reported

that expansion joints were used, while 41 percent did not use

them, and 20 percent did not reply to the question.

Summing up, the general practice was to use 3-inch Southern

yellow pine blocks treated with 15 pounds or more of creosote

per cubic foot by the Bethell process. These were laid with a

concrete foundation, sand cushion, bituminous filler, and the

question of using expansion joints depended on the local condi-

tions in each case.

Difficulties Experienced. Repairs have been reported in 32

percent of the records, while 62 percent reported no repairs. In

most cases the repairs made were of a minor character, and as a

rule, were caused by swelling or shrinking of the wood. In a

few cases blocks were badly worn where heavy castings were

thrown upon them.

Bleeding of the blocks was reported in 9 percent of the records,

but was said to be objectionable in only 2.5 percent of the cases.

Swelling was reported in 29 percent and shrinking in 27 percent

of the records (in some cases both swelling and shrinking were

reported), and these troubles were the cause of most of the dis-

satisfaction reported. Swelling occurred when the blocks be-

came accidentally wet, because of leaky roofs, bursting water

pipes, near drinking fountains, and other accidental causes.

Shrinking occurred in very warm or hot situations, and resulted

in the blocks becoming loose and producing an uneven floor.

- An interesting relation may be shown between the kind of

326 THE PRESERVATION OF STRUCTURAL TIMBER

filler used, and swelling and shrinking reported. Thirty-three

percent of those using bituminous filler reported this trouble,

compared with 55 percent of those using sand filler, 75 percent

where cement grout was used, and 55 percent where no filler was

used.

Eighty-nine percent replied that the blocks were satisfactory,

while 5.6 percent did not reply to the question, and 5.6 percent,

or nine records, stated that the flooring was not satisfactory.

Of the nine unsatisfactory floors, shrinkage of the blocks was

responsible for dissatisfaction in three cases, swelling in two cases,

in two cases the blocks wore out rapidly, poor foundation in one

case and improper laying in one case.

In a large proportion of cases it was reported that wood block

was easy on the feet of the workmen and that they like to work

on it. Noiseless, ease of repairs, low upkeep cost, good trucking

surface, saving of breakage in tools and fragile metal parts

dropped on the floor, warmth, and cleanliness were all reported

as advantages of wood block flooring in 10 or more of the records.

Durability was reported as an advantage in 77 cases, though it

is doubtful if many of the floors had been in service sufficiently

long to warrant a statement as to durability.

In 14 records swelling was given as a disadvantage and shrink-

ing in 12 records. Roughness, reported in 11 records was mostly

caused by shrinkage. High cost was given as a disadvantage

in 11 cases.

GENERAL DISCUSSION

The results of this investigation indicate that treated wood

block makes a desirable type of flooring for many purposes, and

it is likely that its use for interior work will increase. Since its

large use for these purposes is just beginning, one might expect

that unforeseen trouble would develop. The records of 160 floors

given in this report indicate, however, that serious trouble has

developed in a very low percentage of cases.

Most of the trouble has come from shrinkage or expansion of

the blocks. To prevent these troubles it is essential to study

each case where blocks are to be laid, and to treat the blocks

accordingly. For dry situations, the blocks should be well

seasoned before treatment and laid in the floor while thoroughly

dry. In wet or alternately wet and dry situations, dry blocks

would give expansion trouble and, hence, the timber should be

APPENDICES 327

green or only semi-air-dry when laid. Even dry interiors are

liable to be accidentally subjected to water, however; hence, it

would seem desirable as a rule to use bituminous fillers instead

of sand filler.

Sand cushions were probably a source of trouble in several

cases. If there is any vibration, or if the sand is at all liable

to shift, a bituminous or cement grout cushion is to be preferred.

Sand cushions are also liable to cause uneven floors if the blocks

shrink, and it seems likely that many cases of shrinking would

not give serious trouble where bituminous filler and bituminous

or cement grout cushions are used.

Bleeding caused very little trouble. In dry and very warm

situations, where it is most likely to occur, it would be desir-

able to carefully consider the method of treating and handling

the blocks in order to avoid objectionable bleeding.

In a few cases it seems likely that wood block should not be

used. For example, it should not be used where butter or tobacco

products are stored. In some foundries, where hot castings are

thrown upon the floor, the blocks have burned through to the

foundation. Wood blocks may be objectionable where the soiling

or staining of certain classes of merchandise would lower the

value, and in one case where used in a tennis court wood blocks

were a failure and had to be removed.

Wood block was found to be very satisfactory in many cases

where heavy castings are thrown about, where heavy trucks are

moved, and is liked by workmen because it is warm and is easy

on their feet.

The replies from the users of wood block flooring indicate

quite strongly that when new wood block floors are to be laid,

a careful investigation of all the conditions existing or likely to

develop should be made by the manufacturer. The method of

treatment and construction of the floor should then be adapted

to the special conditions found. If this is not done many cases

of dissatisfaction are very liable to develop.

STRENGTH OF CROSS-TIES

As pointed out in Chapter VIII, ties having a low crushing

strength required larger tie plates in order to protect them from

rail wear than ties which were dense and hard. A tie in service

is subject to other strains than crushing. Of these, impact and

bending are the most important. In order to compare the

328 THE PRESERVATION OF STRUCTURAL TIMBER

o.i

Nail Pull (100 Lbs.)

2 3

Specific Gravity

0.2 0.3 0.4 0.5

Average Composite Strength Value ClOO Units )

4

0.6

0.7

Black Loc

2 3 4 5 6 7 8 9 10 11 12 13 14

irst

Hi

:ko

ry

^^

Su

?ar

Ma

p,e

Wl

lite

As]

1

u

Wt

ite

Oai

Birch,

Sweet & Velio

w

v

RedOs

Ik

k\_

Q

Be.

;ch

1

6^

f\

Slippe

ryl

,1m

LongleafPiJ

\*v

Douglas Fir

Black Gum

e,\_

Red Gum 1

Shortleaf Pin

a

e.

Lotlol

1

yPine

Western Lan

h

r-\

Western Hen

loc

Cotton Gum

^

r\

Cypress

Tamarack

Sycamore

eu\_

N

Silver 'Maple

White Elm

i\_

| |

Eastern Hem!

ock

Norway Pine

\*

^

Red Spruce

White Fir

Lodgepole Pi;

le

i

Western fellow

Pirn

K^\_

White

Spruce

^

Weste

rn Red Cedar

BassWoodj

Englemar

Sp

nice

\*

V

Average Composite Strength Value

O Specific Gravity Based on Volume when Green

A Nail Pull Load in Pounds Required to Pull 7d

Cement Coated Wire Nail from Kiln Dry Wood

Alpine Fir

Northern

Wh

teCed

ir

|

1437

APPENDICES

329

strength of various timbers for cross-ties, an analysis of their

mechanical properties was made by the Forest Products Labor-

atory, 1 in which "strength" included the following:

1. Static and impact bending.

2. Compression parallel to the grain and end hardness.

3. Compression perpendicular to the grain and side hardness.

These are given relative weights as follows:

1. 28.5 percent.

2. 31.5 percent.

3. 40.0 percent.

A more detailed analysis of this composite figure of strength for

ties is given in Table 46. The values thus secured for the various

tie timbers are plotted in Fig. 33. In addition this figure shows

the specific gravity of wood and the resistance it offers to the

withdrawal of 7d cement coated nails driven into it. It should

be noted that both the strength of the tie and its resistance to

the withdrawal of nails bear a direct relation to the specific

gravity or dry weight of the wood. Hence, other things being

TABLE 46. SHOWING BASIS OF DEVELOPMENT OF SUGGESTED COMPOSITE

FIGURE

Mechanical property

Relative weight

used in forming

composite figures,

percent

Relation of mechanical property to

use of species for cross-ties

Static bending:

a Modulus of rupture

6 Fiber stress at elastic limit

Impact bending:

a Fiber stress at elastic limit

14.3

7.1

7.1

These properties show the strength

when used as a beam. They are

of primary value in determining

the resistance offered to breaking

due to "center bindings."

Compression parallel to grain:

a Fiber stress at elastic limit

6 Maximum crushing strength

7.2

14.3

These bring out the resistance of-

fered to a compressive force ex-

erted lengthwise along the grain

and are of value in indicating the

resistance offered to lateral pres-

sure on spikes.

End hardness:

10.0

Indicates the resistance to lateral

pressure on spikes.

Side hardness:

Compression per pendicular to

grain:

a Fiber stress at elastic limit

20.0

Indicates the resistance to rail wear,

abrasion, etc.

1 Analysis made by C. P. Winslow and J. A. Newlin.

330 THE PRESERVATION OF STRUCTURAL TIMBER

equal, the specific gravity furnishes an excellent index of the

strength of various woods for cross-ties.

THE DAVIS SPOT TEST

Mr. I. H. Davis has developed a very simple though valuable

test for determining the amount of tar, carbon, and dirt in

creosote. The test is made as follows:

Allow six drops of the sample to fall from a burette upon a

surface of clean white blotting paper. If tar, carbon, or dirt, is

present, it is very easily observed, as it quickly segregates at the

center. The paper should be laid away in a flat position for

several hours in a place free from dust. If then examined, for-

eign matter will be observed in a distinct zone at the center of

the spot. The outer zone very readily indicates the character

of the oil. Experiments with this test made at the United States

Forest Products Laboratory showed that free carbon even in

percentages as small as 0.005 could easily be detected. In per-

centages over 0.5, the amount of carbon was difficult to deter-

mine and an analysis would undoubtedly be necessary.

TOXICITY TO FUNGI OF CERTAIN OF THE MORE IMPORTANT

PRESERVATIVES 1

In order to bring together in convenient form for comparison

the results seeured by various investigators in the use of certain

important preservative substances, Table 47 has been prepared,

indicating the salient features of such tests.

In making comparisons, the sources of error as well as the

degree of refinement which the figures represent, should be fully

considered.

In conclusion, the writers wish to emphasize that any scale of

toxicities derived from Petri-dish tests on the usual nutrient agar

or gelatin media, even when the tests are conducted under exactly

similar conditions, do not necessarily represent the true relative

toxic values of the different compounds, for the interaction be-

tween the toxic compounds, the nutrient substances contained in

the media, and the plant protoplasm is variable and more or less

specific, for each combination."

1 Bui. 227, Bur. Plant Industry, 1915.

APPENDICES

331

332 THE PRESERVATION OF STRUCTURAL TIMBER

a a

O>

E fa

d T3

i S

222S2

'O O O .fl J3

,S ,Q .0 ft ft

a a a a a

PH tf PH M H !

<u v

fc

r M >)

00 4J

^ & &oo b- 15 2

33322 IS

00 00 00 \* WS "\* 00

days

days

OoooQcoco

-

000000X00^00000000-^

oa tc 03 cc

Illl

o o o o

5253

00 00 00 00

O < O O

and

and

o o o

00 CO IO

OOOoOOo<H

ec o

- o

d odd

O

05 C5 cS c3 03 o3

3 .

S :

B-S

II

5

!>>

^fa

:^^

be

be

S g " "2

S g 8 g g

.1 BJ CS >

35oobb<5

ft ^,5.C, J3

s & ft aaaft

1\*11 1 1 1

fafaOOOOOO

e

g-

-S 2 'a 2 .

' '

s

\*"

a

,5 J5 ,fS ^S

1311

4> 4) 0)

1 1 i

2222

J^^ J

2222

S G H C

aaaa

: a

: a

: 8

: S

3

"C 'C 'C \*C 'C

,2 ^^ ,2

e o e o o on

000000

fl O

NN

rt < " - ' '

T3 'O " M &. w HH ' \* \* \*""" I w O

llfhll :IH|a 3 l4|i! e

? ? j s - w B -I i -I I J o ^ ft i .^ ^ -

88^2262, : : : p,'3''S''a ftSoa

S 3 3 o ^r^ : ::. uw ^ ig.^'S'S-

raajoipjQqd'o'o'o'o'o'oo'o'oo iSsOc^eoo

s s ?oi 8 z s g 2 z i s z z ii^^^i

aaai^-3 6 6 66666666 Q o

22^^

APPENDICES

333

Investigator

1

a a

'a 'a

s ss

o c fl

Jif lisas 3

phrey and Fleming

phrey and Fleming

phrey and Fleming

,2 .2 S J2

'ej "oS 'o3 'ol 'cS "oS "cS

SI\*IlJIJJ

a a a

WWW

ll

>> >> >> >>

85 05 e 05

o-e 3-3

o o ^ o o

O O O O O O O

II

|

E

3

|

O O O O O O O

Be 3 .3

o o o

Q

00 OO Tl< 00 OO

00 00 GO 00 00 00 00

(4 ^

mil

1 1 1 1 1 1 1

a a a

ll

-H O O o O

eo 10 m

>-H (N ^H O \* ~

O O O O -H O O

d o" d d d d d

o

o^ooooddd

iO O t

H

a c c a

P P P P

T) -a -a ~o T) -a -d

a a \_a fl fl fl

O GOOD

S p S p

Organism

CO -CO

05 05 - eS cS

111 II

JS ^ ^ J2 ^ ^ ^

Illllll

05 85 cS c5 eS 05 oS

0000000

: S : :J5 : S

: 1 : : ^ j 1

: E J : 2 -c -a

: g 1 : S .SJ

^ u ~ O "\*

|| :| 1 1 8 S |

es annosus

nicola

inosus

IJIJI

a a a a a a a

o o o o o o o

Q O O O O O O

IfllJJlfjS

1 fc^

,v

| : : :

III i

u

8, : ::::::

o : ::::::

Toxic substance

B. ORGANIC COMPOUNDS Continued

(a) Benzol and phenol derivatives C

Gallotannic acid [CuHioOi]

Phenol [C 6 H 5 OH]

Phenol, pure

O-nitrophenol [CsHiNOiOH]

P-nitrophenol

Sodium salt of

O-nitrophenol, 63 percent 1

P-nitrophenol, 60 percent 1

2:4 dinitrophenol [CH 3 (NO 2 ) 2 OH]

2:4 dinitrophenol, 33 percent 1 . . . .

Salycilic acid [CeEUOH-COOH]

Sodium picrate [CH2(NOj) 3 ONa], 40

Thymol [CeHaCHsCsHTOH]

(6) Tars and creosotes

Coal-tar creosote:

Straight run, American (sp. gr. 1.0

5 percent gum-arabic emulsion. . . .

German (sp. gr. 1.09 at 15 C.)

Sp. gr. 1.048 at 60 C

5 percent gum-arabic emulsion. . . .

German (sp. gr. 1.062 at 38 C.). .

German (sp. gr. 1.062 at 38 C.). . .

German (sp. gr. 1.062 at 38 C.). . .

German (sp. gr. 1.062 at 38 C.). .

Carbolineum:

Avenarius (sp. gr. 1.126 at 16.5 C

Avenarius (sp. gr. 1.126 at 16.5 C

S. P. F. (sp. gr. 1.127 at 16 C.) . . .

334 THE PRESERVATION OF STRUCTURAL TIMBER

f

ig

Durato

teat

>>>>>>>>>>

Ji A A X -G

aaaaa

33333

eaa

333

aas

33^

.3.3

f if # i; S ? it

Tj< 1$ Tj< Tj< <\*< Tf \*

as

O 1C 1C O O "5

00 I-H O \* CO <O ,\_;

o o o o o o a

i

e s s ass

333333

s s s s s s

|||

\*.s !s

P 03 ft

I I 1

8^

iiiii

ft

o

APPENDICES

335

7

1il|||||ll^

336 THE PRESERVATION OF STRUCTURAL TIMBER

INVESTIGATION OF THE RELATIVE INFLAMMABILITY OF UN-

TREATED AND TREATED SIDING AND SHINGLES 1

Hitherto, in this country, the use of wood treated with fire-retardent

chemicals has been largely confined to interior work. The possibility of

treating building material for exterior use, such as siding and shingles, is the

object of the investigation discussed in this part of the report.

The results obtained in the tests on the inflammability of treated woods

were made use of in this work on the inflammability of the special forms

siding and shingles. The chemicals used were all soluble in water; there-

fore, their use in rendering shingles non-inflammable is not practical with-

out an additional waterproof coating (such as a paint coating).

To make wooden shingles fire retardent, it was desirable to inject an

insoluble fire-retardent chemical that would not be washed from the wood.

It was decided that insoluble borates, which fuse when heated, offered some

promise of success, and a method of treatment was experimented upon which

would allow insoluble borates to be precipitated in the wood. This method

consisted in saturating the wood by a pressure or soaking process with boric

acid or any soluble borate, bi-borate or perborate solution. The wood was

then dried and a second treatment given, forcing into the wood by pressure

a solution of any soluble salt, which would combine chemically and form an

insoluble borate, bi-borate or perborate.

The experimental treatments were made using borax and zinc chloride,

due to their relative low cost, thus precipitating zinc borate in the wood.

The advantages of this treatment would seem to be:

1. The substance precipitated in the wood being insoluble in water should

not be washed or leached from the wood.

2. The substance precipitated in the wood is a fusible compound which,

when subjected to temperatures high enough to cause distillation of the

wood, fuses and forms a protective coat in the wood cells.

3. The treatment could be made in such a manner that an excess of zinc

chloride could be left in the shingles in order to give them a preservative

treatment against decay. Also other toxic salts such as sodium fluoride

could be injected together with either the borax or zinc chloride solution to

obtain this effect. Due consideration would have to be given, however, to

any contamination of rain water by these salts. Should this be used for

drinking purposes, an excess of borax should be injected to neutralize all of

the zinc chloride. No other preservative salt suitable for this purpose is

known. It seems likely that soluble preservatives would to a considerable

extent be retained in the wood by the insoluble zinc borate precipitate.

The disadvantages of this method would seem to be:

1. The combination of the two chemicals besides forming an insoluble

substance also forms a soluble salt, in this case sodium chloride, which would

have a corrosive action on the common iron shingle nails now in use.

2. The double injection method of making the treatment with an inter-

mediate drying period is more expensive than a single treatment.

i Report by R. E. Prince, Forest Products Laboratory, Madison, Wis., July, 1915

APPENDICES 337

MATERIAL USED

Inflammability Apparatus. This apparatus consisted of a chamber made

of 1/4-inch asbestos board (sold under the trade name of transite) 22 inches

long, 10 inches wide and 7 inches deep. The upper 10 inches of the appara-

tus was used as a heating chamber. The heat was obtained from an electric

heating coil made by winding flat nichrome ribbon on a silica plate 4 inches

square. This plate or coil was protected by another silica plate of the same

size. The two plates were fastened together and placed in the apparatus

in such a manner that the heat radiated to the lower part of the test specimen

which was placed 3/4 inch distant.

A gas pilot light was allowed to barely burn just below the center of the

heating plates. This pilot light was made so that it could be flashed up in

front of the heated specimen, which was supported in the apparatus by

means of a carrier. This carriage allowed the test specimen to be suspended

in the apparatus at any desired distance from the heating plate, but during

the test it was placed 3/4 inch distant.

Treating Apparatus. The treatments were made in a 1 1/2 by 4-foot

cast-iron treating cylinder. The preservative and specimens, in tin con-

tainers, were placed in the cylinder and subjected to air pressure.

Wood. To determine the value of various chemical treatments in render-

ing shingles and siding non-inflammable and slow burning, western red cedar

shingles, purchased at a local lumber yard, free from knots and decay, were

used. Three shingles (6 inches wide) were used in each test. They were

air-dry when purchased and treated.

Cypress siding was also used in these test. Three test pieces 5 1 /2 by 1 /4 by

12 inches were used in each test. This material was air-dried before testing.

Preservative. The chemicals used in these tests were :

(a) Ammonium phosphate dibasic.

(6) Ammonium phosphate.

(c) Ammonium chloride.

(d) Ammonium alum.

(e) Aluminum sulphate.

(/) Sodium borate.

(g) Zinc chloride.

Injection with Chemicals. Three specimens of cypress siding and six red

cedar shingles were weighed and placed in tin containers together with the

treating solution which had previously been heated to 150 F. The con-

tainer was then placed in a small treating cylinder and a pressure of 130

pounds per square inch applied by means of compressed air. This pressure

was maintained until the specimens were saturated, which required approxi-

mately 2 hours. The pieces were then removed and weighed and the amount

of salt absorbed was determined.

After treatment the pieces were allowed to season for 3 or 4 weeks or

until they came back to approximately the same weight as before treatment,

plus the amount of salt absorbed. 1 This method was followed in order to

obtain an air-dry moisture condition in the wood.

1 The moisture content of these test specimens before treatment was not taken. The

specimens were air-seasoned in the laboratory and contained approximately 10 percent of

moisture when tested.

338 THE PERSERVATION OF STRUCTURAL TIMBER

Inflammability Test on Natural and Treated Shingles and Siding. This

test was made using the Inflammability Apparatus in the following manner :

Sufficient electric current was passed through the heating coil to give the

silica plate a temperature of approximately 325 C. 1 The temperature of

the plate was recorded by means of a pyrometer of the thermo-couple type,

the couple lying flat against the plate. A constant temperature was main-

tained as nearly as possible throughout the tests until the shingles ignited.

When the temperature of the plate was constant at 325 C. the test speci-

men was placed in the carrier and moved a distance of 3/4 inch from the

plate. This brought the lower part of the specimen directly opposite the

heating plate. The radiated heat caused the wood to distill or to give off

volatile, inflammable gases. In order to ignite these gases the pilot light

was flashed up past the face of the specimen at 5-second intervals until igni-

tion took place. The length of time necessary to ignite the specimen was

recorded by means of a stop watch.

Three tests were made in this series as follows:

Test A, in which the specimen was allowed to burn in this manner for 1

minute after ignition took place. The specimen in its carrier was then

drawn back about 4 inches from the heated zone and allowed to burn out.

The electric current was not turned off during this period. The length of

time of burning, the spreading of the flame and the condition of the speci-

men after burning were all recorded. Three specimens were used with each

preservative in this test, and the results averaged.

Test B was identical with Test A except that the specimen was left in

position for 6 minutes after ignition occurred. The length of time before

ignition took place, the length of time of burning, the spreading of the flame,

and the condition of the shingle after burning were recorded as in Test A.

Test C was identical with Test A except that the specimen was left in

position not over 12 minutes, or until the upper portion was consumed.

The length of time before ignition took place, the length of time of burning,

etc., were recorded as in the other tests.

Tests A and B were used with natural and treated shingles.

Test C was used with natural and treated siding.

DISCUSSION OF RESULTS OF THE TESTS WITH CYPRESS SIDING

AND RED CEDAR SHINGLES

Cypress Siding. It was found that if the chemicals that proved effective

in retarding the combustion of noble fir in the previous tests were injected

into cypress siding, very good results were obtainable. The results of the

tests are shown in Table 48. The untreated cypress ignited and was practi-

cally consumed in 9 minutes. Cypress treated respectively with a 6 percent

ammonium phosphate solution, a 10 percent ammonium sulphate solution, a

solution containing 3 parts of ammonium phosphate and 5 parts ammonium

sulphate in 100 parts, and a 10 percent borax solution did not ignite and

burn to any extent during the test.

As in the former tests on small specimens, ammonium alum and aluminum

sulphate or a mixture of the two did not prove satisfactory in retarding the

1 This temperature was used since it was found to give easily measured time and tem-

perature readings in this apparatus.

APPENDICES

339

s >

III!

> ? 3 ^

iVla?

Eo^.S

Burned violen

consumed.

di

y

p

fc^

flam

p.

Flashing of

the specim

,

ing

ugh.

a

glo

ro

lllv

\*?.!!

gg'SoS

S H |I^

o^fc-2

1|gS

I2a-g

-'88

iSfl^

1 J3J

ic fla

ntilt

ame

imen

fe C-" x

"S .AgJ

O 4) C

ss-a H

l|!:i

2 0\*3 2

^5j3 o- O

H si o S ft

fl

1

of test.

heated

ire

om

J T3 2

&ft

^^

sa^

a

'

ntire time of test.

from the heated

n.

M 4)

JJ

IP

U OO.C

M W

\*- s

nl

.

a s

3~S-

00 S G

6?3

10 G 2

340 THE PRESERVATION OF STRUCTURAL TIMBER

I

52

a

B

9

a

"3\*0

55

o

A

a^

a

1

j

a .

,>>

ct

'5 a

a

a]

03

\_(-] .5

^ a

2

"a

I

'S

|I

1

03

P

2

\*S

11

1

Remarks

ently. The shingles were e

ough in 6 min. without igni

e and burn for short time i

t entirely fire resistant.

angles tested, 8 charred thro

d 5 showed a small flame dt

iod.

|

1

|

a

1

if

1

"cS

o

1

1

3

03

OS

en

1

1

b

03

a

CO

a

M

a

I

1

o

B

1

1

burned approximately 1 mi

out and could not be ignitec

burned hole in shingle at the

plate. Then went out and (

in.

burned for few minutes and

ic burning was very poor.

s-g

II

Charred thi

a\*

i|

ass

= 99

ill

i|

a

o

1

Burning wa

time, 28 se

No ignition

Burned poo

No ignition

II

'a'a

31

U

Ignited and

site heated

ignited aga

Ignited and

go out. T

321

o :

I

i

;

I

If

oj'2

03 .

I

:

>

|||

SH

CO

CO

CO

CO

CO

CO

CO

CO

CO

CO

CO

CO

CO

\*%

i

I'

13 "ft" 3 d

3 M .>3,

13

1

"3

.S

3

83

3

B

8

1

-

a

.2

a\*

3

marks

<N

2

03

"t^ "

o

-2 3

'3

CO

o

08

a,'-5 "0

. '

ft\*

a<o

6

i

\* \*\* -2

s

ro

CO

^

10

.f

t-H

o

1

ro

>

^ o

^

o

o

"eS

^

I

fc

55

. \*

a\*

a ^

5 ^3 ^^

.10

10

iO

o

iO

O

|

i ^

U co

IN

CO

IN

CO

<N

CO

CO

CN

CO

CN

CO

IN

CO

IN (N

COCO

CO

(N

CO

CM

CO

<4

J ^ ^S

1

JdJ

tC

CO

CO

CO

CO

CO

CO

CO

CO

CO

ro

COCO

CO

CO

CO

3

3\_a.2 fe

\*"\*

55

"ra 3

5 wa

-^

a <\*- '^3 '\*3

1

.\*\*.\*

0> O e8 3

o

CO

^

IO

CO

J^

00

IN-\*

CO-\*

ooo

coo

IO

t^ r

B

rH

03 43 g

b

o

.2

.2

"a "

la

a

o

1

el 3

03

rC3

>

PJ"

Q

O "w

03

o

a

T3

T3

9

\*\*'p

\*

2

Treatment

Chemical

reated

monium phosphate

monium phosphate

5

I

S

3

'3

o

a

nonium sulphate. .

monium sulphate..

monium sulphate. .

monium sulphate. .

monium phospha

monium sulphate i

monium phosphs

monium sulphate.

mm borate

B borate 1 from zir

e. Sodium borate.

chloride

imonium) alum. . .

minum sulphate. . .

a

3

5

a

5

3

3

a

s a

36

T3T)

BT3

g

C 3

&

2|

f

f

j

2

<JS

4\*

mm

SI\*\*

1

-J.-<

APPENDICES

341

w PQ

ft

a -s g 8

a ja \*

y S 0)

I l.s

II

ill

c ^,

S in

iii?

BB-iZ

S3Z.1

s

ft

342 THE PRESERVATION OF STRUCTURAL TIMBER

combustion of wood. This corresponds with the results that were obtained

when these chemicals were applied to noble fir in the previous tests. With

these tests a certain amount of burning occurred, although it was much less

severe than with untreated wood.

Table 49 gives the results of tests on treated and untreated shingles. It

will be noted that the natural red cedar shingles were exposed to the heating

plate for 1 minute after ignition. Ignition occurred after an exposure of

43 seconds. These shingles were entirely consumed. The treated shingles

were exposed to the heated plate for 6 minutes and in no case were they

consumed.

Table 50 shows the effect of painting or staining shingles that had pre-

viously been treated with fire-retarding chemicals. It did not appear to

detract materially from the fire-retarding treatments.

The following table gives the strengths of the various solutions together

with the estimated amount and the initial cost of the preservative necessary

to render 1000 red cedar shingles (four bundles) fire retardent. In the case

where the treatment necessitates waterproofing, the estimated cost of paint

for painting three-fourths of both sides of 1000 shingles is given.

TABLE 51

Estimated

Esti-

cost of paint

Total cost

Chemical fire retardent

Estimated ab-

sorption of pre-

servative by

(1000) 4 bundles

of red cedar

shingles

Cost

per

pound of

chemical

mated

cost of

chem-

icals to

fireproof

1000

shingles

necessary to

cover 3/4 of

(1000)

shingles both

sides, average

cost of cheap

roof paint 50

cents per

of chem-

icals and

paint nec-

essary to

fireproof

1000 red

cedar

shingles

gallon

Pounds

Pounds

solution

dry salt

4% solution ammonium

phosphate dibasic

266

10.64

$0.0875

$0.94

$1.40

$2.34

7% solution of ammo-

nium sulphate

266

18.62

0.035

0.65

1.40

2.05

3 % ammo, phos- }

phate 1 mix-

7.98

0.0875

4% ammo, sul- [ ture

266

10.64

0.0350

1.08

1.40

2.48

phate

8 % sodium borate (borax)

266

21.28

0.0375

0.80

1.40

2.20

Zinc borate using 3%

solution of zinc chloride

10 % solution of borax . . .

266

7.98

26.60

0.0350

. 0380

1.29

Not

necessary

1.29

Mixture of 7 1/2 % ammo

alum and 7 1/2 % alumi-

266

19.95

19.95

0.020

0.010

0.60

1.40

2.00

num sulphate

From this table it will be noted that the cost of treating shingles with the

additional cost of painting is so high that they would probably not find favor

among the majority of builders. The cost of treating shingles with zinc

borate is appreciably less than treating with a soluble salt and afterward

painting.

The shingles treated with zinc borate in this test were, for a period of 2

APPENDICES 343

weeks, alternately placed under running water for 24 hours and then dried

for 24 hours. They were then allowed to air-dry for several weeks before

testing. This test gives an indication of the permanency of the treatment.

An exposure test of long duration is now being made. One of the advan-

tages of this method of treating shingles is that an excess of zinc chloride

can be left in the shingles which will offer a strong resistance to decay.

Also other toxic salts can be injected together with either the zinc chloride

or borax solutions. Their permanency in the wood is a matter for further

consideration.

Additional Shipping Weight. From Table 51 will be seen the estimated

absorption in pounds of the various salts used in these tests for 1000 shingles.

In no case is the weight of a bundle of shingles increased over 30 pounds per

bundle.

In the table of costs it was assumed that painting would be necessary to

retain the soluble salts in the wood. It is not known how long the paint

would retain these salts, but probably it would have to be renewed every

few years. This would add greatly to the upkeep of such shingles, hence

the zinc borate treatment is by far the cheapest of those tested.

Conclusion on the Inflammability of Untreated and Treated Siding and

Shingles. From a consideration of the data obtained on the inflammability

of untreated and treated siding and shingles it appears that:

1. The inflammability of cypress siding was decreased to the extent of

preventing the flaming of the specimen by the use respectively of a 6 percent

solution of ammonium phosphate, a 10 percent solution of the ammonium

sulphate, a mixture of both to the proportion of 3 parts phosphate and 5

parts sulphate in 100 parts of solution, and a 10 percent solution of sodium

borate injected into the wood.

2. The corrosive action of the salt will more or less affect the cost of each

treatment.

3. The inflammability of red cedar shingles was decreased by the use re-

spectively of a 4 percent solution ammonium phosphate, a 7 percent solution

of ammonium sulphate, a solution containing 3 parts ammonium phosphate

and 4 parts ammonium sulphate in 100 parts, an 8 percent solution of borax,

and a double treatment with zinc chloride and sodium borate precipitating

zinc borate in the wood.

4. All of the chemicals used with the exception of zinc borate are soluble

in water, and if used in treating wooden shingles they would leach from the

wood unless a waterproofing coat were applied.

5. The cost of treating and painting 1000 shingles by any of the methods

discussed would be greater than treating 1000 shingles with zinc borate.

INVESTIGATION OF THE RELATIVE INFLAMMABILITY OF UN-

PAINTED AND PAINTED SHINGLES AND SIDING

The use of various kinds of paints in rendering wood slow burning was

included in the investigation. A number of paints sold as fire retardents

were submitted by various manufacturers. These paints were of two kinds :

1. Oil paints.

2. Cold water paints.

344 THE PRESERVATION OF STRUCTURAL TIMBER

The oil paints were applied to shingles and the cold water paints to cypress

siding.

Several creosote stains, not considered by the manufacturers as fire re-

tardents, were also included in these tests in order to obtain the relative

inflammability of shingles treated with this type of stain.

A number of paints were prepared at the laboratory and tested in com-

parison with the co-operative paints.

The following table gives the name of each paint and stain tested and the

co-operator submitting the sample:

Oil paints sold as fire retardents Co-operator

(a) Solvar Hoffman Solvar Roofing Paint Co.

(6) "Rabok" liquid carbon paint. . . . \ ,

;.,,,,,.., > Rabok Manufacturing Co.

(c) "Rabok' Lumisheen paint J

(d) Burns, improved cement coating. . C. L. Burns.

(e) Wadsworth Bay State brick and

cement coating Wadsworth, Rowland Co.

(/) Clapp fire-resisting paint The Clapp Fire-resisting Paint Co.

(g) L. & S. cement coating Laird & Sinclair Paint Manf rs.

Oil paints prepared at laboratory

(h) One-pigment paint Forest Service.

(i) Composite paint Forest Service.

(j) Paint containing zinc borate Forest Service.

Oil stains not sold as fire retardents

(/c) Cabot shingle stain Samuel Cabot (Inc.).

(I) Barrett "Velvex" creosote shingle

stain Barrett Manufacturing Co.

Cold water paints

(m) Pyrolin white spray Pyrolin Products Co.

(n) Nepolite paint Neptune Paint Co.

(o) Permanite M. Ewing Fox & Co.

(p) Pyrolin factory paint Pyrolin Products Co.

MATERIAL USED

Inflammability Apparatus. Inflammability apparatus as described in this

paper was used in making these tests.

Wood. Six western red cedar shingles 6 inches in width that were air-

dried in the laboratory and free from knots and decay were used for testing

the efficiency of the oil paints. In the case of the cold water paints, cypress

siding dressed to a uniform thickness of 1/4 inch was used.

Considerable variations in the moisture content or the specific gravity of

the shingles and siding did not appear to influence the results obtained in

some preliminary tests using this method. Therefore, no data were collected

on the moisture content of the specimens at time of testing. They were,

however, all air-dried under the same condition and hence were probably

practically of the same moisture content.

APPENDICES 345

Paints. The following paints were applied to shingles:

Co-operative oil paints Color

1 Solvar roofing paint Black

1 Rabok "Liquid Carbon" paint Black

1 Rabok "Lumisheen" paint Black

Burns' improved cement coating White

Bay State brick and cement coating White

L. & S. cement coating Red

1 Clapp fire-resisting paint Black

Co-operative oil shingle stains

Cabot shingle stain.

Barrett "Velvex" creosote shingle stain.

Oil paints prepared at laboratory

for comparison Color

A one-pigment paint Green

A composite paint White

A one-pigment paint (same as above) containing

fire retardent Green

The following paints were applied to 1/4-inch cypress siding:

Co-operative interior paints

Pyrolin "White Spray" cold water paint.

Permanite cold water paint.

Nepolite cold water paint.

Pyrolin factory interior paint.

Paint prepared at laboratory for comparison

White lead and oil paint.

METHOD OF CONDUCTING TESTS

Preparation of Paints and Painting of Specimens. The shingles in each

case were painted with two coats of each of the oil paints, all of the shingle

being painted except 2 inches at the top which represents the thin end of

the shingle. The first coat was always allowed to dry for 3 days before

the second was applied. In the case of stains the shingles were dipped. The

specimens were not tested until the coat had dried for approximately 45 days.

This gave the paint sufficient time to become hard and dry.

The specimens of siding were given two coats of each of the cold water

paints and allowed to dry in the laboratory approximately 15 days before

they were tested.

The one-pigment paint used for comparison was prepared from chrome

green pigment to represent a common green roof paint.

The composite paint used for comparison contained several pigments and

was prepared to represent a good house paint. It is similar to one that has

given good results in durability tests made by the National Paint Manu-

facturing Association.

1 The color of these paints is restricted to black.

346 THE PRESERVATION OF STRUCTURAL TIMBER

The one-pigment paint containing the fire retardent was prepared from

chrome green pigment and zinc borate.

These paints had the following composition :

One-pigment paint

Chrome green pigment 2 1/2 pounds

Boiled linseed oil 1 gallon

Composite paint

Pigments 15 pounds

Boiled linseed oil 1 gallon

The composition of pigment in this paint was:

Basic lead carbonate (white lead) 22 percent

Zinc oxide 50 percent

Calcium carbonate 2 percent

Kaolin 26 percent

Fire-retarding paint

Chrome green pigment 2 1/2 pounds

Zinc borate , 7 pounds

Boiled linseed oil 1 gallon

Inflammability Test on Natural and Painted Shingles and Siding. This

test was made using the apparatus in the same manner as described in the

first part of this paper.

DISCUSSION OF RESULTS

Oil Paints. Tables 52 and 53 show the results of the inflammability

tests on shingles, unpainted and painted with oil paints and stains. It will

be noted that in Test A where the shingles were exposed to the heating plate

for a period of 1 minute after ignition occurred only the unpainted shingles

were consumed. This test might be considered as representative of what

would probably occur should a spark or burning ember fall upon a wooden

shingle roof. It is evident in this test that the unpainted shingle obtained

such a good start, during the 1-minute exposure, that it was entirely con-

sumed. The various paint coatings appeared to retard burning but not the

time required for ignition. In a good many cases the oil contained in the

paint or stain caused flashing, but as soon as this oil was consumed the burn-

ing ceased. This was especially so with shingle stains. Just how danger-

ous such a fire would be should a number of painted shingles on a roof

become ignited and burn as a whole can only be determined by a test on

a larger scale.

Test B shows that when these painted shingles were given a more severe

test, by heating for 6 minutes after ignition, a number of paints did not

offer any marked protection.

A decision as to which was the most efficient paint will not be attempted

until the results of a test on a larger scale are obtained. The shingles painted

with Rabok "Lumisheen" paint were hard to ignite, but after ignition burned

vigorously and were entirely consumed. Also Wadsworth Bay State brick

APPENDICES

347

.

l

a s\*

^ss

1\*1

.C 60 S

^.a'i

^1 &

ilj

^g

o&S

l!l

SS5

Gradually

burning was

ed violently whi

ved from heated

ted area.

|!1

iii

te. Ater gn

out. The fla

heated zone.

ately 1 min.

Hard to gn

ally dying

mens from

for approxim

olenty

ne.

? li

is\*

123 S

|3|3

s s|

I'sti

bo

I

'a

lx

\*!

Is

|!

Ill

H|

HI

II <

ils=

9

348

THE PRESERVATION OF STRUCTURAL TIMBER

1

V

to

1

^ 4) CD

1

o

1

a

1

a

a

d

0)

"S

M

3

^

1

O

1

7

Remarks

ently. The average time necessary to

lese specimens was 5 min. and 20 sec.

iin., poorly at first, gradually growing

nsumed. 1

rly entire time. Shingles not destroyed,

le top of the shingle was purposely ignite<

j effect of the paint on the back of the

stopped when the painted part was read

after placing in apparatus. Entirely coi

ently. Entirely consumed.

7

3

o

^>i

"

'5

a

W

d

.2

'S

a

1

fa

n

>

~=l

s

CQ ^

S

1

1

02

1

bO

t fl

73

1

tb

03

a

1

IN

1

1

>>".

11

if

o

e

>>

Is

. -3

1

1

02

1

1

.3

if

1

13.

1

a

I

B

i

S

^Q

S

^"

ently. Entirely consumed. 1

which was below the heating plate.

Burned vio

consume tl

Burned 6 n

Entirely cc

Burned poo

eral cases t

to note th<

The flame

Flashed just

o

1

3

1

1

3

Burned po<

three-fourt

Burned poo

sumed.

Burned vio

Shingles er

Flashed 10

consumed.

Burned vio'

average tir

Burned viol

>wer 2 inches

ft?

M -J

| .

|

O

O

o

|

g

<N

7

2

S o5 ^

^ r^4

!\*

p|

||1

eo

CO

1C

LC

1C

CD

f.

CD

<\*

8

T3

&l

a

u

]

1

\*3

d

|

CO

CO

CD

CO

.

CD

CO

CO

CD

o>

't\*

fl

gco

CO

t.

CO

^

O

"5

h.

S

^

\*

M O

o-l

02

2\*""

BE

M

.s

fH

(N

,\_,

,\_,

,\_,

g

<< 02

^ :

:

"

3

S a

S

3

13 2"c

|-fj

^1

CO

CO

(N

co

CO

^5

CO

CO

CO\*

CO

C^

CO

co

3

rb

| ft

J

!8

8

.0 2

CO

CO

CO

CO

CO

CO

CO

CO

CO

CO

90

CO

as

a >

^j

I'-i"

1

a

V

1

s

g i

C

1

s

1

1

S

I

1

tu^

:

a

a

T3

"a

8

fl

4(

08 flrt

fl

.

w

a

a

'3

o

S

a

&

. "+3

c

a

T3

I

a

.3

5

1

s

s

a

.2 fl

s

.M

o

a

"

1

3

1

02

One-pigment pa

at laboratory.

1 Composite pain

1 laboratory.

One-pigment pa

above, contain

ate, developec

tory.

?

"o

co

^

03

o

.M

J

c

CJ

1 Rabok "Lumis

1

M

. C

|1

If

a

9

02

1

1 Clapp fire-resist

I Cabot's shingle

(Barrett's " Veh

shingle stain.

1 Entirely cons

APPENDICES

349

L'

s

s

i.j. ^.-a \*>

g S-r a)^3

d

\*P

c

^ o-o'S o

3

.

. consumed.

M

"S

i

>,

specimen V

;umed.

ed violently

111

1

a

1

graduall

r consum

a

8

+ a

'S 2

.SftJ

1

S > S-O TO

S|2SS^

I

1

gTS

ll

g|fl'S3'3

9

\*-^

'

o ^

rt S

S (^ -^ "\*^ 6JD

3

n fl

u V

\*H &>

fe 3

g r"S~g.2.9

^2

-Sfl

"2

5

5

'||| ^g|

-2 ^

c

JG

^

&

.-jQ

5-J

\_ 3^

o

"a

fe

-:<

S|

51\*3^ c

g

1

u

-2 .

^ p

O u

-\*-> o

^O||H'S

c

P

iJ 1 ""\*

\*> ^

\*\* fl S]

d3

1

1>!

11

3^

cJ

"o -^^ c

CO

CO

9

3

CQ

1=5

&3

S^ 1

C/3

lllll

H

fk

><

O

fa

llfsl

r

8

<N

8

cj

s

O

> 2 ^"M G

1

<^

1

OS

<N

i-l

O

i-H

C3

1

H

S

fa

Q

1

1 1

o a>

1

1

1

1

1

Is ?

dl

V

S

0)

c

1

P

3

sS <5

Sw

W

W

W

1

H

a

T

S'5

5 S -5

1"

o

00

CO

N

l\_

ll 1

^^

IQ

o J^

c

H

^3 \*2

03

\*o

CO

co

CO

\_5

S

^

(N

9

PQ

H

G TJ

o i fl a

M O^3 v

Sd^ e -|

o" 5

o

U5

ip

jo

a c aj'C ^\*

> C -JS a> m

M

CO

CO

co

co

CO

<% 0.08

a

"Sag

jis

i'l"

CO

CO

CO

CO

CO

CO

a

V

S \*

cypress. .

'o

03

V

J3

a

Q

o v

4a

1

1

2\*i

5

'3

I

1

H

^

.t^"c

2s

a

S

fc

a

^\_

^"^

350 THE PRESERVATION OF STRUCTURAL TIMBER

and cement coating and Burns' improved cement coating both retarded

ignition.

The use of zinc borate in the common green paint appeared to act as a

fire retardent. Shingles painted with the green paint containing the zinc

borate were not entirely consumed as in the case of the shingles painted with

the green paint alone.

The cost of zinc borate manufactured commercially could not be deter-

mined. Probably this is not produced commercially at the present time.

Assuming, however, 1 pound of borax at $0.038 per pound and 0.35 pound

zinc chloride at $0.035 per pound, the cost would be $0.048 per pound for

ingredients. Using 7 pounds zinc borate, 21/2 pounds of green pigment at

$0.125 per pound, and 1 gallon linseed oil at 60 cents, the resulting mixture

would cost $1.25. This, of course, would produce somewhat more than 1

gallon of paint.

The question of the application of paints on wooden shingles is worthy

of consideration. To paint a shingle roof properly, at least three-fourths of

each shingle should be painted before laying. The reason for this is that in

painting shingles on the roof more or less paint will be deposited where one

laps over the other. Upon drying, this surplus paint forms a dam that holds

back the rain water, thus making an ideal condition for the growth of fungus.

Paints must also be renewed occasionally and where they are used on a roof

and subject to the most strenuous of weather conditions they would have

to be renewed at comparatively frequent intervals, which would result in

the trouble mentioned above, besides being a source of considerable expense.

Cold Water Paints. It is generally known that lime paints, such as white-

wash, etc., when applied to a wooden surface will offer considerable protec-

tion from fire. This knowledge has led numerous paint manufacturers to

manufacture fire-retarding paints for interior use. Table 54 gives the results

of inflammability Test C made on several of these paints. White lead (as a

staple white pigment in oil paints) was used as a means of comparison.

CONCLUSION ON FIRE-RETARDING PAINTS

Oil Paints. From the data obtained on the fire-retardent paints tested

it is evident that:

1. All of the paints and stains tested offered some protection as shown by

Test A. The unpainted shingles in this test were entirely consumed, while

in the case of painted and stained shingles not one was wholly destroyed.

The more severe Test B eliminated the less efficient paints.

2. The addition of a metallic borate to a paint appears to be of advantage.

The shingles painted with the green roof paint without the zinc borate were

entirely destroyed in Test B, while the same paint containing 7 pounds of

the borate to the gallon proved very efficient in both tests.

3. It is difficult to show how the application of any paint on wooden

shingle roofs would be satisfactory unless about three-fourths of both sides

of each shingle was painted, because in a practical application the shingles

would have to be dipped which would require the painting of both sides.

Even then it might be questioned whether the fire-retarding value of any of

the paints tested would be great enough to warrant their use, especially if

APPENDICES 351

the cost of such a treatment is as great if not greater than the cost of an

efficient chemical injection.

Interior Paints. The especially prepared interior paints used in these

tests have a considerable influence in rendering wood fire retardent, and can

be recommended for interior use, if the results of this method of testing can

be considered practical. In each case the painted boards resisted ignition

longer than the untreated boards. The Pyrolin factory interior white paint

was especially effective in preventing ignition and spreading of fire in these

tests.

GENERAL CONCLUSIONS

From a consideration of all of the data given in this report it appears that:

1. There was very little variation in the inflammability of the various

species of untreated woods when tested at the higher temperatures. For

example, all of the specimens tested at 375 C. ignited within 2 minutes.

2. Ammonium salts and sodium borate gave more efficient results than

the other chemicals tested in rendering wood fire retardent. All of the

other salts tested either did not prevent free combustion of the wood when

injected in moderate quantities or they reacted with the wood, weakening

and discoloring it.

3. None of the chemical fire retardents used, when injected into the wood,

prevented it from glowing or charring.

4. Wooden shingles may be rendered fire retardent by injecting certain

chemicals. The additional cost of painting which is necessary with water-

soluble salts would, in most cases, no doubt, restrict the use of such treat-

ments.

5. The use of insoluble metallic borates precipitated in shingles appears

to be the most practical of the methods studied for rendering wooden shingles

fire retardent.

6. All of the paints tested with shingles rendered them to some degree

more fire retardent. The most effective of the paints tested which were

suitable for outside use was one containing zinc borate pigment which acted

as a fire retardent.

7. Shingle stains of the type tested did not greatly increase the inflam-

mability of the shingles, even though they were applied shortly before being

tested. Their use as a means of decorating treated shingles should, no

doubt, be allowed as they do not detract materially from the fire-retarding

treatment.

8. The paints tested which were designed for interior use were in general

more effective than the paints designed for outside use, in retarding fire.

9. The method of application of a paint is of considerable importance.

It would seem to be good practice with shingles to apply the paint to ap-

proximately three-fourths of both sides before laying the shingle.

10. Best results in the treatment of shingles are shown in the following

table (55). It will be noted that shingles treated with 4 percent solutions

of ammonium phosphate, 10 percent borax and a mixture of 3 percent am-

monium phosphate and 4 percent ammonium sulphate did not ignite at all.

If protected with a waterproof paint, these shingles should give satisfactory

service.

352

THE PRESERVATION OF STRUCTURAL TIMBER

TABLE 55. SHOWING THE RELATIVE VALUE OF THE VARIOUS PROCESSES

FOR TREATING SHINGLES THAT ARE CONSIDERED OF IMPORTANCE

Treatment given

Average

time of ex-

posure to

heating

plate

before

ignition

took place

Average

duration of

burning

after

ignition

Remarks

Chemical or paint

used

Strength

of treat-

ing solu-

tion

Percent

Min. Sec.

Min. Sec.

Ammonium phosphate

4

No ignition

Exposed 6 min. Chemical

soluble in water. Painting

necessary. 1

Ammonium phosphate

8

No ignition

Exposed 6 min. Chemical

soluble in water. Painting

necessary, i Chemical rela-

tively cheap.

Ammonium phos-

3

No ignition

Exposed 6 min. Chemical

phate and ammonium

soluble in water. Painting

sulphate.

4

No ignition

necessary.

Borax

10

No ignition

Exposed 6 min. Chemical

souble in water. Painting

necessary.

Exposed 6 min. Ignited and

Zinc borate, from

3

See

burned poorly for 1 min. when

zinc chloride and

remarks

flame went out and could

borax.

10

not be ignited again. Salt

is soluble in water. Paint-

ing not necessary.

Rabok "Lumisheen"

2 10

5 40

Exposed 6 min. Hard to

paint.

ignite. Heat so intense after

ignition that shingle was en-

tirely consumed. Color sil-

very black.

Paint containing zinc

1 7

6

Exposed 6 min. Burned

borate and color pig-

poorly entire time. Paint

ment, developed at

prohibited spreading of the

laboratory.

flame.

Red oxide of iron and

1 3

6

te

asbestine paint.

White lead zinc oxide

1 3

6

u

and asbestine paint. 2

Chrome green fo&riurn,

1 28

6 15

n

sulphate and asbes-

tine paint. 2

1 The painting of these shingles does not retract from the fire-retarding value of the chem-

ical treatment.

1 Paints submitted by H. A. Gardner, Institute of Industrial Research.

INDEX

Abrasion, importance of, 25

protection of ties from, 141

Absorption, effect of density of wood

upon, 31

difficulty in measuring, 116

measured by gages and scales,

103

of preservatives (see penetra-

tion)

variation in different woods, 138

A.C.W. process, description of, 59

Aczol, description of, 253

Adzing, advantages of before treat-

ment, 147

machines, apparatus and cost

of, 106

Air pressure, effect of upon treat-

ment, 112

pumps, cost and use of in plants,

97

seasoning, description of, 44

Alkaline soils, action upon wood,

26

soils, decay of wood in, 221

Allardyce process, description of, 63

Allis-Chalmers Co., table on plant

costs, 125

American Ry. Eng. Ass'n, specifica-

tions for creosote, 83, 261

Ammonium chloride, as a fire retard-

ant, 216

Analysis, of creosote, 261

of zinc chloride, 297

Anchors, construction of, 93

Angier, F. J., on the use of air

pumps, 97

on grouping ties, 138

Annual ring, definition of, 34

Anthrasota, description of, 254

Asbestos packing, use of in doors, 94

Association for Standardizing Pav-

ing Spec., specifications for

creosote, 84

Atlas wood pres. description of, 254

B

Bailey, I. W., experiments of, on

penetration, 38

Bark, necessity for peeling, 41

effect of on life of piling, 183

Barrels, used for open tank plants,

89

Barrett's Grade I Oil, description

of, 255

Barns, paving blocks in, 204, 322

Barol, description of, 255

Bateman, E., method for analyzing

zinc chloride, 74

Beachwood creosote, description of,

254

Bet hell process, description of, .">(>

Birds, destruction of wood caused

by, 27

protection against, 221

Bleeding, of wood blocks, 201

Block signals, use of treated ties

between, 241

Blocks, equipment for making, 105

oil for, 84

Blocks, for factories, 322

B.M. Preservative, description of,

253

B.M. Process, description of, 249

Boats, preservation of, 186

Boiler house, construction of, 98

Boiling, effect of on strength of

wood, 229

Boiling process, description of, 48, 57

Bolt doors, construction of, 94

Bolts, use of in doors, 94

Borax, as a fire retardant, 216

353

354

INDEX

Boring holes in posts to preserve

them, 175

Boring ties, machines for, 106

effect of, in holding spikes, 146

Boucherie process, for treating poles,

163

Bridge timbers, substitutes for, 246

durability of, 311

Brush treatments, description of, 51

Brush treatments, for poles, 160

for posts, 175

Buehler process, description of, 58

Buggies (see cars)

Builders of treating plants, 261

Buildings, methods of treating lum-

ber in, 209

substitution for wood in, 247

Burlap, used in protecting piling, 183

Burnett process, description of, 60

Burnett, Wm., 73

Butterfield, J. T., tests on the elec-

trical resistance of wood,

234

Canals, use of in plants, 100

Capital, invested in wood preserv-

ing plants, 2

Carbolineum, Avenarius, description

of, 252

Carbolineum, S.P.F., description of,

252

Carbolic acid, toxicity of, 72

Carbon, in creosote, 121

Card process, description of, 61

improvement in, 93

Cars, construction of cylinder, 100

treatment of wood in, 209

substitutes for wood in, 247

C. A. Wood Preserver, description of,

252

Cecil-Williams process, description

of, 252

Cell walls, absorption by, 32

Cement, used in protecting piles, 184

Charring, as a means of preserving

wood, 51

poles, 160

posts, 174

Checks, prevented by "S-irons, " 158

Chemical composition of cell wall,

effect of on penetration, 39

Chicago Creosoting Co., design of

block plant, 106

Coal tar creosote, composition and

value of, 81

specifications for, 83

Coal tars, discussion of, 78

Coils, construction of in retort, 93

Compression, of wood in cylinder,

117

Concrete, poles set in, 160

Concrete ties, use of, 244

Conduits, substitutes for wood, 248

Conservation of timber, affected by

preserving wood, 2

Conserve description of, 254

Consumption of wood preservatives

in the U. S., 259

Copperized oil, description of, 252

Copper sulphate, its value as a wood

preservative, 71

Corrosion of spikes, in zinc treated

ties, 241

Corrosion of steel, by preservatives,

68

Cost of pressure plants, 124

of fireproofing wood, 218

of treating cross arms, 170

of treating mine timbers, 192

of treating paving blocks, 202

of treating piling, 185

of treating poles, 165

of treating posts, 178

of treating shingles, 207

of treating ties, 150

Cranes, use of in plants, 100

Creoaire process, description of, 251

Creoline, description of, 254

Creo-resinate process, description of,

250

Creosotes, their value as wood pre-

servatives, 75

classification of, 77

Creosote, definition of, 76

evaporation of, 67

expansion of, due to tempera-

ture, 117

INDEX

355

Creosote, method of manufacture,

79

Creosote process (see Bethell proc-

ess)

Creosote, as a fire retardant, 219

effect on human skin, 82

effect on the strength of wood,

230

Forest Service method of analy-

sis, 270

list of manufacturers of, 255

specifications for, 261

Cresol-calcium process, description

of, 251

Cross arms, woods used for, 168

methods of seasoning, 168

manufacture of, 168

Cross arms, economy in treating, 171

cost of treating, 170

treatment of, 169

Crude oil, for treating posts, 174

effect on strength of wood, 231

Crude oils, value of, as wood pre-

servatives, 75

Crumby, J. J., on the life of posts,

179

Curtis, W. G., 57

Cutting season, effect of, on treat-

ment, 140

Cylinder cars, construction of, 100

Cylinder, expansion of due to tem-

perature, 117

Cylinders (see retorts)

Davis, spot test, 330

Decay, discussion of, 15

Decayed poles, reenf orcement of, 164

Density of wood, effect upon pene-

tration, 31

Deterioration of timber, discussion

of factors which cause, 15

Dipping treatments, description of,

52

posts, 174

Dock, construction of loading, 99

Doors, construction of in retorts,

94

Durability, of green and seasoned

wood, 43

of American timbers, 275

records on life of wood, 298,

304-321

E

Economy, in treating ties, 151

mine timbers, 193

piling, 186

poles, 166

posts, 178

Egypt, history of wood preservation

in, 9

Electrical resistance of treated

wood, 234

Electrolysis, in protecting piling,

184

Empty cell process (see Lowry and

Rueping processes)

Errors, in operating plants, 116-120

Europe, history of wood preservation

in, 9

Evaporation of creosote, 67

Expansion of creosote due to tem-

perature, 117

Factories, paving blocks in, 204, 322

treatment of wood in, 210, 322

Fence posts (see posts)

Fiber-saturation point, definition of,

44, 225

Final vacuum, effect of, 109

Fir, used for cross arms, 168

Fire, destruction of wood caused by,

25, 213

in mines, 192

Fire-killed timber, utilization of, 8

Fireproofed wood, objections to, 214

Fireproofing plants, list of, 259

Fireproofing wood, theory of, 214

chemicals used in, 216

cost of, 218

methods of, 215

tests to determine the efficiency

of, 217, 336

356

INDEX

Fire protection, in plants, 105

Forest management, effect of wood

preservation upon, 3

Forests, composition of affected by

wood preservation, 3

Form of ties, 131

Freight, decreased by seasoning

poles, 159

Full-cell process (see Bethell proc-

ess)

Fungi, description and classification

of, 16

Furniture, methods of protecting

rustic, 211

G

Gages, location and construction of,

92

use of, in measuring absorption,

103

Gerry, Eloise, experiments on tylo-

ses, 36

Goltra, W. F., on transfer tables, 99

Goltra process, description of, 250

Greeks, on methods of preserving

wood, 9

Greenheart, for piling, 181

Greenhouses, treatment of wood in,

209

Grouping, value of, in ties, 139

Growth, effect of upon treatment,

141

Guard rails, construction of, 93

Guissani process, description of, 54

H

Hasselman process, description of,

250

Hatt, W. K., tests on the strength of

spikes, 147

effect of various processes on

strength of ties, 233

Heartwood, effect on penetration, 33

Herodotus, on preservation of mum-

mies, 9

Hewn ties (see ties)

History of wood preservation, 9

Holz-Helfer, description of, 253

Humphrey, C. J., toxicity test by, 65

Hunt, G. M., on Boucherizing poles,

163

I

Imperial Wood Preservative, de-

scription of, 254

Inflammability of wood treated with

zinc and creosote, 219

tests to determine, of wood, 217,

336

Initial absorption, difficulty in meas-

uring, 116

Insects, destruction of wood by, 18

in rustic furniture, 221

Inspection of treatments, notes on,

122

Inspector's laboratory, equipment

for, 104

Isaacs, J. D., 57

Jodelite, description of, 254

K

Kempfer, W. H., on treating poles,

162

Kickback, significance of, 118

Kreodone, description of, 254

Kyanizing, description of process, 53

for poles, 163

Laboratory, need for an inspector's,

104

Lagging, the retort, advantages of,

95

treatment of, in mines, 192

Leakage, prevention of, in doors, 94

Letteney, description of, 255

Liebig, on theory of decay, 15

Lightning equipment, in plants, 105

Limnoria, description of, 24

Loading dock (see dock)

Locustine, description of, 254

Log cabins, methods of protecting,

211

INDEX

357

Logs, effect of wood preservation

upon inferior, 8

methods of preserving, 211

Lowry process, description of, 59

Lumber, methods of treating, 208

Lyster, description of, 254

M

Machine shop, construction of, 98

Marine borers, description of, 20

Measuring tanks, types of, 101

Mechanical abrasion, destruction of

wood by, 25

Mercuric chloride, its value as a

preservative, 71

Mine timbers, selection of, 188

cost of treating, 192

durability of, 298, 313

economy in treating, 193

manufacture of, 189

methods of treatment, 190

seasoning of, 189

substitutes for, 245

Mines, danger of fire in, 192

Mixing tanks, construction of, 101

Moisture, distribution in posts, 65

effect of in wood on treatment,

140

method of determining in creo-

soted wood, 273

Montanin, description of, 254

Mummies, preservation of, 9

Mykatin, description of, 254

N

National Electric Light Ass'n, analy-

sis of creosote, 264

specifications for water gas creo-

sote, 85

Nausitoria, description of, 21

Newlin, J. H., experiments in driving

spikes, 145

tests on shrinkage, 226

Nonpressure process, description of,

53

N. S., Special, description of, 254

O

Odor of preservatives, 69

Oil, seasoning in, 48

Oil tars, discussion of, 78

Oils, crude, value of, 75

Open tank plants, types of, 89

list of in U. S., 258

Open tank process, description of, 54

Open tank, treatments for poles, 161

Operation of plants, 89

Oxalic acid, as a fire retardant, 216

Packing, for retort doors, 94

Paint, on treated wood, 69

value of in preserving wood, 87

Paints, fireproofing, 343

Palmetto, for piling, 181

Patents, list of, for preserving wood,

276

Pavements, efficiency of various, 197

Paving blocks, manufacture of, 105-

198

expansion of, 201

methods of laying, 202

oil for, 84

troubles with, 200

Paving blocks, cost of treatment, 202

advantages of, 203

durability of, 299, 317

for barns and factories, 204, 322

history of, 195

methods of treatment, 199

number used, 196

woods used for, 197

Penetration, of preservative, effect

of structure on, 31

effect of cell slits upon, 39

effect of composition of cell wall

upon, 39

effect of heartwood on, 33

effect of pits upon, 38

effect of resin ducts upon, 36

effect of sapwood on, 33

effect of tyloses upon, 35

effect of vessels upon, 35

in springwood, 34

358

INDEX

Penetration in summerwood, 34

of various preservatives in

wood, 70

Peeling bark, necessity for, 37

Peeling timber, necessity for, 41

Perforations, in poles to aid pene-

tration, 161

Petri dish, method for determining

toxicity, 65

Petroleum (see crude oils)

Pettigrew, experiments with mum-

mies, 9

Pholas, description of, 22

Piling, life of, 16, 309

cost of treating, 185

economy in treating, 186

manufacture of, 182

methods of seasoning, 182

treatment, 183

substitutes for wood, 244

woods used for, 181

Piping, use of in plants, 104

Pitch streaks, in preserving posts,

177

Pits, effect on penetration, 38

Plants, construction and operation

of, 89

cost of pressure, 124

list of wood preserving in U. S.,

255

Plates, bearing on ties, 141

Pliny, on Grecian methods of pre-

serving wood, 9

Pole borer, description of, 19

Poles, attacked by woodpeckers, 27

cost of treating, 165

economy of treatment, 166

life of, 166-301, 314

manufacture of, 156

methods of treating, 159

reinforcing decayed, 164

perforations in, 161

saving in freight due to season-

ing, 159

seasoning of, 156-158

selection of species for, 156

shrinkage in, 159

substitutes for, 244

woods used in making, 156

Pollution of streams, 122

Pores (see vessels)

Posts, woods used in making, 172

cost of treating, 178

economy in treating, 178

life of, 179, 317, 321

method and time of cutting, 173

of seasoning, 173

substitutes for wood, 245

treatment of, 174

Powder post insects, description of,

18

Powell process, description of, 250

Preliminary air, effect of, 112

Preliminary vacuum, effect of, 107

Preservatives, corrosive action of,

68

amounts used in U. S., 259

properties of efficient, 64

purity of, 121

toxicity of, 66, 330

used in treating wood, 251

Preservol, description of, 252

Pressure, effect of, on strength of

wood, 232

Pressure, effect of, on treatments,

115

Pressure plants, essential parts of,

91

Prince, R. E., on fireproofing woods,

216, 336

Processes, for preserving wood, 50

Pump house, construction of, 96

R

Rails, construction of guard, 93

Receiving tanks, use of, 101

Records, on the durability of timber,

298, 304-321

Resin ducts, effect upon penetration,

36

Retort house, construction of, 91

Retorts, construction of, 91

Robbins process, history of, 13

description of, 250

Roofs, on ties, value of, 135

Rueping process, description of, 60

Rutgers process, description of, 61

INDEX

359

Sand storms, protection against, 223

Sap stain, damage caused by, 29

protection against, 222

Sapwood Antiseptic, description of,

253

Sapwood, effect on penetration, 33

distribution on ties, 132

absorption by, 138

Sawmill, in plants, 105

Scales, use of, in measuring absorp-

tion, 103

Season, of year, effect of on treat-

ment, 40, 140

Seasoning timber, necessity for, 42

cross arms, 245

effect on decay, 43

checking, 43

decreasing freight, 43

strength of wood, 224

in hot air, 46

in oil, 48

in open air, 44

in saturated steam, 46

in superheated steam, 47

in water, 48

methods used in, 44

mine timbers, 189

piling, 182

poles, 158

posts, 173

ties, 197

Seasoning yards, care of, 45

Seeley process, history of, 12

description of, 54

Shingles, woods used for, 205

cost of treating, 207

method of treating, 206

substitutes for wood, 247

treated against fire, 206, 336

Shipworms, description of, 20

Shower baths, use of for employees,

104

Shrinkage, in poles, 159

equations for, 226

Signals, block, use of treated ties

between, 241

Silos, treatment of wood in, 209

Slipperiness, in wood blocks, 200

Slits, effect of, in cell walls upon

penetration, 39

Smith, C. S., on treatment of poles,

163

Sodium carbonate, as a fire retard-

ant, 216

Sodium fluoride, its value as a pre-

servative, 72, 253

Sodium silicate, its value as a pre-

servative, 252

Soil, effect of alkaline, upon wood,

26, 221

Specifications, for creosote, 261

for zinc chloride, 73

Sphaeroma, 25

Spider doors, construction of, 94

Spikes, kinds, and use of, 143, 328

use of screw, 146

Spirittine, description of, 252

Spot test, Davis, 330

Springwood, effect on penetration,

34

Square sets, treatment of, 191

S-rons, prevention of checking, 158

Stains, value of, in preserving wood,

87

Steam, seasoning in saturated, 46

superheated, 47

Steam coils (see coils)

Steaming, effect on strength of wood,

226

Steel, corrosion of, by preservatives,

68

Steel ties, use of, 243

Stone, poles set in crushed, 160

posts set in crushed, 174

Storage tanks, use and construction

of, 101

Streams, pollution of, 122

Strength of wood affected by sea-

soning, 43, 224

by boiling, 229

by preservatives, 70, 230

by crude oil, 231

by pressure, 232

by temperature, 231

steaming, 226

zinc chloride, 230

360

INDEX

Strength of wood affected by various

processes, 232

of ties, 144, 327

Stubs, used for reinforcing poles, 164

Substitutes, for treated timber, 243

Summerwood, effect of on penetra-

tion, 34

Tanks, construction of, 101

Tars, classification of, 77

Teesdale, C. H., experiments on

penetration, 37

on absorption of creosote by

wood, 230

on paving blocks, 322

Temperature, effect of on strength of

wood, 231

Teredo, description of, 21

Test tracks, need for, 154

Thermometer, location of in retort,

92

Thilmany process, history of, 13

description of, 249

Thinning forests, effect of wood pre-

servation on, 7

Tiemann, H. D., experiments in

penetration, 39

effect of temperature on wood,

231

tests on strength of wood, 224

Tie plates, types and use of, 141

Ties, selection of species for, 128

cost of treating, 150

crushing strength of, 144, 327

durability of, 303, 304

economy in treating, 151

form of, 131

grouping, to secure uniform

treatment, 136

hewn vs. sawed, 129

length of time to season, 135

peeling, 41

sawed, value of, 129

seasoning of, 134

selection of treating process for,

148

substitutes for wood, 243

Tillson, G. W., studies of street

pavements, 196

Timberasphalt, description of, 252

Timber supply, effect of wood pre-

serving on, 2

Toxicity, of preservatives, 65, 330

Track scales, use of, 103

Transfer tables, use of, 99

Treated timber, amount of in U S.,

259

Turtles (see anchors)

Tyloses, effect of, on penetration, 35

U

United States, history of wood pres-

ervation in, 11

Utilization, of top logs, caused by

wood preservation, 8

i

V

Vacuum, effect of in treating timber,

107

Vessels, effect of, on penetration, 35

Volume, of charge, difficulty in

measuring, 116

Vulcanizing process, description of,

251

W

Waste, in hewing ties, 130

Water-gas-tar creosote, derivation

and composition of, 85

description of, 253

for wood blocks, 199

specification for, 85

Water-gas tar (see oil tars)

Water, its existence in wood, 43

in oil, 121

soaking wood in, 48

Wellhouse process, description of, 62

Winslow, C. P., on creosotes, 75

Winter, effect of, on cutting timber

in, 40

Wood-block paving, oil used for, 84

Wood creosote, description of, 253

Wood, effect of water in on strength,

43

INDEX

361

Wood, expansion of due to tempera-

ture, 120

Wood louse, description of (see

Limnoria)

Woodpeckers, destruction of wood

by, 27

Wood preservation, definition of, 1

Wood preserving industry, impor-

tance of, 1

Wood preserving plants, list of in

U. S., 255

builders of, 261

Wood tar creosote, derivation and

composition of, 86

Wood tars, discussion of, 79

Working tanks, use of, 101

Wyoming Experiment Station, tests

on posts, 175

Xylotrya, description of, 20

Y

Yarborough, R. W., on lagging

retorts, 96

Yard, arrangement of, 99

care of, 45

method of handling timbers in,

100

Year, effect of time of, on treatment,

40

Zinc chloride, as a fire retardant,

219

changes in solutions, 122

effect upon the strength of

wood, 230

its value as a preservative, 72

manufacturers of, 255

method of analyzing, 297

in wood, 74

specification for, 73

visual tests for, 74

Zinc chloride process (see Burnett

process)

Zinc tannin process (see Wellhouse

process)

Zon, R., on the manufacture of ties,

130

F. V. ATKINSON.

TA

424.

W4

1916

Weiss, Howard Frederick

The preservation of

structural timber. 2d ed

rev. and enl.

OCT 1 4

PLEASE DO NOT REMOVE

SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO

LIBRARY