COOPERAGE

"Science ought to teach us to see the invisible as well as the visible in nature; to picture in our mind's eye those operations that entirely elude the eye of the body; to look at the very atoms of matter in motion, and at rest, and to follow them forth into the world of senses."

TYNDALL.

COOPERAGE

A TREATISE ON MODERN SHOP PRACTICE AND METHODS; FROM THE TREE TO THE FINISHED ARTICLE

PROFUSELY ILLUSTRATED

COMPILED AND WRITTEN
BY
J. B. WAGNER

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Dedication

"This volume is respectfully dedicated to those inventors, designers and builders of cooperage machinery and appliances, whose skill and devoted efforts along these lines have contributed so largely toward the perfection of our present methods of manufacture, placing our factories in the front rank with the leading industries of the world."

The Author.

PREFACE

The preparation of this work has occupied the writer's spare moments for a number of years. Originally the matter was not intended for publication, but the manuscript has grown so large and complete, which consideration, combined with many repeated requests, has induced the writer to publish the matter in book form.

While all other trades and professions have their literature more or less complete, the cooperage industry has never before been represented by any technical work, and appears to have been neglected along these lines. Therefore, we trust that the trade will appreciate our endeavors in bringing before them this work, as well as the difficulties encountered in compiling it, from the fact that it is the first of its kind in existence, and we hope that it will eventually prove to them a valuable aid.

The man that studies and applies himself attentively to any subject, seeks to advise his fellow-workman or give an exposition of the general principles of any science, industry or trade, or of improving conditions generally, often meets at times with severe criticism. As there seems to be present in the minds of most persons a certain amount of doubt and uncertainty as to the wisdom and ability of any person to advise them in these matters, even if the writer has been for a long time a student on the particular subject on which he writes.

Therefore, in presenting this volume, which is launched, not as a literary effort nor as a scientific essay, but rather as a practical discussion of principles and methods, the writer is aware that his efforts may meet with such criticism; but we do not desire to leave the impression that it is our own individual work, or that it is an expression of opinion of a single individual, but rather a grouping together of ideas offered by a considerable number of persons connected with the trade in its different branches, together with data continually collected during the author's extended career, both in this country and in Europe, of over a quarter of a century.

In regard to originality, we lay claim to very little, for, although the facts contained in a large number of the items have been gained through years of practical experience, we are indebted to others for a greater portion, and merely lay claim to have, as a great poet has said, "gathered the fruits of other men's labors and bound them with our own string." And we trust our efforts will present some information that may be applied with advantage, or serve at least as a matter of consideration or investigation.

Although much of the information contained in this volume exists in the experience of practical men of the trade and in other technical and mechanical works, it has never before been published in systematic and accessible form and with special application to the cooperage industry. In every case our aim has been to give the facts, and wherever a machine or appliance has been illustrated or commented upon, or the name of the maker has been mentioned, it is not with the intention either of recommending or disparaging his or their work, but are made use of merely to illustrate the text.

The writer has endeavored to discuss the principles and methods in as plain common-sense words as the English language will permit, and the preparation of the following pages has been a work of pleasure to the author. If they prove beneficial and of service to his fellow-workmen, he will have been amply repaid.

THE AUTHOR.

ACKNOWLEDGMENT

The writer desires to acknowledge the kind assistance rendered him by such able writers as Mr. E. A. Sterling, Filibert Roth, and others, of the Forest Service, Department of Agriculture, for the use he has made of extracts from some of their admirable articles written for this department, and the Hon. Gifford Pinchot, forester, for his very kind permission in the use of same.

To our trade journals, notably, *The National Coopers' Journal,—The Barrel and Box—Packages,* and to numerous managers and superintendents of well-known mills and factories, and to individual fellow-workmen throughout the country.

Much valuable information was furnished and many of the engravings which were used to illustrate the machinery were kindly loaned to the writer by the following named firms:

Baldwin, Tuthill & Bolton.......Grand Rapids, Mich.
Rochester Barrel Machine Works.....Rochester, N. Y.
Wm. E. Hill & Co....................Kalamazoo, Mich.
Merritt Manufacturing Co............Lockport, N. Y.
E. & B. Holmes Machinery Co...........Buffalo, N. Y.
U. S. Department Agriculture......Washington, D. C.
Defiance Machine Works..............Defiance, Ohio
The Noble Machine Works..........Fort Wayne, Ind.
Covel Manufacturing Co........Benton Harbor, Mich.
John S. Oram........................Cleveland, Ohio
The Peter Gerlach Co................Cleveland, Ohio
The Geo. Chaloner's Sons Co............Oshkosh, Wis.

To these the author takes pleasure in herein acknowledging his indebtedness, with many thanks, for a large number of facts and for other assistance rendered him.

The Author.

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GENERAL REMARKS

Although wood has been in use so long and so universally, there still exists a remarkable lack of knowledge regarding its nature, not only among ordinary workmen, but among those who might be expected to know its properties. As a consequence the practice is often faulty and wasteful in the manner of its use. Experience has been almost the only teacher, and notions—sometimes right, sometimes wrong—rather than well-substantiated facts, lead the workman. One reason for this imperfect knowledge lies in the fact that wood is not a homogeneous material, but a complicated structure, and so variable that one piece will behave very differently from another, although cut from the same tree. Not only does the wood of one species differ from that of another, but the butt cut differs from that of the top log, the heartwood from the sapwood, the wood of the quickly grown sapling of the abandoned field, from that of the slowly grown old monarch of the forest. Even the manner in which the tree was sawn and the condition in which the wood was cut and kept influence its behavior and quality. It is, therefore, extremely difficult to study the material for the purpose of establishing general laws. The experienced woodsman will look for straight-grained, long-fibred woods, with the absence of disturbing resinous and coloring matter, knots, etc., and will quickly distinguish the more porous red or black oaks from the less porous white species, *Quercus-alba.* That the inspection should have regard to defects and unhealthy conditions (often indicated by color) goes without saying, and such inspection is usually practised. That knots, even the smallest, are defects, which for some uses condemn the material altogether, needs hardly to be mentioned. But that season-checks, even those that have closed by subsequent shrinkage, remain elements of weakness is not so readily appreciated, yet there cannot be any doubt of this, since this, the intimate connections of the wood fibres when once interrupted are never re-established. The careful woods-foreman and stock manufacturer, therefore, is concerned as to the manner in which his timber is treated after the felling, for, according to the more or less careful seasoning of it, the season-checks—not altogether avoidable—are more or less abundant. This is practically recognized by sawing the stave and heading bolt at least two inches longer than is actually required, in order to eliminate these season-checks, should there be any, when the bolt is sawn or cut into staves and heading, and by splitting or quartering the cooperage stock, more or less, in the woods and seasoning it partly shaped. There is no country where wood is more lavishly used and criminally neglected than in the United States, and none in which nature has more bountifully provided for all reasonable requirements. In the absence of proper efforts to secure reproduction, the most valuable kinds are rapidly being decimated, and the necessity of a more rational and careful use of what remains is clearly apparent. By greater care in selection, however, not only can the duration of the supply be extended, but more satisfactory results will accrue from its practice. The structure of wood affords the only reliable means of distinguishing the different kinds. Color, weight, smell and other appearances, which are often direct or indirect results of structure, may be helpful in this distinction, but cannot be relied upon entirely. In addition, structure underlies nearly all the technical properties of this important product, and furnishes an explanation why one piece differs as to these properties from another. Structure explains why oak is heavier, stronger and tougher than pine; why it is harder to saw and plane, and why it is so much more difficult to season without injury. From its less porous structure alone it is evident that a piece of young and thrifty oak is stronger than the porous wood of an old or stunted tree, or that a Georgia or long-leafed pine excels white pine in weight and strength. Keeping especially in mind the arrangement and direction of the fibres of wood, it is clear at once why "knots and cross-grain" interfere with the strength of timber. It is due to the structural peculiarities that "honeycombing" occurs in rapid seasoning, that "checks or cracks" extend radially and follow pith rays, that tangent or bastard stock shrinks and warps more than that which is quarter-sawn. These same peculiarities enable oak to take a better finish than basswood or coarse-grained pine.

CLASSES OF TREES

The timber of the United States is furnished by three well-defined classes of trees: the needle-leaved, naked-seeded conifers, such as pine, cedar, etc., the broad-leaved trees, such as oak, poplar, etc., and to an inferior extent by the (one-seed leaf) palms, yuccas, and their allies, which last are confined to the most southern parts of the country. Broad-leaved trees are also known as deciduous trees, although, especially in warm countries, many of them are evergreen, while the conifers are commonly termed "evergreens," although the larch, bald cypress and others shed their leaves every fall, and even the names "broad-leaved" and "coniferous," though perhaps the most satisfactory, are not at all exact, for the conifer "ginkgo" has broad leaves and bears no cones. Among the woodsmen, the woods of broad-leaved trees are known as "hardwoods," though poplar is as soft as pine, and the "coniferous woods" are "softwoods," notwithstanding that yew ranks high in hardness even when compared to "hardwoods." Both in the number of different kinds of trees or species and still more in the importance of their product the conifers and broad-leaved trees far excel the palms and their relatives. In the manner of growth both conifers and broad-leaved trees behave alike, adding each year a new layer of wood, which covers the old wood in all parts of the stem and limbs. Thus the trunk continues to grow in thickness throughout the life of the tree by additions (annual rings), which in temperate climates are, barring accidents, accurate records of the tree. With the palms and their relatives the stem remains generally of the same diameter, the tree of a hundred years old being as thick as it was at ten years, the growth of these being only at the top. Even where a peripheral increase takes place, as in the yuccas, the wood is not laid on in well-defined layers; the structure remains irregular throughout. Though alike in their manner of growth, and therefore similar in their general make-up, conifers and broad-leaved trees differ markedly in the details of their structure and the character of their wood. The wood of all conifers is very simple in its structure, the fibres composing the main part of the wood being all alike and their arrangement regular. The wood of broad-leaved trees is complex in structure; it is made up of different kinds of cells and fibres and lacks the regularity of arrangement so noticeable in the conifers. This difference is so great that in a study of wood structure it is best to consider the two kinds separately. In this country the great variety of woods, and of useful woods at that, often makes the mere distinction of the kind or species of tree most difficult. Thus there are at least eight pines of the thirty-five native ones in the market, some of which so closely resemble each other in their minute structure that they can hardly be told apart, and yet they differ in quality and are often mixed or confounded in the trade. Of the thirty-six oaks, of which probably not less than six or eight are marketed, we can readily recognize by means of their minute anatomy at least two tribes—the white and black oaks. The same is true as to the eleven kinds of hickory, the six kinds of ash, etc., etc. The list of names of all trees indigenous to the United States, as enumerated by the Forest Service, is 495 in number, the designation of "tree" being applied to all woody plants which produce naturally in their native habitat one main, erect stem, bearing a definite crown, no matter what size they attain.

WOOD OF CONIFEROUS TREES

Examining a smooth cross-section or end face of a well-grown log of Georgia pine, we distinguish an envelope of reddish, scaly bark, a small whitish pith at the centre, and between these the wood in a great number of concentric rings.

BARK AND PITH

The bark of a pine stem is thickest and roughest near the base, decreases rapidly in thickness from one and one-half inches at the stump to one-tenth inch near the top of the tree, and forms in general about ten to fifteen per cent. of the entire trunk. The pith is quite thick, usually one-eighth to one-fifth inch in southern species, though much less so in white pine, and is very thin, one-fifteenth to one-twenty-fifth inch in cypress, cedar and larch. In woods with a thick pith, this latter is finest at the stump, grows rapidly thicker upward, and becoming thinner again in the crown and limbs, the first one to five rings adjoining it behaving similarly.

SAP AND HEARTWOOD

A zone of wood next to the bark, one to three inches wide and containing thirty to fifty or more annual or concentric rings, is of a lighter color. This is the sapwood, the inner darker part of the log being the heartwood. In the former many cells are active and store up starch and otherwise assist in the life processes of the tree, although only the last or outer layer of cells forms the growing part, and the true life of the tree. In the heartwood all the cells are lifeless cases, and serve only the mechanical function of keeping the tree from breaking under its own great weight or from being laid low by the winds. The darker color of the heartwood is due to infiltration of chemical substances into the cell walls, but the cavities of the cells in pine are not filled up, as is sometimes believed, nor do their walls grow thicker, nor are their walls any more liquefied than in the sapwood. Sapwood varies in width and in the number of rings which it contains even in different parts of the same tree. The same year's growth which is sapwood in one part of a disk may be heartwood in another. Sapwood is widest in the main part of the stem and varies often within considerable limits and without apparent regularity. Generally it becomes narrower toward the top and in the limbs, its width varying with the diameter, and being least in a given disk on the side which has the shortest radius. Sapwood of old and stunted pines is composed of more rings than that of young and thrifty specimens. Thus in a pine two hundred and fifty years old a layer of wood or annual ring does not change from sapwood to heartwood until seventy or eighty years after it is formed, while in a tree one hundred years old or less it remains sapwood only from thirty to sixty years. The width of the sapwood varies considerably for different kinds of pine. It is small for long-leaf and white pine and great for loblolly and Norway pines. Occupying the peripheral part of the trunk, the proportion which it forms of the entire mass of the stem is always great. Thus even in old trees of long-leaf pine the sapwood forms about forty per cent. of the merchantable log, while in the loblolly and in all young trees the bulk of the wood is sapwood.

THE ANNUAL OR YEARLY RING

The concentric annual or yearly rings which appear on the end face of a log are cross-sections of so many thin layers of wood. Each such layer forms an envelope around its inner neighbor, and is in turn covered by the adjoining layer without, so that the whole stem is built up of a series of thin, hollow cylinders, or rather cones. A new layer of wood is formed each season, covering the entire stem, as well as all the living branches. The thickness of this layer or the width of the yearly ring varies greatly in different trees, and also in different parts of the same tree. In a normally grown thrifty pine log the rings are widest near the pith, growing more and more narrower toward the bark. Thus the central twenty rings in a disk of an old long-leaf pine may each be one-eighth to one-sixth inch wide, while the twenty rings next to the bark may average only one-thirtieth inch. In our forest trees, rings of one-half inch in width occur only near the centre in disks of very thrifty trees, of both conifers and hardwoods. One-twelfth inch represents good thrifty growth, and the minimum width of 1/200 inch is often seen in stunted spruce and pine. The average width of rings in well-grown old white pine will vary from one-twelfth to one-eighteenth inch, while in the slower growing long-leaf pine it may be one-twenty-fifth to one-thirtieth of an inch. The same layer of wood is widest near the stump in very thrifty young trees, especially if grown in the open park; but in old forest trees the same year's growth is wider at the upper part of the tree, being narrowest near the stump, and often also near the very tip of the stem. Generally the rings are widest near the centre, growing narrower toward the bark. In logs from stunted trees the order is often reversed, the interior rings being thin and the outer rings widest. Frequently, too, zones or bands of very narrow rings, representing unfavorable periods of growth, disturb the general regularity. Few trees, even among pines, furnish a log with truly circular cross-section. Usually it is an oval, and at the stump commonly quite an irregular figure. Moreover, even in very regular or circular disks the pith is rarely in the centre, and frequently one radius is conspicuously longer than its opposite, the width of some rings, if not all, being greater on one side than on the other. This is nearly always so in the limbs, the lower radius exceeding the upper. In extreme cases, especially in the limbs, a ring is frequently conspicuous on one side, and almost or entirely lost to view on the other. Where the rings are extremely narrow, the dark portion of the ring is often wanting, the color being quite uniform and light. The greater regularity or irregularity of the annual rings has much to do with the technical qualities of the timber.

SPRING AND SUMMER-WOOD

Examining the rings more closely, it is noticed that each ring is made up of an inner, softer, light-colored and an outer, or peripheral, firmer and darker-colored portion. Being formed in the forepart of the season, the inner, light-colored part is termed spring-wood, the outer, darker-portioned being the summer-wood of the ring. Since the latter is very heavy and firm, it determines to a very large extent the weight and strength of the wood, and as its darker color influences the shade of color of the entire piece of wood, this color effect becomes a valuable aid in distinguishing heavy and strong from light and soft pine wood. In most hard pines, like the long-leaf, the dark summer-wood appears as a distinct band, so that the yearly ring is composed of two sharply defined bands—an inner, the "spring-wood," and an outer, the "summer-wood." But in some cases, even in hard pines, and normally in the woods of white pines, the spring-wood passes gradually into the darker summer-wood, so that a darkly defined line occurs only where the spring-wood of one ring abuts against the summer-wood of its neighbor. It is this clearly defined line which enables the eye to distinguish even the very narrow lines in old pines and spruces. In some cases, especially in the trunks of Southern pines, and normally on the lower side of pine limbs, there occur dark bands of wood in the spring-wood portion of the ring, giving rise to false rings, which mislead in a superficial counting of rings. In the disks cut from limbs these dark bands often occupy the greater part of the ring, and appear as "lunes," or sickle-shaped figures. The wood of these dark bands is similar to that of the true summer-wood. The cells have thick walls, but usually the compressed or flattened form. Normally, the summer-wood forms a greater proportion of the ring in the part of the tree formed during the period of thriftiest growth. In an old tree this proportion is very small in the first two to five rings about the pith, and also in the part next to the bark, the intermediate part showing a greater proportion of summer-wood. It is also greatest in a disk taken from near the stump, and decreases upward in the stem, thus fully accounting for the difference in weight and firmness of the wood of these different parts. In the longleaf pine the summer-wood often forms scarcely ten per cent. of the wood in the central five rings; forty to fifty per cent. of the next one hundred rings; about thirty per cent. of the next fifty, and only about twenty per cent. in the fifty rings next to the bark. It averages forty-five per cent. of the wood of the stump and only twenty-four per cent. of that of the top. Sawing the log into boards, the yearly rings are represented on the board faces of the middle board (radial sections) by narrow parallel stripes (see Fig. 1), an inner, lighter stripe

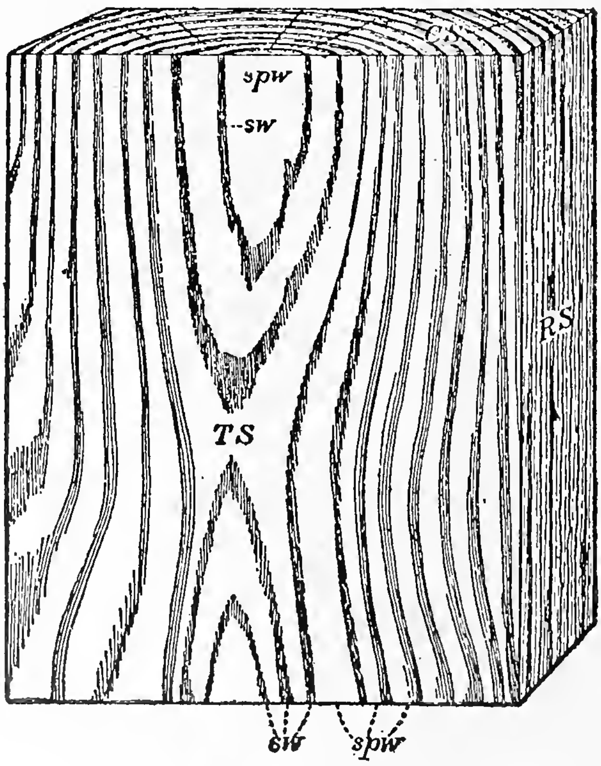


FIG. 1. BOARD OF PINE. *CS*, cross-section; *RS*, radial section, *TS*, tangential section; *sw*, summer-wood; *spw*, spring-wood.

and its outer, darker neighbor always corresponding to one annual ring. On the faces of the boards nearest the slab (tangential or bastard boards) the several years' growth should also appear as parallel, but much broader stripes. This they do if the log is short and very perfect. Usually a variety of pleasing patterns is displayed on the boards, depending on the position of the saw cut and on the regularity of growth of the log. (See Fig. 1.) Where the cut passes through a prominence (bump or crook) of the log, irregular, concentric circlets and ovals are produced, and on almost all tangent boards arrow or V-shaped forms occur.

ANATOMICAL STRUCTURE

Holding a well-smoothed disk or cross-section one-eighth inch thick toward the light, it is readily seen that pine wood is a very porous structure. If viewed with

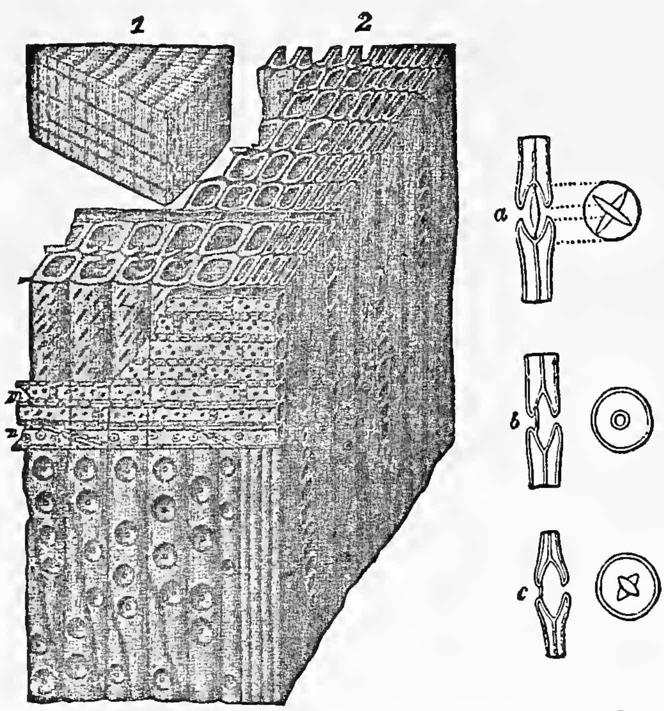


FIG. 2. WOOD OF SPRUCE. *1*, natural size; *2*, small part of one ring magnified 100 times. The vertical tubes are wood fibres, in this case all "tracheids." *m*, medullary or pith ray; *n*, transverse tracheids of pith ray; *a*, *b*, and *c*, bordered pits of the tracheids, more enlarged.

a strong magnifier, the little tubes, especially in the spring-wood of the rings, are easily distinguished, and their arrangement in regular, straight, radial rows is apparent. Scattered through the summer-wood portion of the rings numerous irregular grayish dots (the resin ducts) disturb the uniformity and regularity of the structure. Magnified one hundred times, a piece of spruce, which is similar to pine, presents a picture like that shown in Fig. 2. Only short pieces of the tubes or cells of which the wood is composed are represented in the picture. The total length of these fibres is from one-twentieth to one-fifth inch, being smallest near the pith, and is fifty to one hundred times as great as their width. (See Fig. 3.) They are tapered and closed at their ends, polygonal or rounded and thin-walled, with large cavity, lumen or internal space in the spring-wood, and thick-walled and flattened radially, with the internal space or lumen much reduced in the summer-wood. (See right-hand portion of Fig. 2.) This flattening together with the thicker walls of the cells, which reduces the lumen, causes the greater firmness and darker color of the summer-wood. There is more material in the same volume. As shown in the figure, the tubes, cells, or "tracheids" are decorated on their walls by circlet-like structures, the "bordered pits," sections of which are seen more

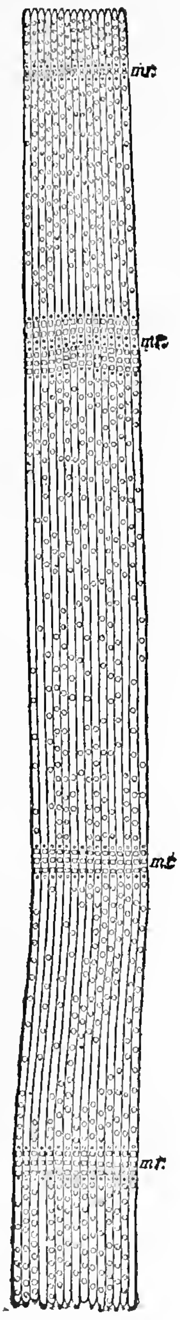


FIG. 3. GROUP OF FIBRES FROM PINE WOOD. Partly schematic. The little circles are "border pits." (See Fig. 2, *a-c*.) The transverse rows of square pits indicate the places of contact of these fibres and the cells of the neighboring pith rays. Magnified about 25 times.

magnified at *a, b* and *c,* Fig. 2. These pits are in the nature of pores, covered by very thin membranes, and serve as waterways between the cells or tracheids. The dark lines on the side of the smaller piece (1, Fig. 2) appear when magnified (in 2, Fig. 2) as tiers of eight to ten rows of cells, which run radially (parallel to the rows of tubes or tracheids), and are seen as bands on the radial face and as rows of pores on the tangential face. These bands or tiers of cell rows are the medullary rays or pith rays, and are common to all our lumber woods. In the pines and other conifers they are quite small, but they can readily be seen even without a magnifier. If a radial surface of split-wood (not smoothed) is examined, the entire radial face will be seen almost covered with these tiny structures, which appear as fine but conspicuous cross-lines. As shown in Fig. 2, the cells of the medullary or pith rays are smaller and very much shorter than the wood fibre or tracheids, and their long axis is at right angles to that of the fibre. In pines and spruces the cells of the upper and lower rows of each tier or pith ray have "bordered" pits, like those of the wood fibre or tracheids proper, but the cells of the intermediate rows and of all rows in the rays of cedars, etc., have only "simple" pits, i. e., pits devoid of the saucer-like "border" or rim. In pine, many of the pith rays are larger than the majority, each containing a whitish line, the horizontal resin duct, which though much smaller, resembles the vertical ducts seen on the cross-section. The larger vertical resin ducts are best observed on removal of the bark from a fresh piece of white pine cut in winter, where they appear as conspicuous white lines, extending often for many inches up and down the stem. Neither the horizontal nor the vertical resin ducts are vessels or cells, but are openings between cells, i. e., intercellular spaces, in which the resin accumulates, freely oozing out when the ducts of a fresh piece of sapwood are cut. They are present only in our coniferous woods, and even here they are restricted to pine, spruce and larch, and are normally absent in fir, cedar, cypress and yew. Altogether, the structure of coniferous wood is very simple and regular, the bulk being made up of the small fibres called tracheids, the disturbing elements of pith rays and resin ducts being insignificant, and hence the great uniformity and great technical value of coniferous woods.

LIST OF THE MORE IMPORTANT CONIFEROUS WOODS

CEDAR.—Light, soft, stiff, not strong, of fine texture; sap and heartwood distinct, the former lighter, the latter a dull grayish brown or red. The wood seasons rapidly, shrinks and checks but little, and is very durable. Used like soft pine, but owing to its great durability preferred for shingles, etc. Small sizes used for posts, ties, etc. Cedars usually occur scattered, but they form in certain localities forests of considerable extent.

a. White Cedars.—Heartwood a light grayish color.

1. White Cedar (*Thuya occidentalis*) (Arborvitæ). Scattered along streams and lakes, frequently covering extensive swamps; rarely large enough for lumber, but commonly used for posts, ties, etc. Maine to Minnesota and northward.

2. Canoe Cedar (*Thuya gigantea*) (Red Cedar of the West). In Oregon and Washington a very large tree, covering extensive swamps; in the mountains much smaller, skirting the water courses; an important lumber

tree. Washington to Northern California and eastward to Montana.

3. WHITE CEDAR (*Chamæcyparis thyoides*). Medium-sized tree, wood very light and soft. Along the coast from Maine to Mississippi.

4. WHITE CEDAR (*Chamæcyparis Lawsoniana*) (PORT ORFORD CEDAR, OREGON CEDAR, LAWSON'S CYPRESS, GINGER PINE). A very large tree, extensively cut for lumber; heavier and stronger than the preceding. Along the coast line of Oregon.

5. WHITE CEDAR (*Libocedrus decurrens*) (INCENSE CEDAR). A large tree, abundantly scattered among pine and fir; wood fine-grained. Cascades and Sierra Nevada of Oregon and California.

b. RED CEDARS.—Heartwood red.

6. RED CEDAR (*Juniperus Virginiana*) (SAVIN JUNIPER). Similar to white cedar, but of somewhat finer texture. Used in cabinetwork, for cooperage, for veneers, and especially for lead pencils, for which purpose alone several million feet are cut each year. A small to medium-sized tree scattered through the forests, or in the West sparsely covering extensive areas (cedar brakes). The red cedar is the most widely distributed conifer of the United States, occurring from the Atlantic to the Pacific, and from Florida to Minnesota, but attains a suitable size for lumber only in the Southern, and more especially the Gulf States.

7. REDWOOD (*Sequoia sempervirens*). Wood in its quality and uses like white cedar, the narrow sapwood whitish; the heartwood light red, soon turning to brownish red when exposed. A very large tree, limited to the coast ranges of California, and forming considerable forests, which are rapidly being converted into lumber.

CYPRESS.

8. Cypress (*Taxodium distichum*) (Bald Cypress; Black, White, and Red Cypress). Wood in its appearance, quality, and uses similar to white cedar. "Black cypress" and "white cypress" are heavy and light forms of the same species. The cypress is a large, deciduous tree, occupying much of the swamp and overflow land along the coast and rivers of the Southern States.

FIR.—This name is frequently applied to wood and to trees which are not fir; most commonly to spruce, but also, especially in English markets, to pine. It resembles spruce, but is easily distinguished from it, as well as from pine and larch, by the absence of resin ducts. Quality, uses, and habits similar to spruce. Used extensively for fish and oil cooperage on the Pacific Coast.

9. Balsam Fir (*Abies balsamea*). A medium-sized tree scattered throughout the northern pineries; cut in lumber operations whenever of sufficient size, and sold with pine or spruce. Minnesota to Maine and northward.

10. White Fir (*Abies grandis* and *Abies concolor*). Medium to very large-sized tree, forming an important part of most of the Western mountain forests, and furnishing much of the lumber of the respective regions. The former occurs from Vancouver to Central California and eastward to Montana; and the latter from Oregon to Arizona and eastward to Colorado and New Mexico.

11. White Fir (*Abies amabalis*). Good-sized tree, often forming extensive mountain forests. Cascade Mountains of Washington and Oregon..

12. Red Fir (*Abies nobilis*) (not to be confounded with Douglas spruce. See No. 37). Large to very large tree,

forming extensive forests on the slope of the mountains between 3,000 and 4,000 feet elevation. Cascade Mountains of Oregon.

13. Red Fir (*Abies magnifica*). Very large tree, forming forests about the base of Mount Shasta. Sierra Nevada of California, from Mount Shasta southward.

HEMLOCK.—Light to medium weight, soft, stiff but brittle, commonly cross-grained, rough and splintery; sapwood and heartwood not well defined; the wood of a light reddish-gray color, free from resin ducts, moderately durable, shrinks and warps considerably, wears rough, retains nails firmly. Used principally for dimension stuff and timbers. Hemlocks are medium to large-sized trees, commonly scattered among broad-leaved trees and conifers, but often forming forests of almost pure growth.

14. Hemlock (*Tsuga canadensis*). Medium-sized tree, furnishes almost all the hemlock of the Eastern market. Maine to Wisconsin; also following the Alleghanies southward to Georgia and Alabama.

15. Hemlock (*Tsuga mertensiana*). Large-sized tree, wood claimed to be heavier and harder than the Eastern form and of superior quality. Washington to California and eastward to Montana.

LARCH OR TAMARACK.—Wood like the best of hard pine both in appearance, quality, and uses, and owing to its great durability somewhat preferred in shipbuilding, for telegraph poles, and railroad ties. In its structure it resembles spruce. The larches are deciduous trees, occasionally covering considerable areas, but usually scattered among other conifers.

16. Tamarack (*Larix Americana*) (Hackmatack).

Medium-sized tree, often covering swamps, in which case it is smaller and of poor quality. Maine to Minnesota, and southward to Pennsylvania.

17. Tamarack (*L. occidentalis*). Large-sized trees, scattered, locally abundant. Washington and Oregon to Montana.

PINE.—Very variable, very light and soft in "soft" pine, such as white pine; of medium weight to heavy and quite hard in "hard" pine, of which long-leaf or Georgia pine is the extreme form. Usually it is stiff, quite strong, of even texture, and more or less resinous. The sapwood is yellowish white; the heartwood, orange brown. Pine shrinks moderately, seasons rapidly and without much injury; it works easily; is never too hard to nail (unlike oak or hickory); it is mostly quite durable, and if well seasoned is not subject to the attacks of boring insects. The heavier the wood, the darker, stronger, and harder it is and the more it shrinks and checks. Pine is used more extensively than any other kind of wood. It is the principal wood in common carpentry, as well as in all heavy construction, bridges, trestles, etc. It is also used in almost every other wood industry: for spars, masts, planks, and timbers in shipbuilding; in car and wagon construction; in cooperage, for crates and boxes; in furniture work, for toys and patterns, water pipes, excelsior, etc., etc. Pines are usually large trees with few branches, the straight, cylindrical, useful stem forming by far the greatest part of the tree. They occur gregariously, forming vast forests, a fact which greatly facilitates their exploitation. Of the many special terms applied to pine as lumber, denoting sometimes differences in quality, the following deserve attention:

"White pine," "pumpkin pine," "soft pine" in the Eastern markets refer to the wood of the white pine (*Pinus strobus*), and on the Pacific Coast to that of the sugar pine (*Pinus lambertiana*).

"Yellow pine" is applied in the trade to all the Southern lumber pines; in the Northeast it is also applied to the pitch pine (*P. rigida*); in the West it refers mostly to the bull pine (*P. ponderosa*).

Yellow long-leaf pine, "Georgia pine," chiefly used in advertisement, refers to the long-leaf pine (*P. palustris*).

a. Soft Pines.

18. White Pine (*Pinus strobus*). Large to very large-sized tree. For the last fifty years the most important timber tree of the Union, furnishing the best quality of soft pine. Minnesota, Wisconsin, Michigan, New England, along the Alleghanies to Georgia.

19. Sugar Pine (*Pinus lambertiana*). A very large tree, together with *Abies concolor* forming extensive forests. Important lumber tree. Oregon to California.

20. White Pine (*Pinus monticolo*). A large tree, at home in Montana, Idaho, and the Pacific States. Most common and locally used in Northern Idaho.

21. White Pine (*Pinus flexilis*). A small tree, forming mountain forests of considerable extent and locally used. Eastern Rocky Mountain slopes, Montana to New Mexico.

b. Hard Pines.

22. Long-Leaf Pine (*Pinus palustris*) (Georgia Pine, Yellow Pine, Long-Straw Pine, etc.). Large tree.

Forms extensive forests and furnishes the hardest and strongest pine lumber in the market. Coast region from North Carolina to Texas.

23. Bull Pine (*Pinus ponderosa*) (Yellow Pine). Medium to very large-sized tree, forming extensive forests in Pacific and Rocky Mountain regions. Furnishes most of the hard pines of the West; sapwood wide; wood very variable.

24. Loblolly Pine (*Pinus tæda*) (Slash Pine, Old Field Pine, Rosemary Pine, Sap Pine, Short-Straw Pine, etc.). Large-sized tree. Forms extensive forests; wider-ringed, coarser, lighter, softer, with more sapwood than the long-leaf pine, but the two are often confounded. This is the common lumber pine from Virginia to South Carolina, and is found extensively in Arkansas and Texas. Southern States, Virginia to Texas and Arkansas.

25. Norway Pine (*Pinus resinosa*). Large-sized tree, never forming forests, usually scattered or in small groves, together with white pine; largely sapwood and hence not durable. Minnesota to Michigan; also in New England to Pennsylvania.

26. Short-Leaf Pine (*Pinus echinata*) (Slash Pine, Carolina Pine, Yellow Pine, Old Field Pine). Resembles loblolly pine; often approaches in its wood the Norway pine. The common lumber pine of Missouri and Arkansas. North Carolina to Texas and Missouri.

27. Cuban Pine (*Pinus cubensis*) (Slash Pine, Swamp Pine, Bastard Pine, Meadow Pine). Resembles long-leaf pine, but commonly has wider sapwood and coarser grain; does not enter the markets to any great extent. Along the coast from South Carolina to Louisiana.

28. Bull Pine (*Pinus jeffreyi*) (Black Pine). Large-sized tree, wood resembling bull pine (*Pinus ponderosa*); used locally in California, replacing *P. ponderosa* at high altitudes.

29. Black Pine (*Pinus murrayana*) (Lodge Pole Pine, Tamarack). Rocky Mountains and Pacific regions.

30. Pitch Pine (*Pinus rigida*). Along the coast from New York to Georgia, and along the mountains to Kentucky.

31. Jersey Pine (*Pinus inops*) (Scrub Pine). Along the coast from New York to Georgia and along the mountains to Kentucky.

32. Gray Pine (*Pinus banksiana*) (Scrub Pine). Maine, Vermont, and Michigan to Minnesota.

REDWOOD. (See Cedar.)

SPRUCE.—Resembles soft pine, is light, very soft, stiff, moderately strong, less resinous than pine; has no distinct heartwood, and is of whitish color. Used like soft pine, but also employed as resonance wood and preferred for paper pulp. Used for all classes of cooperage and woodenware on the Pacific Coast, taking to some extent the place of oak for wine cooperage. Spruces, like pines, form extensive forests. They are more frugal, thrive on thinner soils, and bear more shade, but usually require a more humid climate. "Black" and "white" spruce as applied by lumbermen usually refer to narrow and wide-ringed forms of the black spruce (*Picea nigra*).

33. Black Spruce (*Picea nigra*). Medium-sized tree, forms extensive forests in Northeastern United States and in British America; occurs scattered or in groves, especially in low lands throughout the northern pineries.

Important lumber tree in Eastern United States. Maine to Minnesota, British America, and on the Alleghanies to North Carolina.

34. White Spruce (*Picea alba*). Generally associated with the preceding. Most abundant along streams and lakes, grows largest in Montana and forms the most important tree of the subarctic forest of British America. Northern United States from Maine to Minnesota; also from Montana to Pacific, British America.

35. White Spruce (*Picea engelmanni*). Medium to large-sized tree, forming extensive forests at elevations from 5,000 to 10,000 feet above sea level; resembles the preceding, but occupies a different station. A very important timber tree in the central and southern parts of the Rocky Mountains. Rocky Mountains from Mexico to Montana.

36. Tide Land Spruce (*Picea sitchensis*). A large-sized tree, forming an extensive coast-belt forest. Along the seacoast from Alaska to Central California. Used extensively for cooperage and woodenware in the West.

BASTARD SPRUCE.—Spruce or fir in name, but resembling hard pine or larch in the appearance, quality, and uses of its wood.

37. Douglas Spruce (*Pseudotsuga douglasii*) (Yellow Fir, Red Fir, Oregon Pine). One of the most important trees of the Western United States; grows very large in the Pacific States, to fair size in all parts of the mountains, in Colorado up to about 10,000 feet above sea level; forms extensive forests, often of pure growth. Wood very variable, usually coarse-grained and heavy, with very pronounced summer-wood, hard and strong ("red" fir), but often fine-grained and light ("yellow" fir). It replaces hard pine and is especially suited to heavy con-

struction. From the plains to the Pacific Ocean, from Mexico to British America.

TAMARACK. (See Larch.)

YEW.—Wood heavy, hard, extremely stiff and strong, of fine texture with a pale yellow sapwood, and an orange-red heart; seasons well and is quite durable. Yew is extensively used for archery, bows, turners' ware, etc. The yews form no forests, but occur scattered with other conifers.

38. Yew (*Taxus brevifolia*). A small to medium-sized tree of the Pacific region.

Wood of Broad-Leaved Trees.

On a cross-section of oak, the same arrangement of pith and bark, of sapwood and heartwood, and the same disposition of the wood in well-defined concentric or annual rings occur, but the rings are marked by lines or rows of conspicuous pores or openings, which occupy the greater part of the spring-wood for each ring (see Fig. 4, also 6), and are, in fact, the hollows of vessels through which the cut has been made. On the radial section or quarter-sawn board the several layers appear as so many stripes (see Fig. 5); on the tangential section or "bastard" face patterns similar to those mentioned for pine wood are observed. But while the patterns in hard pine are marked by the darker summer-wood, and are composed of plain, alternating stripes of

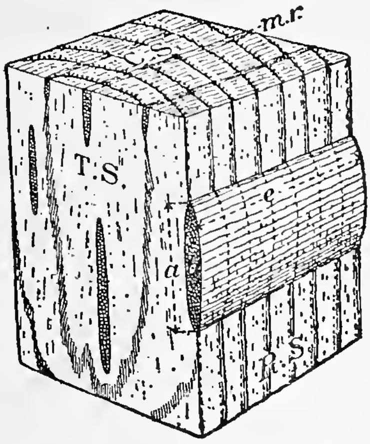


Fig. 4. Block of Oak. *C.S.*, cross section; *R.S.*, radial section; *T.S*, tangential section; *m.r.*, medullary or pith ray; *a*, height; *b*, width, and *e*, length of pith ray.

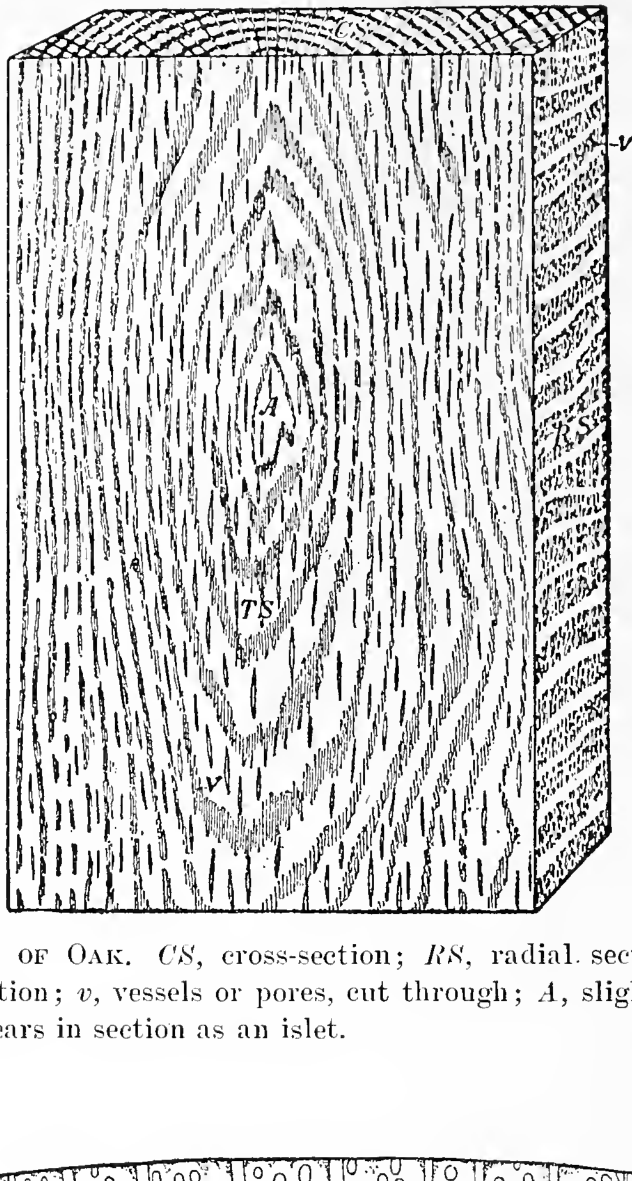


FIG. 5. BOARD OF OAK. *CS*, cross-section; *RS*, radial section; *TS*, tangential section; *v*, vessels or pores, cut through; *A*, slight curve in log which appears in section as an islet.

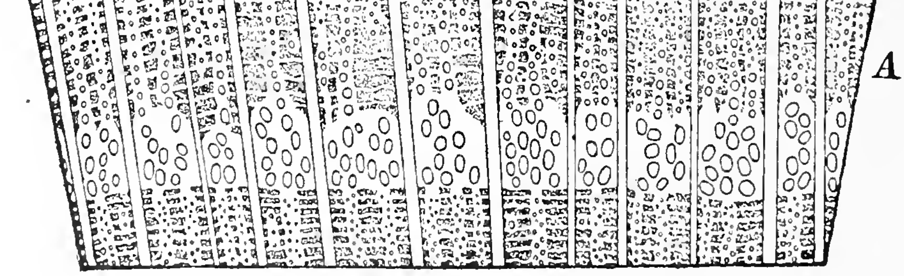


FIG. 6. CROSS-SECTION OF OAK MAGNIFIED ABOUT 5 TIMES.

darker and lighter wood, the figures in oak (and other broad-leaved woods) are due chiefly to the vessels, those of the spring-wood in oak being the most conspicuous. (See Fig. 5). So that in an oak table, the darker, shaded parts are the spring-wood, the lighter unicolored parts the summer-wood. On closer examination of the smooth cross-section of oak, the spring-wood part of the ring is found to be formed in great part of pores; large, round, or oval openings made by the cut through long vessels. These are separated by a grayish and quite porous tissue (see Fig. 6, A), which continues here and there in the form of radial, often branched, patches (not the pith rays) into and through the summer-wood to the spring-wood of the next ring. The large vessels of the spring-wood, occupying six to ten per cent. of the volume of a log in very good oak, and twenty-five per cent. or more in inferior and narrow-ringed timber, are a very important feature, since it is evident that the greater their share in the volume, the lighter and weaker the wood. They are smallest near the pith, and grow wider outward. They are wider in the stem than limb, and seem to be of indefinite length, forming open channels, in some cases probably as long as the tree itself. Scattered through the radiating gray patches of porous wood are vessels similar to those of the spring-wood, but decidedly smaller. These vessels are usually fewer and larger near the spring-wood, and smaller and more numerous in the outer portions of the ring. Their number and size can be utilized to distinguish the oaks classed as white oaks from those classed as black and red oaks. They are fewer and larger in red oaks, smaller but much more numerous in white oaks. The summer-wood, except for these radial grayish patches, is dark colored and firm. This firm portion, divided into bodies or strands by these patches of porous wood, and also by fine wavy, concentric lines of short, thin-walled cells (see Fig. 6, *A*), consists of thin-walled fibres (see Fig. 7, *B*), and is the chief element of strength in oak wood. In good white oak it forms one-half or more of the wood, if it cuts like horn, and the cut surface is shiny, and of a deep chocolate brown color. In very narrow-ringed wood and in inferior red oak it is usually much reduced in quantity as well as quality. The pith rays of the oak, unlike those of the coniferous woods, are at least in part very large and conspicuous. (See Fig. 4, their height indicated by the letter *a*, and their width by the letter *b*.) The large medullary rays of oak are often twenty and more cells wide and several hundred cell rows in height, which amount commonly to one or more inches. These large rays are conspicuous on all sections. They appear as long, sharp, grayish lines on the cross-section; as short, thick lines, tapering at each end, on the tangential or "bastard" face, and as broad, shiny bands, "the mirrors," on the radial section. In addition to these coarse rays, there is also a large number of small pith rays, which can be seen only when magnified. On the whole, the pith rays form a much larger part of the wood than might be supposed. In specimens of good white oak it has been found that they formed about sixteen to twenty-five per cent. of the wood.

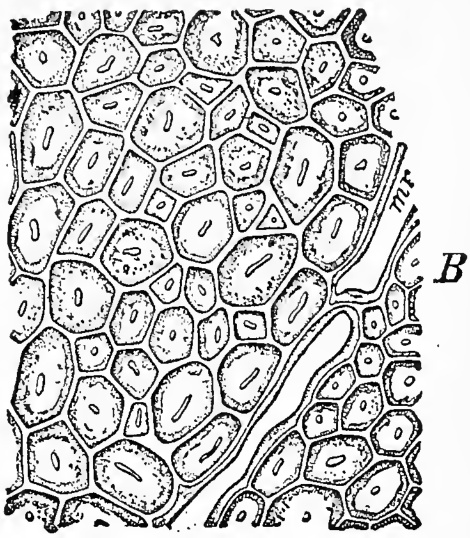


FIG. 7. PORTION OF THE FIRM BODIES OF FIBRES WITH TWO CELLS OF A SMALL PITH RAY. *mr*, Highly magnified.

MINUTE STRUCTURE

If a well-smoothed thin disk or cross-section of oak (say one-sixteenth inch thick) is held up to the light, it looks very much like a sieve, the pores or vessels appearing as clean-cut holes. The spring-wood and gray patches are seen to be quite porous, but the firm bodies of fibres between them are dense and opaque. Examined with the magnifier it will be noticed that there is no such regularity of arrangement in straight rows as is conspicuous in pine. On the contrary, great irregularity prevails. At the same time, while the pores are as large as pin holes, the cells of the denser wood, unlike those of pine wood, are too small to be distinguished. Studied with the microscope, each vessel is found to be a vertical row of a great number of short, wide tubes, joined end to end. (See Fig. 8, *c*.) The porous spring-wood and radial gray tracts are partly composed of smaller vessels, but chiefly of tracheids, like those of pine, and of shorter cells, the "wood parenchyma," resembling the cells of the medullary rays. These latter, as well as the fine concentric lines mentioned as occurring in the summer-wood, are composed entirely of short, tube-like parenchyma cells, with square or oblique ends. (See Fig. 8, *a* and *b*.) The wood fibres proper, which form the dark, firm bodies referred to, are very fine, thread-like cells, one-twenty-fifth to one-tenth inch long, with a wall commonly so thick that scarcely any empty internal space or lumen remains. (See Figs. 8, *e*, and 7 *B*.) If, instead of oak, a piece of poplar or basswood (see Fig. 9) had been used in this study, the structure would have been found to be quite different. The same kinds of cell-elements, vessels, etc., are to be sure, present, but their combination and arrangement are different, and thus from the great variety of possible combinations results the great variety of structure and, in consequence, of the qualities which distinguish the wood of broad-leaved trees. The sharp distinction of sapwood and heartwood is wanting; the rings are not so clearly defined, the vessels of the wood are small, very numerous, and rather evenly scattered through the wood of the annual ring, so that the distinction of the ring almost vanishes and the medullary or pith rays in poplar can be seen without being magnified only on the radial section.

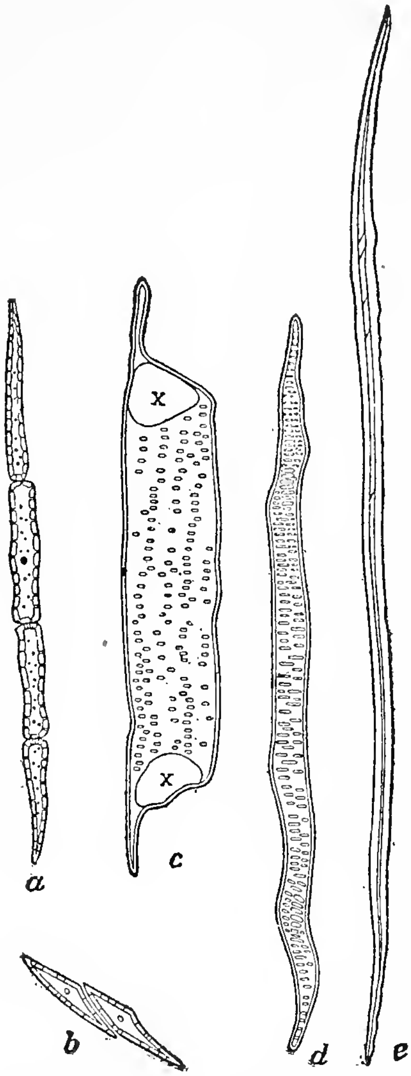


Fig. 8. Isolated Fibres and Cells. *a*, Four cells of wood, parenchyma; *b*, two cells from a pith ray; *c*, a single joint or cell of a vessel, the openings *x* leading into its upper and lower neighbors; *d*, tracheid; *e*, wood fibre proper.

LIST OF MOST IMPORTANT BROAD-LEAVED TREES (HARDWOODS)

Woods of complex and very variable structure, and therefore differing widely in quality, behavior, and consequently in applicability to the arts.

ASH.—Wood heavy, hard, strong, stiff, quite tough, not durable in contact with soil, straight-grained, rough on the split surfaces and coarse in texture. The wood shrinks moderately, seasons with little injury, stands well and takes a good polish. In carpentry, ash is used for stairways, panels, etc.; it is used in shipbuilding, in the construction of cars, wagons, etc.; in the manufacture of farm implements, machinery, and especially of furniture of all kinds; for cooperage, baskets, oars, tool handles, hoops, etc. The trees of the several species

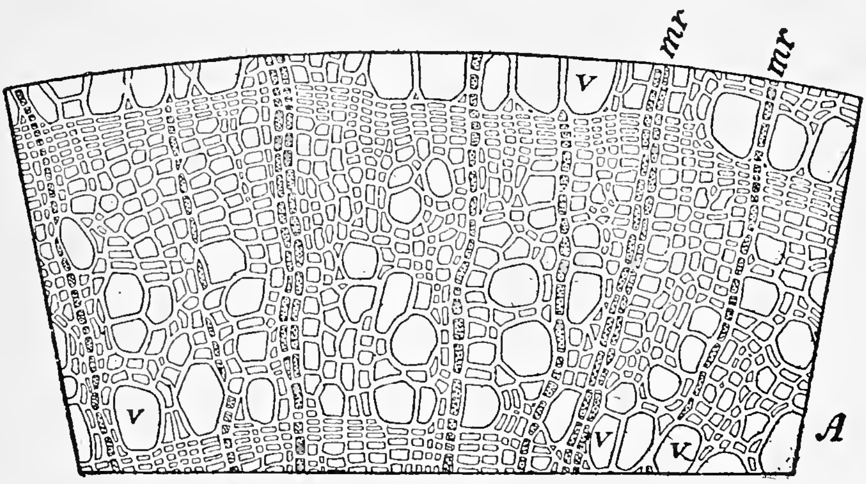


Fig. 9. Cross-Section of Basswood (Magnified). *v*, Vessels; *mr*, pith rays.

of ash are rapid growers, of small to medium height with stout trunks. They form no forests, but occur scattered in almost all our broad-leaved forests.

1. White Ash (*Fraxinus Americana*). Medium, sometimes large-sized tree. Basin of the Ohio, but found from Maine to Minnesota and Texas.

2. Red Ash (*Fraxinus pubescens*). Small-sized tree. North Atlantic States, but extends to the Mississippi.

3. Black Ash (*Fraxinus sambucifolia*) (Hoop Ash, Ground Ash). Medium-sized tree, very common. Maine to Minnesota and southward to Alabama.

4. Blue Ash (*Fraxinus quadrangulata*). Small to medium-sized tree. Indiana and Illinois; occurs from Michigan to Minnesota and southward to Alabama.

5. Green Ash (*Fraxinus viridis*). Small-sized tree. New York to the Rocky Mountains, and southward to Florida and Arizona.

6. Oregon Ash (*Fraxinus Oregana*). Medium-sized tree. Western Washington to California.

ASPEN. (See Poplar.)

BASSWOOD.

7. Basswood (*Tilia Americana*) (Lime Tree, American Linden, Lin, Bee Tree). Wood light, soft, stiff but not strong, of fine texture, and white to light brown color. The wood shrinks considerably in drying, works and stands well. It is used for cooperage, in carpentry, in the manufacture of furniture and woodenware, both turned and carved; for toys, also for panelling of car and carriage bodies. Medium to large-sized tree. Common in all northern broad-leaved forests; found throughout the Eastern United States.

8. White Basswood (*Tilia heterophylla*). A small-sized tree most abundant in the Alleghany region.

BEECH.

9. Beech (*Fagus ferruginea*). Wood heavy, hard, stiff, strong, of rather coarse texture, white to light brown in color, not durable in the ground, and subject to the inroads of boring insects. It shrinks and checks considerably in drying, works and stands well and takes a good polish. Used extensively in slack cooperage, for furniture, in turnery, for handles, lasts, etc. Abroad it is very extensively used by the carpenter, millwright, and wagon maker, in turnery and wood carving. The beech is a medium-sized tree, common, sometimes forming forests. Most abundant in the Ohio and Mississippi basin, but found from Maine to Wisconsin and southward to Florida.

BIRCH.—Wood heavy, hard, strong, of fine texture; sapwood whitish, heartwood in shades of brown with red and yellow; very handsome, with satiny lustre, equalling cherry. The wood shrinks considerably in drying, works well and stands well and takes a good polish, but is not durable if exposed. Birch is used extensively for hoops in cooperage; for finishing lumber in building, in the manufacture of furniture, in wood turnery; for spools, boxes, wooden shoes, etc.; for shoe lasts and pegs; for wagon hubs, ox yokes, etc.; also in wood carving. The birches are medium-sized trees, form extensive forests northward, and occur scattered in all broad-leaved forests of the Eastern United States.

10. Cherry Birch (*Betula lenta*) (Black Birch, Sweet Birch, Mahogany Birch). Medium-sized tree, very common. Maine to Michigan and to Tennessee.

11. Yellow Birch (*Betula lutea*) (Gray Birch). Medium-sized tree; common. Maine to Minnesota and southward to Tennessee.

12. Red Birch (*Betula nigra*) (River Birch). Small to medium-sized tree; very common; lighter and less valuable than the preceding. New England to Texas and Missouri.

13. Canoe Birch (*Betula papyrifera*) (White Birch, Paper Birch). Generally a small tree; common, forming forests; wood of good quality but light. All along the northern boundary of the United States and northward, from the Atlantic to the Pacific.

BLACK WALNUT. (See Walnut.)

BLUE BEECH.

14. Blue Beech (*Carpinus Caroliniana*) (Hornbeam, Water Beech, Ironwood). Wood very heavy, hard, strong, very stiff, of rather fine texture, and white color; not durable in the ground; shrinks and checks considerably in drying, but works well and stands well. Used

chiefly in turnery for tool handles, etc. Abroad, much used by mill and wheelwrights. A small tree, largest in the Southwest, but found in nearly all parts of the Eastern United States.

BOIS D'ARC. (See OSAGE ORANGE.)

BUCKEYE (HORSE CHESTNUT). Wood light, soft, not strong, often quite tough, of fine and uniform texture and creamy white color. It shrinks considerably in drying, but works and stands well. Used for woodenware, artificial limbs, paper pulp, and locally also for building purposes. Small-sized trees, scattered, never forming forests.

15. OHIO BUCKEYE (*Æsculus glabra*) (FETID BUCKEYE). Alleghanies, Pennsylvania to Indian Territory.

16. SWEET BUCKEYE (*Æsculus flava*). Alleghanies, Pennsylvania to Texas.

BUTTERNUT.

17. BUTTERNUT (*Juglans cinerea*) (WHITE WALNUT). Wood very similar to black walnut, but light, quite soft, not strong and of light brown color. Used chiefly for finishing lumber, cabinet work, and cooperage. Medium-sized tree, largest and most common in the Ohio basin. Maine to Minnesota and southward to Georgia and Alabama.

CATALPA.

18. CATALPA (*Catalpa speciosa*). Wood light, soft, not strong, brittle, durable, of coarse texture and brown color. Used for ties and posts, but well suited for a great variety of uses. Medium-sized tree. Lower basin of the Ohio River, locally common. Extensively planted, and therefore promising to become of some importance.

CHERRY.

19. Cherry (*Prunus serotina*). Wood heavy, hard, strong, of fine texture; sapwood yellowish white, heartwood reddish to brown. The wood shrinks considerably in drying, works well and stands well, takes a good polish, and is much esteemed for its beauty. Cherry is chiefly used as a decorative finishing lumber for buildings, cars, and boats, also for furniture and in turnery. It is becoming too costly for many purposes for which it is naturally well suited. The lumber furnishing cherry of this country, the wild black cherry (*Prunus serotina*), is a small to medium-sized tree, scattered through many of the broad-leaved woods of the western slope of the Alleghanies, but found from Michigan to Florida and west to Texas. Other species of this genus, as well as the hawthorns (*cratœgus*) and wild apple (*Pyrus*), are not commonly offered in the market. Their wood is of the same character as cherry, often even finer, but in small dimensions.

CHESTNUT.

20. Chestnut (*Castanea vulgaris* var. *Americana*). Wood light, moderately soft, stiff, not strong, of coarse texture; the sapwood light, the heartwood darker brown. It shrinks and checks considerably in drying, works easily, stands well, and is very durable. Used in cooperage, cabinet work, for railway ties, telegraph poles, and locally in heavy construction. Medium-sized tree. Very common in the Alleghanies. Occurs from Maine to Michigan and southward to Alabama.

21. Chinquapin (*Castanea pumila*). A small-sized tree, with wood slightly heavier but otherwise similar to the preceding. Most common in Arkansas, but with nearly the same range as the chestnut.

22. Chinquapin (*Castanopsis chrysophylla*). A medium-sized tree of the western ranges of California and Oregon.

COFFEE TREE.

23. Coffee Tree (*Gymnocladus canadensis*) (Coffee Nut). Wood heavy, hard, strong, very stiff, of coarse texture, durable, the sapwood yellow, the heartwood reddish brown; shrinks and checks considerably in drying; works and stands well, and takes a good polish. It is used to a limited extent in cabinet work. A medium to large-sized tree; not common. Pennsylvania to Minnesota and Arkansas.

COTTONWOOD. (See Poplar.)

CUCUMBER TREE. (See Tulip.)

ELM.—Wood heavy, hard, strong, very tough; moderately durable in contact with the soil; commonly cross-grained, difficult to split and shape, warps and checks considerably in drying, but stands well if properly handled. The broad sapwood whitish, heartwood brown, both with shades of gray and red; on split surfaces rough, texture coarse to fine, capable of high polish. Elm for years has been the principal wood used in slack cooperage, for staves and hoops. Also used in the construction of cars, wagons, etc.; in boat and shipbuilding; for agricultural implements and machinery; in saddlery and harness work, and particularly in the manufacture of all kinds of furniture, where the beautiful figures, especially those of the tangential or bastard section, are just beginning to be duly appreciated. The elms are medium to large-sized trees, of fairly rapid growth, with stout trunk, form no forests of pure growth, but are found scattered in all the broad-leaved woods of our country, sometimes forming a considerable portion of the arborescent growth.

24. White Elm (*Ulmus Americana*) (American Elm, Water Elm). Medium to large-sized tree, common. Maine to Minnesota, southward to Florida and Texas.

25. Rock Elm (*Ulmus racemosa*) (Cork Elm, Hickory Elm, White Elm, Cliff Elm). Medium to large-sized tree. Michigan, Ohio, from Vermont to Iowa, southward to Kentucky.

26. Red Elm (*Ulmus fulva*) (Slippery Elm, Moose Elm). The red or slippery elm is not so large a tree as the white elm, though it occasionally attains a height of 135 feet and a diameter of 4 feet. It grows tall and straight, and thrives in river valleys. The wood is heavy, hard, elastic, strong, moderately durable in contact with the soil, splits easily when green, works fairly well, and stands well, if properly seasoned. Careful seasoning and handling are essential for the best results. Trees can be utilized for posts when very small. When green the wood rots very quickly in contact with the ground. Poles for posts should be cut in summer and peeled and dried before setting. The wood becomes very tough and pliable when steamed, and is of value for sleigh runners and for ribs of canoes and skiffs. Together with white elm it is extensively used for staves and hoops in slack cooperage, and also for furniture. The thick, viscous inner bark, which gives the tree its descriptive name, is quite palatable, slightly nutritious, and has a medicinal value. Found chiefly along water courses. New York to Minnesota, and southward to Florida and Texas.

27. Cedar Elm (*Ulmus crassifolia*). Small-sized tree, quite common. Arkansas and Texas.

28. Winged Elm (*Ulmus alata*) (Wahoo). Small-sized tree, locally quite common. Arkansas, Missouri and Eastern Virginia.

GUM.—This general term applies to three important species of gum in the South, the principal one usually being distinguished as "red" or "sweet" gum (see Fig. 50); the next in importance being the "tupelo" or "bay poplar" (see Fig. 54); and the least of the trio is designated as "black" or "sour" gum. Up to the year 1900 little was known of gum as a wood for cooperage purposes, but by the continued advance in price of the woods used, a few of the manufacturers, looking into the future, saw that the supply of the various woods in use was limited, that new woods would have to be sought, and gum was looked upon as a possible substitute, owing to its cheapness and abundant supply. No doubt in the future this wood will be used to a considerable extent in the manufacture of both tight and slack cooperage. At present gum is used quite extensively and with varied results in slack packages, principally sugar, salt, etc., and recently has been experimented upon for tight cooperage, principally for oil and syrup packages. In the manufacture of gum, unless the knives and saws are kept very sharp, the wood will break out, the corners having a tendency to split off; and also much difficulty has been experienced in seasoning and kiln-drying.

In the past, gum, having no marketable value, has been left standing after logging operations, or, where the land has been cleared for farming, has been girdled and allowed to rot, and then felled and burned as trash. Now, however, that there is a market for the timber, it will be profitable to cut the gum with the other hardwoods, and as this species of wood is coming in for a greater share of attention than ever before in the cooperage world, it is well to make some special points of study in regard to manufacturing it. Most of the study of gum heretofore has been concentrated on the one subject of drying, which requires its share of attention too, but at the same time there is not a point anywhere in the process of its manufacture, from the tree to the finished product, but that will furnish opportunity for much study and experiment.

29. Red Gum (*Liquidamber styraciflua*) (Sweet Gum, Liquidamber, Bilsted). The wood is about as stiff and as strong as chestnut, rather heavy, it splits easily and is quite brash, commonly cross-grained, of fine texture, and has a large proportion of whitish sapwood, which decays rapidly when exposed to the weather; but the reddish-brown heartwood is quite durable, even in the ground. The green wood contains much water, and consequently is heavy and difficult to float, but when dry it is as light as basswood. The great amount of water in the green wood, particularly in the sap, makes it difficult to season by ordinary methods without warping and twisting. This fault can be overcome, however, by care and special treatment. It does not check badly, is tasteless and odorless, and when once seasoned swells and shrinks but little, unless exposed to the weather.

RANGE OF RED GUM

Red gum is distributed from Fairfield County, Conn., to Southeastern Missouri, through Arkansas and the Indian Territory to the valley of the Trinity River in

Texas, and eastward to the Atlantic Coast. Its commercial range is restricted, however, to the moist lands of the lower Ohio and Mississippi basins and of the southeastern coast. It is one of the commonest timber trees in the hardwood bottoms and drier swamps of the South. It grows in mixture with ash, cottonwood and oak. (See Fig. 52.) It is found also to a considerable extent on the lower ridges and slopes of the southern Appalachians, but there it does not reach merchantable value and is of little importance. Considerable difference is found between the growth in the upper Mississippi bottoms and that along the rivers on the Atlantic Coast and on the Gulf. In the latter regions the bottoms are lower, and consequently more subject to floods and to continued overflows. (See Fig. 54.) The alluvial deposit is also greater, and the trees grow considerably faster. Trees of the same diameter show a larger percentage of sapwood there than in the upper portions of the Mississippi Valley. The Mississippi Valley hardwood trees are for the most part considerably older, and reach larger dimensions than the timber along the coast.

FORM OF THE RED GUM

In the best situations red gum reaches a height of 150 feet, and a diameter of five feet. These dimensions, however, are unusual. The stem is straight and cylindrical, with dark, deeply furrowed bark, and branches often winged with corky ridges. In youth, while growing vigorously under normal conditions, it assumes a long, regular, conical crown, much resembling the form of a conifer. (See Fig. 52.) After the tree has attained its height growth, however, the crown becomes rounded, spreading, and rather ovate in shape. When growing in the forest the tree prunes itself readily at an early period, and forms a good length of clear stem, but it branches strongly after making most of its height growth. The mature tree is usually forked, and the place where the forking commences determines the number of logs in the tree or its merchantable length, by preventing cutting to a small diameter in the top. On large trees the stem is often not less than eighteen inches in diameter where the branching begins. The over-mature tree is usually broken and dry-topped, with a very spreading crown, in consequence of new branches being sent out.

TOLERANCE OF RED GUM

Throughout its entire life red gum is tolerant in shade, there are practically no red gum seedlings under the dense forest cover of the bottom land, and while a good many may come up under the pine forest on the drier uplands, they seldom develop into large trees. As a rule seedlings appear only in clearings or in open spots in the forest. It is seldom that an overtopped tree is found, for the gum dies quickly if suppressed, and is consequently nearly always a dominant or intermediate tree. In a hardwood bottom forest the timber trees are all of nearly the same age over considerable areas, and there is little young growth to be found in the older stands. The reason for this is the intolerance of most of the swamp species. A scale of tolerance containing the important species, and beginning with the most light demanding, would run as follows: Cottonwood, sycamore, red gum, white elm, red oak, white ash and red maple.

DEMANDS UPON SOIL AND MOISTURE

While the red gum grows in various situations, it prefers the deep, rich soil of the hardwood bottoms, and there reaches its best development. (See Fig. 50.) It requires considerable soil moisture, though it does not grow in the wetter swamps, and does not thrive on dry pine land. Seedlings, however, are often found in large numbers on the edges of the uplands and even on the sandy pine land, but they seldom live beyond the pole stage. When they do, they form small, scrubby trees that are of little value. Where the soil is dry the tree has a long tap-root. In the swamps, where the roots can obtain water easily, the development of the tap-root is poor, and it is only moderate on the glade bottom lands, where there is considerable moisture throughout the year, but no standing water in the summer months.

REPRODUCTION OF RED GUM

Red gum reproduces both by seed and by sprouts. (See Fig. 52.) It produces seed fairly abundantly every year, but about once in three years there is an extremely heavy production. The tree begins to bear seed when twenty-five to thirty years old, and seeds vigorously up to an age of one hundred and fifty years, when its productive power begins to diminish. A great part of the seed, however, is abortive. Red gum is not fastidious in regard to its germinating bed; it comes up readily on sod in old fields and meadows, on decomposing homus in the forest, or on bare clay-loam or loamy sand soil. It requires a considerable degree of light, however, and prefers a moist seed bed. The natural distribution of the seed takes place for several hundred feet from the seed trees, the dissemination depending almost entirely on the wind. A great part of the seed falls on the hardwood bottoms when the land is flooded, and is either washed away or, if already in the ground and germinating, is destroyed by the long continued overflow. After germination, the red gum seedling demands, above everything else, abundant light for its survival and development. It is for this reason that there is very little young growth of red gum, either in the unculled forest or on culled lands, where, as is usually the case, a dense undergrowth of cane, briers, and rattan is present. Under the dense underbrush of cane and briers throughout much of the virgin forest, reproduction of any of the merchantable species is of course impossible. And even where the land has been logged over, the forest is seldom open enough to allow reproduction of cottonwood and red gum. Where, however, seed trees are contiguous to pastures or cleared land, scattered seedlings are found springing up in the open, and where openings occur in the forest, there are often large numbers of red gum seedlings, the reproduction generally occurring in groups. But over the greater part of the Southern hardwood bottom land forest reproduction is extremely scanty. The growth of red gum during the early part of its life, and up to the time it reaches a diameter of eight inches breast-high, is extremely rapid, and, like most of the intolerant species, it attains its height growth at an early period. Gum sprouts readily from the stump, and the sprouts surpass the seedlings in rate of height growth for the first few years, but they seldom form large timber trees. The capacity to sprout when cut is confined to the younger trees. Those over fifty years of age seldom sprout. For this reason sprout reproduction is of little importance in the forest. The principal requirements of red gum, then, are a moist, fairly rich soil and good exposure to light. Without these it will not reach its best development.

SECOND GROWTH

Second-growth red gum occurs to any considerable extent only on land which has been thoroughly cleared. Throughout the South there is a great deal of land which was in cultivation before the war, but which during the subsequent period of industrial depression was abandoned and allowed to revert to forest. These old fields are now mostly covered with second-growth forest, of which red gum forms an important part. (Fig. 52.) Frequently over fifty per cent. of the stand consists of this species, but more often, and especially on the Atlantic Coast, the greater part is of cottonwood or ash. These stands are very dense, and the growth is extremely rapid. Small stands of young growth are also often found along the edges of cultivated fields. In the Mississippi Valley the abandoned fields on which young stands have sprung up are for the most part being rapidly cleared again. The second growth here is considered of little value in comparison with the value of the land for agricultural purposes. In many cases, however, the farm value of the land is not at present sufficient to make it profitable to clear it, unless the timber cut will at least pay for the operation. There is considerable land upon which the second growth will become valuable timber within a few years. Such land should not be cleared until it is possible to utilize the timber.

30. Tupelo Gum (*Nyssa aquatica*) (Bay Poplar, Cotton Gum). The close similarity which exists between red and tupelo gum, together with the fact that tupelo is often cut along with red gum, and marketed with the sapwood of the latter, makes it not out of place to give consideration to this timber. The wood has a fine, uniform texture, is moderately hard and strong, is stiff, not elastic, very tough and hard to split, but easy to work with tools. Tupelo takes glue, paint, or varnish well, and absorbs very little of the material. In this respect it is equal to yellow poplar and superior to cottonwood. The wood is not durable in contact with the ground, and requires much care in seasoning. The distinction between the heartwood and sapwood of this species is

marked. The former varies in color from a dull gray to a dull brown; the latter is whitish or light yellow, like that of poplar. The wood is of medium weight, about thirty-two pounds per cubic foot when dry, or nearly that of red gum and loblolly pine. After seasoning it is difficult to distinguish the better grades of the sapwood from poplar. Owing to the prejudice against tupelo gum, it was until recently marketed under such names as bay poplar, swamp poplar, nyssa, cotton gum, circassian walnut and hazel pine. Since it has become evident that the properties of the wood fit it for many uses, the demand for tupelo has largely increased, and it is now taking rank with other standard woods under its rightful name. Heretofore the quality and usefulness of this wood were greatly underestimated, and the difficulty of handling it was magnified. Poor success in seasoning and kiln-drying was laid to defects of the wood itself, when, as a matter of fact, the failures were largely due to the absence of proper methods in handling. The passing of this prejudice against tupelo is due to a better understanding of the characteristics and uses of the wood. Handled in the way in which its particular character demands tupelo is a wood of value.

USES OF THE WOOD

Tupelo is now used in the manufacture of slack cooperage, principally for heading. Is used extensively for house flooring and inside finishing, such as mouldings, door jams, and casings. A great deal is now shipped to European countries, where it is highly valued for different classes of manufacture. Much of the wood is used in the manufacture of boxes, since it works well upon rotary veneer machines. There is also an increasing demand for tupelo for laths, wooden pumps, violin and organ sounding boards, coffins, mantel work, conduits and novelties. It is also used in the furniture trade for backing, drawers and panels.

RANGE OF TUPELO GUM

Tupelo occurs throughout the coastal region of the Atlantic States from Southern Virginia to Northern Florida, through the Gulf States to the valley of the Nueces River in Texas, through Arkansas and Southern Missouri to Western Kentucky and Tennessee, and to the valley of the lower Wabash River. Tupelo is being extensively milled at present only in the region adjacent to Mobile, Ala., and in Southern and Central Louisiana, where it occurs in large merchantable quantities, attaining its best development in the former locality. The country in this locality is very swampy (see Fig. 54), and within a radius of one hundred miles tupelo gum is one of the principal timber trees. It grows only in the swamps and wetter situations (see Fig. 54), often in mixture with cypress, and in the rainy season it stands in from two to twenty feet of water.

31. Black Gum (*Nyssa sylvatica*) (Sour Gum). Black gum is not cut to much extent, owing to its less abundant supply and poorer quality, but is used for repair work on wagons, for cattle yokes, and for other purposes which require a strong non-splitting wood. It is distributed from Maine to Southern Ontario, through Central Michigan to Southeastern Missouri, southward to the valley of the Brazos River in Texas, and eastward to the Kissimmee River and Tampa Bay in Florida. It is found in the swamps and hardwood bottoms, but is more abundant and of better size on the slightly higher ridges and hummocks in these swamps, and on the mountain slopes in the southern Allegheny region. Though its range is greater than that of either the red or tupelo gum, it nowhere forms an important part of the forest.

HACKBERRY.

32. Hackberry (*Celtis occidentalis*) (Sugar Berry). The wood handsome, heavy, hard, strong, quite tough, of moderately fine texture, and greenish or yellowish white color; shrinks moderately, works well and stands well, and takes a good polish. Used to some extent in slack cooperage, but little used in the manufacture of furniture. Medium to large-sized tree, locally quite common, largest in the lower Mississippi Valley. Occurs in nearly all parts of the Eastern United States.

HICKORY.—Wood very heavy, hard and strong, proverbially tough, of rather coarse texture, smooth and of straight grain. The broad sapwood white, the heartwood reddish nut brown. It dries slowly, shrinks and checks considerably; is not durable in the ground, or if exposed, and, especially the sapwood, is always subject to the inroads of boring insects. Hickory excels as carriage and wagon stock, but is also extensively used in the manufacture of implements and machinery, for tool handles, timber pins, for harness work, dowel pins and hoops in cooperage. The hickories are tall trees with slender stems, never form forests, occasionally small groves, but usually occur scattered among other broad-leaved trees in suitable localities. The following species all contribute more or less to the hickory of the market.

33. Shagbark Hickory (*Hicoria ovata*) (Shellbark Hickory). A medium to large-sized tree, quite common; the favorite among hickories; best developed in the Ohio and Mississippi basins; from Lake Ontario to Texas, Minnesota to Florida.

34. Mockernut Hickory (*Hicoria alba*) (Black Hickory, Bull and Black Nut, Big Bud, and White-Heart

HICKORY). A medium to large-sized tree, with the same range as the foregoing; common, especially in the South.

35. PIGNUT HICKORY (*Hicoria glabra*) (BROWN HICKORY, BLACK HICKORY, SWITCH-BUD HICKORY). Medium to large-sized tree, abundant, all Eastern United States.

36. BITTERNUT HICKORY (*Hicoria minima*) (SWAMP HICKORY). A medium-sized tree, favoring wet localities, with the same range as the preceding.

37. PECAN (*Hicoria pecan*) (ILLINOIS NUT). A large tree, very common in the fertile bottoms of the Western streams. Indiana to Nebraska and southward to Louisiana and Texas.

HOLLY.

38. HOLLY (*Ilex opaca*). Wood of medium weight, hard, strong, tough, of fine texture and white color; works well and stands well, used for cabinet work and turnery. A small tree. Most abundant in the lower Mississippi Valley and Gulf States, but occurring eastward to Massachusetts and north to Indiana.

HORSE-CHESTNUT. (See BUCKEYE.)

IRONWOOD. (See BLUE BEECH.)

LOCUST.—This name applies to both of the following:

39. BLACK LOCUST (*Robinia pseudacacia*) (BLACK LOCUST, YELLOW LOCUST). Wood very heavy, hard, strong, and tough, of coarse texture, very durable in contact with the soil, shrinks considerably and suffers in seasoning; the very narrow sapwood yellowish, the heartwood brown, with shades of red and green. Used for wagon hubs, tree nails or pins, but especially for ties, posts, etc. Abroad it is much used for furniture and farming implements and also in turnery. Small to me-

dium-sized tree. At home in the Alleghanies, extensively planted, especially in the West.

40. Honey Locust (*Gleditschia triacanthos*) (Black Locust, Sweet Locust, Three-Thorned Acacia). Wood heavy, hard, strong, tough, of coarse texture, susceptible of a good polish, the narrow sapwood yellow, the heartwood brownish red. So far, but little appreciated except for fences and fuel; used to some extent for wagon hubs and in rough construction. A medium-sized tree. Found from Pennsylvania to Nebraska, and southward to Florida and Texas; locally quite abundant.

MAGNOLIA. (See Tulip.)

MAPLE.—Wood heavy, hard, strong, stiff, and tough, of fine texture, frequently wavy-grained, this giving rise to "curly" and "blister" figures; not durable in the ground, or when otherwise exposed. Maple is creamy white, with shades of light brown in the heart, shrinks moderately, seasons, works and stands well, wears smoothly, and takes a fine polish. The wood is used in slack cooperage, and for ceiling, flooring, panelling, stairway, and other finishing lumber in house, ship and car construction. It is used for the keel of boats and ships, in the manufacture of implements and machinery, but especially for furniture, where entire chamber sets of maple rival those of oak. Maple is also used for shoe lasts and other form blocks; for shoe pegs; for piano actions, school apparatus; for wood type in show bill printing, tool handles; in wood carving, turnery, and scroll work, and is one of our most useful woods. The maples are medium-sized trees, of fairly rapid growth; sometimes form forests, and frequently constitute a large proportion of the arborescent growth.

41. Sugar Maple (*Acer saccharum*) (Hard Maple, Rock Maple). Medium to large-sized tree, very common, forms considerable forests. Maine to Minnesota, abundant, with birch, in parts of the pineries, southward to Northern Florida; most abundant in the region of the Great Lakes.

42. Red Maple (*Acer rubrum*) (Swamp Maple, Water Maple). Medium-sized tree. Like the preceding, but scattered along watercourses and other moist localities.

43. Silver Maple (*Acer saccharinum*) (Soft Maple, Silver Maple). Medium-sized tree, common; wood lighter, softer, inferior to hard maple, and usually offered in small quantities and held separate in the markets. Valley of the Ohio, but occurs from Maine to Dakota and southward to Florida.

44. Broad-Leaved Maple (*Acer macrophyllum*). Medium-sized tree, forms considerable forests, and, like the preceding, has a lighter, softer, and less valuable wood. Pacific Coast regions.

MULBERRY.

45. Red Mulberry (*Morus rubra*). Wood moderately heavy, hard, strong, rather tough, of coarse texture, durable; the sapwood whitish, heartwood yellow to orange brown; shrinks and checks considerably in drying; works well and stands well. Used in cooperage and locally in shipbuilding and in the manufacture of farm implements. A small-sized tree. Common in the Ohio and Mississippi valleys, but widely distributed in the Eastern United States.

OAK.—Wood very variable, usually very heavy and hard, very strong and tough, porous, and of coarse texture; the sapwood whitish, the heartwood "oak" brown to reddish brown. It shrinks and checks badly, giving trouble in seasoning, but stands well, is durable, and little subject to the attack of insects. Oak is used for many purposes, and is the chief wood used for tight cooperage; was also used quite extensively in former years for slack cooperage, but on account of its increased value had to be abandoned for cheaper woods. It is used in shipbuilding, for heavy construction, in carpentry, in furniture, car and wagon work, turnery, and even in wood carving; also in the manufacture of all kinds of farm implements, wooden mill machinery; for piles and wharves, railway ties, etc. The oaks are medium to large-sized trees, forming the predominant part of a large portion of our broad-leaved forests, so that these are generally termed "oak forests," though they always contain a considerable proportion of other kinds of trees. Three well-marked kinds—white, red, and live oak—are distinguished and kept separate in the market. Of the two principal kinds "white oak" is the stronger, tougher, less porous, and more durable. "Red oak" is usually of coarser texture, more porous, often brittle, less durable, and even more troublesome in seasoning than white oak. In carpentry and furniture work red oak brings about the same price at present as white oak. The red oaks everywhere accompany the white oaks, and, like the latter, are usually represented by several species in any given locality. "Live oak," once largely employed in shipbuilding, possesses all the good qualities (except that of size) of white oak, even to a greater degree. It is one of the heaviest, hardest, toughest, and most durable woods of this country; in structure it resembles the red oaks, but is much less porous.

46. White Oak (*Quercus alba*). Medium to large-sized tree. Common in the Eastern States, Ohio and Mississippi valleys; occurs throughout Eastern United States.

47. Bur Oak (*Quercus macrocarpa*) (Mossy-Cup Oak, Over-Cup Oak). Large-sized tree, locally abundant, common. Bottoms west of Mississippi; range farther west than the preceding.

48. Swamp White Oak (*Quercus bicolor*). Large-sized tree, common. Most abundant in the Lake States, but with a range as in white oak.

49. Yellow Oak (*Quercus prinoides*) (Chestnut Oak, Chinquapin Oak). Medium-sized tree. Southern Alleghanies, eastward to Massachusetts.

50. Basket Oak (*Quercus michauxii*) (Cow Oak). Large-sized tree. Locally abundant; lower Mississippi and eastward to Delaware.

51. Over-Cup Oak (*Quercus lyrata*) (Swamp White Oak, Swamp Post Oak). Medium to large-sized tree, rather restricted; ranges as in the preceding.

52. Post Oak (*Quercus obtusiloba*) (Iron Oak). Medium to large-sized tree. Arkansas to Texas, eastward to New England and northward to Michigan.

53. White Oak (*Quercus durandii*). Medium to small-sized tree. Texas, eastward to Alabama.

54. White Oak (*Quercus garryana*). Medium to large-sized tree. Washington to California.

55. White Oak (*Quercus lobata*). Medium to large-sized tree. Largest oak on the Pacific Coast, California.

56. Red Oak (*Quercus rubra*) (Black Oak). Medium to large-sized tree; common in all parts of its range. Maine to Minnesota, and southward to the Gulf.

57. Black Oak (*Quercus tinctoria*) (Yellow Oak).

Medium to large-sized tree. Very common in the Southern States, but occurring north as far as Minnesota, and eastward to Maine.

58. Spanish Oak (*Quercus falcata*) (Red Oak). Medium-sized tree. Common in the South Atlantic and Gulf region, but found from Texas to New York, and north to Missouri and Kentucky.

59. Scarlet Oak (*Quercus coccinea*). Medium to large-sized tree. Best developed in the lower basin of the Ohio, but found from Maine to Missouri, and from Minnesota to Florida.

60. Pin Oak (*Quercus palustris*) (Swamp Spanish Oak, Water Oak). Medium to large-sized tree, common along borders of streams and swamps. Arkansas to Wisconsin, and eastward to the Alleghanies.

61. Willow Oak (*Quercus phellos*) (Peach Oak). Small to medium-sized tree. New York to Texas, and northward to Kentucky.

62. Water Oak (*Quercus aquatica*) (Duck Oak, Possum Oak, Punk Oak). Medium to large-sized tree, of extremely rapid growth. Eastern Gulf States, eastward to Delaware, and northward to Missouri and Kentucky.

63. Live Oak (*Quercus rirens*). Small-sized tree. Scattered along the coast from Virginia to Texas.

64. Live Oak (*Quercus chrysolepis*) (Maul Oak, Valparaiso Oak). Medium-sized tree. California.

OSAGE ORANGE.

65. Osage Orange (*Maclura aurantiaca*) (Bois d'Arc). Wood very heavy, exceedingly hard, strong; not tough, of moderately coarse texture, and very durable; the sapwood yellow, heartwood brown on the end, yellow on longitudinal faces, soon turning grayish brown if exposed. It shrinks considerably in drying, but once dry

it stands unusually well. Formerly much used for wheel stock, in the dry regions of Texas; otherwise employed for posts, railway ties, etc. Seems too little appreciated; it is well suited for turned ware and especially for wood carving. A small-sized tree, of fairly rapid growth. Scattered through the rich bottoms of Arkansas and Texas.

PERSIMMON.

66. PERSIMMON (*Diospyros virginiana*). Wood very heavy and hard, strong and tough; resembles hickory, but is of finer texture; the broad sapwood cream color, the heartwood black; used in turnery, for shuttles, plane stocks, shoe lasts, etc. Small to medium-sized tree. Common and best developed in the lower Ohio Valley, but occurs from New York to Texas and Missouri.

POPLAR. (see also TULIPWOOD).—Wood light, very soft, not strong, of fine texture and whitish, grayish to yellowish color, usually with a satiny lustre. The wood shrinks moderately (some cross-grained forms warp excessively), but checks very little; is easily worked, but is not durable. Used in cooperage, as building and furniture lumber, for crates and boxes (especially cracker boxes), for woodenware and paper pulp.

67. COTTONWOOD (*Populus monilifera*). Large-sized tree; forms considerable forests along many of the Western streams, and furnishes most of the cottonwood of the market. Mississippi Valley and West; New England to the Rocky Mountains.

68. BALSAM (*Populus balsamifera*) (BALM OF GILEAD). Medium to large-sized tree. Common all along the northern boundary of the United States.

69. BLACK COTTONWOOD (*Populus trichocarpa*). The

largest deciduous tree of Washington; very common. Northern Rocky Mountains and Pacific region.

70. Cottonwood (*Populus fremontii* var. *wislizeni*). Medium to large-sized tree; common. Texas to California.

71. Poplar (*Populus grandidentata*). Medium-sized tree, chiefly used for pulp. Maine to Minnesota and southward along the Alleghanies.

72. Aspen (*Populus tremuloides*). Small to medium-sized tree, often forming extensive forests and covering burned areas. Maine to Washington and northward, south in the western mountains to California and New Mexico.

SOUR GUM. (See Gum.)

RED GUM. (See Gum.)

SASSAFRAS.

73. Sassafras (*Sassafras sassafras*). Wood light, soft, not strong, brittle, of coarse texture, durable; the sapwood yellow, heartwood orange brown. Used to some extent in slack cooperage, for skiffs, fencing, etc. Medium-sized tree, largest in the lower Mississippi Valley. Occurs from New England to Texas and from Michigan to Florida.

SWEET GUM. (See Gum.)

SYCAMORE.

74. Sycamore (*Platanus occidentalis*) (Buttonwood, Button-Ball Tree, Water Beech). Wood moderately heavy, quite hard, stiff, strong, tough, usually cross-grained, of coarse texture, and white to light brown color; the wood is hard to split and work, shrinks moderately, warps and checks considerably, but stands well. It is used in slack cooperage, and quite extensively for draw-

ers, backs, bottoms, etc.; in cabinet work, for tobacco boxes, and also for finishing lumber, where it has too long been underrated. A large tree, of rapid growth. Common and largest in the Ohio and Mississippi valleys, at home in nearly all parts of the Eastern United States.

75. Sycamore (*Platanus racemosa*). The California species resembles in its wood the Eastern form.

76. Tulip Tree (*Liriodendron tulipifera*) (Yellow Poplar, White Wood). Wood quite variable in weight, usually light, soft, stiff but not strong, of fine texture, and yellowish color; the wood shrinks considerably, but seasons without much injury; works and stands remarkably well. Used in slack cooperage, for siding, for panelling and finishing lumber in house, car, and shipbuilding, for sideboards and panels of wagons and carriages; also in the manufacture of furniture, implements and machinery, for pump logs, and almost every kind of common woodenware, boxes, shelving, drawers, etc. An ideal wood for the carver and toy man. A large tree, does not form forests, but is quite common, especially in the Ohio basin. Occurs from New England to Missouri and southward to Florida.

77. Cucumber Tree (*Magnolia acuminata*). A medium-sized tree, most common in the southern Alleghanies, but distributed from New York to Arkansas, southward to Alabama and northward to Illinois. Resembling, and probably confounded with, tulip wood in the markets.

TUPELO. (See Gum.)

WALNUT.

78. Black Walnut (*Juglans nigra*). Wood heavy, hard, strong, of coarse texture; the narrow sapwood whitish, the heartwood chocolate brown. The wood

shrinks moderately in drying, works well and stands well; takes a good polish. It is quite handsome, and has been for a long time the favorite cabinet wood in this country. Walnut, formerly used even for fencing, has become too costly for ordinary uses, and is to-day employed largely as a veneer, for inside finish and cabinet work; also in turnery, for gunstocks, etc. Black walnut is a large tree, with stout trunk, of rapid growth, and was formerly quite abundant throughout the Alleghany region, occurring from New England to Texas, and from Michigan to Florida.

WHITE WALNUT. (See BUTTERNUT.)

WHITE WOOD. (See TULIP and also BASSWOOD.)

WHITE WILLOW.

79. WHITE WILLOW (*Salix alba*). The wood is very soft, light, flexible and fairly strong, is fairly durable in contact with the soil, works well and stands well when seasoned. Medium-sized tree characterized by a short, thick trunk and a large, rather irregular crown composed of many small branches. The size of the tree at maturity varies with the locality. In the region where it occurs naturally, a height of seventy or eighty feet, and a diameter of three or four feet are attained. When planted in the Middle West, a height of from fifty to sixty feet, and a diameter of one and one-half to two feet, are all that may be expected. When close planted on moist soil, the tree forms a tall, slender stem well cleared of branches. Is widely naturalized in the United States. It is used in slack cooperage, and for cricket and baseball bats. Charcoal made from the wood is used in the manufacture of gunpowder. It has been generally used for fence posts on the northwestern plains, because of scarcity of better material. Well-seasoned posts will last from four to seven years.

YELLOW POPLAR.

80. Yellow Poplar (*Liriodendron tulipifera*) (Tulip Tree, Whitewood, Poplar, White Poplar, Blue Poplar, Hickory Poplar). Wood usually light, but varies in weight; it is soft, tough, but not strong, of fine texture, and yellowish color. The wood shrinks considerably, but seasons without much injury and works and stands exceedingly well. The sapwood is thin, light in color, and decays rapidly. It is fairly durable when exposed to the weather or in contact with the ground. The mature forest-grown tree has a long, straight, cylindrical bole, clear of branches for at least two-thirds of its length, surmounted by a short, open, irregular crown. When growing in the open, the tree maintains a straight stem, but the crown extends almost to the ground, and is of conical shape. Yellow poplar ordinarily grows to a height of from 100 to 125 feet, with a diameter of from three to six feet, and a clear length of about 70 feet. Trees have been found 190 feet tall and ten feet in diameter. The wood is used in slack cooperage, for siding, panelling, and interior finishing, and in the manufacture of toys, boxes, culinary woodenware, wagon boxes, carriage bodies and backing for veneer. It is in great demand throughout the vehicle and implement trade, and also makes a fair grade of wood pulp. Occurs from New England to Missouri and southward to Florida.

DIFFERENT GRAINS OF WOOD

The terms "fine-grained," "coarse-grained," "straight-grained" and "cross-grained" are frequently applied in the trade. In common usage, wood is coarse-grained if its annual rings are wide; fine-grained if they are narrow. In the finer wood industries a fine-grained wood is capable of high polish, while a coarse-grained wood is not, so that in this latter case the distinction depends chiefly on hardness, and in the former on an accidental case of slow or rapid growth. Generally if the direction of the wood fibres is parallel to the axis of the stem or limb in which they occur, the wood is straight-grained; but in many cases the course of the fibres is spiral or twisted around the tree (as shown in Fig. 10) and sometimes commonly in the butts of gum and cypress, the fibres of several layers are oblique in one direc-

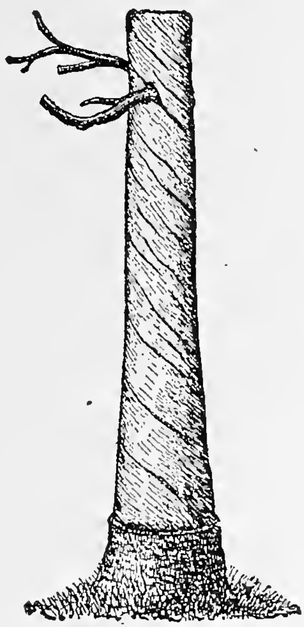


FIG. 10

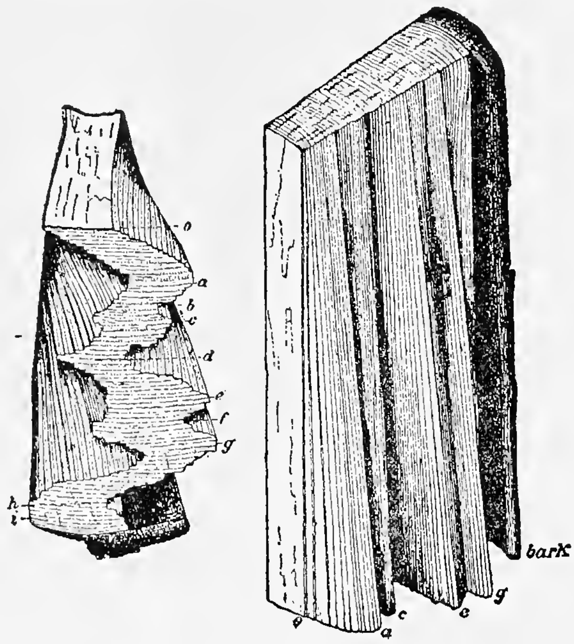


FIG. 11

FIG. 10. SPIRAL GRAIN. Season checks, after removal of bark, indicate the direction of the fibres or grain of the wood.

FIG. 11. ALTERNATING SPIRAL GRAIN IN CYPRESS. Side and end view of same piece. When the bark was at *o* the grain of this piece was straight From that time, each year it grew more oblique in one direction, reaching a climax at *a*, and then turned back in the opposite direction. These alternations were repeated periodically, the bark sharing in these changes.

tion, and those of the next series of layers are oblique in the opposite direction. (As shown in Fig. 11 the wood is cross or twisted grain.) Wavy-grain in a tangential plain as seen on the radial section is illustrated in Fig. 12, which represents an extreme case observed in beech. This same form also occurs on the radial plain, causing the tangential section to appear wavy or in transverse folds. When wavy-grain is fine (i. e., the folds or ridges small but numerous) it gives rise to the "curly" structure frequently seen in maple. Ordinarily, neither wavy, spiral, nor alternate grain is visible on the cross-section; its existence often escapes the eye even on smooth, longitudinal faces in the sawed material, so that the only safe

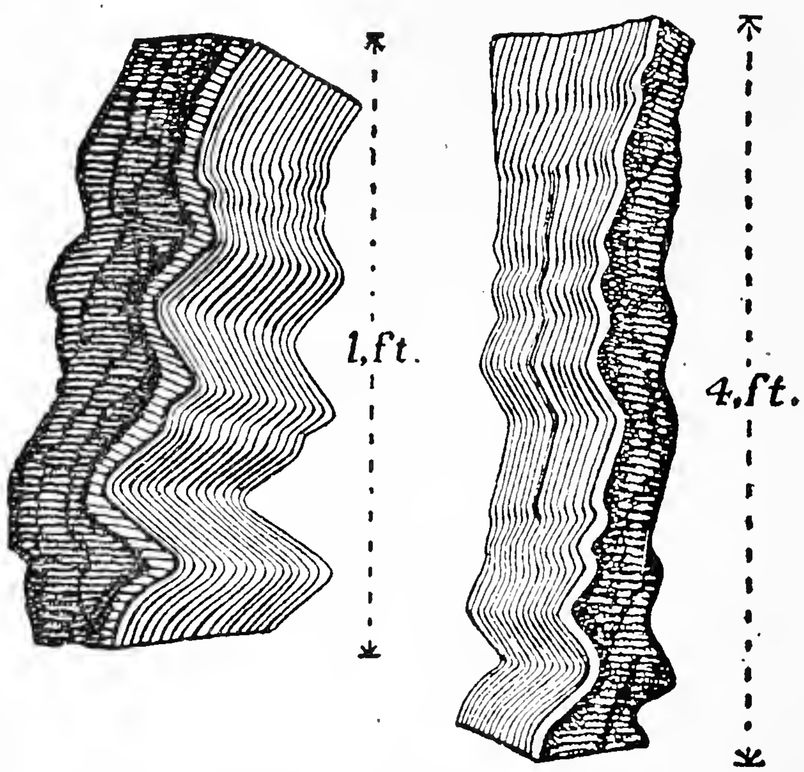


FIG. 12. WAVY-GRAIN IN BEECH; AFTER NÖRDLINGER

guide to their discovery lies in splitting the wood in two, in the two normal plains. Generally the surface of the wood under the bark, and therefore also that of any layer in the interior, is not uniform and smooth, but is channelled and pitted by numerous depressions, which differ greatly in size and form. Usually, any one depression or elevation is restricted to one or few annual layers

(i. e., seen only in one or few rings) and is then lost, being compensated (the surface at the particular spot evened up) by growth. In some woods, however, any depression or elevation once attained grows from year to year and reaches a maximum size, which is maintained for many years, sometimes throughout life. In maple, where this tendency to preserve any particular contour is very great, the depressions and elevations are usually small (commonly less than one-eighth inch) but very numerous. On tangent boards of such wood, the sections, pits, and prominences appear as circlets, and give rise to the beautiful "birdseye" or "landscape" structure. Similar structures in the burls of black ash, maple, etc., are frequently due to the presence of dormant buds, which cause the surface of all the layers through which they pass to be covered by small conical elevations, whose cross-sections on the sawed board appear as irregular circlets or islets, each with a dark speck, the section of the pith or "trace" of the dormant bud in the centre. In the wood of many broad-leaved trees the wood fibres are much longer when full grown than when they are first formed in the cambium or growing zone. This causes the tips of each fibre to crowd in between the fibres above and below, and leads to an irregular interlacement of these fibres, which

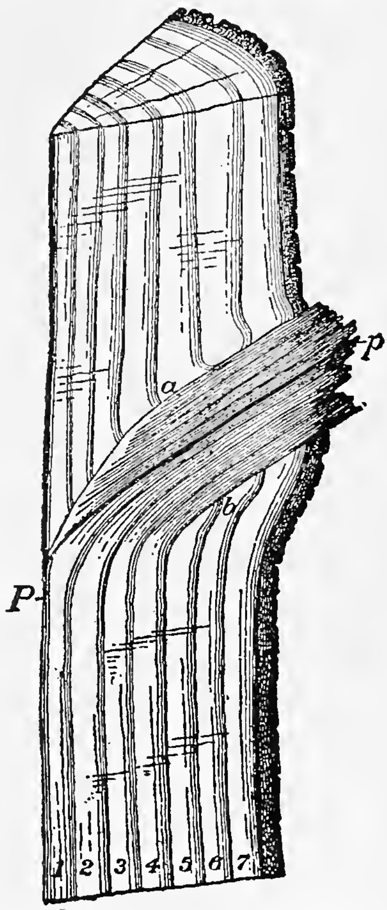


*FIG. 13. SECTION OF WOOD SHOWING POSITION OF THE GRAIN AT BASE OF A LIMB.

*P, pith of both stem and limb; *1-7*, seven yearly layers of wood; *a, b*, knot or basal part of a limb which lived four years, then died and adds to the toughness, but reduces the cleavability of the wood. At the juncture of the limb and stem the fibres on the upper and lower sides of the limb behave differently. On the lower side they run from the stem into the limb, forming an uninterrupted strand or tissue and a perfect union. On the upper side the fibres bend aside, are not continuous into the limb, and hence the connection is not perfect. (See Fig. 13.) Owing to this arrangement of the fibres, the cleft made in splitting never runs into the knot if started on the side above the limb, but is apt to enter the knot if started below, a fact well understood in woodcraft. When limbs die, decay, and break off, the remaining stubs are surrounded, and may finally be covered by the growth of the trunk and thus give rise to the annoying "dead" or "loose" knots.

COLOR AND ODOR

Color, like structure, lends beauty to the wood, aids in its identification, and is of great value in the determination of its quality. Considering only the heartwood, the black color of the persimmon, the dark brown of the walnut, the light brown of the white oaks, the reddish brown of the red oaks, the yellowish white of the tulip and poplars, the brownish red of the redwood and cedars, the yellow of the papaw and sumac, are all reliable marks of distinction, and color. Together with lustre and weight, are only too often the only features depended upon in practice. Newly formed wood, like that of the outer few rings, has but little color. The sapwood generally is light, and the wood of trees which form no heartwood changes but little, except when stained by forerunners of

broke off near the stem, leaving the part to the left of *a*, *b*, a "sound" knot, the part to the right a "dead" knot, which would soon be entirely covered by the growing stem.

disease. The different tints of colors, whether the brown of oak, the orange-brown of pine, the blackish tint of walnut, or the reddish cast of cedar, are due to pigments, while the deeper shade of the summer-wood bands in pine, cedar, oak, or walnut is due to the fact that the wood being denser, more of the colored wood substance occurs on a given space, i. e., there is more colored matter per square inch. Wood is translucent, a thin disk of pine permitting light to pass through quite freely. This translucency affects the lustre and brightness of lumber. When lumber is attacked by fungi, it becomes more opaque, loses its brightness, and in practice is designated "dead," in distinction to "live" or bright timber. Exposure to air darkens all wood; direct sunlight and occasional moistening hastens this change, and causes it to penetrate deeper. Prolonged immersion has the same effect, pine wood becoming a dark gray, while oak changes to a blackish brown. Odor, like color, depends on chemical compounds, forming no part of the wood substance itself. Exposure to weather reduces and often changes the odor, but a piece of long-leaf pine, cedar, or camphor wood exhales apparently as much odor as ever when a new surface is exposed. Heartwood is more odoriferous than sapwood. Many kinds of wood are distinguished by strong and peculiar odors. This is especially the case with camphor, cedar, pine, oak and mahogany, and the list would comprise every kind of wood in use were our sense of smell developed in keeping with its importance. Decomposition is usually accompanied by pronounced odors. Decaying poplar emits a disagreeable odor, while red oak often becomes fragrant, its smell resembling that of heliotrope.

WEIGHT OF WOOD

A small cross-section of wood (as in Fig. 14) dropped into water sinks, showing that the substance of which wood fibre or wood is built up is heavier than water. By immersing the wood successively in heavier liquids, until we find a liquid in which it does not sink, and comparing the weight of the same with water, we find that wood substance is about 1.6 times as heavy as water, and that this is as true of poplar as of oak or pine. Separating a single cell (as shown in Fig. 15, *a*), drying and then dropping it into water, it floats. The air-filled cell cavity or interior reduces its weight, and, like an empty corked bottle, it weighs less than the water. Soon, however, water soaks into the cell, when it fills up and sinks. Many such cells grown together, as in a block of wood, sink when all or most of them are filled with water, but will float as long as the majority of them are empty or only partially filled. This is why a green, sappy pine pole soon sinks in "driving" (floating). Its cells are largely filled before it is thrown in, and but little additional water suffices to make its weight greater than that of the water. In a good-sized white pine log, composed chiefly of empty cells (heartwood), the water requires a very long time to fill up the cells (five years would not suffice to fill them all), and therefore the log may float for many months. When the wall of the wood fibre is very thick (five-eighths or more of the volume, as in Fig. 15, *b*), the fibre sinks whether empty or filled. This applies to most of the fibres of the dark summer-wood bands in pines, and to the compact fibres of oak or hickory, and many, especially

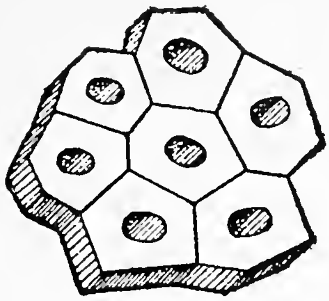


FIG. 14. CROSS-SECTION OF A GROUP OF WOOD FIBRES. Highly magnified.

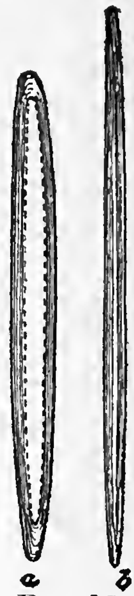


FIG. 15. ISOLATED FIBRES OF WOOD.

tropical woods, have such thick-walled cells and so little empty or air space that they never float. Here, then, are the two main factors of weight in wood: the amount of cell wall or wood substance constant for any given piece, and the amount of water contained in the wood, variable even in the standing tree, and only in part eliminated in drying. The weight of the green wood of any species varies chiefly as a second factor, and is entirely misleading, if the relative weight of different kinds is sought. Thus some green sticks of the otherwise lighter cypress

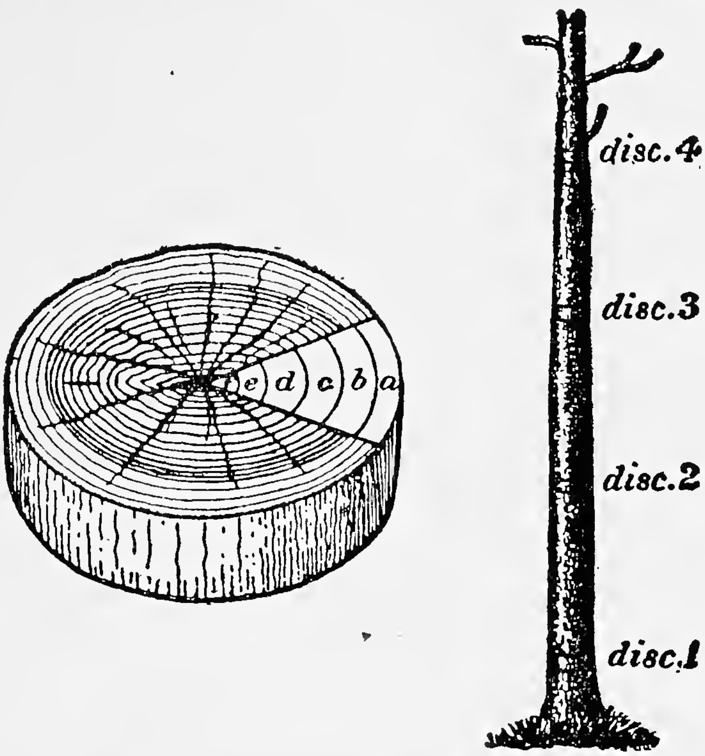


Fig. 16. Orientation of Wood Samples.

and gum sink more readily than fresh oak. The weight of sapwood or the sappy, peripheral part of our common lumber woods is always great, whether cut in winter or summer. It rarely falls much below forty-five pounds, and commonly exceeds fifty-five pounds to the cubic foot, even in our lighter wooded species. It follows that the green wood of a sapling is heavier than that of an old tree, the fresh wood from a disk of the upper part of a tree often heavier than that of a lower part, and the wood near the bark heavier than that nearer the pith; and also that the advantage of drying the wood before shipping is most important in sappy and light kinds. When kiln-dried, the misleading moisture factor of weight is uniformly reduced, and a fair comparison possible. For the sake of convenience in comparison, the weight of wood is expressed either as the weight per cubic foot, or, what is still more convenient, as specific weight or density. If an old long-leaf pine is cut up (as shown in Fig. 16) the wood of disk No. 1 is heavier than that of disk No. 2, the latter heavier than that of disk No. 3, and the wood of the top disk is found to be only about three-fourths as heavy as that of disk No. 1. Similarly, if disk No. 2 is cut up, as in the figure, the specific weight of the different parts is:

a, about 0.52
b, about 0.64
c, about 0.67
d, e, f, about 0.65

showing that in this disk at least the wood formed during the many years' growth, represented in piece *a*, is much lighter than that of former years. It also shows that the best wood is the middle part, with its large proportion of dark summer bands. Cutting up all disks in the same way, it will be found that the piece *a* of the first disk is heavier than the piece *a* of the fifth, and that piece *c* of the first disk excels the piece *c* of all the other disks. This shows that the wood grown during the same number of years is lighter in the upper parts of the stem; and if the disks are smoothed on their radial surfaces and set up one on top of the other in their regular order, for the sake of comparison, this decrease in weight will be seen to be accompanied by a decrease in the amount of summer-wood. The color effect of the upper disks is conspicuously lighter. If our old pine had been cut one hundred and fifty years ago, before the outer, lighter wood was laid on, it is evident that the weight of the wood of any one disk would have been found to increase from the centre outward, and no subsequent decrease could have been observed. In a thrifty young pine, then, the wood is heavier from the centre outward, and lighter from below upward; only the wood laid on in old age falls in weight below the average. The number of brownish bands of summer-wood are a direct indication of these differences. If an old oak is cut up in the same manner, the butt cut is also found heaviest and the top lightest, but, unlike the disk of pine, the disk of oak has its firmest wood at the centre, and each successive piece from the centre outward is lighter than its neighbor. Examining the pieces, this difference is not as readily explained by the appearance of each piece as in the case of pine wood. Nevertheless, one conspicuous point appears at once. The pores, so very distinct in oak, are very minute in the wood near the centre, and thus the wood is far less porous.

Studying different trees, it is found that in the pines, wood with narrow rings is just as heavy as and often heavier than the wood with wider rings; but if the rings are unusually narrow in any part of the disk, the wood has a lighter color; that is, there is less summer-wood and therefore less weight. In oak, ash, or elm trees of thrifty growth, the rings, fairly wide (not less than one-twelfth inch), always form the heaviest wood, while any piece with very narrow rings is light. On the other hand, the weight of a piece of hard maple or birch is quite independent of the width of its rings. The bases of limbs (knots) are usually heavy, very heavy in conifers, and also the wood which surrounds them, but generally the wood of the limbs is lighter than that of the stem, and the wood of the roots is the lightest. In general, it may be said that none of the native woods in common use in this country are when dry as heavy as water, i. e., sixty-two pounds to the cubic foot. Few exceed fifty pounds, while most of them fall below forty pounds, and much of the pine and other coniferous wood weigh less than thirty pounds per cubic foot. The weight of the wood is in itself an important quality. Weight assists in distinguishing maple from poplar. Lightness coupled with great strength and stiffness recommends wood for a thousand different uses. To a large extent weight predicates the strength of the wood, at least in the same species, so that a heavy piece of oak will exceed in strength a light piece of the same species, and in pine it appears probable that, weight for weight, the strength of the wood of various pines is nearly equal.

WEIGHT OF KILN-DRIED WOOD OF DIFFERENT SPECIES

Species	Approximate Specific Weight	Approximate Weight of 1 Cubic Foot	Approximate Weight of 1,000 Feet Lumber
		Pounds	Pounds
(a) Very Heavy Woods: Hickory, Oak, Persimmon, Osage Orange, Black Locust, Hackberry, Blue Beech, Best of Elm, and Ash	0.70–0.80	42–48	3,700
(b) Heavy Woods: Ash, Elm, Cherry, Birch, Maple, Beech, Walnut, Sour Gum, Coffee Tree, Honey Locust, Best of Southern Pine and Tamarack	0.60–0.70	36–42	3,200
(c) Woods of Medium Weight: Southern Pine, Pitch Pine, Tamarack, Douglass Spruce, Western Hemlock, Sweet Gum, Soft Maple, Sycamore, Sassafras, Mulberry, Light Grades of Birch, and Cherry	0.50–0.60	30–36	2,700
(d) Light Woods: Norway and Bull Pine, Red Cedar, Cypress, Hemlock, the Heavier Spruce and Fir, Redwood, Basswood, Chestnut, Butternut, Tulip, Catalpa, Buckeye, Heavier Grades of Poplar	0.40–0.50	24–30	2,200
(e) Very Light Woods: White Pine, Spruce, Fir, White Cedar, Poplar	0.30–0.40	18–24	1,800

SECTION II

ENEMIES OF WOOD

ENEMIES OF WOOD

GENERAL REMARKS

From the writer's personal investigations of this subject in different sections of the country, the damage to forest products of various kinds from this cause seems to be far more extensive than is generally recognized. Allowing a loss of five per cent. on the total value of the forest products of the country, which the writer believes to be a conservative estimate, it would amount to something over $30,000,000 annually. This loss differs from that resulting from insect damage to natural forest resources, in that it represents more directly a loss of money invested in material and labor. In dealing with the insects mentioned, as with forest insects in general, the methods which yield the best results are those which relate directly to preventing attack, as well as those which are unattractive or unfavorable. The insects have two objects in their attack: one is to obtain food, the other is to prepare for the development of their broods. Different species of insects have special periods during the season of activity (March to November), when the adults are on the wing in search of suitable material in which to deposit their eggs. Some species, which fly in April, will be attracted to the trunks of recently felled pine trees or to piles of pine sawlogs from trees felled the previous winter. They are not attracted to any other kind of timber, because they can live only in the bark or wood of pine, and only in that which is in the proper condition to favor the hatching of their eggs and the normal development of their young. As they fly only in April, they cannot injure the logs of trees felled during the remainder of the year.

There are also oak insects, which attack nothing but oak; hickory, cypress, and spruce insects, etc., which have different habits and different periods of flight, and require special conditions of the bark and wood for depositing their eggs or for the subsequent development of their broods. Some of these insects have but one generation in a year, others have two or more, while some require more than one year for their complete development and transformation. Some species deposit their eggs in the bark or wood of trees soon after they are felled or before any perceptible change from the normal living tissue has taken place; other species are attracted only to dead bark and dead wood of trees which have been felled or girdled for several months; others are attracted to dry and seasoned wood; while another class will attack nothing but very old dry bark or wood of special kinds and under special conditions. Thus it will be seen how important it is for the practical man to have knowledge of such of the foregoing facts as apply to his immediate interest in the manufacture or utilization of a given forest product, in order that he may with the least trouble and expense adjust his business methods to meet the requirements for preventing losses. The work of different kinds of insects, as represented by special injuries to forest products, is the first thing to attract attention, and the distinctive character of this work is easily observed, while the insect responsible for it is seldom seen, or it is so difficult to determine by the general observer from descriptions or illustrations that the species is rarely recognized. Fortunately, the character of the work is often sufficient in itself to identify the cause and suggest a remedy, and in this section primary consideration is given to this phase of the subject.

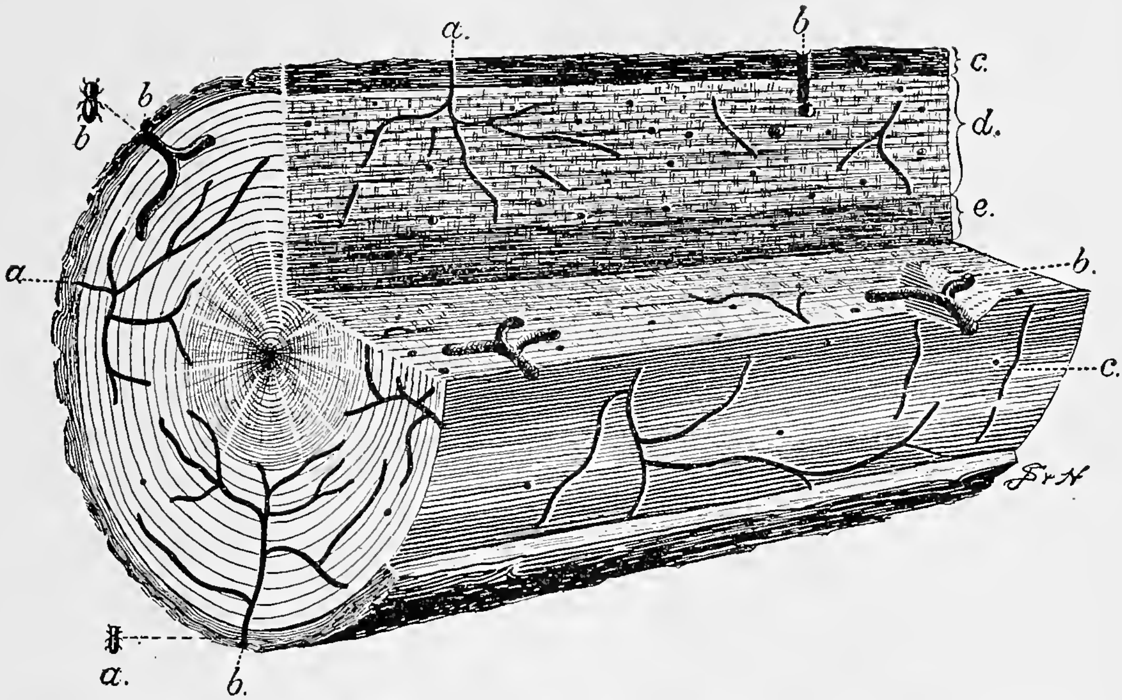


FIG. 17. WORK OF AMBROSIA BEETLES IN TULIP OR YELLOW POPLAR WOOD: *a*, work of *Xyleborus affinis* and *Xyleboris inermis*; *b*, *Xyleboris obesus* and work; *c*, bark; *d*, sapwood; *e*, heartwood.

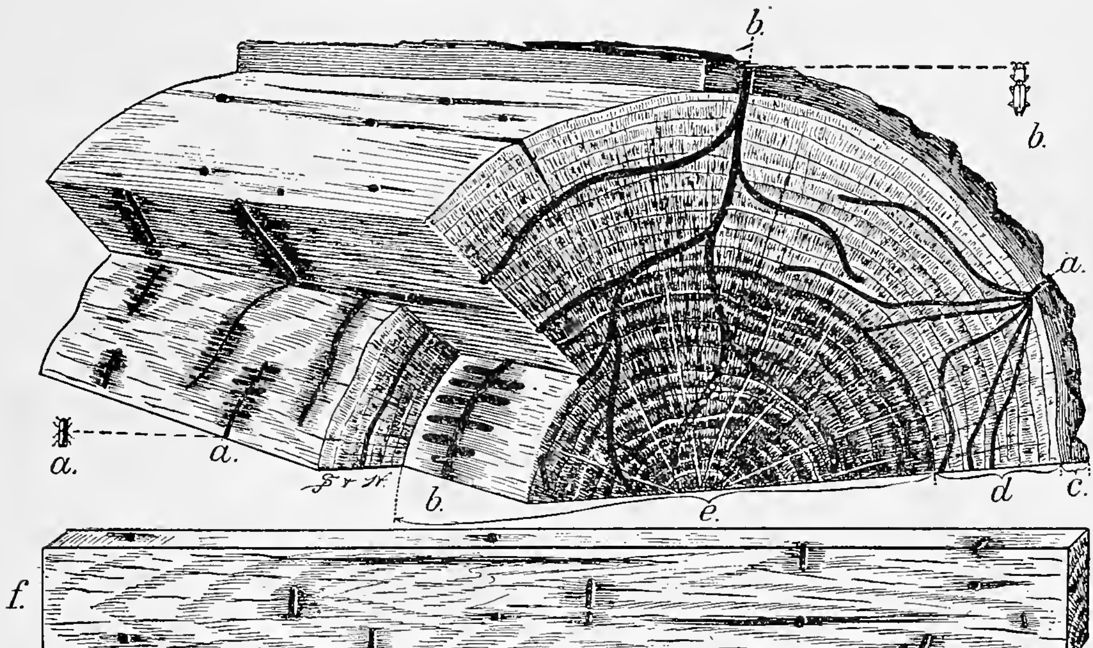


FIG. 18. WORK OF AMBROSIA BEETLES IN OAK: *a*, *Monarthrum mali* and work; *b*, *Platypus compositus* and work; *c*, bark; *d*, sapwood; *e*, heartwood; *f*, character of work in wood from injured log.

AMBROSIA OR TIMBER BEETLES

The characteristic work of this class of wood-boring beetles is shown in Figs. 17 and 18. The injury consists of pinhole and stained-wood defects in the sapwood and heartwood of recently felled or girdled trees, sawlogs, pulpwood, stave and shingle bolts, green or unseasoned lumber, and staves and heads of barrels containing alcoholic liquids. The holes and galleries are made by the adult parent beetles, to serve as entrances and temporary houses or nurseries for the development of their broods of young, which feed on a kind of fungus growing on the walls of the galleries. The growth of this ambrosia-like fungus is induced and controlled by the parent beetles, and the young are dependent upon it for food. The wood must be in exactly the proper condition for the growth of the fungus in order to attract the beetles and induce them to excavate their galleries; it must have a certain degree of moisture and other favorable qualities, which usually prevail during the period involved in the change from living, or normal, to dead or dry wood; such a condition is found in recently felled trees, sawlogs, or like crude products. There are two general types or classes of these galleries: one in which the broods develop together in the main burrows (Fig. 17), the other in which the individuals develop in short, separate side chambers, extending at right angles from the primary galleries. (Fig. 18.) The galleries of the latter type are usually accompanied by a distinct staining of the wood, while those of the former are not. The beetles responsible for this work are cylindrical in form, apparently with a head (the prothorax) half as long as the remainder of the body. (Figs. 17, *a*, and 18, *a*.) North American species vary in size from less than one-tenth to slightly more than two-tenths of an inch, while some of the subtropical and tropical species attain a much larger size. The diameter of the holes made by each species corresponds closely to that of the body, and varies from about one-twentieth to one-sixteenth of an inch for the tropical species.

ROUND-HEADED BORERS

The character of the work of this class of wood and bark-boring grubs is shown in Fig. 19. The injuries con-

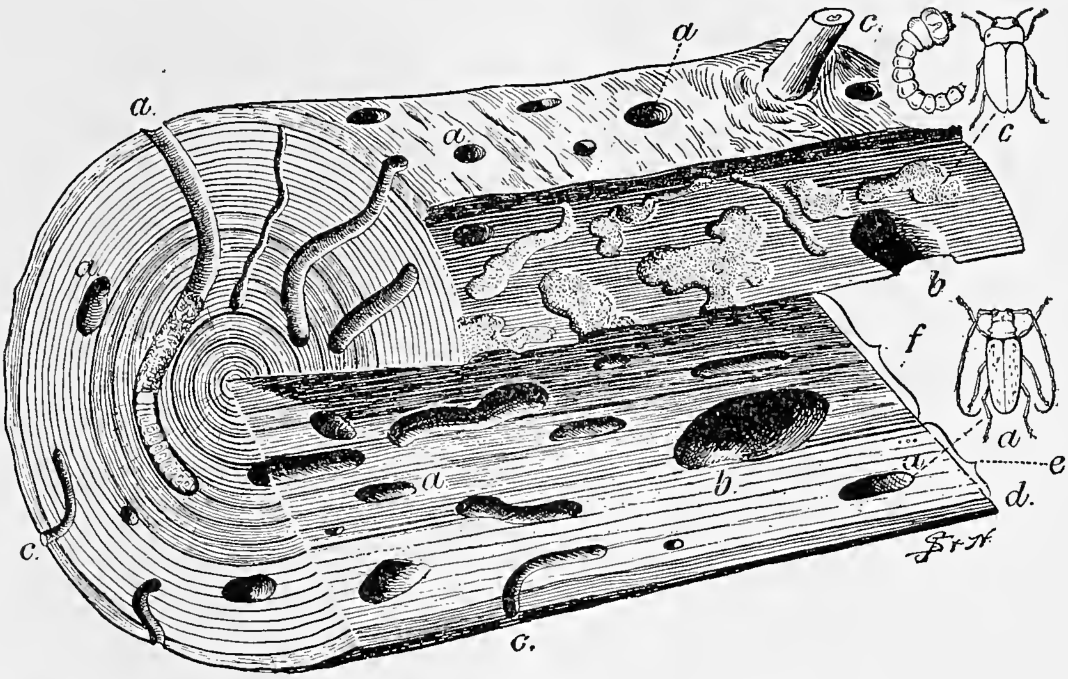


FIG. 19. WORK OF ROUND-HEADED AND FLAT-HEADED BORERS IN PINE: *a*, work of round-headed borer, "sawyer," *Monohammus* sp., natural size; *b*, *Ergates spiculatus*; *c*, work of flat-headed borer, *Buprestis*, larva and adult; *d*, bark; *e*, sapwood; *f*, heartwood.

sist of irregular flattened or nearly round wormhole defects in the wood, which sometimes result in the destruction of the valuable parts of wood or bark material. The sapwood and heartwood of recently felled trees, sawlogs, poles, posts, mine props, pulpwood and cordwood, also lumber or square timber, with bark on the edges, and construction timber in new and old buildings, are injured by wormhole defects, while the valuable parts of stored oak and hemlock tanbark and certain kinds of wood are converted into worm-dust. These injuries are caused by the young or larvæ of long-horned beetles. Those which infest the wood hatch from eggs deposited in the outer bark of logs and like material, and the minute grubs hatching therefrom bore into the inner bark, through which they extend their irregular burrows, for the purpose of obtaining food from the sap and other nutritive material found in the plant tissue. They continue to

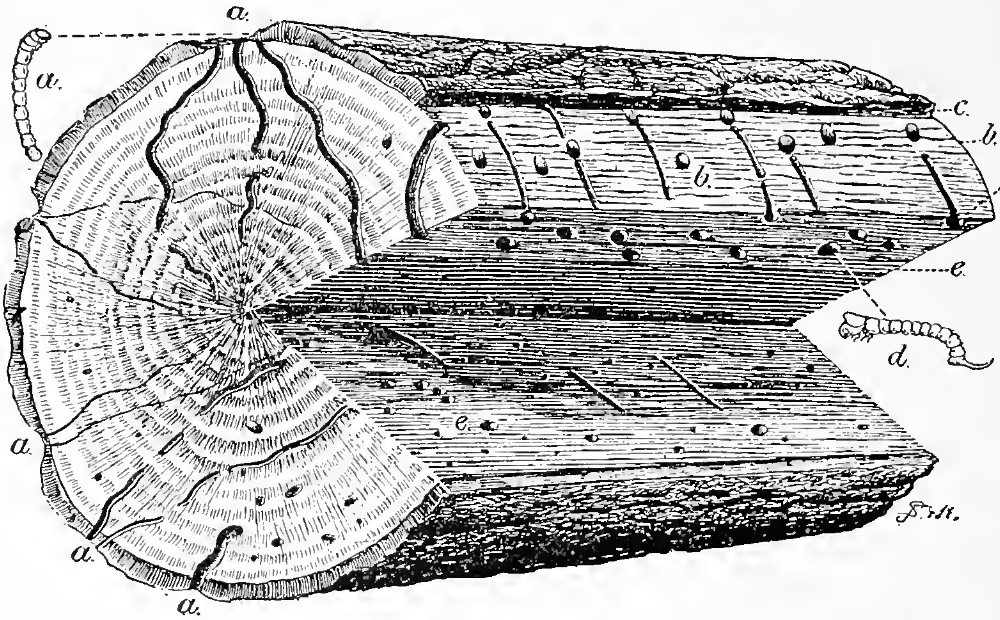


Fig. 20. Work of Timber Worms in Oak: *a*, work of oak timber worm, *Eupsalis minuta*; *b*, barked surface; *c*, bark; *d*, sapwood timber worm, *Hylocœtus lugubris*, and work; *e*, sapwood.

extend and enlarge their burrows as they increase in size, until they are nearly or quite full grown. They then enter the wood and continue their excavations deep into the sapwood or heartwood until they attain their normal size. They then excavate pupa cells in which to transform into adults, which emerge from the wood through exit holes in the surface. This class of borers is represented by a large number of species. The adults, however, are seldom seen by the general observer unless cut out of the wood before they have emerged.

FLAT-HEADED BORERS

The work of the flat-headed borers (Fig. 19) is only distinguished from that of the preceding by the broad, shallow burrows, and the much more oblong form of the exit holes. In general, the injuries are similar, and affect the same class of products, but they are of much less importance. The adult forms are flattened, metallic-colored beetles, and represent many species, of various sizes.

TIMBER WORMS

The character of the work done by this class is shown in Fig. 20. The injury consists of pinhole defects in the sapwood and heartwood of felled trees, sawlogs and like material which have been left in the woods or in piles in the open for several months during the warmer seasons. Stave and shingle bolts and closely piled oak lumber and square timbers also suffer from injury of this kind. These injuries are made by elongate, slender worms or larvæ, which hatch from eggs deposited by the adult beetles in the outer bark, or, where there is no bark, just beneath the surface of the wood. At first the young larvæ bore almost invisible holes for a long distance through the sapwood and heartwood, but as they increase in size the same holes are enlarged and extended until the larvæ have attained their full growth. They then transform to adults, and emerge through the enlarged entrance burrows. The work of these timber worms is distinguished from that of the timber beetles by the greater variation in the size of holes in the same piece of wood, also by the fact that they are not branched from a single entrance or gallery, as are those made by the beetles.

POWDER POST BORERS

The character of work of this class of insects is shown in Figs. 21, 22 and 23. The injury consists of closely placed burrows, packed with borings, or a completely de-

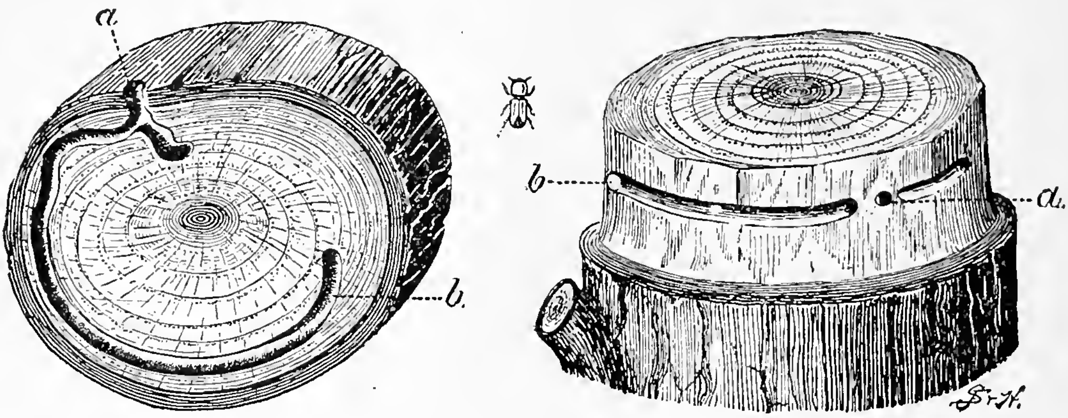


FIG. 21. WORK OF POWDER POST BEETLE, *Sinoxylon basilare*, IN HICKORY POLES, showing transverse egg galleries excavated by the adult; *a*, entrance; *b*, gallery; *c*, adult.

stroyed or powdered condition of the wood of seasoned products, such as lumber, crude and finished handle and wagon stock, cooperage and wooden truss hoops, fur-

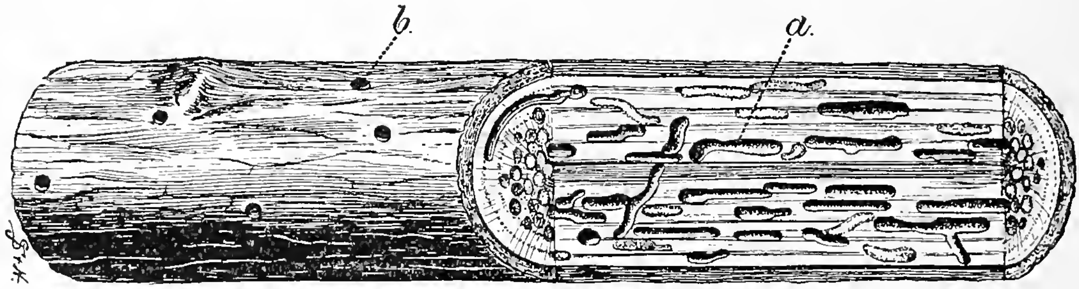


FIG. 22. WORK OF POWDER POST BEETLE, *Sinoxylon basilare*, IN HICKORY POLE: *a*, character of work by larvæ; *b*, exit holes made by emerging broods.

niture, and inside finish woodwork, in old buildings, as well as in many other crude or finished and utilized woods. This is the work of both the adults and young stages of some species, or of the larval stage alone of others. In the former, the adult beetles deposit their eggs in burrows or galleries excavated for the purpose, as in Figs. 21 and 22, while in the latter (Fig. 23) the eggs are on or beneath the surface of the wood. The grubs complete the destruction by boring through the solid wood in all directions and packing their burrows with the powdered wood. When they are full grown they transform to the adult, and emerge from the injured material through holes in the surface. Some of the species continue to work in the same wood until many generations have developed and emerged, or until every particle of wood tissue has been destroyed and the available nutritive substance extracted.

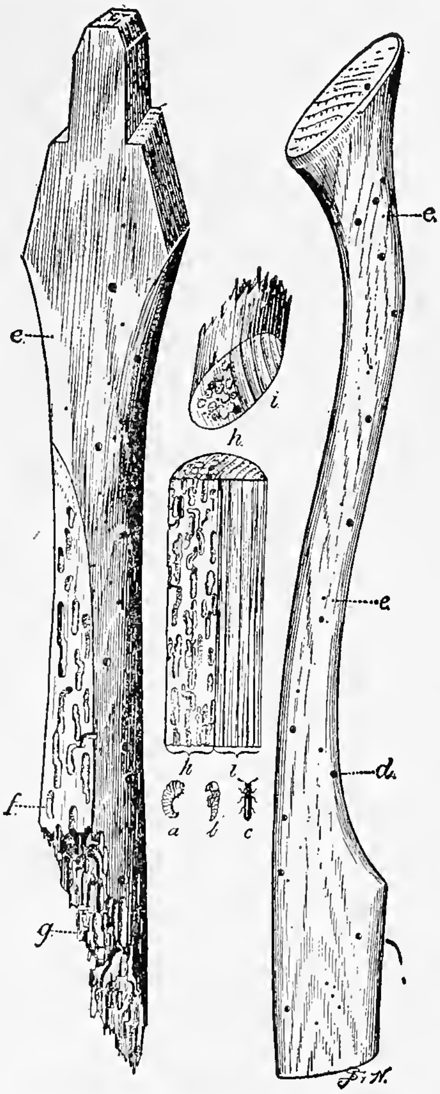


FIG. 23 WORK OF POWDER POST BEETLE, *Lyctus striatus*, IN HICKORY HANDLES AND SPOKES: *a*, larva; *b*, pupa; *c*, adult; *d*, exit holes; *e*, entrance of larvæ (vents for borings are exits of parasites); *f*, work of larvæ; *g*, wood, completely destroyed; *h*, sapwood; *i*, heartwood.

CONDITIONS FAVORABLE FOR INSECT INJURY—CRUDE PRODUCTS—ROUND TIMBER WITH BARK ON

Newly felled trees, sawlogs, stave and heading bolts, telegraph poles, posts, and the like material, cut in the fall and winter, and left on the ground or in close piles during a few weeks or months in the spring or summer, causing them to heat and sweat, are especially liable to injury by ambrosia beetles (Figs. 17 and 18), round and flat-headed borers (Fig. 19), and timber worms (Fig. 20), as are also trees felled in the warm season, and left for a time before working up into lumber. The proper degree of moisture found in freshly cut living or dying wood, and the period when the insects are flying, are the conditions most favorable for attack. This period of danger varies with the time of the year the timber is felled and with the different kinds of trees. Those felled in late fall and winter will generally remain attractive to ambrosia beetles, and to the adults of round and flat-headed borers during March, April and May. Those felled in April to September may be attacked in a few days after they are felled, and the period of danger may not extend over more than a few weeks. Certain kinds of trees felled during certain months and seasons are never attacked, because the danger period prevails only when the insects are flying; on the other hand, if the same kinds of trees are felled at a different time, the conditions may be most attractive when the insects are active, and they will be thickly infested and ruined. The presence of bark is absolutely necessary for infestation by most of the wood-boring grubs, since the eggs and young stages must occupy the outer and inner portions before they can enter the wood. Some ambrosia beetles and timber worms will, however, attack barked logs, especially those in close piles, and others shaded and protected from rapid drying. The sapwood of pine, spruce, fir, cedar, cypress, and like softwoods is especially liable to injury by ambrosia beetles, while the heartwood is sometimes ruined by a class of round-headed borers, known as "sawyers." Yellow poplar, oak, chestnut, gum, hickory, and most other hardwoods are as a rule attacked by species of ambrosia beetles, sawyers, and timber worms, different from those infesting the pines, there being but very few species which attack both. Mahogany and other rare and valuable woods imported from the tropics to this country in the form of round logs, with or without bark on, are commonly damaged more or less seriously by ambrosia beetles and timber worms. It would appear from the writer's investigations of logs received at the mills in this country, that the principal damage is done during a limited period—from the time the trees are felled until they are placed in fresh or salt water for transportation to the shipping points. If, however, the logs are loaded on the vessel direct from the shore, or if not left in the water long enough to kill the insects, the latter will continue their destructive work during transportation to this country and after they arrive, and until cold weather ensues or the logs are converted into lumber. It was also found that a thorough soaking in sea-water, while it usually killed the insects at the time, did not prevent subsequent attacks by both foreign and native ambrosia beetles; also, that the removal of the bark from such logs previous to their immersion did not render them entirely immune. Those with the bark off were attacked more than those with it on, owing to the greater amount of saline moisture retained by the bark.

HOW TO PREVENT INJURY

From the foregoing it will be seen that some requisites for preventing these insect injuries to round timber are:

1. To provide for as little delay as possible between the felling of the tree and its manufacture into rough products. This is especially necessary with trees felled from April to September, in the region north of the Gulf States, and from March to November in the latter, while the late fall and winter cutting should all be worked up by March or April.

2. If the round timber must be left in the woods or on

the skidways during the danger period, every precaution should be taken to facilitate rapid drying of the inner bark, by keeping the logs off the ground, in the sun, or in loose piles; or else the opposite extreme should be adopted and the logs kept in water.

3. The immediate removal of all the bark from poles, posts and other material which will not be seriously damaged by checking or season cracks.

4. To determine and utilize the proper months or seasons to girdle or fell different kinds of trees. Bald cypress in the swamps of the South are girdled in order that they may die, and in a few weeks or months dry out and become light enough to float. This method has been extensively adopted in sections where it is the only practicable one by which the timber can be transported to the sawmills. It is found, however, that some of these girdled trees are especially attractive to several species of ambrosia beetles (Figs. 17 and 18), round-headed borers (Fig. 19) and timber worms (Fig. 20), which cause serious injury to the sapwood or heartwood, while other trees girdled at a different time or season are not injured. This suggested to the writer the importance of experiments to determine the proper time to girdle trees to avoid losses, and they are now being conducted on an extensive scale by the Forest Service, in co-operation with prominent cypress operators in different sections of the cypress-growing region.

SAPLINGS

Saplings, including hickory and other round hoop-poles and similar products, are subject to serious injuries and destruction by round and flat-headed borers (Fig. 19), and certain species of powder post borers (Figs. 21 and 22) before the bark and wood are dead or dry, and also by other powder post borers (Fig. 23) after they are dried and seasoned. The conditions favoring attack by the former class are those resulting from leaving the poles in piles or bundles in or near the forest for a few weeks during the season of insect activity, and by the latter from leaving them stored in one place for several months.

STAVE, HEADING AND SHINGLE BOLTS

These are attacked by ambrosia beetles (Figs. 17 and 18), and the oak timber worm (Fig 20, *a*), which, as has been frequently reported, cause serious losses. The conditions favoring attack by these insects are similar to those mentioned under "Round Timber." The insects may enter the wood before the bolts are cut from the log or afterward, especially if the bolts are left in moist, shady places in the woods, in close piles during the danger period. If cut during the warm season, the bark should be removed and the bolts converted into the smallest practicable size and piled in such a manner as to facilitate rapid drying.

UNSEASONED PRODUCTS IN THE ROUGH

Freshly sawn hardwood, placed in close piles during warm, damp weather in July and September, presents especially favorable conditions for injury by ambrosia beetles (Figs. 17, *a,* and 18, *a*). This is due to the continued moist condition of such material. Heavy two-inch or three-inch stuff is also liable to attack even in loose piles with lumber or cross sticks. An example of the latter was found in a valuable lot of mahogany lumber of first grade, the value of which was reduced two-thirds by injury from a native ambrosia beetle. Numerous complaints have been received from different sections of the country of this class of injury to oak, poplar, gum and other hardwoods. In all cases it is the moist condition and retarded drying of the lumber which induces attack; therefore, any method which will provide for the rapid drying of the wood before or after piling will tend to prevent losses. It is important that heavy lumber should, as far as possible, be cut in the winter months and piled so that it will be well dried out before the middle of

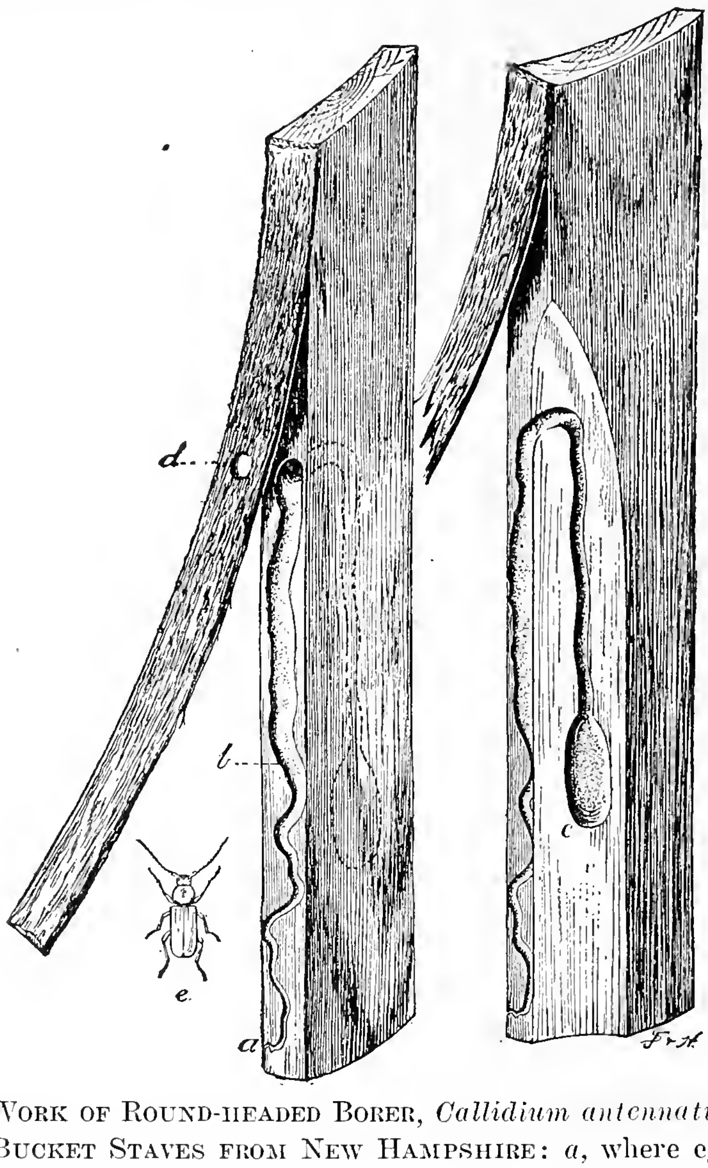


FIG. 24. WORK OF ROUND-HEADED BORER, *Callidium antennatum*, IN WHITE PINE BUCKET STAVES FROM NEW HAMPSHIRE: *a*, where egg was deposited in bark; *b*, larval mine; *c*, pupal cell; *d*, exit in bark; *e*, adult.

March. Square timber, stave and heading bolts, with the bark on, often suffer from injuries by flat or round-headed borers, hatching from eggs deposited in the bark of the logs before they are sawed and piled. One example of serious damage and loss was reported in which white pine staves for paint buckets and other small wooden vessels, which had been sawed from small logs, and the bark left on the edges, were attacked by a round-headed borer, the adults having deposited their eggs in the bark after the stock was sawn and piled. The character of the injury is shown in Fig. 24. Another example was reported from a manufacturer in the South, where the pieces of lumber which had a strip of bark on one side were seriously damaged by the same kind of borer, the eggs having been deposited in the logs before sawing or in the bark after the lumber was piled. If the eggs are deposited in the logs, and the borers have entered the inner bark or the wood before sawing, they may continue their work regardless of methods of piling; but if such lumber is cut from new logs and placed in the pile while green, with the bark surface up, it will be much less liable to attack than if piled with the bark down. This liability of lumber with bark edges or sides to be attacked by insects suggests the importance of the removal of the bark, to prevent damage, or, if this is not practicable, the lumber with the bark on the sides should be piled in open, loose piles with the bark up, while that with the bark on the edges should be placed on the outer edge of the piles, exposed to the light and air. A moist condition of lumber and square timber, such as results from close or solid piles, with the bottom layers on the ground or on a foundation of old decaying logs or near decaying stumps and logs, offers especially favorable conditions for the attack of white ants.

SEASONED PRODUCTS IN THE ROUGH

Seasoned or dry timber in stacks or storage is liable to injury by powder post borers. (Fig. 23.) The conditions favoring attack are: (1) The presence of a large proportion of sapwood, as in hickory, ash, and similar woods; (2) material which is two or more years old, or that which has been kept in one place for a long time; (3) access to old infested material. Therefore, such stock should be frequently examined for evidence of the presence of these insects. This is always indicated by fine, flour-like powder on or beneath the piles, or otherwise associated with such material. All infested material should be at once removed and the infested parts destroyed by burning.

DRY COOPERAGE STOCK AND WOODEN TRUSS HOOPS

These are especially liable to attack and serious injury by powder post borers (Fig. 23), under the same or similar conditions as the preceding.

STAVES AND HEADS OF BARRELS CONTAINING ALCOHOLIC LIQUIDS

These are liable to attack by ambrosia beetles (Figs. 17, *a* and 18, *a*), which are attracted by the moist condition and possibly by the peculiar odor of the wood, resembling that of dying sapwood of trees and logs, which is their normal breeding place. There are many examples on record of serious losses of liquors from leakage caused by the beetles boring through the staves and heads of the barrels and casks in cellars and storerooms. The condition, in addition to the moisture of the wood, which is favorable for the presence of the beetles, is proximity to their breeding places, such as the trunks and stumps of recently felled or dying oak, maple and other hardwood or deciduous trees; lumber yards, sawmills, freshly cut cordwood, from living or dead trees, and forests of hardwood timber. Under such conditions the beetles occur in great numbers, and if the storerooms and cellars in which the barrels are kept stored are damp, poorly ventilated, and readily accessible to them, serious injury is almost certain to follow.

SECTION III

FOREST FIRES

FOREST FIRES

FIRES THE GREATEST ENEMY OF FORESTS

GENERAL REMARKS

Of the many destructive agencies at work in the forests of the United States, fire holds first place, and the loss which it inflicts equals, if it does not surpass, that from all other causes combined. Insect hordes occasionally destroy large areas of valuable forest growth; wasteful and short-sighted lumbering methods, resulting from in-

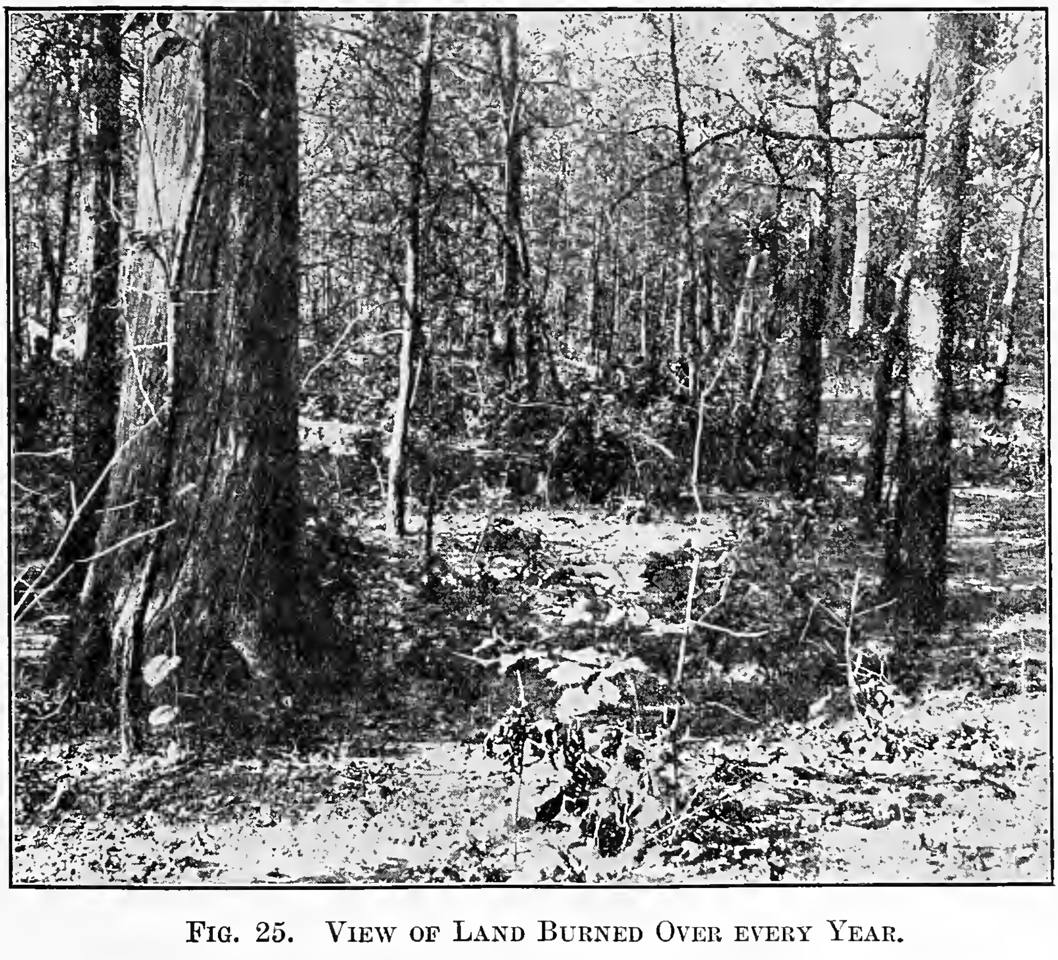


FIG. 25. VIEW OF LAND BURNED OVER EVERY YEAR.

volved economic conditions, have brought about the rapid conversion of much of the finest timberlands into unproductive barrens; and in the far West, excessive and unrestricted grazing has seriously reduced the regenerating power of the forest, and exposed vast areas to injury by flood and erosion. But great as is the damage from these causes, compared with fire they are of secondary importance. Further, it is to the fires which usually precede, accompany, or follow these other agencies that their most serious consequences are often due. Insect attacks often follow when fire has killed or reduced the vitality of timber; the cut-over timber lands of the Great Lakes and other regions would not present such a discouraging aspect had not fire killed the seed trees and young growth (see Fig. 25), which otherwise would have survived even the most pernicious logging enterprises; and in the forests of the West fire again is a potent source of difficulty in adjusting the conflicting claims of the grazing, timber, and water interests.

SOME ESTIMATES OF LOSSES FROM FIRE

Certain as it is that fire is the greatest of forest evils, there exists comparatively little accurate knowledge on which to base an estimate of the total loss from this source. This is due, not to lack of interest so much as to the immensity of the field, and the complex character of the problem which the attempt to make such an estimate presents. Losses of mill and logging machinery, lumber, cordwood, merchantable standing timber, and other property of staple market value can be closely determined by individual losers; but when attempts are made to combine even these definite losses for a State, or for the United States, the result becomes a rough estimate, if not a matter of mere conjecture. Nevertheless, it is indisputable that these losses are enormous, and that, for the country as a whole, they run high into the millions. No less serious, though incapable of money valuation, is the indirect loss due to the destruction of young growth, which is to form our future forests. To this must be added the injury to the forest soil, caused by the burning out of the vegetable matter, indispensable to healthy tree

FIG. 26. EFFECTS OF A FOREST FIRE.

growth. (See Fig. 26.) The most conservative estimates put the average annual loss from forest fires at above $25,000,000. More exact estimates are available for limited regions. For example, a careful estimate made on the ground after the terrific Washington and Oregon fires of 1902 showed a loss in nine days of $12,000,000 worth of forest property. New York State in the spring of 1903 suffered from unusually severe fires in the Adirondacks, involving a direct loss estimated at $3,500,000, in addition to a known expense for fire fighting of $175,000.

LOSSES FROM FIRE WHICH ARE NOT USUALLY CONSIDERED

The severest consequences do not result from these great conflagrations, which partake of the nature of national calamities. Beyond question it is the smaller, unnoted fires which in the aggregate inflict the most serious damage upon the forests of the United States. And this damage is for the most part of a kind from the very nature of the case incapable of exact calculation. In the first place, much fine timber in this country has at present no money value because it is not now accessible. In the second place, the injury which the forest suffers is far greater than that covered by the stumpage value of the standing merchantable timber. Generally the lumberman is immediately concerned only with that part of the fire loss which includes the destruction of timber and lumber that he can sell, and of milling or logging property in the woods. The annihilation of young growth, and the lowering of the forest's water conserving and regenerative powers, do not appear in the profit and loss column of his books. From the point of view of the public interest, the effect of fires on forest reproduction and water conservation is far more important than the destruction of mature timber. Yet the impossibility of even approximately determining the former losses makes them appear less real. Save in limited regions, young forest growth has no recognized value; consequently its destruction by fire is not an appreciated financial loss. In view of the growing scarcity of timber, and of the almost inevitable changes in the general field of forestry, it is safe to prophesy that in the near future the value of young growth will be definitely recognized. Nevertheless, lumbermen have not as yet generally recognized it nor taken steps to encourage or protect such growth. (Fig. 52.)

CONDITIONS WHICH AFFECT FIRE LOSSES

The extent to which lumbering interests suffer from fire depends largely on the region in which they conduct their operations. Broad statements concerning this are subject to exceptions, yet in general it is true that Pacific Coast lumbermen suffer most, and those in the Southern hardwoods least, while the losses of operators in the Lake States and the Northeast fall between the two. The Pacific Coast lumber manufacturer is the heaviest loser, not only because the fires are more severe, but also because his mills and yards are located in the heart of the forest, since he cannot "drive" the streams. In California and eastward, surface fires prevail in the virgin forests, but rarely destroy extensive stands of timber, although individual trees are severely injured and killed. In the Northeast and Great Lakes States fires commonly do not reach their maximum of injury until the lumberman has left; hence, he is not so great a sufferer. In the Southern pineries the frequently occurring grass fires are rarely severe and are seldom troublesome to the lumberman. Old turpentine orchards, where the boxes and excoriated surfaces expose the trees to fire injury, are the exception. Such timber, however, is usually purchased at a low figure and cut before fire does it material damage.

ERRONEOUS IDEAS CONCERNING EFFECTS OF FIRES

The effect of surface and brush fires in large timber is more serious than generally supposed. The prevailing opinion is that mature timber is not injured by such fires, and this has created among lumbermen a feeling of indifference to their occurrence. Few fires in a forest are so slight as to produce no ill effects. Though most of the trees may escape with only a slight blackening or charring of the bark, there are inevitably others which are

FIG. 27. BLACK GUM STILL ALIVE, THOUGH BURNED TO A SHELL. Damage done by a fire.

killed or injured at the base by the burning of brush and debris accumulated about the trunk, or by the fire catching in a break in the bark. (See Fig. 27.) Each successive fire adds its percentage of injury, while all damaged trees are rendered less wind firm. Even in the Southern pines, where the fire injury is near the minimum, the cumulative damage is surprisingly great. The Bureau of Forestry at Washington, D. C., have obtained figures which show that in a turpentine orchard of Florida long-leaf pine, abandoned for five years, thirty-three per cent. of the trees above a diameter of one inch were found dead or down, mainly as a result of a fire, while only one-half of one per cent. of the remaining boxed trees were unburned. The damage in unboxed long-leaf pine of the same region was much less serious, eighty-two per cent. of the stand being sound. Throughout California the opinion so largely prevails that fires in virgin timber are comparatively harmless, that lumbermen allow them to run unless they threaten their mills or are likely to spread to "slashings," in dangerous proximity to valuable timber. This, too, in face of the fact that nothing is more noticeable in the Sierra forests that the burned-out bases of many of the finest sugar and yellow pines. Figures obtained in the logging camps of a lumber company in Tehama County, Cal., show that the "long-butting" necessitated by the burns in the base logs amounts to about 4½ per cent. of the total cut, which is a direct loss of this amount. This does not include the loss in high stumps, where the cut is made above the burn, nor allow for the deduction from the actual scale reading in partially burned-out logs, nor for the inferior lumber near the burns, where the heat has hardened the pitch. In addition to this, many trees have burned down or have been thrown by wind as a consequence of the fire.

VIEWS OF LUMBERMEN CONCERNING FOREST FIRES

The general attitude of lumbermen toward forest fires is one of hopelessness, coupled in a measure with indifference. Fires were not unknown prior to the days of settlement, but since the commercial exploitation of the forests began they have increased in number and severity, until now they are regarded as inevitable. Considering the many causes from which forest fires spring, the difficulty of quickly locating and suppressing them in the incipient stages, and the tremendous and often impossible task of stopping a fire when it has gained full headway, it is not to be wondered at that the lumberman has taken rather a hopeless view of the matter. Furthermore, fire-fighting and even crude measures of protection require an outlay which could not have been borne during the earlier lumbering period. There has been, too, an unfulfilled State duty, which has added to the lumberman's burden. Large sums raised by taxes on forest lands have been going into the State treasuries, yet until very recent years no intelligent effort has been made to assist timber owners to protect their holdings. While lumbermen should have done more for themselves, the laws which should have given them encouragement and assistance have been wanting or totally inadequate. The attitude of indifference which has been shown by lumbermen in many instances is far less excusable than their belief in the impossibility of fire protection. Realizing the fire danger, they have deliberately ignored all sides of the question save that of the most temporary, and have taken the best from the land and abandoned the rest to destruction by fires, which often threatened or destroyed the adjoining property of others. The only justification for this has been the economic conditions which have made the suppression of fire incompatible with profitable lumbering.

CHANGED CONDITIONS

Before the awakening to the needs and possibilities of forestry, and when the forests were considered inexhaustible, indifference and inaction when forest fires occurred was not unnatural. These conditions, however, are now of the past. The end of the virgin timber supply is in sight, and the improved tone of the lumber market is enabling lumbermen to dispose of inferior material, and to realize better prices for all grades. These changes are making it profitable for timber owners to cut more conservatively, and to hold their land for future timber production. In pursuing such a policy, fire protection and the systematic disposal of "slash" by methods which will result in the minimum of injury to young growth and seed trees must follow. It is most encouraging that many large lumber concerns, especially in the West, are favoring the adoption of such a policy, and in a few cases are putting it into practice. In short, lumbermen are beginning seriously to consider the advantages of long-continued management of timber lands, in place of the policy of temporary speculative holdings, upon which their operations have hitherto been based. With this change in general management must come an entirely altered sentiment toward forest fires. They can no longer be ignored, but must be intelligently and systematically guarded against.

FIRE PROTECTION ON PRIVATE LANDS

Without adequate fire protection the practice of forestry on private timber lands will not give the desired results. The leaving of seed trees and modified lumbering methods for the purpose of securing natural reproduction, which is liable to ultimate destruction by fire, appeals neither to the lumberman nor to the forester. Even assuming a recognized market value for young growth, there can be little incentive for encouraging or holding it as long as a constant fire menace remains; hence it follows that fire protection is a fundamental necessity in all plans for forest management on private holdings.

Definite plans for fire protection should precede or accompany all working plans for forest lands, and in most cases fire plans alone will give results which will fully justify their application. It is surprising that individual timber owners have done so little for themselves in matters of fire protection, especially in view of the fact that it is largely a local problem, and can be most satisfactorily dealt with as such. Adequate protection is undeniably a complex and difficult task. It is, however, no greater than many of the logging, milling and transportation difficulties which have been successfully surmounted. It has been neglected merely because financial success has not been dependent upon it. The enterprise and ingenuity of American lumbermen is world renowned. For the cheap and rapid manufacture of lumber, cooperage material, etc., they have developed marvellous mechanical devices. But in matters of fire protection they are still little further advanced than were the pioneers of the industry. Indeed, by opening up the forests and leaving large quantities of inflammable debris, they have rather increased the fire danger. As it was fifty years ago, so it is to-day. No attention is paid to fires until they reach dangerous proportions; then they are fought with characteristic American energy. The mills are often shut down, all available men are employed to fight the flames, and the fire is usually controlled, but at great expense. The more rational and business-like and in the end the more economical method, systematic preventive measures and preparation for promptly extinguishing small fires, has seldom been employed.

NEW DEPARTURES IN DEALING WITH THE FIRE PROBLEM

In keeping with the changed conditions already mentioned, the result of which must be to compel a departure from the old methods, made possible by an abundance of timber, there has of late been evinced a growing disposition to introduce fire protection on forest lands. This has taken the form in some cases of actual attempts to prevent fire from running through mature timber, or young growth and to reduce the fire danger by carefully burning "slash." The greatest difficulty at present is lack of knowledge of how to attain these ends.

BURNING SLASH OR REFUSE

Several lumber companies in various regions have attempted to burn the "slash" on cut-over land, but have not developed a wholly successful system. The owner of an enormous tract of virgin timber in Northern California has employed men to rake away the debris from the larger sugar and yellow pines, and to throw fresh dirt into the cavities previously burned in the bases of the trunks. The same plan has been tried on a small area of long-leaf pine near Ocilla, Ga. Such a procedure will give temporary protection from surface fires, but it leaves all young growth open to destruction and does not get at the root of the evil. The idea has hitherto prevailed that in order to burn "slash" successfully the tops must be lopped and the limbs and other debris piled. This has made the process too expensive for general adoption. As to burning "slash" as it lies, it has been proven that by selecting favorable weather conditions and burning in small blocks or broad lines the fires can be easily controlled. Promising clumps of young growth and seed trees will be protected by clearing around them before the fires are started. Under no condition should there be indiscriminate firing of slash, regardless of method, and without competent supervision.

PLAN FOR PROTECTING MATURE TIMBER

On the California timber lands of a large match company, a plan of fire protection, prepared by the Bureau of Forestry, was in operation during the year 1904. The results at the close of the season were very satisfactory. No serious fires occurred, a marked contrast to the record of recent years, prior to the application of the plan. In addition to an annual systematized burning of the slash on the land logged during the year, the plan provides for a system of trails and telephone lines, whereby all fires may be reported and reached promptly, a lookout station at a commanding point of view, a regular patrol during the dry season, the posting of warning notices, the storing of fire-fighting tools at convenient points, and the working up of an anti-fire sentiment among employees and local inhabitants. With the growing desire for fire protection, the general practices here found successful should, with modifications to suit local requirements, find application elsewhere.

THE QUESTION OF SECOND GROWTH

Assuming that the lumberman finds it advisable to protect his mature timber and burn his slash, the question arises, can he afford to protect the young growth on the cut-over land, or to hold the land for the second crop? It is an undeniable fact that young forest growth in general has no sale value, although in the eyes of the forester its prospective value is considerable. (See Fig. 52.) It thus follows that under the present system of taxing forest lands, and in the face of a constant fire danger, there is little encouragement for lumbermen to hold second growth or to invest money in its protection. Despite these discouraging facts, many lumbermen are retaining their cut-over lands and manifest a desire to preserve the second growth. But no active measures to protect it have been taken except in a few cases, such as those just mentioned. It is not so much the uncertainty of returns, as the danger that all will be lost by fire, that prevents the general retention of lands more suitable for timber production than for agriculture.

FOREST FIRES

THEIR CAUSE AND PREVENTION

One of the chief causes of disastrous forest fires (see Fig. 26) lies in the result of protracted drought. The forest becomes inflammable. Thus on cut-over lands the debris left after lumbering is in condition to catch fire like tinder and to spread it almost like a powder magazine. Every chance spark left unextinguished by smoker or camper, every glowing cinder from locomotive or brush-burner's fire, carries the potentiality of a great conflagration. During the season when fishermen and hunters are enjoying their sport, many build camp-fires and smudges in every direction, and proceed on their way without properly extinguishing them. Under such conditions many incipient forest fires are, and always will be inevitable. The only hope of preventing devastation is through systematic watchfulness to extinguish every little blaze before it has time to gather headway. In general these fires burn rapidly, owing to the inflammable condition of the forest. They are either "crown," "surface" or "ground," the type of fire varying with the character of the forest and the strength of the wind. Usually fires begin on the surface, spreading among the leaves and dead branches. Where deep, dry duff is encountered, combustion works to the bottom of the half peaty mass, stealing along, sometimes without much evidence, above ground, possible even days or weeks, later to develop into a "surface" or "crown fire" under favorable conditions. Among conifers, with their inflammable foliage, surface fires frequently mount to the tops of the trees, and thus become "crown fires." This is the most dangerous and unmanageable form of fire, on account of the great surface offered to combustion, and also because of the powerful draft caused by the rising of the heated air, which fans the flames to uncontrollable fury. Such fires travel with remarkable speed. Culpable carelessness is responsible for the largest part of our forest fires, deliberate incendiarism for no small number, and unavoidable accident for a few. Inexcusable negligence and disregard of legal requirements and the rights of adjoining property have been charged against the railroads. Fully one-half of the fires due to carelessness are caused by the locomotive. A good many fires are also set by logging railways. The laws require the equipment of locomotives with spark arresters and the observance of other precautions against fires. Should the railroads be compelled to adopt these safeguards, much loss would be averted. The railroads themselves will be heavy sufferers in the long run from the devastation for which they are so largely responsible. Next to railroads, "fallowing," or the clearing of land, by burning debris left after lumbering, is probably the most prolific source of fires. As usual, many fires are started through the carelessness of smokers. Smudges and camp-fires imperfectly extinguished cause their full share of damage. The forms of neglect or carelessness outlined above are responsible for a very large percentage of damage done.

METHODS OF FIGHTING SAME

The most effective fighting against forest fires can be done from daybreak until about nine o'clock in the morning. The fires are usually much deadened at this time of day, and the fighters should take advantage of this fact, resting or acting chiefly on the defensive in the middle of the day, and renewing the attack toward evening, when the fires again lose some of their aggressiveness. Surface fires can be checked by raking away the litter on the forest floor in a path a few feet wide, which serves as a line of defense from which the fire can be fought back as it approaches. Where water can be obtained the path should be thoroughly wet down. Shovelfuls of sand dashed upon the blazing wood will also have a deadening effect, and burning grass in the clearings can be thrashed out with the bushy top of a young spruce or balsam, or a few furrows should be turned with a plough across the track of the fire. Usually the presence of duff makes it necessary to dig a trench from one to four feet wide down to the mineral soil, and completely encircling the fire. The roots should be cut through with axes and mattocks, and the mass of peaty material chopped up and shovelled out and sand or dirt heaped against the outer side of the trench, to protect the duff from sparks and heat. When the fire burns through the inner side, where these methods fail or cannot be used, back-firing should be resorted to. Trenches should be dug from two to four feet wide, and the fire applied to the side next the forest fire. If the trenches can be defended successfully for a short time, the fires thus set will burn a distance back from the trench, thus clearing away much of the combustible matter and robbing the conflagration of its energy when the two lines of fire meet. This is a very effective method of fighting forest fires, but extreme caution is necessary in its use.

SECTION IV

SAWS

SAWS

GENERAL SAW INSTRUCTIONS

The successful fitting of saws is directly dependent upon these two essentials: a well-equipped filing room and a capable saw-filer, possessed of a moderate amount of "horse sense" in charge of it. Saws do not run or fit themselves, and they require the proper amount of care and attention in order that they may produce a maximum quantity and improved quality of output on a minimum saw kerf. Therefore, it is an unwise economy that does not provide both essentials. And the most successful mill and factory operators of to-day consider it good practice and a profitable investment to supply every tool or appliance calculated to facilitate the filer's work.

Every operator of a cooperage plant has more or less of a substantial investment in factory and saws. His profits depend largely upon his finished product being well manufactured and with the least amount of waste possible. This cannot be accomplished unless his sawing equipment receives constant care and attention. He spends money for saws which for some operators run finely and last for years, until worn out, while for others they run indifferently and only last for as many weeks, when they are utterly worthless from cracks or other defective conditions, caused by lack of proper care and in some instances by gross carelessness; and the product turned out is of an indifferent quality, while the percentage of waste is enormous. This is probably the suggestion of "no swage," "no sharpener," "irregular tensioning," etc.; or if such tools are in use, they are indifferently used, are defective, out of repair, or inefficient in operation. It is manifestly true that not all mill men can carry on their business with equal success and profit, but it is a self-evident truth to the well-informed that the best results obtainable from saws are contingent upon their being properly sharpened, swaged, tensioned, etc.; results which are obtainable only by close attention to details in the operation of fitting a saw for its particular duty.

SAW-FITTING NOT A MYSTERIOUS PROCESS

After all, saw-fitting is a work in which the little things count more than anything else, and the artistic work on the part of the saw is due more to the amount of attention given to all the little points in gumming, filing, etc., than to any mysterious superiority in skill. It is superiority in a way, of course, but it is simply thorough exercise of care and intelligence in one's duty. There is nothing in the way of mystery in the art of saw-fitting nor about a saw, either. Every subject is comparatively easy of analysis and every fault has a cure, and most of them will disappear themselves if enough attention is given to gumming each tooth alike and in making every tooth cut exactly like the preceding one. Any man who has seen a reasonable amount of service in and around a stave or heading mill; who has labored conscientiously and made good use of the "gray matter" he has been endowed with during such service; who can recognize well-manufactured stock when he sees it, and is possessed of a reasonable amount of skill in the handling of tools, and with intelligence enough to be entrusted with the care of saws, can turn out a good, satisfactory job of saw-filing if he will only use fair judgment and take the pains to follow up these details connected with his work. One of the most important points in connection with effective saw-fitting, no matter whether it is cylinder, pendulum, or any other kind of saw, is to keep the teeth at the same width, and the throats or gullets of the same uniform depth, so that the saw is in perfect running balance. The higher the speed of the saw, the more important this matter of balance becomes, and it is always of more consequence than the average saw-filer gives it credit for being.

Quite frequently a saw may run badly, shake and tremble, and jerk in the cut, doing its work unevenly, so that it leaves heavy ridges on the stock and makes a waste of timber, when the main trouble is lack of balance. The heavier the saw, the less likelihood there is of its growing shaky when it is only a little out of balance, but with the modern tendency to operate thin saws in order to lessen the waste in saw kerf, and the general disposition to run them at high speed, it becomes imperative to have them perfectly balanced. The trouble is the average saw-filer does not realize that a little difference in gumming or a little difference in the width of the teeth may affect the balance of the saw. When one gets down to the real art of saw-filing, it is not so much a matter of that peculiar style of tooth or of getting the teeth so that they will cut, but it occurs to us that the important thing, after all, is to get them to cut smoothly. This they will not do, of course, if the saw is out of balance; but that is only one defect, and there are many others. Too much time is often wasted in the study of design of the tooth, and not enough given to close attention in making each tooth cut exactly like the preceding one, so that the work is smooth and regular.

FILING-ROOM EQUIPMENT

The ideas of mill men and saw-filers differ as to what machines and tools comprise an efficient filing-room outfit, and we consider that in order to make this work complete, it will be necessary to give a list of the several tools, machines, and appliances that are deemed in practice by

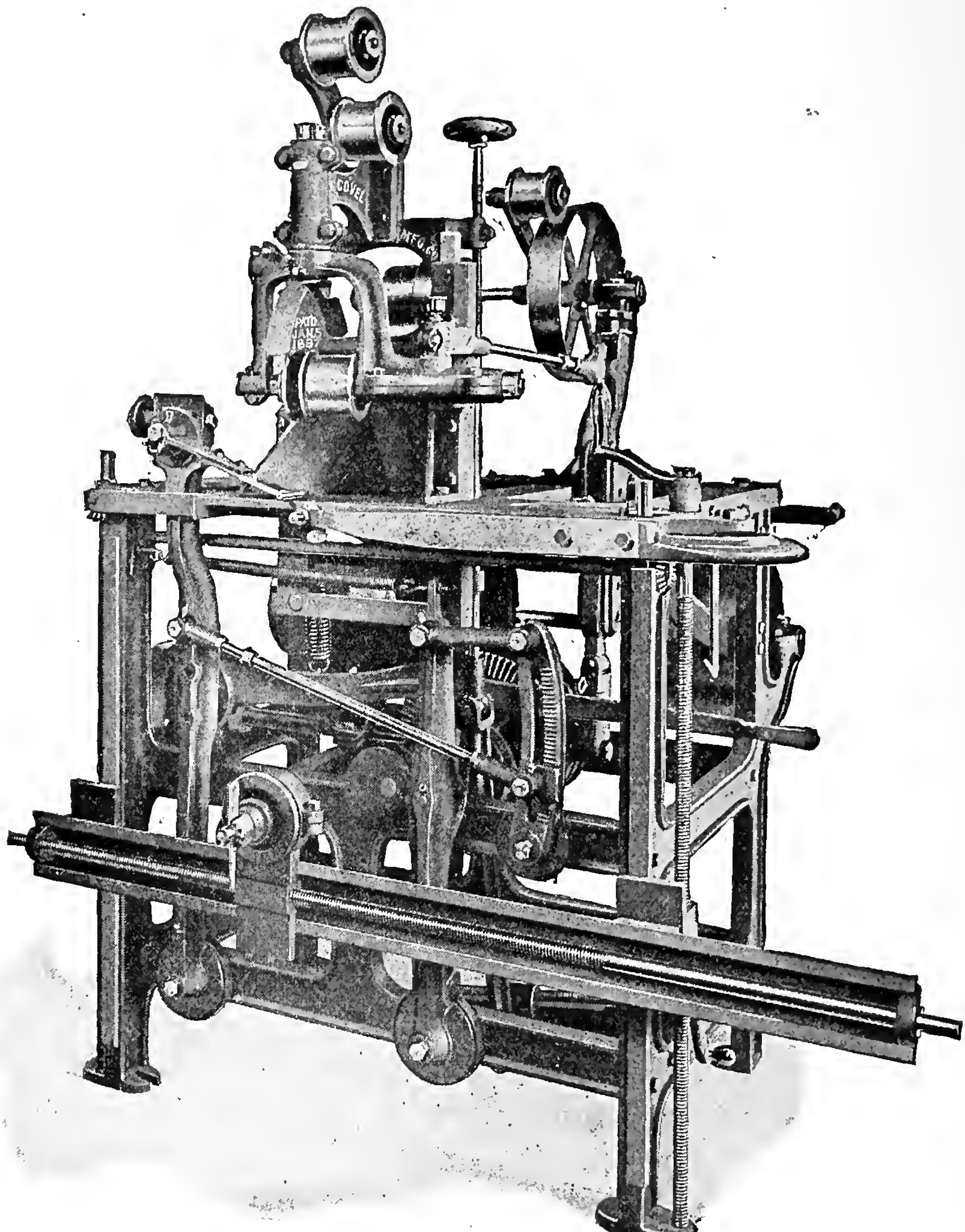


FIG. 28. AUTOMATIC SAW SHARPENER.

the well informed to be necessary or desirable for the different processes through which a saw must pass before it would be considered properly fitted for its particular duty. This list as given comprises an outfit that will please the most critical, and provides a machine or tool for each and every service so far as conceived to date.

FOR SHARPENING OR GUMMING CIRCULARS

An automatic sharpener (Fig. 28) of suitable capacity and of such construction that the teeth are sharpened and kept of the same shape and size throughout, the gate to be so inclined that the emery wheel will drop to the

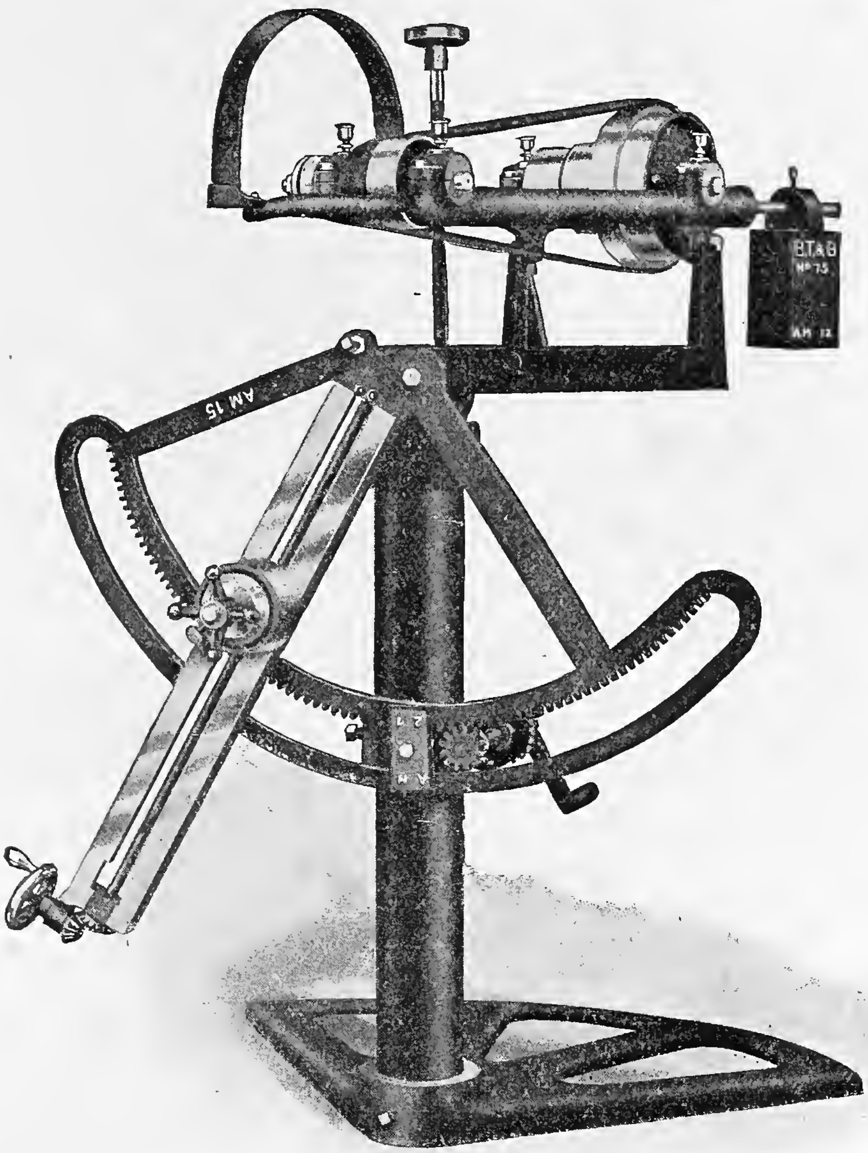


FIG. 29. HAND SHARPENER AND GUMMER.

throat of each tooth. In this manner it avoids burning or case-hardening the points of the teeth. Saws sharpened on an automatic sharpener of this kind will do more work with better results than saws sharpened by hand, with a big saving in files, as emery wheels cost but little compared with hand files. Another excellent machine for sharpening and gumming is shown in Fig. 29, where an automatic machine would be found too expensive or the small number of saws operated would not justify the purchase of an expensive automatic sharpener. This hand sharpener is adjustable, and when in the hands of a capable saw-filer produces excellent results. Of course, more of the saw-filer's time is required in operating a machine of this type. If an automatic sharpener were installed, he would find more time to perform other duties, which probably would be to a better advantage in the long run. This hand gummer also has an attachment whereby planer knives up to twenty-six inches in length may be ground.

FOR SWAGING

An up-to-date and adjustable hand swage of the eccentric type, one that is suitable for circular saws and when in operation does not pinch off the points of the saw teeth, and with the proper adjustment, so that any shaped tooth or any gauge saw desired can be swaged. (See Fig. 30.) The use of a machine swage on all large rip saws is indispensable, and a more general introduction of such a tool for swaging small factory saws would afford results far superior to hand swaging, or the mixed use of swage and spring-set, or the use of spring-set only. Mill men and all users of large or small rip saws are now realizing more than ever the great benefits derived by using on their saws a good swage, instead of the old method of using the spring-set or the upset. Swages are now adapted to all sizes and gauges of circular saws, and to all ordinary shapes of teeth. Their work is rapid and is vastly superior to the upset or spring-set, as it makes a better corner, keeps the saw in round, and affords a sharp, keen cutting tooth that requires but little dress-

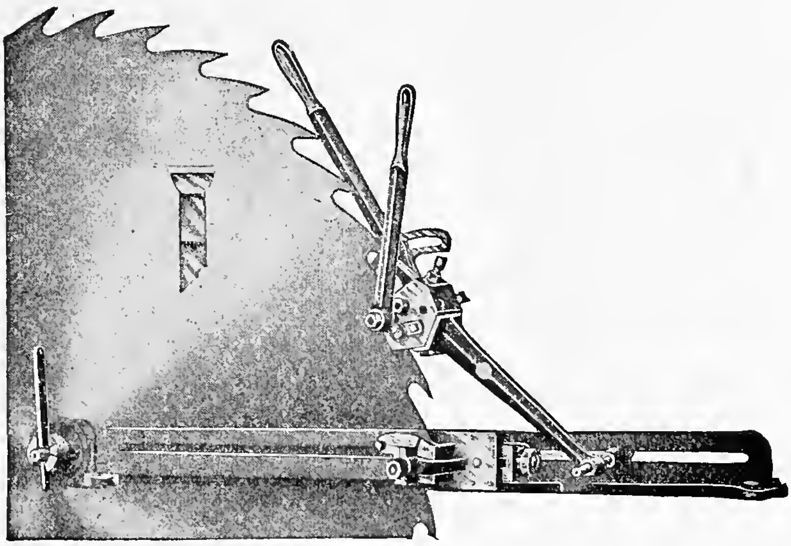


FIG. 30. ADJUSTABLE HAND SWAGE.

ing with emery wheel or file to bring it to a perfect point. A properly swaged saw of any kind will do more and better work and take less power to operate than one fitted with a spring-set, an upset, or with a combined swage and spring-set.

Also an assortment of "upset swages" and a swage bar and hammer, which, though not recommended by modern mill men, may on especial occasions be supplemented.

FOR SIDE DRESSING

A swage shaper or pressure dressing tool (Fig. 31), although as yet not so generally used in the cooperage trade, is now considered as a necessary and indispensable tool by all practical men who are interested in securing the best results in the operation of their circular saws.

Expert saw-filers are coming more and more to use the swage shaper wholly for side-dressing purposes, and while a side file may be used by some with satisfactory results on saws of 12 to 16 gauge, the side file will not do for light-gauged saws. The tool is used similarly to an eccentric hand swage, resting over point of tooth and operated by the lever, to force the side-dressing dies together. This tool completes the work of the swage, and by its use the swaged tooth may be pressed into perfect and uniform shape. A pair of dies press upon the sides of the swaged tooth, compressing the swaging to any desired set or spread, and tapering the tooth downward and backward from the point, making a perfect clearance, with face and point always the widest. This is an ideal way to side-dress a saw tooth, and saves the steel instead of filing it away, as with the side file. It is well worth while to aim for the best results in saw-fitting, and with the use of a swage and swage shaper you will have fewer bad cuts, smoother stock, fewer saws will come off, and less work in hammering and tensioning. Perfect swaging and side-dressing suggest a minimum saw kerf, smoother stock and a reduction in power.

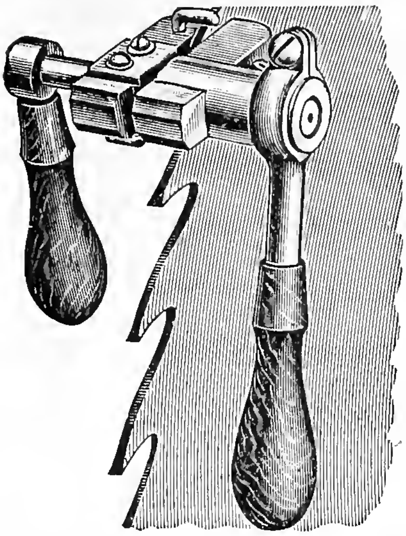


Fig. 31. Side Dresser or Swage Shaper.

FOR HAMMERING AND ADJUSTING

Saws periodically require tensioning. Even the smaller equalizer saws used in stave mills should at times receive this attention in order to secure the best results. For this process is required a round-face and a cross-face hammer, weighing from 2 to 3½ pounds, an iron levelling block or try mandrel, 14 x 72 x 5 inches or smaller, surfaced both sides to permit of reversing, a steel-faced anvil, 14 x 24 x 5 inches or smaller, two steel straightedges, one from 14 to 18 inches long, and one about 48 or 50 inches long, and a tension gauge. These comprise the necessary tools for hammering and adjusting circular saws. (See Fig. 32.)

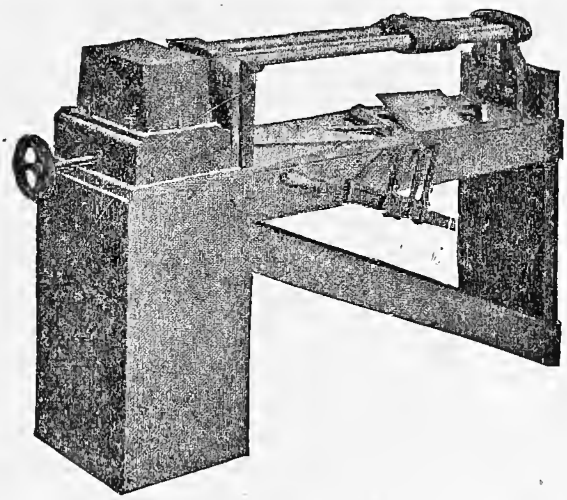


Fig. 32. Tools for Hammering, etc.

FOR SETTING

Where spring-set is used, a circular saw set as shown in Fig. 33 is desirable. It should be adjustable and arranged to take in any size saw, up to, say, 48 inches.

Fig. 33. Circular Saw Set.

This type of saw set is superior to the hand sets so much in use by the trade, and illustrated in Fig. 34. As this type of saw set insures an even amount of set in the teeth, which is of considerable importance, in that it does not weaken the teeth, and is desirable in order to secure a more uniform setting and better results. In conjunction with the above, a setting or striking hammer is necessary. One that does not weigh more than three-quarters to one pound is desirable. A saw gauge (Fig. 35) is also necessary where the hand sets (Fig. 34) are used. There are innumerable types of these gauges in

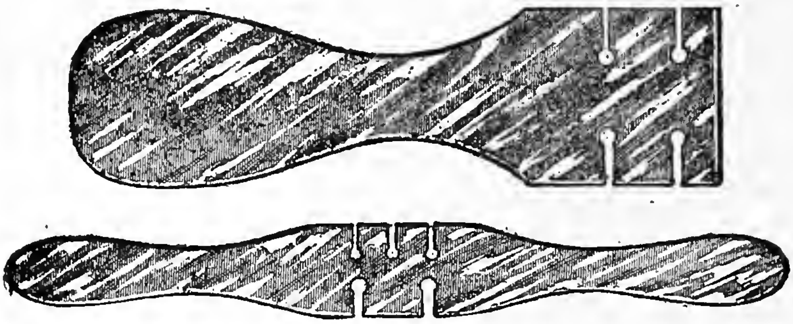


Fig. 34. Hand Saw Set.

use, a great variety of them being made by saw-filers themselves. Some are constructed of wood, others of iron, but the one illustrated is considered by many as the best. Another useful tool in the setting of small saws, particularly the concave heading saws, is a type styled Monarch Patent saw set, which is an extremely simple and inexpensive tool, and very effective in its work. There should also be included in the filing-room equipment a bench vise or saw clamp (Fig. 37) and an emery-wheel dresser.

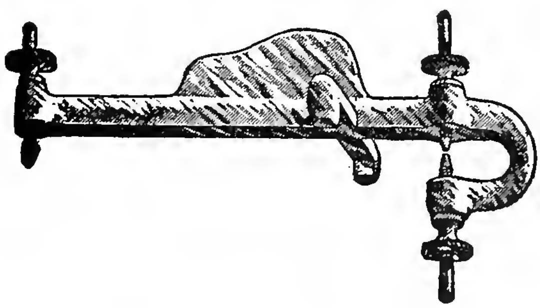


Fig. 35. Saw Gauge.

FOR GUMMING AND SHARPENING DRUM OR CYLINDER SAWS

An extremely useful and very economical tool for use where there are one or more cylinder stave saws in operation is shown in Fig. 38, which is very simple in construction, effective and extremely economical, when compared to labor saved and the cost of hand files. These gummers are adjustable, being so constructed that they can be raised or lowered, as the case may be, and the emery wheel used at any desired angle while the gummer is in use, and are considered a necessary and indispensable tool by all practical men of the trade.

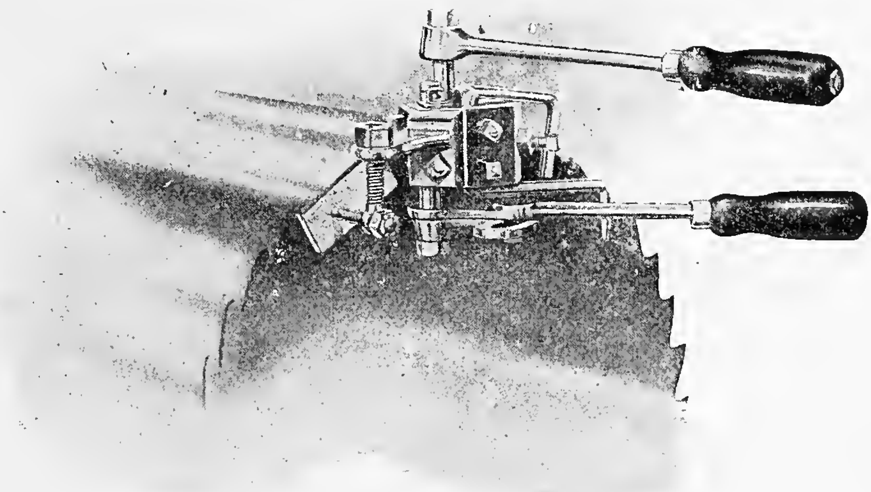


Fig. 36. Cylinder Saw Swage.

FOR SWAGING DRUM OR CYLINDER STAVE SAWS

The swaging of cylinder stave saws has until recent years been looked upon with more or less doubt and suspicion, from the fact that the first tool placed upon the market for this purpose did not quite come up to its requirements; but since other and improved types (Fig. 36) have appeared. The prejudice formerly existing has gradually disappeared. In justice to this tool or this method of sharpening saws, it must be said that cylinder saws can, and are, being swaged just as successfully as band or circular saws, and manufacturers who aim toward economy will do well to include this tool in their filing-room equipment, as they are long past the experimental stage, and are being used successfully by the leading man-

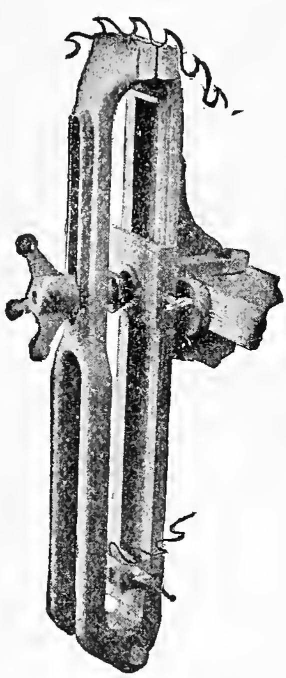


Fig. 37. Bench Vise or Clamp.

ufacturers. In swaging cylinder saws, the saw must be gummed by the emery wheel, gauged for spread of tooth, and side-dressed, the same as ordinary circular saws. In the process of swaging, the teeth are drawn out, refining the steel, which produces a better cutting edge, that is more easily kept sharp. And also by the use of the swage, instead of the old method of spring-set, a thinner gauge saw may be used, which means less saw kerf, and less kerf means less power, and that in its turn spells economy. There are other little advantages and economies besides these in using the swage, such as smoother stock, less files, with less skill to a certain degree in sharpening.

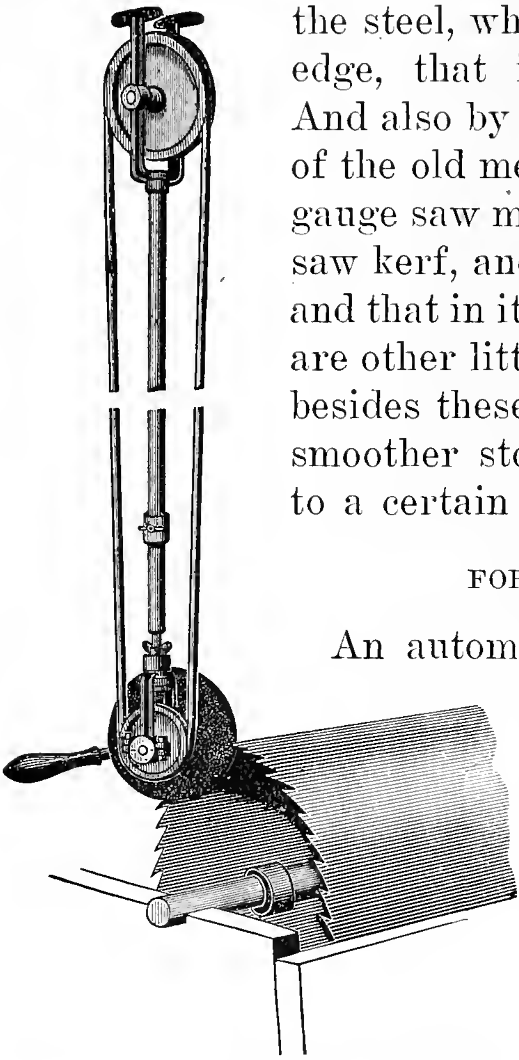


Fig. 38. Cylinder Saw Gummer or Sharpener.

FOR KNIFE-SHARPENING

An automatic knife grinder or sharpener (Fig. 39) is now considered by all successful and modern mill operators as an indispensable tool in the proper equipment of the grinding room. These machines have been so perfected that they are no longer considered as an experiment, but as effective and economical grinders. The machine as shown is adapted to automatically grind the face of circle stave knives of any length. See detail sketch (Figs. 40, 41, 42 and 43) showing the possible grinding of straight or circle knives, which are far superior to hand grinding or filing. A knife-balancing scales (Fig. 39½) should also be included among the grinding- room outfit.

Otherwise the proper balancing of the knives, so essential to the successful operation of the different high-

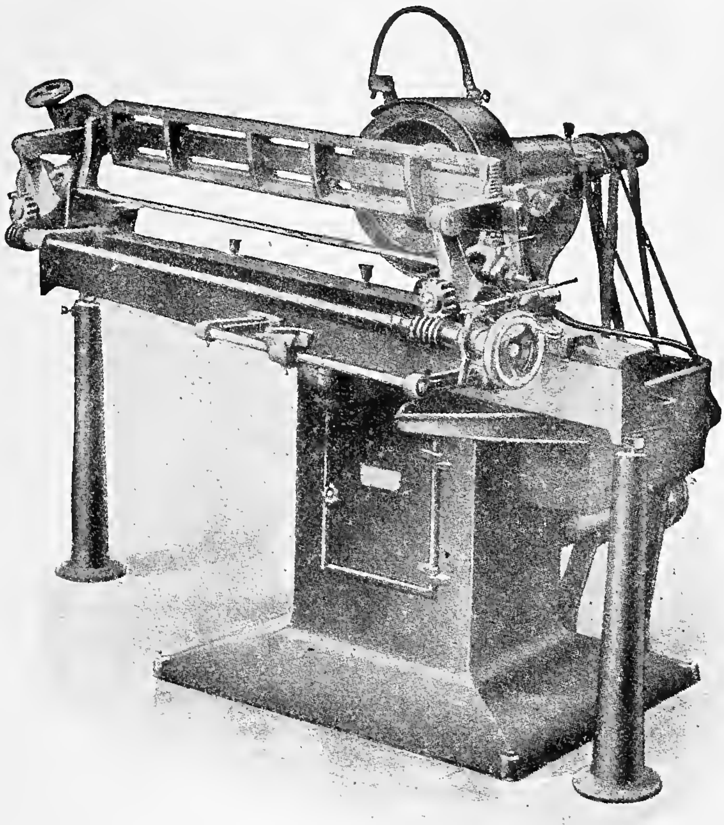


FIG. 39. AUTOMATIC KNIFE SHARPENER OR GRINDER.

speed machines, is an impossibility. It is hardly possible to realize what one ounce of misplaced weight

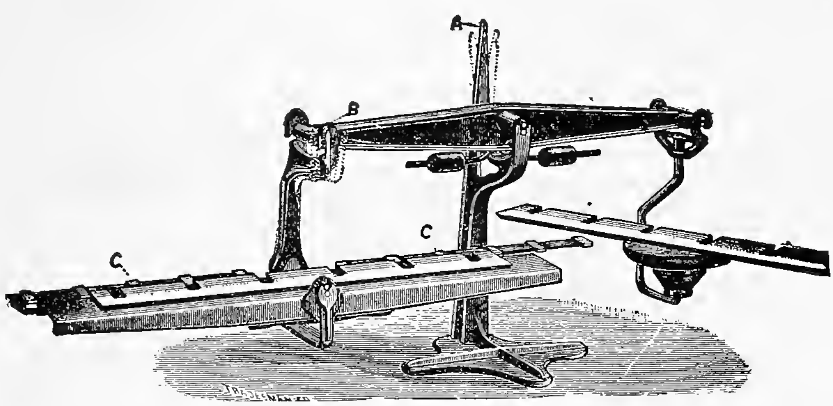


FIG. 39½. KNIFE BALANCING SCALES.

means in a knife. Suppose a pair of knives are of the same weight, knife No. 1 being correct in balance, both ends weighing the same. But the right end of knife No. 2 weighs one ounce more than the right end of knife No. 1. When revolving on a four-inch cylinder at 4,000 revolutions per minute, this ounce exerts a pull

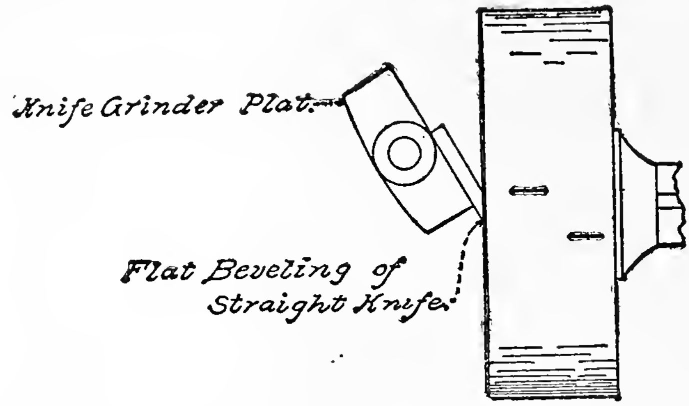


FIG. 40. DETAIL SKETCH OF STRAIGHT BEVEL GRINDING OF KNIFE.

of about 58 pounds, and this is forced through its course 4,000 times a minute, up and down, back and forward.

Is it any wonder that these little defects in rapidly revolving cylinders sometimes cause a whole building to feel

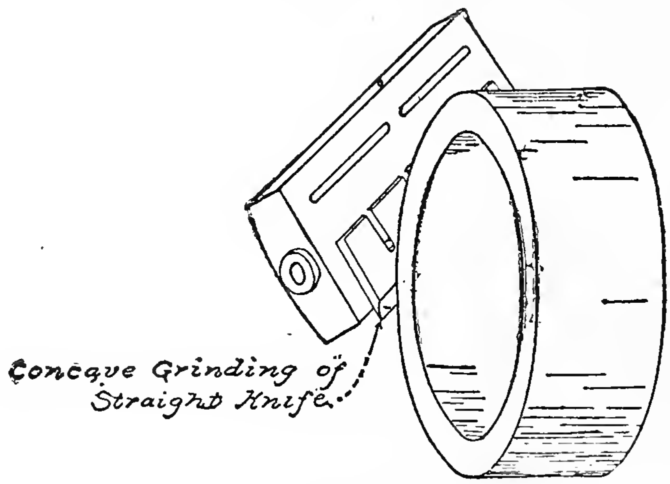


FIG. 41. DETAIL SKETCH OF CONCAVE BEVEL GRINDING OF KNIFE.

the motion? But this is not all. As both knives are of equal weight, the left end of knife No. 2 must weigh one ounce less than the same end of knife No. 1. Then, while revolving, one end of the cylinder is thrown up, the other end is thrown down, producing a vibratory motion, and this practically doubles the defect. Thus the necessity of balancing the ends of the knife, as well as the knife

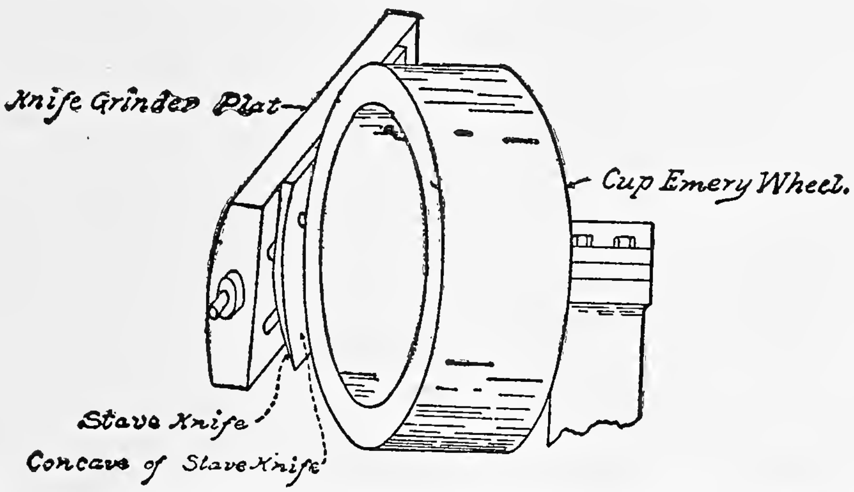


FIG. 42. DETAIL SKETCH OF CONCAVE GRINDING OF STAVE CUTTER KNIFE.

itself, is very plainly seen. Knives out of balance not only produce poor quality of work, but subject the machine upon which they travel to a tremendous strain, and

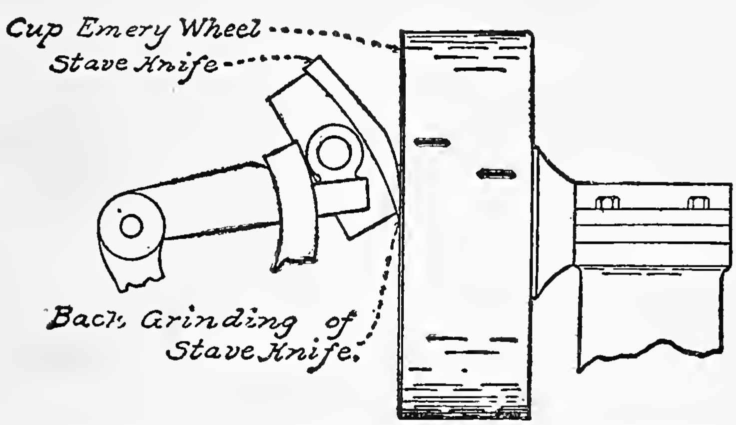


FIG. 43. DETAIL SKETCH OF BACK GRINDING OF STAVE CUTTER KNIFE.

cause the knife cylinder to rattle and the bearings to heat and wear rapidly, which necessitates extra labor in re-babbitting and unnecessary expense in the cost of babbitt metal, not mentioning the probable time lost by employees, through the machine not being in proper repair.

FOR GENERAL USE

All filing or grinding-room outfits should include among their list an emery-wheel grinder for general use, as these simple and inexpensive machines easily prove their economical value by their great saving in cost of files and labor, and can be generally used for almost any purpose where filing is necessary.

SOME CAUSES OF POOR RESULTS IN SAWS

1. Attempting to run too long without sharpening.
2. Irregular and shallow gullets.
3. Uneven setting and filing.
4. Not enough set for proper clearance.
5. Backs of teeth too high for clearance.
6. Too much pitch or hook on teeth.
7. Out of round, and consequently out of balance.
8. Ill-fitting mandrel and pinholes.
9. Collars not large enough in diameter.
10. Weak and imperfect collars.
11. Insufficient power to maintain regular speed.
12. Too thin a saw for the class of work required.
13. Not enough or too many teeth.
14. A sprung mandrel or lost motion in mandrel boxes.
15. Heating of journal next to saw.
16. Carriage not properly aligned with saw.

THE PROPER CARE OF SAWS

One of the most general causes of trouble with saws of all kinds is the first item on the list, "Attempting to run too long without sharpening." The points of the saw teeth are the only parts of the saw that should come in contact with the timber. They should be kept sharp by the frequent use of the file or sharpener, and set by springing, swaging, or spreading when necessary sufficiently to clear the blade of the saw nicely to prevent friction. As the points of the teeth do all the work, they become dull and round, the sides of the points wearing away as well as the points themselves. If there is "only" one corner off, and that corner leaves a ridge, it would have practically the same effect on the saw blade in passing as if all the teeth had corners broken or worn off; and heating will develop unless the saw is set wide, which means unnecessary waste of power and of timber. On the other hand, if one corner is a little longer than the others, leaving a groove instead of a ridge in the face of the work, it does not interfere with the saw blade; but the surface of the stock cut, in order to be smooth when planed, will necessarily have to be cut down to whatever depth that groove extends below the face, and that means an unnecessary waste of just that much timber; so in either case it is imperfect fitting or negligence of one's duty that creates a monetary loss, which could have been prevented by the proper amount of care and attention. When a thin saw is used, with the object of saving timber by lessening the saw kerf, a long or short corner on a tooth makes it necessary to waste it and sometimes more at the planer. Therefore, it is more economical to sharpen the saw before it has become dull and round pointed. Great care should also be taken to maintain the proper shape of the points of the teeth. This can be readily accomplished when necessary by the frequent use of the machine or hand swage, or by the hand file, as the case may be. The gullets or sawdust chambers of the saw teeth should under no circumstances be filed square, and this rule should be applied to the small saws as well as the larger ones. They should in all cases be kept rounded out either by the use of the saw gummer or file. A saw tooth becomes dull on the side or under the point in proportion to the amount of feed. For instance, if the tooth takes one-sixteenth of an inch hold at each revolution, it will become dull to a depth of one-sixteenth of an inch below the point, or more or less as you increase or decrease the amount of feed. A few moments' filing two or three times a day will save much of the time and labor otherwise expended in running a dull saw, and effect a saving in the power consumed, increase the output, and materially improve the quality of the manufactured product. The square corners in the gullet or sawdust chamber is another of the most frequent causes of poor results in saws, which should be guarded against, as they are very liable to cause cracks to appear, particularly when the teeth are dull or during frosty weather.

SAWS OUT OF ROUND

The cutting of a circular or any other saw should be continuous, consequently the saw must be perfectly round to produce the best results. No saw can reasonably be expected to perform good work if it is out of round and consequently out of balance. When a saw has long and short teeth it naturally follows that the longest teeth will do the most work. This throws the heaviest strain on that part of the saw, instead of distributing it equally around the entire circumference. It is fully as important that saws be kept perfectly round as it is that they should be kept well swaged and sharpened. It is a comparatively easy matter to keep saws round with automatic machinery, but it requires considerably more skill to keep them round simply by the action of sharpening with a hand file. All filers should "joint" their saws frequently. In swage-set saws always "joint" after a fresh swaging by holding a piece of an old emery wheel against the teeth while it revolves slowly, thus reducing the teeth to a common length. Then file them again to a keen cutting edge. Keep the saw round, well set and nicely balanced.

SHARPENING AND GUMMING

In sharpening or gumming saws with emery wheels, always use a good free-cutting wheel and never put so much pressure on it or crowd it so fast that the teeth are heated to such an extent that they become blued or case-hardened by the emery wheel. They are liable to break or crumble when in the cut or the next time they are swaged or set with the spring-set. Joint or true the emery wheel occasionally to retain the proper shape of its face, which should be kept round, and to remove the glaze. When gumming, it is always best to gum around the saw several times, instead of finishing each tooth at one operation, for by this method they are less liable to case-harden or blue, and a more uniform gullet or sawdust chamber is obtained. Keep the teeth of the same width, and the throats or gullets of the same uniform depth, so that the saw will be in perfect running balance. After gumming it is advisable to file all around the saw, taking care to remove the fash or burr left on the edges and all the glazed or hard spots caused by the emery wheel. Gumming and sharpening a saw with an emery wheel, especially if you attempt to crowd the work, will have a tendency to cause the saw to "let down" or lose its tension much quicker than by the use of the hand file, as it heats and expands the rim of the saw, putting it in the shape generally termed by mill men "buckled," which makes it appear loose and limber. Many saws are condemned just from this cause and thrown aside as worn out, when by proper work in hammering they can be made as good as new again.

FITTING AND SWAGING

See that the saw slips up freely to fast collar and hangs straight and plumb when tightened up; that the saw mandrel is level and has no end play or lateral motion, as the grain of the wood will push or draw the mandrel endwise no matter how well the saw is kept. Keep the saw sharp, round and swaged or set enough for clearance. An extreme amount of set or swaging, notwithstanding the injudicious waste of timber, increases the tensile strain and also has a tendency to make the saw tremble. The proper amount of set or swaging varies according to the class of timber being cut, hardwoods requiring the least amount of set, and soft or fibrous woods requiring more. The amount of clearance required also depends on the gauge of the saw. In the usual gauges of large circular saws, say, 8, 9 and 10 gauge, a clearance of $\frac{3}{32}$ of an inch equally divided, is about "as little" clearance as should be run, except in hardwoods and frozen timber; then less may be used. In smaller saws, a clearance of "four" to "five gauges" is usually considered sufficient by most filers, and few make a greater distinction than "one" gauge of set, as between hardwoods and softwoods, the hardwoods requiring less. Keep the extreme point of the tooth the widest, and do all the filing or gumming on the under or front side of the tooth, always filing square across the teeth. Never file square corners in the gullets of the saw teeth of any kind, as this renders them liable to break. When there is occasion to swage or upset the teeth of the saw, the proper method is to file them all to a sharp point first, then swage afterward, as this will not only save time, but will save the saw, for the sharper the teeth, the more easily will they swage or upset. Always endeavor to keep the teeth in the same shape they were when new, filing them to a uniform depth and width and with the same amount of rake, for, should they lose any of their hook or rake or sawdust chamber, the saw will not only consume more power, but be harder to keep in order, as well as turn out inferior work, and consequently cause considerable waste of timber. Keep the saws well balanced, round and the gullets or throats well gummed out.

LEAD OF SAWS

The amount of lead required for circular saws should be the least amount that is possible in order to keep the saw in the cut and prevent it from heating at the centre. If the lead into the cut is too great, the saw will heat on the rim; if the lead out of the cut is too much, the saw will heat at the centre. However, we will take this matter up with the individual saws further on in this work.

NUMBER AND STYLE OF TOOTH

The style, shape and number of teeth in saws depend entirely upon its diameter, gauge, the purpose for which the saw is to be used, and the class of timber to be cut. The amount of hook, depth, size, and shape of the sawdust chamber or gullet also play an important part in the working and success of the saw. A long tooth has the demerit of being weak and liable to spring. But it also has the merit of giving a greater clearance to the sawdust chamber. The throat space in front of each tooth must be large enough to contain the sawdust produced by that tooth in each revolution. And the greater the feed, the larger or deeper it must be in order to fulfil its mission, or the more teeth required. If a saw is lacking in the proper amount of hook or the teeth are nearly straight on the face, they will scrape instead of cut, and will soon become dull. This produces no end of trouble in itself, for the teeth will cut hard, and it will require double the amount of power to force the saw through the cut. The severe strain on the teeth when in this dull condition causes them to tremble in the cut, producing a tremulous strain on the saw plate that calls for more tension. And this severe strain on the teeth and at the bottom of the gullets, and especially so if the teeth are long, tends to crack the plate at this point and breaks out the teeth. Although the saw may have tension enough under ordinary conditions, the circumstances referred to above so strain and stretch the edge while the saw is at work that "more" tension is required to guard against the saw running snaky. Considering the elasticity of the steel, it is reasonable to concede that anything that tends to pull or strain the plate will stretch it, and the more it stretches, the more tension is required to enable it to stand up to its work. And it has been fully demonstrated that an extreme amount of tension tends to throw too heavy a strain on the edge of the plate, and eventually it will cause the saw to crack at the gullets. A great many saw filers when their saws get into this condition, instead of adding a little more hook to the teeth and making a good, large, round gullet or sawdust chamber, give the saw "more tension" to overcome this trouble, which might have been remedied otherwise, and is a grave mistake, and will eventually lead to more and greater difficulties.

CIRCULAR RIPSAWS

The standard amount of hook or rake generally given large ripsaws, and which is usually considered "the limit" or "the least" amount that a saw should have to enable it to run successfully and stand up to its work has been found to conform to the following rule: The pitch line of tooth must be tangent to a circle whose diameter is one-half that of the saw. Although this pitch line of tooth is usually considered "standard," a saw will do equally as well with a little more than this. In cases where a spring-set is used on large ripsaws, it is always considered practical to have a larger number of teeth than if the saws were fitted with a full swage set. And, again, it should always be remembered that thin-gauge saws also require a larger number of teeth than saws of a heavier gauge, to do the same class of sawing, as this equalizes the strain on the rim, as well as prevents springing of the teeth. It has been also found advisable, whether rip-saws are fitted with spring or swage set always to file straight across in front and back of the teeth, as a bevelled tooth has a tendency to split the fibres of the wood, instead of cutting it off squarely across, and produces a lateral motion, which causes the teeth to chatter and vibrate in the cut. Many saws are cracked from this cause, although it has been frequently stated that cotton-wood and gum, especially the former, is the most difficult of woods to cut, on account of its fibrous and stringy nature, and that in order to saw this class of timber successfully the saw teeth should be set with a full spring-set, and the points "bevelled" and sharpened to almost a needle point. This wrinkle may be worth trying out. In order to determine the number of teeth required in a saw, it is first necessary to find out the amount of feed the saw is to run on, and if the feed is four inches to every revolution, it is considered standard to have one and one-half tooth for every inch of the diameter of the saw. In other words, if a saw is working on a 4-inch feed, and it is desired to operate a 50-inch saw, it will be necessary to have 75 teeth, and for every additional "inch of feed" carried add 10 teeth; that is, for a 50-inch saw with 5-inch feed 85 teeth, 6-inch feed 95 teeth, and so on, increasing the number of teeth in a slightly less proportion up to any desired amount of "feed." Where the feed is less than four inches the same rule may be applied by reducing the number of teeth in proportion to the reduction in feed. The above rule applies only to the regular gauges used, say, 10 to 16 gauge. Heavier gauge saws require less teeth. This rule applies particularly to saws cutting soft and fibrous timber. For hardwood or frozen timber, where there is sufficient power to maintain a uniform speed, the same rule may be applied. But in mills where the power is limited and of an uneven speed, it is not good policy to have more than one tooth to every inch of the diameter of the saw, as the fewer teeth there are in a saw, the less power it requires to drive it.

THE STANDARD NUMBER OF TEETH IN CIRCULAR RIP SAWS

Diam. Inch	No. Teeth	Diam. Inch	No. Teeth	Diam. Inch	No. Teeth	Heading Saws	
						Diam. Inch	No. Teeth
4	38 to 40	24	34 to 36	50	50 to 70	40	60 to 80
5	38 to 40	26	32 to 34	52	52 to 80	42	60 to 80
6	38 to 40	28	32 to 34	54	54 to 80	44	72 to 90
7	38 to 40	30	32 to 34	56	56 to 90	46	72 to 90
8	38 to 40	32	32 to 34	58	58 to 90	48	80 to 100
9	36 to 38	34	32 to 34	60	60 to 100	50	80 to 100
10	36 to 38	36	34 to 38	62	60 to 100	52	80 to 100
12	36 to 38	38	34 to 33	64	60 to 100	54	84 to 110
14	36 to 38	40	36 to 40	66	72 to 100		
16	36 to 38	42	36 to 40	68	80 to 100		
18	34 to 36	44	36 to 40	70	90 to 100		
20	34 to 36	46	36 to 40	72	90 to 100		
22	34 to 36	48	48 to 60				

CUT-OFF OR CROSS-CUT SAWS

Cut-off saws differ from ripsaws only in the shape of their teeth and the manner of filing or dressing them. The amount of hook necessary for such saws cutting soft or fibrous woods, and which is usually considered most satisfactory, is that the line of pitch on teeth should run through the centre of mandrel hole; and for cutting hardwoods, the amount of hook or pitch is always a little less. The bevel on cross-cut saw teeth should never extend into the gullets or sawdust chamber, in fact, "only" the "points" of the teeth need bevelling. The remainder of the tooth and gullet should be dressed straight across. In heavy cutting the front of the tooth should be filed with "very little" or no bevel. Many saw-filers have adopted the method of filing every seventh tooth square, front and back. This is considered good practice, as it removes the core or V from the kerf and prevents much of the lateral strain. These teeth should be just a trifle shorter than the ones that are bevelled. When sawing very hard or kiln-dried hardwood, it is always considered advisable to use a narrower gullet and a stouter tooth than when cutting green or fresh timber.

STANDARD NUMBER OF TEETH IN CROSS-CUT SAWS

Diam. Inch	No. Teeth	Diam. Inch	No. Teeth	Diam. Inch	No. Teeth	Diam. Inch	No. Teeth
4	100 to 120	18	80 to 90	38	80 to 100	56	90 to 120
5	100 to 120	20	80 to 90	40	80 to 100	58	90 to 120
6	100 to 120	22	72 to 80	42	80 to 100	60	90 to 120
7	100 to 120	24	72 to 80	44	80 to 100	62	100 to 140
8	100 to 120	26	72 to 80	46	80 to 100	64	100 to 140
9	90 to 110	28	72 to 80	48	80 to 100	66	100 to 140
10	90 to 110	30	80 to 90	50	80 to 100	68	100 to 160
12	90 to 100	32	80 to 90	52	80 to 100	70	100 to 160
14	90 to 100	34	80 to 90	54	90 to 120	72	100 to 160
16	80 to 90	36	80 to 90				

COLLARS FOR SAWS

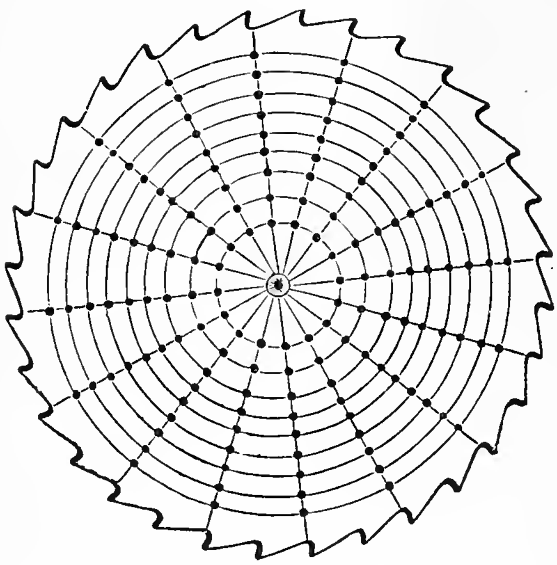
For a perfect-running saw, it is indispensable to have collars and stem of mandrel true and well fitting; any imperfection in these points is multiplied as many times as the saw is larger than the collar. They should be a perfect fit. For large saws, collars should be used that have a perfect bearing of three-quarters of an inch on the outer rim, the other part of the collar clear, as they grip and hold tighter than a solid flat collar. Examine the collars carefully, to see if they are true, and if not, have them made so; also be sure that stem of mandrel fits the hole nice and snug, and offers no obstruction to the saw slipping easily up to and against the fast collar. Test the saw with a straightedge, and if it is found true, place it on the mandrel, tighten up the collars, test it again with the straightedge, and determine if the position of the blade has been altered, observing whether it shows true; if not, the fault is sure to lie in the collars, and should be remedied, otherwise it will likely ruin the saw.

SPEED OF SAWS

This is a very important point for consideration, as all large circular saws being hammered for certain speeds, a hundred revolutions more or less will always make a great difference in the running of the saw. Experience, sometimes well earned, has proven that a saw works better, both as to quality and quantity of its output, when run at a regular speed. It may be remarked in this connection that the prevailing practice for a number of years in America has been to speed saws higher than is really necessary or even advisable; in short, we have had a spell of being speed-wild, trying to see what we can do in the way of high speed, but at present there is an undercurrent of feeling, and a tendency toward easing down a little in speed and taking more pains with the work. This tendency will probably grow stronger, too, as timber becomes more scarce and valuable, and we begin to realize more fully that it is not the quantity we turn out, but what we get out of the timber that goes into the mill that counts the most. And from practical experience it has been proven that it is far better, both from a standpoint of economy and efficiency, to run a saw "too slow" rather than "too fast." When you get a saw speeded too high, and especially if it is not set on a firm foundation, it becomes limber and touchy, will dodge about and manifest every kind of weakness; on the other hand, a saw running too slow, while having its objections, is never attended with serious faults that arise when one is running at too high a speed. And it is always wise to avoid both extremes. The speed of circular saws generally is based on the rim travel per minute, the standard basis for figuring to-day, and advised by the leading saw manufacturers, being about 10,000 to 12,000 feet on the rim. A great deal depends on circumstances, and theoretically, according to this formula, in order to secure the proper rim travel or speed, the smaller the saw the more revolutions it would have to make. A 16-inch saw, for example, figured on this basis, would have to run nearly 2,500 revolutions per minute. Whether or not it should be run at this speed depends on circumstances. If it is a bench or equalizer saw, firmly held, it may be run at this speed and even higher, but if it is a pendulum or swing saw, the speed should not be quite so high, and about 1,800 to 2,000 revolutions would be nearer right. This matter of speed will be taken up more thoroughly with each individual saw further on in this volume.

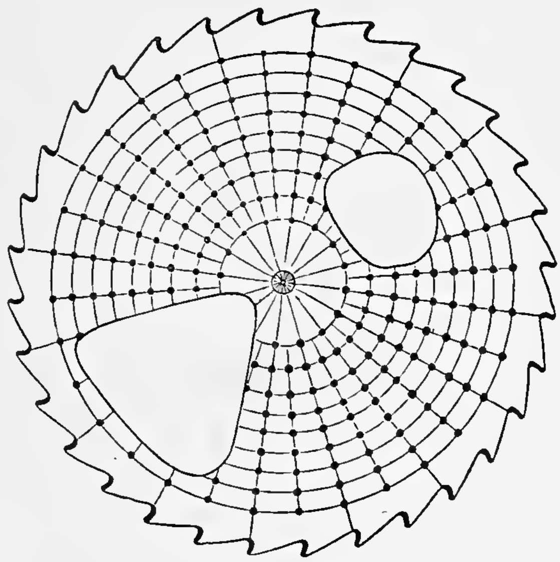
HAMMERING AND TENSIONING

The object to be attained in the hammering of a circular saw is to tension or level it so that it will revolve in a perfect plane when in full motion. It also requires a reserve amount of tension to compensate for the resistance of the cut. This is not so apparent in saws hammered for medium or slow speed with light power as with high-speed saws. All saws if properly made are open toward the centre, this amount being more or less in proportion to the number of revolutions the saw is to run. It would be well for those having charge of the saws to examine them carefully when they arrive from the saw maker, and determine closely how much the saw drops away from the straightedge, and the same amount of tension kept in the saw at all times. The amount of gumming necessary to maintain the shape of the teeth, and the expansion of the rim by motion, together with the resistance of the cut, have all worked together to stretch permanently the rim of the saw, causing it to lose its tension. There is no known process by which this rim may be contracted, so the central portion of the saw must be stretched to compensate for this enlargement of the rim. A saw seldom loses its tension evenly. If it did so, the work of restoring it would be very much simplified. This uneven effect will result from a variety of causes. It may be from an uneven temper of the saw plate, but it more often results from a little unevenness of the tension in the saw. A saw that has lost its tension needs hammering with a round-faced hammer, as shown in Cut No. 1. However, before concluding that the saw requires hammering to adjust the tension, see if there is not some other cause for the trouble, such as the saw being lined into the log too much, which would cause it to draw into the log and heat on the rim, the guides not being properly adjusted, the gullets being too narrow for the feed, or the teeth not being swaged and dressed. Before beginning to hammer it, place the saw upon the anvil, and with the back edge resting upon a support the same height as the anvil, raise the front part of the saw with the hip and left hand, until the centre of the saw is clear of the anvil. Proceed to examine the saw carefully all around with the straight-edge, by applying it between the centre and the rim, at exactly right angles with the supports. Any other angle will show a bend of the plate instead of the condition of



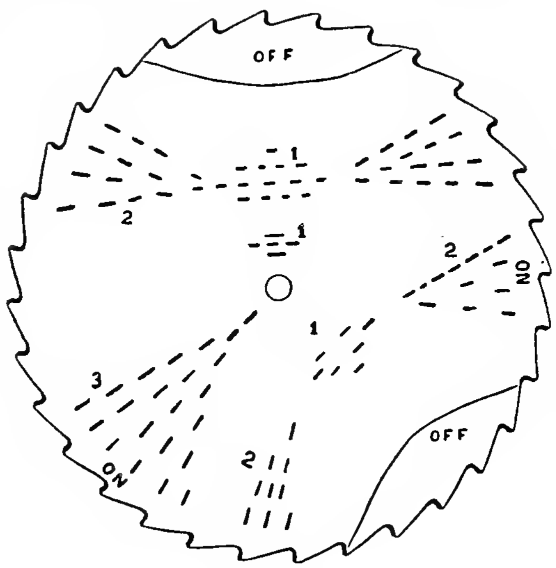
Cut No. 1.

the tension. And note the difference of the parts of the saw as they appear under the straightedge. If any part is found to drop away more than the rest of the saw from the centre of saw to the edge, mark this part as shown in Cut No. 2, and do not hammer as much, if any, at that place, until you have gone over the rest of the saw with the round-faced hammer, as this shows a degree of tension, and perhaps enough for that part of the saw when finished; for such places always show more tension when the balance of the saw is equalized to it. Another part may come up to the edge or show perfectly flat. This part of the saw is stiff and needs hammering for tension, still another part may show full, that is, the rim may drop away from the straightedge. This part of the saw is in a condition that is termed "fast," and needs "more" hammering for tension than any other part. Examine the centre also. This may show flat or perhaps a little full, which indicates that this part of the saw is too stiff. Now proceed to lay off the saw for hammering. Describe a number of circles three inches apart, making the outside one four inches from the rim of the saw and the inside one an inch or so from the collar line. Examine with a straightedge and mark those parts which show "fast" or "stiff" by enclosing them with marks like half circles, of longer or shorter length, according to the conditions. The fast places in such a saw will generally need hammering on all the circles described,



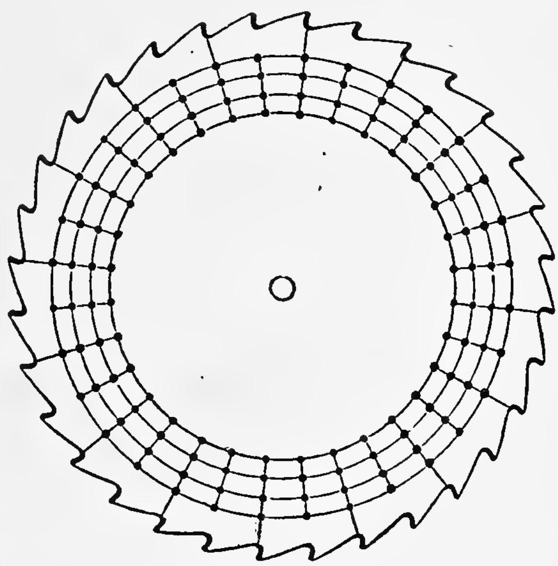
Cut No. 2.

while those which are "stiff" may not extend so far out toward the rim. When all is in readiness for hammering, use a round-faced hammer, weighing from 2 to 3½ pounds, and do not strike too heavy, for it is better to go over the saw several times than to hammer too much at one time and put the saw in a worse shape than it was before you began. After going over one side, mark off the other side, and repeat the operation with as near as possible the same number and weight of blows as struck on the first side, spacing your blows about three inches apart on the circles. These circles are intended as a guide to uniform work. After doing this much, erase all your marks and proceed to level by standing the saw upon the floor in a perpendicular position, and examine both sides of the saw with a long straightedge; and if the hammering has been equally done on both sides, the saw should be very nearly true. If, however, it shows full on one side and dishing on the other, mark these full places; then place the saw on the anvil with the full side up and hammer lightly; test again with the long straightedge, and if it appears true, put it on the anvil and test it for tension, as before explained, to see if it has the proper tension. If not, repeat the operation with the round-faced hammer. After again testing, put the saw on the try mandrel and test with the short straightedge for running true. Mark the places as they run "off" or "on," as shown in Cut No. 3. While turning the saw



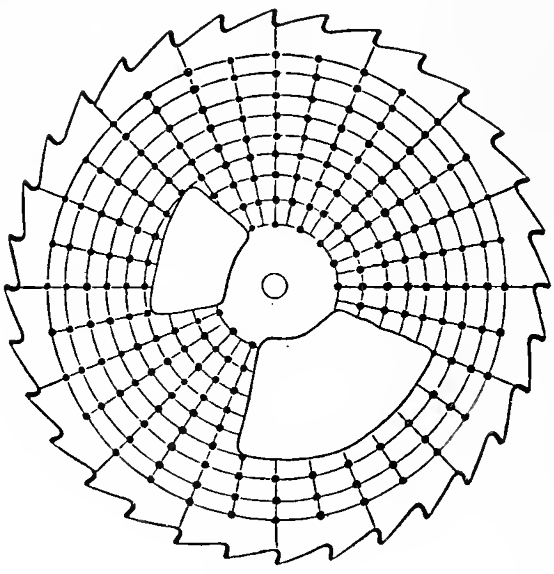
Cut No. 3.

slowly around and where the saw runs "off," lumps will be found most likely, as at 1, 1, 1, or what is termed "twist lumps," as at 2, 2, 2, or both may occur. These lumps must be taken out with a cross-faced hammer, the blows being struck so that they will be in line with the lump; that is, the mark or impression the hammer leaves should run in the same direction that the lump runs, as shown by the straightedge. A twist cannot be taken out with a round-faced hammer, neither is a round-faced hammer liable to twist the saw. On the other hand, by using a cross-faced hammer, twist lumps can be very easily removed, if the blows are struck in line with the lumps. The saw may also be thrown out of true by lumps running toward the centre, as at 3, as shown in Cut No. 3. In this case the saw will be "on" or "off" at points about opposite each other. In removing these twist lumps the hammering must be done carefully, otherwise the tension may be altered. Now put the saw on the arbor, and if for high speed it should sway gently from side to side in getting up to full speed, and will then run steadily and do its work properly; but if it is snaky or rattles in the guides, it needs to be more open toward the centre. Where a saw is too open at the centre, it should be hammered in from the edge, as shown in Cut No. 4; and the distance to hammer in from the edge depends on where the loose parts are on the saw. If the centre is loose to the first line, or the one nearest to the centre, hammer from



Cut No. 4.

the rim to that line; but if it runs out to the next line, hammer only to that line. The degree of opening or looseness necessary depends on the speed the saw is to run. The higher the speed, the more opening or tensioning is necessary, and *vice versa.* An experienced man will stand the saw on the floor, taking hold at the top edge, giving it a sudden shake, and if the centre vibrates and the rim stands stiff, he knows it to be open toward the centre. After deciding upon the necessary tension, see that the saw conforms exactly to it all around when finished. Now go over the saw again carefully, as at the first operation, and mark all the full places, as in Cut No. 5, and hammer alike on both sides, with as nearly as possible the same number and weight of blows as struck on the opposite side. If the work has been properly done, the saw will now show quite an even tension and enough to cause the centre to drop through or vibrate either way, while the rim remains stiff when inclined a little from a perpendicular position. In finishing a saw, be very careful to remove all lumps or ridges near the rim, by laying two or more thicknesses of heavy paper on the anvil. Place the saw with the lump or ridge resting directly on the paper, and by giving a few well-directed, sharp blows, the lumps can be hammered down without expanding the metal, and thereby losing the tension already given, which would be the result if placed on the bare anvil. The more evenly and carefully this is



Cut No. 5.

done, the better the saw will run. In regard to the amount of tension or openings required for different size saws at different speeds, it is not possible to give a rule that will answer all conditions, as thin saws require more tension than heavier gauge saws, and the stronger the power or the higher the speed, the more tension is also required; and in cutting hardwoods a saw requires more tension than for soft or more fibrous woods. Beginners in the art of saw hammering should begin with a small circular cut-off saw, one that can be very easily handled. Go through with the operation as instructed, and after succeeding in putting this in good shape by hammering so that it will run true and smooth, without chattering in the cut, you will have advanced well in the art of saw-hammering, and will be able to operate on larger saws without the risk of failure.

SECTION V

KNIVES

KNIVES

PRACTICAL DISCUSSION

The same argument may be applied to knives as to saws, in that they will not grind or sharpen themselves, and they also require a certain amount of care and attention in order that they may properly perform the work expected of them in an economical and efficient manner. Over ninety per cent. of the difficulty experienced with knives is directly caused by their abuse, and most of this abuse is confined to the grinding room. There are many ways in which a knife may be ruined. In fact, the better the quality of the knife, the easier and more liable it is to be spoiled in grinding. In cases where the temper is drawn in grinding, the evidence is nearly always removed to the next time the emery wheel or grindstone passes over the knife. If you will try the knife with a file, you will notice how soft it is, and should you strike the edge lightly, it will turn over completely, while, no doubt, in another part it may file hard and break out easily at the slightest touch.

DIFFERENT IDEAS ON TEMPER

Some operators and mill men want their knives hard and of a good even temper, and do practically all of their sharpening on the grindstone or emery wheel, while others doing the same class of work want them soft and of a very mild temper, so that they can sharpen or dress them up with a file frequently, without removing them from the machine. Differences of opinion of this sort occur throughout the trade, and directly is one of the causes of occasional poor results of knives, inasmuch as the knife-makers have about arrived at a sort of cosmopolitan temper in their knives, so to speak, in order to give good service under such varied conditions. In order to warrant securing a knife that will answer its purpose and give good and satisfactory results, it is very essential that the knife-maker should know for what purpose the knife is intended, what speed it is to run, and how it is to be sharpened. Whether by the use of a hand file, grindstone or emery wheel, too much is usually taken for granted by the user of the knife, and the knife-maker is commonly left to use his own judgment in the matter. Knives can be, and are, made to meet almost any requirement and under all sorts of conditions, and if properly used and taken care of will invariably give profitable results.

SPEED OF KNIVES

As with saws, speed also has a varying effect upon knives, but, of course, not with such effective results; but speed should always be taken into consideration in order that they may produce the best results. A knife that will work successfully on one machine running at a certain number of revolutions per minute would not perform as satisfactory or stand up to its work as well if run at 100 or more revolutions per minute more or less.

TEMPER OF KNIVES

Two things are very necessary to produce knives that will be satisfactory and perform good service: First, good steel must be used in their construction; it must be of a proper temper or carbon, and should be specially made for the purpose. Second, and the most important element, is the proper temper, without which a knife is of no consequence. This one thing, the tempering of knives, should be the subject of more thought, experiment and careful attention than any other step in the process of manufacture, from the crude ore to the finished product; and even then it retains the greatest degree of uncertainty of any. In the making of steel itself, scientific research and a long line of experiments have reduced the work to a satisfactory degree of positiveness. There are flaws, of course, now and then, as in all things, but generally speaking we are in a position to-day to know pretty well just what we are getting in our steel, what chemical properties and what kind of structure. And the process of manufacture has been perfected enough that the product runs so nearly uniform as not to give serious trouble. The same thing is true in all the mechanical work of making knives, and while it requires care and skilful manipulation at all times to turn out good, satisfactory knives, still, that is comparatively easy to obtain; but when we come to tempering, we strike the most difficult step and process in all the work. This comes partly from the fact that two pieces of metal exactly alike in chemical parts and physical structure may be given what appears to be the same treatment, and yet produce varying results in tempering. This is only a part of the uncertainty, however, and another part comes from the different uses to which knives are put, and the difference in temper required under these various conditions. The problem of temper met with at times would be materially simplified if the knife-maker could know in each instance the exact service required of the knife; that is, if it were a planer knife, if he knew just the kind of wood it was to be used on, speed at which it would be run, and average depth of cut. If users of knives would always bear this fact in mind when ordering their knives of the knife-makers, and then give them the proper attention in grinding or sharpening, they would find that the knives would always perform their proper amount of work with entire satisfaction, as the knife-makers have made this matter of temper, through a long and ceaseless line of experiments and study, a work with a certain degree of positiveness and satisfaction. And they can invariably be relied upon to furnish an article that will produce the results expected under ordinary circumstances. It is worthy of remark in this connection, however, that users of knives are beginning to realize the general importance of this subject of tempering to a certain extent, and have more respect for the temper that has been put into their knives. In times gone by, and even among some careless workmen to-day, there has been many a carefully tempered knife practically spoiled by careless grinding.

TEMPERING SOLUTIONS

1. To 6 quarts of soft water add 1 ounce of corrosive sublimate and two handfuls of common salt. When dissolved, the mixture is ready for use. The first gives toughness, the latter hardness to the steel. Remember this is deadly poison.

2. Soft water, 3 gallons; common salt, 2 quarts; sal-ammoniac and saltpetre, of each 2 ounces; ashes from white ash bark, 1 shovelful. Do not hammer too cold. To avoid flaws do not heat too high, which opens the pores of the steel. If heated carefully you will get hardness, toughness, and the finest quality.

3. Common salt, 4 ounces; saltpetre, ½ ounce; pulverized alum, 1 ounce; 1 gallon soft water. Heat the articles to a cherry red and quench, but do not draw temper.

4. Saltpetre and alum, each 2 ounces; sal-ammoniac, ½ ounce; common salt, 1½ ounces; 2 gallons soft water. Heat parts to be tempered to a cherry red and quench.

TO TEMPER KNIVES

Take a vessel of proper width to receive the length of the knife, put some water in the bottom, and pour an inch of oil on top. Heat the edge of your knife an even cherry red back as far as you wish to harden it, and holding it level, thrust the edge into the oil for a moment, until the color leaves; then slowly let it down into the water. The oil cools without cracking and the water prevents the heat in the body from drawing the edge. It is not necessary to harden all knives in this manner, as the oil alone will produce a sufficient hardness in ordinary cases if a large enough body of oil is used and the edge of the knife is immersed with a stirring motion. It can then be tempered to about 500 degrees (brown-yellow color) by the heat of the body of the knife and suddenly cooled in water at about 80 degrees.

TABLE OF TEMPERS TO WHICH TOOLS SHOULD BE DRAWN

TOOL	COLOR	DEG. OF TEM. FAHR.
Axes	Dark purple	550
All cutting tools for soft material	Very light yellow	420
Cold chisels for steel	Light purple	530
Cold chisels for wrought iron	Light purple	530
Cold chisels for cast iron	Dark purple	550
Key drifts	Brown-yellow	500
Wood chisels	Spotted red-brown	510
Hammer faces	Very pale yellow	430
Hand plane irons	Brown-yellow	500
Inserted saw teeth	Straw yellow	460
Screwdrivers	Dark purple	550
Springs	Very dark blue	601
Planer knives	Brown-yellow	500
Planer knives (to be filed)	Purple-blue	531

TO TEMPER OLD FILES

Grind out the cuttings on one side of the file until a bright surface is obtained; then moisten the surface with a little oil, and place the file on a piece of red-hot plate with the bright side upward. In about a minute the bright surface will begin to turn yellow, and when the yellow has deepened to about the color of straw, plunge in cold water.

EMERY WHEELS—THEIR USE

The emery wheel consists of grains of emery and a composition called the texture, which binds these grains together.

In regard to the size of the grains the wheel is said to be coarse or fine in grade. In regard to its texture it is called hard or soft.

To distinguish the grades, they are numbered from the dimension of the meshes through which the grains pass.

Thus, grade 10 means that the distance between the wires of the mesh is 10 to the inch.

Some of the substances used to hold the grains of emery together are hard rubber, shellac, ordinary glue and a mixture of linseed oil and litharge.

The relative hardness of the texture is indicated by letters. Thus, A indicates a soft wheel; B, a harder wheel; M, medium wheel, and so on.

The vitrified emery wheel is made with a cement which contracts slightly while cooling, leaving small pores or cells through which water introduced at the centre is thrown to the surface by centrifugal force. This flow of water operates to carry off the cuttings and the detached emery.

The grade and texture of the wheel in certain kinds of work is fairly within the following limits:

Wheels of coarse grain and hard texture are suitable for rough grinding in which accuracy and finish are not required.

Wheels having medium grains and hard texture are serviceable for sharpening or gumming saws, etc.

Wheels with medium grains and soft texture are suitable for free cutting on broad surfaces of iron, steel or brass.

Wheels with fine grain and soft texture are suitable for grinding fine tools, knives, etc., for which the duty is light, but the demand for accuracy imperative.

In regard to finish, it is to be observed that the harder the substance to be ground, the coarser must be the grade of the wheel. Some emery grinders are fitted with a cast-iron box or tank to hold water, with a small pump to force the water up to the emery wheel. This is an ideal grinder where emery wheels are used, but great care should be exercised that oil or grease does not get into the tank, for, should this occur, and the oil or grease get onto the emery wheel, that wheel begins to glaze, heat and burn. After oil has once reached the emery wheel, it is next to impossible to keep the face from glazing, and this is one of the many ways to ruin a knife. Frequent use of the emery-wheel dresser is the only remedy. There are many grades and qualities of emery wheels, and care should be exercised in selecting the proper grade for your use. For knife-grinding, an emery wheel should be free-cutting and fine of quality; and free-cutting means that they wear out much faster than the wheels that are hard, and will heat and glaze. If the emery wheel is too hard, it will either draw the temper or cause a number of fine cracks to appear in the face of the knife. Either the knife edge will turn over if the temper is drawn or break out if burned or if cracks appear. It is not always the case that the knife breaks out the first time it is used after grinding. Sometimes it is weeks or months before the trouble puts in an appearance. It is always best, in the case of a good quality knife, or where good, clean work must be performed, to do the sharpening on a grindstone, in preference to the emery wheel, as better satisfaction is always given, and one is not so liable to heat or burn the knife. In all cases of knife-grinding on an emery wheel, the motion should be from the point or edge to the heel of the bevel on the knife, as in this way you are less liable to draw the temper.

SPEED OF EMERY WHEELS

An emery wheel can be run too fast—So fast, in fact, that it will not cut, and is also a very dangerous operation. The usual speed employed in ordinary work is 5,000 feet on the surface, but in special cases it is sometimes desirable to run them at a lower or higher rate, according to requirements; but 5,000 feet is generally considered as giving the best results. And at this periphery rate the stress on the wheel is 75 pounds per square inch. The flanges for an emery wheel should be at least one-third the diameter of the wheel, and one-half the diameter of the wheel would be more desirable. Wheels should "never" be mounted unless the bore is an easy fit, and the flanges the proper size, so as to insure against unnecessary accidents. Below will be found a table of speeds for emery wheels, as recommended by the leading emery-wheel manufacturers as safe, and at which the best results are obtained:

Diam. of Wheel	Rev. per Minute for Surface Speed of 4,000 Feet	Rev. per Minute for Surface Speed of 5,000 Feet	Rev. per Minute for Surface Speed of 6,000 Feet	Diam. of Wheel	Rev. per Minute for Surface Speed of 4,000 Feet	Rev. per Minute for Surface Speed of 5,000 Feet	Rev. per Minute for Surface Speed of 6,000 Feet
3 inches	5093	6366	7639	24 inches	637	796	955
4 "	3820	4775	5730	26 "	586	733	879
5 "	3056	3820	4584	28 "	546	683	819
6 "	2546	3183	3820	30 "	509	637	764
7 "	2183	2728	3274	32 "	477	596	716
8 "	1910	2387	2865	34 "	449	561	674
10 "	1528	1910	2292	36 "	424	531	637
12 "	1273	1592	1910	38 "	402	503	603
14 "	1091	1364	1637	40 "	382	478	573
16 "	955	1194	1432	42 "	364	455	546
18 "	849	1061	1273	44 "	347	434	521
20 "	764	955	1146	46 "	332	415	498
22 "	694	868	1042	48 "	318	397	477

SECTION VI

PRODUCTION OF SLACK COOPERAGE STOCK

SLACK STOCK PRODUCTION

GENERAL REMARKS

To the average citizen, a barrel is simply "a barrel," and he rarely thinks of the important part it plays in many industries of to-day. He never stops to think how seriously trade would be handicapped if the barrel supply were suddenly to give out. But a moment's thought will serve to convince the most sceptical that the "homely barrel" is a more important factor in industry than it is sometimes credited with being. This is particularly true of the "slack barrel," as they were in use long before King Solomon's Temple was thought of, as "meal barrels" are mentioned in the good Book in several places, and no doubt were made about 910 years B. C. More than eighteen hundred years ago Pliny, an original investigator, who lost his life trying to find out what made a volcano smoke, endeavored to trace to its origin an industry that was even then ancient and honorable. In time he located a race of people engaged in the industry at the foot of the Alps.—"And invented and pursued by a people regarded with awe, as a superior race, by the tribes who near them did dwell, but who could not tell when 'they' did begin." In the cooperage industry today there are two classes of barrels, commonly termed by their users "tight barrels" and "slack barrels." This volume will deal exclusively with the latter class, which is designated "slack" from the fact that they are only used to hold commodities which are not in liquid form, such as sugar, flour, salt, cement, fruit, and vegetables. The woods used for its construction are chiefly elm, pine, gum, beech, and basswood, named in the order of their importance. Some thirty or forty years ago the only wood used to any great extent in the manufacture of the slack barrel was oak, but the upward trend in value of that wood caused the trade to change first to elm, which was then known as the "patent elm stave," and then, in time, as elm became scarcer and more valuable, to beech, maple, sycamore, gum, and a number of other different woods which are in use to-day. But on account of its great strength and toughness, elm has long been the principal and favorite wood used for staves and hoops, and it will continue to remain so until the supply is exhausted. The production of elm staves has decreased over fifty per cent in the last seven years. Elm is cut most largely in the Northern States, and particularly in Wisconsin, Indiana, and Michigan, and the exhaustion of the supply in those States has had a most serious effect upon the slack cooperage industry. It has been estimated that there are not half the staves manufactured in Michigan at the present writing that there were ten years ago. Saginaw, Mich., which formerly was considered the principal home of the industry, is now producing stock only in a small way. As a matter of fact, most of the slack cooperage stock made in Michigan at this time comes from the northern peninsula, instead of the southern peninsula, as was formerly the case. There has been a very great increase in the use of gum for staves, and more so for heading, within the last few years, in fact, since the year 1900, when this wood made its initial appearance. Owing to its cheapness and abundant supply, it was experimented with and found to be quite satisfactory when care was taken in its seasoning. Basswood has always been the preferred wood for heading, because of its soft, even texture and light color, but it is now gradually being replaced by gum, which is no doubt destined to be the most important wood of the future in the manufacture of the slack barrel. In fact, it is now ranked as second to elm, both as a stave and as a heading wood. For the manufacture of hoops it has not thus far proved adaptable, and will hardly answer for this purpose, on account of its peculiar properties, and from the fact that it splits easily and is quite brash.

PRODUCTION OF SLACK STOCK

The complete report of the United States Forest Service on the production of slack cooperage stock for the year 1908 gives detailed statistics on the output of 1,151 establishments, as against 950 for the preceding year. This substantial increase in the number of establishments reporting for 1908, as compared with 1907, indicates not only a more thorough canvass, but also a greater degree of co-operation on the part of the manufacturers in the latter year, and largely as a result the statistics of the industry show general increases in quantity and value over previous years, despite the fact that industrial conditions obtaining were unfavorable. The data were obtained entirely by correspondence, and the better results secured at this canvass, as compared with those secured at any previous canvass, are due to the fact that a practically complete list of manufacturers was compiled in advance, and also to the fact that manufacturers made much more satisfactory reports. Since statistics on this industry have only recently been compiled in a comprehensive manner, it is impossible to draw conclusions as to the relative completeness of the returns. But as these are the only available statistics to be had on this important subject, we will necessarily have to be content with them as they are. Slack cooperage stock comprises the three materials essential to the manufacture of a slack barrel, namely, staves, heading, and hoops.

In aggregate value the reported production of these commodities in 1908 exceeded that of 1907 by $1,100,398, or very nearly 7 per cent., the increase being from $15,800,253 to $16,900,651. The three branches of the slack cooperage industry are not co-ordinated, the manufacture of staves, heading, and hoops, respectively, constituting to a large extent separate and independent industries. Consequently, the totals of production of the three commodities in any one year seldom harmonize. The tendency through a series of years, however, is toward an equalization or balancing in production. Combining the totals of production for several years practically eliminates the seeming inconsistencies and shows stave and hoop production for substantially the same number of barrels, with an excess of heading, a large part of which was probably consumed in repairing second-hand barrels. An interesting fact disclosed by the statistics of the last few years is the increasing number of establishments which turn out staves and heading as by-products in the manufacture of lumber.

WOODS CHIEFLY USED FOR SLACK COOPERAGE

Table I summarizes the production of staves, heading, and hoops, and shows the total manufactured from each species, with the average value per 1,000 for the years 1906, 1907 and 1908. The total reported production for the year 1908 was 1,557,644,000 staves, valued at $8,912,957, or $5.72 per 1,000 staves; 123,849,000 sets of heading, valued at $5,661,713, an average of a little more than 4½ cents per set; 336,484,000 hoops, valued at $2,325,981, or $6.91 per 1,000. Staves were manufactured in considerable quantities from nineteen different kinds of wood. The most important of these was red gum, which furnished about one-fifth of the total number, which was to be expected, as this species is rapidly superseding elm and all others as a stave and heading wood. Next in importance come pine, elm, beech and maple, in the order as stated. These five species furnished practically three-quarters of the total number manufactured. The total production of staves reported for 1908 exceeded that reported for 1907 by 381,667,000, or 32.5 per cent. There was an increase of 17,775,000 sets of heading, or 16.8 per cent. Nineteen kinds of wood were in 1908 used in sufficient quantities in the manufacture of staves and heading to be separately shown; tamarack, tupelo, willow, and yellow poplar having been included under "all other" woods in 1907. Fewer slack barrel staves of spruce, hemlock, basswood, and yellow poplar were manufactured in 1908 than in 1907, while there were increases in all other woods. For red gum the increase amounted to 50.4 per cent.; for pine, 33.7 per cent.; for elm, 21.7 per cent.; for beech, 32.7 per cent., and for maple, 28.2 per cent. Although relatively large increases occurred in many other kinds of wood, in no case did the quantity of staves manufactured from any of such woods form as much as 6 per cent. of the total quantity manufactured in 1908. The five kinds of wood which had a production of more than 97,000,000 staves each in both 1907 and 1908 ranked as follows in the two years: Red gum, pine, elm, beech, and maple. In 1908 these woods furnished 1,076,267,000 staves, or 69.1 per cent. of the total number produced in that year, and only about 100,000,000 staves less than the total number manufactured during 1907. Red gum staves formed 20.4 per cent. of the total production in 1908; pine, 17.7 per cent.; elm, 12.4 per cent.; beech, 10.7 per cent.; maple, 8 per cent.; and chestnut, 5.1 per cent.

In the manufacture of heading, only elm, beech, ash, spruce, oak, and sycamore showed decreases, as compared to 1907. No decrease, however, amounted to more

TABLE I. SLACK COOPERAGE STOCK PRODUCTION. 1906-1907-1908

Kind of Wood	Staves			Heading (Sets)			Hoops		
	1906	1907	1908	1906	1907	1908	1906	1907	1908
Totals..........	1,097,063,000	1,175,977,000	1,557,644,000	129,555,000	106,074,000	123,849,000	330,892,000	490,570,000	336,484,000
Red Gum	142,952,000	210,814,000	317,016,000	16,519,000	11,466,000	17,249,000	....	1,840,000	2,863,000
Pine	187,584,000	205,878,000	275,239,000	28,730,000	27,208,000	39,347,000	*...........	3,996,000	105,000
Elm	248,118,000	158,440,000	192,882,000	19,472,000	9,165,000	4,978,000	302,628,000	469,734,000	326,894,000
Beech	80,052,000	125,354,000	166,383,000	11,686,000	17,711,000	15,294,000	....	....	131,000
Maple	99,642,000	97,319,000	124,747,000	9,317,000	11,695,000	13,323,000	*...........	1,747,000	307,000
Chestnut	69,674,000	74,982,000	79,633,000	292,000	733,000	779,000	*...........	2,000,000	180,000
Ash	47,603,000	70,128,000	74,494,000	2,856,000	7,434,000	4,297,000	12,515,000	1,580,000	2,135,000
Spruce	31,605,000	76,445,000	60,012,000	1,027,000	2,555,000	2,245,000	....	....	....
Oak	70,869,000	37,871,000	53,737,000	2,710,000	2,814,000	2,092,000	6,670,000	2,775,000	586,000
Birch	62,754,000	21,479,000	52,739,000	2,948,000	2,146,000	3,961,000	2,466,000	2,489,000	1,173,000
Cottonwood	21,912,000	46,923,000	51,062,000	9,162,000	1,784,000	2,067,000	....	....	....
Sycamore	8,214,000	2,579,000	23,454,000	362,000	297,000	271,000	....	....	....
Tamarack	*...........	1,120,000	13,856,000	*...........	40,000	431,000	....	....	....
Hemlock	12,453,000	16,535,000	12,717,000	*...........	574,000	1,277,000	....	....	....
Basswood	8,307,000	18,640,000	6,306,000	15,653,000	9,587,000	10,186,000	....	....	....
Tupelo	*...........	2,000,000	5,120,000	*...........	206,000	4,237,000	....	....	....
Willow	*...........	2,000,000	4,485,000	*...........	106,000	240,000	*...........	*...........	*...........
Yellow Poplar ..	*...........	4,999,000	4,244,000	*...........	389,000	791,000	....	....	....
Hickory	*...........	*...........	1,463,000	*...........	*...........	2,000	*...........	3,708,000	1,510,000
All other	5,324,000	2,471,000	38,055,000	8,821,000	166,000	782,000	6,613,000	701,000	600,000

*Classified that year under head of "All Other."

than 4,187,000 sets, while the increase in pine alone was over 12,000,000 sets. As with staves, so in the manufacture of heading, five principal woods were used. Though the same woods are generally used for both purposes, in heading pine ranked first, with 31.8 per cent. of the total production; red gum second, with 13.9 per cent.; beech third, with 12.3 per cent.; maple fourth, with 10.8 per cent.; and basswood fifth, with 8.2 per cent. The production from these woods was 95,399,000 sets, or 77 per cent. of the total. In the production of hoops only ten kinds of wood were reported in sufficient quantities to warrant a separate presentation for 1908. Of these, red gum, ash, and beech, which latter wood was not separately tabulated in 1907, showed increases in 1908, as compared with 1907. In elm alone there was a decrease of $142,-840,000, or nearly 93 per cent. of the decrease in the total production of hoops for the year. This is accounted for by the fact that the elm hoop is being fast supplanted by wire and flat steel hoops.

Table II shows the quantity, value, and average value per thousand of staves, hoops, and sets of heading produced in 1908 from the different kinds of wood. The aggregate value of the reported production of staves, heading, and hoops in 1908 was $16,900,651, an increase of $1,100,398, or nearly 7 per cent., over the value of these products in 1907. In average value per thousand at point of production, staves decreased from $6.14 in 1907 to $5.72 in 1908, or a decrease of 42 cents. Among the individual species, the decreases, while general, were in the most instances small.

Ash, for which the highest average value, $7.96, was reported in 1907, decreased to $6.52 in 1908, while the loss in elm—the next highest species in 1907—was from $7.53 to $7.16 per thousand staves. Among other important woods the decreases were as follows: Red gum,

TABLE II. SLACK COOPERAGF STOCK. YEAR 1908

Quantity, Value and Average Value of Each Class of Product

Kind of Wood	Staves			Heading			Hoops		
	Quantity	Value	Average Value per 1,000	Quantity (Sets)	Value	Average Value per Set	Quantity	Value	Average Value per 1,000
Total	1,557,644,000	$8,912,957	$5.72	123,849,000	$5,661,713	$0.0457	336,484,000	$2,325,981	$6.91
Red Gum.....	317,016,000	1,727,688	5.45	17,249,000	934,942	.0542	2,863,000	32,691	11.42
Pine	275,239,000	1,343,005	4.88	39,347,000	1,318,410	.0335	105,000	910	8.67
Elm	192,882,000	1,381,728	7.16	4,978,000	229,630	.0461	328,894,000	2,241,929	6.86
Beech	166,383,000	1,042,958	6.27	15,294,000	724,997	.0474	131,000	1,322	10.09
Maple	124,747,000	750,566	6.02	13,323,000	594,955	.0446	307,000	1,150	3.75
Chestnut	79,633,000	338,015	4.24	779,000	30,656	.0393	180,000	840	4.67
Ash	74,494,000	485,889	6.52	4,297,000	262,112	.0610	2,135,000	14,730	6.90
Spruce	60,012,000	308,303	5.14	2,245,000	107,637	.0479			
Oak	53,737,000	344,710	6.41	2,092,000	116,014	.0554	586,000	6,243	10.65
Birch	52,739,000	339,380	6.44	3,961,000	215,418	.0543	1,173,000	5,326	4.54
Cottonwood ..	51,062,000	329,978	6.46	2,067,000	113,736	.0550			
Sycamore	23,454,000	131,312	5.60	271,000	13,101	.0483			
Tamarack	13,856,000	70,361	5.08	431,000	16,499	.0382			
Hemlock	12,717,000	60,624	4.77	1,277,000	55,674	.0436			
Basswood	6,306,000	35,485	5.63	10,186,000	611,545	.0600			
Tupelo	5,120,000	20,100	3.93	4,237,000	219,501	.0518			
Willow	4,485,000	31,370	6.99	240,000	13,101	.0546			
Yellow Poplar.	4,244,000	23,211	5.47	791,000	40,220	.0508			
Hickory	1,463,000	8,035	5.49	2,000	80	.0400	1,510,000	16,340	10.82
All Other......	38,055,000	140,239	3.69	782,000	43,485	.0556	600,000	4,500	7.50

from $5.88 to $5.45; pine, from $5.17 to $4.88; beech, from $6.31 to $6.27; maple, from $6.27 to $6.02; while for spruce the average value per thousand, $5.14, was the same in both years.

Although the production of heading was greater in 1908, the average value per set showed a decrease from .0477 in 1907 to .0457 in 1908, or .0200 per set. This is probably due to the fact that gum is rapidly superseding other species as a heading wood. The greatest loss in value occurred in cottonwood, the decrease in average value per set of heading cut from this species amounting to .0110, while for pine, the principal species consumed in slack barrel heading manufacture, the decrease was .0072 per set. Practically the only woods which showed increases in value were oak, ash, beech, spruce, and sycamore; but only a relatively small quantity of sycamore was manufactured. The highest average value, .0610, in 1908, was reported for ash, and the lowest average value, .0335, for pine.

In both quantity and value the hoop production in 1908 was less than that reported for the preceding year. The principal wood used in the manufacture of hoops in 1908, as formerly, was elm, 97.1 per cent. of the total number being made from this species. Only four other kinds of wood were used to any considerable extent; and these, in the order named, were red gum, ash, hickory, and birch. The highest average value per thousand hoops, $11.42, was reported for red gum, while the lowest, $3.75, was reported for maple. With respect to the average value per thousand hoops, both oak and maple showed increases in 1908, as compared with 1907, while elm showed a loss. In the case of the total production from all woods a decrease of 26 cents occurred. This decrease in value was probably due in part to the increased use of wire and flat steel hoops.

In connection with the value of staves, heading, and hoops, it is interesting to note the various forms into which slack cooperage stock is manufactured, and the woods used for these forms. Flour and sugar barrels represent the highest grades manufactured, and after these come cement, lime, and salt barrels. Inferior grades are those barrels which are known as truck barrels, used for fruit and vegetables of many kinds and for crockery and glassware, and the barrels and kegs used in the hardware trade. Butter tubs, although not considered of so high a grade as flour or sugar barrels, are hardly a low-grade product.

In the East white ash and spruce are used extensively for butter-tub staves, and elm, maple, and basswood for bottoms and covers. Elm is used largely in the manufacture of the highest grade barrel, while pine is used largely for the inferior grades. Gum makes a clean, smooth stave, and its value is now being appreciated as a result of more careful methods of seasoning and manufacture. This is clearly shown by the increased production of staves from this wood. Considerable attention of late has been drawn to the substitution of the sack for the slack barrel. It is believed that for many of the lower grades of packages this will help to solve the problem of timber supply, though for certain products and classes of shipment a wooden barrel is much preferred. Crates, boxes, and baskets have in recent years been used to a large extent in the transportation of many of the fruits and vegetables which were formerly transported in barrels.

SLACK BARREL STAVE PRODUCTION

Table III shows the production of staves in the different States by kinds of wood. Nearly two-thirds of the slack barrel staves manufactured are produced in the

TABLE III. QUANTITY OF SLACK BARREL STAVES MANUFACTURED—BY KINDS OF WOOD AND BY STATES AND TERRITORIES. 1908

State	Totals	Red Gum	Pine	Elm	Beech	Maple	Chestnut	Ash	Spruce	Oak	Birch	Cottonwood	All Other
United States	1,557,644,000	317,016,000	275,239,000	192,882,000	166,383,000	124,747,000	79,633,000	74,494,000	60,012,000	53,737,000	52,739,000	51,062,000	86,246,000
Alabama	12,927,000		12,902,000										25,000
Arkansas	217,354,000	92,428,000	8,415,000	10,196,000		3,243,000		49,485,000		270,000		16,947,000	36,370,000
Delaware	2,220,000		2,220,000										
Florida	13,415,000		13,415,000										
Georgia	6,846,000	260,000	5,534,000					300,000		50,000			702,000
Illinois	55,808,000	27,383,000		15,721,000	800,000	4,249,000		1,040,000		200,000	263,000	2,703,000	3,446,000
Indiana	31,981,000	4,825,000		8,271,000	3,770,000	5,309,000		1,083,000		428,000	1,042,000	3,000,000	4,253,000
Kentucky	29,515,000	20,675,000	130,000	3,560,000	680,000	860,000		710,000		620,000	20,000	560,000	1,700,000
Louisiana	25,946,000	10,940,000	381,000					2,950,000		100,000		7,575,000	4,000,000
Maine	67,903,000	1,147,000	3,495,000	210,000	1,111,000	1,369,000	33,000	547,000	49,741,000	775,000	1,512,000	1,166,000	6,797,000
Maryland	22,796,000		22,796,000										
Massachusetts	9,712,000		6,946,000				770,000						
Michigan	201,190,000		1,855,000	80,629,000	46,833,000	47,857,000		1,672,000	250,000	115,000	5,929,000	50,000	16,000,000
Minnesota	9,188,000		700,000	1,700,000		50,000		50,000		200,000	375,000		6,113,000
Mississippi	29,744,000	11,838,000	8,806,000	1,600,000	100,000	100,000		100,000			100,000	7,000,000	100,000
Missouri	146,043,000	113,324,000	25,000	13,937,000		2,300,000		10,697,000				1,810,000	3,950,000
New Hampshire	47,157,000		44,802,000		100,000	425,000	770,000			425,000	200,000	35,000	400,000
New York	68,778,000	61,000	40,000	10,216,000	31,482,000	11,906,000	70,000	1,150,000		65,000	12,928,000	540,000	320,000
North Carolina	17,792,000	11,400,000	3,392,000										3,000,000
Ohio	58,499,000	47,000		34,693,000	7,751,000	8,010,000	93,000	1,274,000		2,207,000	20,000	716,000	3,688,000
Pennsylvania	202,764,000	100,000	16,797,000	500,000	73,221,000	33,523,000	54,422,000	258,000		1,038,000	21,658,000		1,247,000
South Carolina	845,000		845,000										
Tennessee	50,551,000	15,782,000	220,000	2,947,000		610,000	5,000	2,349,000		16,844,000	100,000	7,572,000	4,122,000
Vermont	7,180,000		210,000	200,000				200,000	6,540,000			15,000	15,000
Virginia	168,537,000	6,181,000	110,058,000	600,000	470,000	1,545,000	20,659,000	166,000		25,563,000		1,000,000	2,295,000
Washington	2,640,000	350,000							2,000,000			140,000	150,000
West Virginia	8,692,000	272,000	455,000	20,000	65,000	297,000	2,561,000	20,000	40,000	4,757,000	15,000		190,000
Wisconsin	29,296,000		6,805,000	7,200,000		2,969,000				40,000	8,317,000		3,935,000
All Other States*	12,325,000		3,995,000	682,000		125,000	250,000	438,000			110,000	63,000	6,662,000

*Includes Arizona, California, Idaho, Oregon, Oklahoma, Rhode Island and Texas.

TABLE IV. QUANTITY (SETS) OF SLACK BARREL HEADINGS MANUFACTURED—BY KINDS OF WOOD AND BY STATES AND TERRITORIES. 1908

State	Totals	Pine	Red Gum	Beech	Maple	Basswood	Elm	Ash	Tupelo	Birch
United States	123,849,000	39,347,000	17,249,000	15,294,000	13,323,000	10,186,000	4,978,000	4,297,000	4,237,000	3,961,000
Alabama	4,071,000	3,032,000	239,000	....	....	....	800,000	....	....	....
Arkansas	20,486,000	15,502,000	3,558,000	....	....	....	25,000	1,198,000	200,000	....
Florida	904,000	904,000	....	....	....	....	....	....	....	....
Georgia	897,000	885,000	4,000	....	....	....	....	....	....	....
Illinois	1,851,000	....	1,171,000	....	520,000	....	20,000	44,000	....	20,000
Indiana	3,484,000	....	350,000	129,000	830,000	234,000	1,296,000	270,000	....	100,000
Kentucky	6,309,000	526,000	3,235,000	430,000	878,000	25,000	856,000	3,000	14,000	....
Louisiana	3,083,000	11,000	160,000	....	....	....	10,000	10,000	1,465,000	....
Maine	4,869,000	2,036,000	211,000	35,000	44,000	16,000	33,000	11,000	25,000	47,000
Massachusetts	1,310,000	1,244,000	....	....	10,000	5,000	....	....	....	7,000
Michigan	22,585,000	156,000	70,000	8,576,000	7,949,000	2,096,000	828,000	606,000	....	792,000
Minnesota	2,206,000	200,000	....	....	....	1,181,000	100,000	90,000	....	98,000
Missouri	8,523,000	....	5,952,000	....	65,000	....	20,000	1,246,000	1,142,000	....
New Hampshire	6,428,000	6,387,000	....	....	....	....	....	....	....	....
New York	4,886,000	519,000	504,000	1,126,000	713,000	166,000	369,000	22,000	....	672,000
North Carolina	1,675,000	200,000	735,000	....	....	....	....	....	740,000	....
Ohio	1,911,000	25,000	20,000	187,000	202,000	818,000	242,000	289,000	....	....
Pennsylvania	9,283,000	990,000	21,000	4,806,000	2,015,000	50,000	13,000	25,000	....	1,278,000
Tennessee	1,077,000	....	60,000	5,000	....	....	71,000	....	100,000	....
Vermont	116,000	20,000	6,000	....	20,000	15,000	5,000	....	....	....
Virginia	9,159,000	6,493,000	385,000	....	10,000	131,000	30,000	....	551,000	....
Washington	210,000	....	10,000	....	....	....	....	....	....	....
Wisconsin	7,946,000	52,000	538,000	....	37,000	5,449,000	260,000	483,000	....	947,000
All other States*	574,000	135,000	20,000	....	....	....	....	....	....	....

*Includes Arizona, California, Delaware, Idaho, Maryland, Mississippi, Oklahoma, Oregon, Rhode Island, South Carolina, Texas and West Virginia.

TABLE IV—Continued. QUANTITY (SETS) OF SLACK BARREL HEADING MANUFACTURED—BY KINDS OF WOOD AND BY STATES AND TERRITORIES. 1908.

STATE	SPRUCE	OAK	COTTON-WOOD	HEMLOCK	YELLOW POPLAR	CHESTNUT	TAMARACK	SYCAMORE	WILLOW	ALL OTHER
United States	2,245,000	2,092,000	2,067,000	1,277,000	791,000	779,000	431,000	271,000	240,000	784,000
Alabama	…	…	…	…	…	…	…	…	…	…
Arkansas	…	…	…	…	…	…	…	…	…	3,000
Florida	…	…	…	…	…	…	…	…	…	…
Georgia	…	…	…	…	…	…	…	…	…	8,000
Illinois	…	8,000	33,000	…	…	…	…	30,000	…	8,000
Indiana	…	50,000	135,000	…	…	…	…	60,000	…	…
Kentucky	…	78,000	44,000	…	104,000	29,000	…	84,000	3,000	…
Louisiana	…	30,000	1,190,000	…	…	…	…	…	210,000	…
Maine	1,980,000	1,000	82,000	38,000	…	…	…	4,000	…	306,000
Massachusetts	15,000	10,000	9,000	…	…	10,000	…	…	…	…
Michigan	…	161,000	103,000	1,137,000	…	…	85,000	24,000	2,000	…
Minnesota	…	40,000	201,000	…	…	…	296,000	…	…	…
Missouri	…	…	98,000	…	…	…	…	…	…	…
New Hampshire	…	…	…	…	…	41,000	…	…	…	…
New York	…	207,000	53,000	52,000	…	400,000	…	…	25,000	28,000
North Carolina	…	…	…	…	…	…	…	…	…	…
Ohio	…	43,000	17,000	…	17,000	…	…	49,000	…	2,000
Pennsylvania	…	65,000	…	…	…	20,000	…	…	…	…
Tennessee	…	380,000	…	…	356,000	85,000	…	20,000	…	…
Vermont	50,000	…	…	…	…	…	…	…	…	…
Virginia	…	981,000	20,000	…	314,000	144,000	…	…	…	100,000
Washington	200,000	…	…	…	…	…	…	…	…	…
Wisconsin	…	5,000	74,000	50,000	…	…	50,000	…	…	1,000
All other States	…	33,000	8,000	…	…	50,000	…	…	…	328,000

*Includes Arizona, California, Delaware, Idaho, Maryland, Mississippi, Oklahoma, Oregon, Rhode Island, South Carolina, Texas and West Virginia.

following States, named in the order of their importance from a standpoint of quantity: Arkansas, Pennsylvania, Michigan, Virginia, and Missouri. In the production of elm staves Michigan leads, followed by Ohio, Illinois, and Missouri. These four States produce the bulk of this stock. Maple staves are produced chiefly in Michigan and Pennsylvania. Nearly one-half of the total number of pine staves is produced in Virginia. This gives Virginia her rank of fourth place in order of importance for number of staves. Missouri leads in the manufacture of gum staves, producing more than one-third of the total manufactured, followed by Arkansas and Illinois. The oak staves, practically all of which are some form of red oak, are manufactured chiefly in Virginia and Tennessee. Chestnut staves are manufactured almost entirely in Pennsylvania, which produced over two-thirds of the total manufactured. Beech and birch staves are also manufactured chiefly in Pennsylvania, as nearly one-half of the total number come from that State. Ash staves are produced mostly in Arkansas. Maine ranks first in spruce staves, having produced over 80 per cent. of the total manufactured. The quantity manufactured from the other species in that State is comparatively unimportant. Delaware, Maryland, and Florida, as reported, manufacture pine staves exclusively.

SLACK BARREL HEADING PRODUCTION

Table IV shows that the total production of heading for 1908 was 123,849,000 sets, thirty-five States and Territories reporting; but Michigan and Arkansas were the centres of manufacture. Michigan led with 18.2 per cent. of the total number of sets of heading, and Arkansas came second, with 16.5 per cent. In 1907 Michigan and Pennsylvania were the leading States, but in 1908 their heading production had decreased 3.2 per cent. and 8.1

per cent., respectively, and the production in Arkansas had increased 241.1 per cent. In the production of red gum heading Missouri was the leading State, with 34.5 per cent., followed by Arkansas, with 20.6 per cent., and Kentucky, with 18.8 per cent. Of the pine heading, 39.4 per cent. was made in Arkansas, while Virginia and New Hampshire were close rivals for second place, with 16.5 per cent. and 16.2 per cent., respectively, of the total production. Michigan reported 56.1 per cent. of the beech heading and 59.7 per cent. of the maple heading, while Pennsylvania ranked second in both of these kinds of wood, with 31.4 per cent. of the former and 15.1 per cent. of the latter. The only other wood of which more than 10,000,000 sets were produced was basswood, and of the total production of this wood Wisconsin reported 53.5 per cent. and Michigan 20.6 per cent. Over three-fourths of the entire heading production of Arkansas was pine. From Michigan a large number of woods were reported, the chief kinds being beech, maple, and basswood. In Pennsylvania the principal woods were beech, maple, and birch, while in Virginia pine was practically the only wood used, although several other kinds of wood were reported in small quantities.

SLACK BARREL HOOP PRODUCTION

Table V shows the production of slack barrel hoops in 1908 by States and by kinds of wood. In distinct contrast to slack stave and heading manufacture, the hoop production is to a large extent localized and the sources of material limited to a relatively small number of species. Of the total number reported for the United States (336,484,000) elm is credited with a production of 326,-894,000, or 97.1 per cent. Ohio, Michigan, and Indiana together reported 277,121,000, or 82.4 per cent. No wood besides elm was reported as forming more than 1 per

TABLE V. QUANTITY OF SLACK BARREL HOOPS MANUFACTURED—BY KINDS OF WOOD AND BY STATES FOR 1908

State	Total	Elm	Red Gum	Ash	Birch	Hickory	Oak	Maple	Chestnut	Beech	Pine	All Other
United States..	336,484,000	326,894,000	2,863,000	2,135,000	1,173,000	1,510,000	586,000	307,000	180,000	131,000	105,000	600,000
Arkansas	15,256,000	15,144,000					112,000					
Georgia	155,000	15,000		35,000	80,000		25,000					
Illinois	12,500,000	12,500,000										
Indiana	73,934,000	73,904,000				30,000						
Kentucky	1,950,000		750,000	250,000		900,000	40,000				10,000	
Maine	2,867,000	1,924,000		2,000	783,000		122,000	25,000		11,000		
Michigan	87,889,000	86,489,000	400,000	1,000,000								
Missouri	8,563,000	8,490,000	73,000									
New Hampshire	1,300,000	780,000		48,000	60,000		180,000	12,000	80,000	120,000	20,000	
New York.......	530,000	30,000			250,000			150,000	100,000			
Ohio	115,298,000	113,476,000	1,622,000				80,000	120,000				
Pennsylvania ..	258,000	250,000	8,000									
Tennessee	14,239,000	13,872,000	10,000			330,000	27,000					
Washington	600,000											600,000
Wisconsin	1,050,000			800,000		250,000						
All Other States*	95,000	20,000									75,000	

*Includes Florida and Virginia.

cent. of the total amount. Kentucky produced 60 per cent. of the hickory hoops, while New York led in the production of maple and chestnut hoops. Michigan produced 46.7 per cent. of the ash hoops, and Maine 66.7 per cent. of the total number of birch hoops. The elm hoop production was reported from 13 States, though 83.8 per cent. of the production from this kind of wood was manufactured in three States—Ohio, Michigan, and Indiana. While the elm hoop maintains its prestige over other woods, iron in late years, to a considerable extent, has supplanted wood as hoop material for certain kinds of slack barrels. Elm as a wood is especially adapted to the manufacture of hoops, on account of its great toughness and flexibility, and for this reason it is doubtful whether it will ever be superseded by any other wood. Hickory would possibly be as acceptable if it grew in sufficient quantities and could be manufactured cheaply enough to compete with elm. There is no doubt but that in the future all slack barrels will be bound with either wire or flat steel hoops.

REVIEW OF FOREST REPORT

From a study of this forest report, it will be seen that it shows red gum as ranking first in the quantity of staves manufactured, it having exceeded pine by nearly 42,000,000, and elm by 125,000,000, while for the year previous, 1907, it only exceeded pine by 5,000,000, and elm by 52,000,000 staves, showing that red gum is rapidly coming into favor as a stave and heading wood. This was to be expected; in fact, gum is destined to be the future wood used in the construction of the slack barrel. As a heading wood red gum ranked second in 1908, having moved up from fourth place in 1907, being exceeded by pine in 1908 by over 22,000,000 sets. No doubt pine has also been growing in prominence in the slack cooperage industry, in fact, more than it has been given credit for, and must have been favored for other cooperage purposes besides salt and lime barrels. From this report it will be seen that more than one-half of these pine staves and 16.5 per cent. of the heading produced are manufactured in the State of Virginia, and is the cause of Virginia taking fourth place in the rank of States, according to the quantity of staves and heading produced, and it gives Virginia much more prominence in the slack cooperage trade than one might judge it had from a review of the markets.

About one-half of the total production of staves as reported, were manufactured in the following four States, named in the order of the quantity produced: Arkansas, Pennsylvania, Michigan, and Virginia. Red gum comes principally from Missouri and Arkansas, these two States having furnished 96.2 per cent. of the total production of staves. Elm, maple, and hemlock are mostly manufactured in Michigan, while Pennsylvania ranks first in the production of beech, chestnut and birch staves, and Arkansas and Missouri are the main sources of supply of the ash staves. Maine ranks first in spruce, having furnished about 81.7 per cent. of the entire production. Michigan ranks first in the manufacture of heading, with Arkansas a close second, Pennsylvania third, and Virginia fourth. These four States furnish practically one-half of the total heading production. Ohio ranks first as a producer of hoops, leading Michigan, which comes second, by nearly 28,000,000 hoops, Indiana being third, these three States being the principal hoop centres, having furnished 81.8 per cent. of the total production. It may be possible that these figures as to exact source of supply may be affected somewhat by the headquarters or the selling points of certain hoop mills being located in the cities of the States named, and the reports emanating therefrom instead of direct from the different mills. The item of hoops admittedly does not take into due consideration large quantities of hand-shaved hoops of hickory and other woods which are made by farmers and others who are not classed as manufacturers, and consequently do not furnish reports. The most remarkable point about this forest report, and the two unexpected conditions found therein. One is the fact that it has red gum as ranking second to elm as a hoop wood and as to quantity produced, and the other and most astonishing feature is the high price obtained for them, it ranking first in value, being $11.42 per thousand; while hickory, oak and elm, admittedly the better wood for hoops, rank second, third, and eighth, respectively. And also that it ranks pine as being fifth in value, while ash, elm and chestnut rank seventh, eighth, and ninth, respectively.

SECTION VII

HARVESTING RAW MATERIAL

HARVESTING RAW MATERIAL

The harvesting of raw material for the production of slack cooperage stock is a matter which few cooperage concerns have succeeded in reducing to a scientific system. Of course, each manager will inaugurate details that are best suited to his locality and that he can best manage. But some general rules will apply to all. First, never allow the supply of timber to become exhausted when conditions will warrant the full operation of the factory. Second, do not overstock with raw material to such an extent that some of it will rot and become worthless before it is worked up into the finished material. Third, do not purchase or transport to the mill such raw material that will not work up economically into that for which it is intended. It does not pay to allow the supply of raw material to become exhausted at the mill when there is a demand for the finished product, because there are always certain fixed expenses which must be met, such as taxes, insurance, salaries, and maintenance of plant, etc., whether the factory is producing its revenue or not. And the larger the concern, the heavier this fixed expense becomes, and this must all be earned when the mill is again in operation. Hence the necessity of keeping the machinery at work when there is a demand for the finished product. If an overstock of raw material for any particular class of cooperage stock is purchased or logged and kept on hand too long, its value becomes impaired by rot, sun checks, etc., and often the wood becomes so hard through seasoning that it is more difficult and expensive to work, whereas, had it been worked promptly when it was green and fresh from the tree, it would have been handled with greater profit and less waste, to say nothing about the convenience.

The near approach of the time when it will be inexpedient or impossible to manufacture slack staves from elm or slack barrel heading from basswood makes the question of producing them from other woods, such as beech, birch, maple, and gum, one of great importance and interest. Cottonwood timber as a stave proposition is also a thing of the past, or nearly so; in fact, it is in about the same position as elm, and it is only a matter of a very short time when cottonwood staves, as well as elm staves, will be produced in very small quantities. Some of the woods that produce excellent slack cooperage stock rot or decay rapidly unless continuously kept immersed in the log pond. Different species differ in their resistance to decay; for instance, basswood is more durable than pine in this respect, and oak is better than beech, but in most cases the conditions of warmth and moisture in particular locations have much to do with its durability. So much so, in fact, that predictions as to its durability become mere guesswork. Sapwood of any particular species is always more subject to decay than the heartwood, and doubly so where the latter is protected by resinous substances, such as in pine and cedar. In fact, all woods that contain thick sap, such as gum, sycamore, poplar, etc., are more liable to decay and rot than woods that have a thinner sap. It would be impossible to operate a stave or heading mill profitably and waste the sap portion of the timber. It has been found that several months' immersion in water improves the durability of sapwood to a considerable extent, but only impregnation with preservative salts seems to render it perfectly secure, and this operation is entirely out of the question. But wood kept immersed in water will remain practically the same

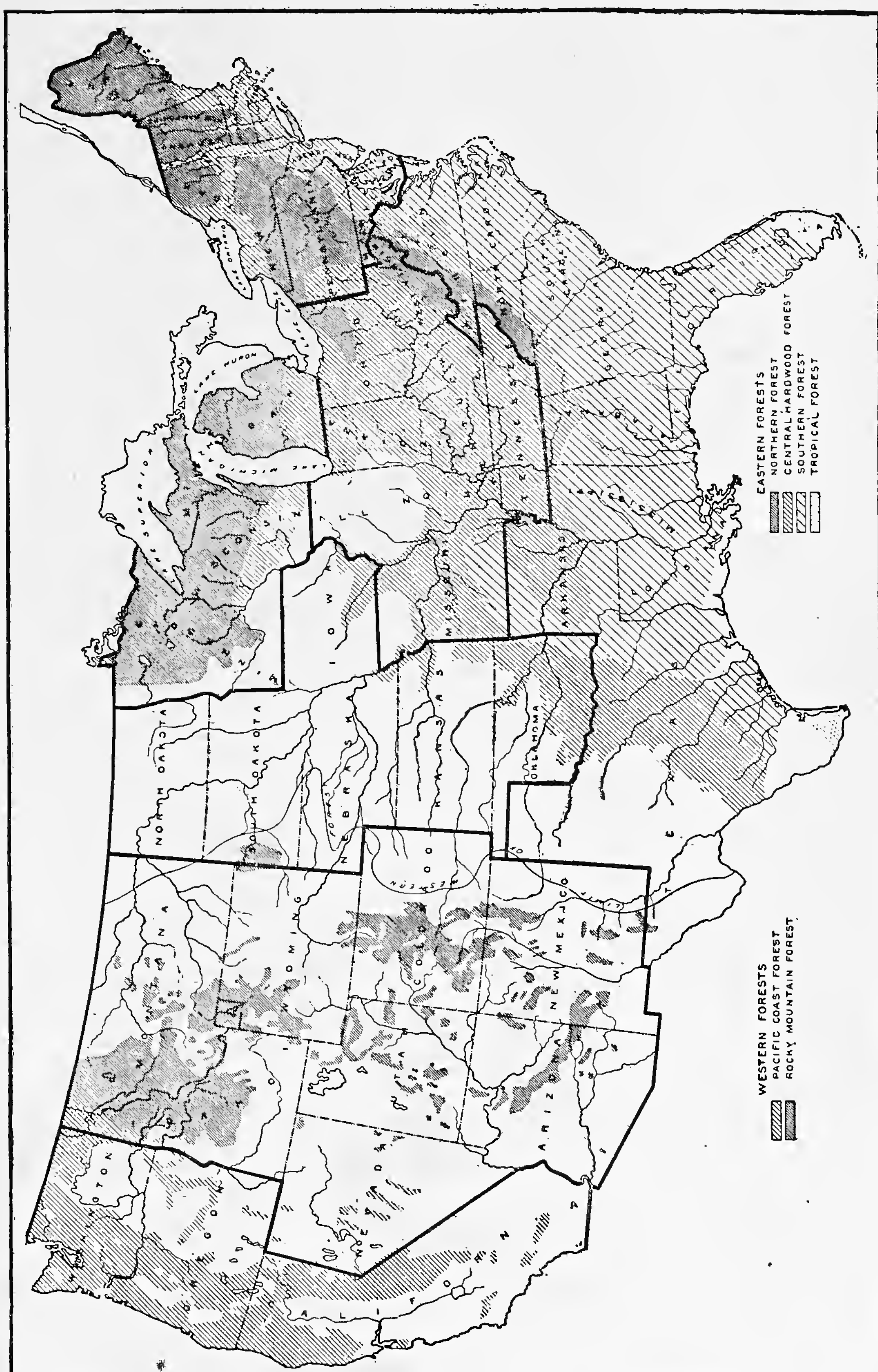


FIG. 44. FOREST REGIONS OF THE UNITED STATES. The unshaded areas are treeless, except along the streams.

for centuries. It is only when living organisms attack it with their strong solvents and convertants that change and decay set in.

This impresses one with the fact that too much attention cannot be given to the care of the logs before they are sawn or worked up into stock in order to secure the maximum amount of timber with the least possible waste; and it has been proven that in the ordinary run of mills, only about 50 to 60 per cent. of the contents of the log which goes into the mill finally emerges in the manufactured form of the finished product. And that in the case of heading, only about 25 per cent. of the actual volume of the log finally goes into the barrel head, leaving the enormous waste of 75 per cent. of the timber furnished the mill for stock manufacture to be eventually used as fuel, or dragged out into the yards to be used as filling for mudholes, or disposed of through other means from which the mill owner derives no revenue. The total percentage of ultimate waste in manufacturing cooperage stock, even in the best-regulated plants, is enough to make a man's hair stand on end. This is *the* point in slack stock manufacture that will bear watching, providing one wishes to study economy in mill operation.

TIME OF FELLING

Winter felling of trees has long been the general rule, since conditions continue to make it the best and most economical season for the logger. Moreover, sap contains fewer nitrogenous substances in winter than at any other season, and since fungi obtain much of their food from these substances, winter-cut timber, on account of the low temperature of the season, is least liable to attack from this source. Wood cut in the fall of the year, when the sap is down, usually seasons more gradually, and at that time of the year the wood fibres shrink more uniformly, and thus checking is less serious. Though in nearly all cases winter-cut wood is heavier than wood cut at any other season, yet, after six or eight months' seasoning, under ordinary climatic conditions, it so nearly approaches the weight of the lightest, that the

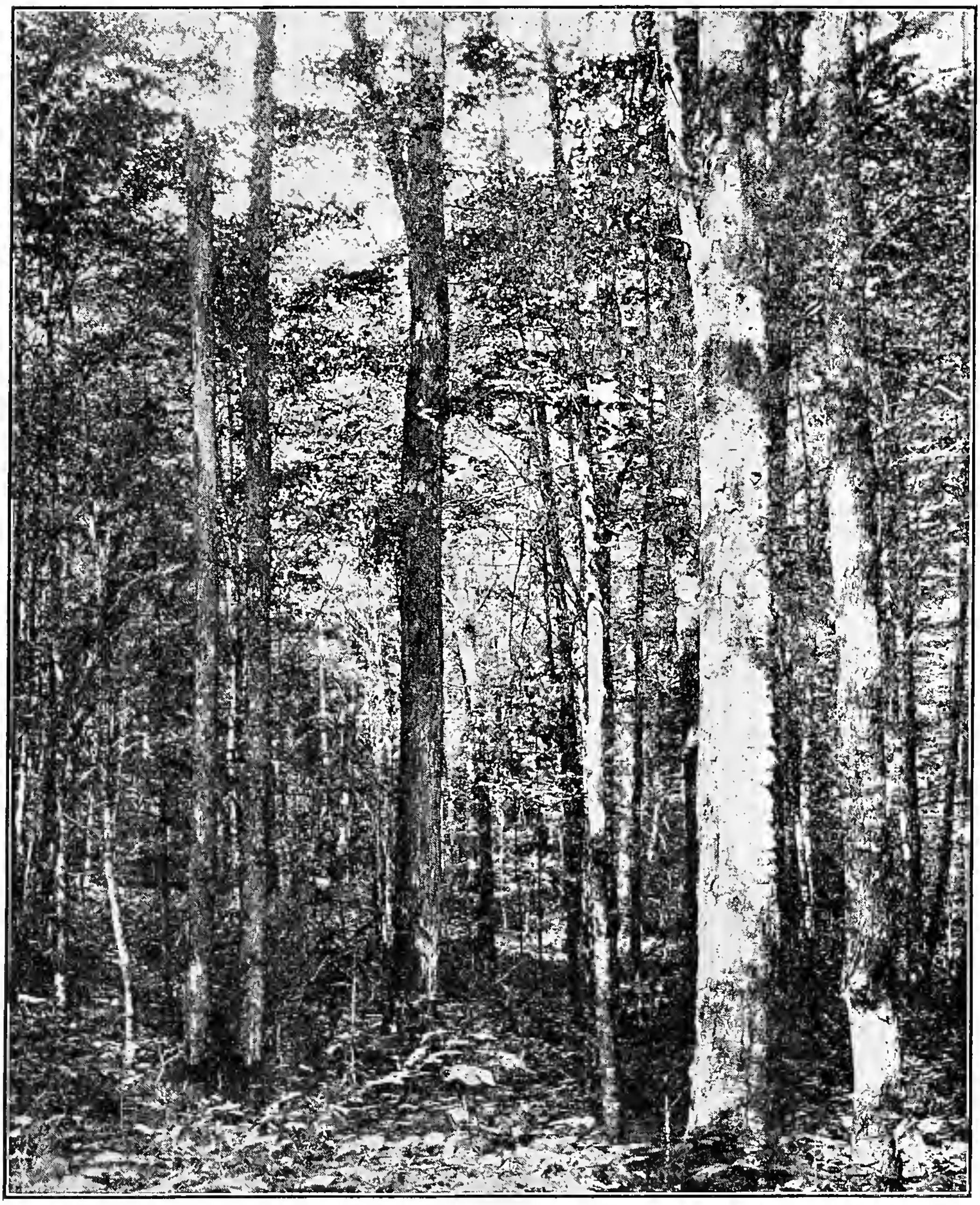


Fig. 45. A Typical Hardwood Forest, with Undergrowth of Young Beech and Maple and Scattering Witch Hobble and Moosewood.

difference is practically negligible. From the standpoint of seasoning, checking, and susceptibility to decay, spring and winter are the best seasons of the year for cutting. Other considerations, such as custom, availability of labor, etc., also make winter cutting preferable. But aside from these preferences, the season of the year or

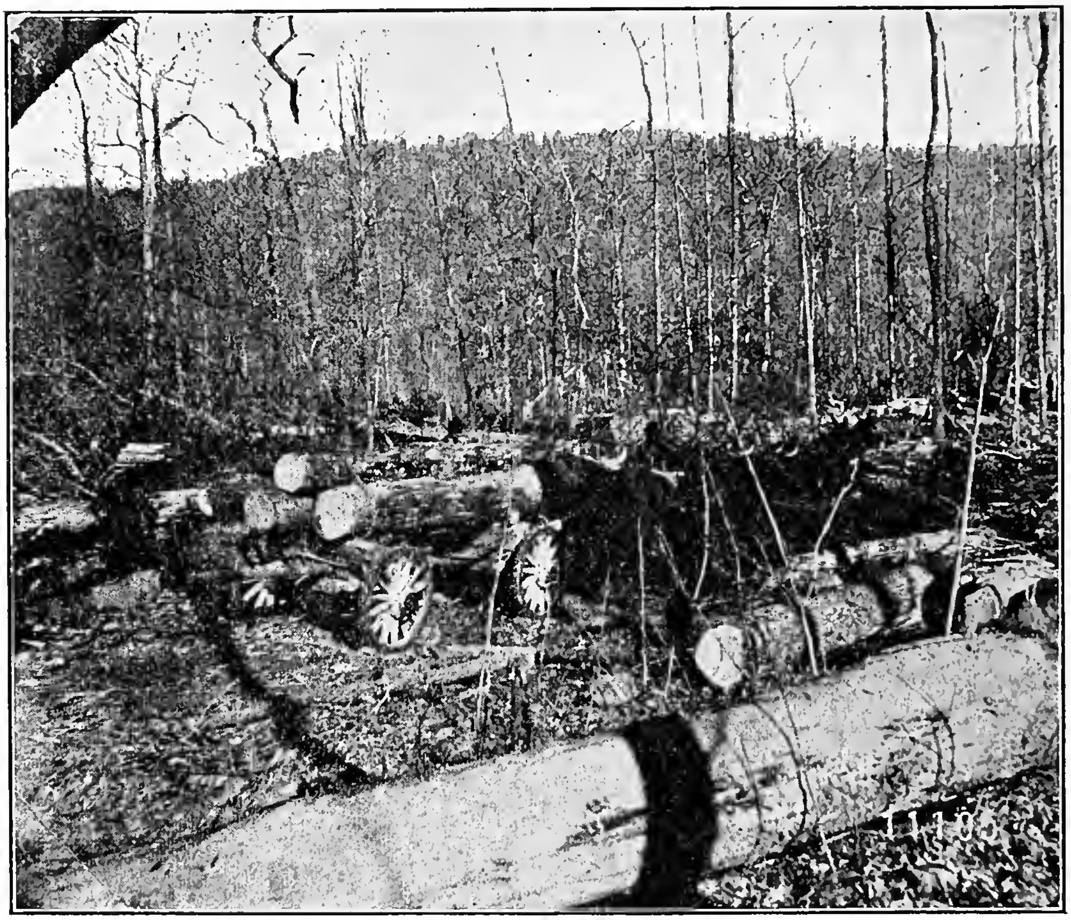


Fig. 46. Hauling Logs, a Familiar Picture to the Woodsman.

the phase of the moon has no noticeable influence on its strength or durability; in short, seasoning does not in itself furnish a conclusive argument for cutting in any one season, as, if the wood is properly taken care of, by being promptly worked up and protected by proper methods in piling or by seasoning and kiln-drying, there would be no noticeable difference between summer and winter felled wood.

Usually, summer-felled wood, on account of the prevalent high temperatures, and at times to unnecessary exposure to the sun, the wood checks more rapidly if left for any length of time to the weather than winter-felled wood; and since season checks favor the entrance of both

FIG. 47. WASTE IN WOODS OPERATIONS. An unnecessarily high stump; also a sound log overlooked by the woodsman.

moisture and fungus, which facilitate destruction, it is therefore considered more advisable to cut timber during the winter season. Trees normally contain the greatest amount of water during that period when the roots are active and the leaves are not yet out. This activity commonly begins in January, February or March, the exact time varying with the kind of timber and the local atmospheric conditions. And it has been found that green wood becomes lighter or contains less water in late spring or early summer, when transpiration through the foliage is most rapid.

The amount of water at any season, however, is doubtless much influenced by the amount of moisture in the

Fig. 48. Good and Bad Cutting. The small trees have been left to seed up the opening made by the removal of the larger ones, but the stumps show unnecessary waste, in that they have been cut much higher than was necessary.

soil. The conclusions, then, taken from the arguments as set forth, would be that "winter-cut" wood seasons more regularly than that cut at any other season of the year, but does not, for many months at least, reach as low a weight as wood cut in late spring or early summer which is seasoned equally as long; that in timber of approximately the same age and growth, that cut in the winter season will have the greatest specific gravity, while that which is cut in autumn will have the least; that from the standpoint of seasoning, spring and winter are the best times for cutting, and that if timber is carefully cut,

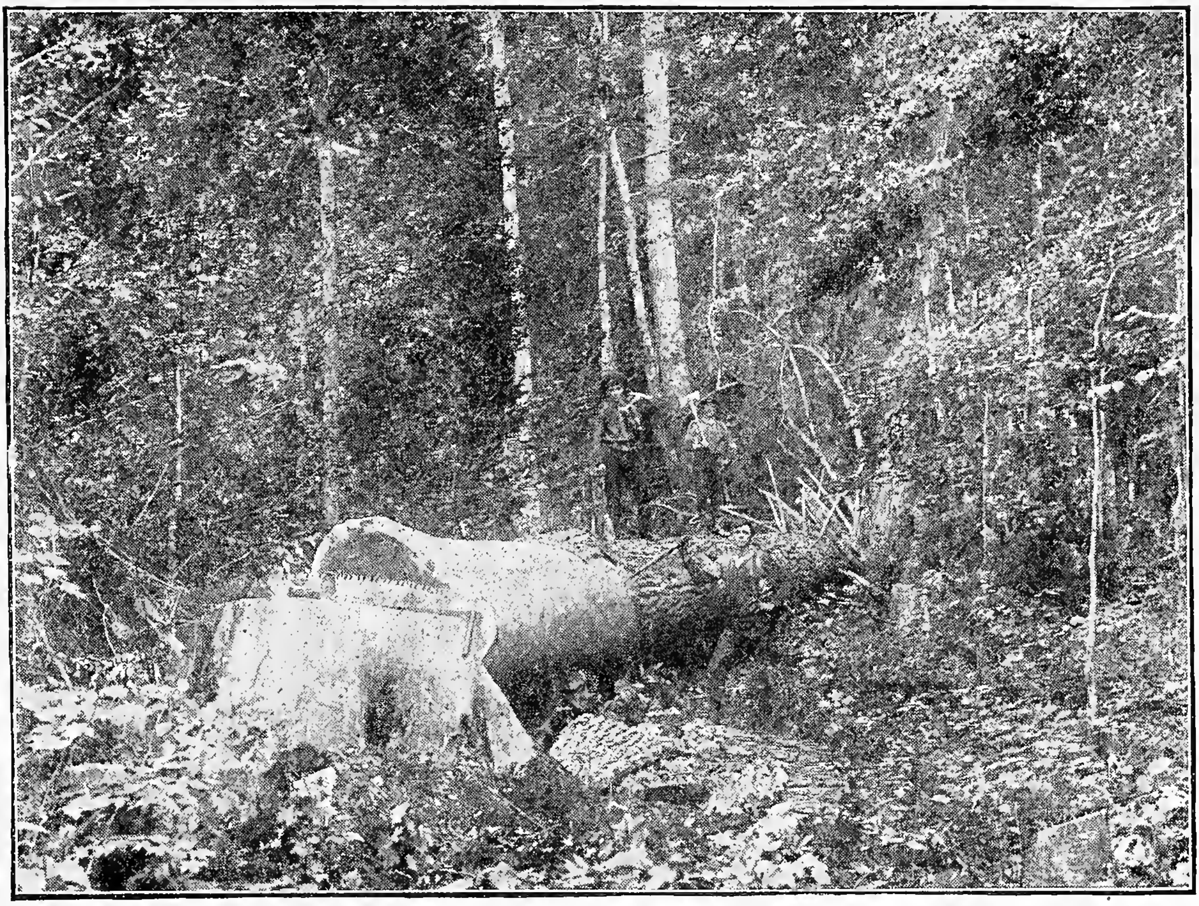


FIG. 49. A LARGE HEMLOCK.

checking during air seasoning is comparatively slight; but if the timber is split or shattered in felling, serious checking may result; that if wood which is cut in the summer season is protected or given the proper care and attention as mentioned, no noticeable difference exists. So that the practical consideration in favor of winter cutting is of determining importance.

WOODS MANAGEMENT

Where cooperage stock manufacturers do their own logging or cut their own raw material in the forests, it is highly imperative that the woods foreman should be a practical man, thoroughly conversant with the business and methods "at the mill," and have a knowledge as to

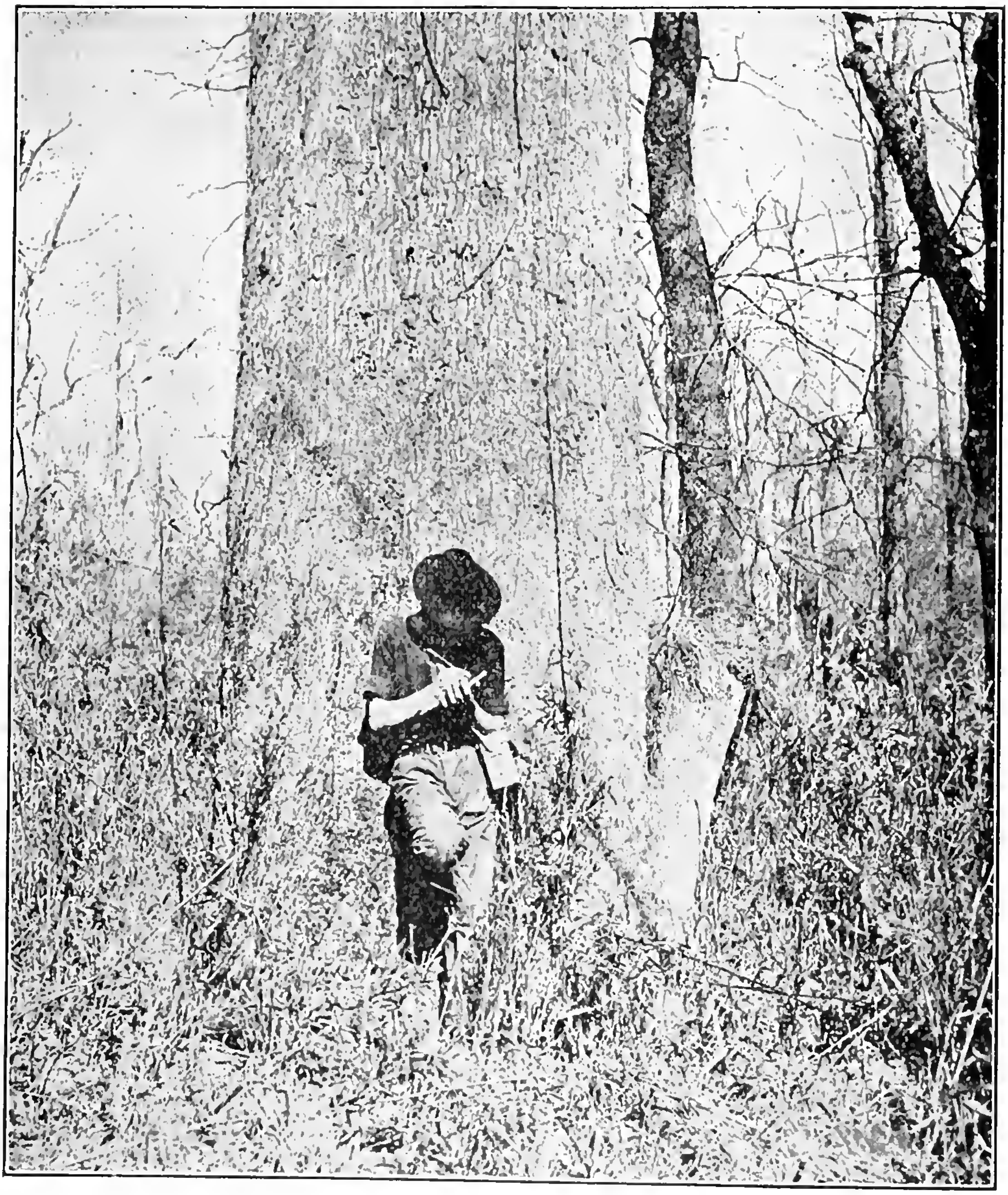


FIG. 50. A LARGE RED GUM.

the purpose for which a log or tree is best suited. He should also be well trained in the matter of economy in waste, as there is no doubt but that the greatest quantity and percentage of waste can be traced to this quarter (see Figs. 47 and 48), where a lack of careful supervision

Fig. 51. A Large Cottonwood. One of the associates of red gum.

and knowledge often leads to wilful destruction of valuable timber. And in view of the rapid decrease in the supply, it would be well in all forest operations to give more attention to this point. Logs or bolts are often cut at an inopportune time, or more rapidly than is necessary, and left lying in the woods (see Fig. 55) until they discolor, check, decay, or become sour and useless for the purpose for which they are intended.

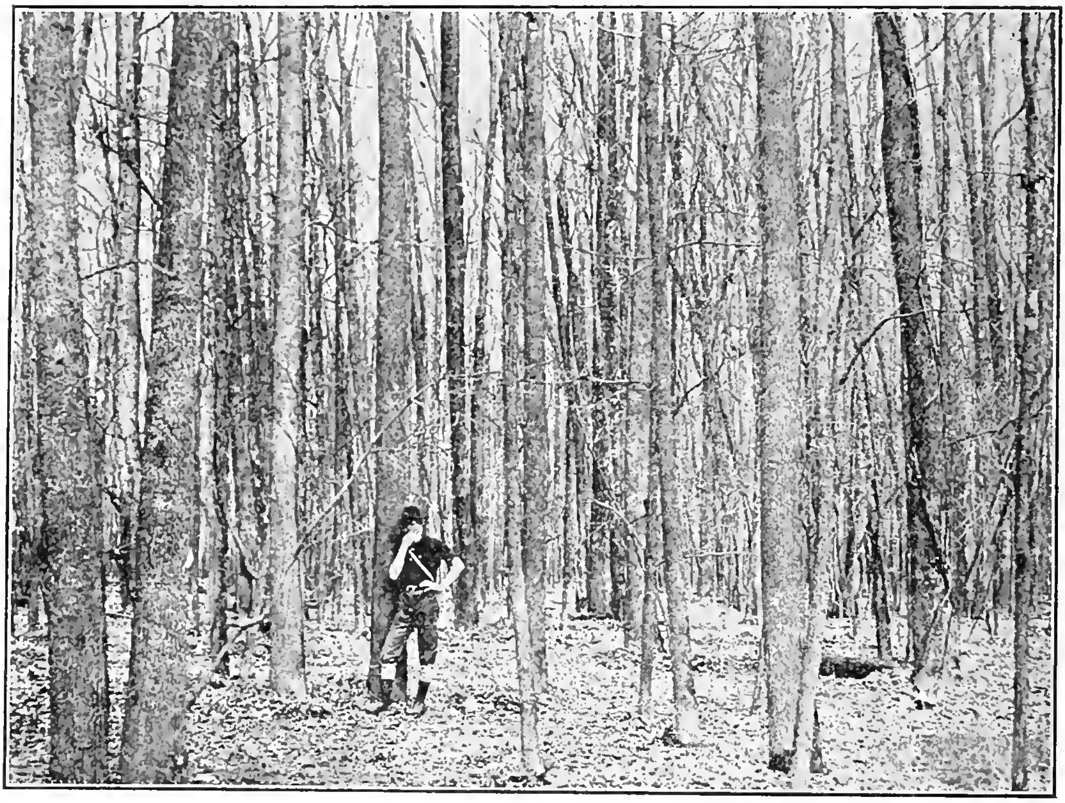


Fig. 52. Second Growth Red Gum, Ash, Cottonwood, and Sycamore.

The woodsman should also appreciate the fact that stave and heading mills can sometimes utilize a block 16 or 18 inches long, as well as a log 16 feet in length. Still, thousands of such short blocks of apparently good quality, or tops, the lower ends of which would make excellent stave or heading bolts, are abandoned and left in the woods to rot and decay (see Fig. 47), whereas if these short blocks were sent to the mill, staves or headings could possibly be made for the smaller sized packages and a saving created which would be astonishing to even the most economical of mill operators. Considering the waning supply of timber suitable for use in the slack cooperage industry, it would

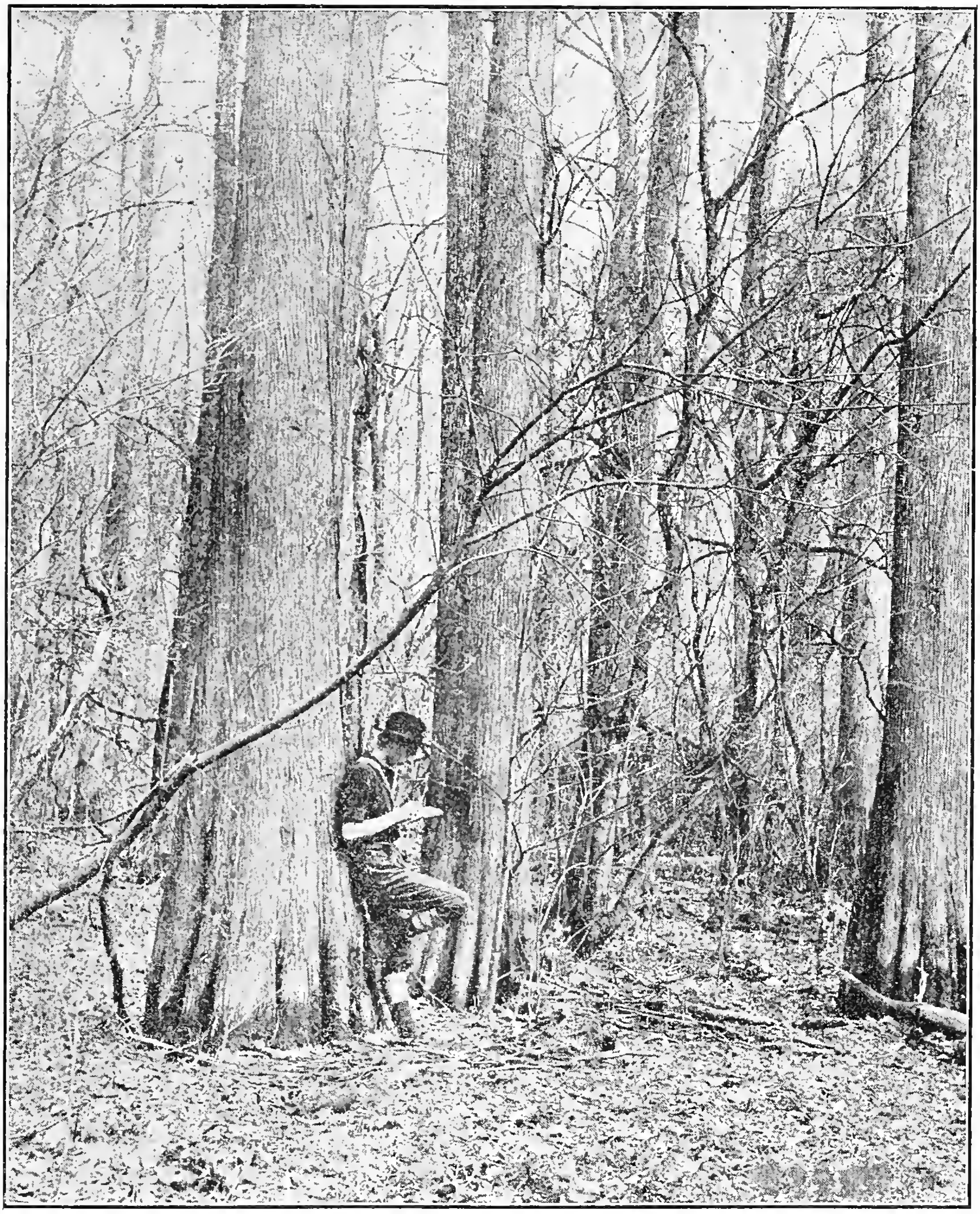


Fig. 53. A Cypress Slough in the Dry Season.

be well for all operations in the woods to be planned with a view to encouraging reproduction. This object can best be accomplished by cutting conservatively at present, by using the utmost care to preserve and protect the younger trees, and by keeping fires off the land. Cutting without any regard to a diameter limit or with no inten-

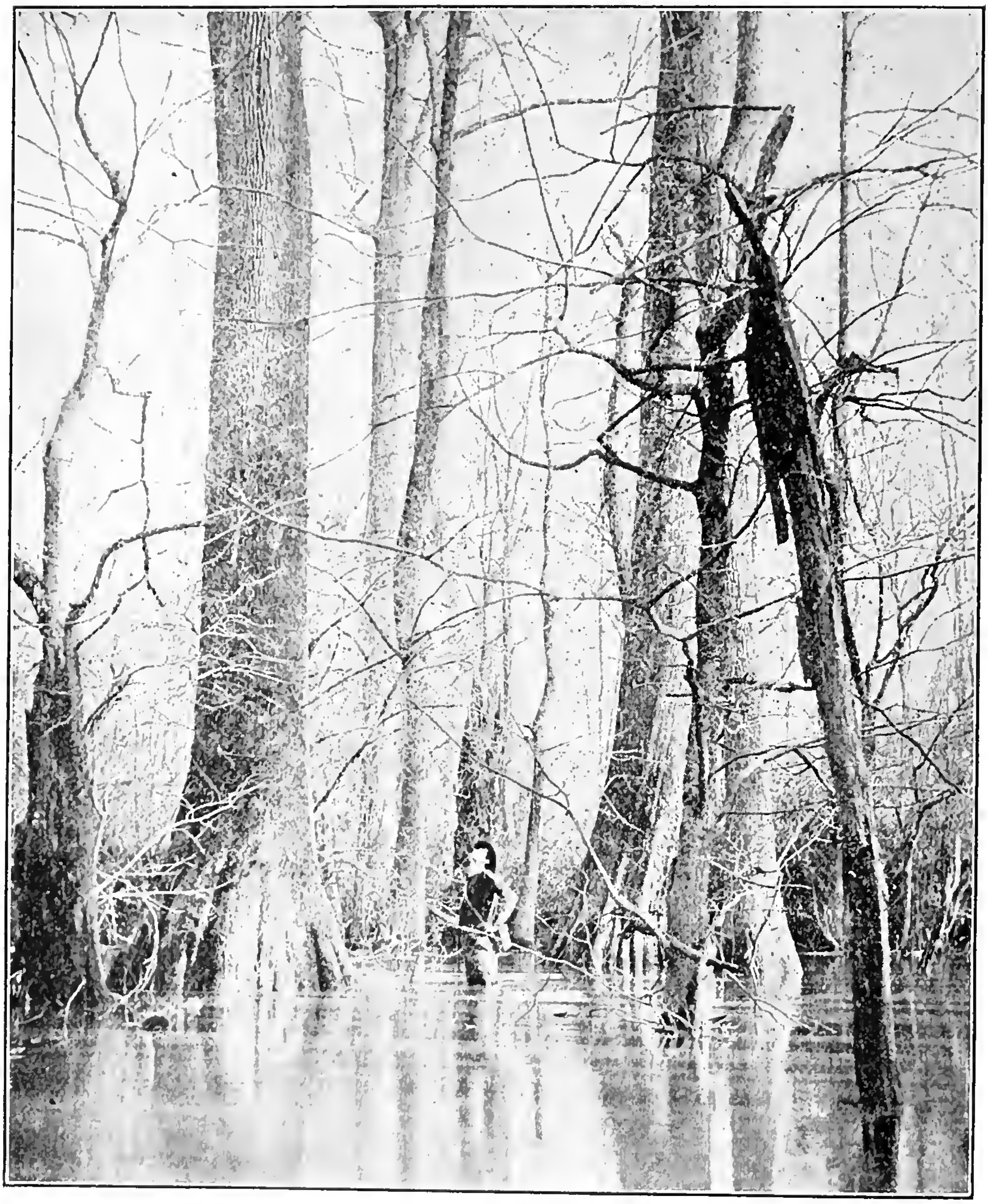


Fig. 54. A Tupelo Gum Slough.

tion of leaving seed trees is the most unsatisfactory method, as is shown by the present depleted condition of our forests. Had these principles been inaugurated in all woods operations twenty years ago, we would not now be seeking substitutes for the woods which are rapidly being exhausted.

Owing to the number of different species in the forests, the diameter to which trees are now cut varies

FIG. 55. PEELED RED GUM LOGS SEASONING IN THE WOODS.

considerably. It hardly pays to take out logs less than 8 inches in diameter at the small end, or 10 inches breast high. Trees under 10 inches breast high should not be taken, as the extra amount of labor incurred in handling these small logs, together with the difficulty experienced in producing good stock, does not warrant such wilful destruction or demoralization of our source of supply. Some mills have been known to cut stock from trees 6 to 7 inches in diameter. Staves produced from such timber are not fit for first-class packages, as being necessarily "bastard cut," they warp and shrink unevenly in drying, and will not stand the strain subjected to them in the modern methods of machine manufacture. Of course, they would answer for fruit or vegetable packages, when manufactured by hand, but should be sold as such, and not as an A No. 1 stave for other purposes. In cutting, all possible care should be exercised to save the younger trees, as they are the future forest supply, and waste should be avoided by cutting as low on the stump and utilizing as much of the tree as practicable. (See Figs. 47 and 48.) The forest is seldom clean enough to allow of much reproduction, and anything that will tend to reduce the waste will therefore be of great benefit, both to the operator and to the young seedlings that are springing up in the bed of the forest. Small trees should not be cut, present methods notwithstanding to the contrary, and in logging every effort should be put forth to save them. Whatever young growth is left on the ground after cutting will form the basis of the next crop of timber, and the seedlings which start at this time form the nucleus of future crops. The object in view should be to obtain the greatest yield from the land in two cuttings, perhaps twenty years apart.

Working plans of such nature are particularly successful on hardwood bottom land, for the species there are nearly all of rapid growth, and protection from fire is fairly simple. Careful management in all cases is strongly advisable, as much of the land when cut over promises to produce worthless woods unless care is taken to leave seed trees and to favor the young growth of desirable species. With proper forest management, land is capable of yielding permanently high returns.

THE DIFFICULTIES OF TRANSPORTING GUM

In the handling of red and tupelo gum, a large proportion of this wood growing in the South and along the Atlantic Coast is usually transported from the forests to the mills by means of the streams. The unusual weight of the green timber of this species is so great that it scarcely floats. Probably one-third of the logs, those with the largest amount of sapwood, sink. On the coast, where the percentage of sapwood is larger than in the Mississippi States, very few, if any, of the logs will float. To overcome this difficulty, various methods of driving out the sap of the logs before they have been thrown into the water have been tried. For small operations, the method usually employed is to fell the trees in the fall, peel them, and allow them to lie two or three months in the woods (Fig. 55) before they are floated or until the high water sets in, late in the winter, when the logs are floated along roads cut through the forest to the river, and thence rafted or floated down to the mills. In some cases girdling is resorted to, allowing them to die on the stump. The girdling is done in the summer season, usually starting about the first of July and continuing to within ninety days of high water. It has been found by experience however, that though these methods render the log floatable, they cause the sapwood to decay by exposing it to the air and weather, and thus destroy much of the marketable value of that part of the tree. In the early history of gum it was thought by many mill men that if the tree was girdled one year, allowed to die, and afterward cut, that the amount of red or heartwood would be increased. This was based on the theory that the darker color of the heartwood was caused by the death of the sapwood, and that the killing of the tree would tend to change the sapwood into heartwood. This theory has been exploded and abandoned, and in cutting gum, little girdling is now done for this purpose. Owing to the large supply of this timber in the Southern forests, and its cheapness as compared to other species, it will no doubt be looked upon with more favor as a cooperage wood in the years to come, and its price will doubtless remain where it is for a few years at least. After this, since the supply of gum will rapidly diminish, it will increase accordingly in value.

SITE AND ARRANGEMENT OF THE MILL

In the selection of the mill or factory site, good judgment and tact is essential, for if the plant is not properly situated, so as to receive the raw material and dispose of the finished product to the best possible advantage, the manufacturer will find it very perplexing, and be at a disadvantage and unable to compete with his competitors, who are fortunately more suitably located. Unless the mill is arranged in such a manner that the different stages of manufacture are carried out in progressive order, there will be a considerable amount of unremunerative labor. The ideal mill or factory is that in which there is no unnecessary handling of raw material, and in which everything when received at the works is stored so as to be readily available when needed, and thereafter so handled throughout the whole course of manufacture that it will not go through any backward movement, but forward from stage to stage, until ready for the market. A mill pond is essential to all well-equipped plants, where economy is sought, although it is not an absolute necessity, excepting where the supply of timber is cut during the winter for the entire year. Then a good sized pond is necessary, for it not only preserves the timber, but it is beneficial and economical in handling same from storage to mill. Next in importance is the question of grades, elevation, balance and the law of gravitation. The first operation of the mill should be to elevate the raw material to a point where it would be a continual down grade until the finished product reached the car or loading point, ready to be billed out, with the least possible amount of labor in handling. This may seem to some to be trivial, but is of primary importance in all mills where economy is sought in the manufacture of cooperage stock, and economy coupled with brainy management is necessary, especially in the manufacture of cooperage stock to-day, as the future of the barrel as a popular package very largely depends upon the use of modern methods and the practice of such economies in order that its cost may be kept within the necessary limits, beyond which it is not safe to go.

The machinery on the market to-day for the manufacture of slack cooperage stock is worthy of comment, and the manufacturers of same have accomplished much. They have given us machines and appliances with which we can, with the proper care, produce first-class stock from raw material in an efficient and able manner. The rapidity, perfection, and complete adaptability of these machines for their especial purpose are exceedingly creditable, and these modern machines and appliances should be installed wherever it is possible to use them, in order to lessen the expense, make the work easy, or more rapid in its production.

THE UNLOADING SWITCH

Whether a log pond is installed or not, the road bed of the unloading switch which brings the logs or raw material to the mill should be so constructed with the proper amount of slant toward the pond or receiving platform that when the trip chains are loosened with a cant hook, which is easily accomplished, the logs will roll of their own accord into the pond. This is another point in economy that should not be forgotten, as one man can easily and without much effort discharge a trainload of logs in a very short space of time.

THE SLACK STOCK MILL

Mills for the manufacture of slack stock are of several different types. Some manufacture staves only, others heading only, some manufacture staves and heading while still others manufacture staves in connection with a hoop mill, generally making elm staves especially. And, again, some mills manufacture staves, heading and hoops, which is an ideal arrangement, as the logs can then be worked up into that class of stock for which they are best adapted. Ordinarily, staves when manufactured at a hoop mill do not run as large a per cent. No. 1 from the fact that the better grade of logs must necessarily be cut into hoops. If the staves are carefully graded, usually from 40 to 60 per cent. is considered favorable. Heading would be more suitable for manufacture in connection with a hoop mill than staves, from the fact that the bolts are shorter, and a poorer grade of timber can be utilized more advantageously than in staves or hoops.

SECTION VIII

SLACK STAVE MANUFACTURE

SLACK STAVE MANUFACTURE

GENERAL REMARKS

In the manufacture of slack barrel staves there are several distinct branches of the business, in any one of which success or failure means profits or loss to the industry. These divisions are, first, timber; second, factory work; third, piling or air seasoning, and fourth, jointing and packing. As in the manufacture of any kind of cooperage stock good timber is essential to good staves, yet one can be careful, using good tact and judgment in purchasing good timber, and getting it to the mill in proper shape, and still manufacture very inferior stock if the processes above mentioned are carelessly performed or neglected. It has been proven beyond a doubt that the extremely small and crooked timber is not profitable to work, and should be left standing in the forest until it has grown to the proper size, which should be at least ten inches breast high.

The increased cost of labor in handling, transporting, etc., is so great that it is difficult to secure more than the bare cost out of such timber. Dead timber and logs that have been left in the woods or on the yard until they have become decayed or are partially so cause no little amount of difficulty and loss at the mill, and are the direct cause of a great many complaints of defective stock, and more especially so in the No. 2 grade.

There has been considerable discussion as to how brash or how dead it is permissible for a stave to be and not be considered a dead cull. As to the No. 1 grade, these brash or dead timber staves should never be put into that class, and a great many should not even be put into the No. 2 grade; in fact, it would be far better and more economical for all parties concerned if this class of timber was left in the woods. A stave that will break or bend with as little pressure as is required to make an ordinary produce barrel should certainly be thrown out. And it will be found preferable to leave such timber in the woods rather than culling them at the jointers after more or less labor and expense has been incurred in the handling, etc.

THE WASTE PROBLEM

The total percentage of ultimate waste in manufacturing cooperage stock, even in the best-regulated mills, is astonishing, and few operators are aware of their enormous loss from this least respected point in economy. So far, forest utilization has been of the most wasteful kind, and only a relatively small percentage of the actual wood content of our trees finally reaches the consumer in the form of staves, hoops, or heading. Studies made by the Forest Service of the Department of Agriculture indicate that in the manufacture of staves and hoops only 50 to 60 per cent. of the contents of the log which goes into the mill finally emerge in the manufactured form, and that with heading perhaps no more than 25 to 30 per cent. of the actual volume of the log finally goes into the finished package.

Much of this lack of utilization cannot very well be prevented, yet there are possibilities of much greater economy than is generally practised. For instance, upon careless inspection, logs are often assumed to be suitable for stave bolts, and are cut into lengths which are multiples of the length required, and are subsequently found to be fit only for heading, which requires much shorter lengths. This causes an unnecessary amount of waste, which could have been prevented by a more careful determination at first of the purpose for which the log was best fitted to serve. And, again, logs are often bolted up into 32-inch lengths for the purpose of cutting into the regular 30-inch staves, and are later cut up into 28-inch staves or shorter, which means a waste in the first instance of two to three inches on every bolt, which could be averted by bolting out for each particular length or size. This argument also stands for the different heading sizes.

Waste also occurs sometimes because the logs lie in the woods or on the yard until they are so badly checked that it is necessary to cut off considerable of each end before the sound timber is reached, and they are sometimes checked so badly all through that over 50 per cent. of the log is worthless. Waste is increased, also, if the bolts are split instead of sawn, since in this case the first and last two or more staves cut from each bolt must be discarded, because the bolt is uneven; and, again, by splitting, the rift naturally follows the grain of the wood, and in cases of cross-grained timber, the bolts would have a wavy surface (Fig. 12) and be twisted or wider at one end than at the other, causing considerable waste. Hence, a given volume of timber will produce more staves when the bolts are sawn than if they were split or riven.

Considerable waste can often be traced to faulty methods of manufacture and in the handling of stock. In order to utilize all the timber and give each log its most economical place, the different departments of the mill must work in harmony and for a common cause. A log that will not make a good hoop will very often do for staves, and one too poor or too small for staves will often turn out excellent heading. Where a mill manufactures only one class of stock, it would be advisable for them to have some side line, such as head liners, keg stock, tie plugs, or furniture stock, whereby they could utilize their waste to advantage.

The waste from careless stave jointing is another item of great importance. If the species of wood is hard to cut and contains many knots, the jointer will very often needlessly cull hundreds of staves, the defects of which could have been cut around and the timber saved. Improper methods in cutting and bolting for staves is another great cause of waste. In some mills the log, instead of first being cut into blocks of the proper length and then quartered into stave bolts, is first sawn into cants or quartered along the whole length of the log and then divided or sawn into the requisite lengths for stave bolts. This method, as generally practised, does not shape the bolt to the proper slanting form. Moreover, the grain of the log generally does not run parallel to its axis all the way through, and for this reason the bolts prepared in this manner will be more or less cross-grained and hence produce a poor grade of staves. Then, again, much waste is often due to careless management. The cooperage man must have green timber, and yet hundreds of logs or blocks will often be allowed to lie on the yard or in the woods until they become too dry to be worked economically or are so badly checked that they are hardly fit for the purpose for which they were intended. Heading blanks will very often be cut 21 inches long, when only 17⅛-inch and even 15½-inch heading will be circled out of them, and the heading matcher in his haste or carelessness will also often cause another waste of two inches or more by the wrong choice of pieces. The question of seasoning on the yard is another important factor in the waste problem. Stock is often piled in the open, the ricks or piles left uncovered, not properly elevated from the ground, or not sufficient air space left between the piles. Under these conditions the top layers will twist and warp and the bottom layers will rot, while very often the entire pile will become covered with a thick, greenish mould.

An up-to-date slack cooperage plant should utilize every part of the bolt or log—bark, sawdust, and wood of every conceivable shape—and this can be accomplished with the proper energy and by an expenditure in the first cost which will soon be repaid to the mill owner. As to what can be made to utilize the waste, it depends somewhat on location and surrounding conditions. Headliners are a stock product that can be made to utilize some of the waste that accumulates in the form of cull hoops. However, in converting timber into hoops, especially direct from the log, there is quite a lot of stock that is not cut into hoops on account of knots and other defects, and this may be utilized for different products.

One line of work, and a very important one in some localities, is to make small-dimension stock for chair factories, including rungs, posts, seat frames, backs, and, in fact, all parts of various kinds of chairs and other furniture. It is an interesting line of work, too, when followed up right, the only drawback being the difficulty in securing fair prices for the material.

In some localities there is a chance to make crate stock of various kinds to advantage out of scrap material, and this wood, on account of its toughness, makes excellent crate stock. Trunk strips offer another opening, and really furnish an excellent line of work when you once get into it, because it is a little better quality of stock than ordinary crate strips, and in consequence brings better prices. Elm is the favored wood for trunk strips, and as this work includes numerous short lengths, they can frequently be made to advantage along with hoops, and made to assist materially in utilizing stock that would otherwise go to waste.

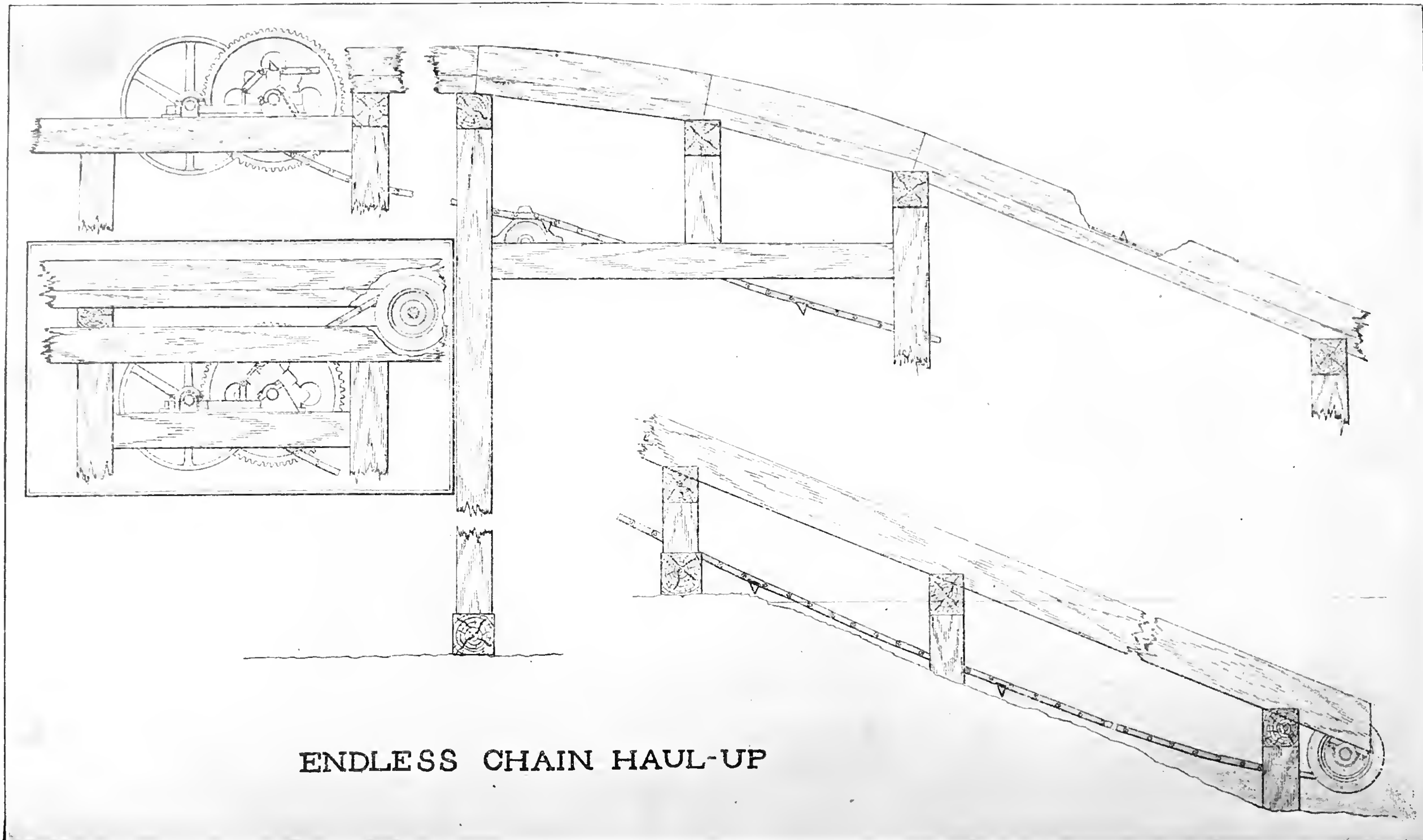


Fig. 56. Endless Chain Log Haul-up.

There are probably a number of other items that might be included here, such as tie plugs, wooden spools, etc., but with these to start on you should be able to keep building on to this list right along. It is interesting to note the variety of conditions and how they are overcome in various sections in the manufacture of slack stock.

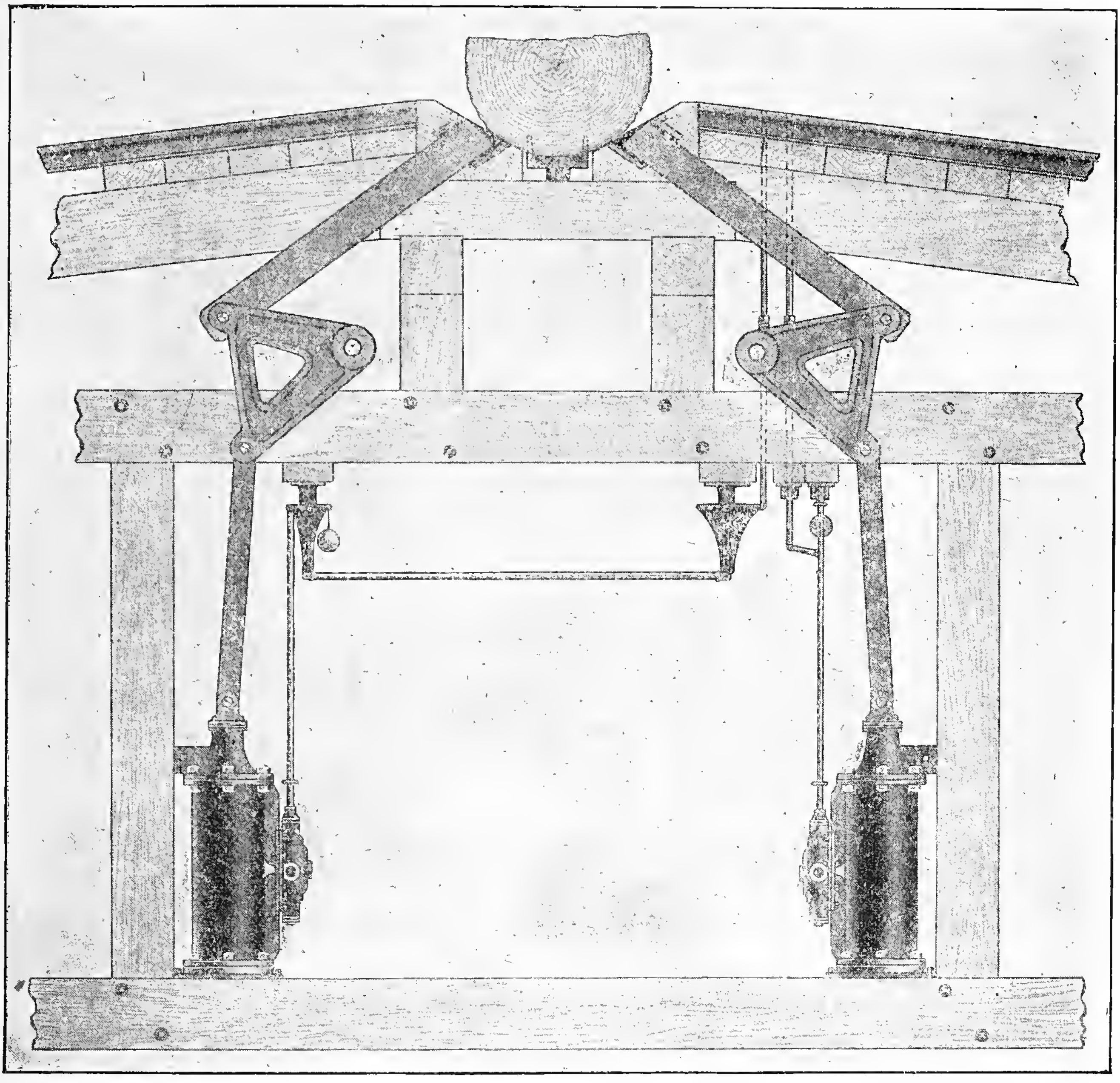


Fig. 57. Steam Kicker or Log Unloader.

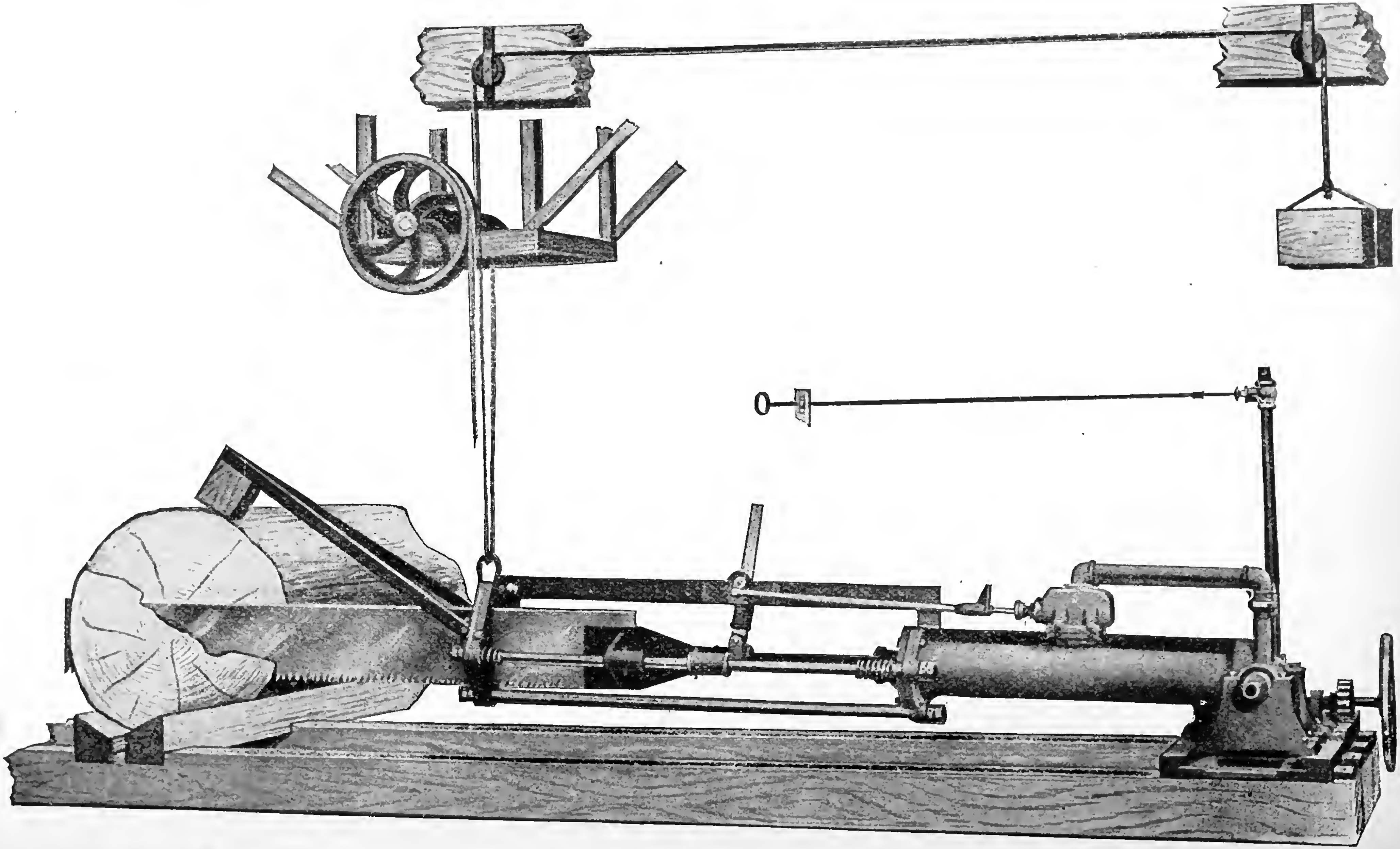


Fig. 58. Direct-acting Steam Drag Saw.

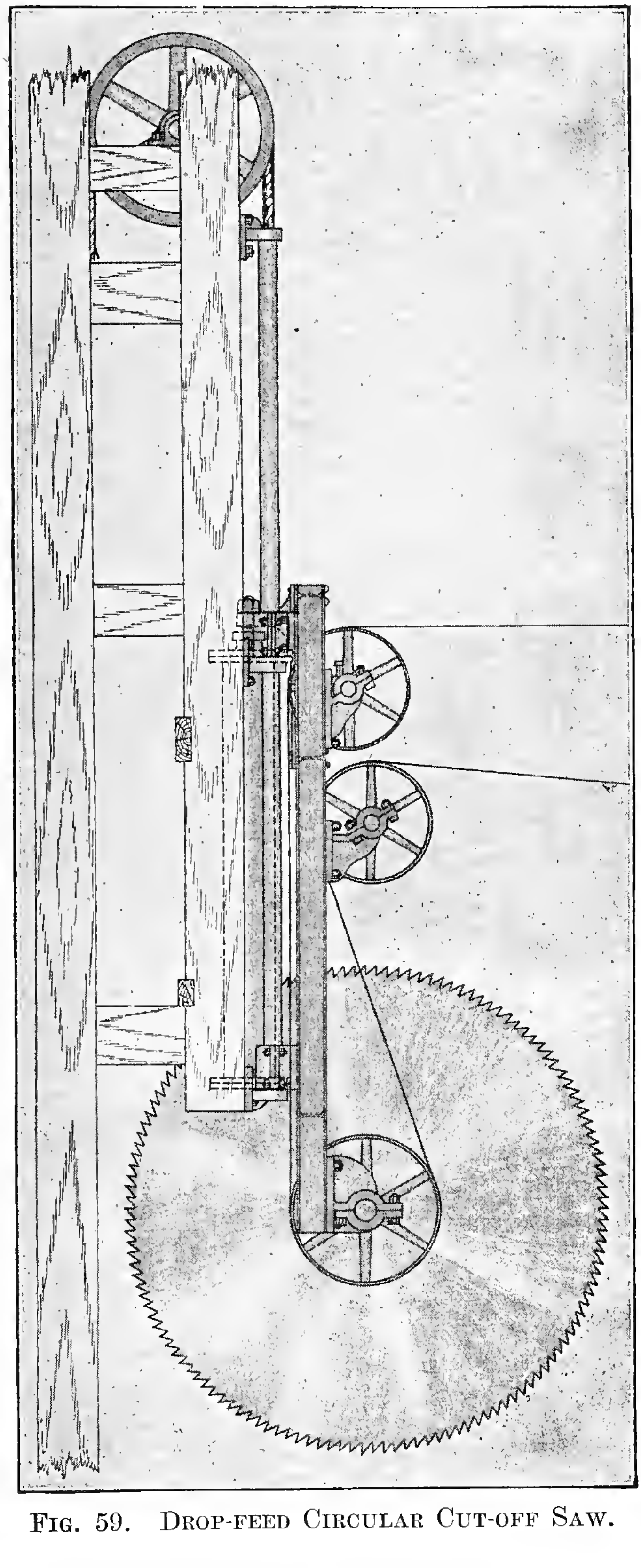


FIG. 59. DROP-FEED CIRCULAR CUT-OFF SAW.

The conditions vary as to climatic influences, such as in the North we must remember that the low temperature exerts influences that in the South are not even con-

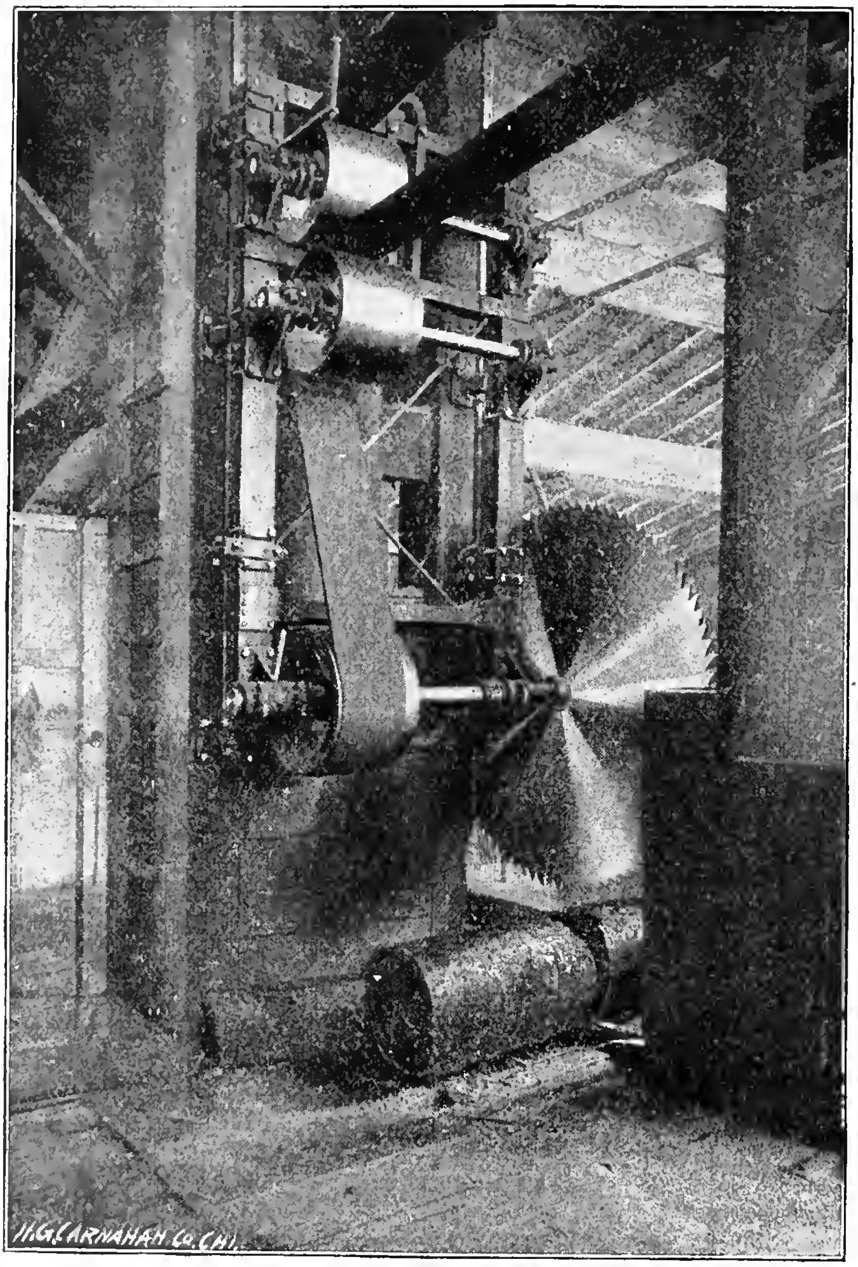


FIG. 60. DROP-FEED CIRCULAR CUT-OFF SAW IN ACTION. Right-hand view.

jectured. The warm and unpleasant summer months control the character of labor very seriously in the South. The Northerner never dreams of this. The Easterner faces the problem of the very excessive prices of the raw material, that would paralyze the Middle-Westerner or Southerner. He therefore overcomes this by utilizing

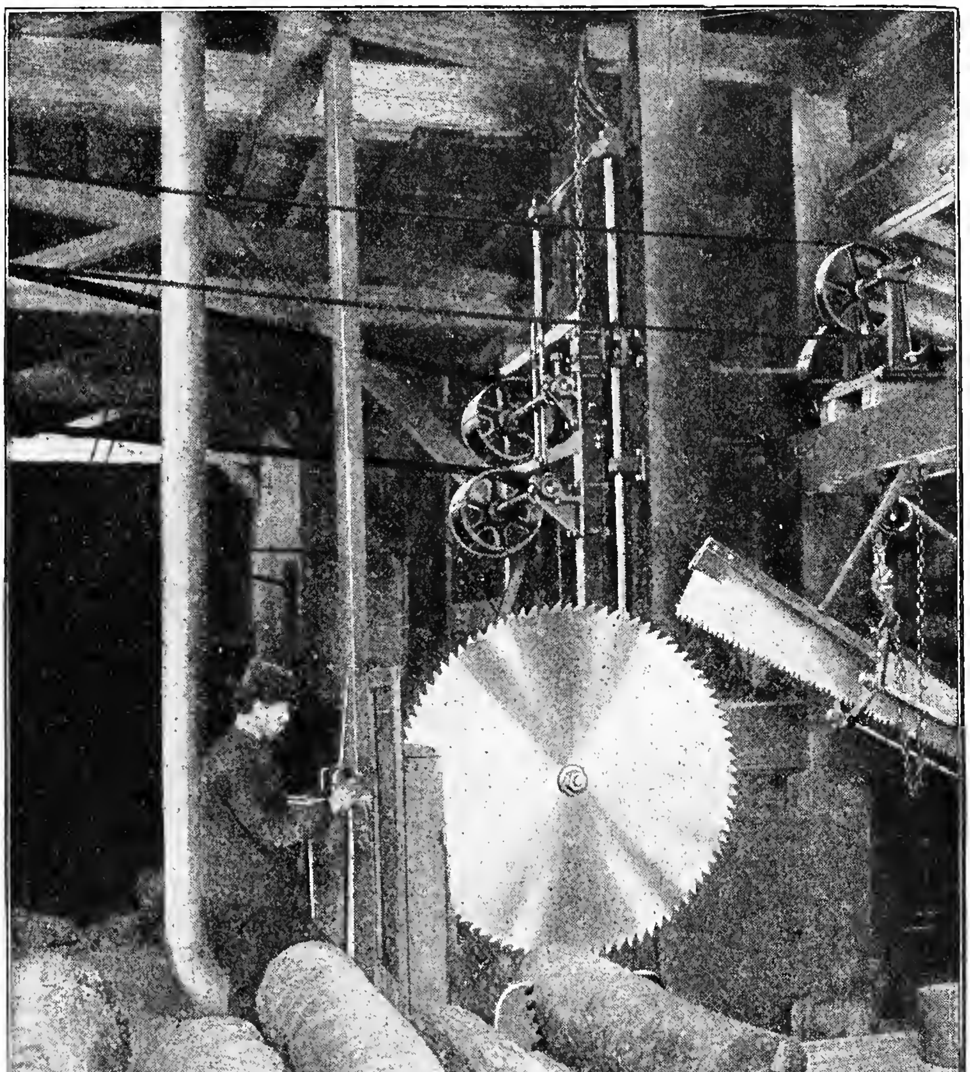


Fig. 61. Drop-feed Circular Cut-off Saw in Action. Left-hand view.

every particle of the log in ways the Southerner would not think of. In the West or extreme West the manufacturing of slack barrel staves, heads, and hoops has not received the attention that it has in other sections the tree or its product being manufactured into lumber for building purposes.

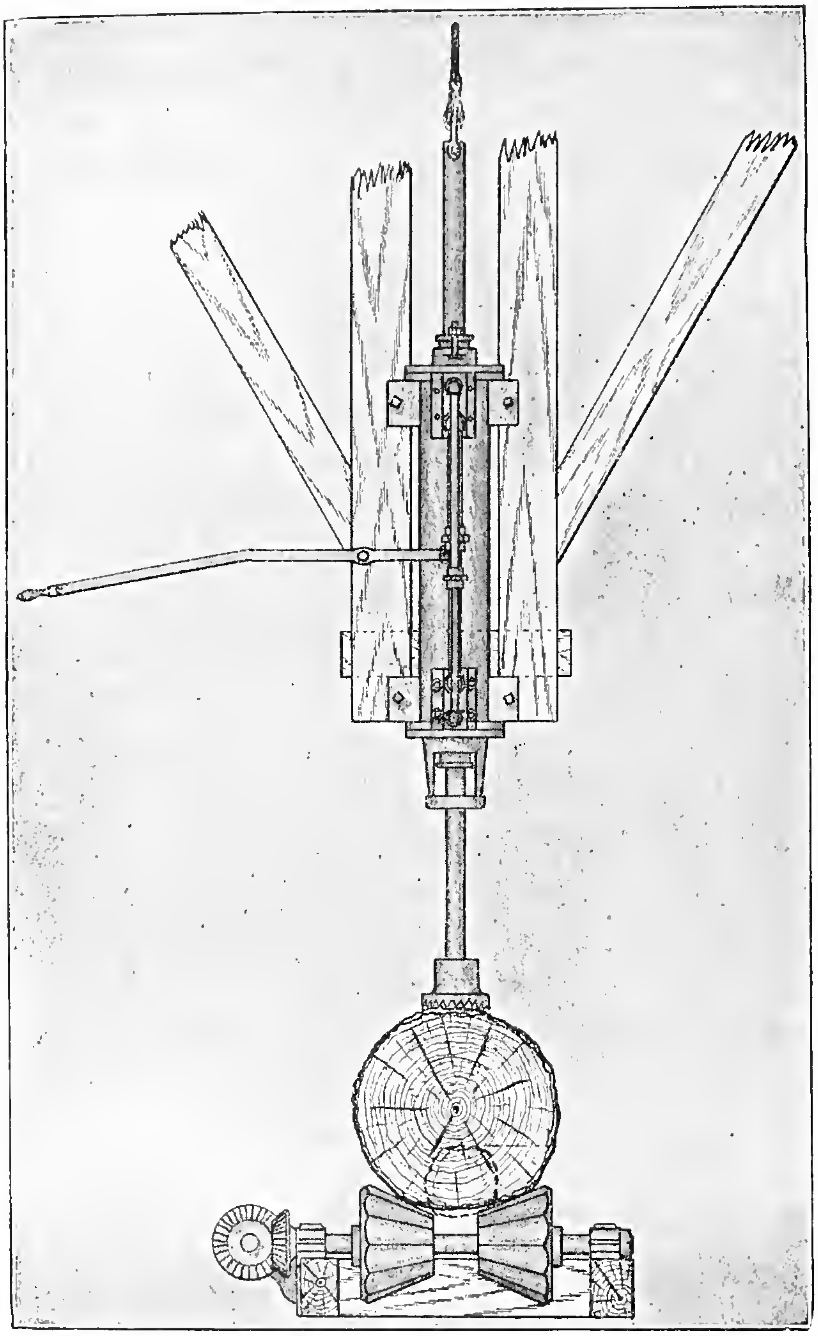


Fig. 62. Over-head Style Steam Dog.

THE BOLTING ROOM

The bolting room is where the timber is sawn into the proper lengths for cutting into staves, heading or hoops.

The logs should be brought into this department from the log pond on an inclined log trough by means of an endless chain log jacker or log haul-up (see Fig. 56), and landed on the sorting deck, where they can be properly inspected and put to the uses for which they are best adapted, the better grade of logs, ones with the straightest grain and the least defects, such as knots, checks, etc., going into hoops or staves and the more inferior ones put aside for heading. Some mills may find use for a steam kicker or log unloader (see Fig. 57) for throwing logs out of the log trough in the mill. This machine can be used either singly, as shown in cut of complete deck, or double, as shown in this cut. The double machine consists of two rock shafts, to which are attached as many heavy cast arms as desired for length of log they are to handle. To these are attached the shover arms, which should be of forged steel hinged at the bottom end to the cast arms and working through cast guides located in the deck at sides of trough. These shafts and arms are in turn operated by means of two steam cylinders attached to the shafts by means of connecting rods and a heavy cast arm on rock shaft. The machine can be operated by means of a lever or by two foot treads. In most cases the foot treads are used, and are generally placed on one side of the log way.

THE CUT-OFF SAW

The logs should then be taken to the cut-off saw, to be sawn into the proper lengths for staves or heading. For this particular work some use what is termed a "drag saw" (see Fig. 58), others use a "drop circular saw" (see Figs. 59, 60 and 61), which show same in action), and in some mills both types are used, as in some instances where an extra large log is brought into the mill, the drag saw is brought into use, but for small-diameter logs, up to 30 inches in diameter, the drop-feed circular cut-off saw is the more efficient. For use in conjunction with the drag or drop-feed circular cut-off saw, for holding the logs firm and in position while being sawn, are what are termed "steam dogs." (See Figs. 62 and 63.) The former type is what is termed the "overhead style of steam dog," and where timber does not run very large, this dog is very effective.

The mechanism will be seen by a glance at the cut. It is a steam cylinder, usually 8 inches in diameter by 48

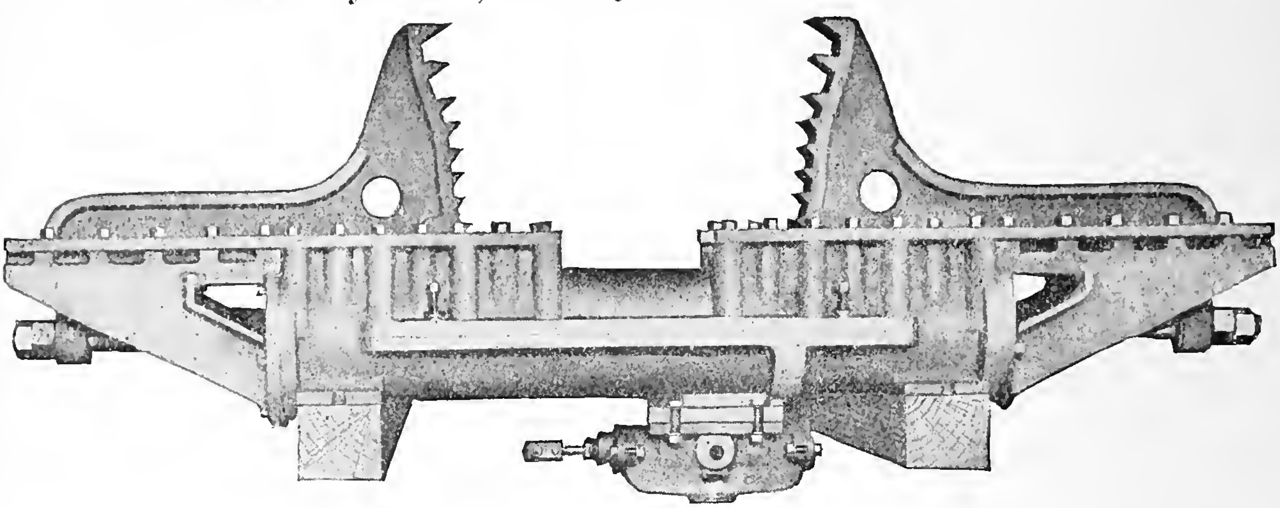


FIG. 63. FLOOR-LEVEL STYLE STEAM DOG.

inches long, mounted directly over the rolls or log trough where stock is to be dogged. The end of the piston is provided with corrugated head. When stock is in position to be sawn, steam is admitted at top end of cylinder; the corrugated head strikes the log, the steam pressure is kept on until cut is made, when steam is admitted into the lower end of the cylinder and the piston is raised, permitting the log to be advanced for the next cut. Fig. 63 is what is termed the "floor-level type of steam dog," and will give a very fair idea of the most simple, compact and powerful steam dog ever designed for holding logs firmly in position while being sawn. It will dog instantly a 6-inch or a 5-foot log. It consists principally of two heavy jaws working in planed ways on top side of cylinder, and attached direct to the piston rods which extend from each end of cylinder.

These pistons and rods are entirely separate, but both are under absolute control, by means of the one valve which is operated either by lever or foot tread. One great point in favor of this type of machine is the small amount of space it occupies; the steam cylinder is usually 8 inches in diameter by 48 inches long. It can be readily put in a ground-floor mill and can be located in log trough, as shown in cut, with log chain passing through its centre, or can be placed at end or between geared rolls. When fast cutting of blocks is desired it is almost indispensable.

THE DRAG SAW

The drag saw (see Fig. 58) is what is termed a direct-acting steam drag saw, and is very simple, compact, and effective. This machine occupies very little space, and is virtually a self-contained steam engine on a small scale with a saw blade fastened to the piston rod. Its parts consist mainly of a base, a cylinder, the steam valve and connections, a cross-head which is attached directly to the piston, and to which saw blade is secured; a saw guide and a device for raising and lowering saw and feeding it while it is in the cut, which consists mainly of ropes, pulleys, and a counterweight.

On the capacity of this saw depends the output of the entire mill, and it is of the greatest importance that it should be given the best possible attention in order to insure its usefulness. It should be 8 feet long, 14 inches wide, 9 gauge thick and have 80 teeth, with a speed of 150 strokes per minute. The teeth should be 1¾ inches long by ⅜ inch wide and have a lance point, with a slight hook or slant toward the rear end of the saw. The tooth or cutting edge of saw should in all cases be perfectly straight. If it is allowed to become low or hollow in the centre, the saw blade will jump, which interferes with its cutting rapidly, and is one of the common causes of difficulty with this machine. A drag saw should be hammered as stiff as it is possible to make it, in order to insure the saw blade against buckling on the forward stroke and flopping from side to side on its return stroke; the teeth should be jointed level to insure a straight cut and have about ¼-inch set for a 9-gauge saw, other gauges in like proportion.

THE DROP-FEED CIRCULAR CUT-OFF SAW

The drop-feed circular cut-off saw (see Figs. 59, 60, and 61), in conjunction with the drag saw as shown in Fig. 58, being the most important saws in the mill, should be always kept in first-class condition, in order to insure a maximum output from the mill. These drop saws are journaled to a $2\frac{15}{16}$-inch saw arbor. The frame and saw are counterbalanced, so that when steam is turned off the cylinder the saw will always be up out of the way. The feed is furnished by a 6-inch steam cylinder usually 56 inches long, and so arranged as to be under perfect control of the operator at all times, who can vary it according to the timber to be cut, thus getting all possible capacity out of saw. These saws are usually driven direct from line or main shaft, the two pulleys at the top of frame acting as idlers and tighteners; these machines when properly taken care of will cut through a 20-inch log in ten seconds, and for this purpose they cannot be surpassed. Capacity depends entirely upon the rapidity with which logs can be brought up to the saw and the bolts taken away. It is advisable in conjunction with this saw to use an endless-chain conveyor for bringing logs to the saw. Saws for this machine should be 66

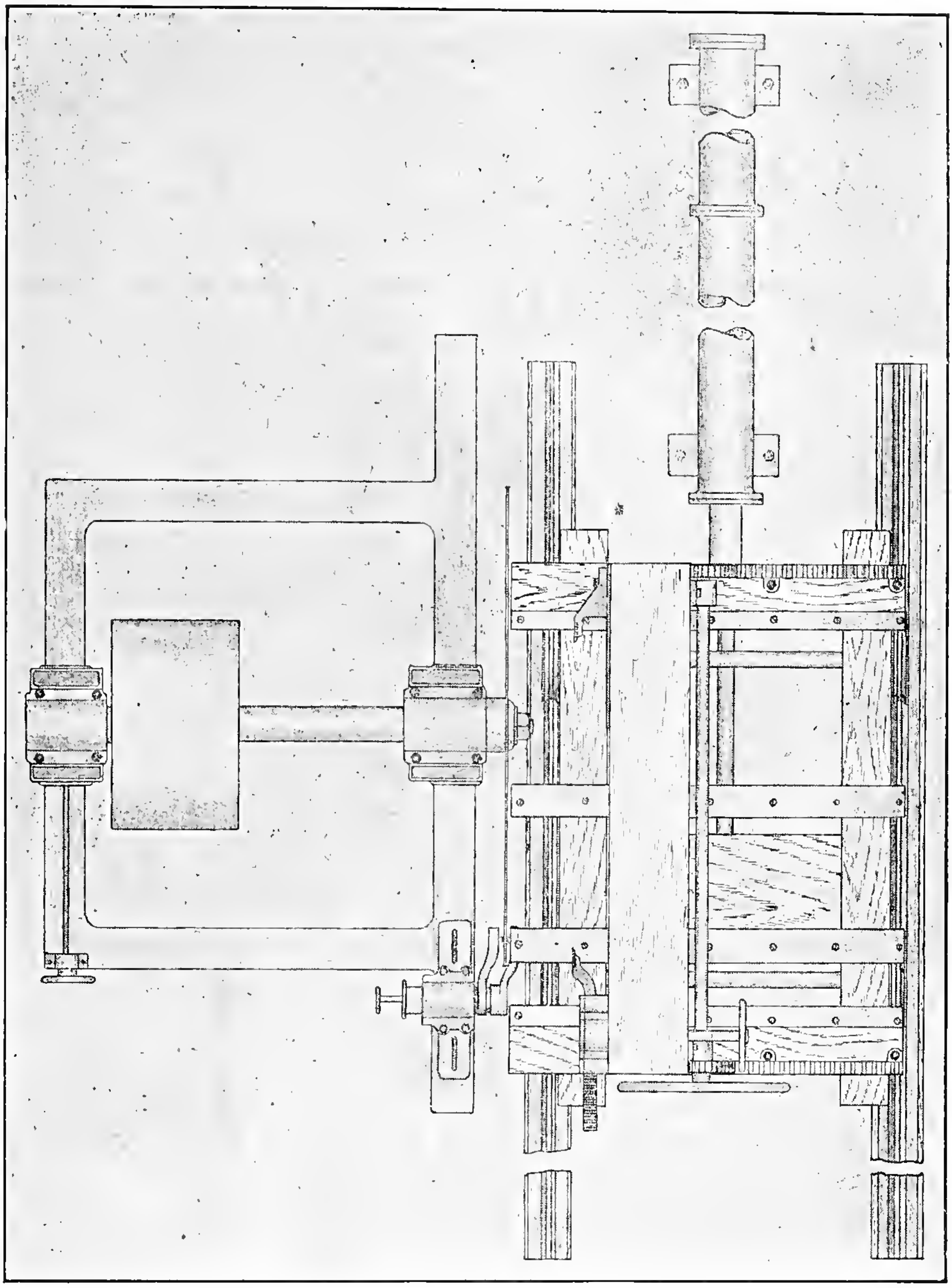


Fig. 64. Plan of Horizontal Bolting Saw.

inches in diameter, inserted teeth, 7 gauge at rim, 6 gauge at mandrel hole, with 96 teeth, and should be maintained at a speed of 600 revolutions per minute. When sharpening, the same cutting angles should be preserved, and the gullets kept round. These inserted-tooth saws are sharpened and dressed the same as a solid-tooth saw, and the general directions in this work, under the head of "Saws," for the dressing of solid-tooth saws will apply. When changing teeth, first drive them into position by placing a swage on the cutting edge and striking a blow with a light hammer. Care should be exercised not to expand the rim of the saw by rivetting too tightly, for if this operation is not properly done the tension of the saw will be destroyed. It is only necessary to rivet enough to secure the tooth firmly. The surplus metal of the rivet may then be chipped off with a cold chisel in order that it may not interfere with the running of the saw.

THE BOLTING SAW

The blocks as they come from the drop or drag saw are then passed to the bolting saws, as shown in Fig. 64. These saws should be as large as the frame will allow, as a large-sized saw will enable the operator to split large-sized blocks through the centre without the necessity of chopping or splitting the bolt, which saves a great deal of timber and unnecessary labor. Experience has proven that a 60-inch saw gives the best results. This saw should be 8 gauge straight, 50 teeth, and running 800 revolutions per minute. The teeth should have full ¼-inch set or swage, and pitch line should intersect a line at half the distance between centre and rim of saw; this gives a good hook to the teeth. The back of the teeth should be kept low to avoid friction, about one-fourth inch down, a half inch from the point of tooth, measuring from a straight line from point of one tooth to the point of the next one. The teeth should have ample throat to chamber the dust, but should not exceed 1½ inches long.

A safe rule is to make the length of the teeth half the distance between them, unless the teeth are more than three inches apart, when 1½ inches should be the length. If the teeth are too long, they will not permit the dust to pack in the throat or dust chamber, so that it can be carried through the cut, but will allow it to pour out at the sides and heat the rim of the saw. A straight-gauge saw is preferable for this reason: it allows the saw to split the log more easily, and without carrying unnecessary set or swage, which is not only a waste of timber, but requires more power to drive the saw. Do not put as high tension in saw as would be necessary if sent to a mill, expecting it to be used six months without hammering, but put the tension in saw for speed of 800 revolutions, and keep it there at all times, examining it every time it comes off the mandrel. Keep the eye or mandrel hole stiff, the rim true and smooth, the saw as near perfectly round as it is possible to get it, as the capacity of the saw depends very much on each tooth doing exactly the same amount of work. There should be duplicate saws, and they should be changed every five hours. With the saw, saw carriage and feed rig in proper condition, 40 cords of stave timber should be flitched from the round block every five hours; then change the saw and go at it again.

STAVE AND HEADING BOLTS

The preparation of stave and heading bolts, prior to their being cut or sawn into staves and heading pieces, is of much more importance than the average man at the mill generally allows. In the first instance it matters not how much attention is placed upon the operation of jointing or piling if the staves are not cut properly from the bolt, or the bolt is not properly prepared so as to allow of proper cutting. The staves will be, more or less, of inferior quality. The extra trimming in consequence of the bolts having been improperly prepared is expensive, because it consumes time that might otherwise have been expended in cutting good staves if the bolts had been right, and the trimming also cuts away a

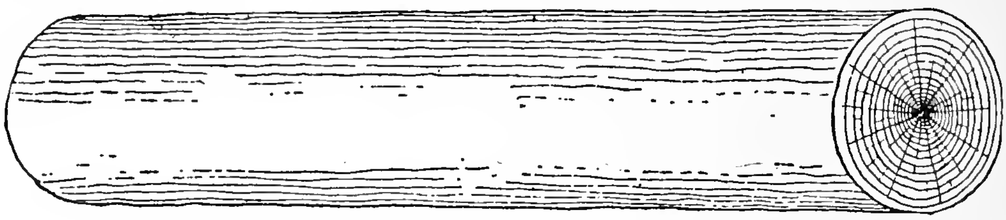


FIG. 65. A LOG BEFORE BEING SAWN INTO BOLTS.

large amount of valuable timber, which is unnecessarily wasted, or timber that would have been valuable if it had been handled right by the bolt being properly prepared. Fig. 65 shows the log as it comes from the tree or forest and prior to being cut into stave or heading bolts by the drag or drop saw. Fig. 66 shows the timber cut into the proper lengths for bolting. It has been proven that in

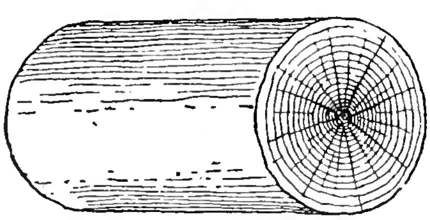


FIG. 66. A BOLT BEFORE BEING QUARTERED.

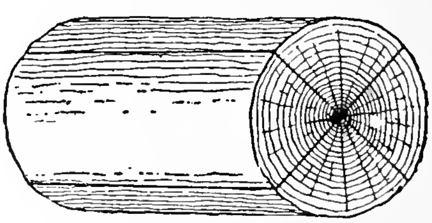


FIG. 67. BOLT SHOWING METHOD OF QUARTERING.

southern climates, where germs are active, or where stave and heading bolts are stored in enormous piles, causing them to heat and sweat, thus breeding germ life, it is always advisable to remove the bark after felling. In a cold climate this would be unnecessary. Fig. 67 shows the proper manner of sawing or splitting timber of large diameter into stave bolts, and is termed by the trade as quartering, so as to allow of keeping with the grain when cutting into staves. These flitches should be sawn so that the staves when cut will average about four inches. This is one important point the operator at the bolter should always bear in mind, as otherwise the staves will run either too wide or too narrow. The usual run of flitches should be from 3 to 6 inches, with the majority of them nearer 4½ inches, so that they will finish when

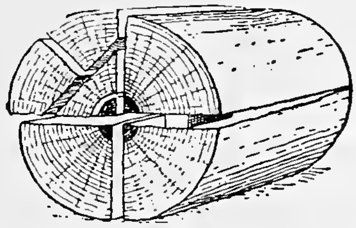


Fig. 68. Properly Quartered Stave Bolt or Flitch.

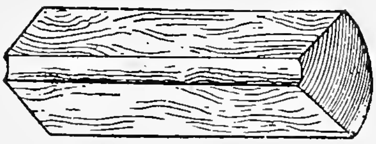


Fig. 69. Stave Bolt or Flitch Ready for the Stave Cutter or Cylinder Stave Saw.

jointed to 4 inches, the proper average for slack barrel staves. In quartering bolts, it is a well-known fact that splitting them into flitches with a maul and wedge, instead of performing this work with a power bolter, is extremely wasteful, since in this case the rift naturally follows the grain of the wood, and in cases of cross-grained timber the bolts would have a wavy surface, be twisted and therefore wider at one end than at the other, necessitating several cuts before a full or complete stave could be produced. Hence, a given volume of timber will produce more staves when the bolts or flitches are sawn than if they were split or riven. Fig. 68 shows stave bolt properly quartered and ready for the steam boxes, prior to being cut into staves. Fig. 69 shows stave bolt cut to uniform length on bolt equalizer and bark peeled off, ready for the stave

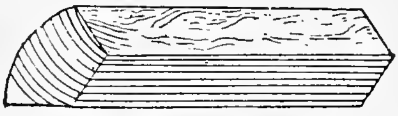


Fig. 70. Stave Bolt Showing Method of Cutting or Sawing into Staves,

cutter after having been properly steamed. Fig. 71 shows heading bolt properly prepared from tree or log. Fig. 72

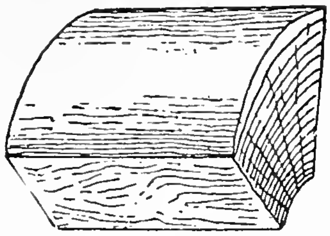


Fig. 71. Heading Bolt Properly Prepared.

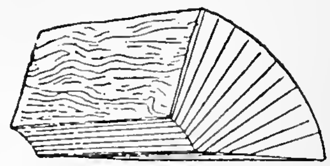


Fig. 72. Heading Bolt Showing Method of Sawing.

shows proper method of sawing pieces of heading from heading bolt.

STEAM BOXES FOR STAVE BOLTS

The operation of steaming the timber at the stave mill, prior to being cut into staves, is an important link in slack stave manufacture, and one that should be given more attention than the average mill man has applied to it. It is a well-known fact that one of the greatest faults of the average stave mill is either lack of steam capacity, or poorly constructed and inefficient steam boxes, or both. In general, well-steamed wood shears about one-third more easily than merely wet wood, and makes a brighter and much smoother stave. Timber that is not properly steamed or not steamed enough will produce a stave that is rough, washboardy, of uneven thickness, and with the fibres of the wood badly shattered, by the knife forcing its way through the bolt, and is liable to appear mouldy and stained when taken from the pile; and, again, if the timber is steamed too much, the stock will be woolly and rough, giving the appearance of dead timber; this is especially so in the case of elm, cottonwood, soft or silver maple. It is being demonstrated now and then that some of the stave bolts are suffering from over-steaming. And when one gets the whole thing properly analyzed it will likely be found that the damage in over-steaming is more generally that of too intense steaming, that is, the use of too much heat or too high a pressure. Almost any one knows that wood can be steamed too much. Elm, cottonwood, etc., which are comparatively easy to soften with steam for cutting, can be steamed until they are difficult to cut smoothly, as they get woolly and the fibres of the wood hang across the knife, and the general effect is almost the same as if they were cut with a rough-edged knife. What is desired is to soften the timber to the highest degree of sponginess without loosening the fibres of the wood from each other to such an extent as to cause woolly or fuzzy cutting. There are really several troubles that develop from excessive steaming, but the most serious and permanent one is that of injury to the wood itself by loosening the bond of the fibres. Other incidental troubles are that it causes cracking of the bolts, which, in its turn, increases the size of the waste pile.

The principal object to be obtained in steaming the wood before cutting, is to extract or force as much of the sap and nitrogenous substances out of the timber as possible, at the same time making the fibres of the wood soft and pliable so that it will shear or cut easily, and dry quickly after being cut, in order to lessen the possibilities of the staves moulding. When staves mould in the pile it is evident that either the timber was not properly steamed and the sap extracted, the steam not hot enough, so that the dampness will evaporate from the stave quickly, or else the stock is piled too closely together, causing it to heat and sweat. To properly steam stave bolts of beech, birch, sycamore, hard maple, and gum, requires that the steam be more or less dry and of good pressure. By this we mean that exhaust steam from the engine alone will not produce satisfactory results, as it has not sufficient pressure to enter into the hard fibres of the wood. From this it is readily apparent that it is necessary in order to insure effective results to construct strong, tight steam-boxes and have at all times a sufficient supply of good steam.

From careful observation at one of the largest stave mills in this country, where hardwoods are cut exclusively, it has been found that by the addition to the factory boilers of a standard feed water regulator, in order that the water in the boilers may be kept as near 1½ gauge as possible, with the steam pressure maintained at 100 pounds, that the quality of the steam is improved, that it drives the sap out of the timber quickly, and produces a brighter and smoother stave than if no attention was paid to feed or pressure in the boilers. This method also lessens the possibility of mould appearing on the stave. In the case of elm, cottonwood, etc., this method is reversed by increasing the water and lowering the pressure in the boilers, as if these woods are subjected to too severe steaming the stock will appear woolly and rough, as previously explained, and is often mistaken for dead timber.

The manufacture of gum timber into staves seems to have been a problem. Most of the difficulty experienced can be duly traced to improper steaming and jointing. If more attention were paid to details in steaming, no doubt these difficulties would gradually disappear. Gum properly manufactured makes an excellent stave, providing the fibres of the wood are not completely shattered in cutting, caused by insufficient or improper steaming. Where gum is cut entirely, there are quite a few adherents to the method of boiling them, after the manner of hoop plank, instead of steaming them. By boiling it is claimed they secure a much better stave, and experiments have proven that the wood shears easier by boiling the bolts for about 7 hours than if they were steamed by the old process for 24 hours. This point is well worth considering, as no doubt it would be more economical to boil them, using exhaust steam, for 7 hours, than by steaming them for 24 hours. Of course, the problem of labor would have to be taken into consideration, as the expense of handling the bolts to and from the boiling vat would probably be greater. The whole problem of steaming resolves itself into this: Where timber, such as elm, cottonwood, soft or silver maple, etc., is to be cut into staves, the steaming process should be of a mild nature, using exhaust steam or steam of a very low pressure. There seems to be a difference of opinion in this case as to whether live or exhaust steam should be used. Some maintain that the live steam is the best, because it is more forceful, while others show a preference for exhaust steam, and still others use a combination of both live and exhaust steam. A great deal depends upon the condition of the bolts to be steamed whether or not they need moisture in the heating, or simply need heat alone, and have sufficient moisture within themselves. Naturally, a bolt sawn from a freshly felled tree would have considerable moisture within itself, and would only require heat sufficient to soften the fibres of the wood, while one sawn from an old log or tree that had been lying in the woods or on the yard for some time would require considerably more moisture in the heating in order to soften the fibres of the wood properly.

Late investigations on the subject of steaming have developed the idea that too much heat and not sufficient moisture is made use of. Ordinarily, stave bolts are steamed approximately 24 hours with a combination of live and exhaust steam. It is now thought that longer time and less heat, or lower pressure, would give better results. On this theory, the exhaust steam alone should be better than the live steam, because it is not quite so hot and has more moisture. But in the case of hardwoods, such as beech, birch, sycamore, hard maple, etc., it has been proven that the steam must be more or less dry, as stated before, in order to secure best results.

There are different types of steam-boxes in use, and the tendency is, where new plants are constructed, to make them of concrete, which is no doubt the most satisfactory method. Although steam-boxes properly constructed of timbers have in some instances been found to give entire satisfaction, the concrete box, which is somewhat more expensive, is absolutely tight, and probably the cheapest in the long run, as the maintenance is a very small item.

Where steam-boxes are constructed of wood, it is often necessary to rebuild them as often as once every two or three years, and in some cases it has been found necessary to rebuild them oftener than that. A fairly good construction of wooden box is made by using 6 x 6-inch timbers, each additional timber being bolted down to the last one with ¾-inch bolts 12 inches long, spaced about 18 inches apart, and the joints properly caulked when finished with oakum. The idea of using bolts only 12 inches long enables one to draw the timbers tighter together than if longer ones were used, and four or more timbers taken at one time. This method makes a much better and more satisfactory construction than if built up of two layers of tongue and grooved flooring lined with tar paper between, as the wood naturally shrinks and swells when steam is admitted; and eventually the inside layer will buckle or raise up, and the consequence is a leaky steam-box.

In regard to the use of concrete for this purpose, there is a wide difference of opinion as to its ultimate value. Probably the chief source of difficulty and disappointment, when they occur from its use, is from cracks and from the work costing in excess of all previous calculations. There may be other sources of disappointment, such as improper mixture, unwise designing, or ignorant handling, but where the boxes are properly designed, placed upon good, firm foundations, and the concrete properly mixed and well tamped in the moulds, and reinforced with sufficient iron rods, no considerable difficulty should be experienced, and the steam-boxes should give perfect satisfaction, both as to cost of maintenance and quality of work produced.

This problem of concrete cracking is one that even the experts do not seem able to explain away satisfactorily, or to positively guard against. At first cracks were almost universally attributed to faulty foundations. There is no doubt but that at least a part of them are due to this cause, but time and experiments have demonstrated that in monolithic concrete construction, where a wall is put up in a solid mass in large units, cracks will develop, regardless of foundations. It appears to be a matter of contraction probably, both in the setting of the cement and the changing temperature and moisture conditions of the weather after it is set. Expansion and contraction make up the most serious problems of construction, and must be taken into consideration at all times.

It appears to the writer that about the best solution of the crack problem in connection with the use of concrete would be to use it in the form of blocks or in smaller units, rather than what is termed monolithic work; but it would be a matter of experiment to determine whether this form of construction would be entirely satisfactory for use as a steam-box. It has been used in this form for dry-kiln construction, and found to give excellent results, and no doubt could be successfully used for steaming purposes.

In the matter of costs for concrete work for this purpose, and the probable reason that invariably such construction exceeds the costs calculated, contains food for thought. As an illustration, the usual mixture for concreting in monolithic form, is to take proportions about as follows: One part good Portland cement, two parts sharp sand, and four parts crushed stone. Counting these parts as yards, one, two, and four yards make a total of seven yards; but instead of making seven yards of concrete, they really only make about four yards, or the amount of crushed stone put in, or, in other words, the amount of crushed stone represents the aggregate, and the sand and cement simply fill in the voids between the stone. This is probably one reason why concrete work invariably exceeds the costs calculated upon.

When commencing the foundation for concrete steamboxes, the first important thing to consider is the nature of the ground. If the foundation is to rest on stone, the surface which is to receive it should be flat and level, or, if the stone is sloping, it should be cut into steps; otherwise the foundation may slide or part and cause cracks to appear. Damp clay or clay that is continually moist is slippery and makes a poor foundation, as it is treacherous and settles unevenly and in all directions. Dry clay has a tendency to draw moisture from the air, and near the surface will expand and contract, depending on the condition of the weather. In many places it makes a poor foundation, but in some sections, where the land is kept well drained and the surface water runs away quickly, it makes a good base for a foundation, and may be trusted with from one to two tons per square foot, when the foundation goes from four to five feet in depth. The ideal base for a foundation for concrete work is "hard-pan." This, next to stone, is the nearest to being non-compressible. Next to hard-pan is gravel or sand, and if possible, this should be compacted with large quantities of water. Either of these will compress or settle some, but can be depended upon to sustain three to four tons per square foot of surface, this depending upon conditions. The bottom of the foundations should be below frost line, otherwise the frost may distort them. Between four and five feet in depth should be the minimum. Where the soil is uneven and treacherous from being continually wet or swampy, piles should be resorted to. These should be spaced about 2½ feet apart, centre to centre, and sawn off not higher than the line of permanent moisture, and the concrete base built over them, commencing 6 inches below the top of the piles. This running of the tops of the piles up into the concrete base holds them so they cannot spread, and is an important point where the foundation is laid in ground of this nature. If proper care is exercised in the foundation work of concrete steam-boxes, no difficulty of a serious nature will be experienced through cracks appearing in the main body of the work. As a rule, this, the most important point in concrete construction, has been given the least attention. In mixing the concrete, the sand should be clean and sharp, and free from soil or dirt of any kind, as any loam mixed with it has a tendency to retard its setting, and the completed work will be somewhat inferior. Where creek sand and gravel are used, a little more cement is necessary. It is calculated that sand has voids amounting to one-third of its bulk, so that if one part of cement be mixed with three parts of sand, the voids will be filled, and there will be no increase of volume in the sand; and that to use less cement than the above will leave voids in the sand, depending on the less amount used. A specially good brand of cement may carry four parts of sand, and make as strong concrete as another brand will when carrying three parts, but it is well not to use more than three parts sand to one part cement, and even two to one would be safer.

A good brand of Portland cement should be used in concrete work for steam-boxes, and where Rosendale cement is used, it would be well to use even less sand. From this it will be seen that the lower-priced cement is not always the cheapest. The stone used should be crushed from a good quality of granite, a strong limestone, or trap-rock, and broken so that it would pass through a 2-inch ring. Stone of a slaty character of any kind or limestone similar in form to slate rock does not make a good concrete. The mixture should be in the proportions of one part good Portland cement, two parts sharp sand, and four parts broken stone. The cement is improved by working and driving down solid in the moulds, and only sufficient water should be used, so that when the concrete is well rammed the water will just show on the surface. After the moulds have been removed, the walls should be faced with a mixture of one part cement to two parts sand, putting on a coat about one inch thick. To do this work it will take approximately one barrel of cement to every 14 square yards of surface. If the above information is followed closely, the steam-boxes when finished should be a source of pleasure to their owner, and eliminate all difficulties from this source.

THE DUTCH OVEN OR BULLDOG FURNACE

Next in importance to good, tight steam-boxes, ample steam capacity is of great consequence, and experience has proven that the so-called Dutch oven or bulldog furnace renders more and better satisfaction in stave mills than any other type, as it is not only a labor saver, but all kinds of culls, sawdust, bark, etc., can be thrown into it without much effort, making it easily the most economical furnace for this purpose. And it is remarkable how much service can be secured from a modern-sized boiler with this attachment.

A water heater also adds a great deal to the capacity of a boiler, and it is often cheaper to install one, in preference to adding another unit, or purchasing a larger boiler. This Dutch oven is simply an extension built in front of the boiler (see Fig. 73), into which the fire grates are placed, instead of being put inside the boiler wall proper, and underneath the front end of the boiler. The details of construction differ, but the general idea

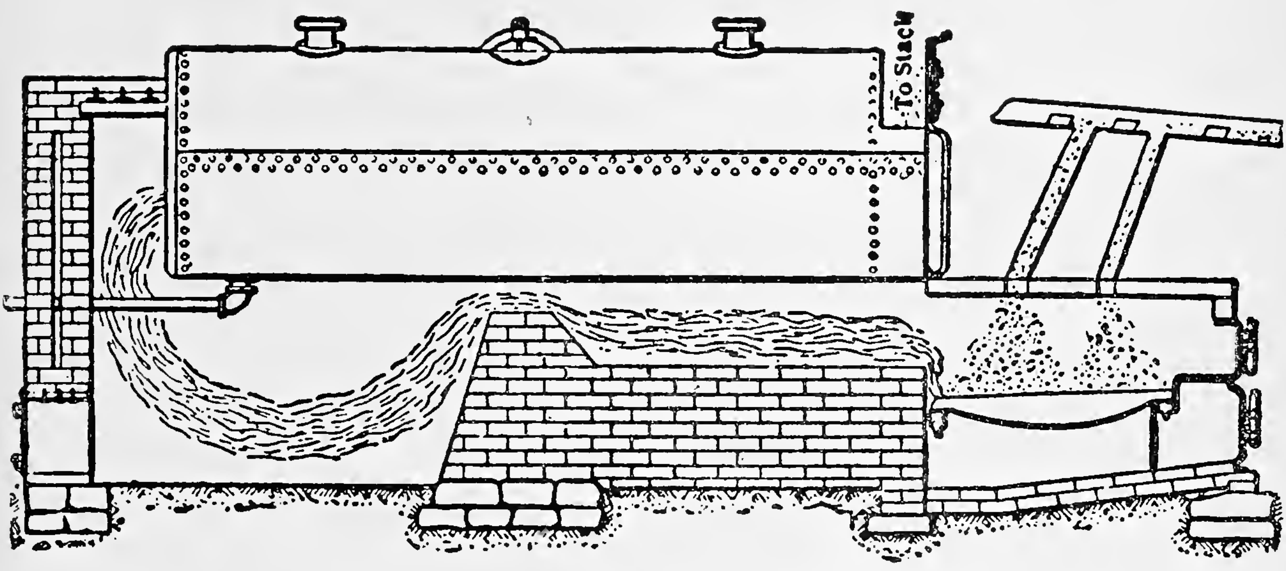


FIG. 73. DUTCH-OVEN OR BULL-DOG FURNACE.

is the same in all cases. These ovens are generally built about 10 feet long and should be fully as wide, and can very well be even wider than the boiler front itself. The oven illustrated shows the sawdust being conveyed direct to the furnace through the blowpipe, and can be dropped in equally as well with a chain conveyor. There should be an extra large opening on top to allow the fireman to shovel or scrape the larger pieces, blocks, etc., into the furnace from the floor level. The blowpipe or chain conveyor should be arranged in such a manner, having an extra leg or side extension with a switch or damper attached, so that when no fuel is wanted directly under the boiler, it can be thrown to one side.

STAVE BOLT EQUALIZING MACHINE

When the stave bolts leave the steam-boxes after having been properly steamed, they are taken directly to the bolt equalizer, as shown in Fig. 74. This machine should be located on the left-hand side of the stave cutter

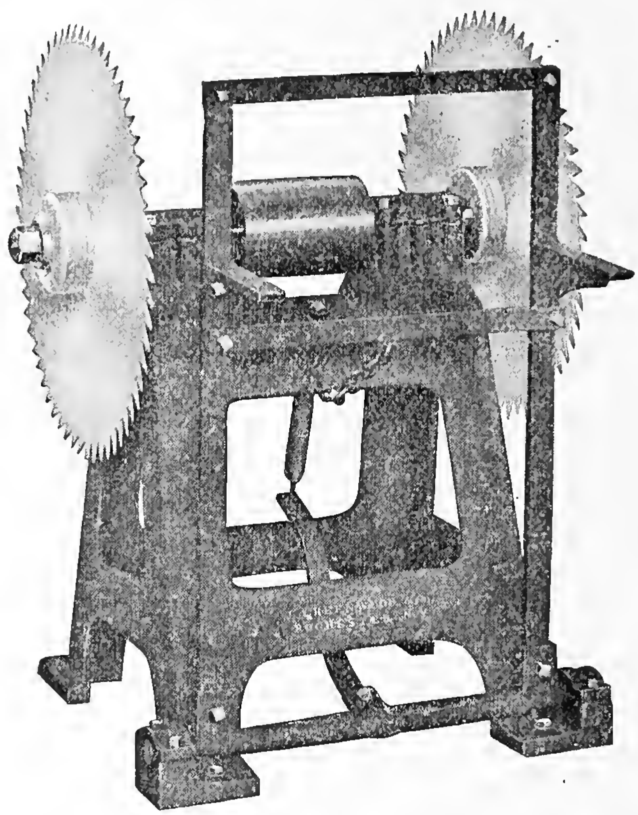


Fig. 74. Stave Bolt Equalizer.

and about three feet from it, so that the operator can place the equalized bolt on a rack convenient for the man at the stave cutter. These bolts should be barked or the bark well removed before they are equalized, in order that the work will not interfere with the stave cutters. The important work of these equalizers is to equalize the ends of the bolts to the desired length and leave them smooth and square on the ends. The saws for this machine should be 32 inches in diameter, 11 gauge straight, with 64 teeth, and maintained at a speed of 1,800 revolutions per minute; the pitch line of tooth should run through the eye of the saw. An equalizer rig, one that cuts both ends of the stick at once, is one class of sawing machine that you cannot give lead to clear the body of the saw; consequently there is more or less trouble with the stock binding between the saws. Sometimes warmth from the journal boxes will cause enough expansion in the eye of the saws to make them incline to dish a little, and as your stock is passing between them on the inner side at all times, the tendency is naturally to dish out, increasing the length of the material a little and causing the stock to bind, which augments the heating and makes the trouble worse. Where saws are interchangeable, a little relief can be had by changing sides with the saws from time to time; where this is not practical or involves too much trouble, about the only immediate remedy is to give more set on the inside of the saw. Of course, by doing this the inside teeth simply tear down the wood, and leave a woolly end, giving the staves a ragged appearance. Another and probably better method is to hammer them with more tension out near the rim, because they cut hot timber, which has a tendency to heat the body of the saw, and make it expand more than if cutting cold timber. There is a point about filing equalizer saws which is worth keeping in mind. Sometimes in cross-cutting stave bolts, you will notice instead of the end cutting out smoothly, the corner where the saw comes out shows splinters, or, as they are sometimes called, whiskers, which at times are rather annoying. These are frequently due to the fact that the average cross-cut saw used in equalizing wears most on the side next to the bolt, or inside, because that is where the heavy timber is and the rigid cutting done; and in the process of filing from time to time, the inside teeth of the saw become a little shorter than the outside teeth, and that is really what makes the splinters or whiskers. The outside teeth cut through just a fraction ahead of the inside ones, and that leaves the fibres of the wood loose so that they are driven back on the finished end instead of cutting clean. The way to get the clean cut on this inside or finished end, is to joint the saws so that they are a little shorter on the outside, say, $\frac{1}{32}$ of an inch, or it won't hurt to make it $\frac{1}{16}$ of an inch; then file carefully to a point and note the results, and it will be found that the whiskers or splinters, instead of being on the bolt end, are on the end block that is cut off, where they will do no harm, and it really makes the saw run better and cut cleaner. In fitting equalizer saws this is a good point to keep in mind, and it will not merely have to be done once, but quite frequently, because the inside teeth are the ones which do the most work, and the outside ones will have to be kept jointed down from time to time as the saw wears. Where equalizer saws of an uneven gauge are used, they should be made straight on the inside, to allow the bolt to go forward toward the centre of the saw without bearing against it, which would cause them to flare out at the rim, making the bolt on the side cut through a trifle longer. This is one of the causes of bolts not being cut square, and produces staves of uneven length, a serious matter, but one that is neglected in the average factory.

CRACKS IN EQUALIZER SAWS

These cracks in equalizer and cross-cut saws of one kind and another present a very interesting study, and one that is very elusive when you try to run it down to an exact solution. It is a peculiar fact that cross-cut saws crack more frequently than ripsaws, and a big circular mill saw very seldom cracks, while the little cross-cut saw has such a general habit of cracking that it may be called a sort of family characteristic. "It's the shape of the teeth and the sharp gullets," the saw man says, and advises you to use round-edge files or take other means of preventing them from getting square and sharp gullets. Still, it is a peculiar fact that after a crack or two comes in the rim of the cross-cut saw, you can file all the square and sharp gullets you want to and it's not very likely to do any more cracking, not nearly as likely as it is to crack once, even though you take all manner of pains to prevent square gullets and sharp corners. The thing to do, of course, when a crack makes its appearance, is to drill a hole at the end of the crack, so that it may not go farther. The cause of cracks comes from the rim or outer edge of the saw being tight, requiring more tension to prevent the saw being wavy on the rim when it is speeded up, and gets the expanding strain of centrifugal force, and also the strain of cutting against the grain of the wood. In order to insure the saw standing up to its work, the saw man generally puts in a little more tension than is called for, so as to give a factor of safety to take care of the let-down that comes from service. As a consequence, the rim of the saw is like a tight band on a hub or anything of like nature, and a little wrench or jerk starts it cracking. There is really no universal remedy for it; the matter might be helped a little if you have the tools and will do it carefully by hammering lightly around the base of the teeth, so as to expand the extreme outer rim a little, and leave the supporting tension of the saw just inside the rim, say, about a half inch, and leave the part of the saw that carries the teeth free from internal strain, and to support only that caused by the cut.

STAVE-CUTTING MACHINE

After the stave bolts have been properly barked and equalized, they are then taken to the stave-cutting machine, a front view of which is shown in Fig. 75. For this purpose a machine is generally used having a knife 36 inches long and 6½ inches wide, with a face ground to a circle of 20 inches. The steel rib facings should be reversible and hardened at each end to prevent wear and discoloring the staves. In some cases brass facings are used and found to give good satisfaction. These ribs, which are the gauges that determine the thickness of the stave, should be kept in perfect circle with the tumbler. The tumbler should be true on its face and the knife

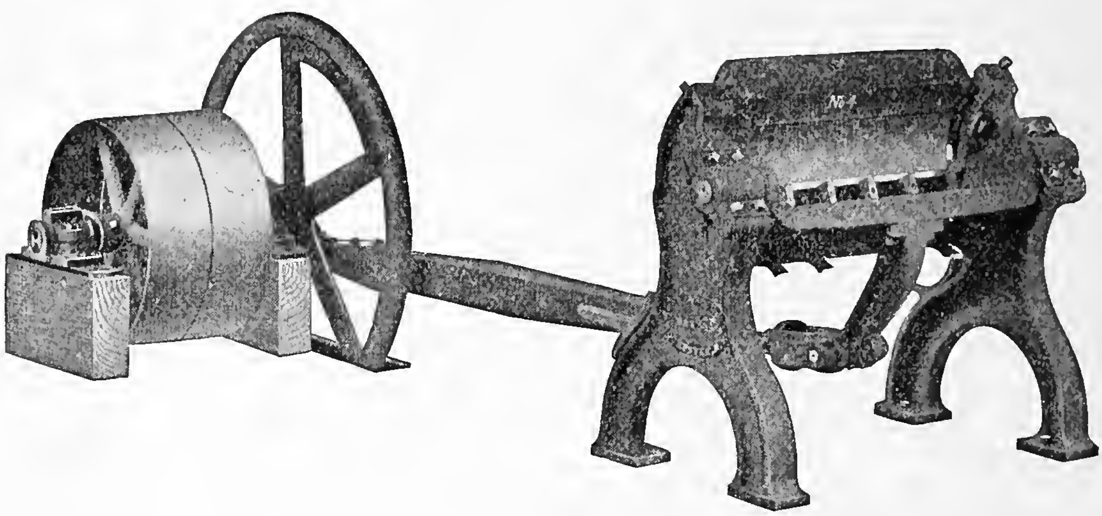


Fig. 75. Stave Cutter.

ground as thin as is possible without injuring its strength, and should be set with a lead or draft of 1/32 inch. The speed of the machine should be as fast as the operator can feed it and perform good work; generally 150 to 160 strokes per minute is the average speed. In the operation of this machine is seen the great advantage of properly flitched timber, which, if sawn out in proper shape, makes the work of the cutter light, and shows increased output with less time and labor than if the timber was split or riven; the cutter simply places the timber in the machine and it almost feeds itself. The trimming of the bolt to get it in shape to cut, and the tipping and turning that is necessary in cutting split timber is almost entirely avoided if the timber is sawn, and turns into staves a large per cent. of material that usually increases the fuel pile when cutting split timber. This is what makes it possible easily to cut from sawn bolts or flitches from 50,000 to 60,000 staves in 10 hours. The cutter operating this machine must give proper attention at all times to the grain of the wood, and see that his bolt is turned and fed into the machine in such a manner that the knife in cutting through the flitches will be running as near quartering as practical, which means that the knife must start into the wood and cut from bark to heart or *vice versa,* thus crossing the grain properly and making a nice, clean, smooth stave, providing the timber has been first properly steamed. This is one of the most important points in connection with stave-cutting, and every cutter should endeavor to make this a study, as if the grain of the wood is not consulted the staves will be rough and of uneven thickness and will not retain their concave-convex shape while drying and seasoning, which is most important. When a stave which has been worked into a barrel, afterward loses its concave shape and becomes convex toward the inside of the barrel, it has surely not been properly cut with the grain, and considerably lessens the strength of the package, as with the least jolt the package is liable to collapse. This item of loss is greatest in staves that change their shape or become flat or convex before they are made into the barrel, and are unfit for the poorest quality of culls. All woods do not show the grain plainly on the end of the stick, as in oak, but the stave cutter must know and consider the grain as if he could see it. When he is cutting staves from cottonwood, gum, and other woods that do not show the grain, he must use good judgment and follow the grain from the shape of the stick, as he can readily distinguish the bark or sap side from the heart side. Some cutters maintain that these woods can be cut any way, either with or without the grain, but it has been proven by long experience that they do not hold their shape and do not cut smooth. A stave cutter that insists that the grain of cottonwood or gum need not be consulted makes many more defective staves, and is the main cause of variance in quality as between one stave mill and another.

Any one of experience knows that there is a vast difference even in the quality of stock made in the same neighborhood, and it can all be traced to this one point, of properly cutting with the grain. Whether the wood used be cottonwood, elm, or beech, the grain should at all times be consulted. Not only is the variance in quality of staves confined to different plants, but often in the same factory and from the same rick of staves two distinct qualities of stock may be discovered, showing probably that one cutter observes the grain, while his fellow-workman does not. Most consumers have learned to understand that quality can be changed at any particular plant, either intentionally or through carelessness, and on very short notice; also, that there is a great difference in staves shipped from the same locality, and this can also be traced to that one important point of cutting with the grain. As to the proper thickness staves should be cut, the following measurements are considered standard, when the staves are dry and in condition for shipment, and should be adhered to as closely as possible:

ELM STAVES

20-inch staves, 6 staves to 2 inches.	28½-in. staves, 5 staves to 1⅞ inches.
21-inch staves, 6 staves to 2 inches.	30-inch staves, 5 staves to 1⅞ inches.
22-inch staves, 6 staves to 2 inches.	32-inch staves, 5 staves to 1⅞ inches.
24-inch staves, 6 staves to 2 inches.	33-inch staves, 5 staves to 1⅞ inches.

34-inch staves, 5 staves to 1⅞ inches.

GUM AND COTTONWOOD STAVES

20-inch staves, 6 staves to 2 inches.	30-inch staves, 5 staves to 1$\frac{15}{16}$ ins.
21-inch staves, 6 staves to 2 inches.	32-inch staves, 5 staves to 1$\frac{15}{16}$ ins.
22-inch staves, 6 staves to 2 inches.	33-inch staves, 5 staves to 1$\frac{15}{16}$ ins.
23½-in. staves, 6 staves to 2 inches.	34-inch staves, 5 staves to 1$\frac{15}{16}$ ins.
24-inch staves, 6 staves to 2 inches.	36-inch staves, 5 staves to 2 inches.
28½-in. staves, 5 staves to 1$\frac{15}{16}$ ins.	40-inch staves, 5 staves to 2$\frac{1}{16}$ ins.

OAK, BEECH AND MAPLE STAVES

20-inch staves, 6 staves to 2 inches.	30-inch staves, 6 staves to 2$\frac{1}{16}$ ins.*
21-inch staves, 6 staves to 2 inches.	32-inch staves, 6 staves to 2⅛ inches.
22-inch staves, 6 staves to 2 inches.	33-inch staves, 6 staves to 2⅛ inches.
23½-in. staves, 6 staves to 2 inches.	34-inch staves, 6 staves to 2⅛ inches.
24-inch staves, 6 staves to 2 inches.	36-inch staves, 6 staves to 2$\frac{3}{16}$ ins.
28½-in. staves, 6 staves to 2⅛ ins.	40-inch staves, 6 staves to 2$\frac{3}{16}$ ins.

NUMBER OF STAVES PER CORD

The number of staves generally produced from a cubic cord or a rank of stave bolts varies considerably, as a great deal depends upon the size of the logs from which the bolts were cut, and upon the kind and quality of the timber. For instance, 1,000 feet of logs 24 inches and over in diameter will make about 1⅓ cords of stave bolts 32 inches long, while 1,000 feet of logs averaging from 12 to 18 inches in diameter will make nearly 2 cords of bolts. From this it will be readily seen that more staves are produced from logs of small diameter than from 1,000 feet of logs measuring 24 inches and over. The general average appears to be about 2,400 staves 30 inches in length from 1,000 feet of logs, scaled Doyle rule, where small and large logs are cut, as well as good and bad ones. Now, getting down to cord measurements, a pile of stave bolts 4 feet high, 12 feet long, and 32 inches wide equals 128 cubic feet or 1 cubic cord, and a good average production would be about 2,000 staves from cottonwood, gum, sycamore, etc., and about 1,900 staves from beech, maple, etc. Another measurement used con-

*It has been the custom to cut 30-inch hardwood staves 6 to 2$\frac{1}{16}$ inches instead of 2⅛ inches, as this thickness is more preferable to all the large machine coopers.

siderably is a rank, which is figured thus: 4 feet high, 8 feet long, and 32 inches wide; this equals 32 square feet or 85½ cubic feet, and is considered a rank. From a rank of stave bolts the general average appears to be about as follows: For ash, 925 staves; for cottonwood, 1,235 staves; for mixed timber, such as gum, sycamore, etc., 1,135 staves.

THE CYLINDER STAVE SAW

In the manufacture of slack staves from hemlock, tamarack, jack pine, pitch pine, spruce, and woods of like nature, the cylinder or drum saw is generally used. (Fig.

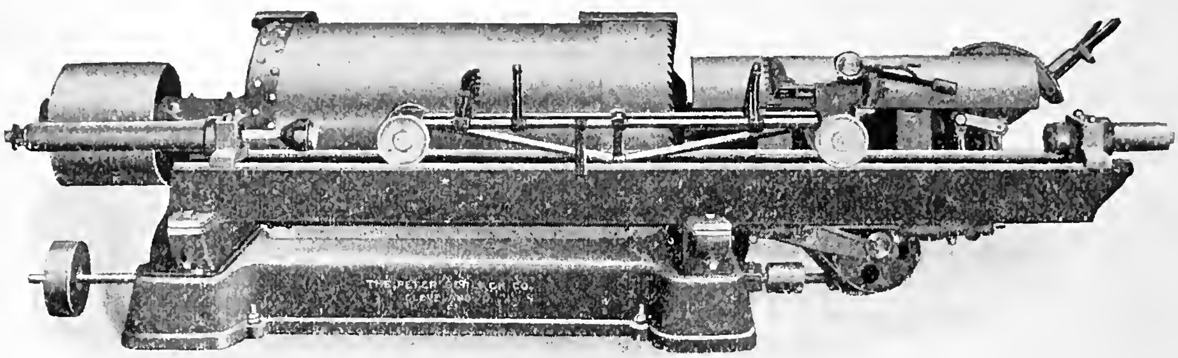


Fig. 76. Cylinder Stave Saw.

76.) As a general proposition, the cutting of pine or the softer woods on veneer machines or slicers has developed some peculiar characteristics of the wood. According to the logical deductions from most of our well-known theories and practices in woodworking, pine, by its nature, cannot be successfully steamed and cut, and especially is this true of the yellow or pitch pine of the South. Notwithstanding all this, however, we are confronted with the fact that lots of yellow pine is being cut to-day, and has been for the past few years, on veneer machines for light packages and crates, including as a prominent item orange boxes. In the softer pines of the North, in the cutting of lighter material, such as basket splints, etc., pine appears to work nicely also; still, those who have attempted to work pine and such woods into slack barrel staves and cut it with a knife say that it does not work successfully. It seems that between the steaming, and the straining and rupture of the grain while cutting, the structure and fibres of the wood are so shattered that after it dries a great many of the staves split apart, falling in some cases almost into splinters. The wood usually separates along the line between the hard and soft streaks, which is termed winter and summer-wood, and in appearance bears some resemblance to wood that has been beaten, somewhat after the manner of what is known as racking black ash strips to make butter-tub hoops. Some of the pine works better than others, but there is enough of this trouble present at all times to render the work generally unsatisfactory and make it more desirable to use cylinder stave saws to make slack barrel staves out of pine wood, whether large or small. You can, of course, cut them on a circular saw also, making straight-sawn staves of the narrow sort, such as is used for salt and lime barrels or similar packages, and which are frequently made from slabs and waste about the sawmill. In other words, this straight sawing process will do where pine staves are a mere incident in some other work; but where the making of staves from pine is a prominent factor, practically the only successful process of manufacture is the use of the cylinder or drum saw. Where gum is sawn on a cylinder stave saw, it has been found by experience that it takes a heavier corner on the teeth when sawing this wood than is required for cutting oak. This appears contrary to what one would naturally suppose. Upon careful examination of the two woods, the natural inference would be that the heavier corner would be required for the oak and that any kind of a light corner would answer for gum. But expert cylinder saw-filers contend differently, and state that not only heavier corners, but more care is required in filing for gum than for oak. In filing the saws, care should be taken that the teeth are kept at the same width and the throats or gullets at the same depth, so that the saw is always in perfect running balance. The higher the speed of the saw the more important this matter of balance becomes, and it is always of more importance than the average filer gives it credit for being. First, see that the teeth are of even length all around, which can be accomplished by holding the side of an old, worn-out emery wheel lightly against point of teeth while saw is in motion; then file the cutting edge square with the face or front of tooth, using an ordinary 8-inch mill saw file, to obtain the correct depth of tooth. After teeth have all been made of even length, chalk the surface of the saw sufficient to retain a pencil mark, on which scribe a line 9/16 inch from point of tooth; then file each one carefully to this line, using a 3/8-inch round file, in order that the throats or gullets are round at the bottom, as sharp, square corners will eventually cause breakage or cracks to appear in saw. As to the proper pitch required for cylinder saw teeth, different people have varying ideas on the matter, just as they do in shaping the teeth; but this rule has been found by experience to give entire satisfaction. Draw a line 6 inches lengthwise of saw—that is, from point of tooth toward pulley end—then measure carefully from this point 4 inches, keeping at right angles with first line or parallel with edge of saw; then from that point draw a line to the point of saw tooth, and this will give the angle or pitch desired. It is only necessary to lay out one tooth in the manner described, after which a tin templet can be cut to correspond with same and the balance of the teeth marked out and dressed accordingly. The set required for a cylinder saw should be the least amount possible in order to clear the saw, and where spring-set is used should not extend more than one-third the depth of tooth. A uniform set can be obtained by using a metal templet and springing each tooth to same. Spring-set is no longer used and is not a desirable method, as it weakens the tooth, and where knotty timber is sawn the teeth have a tendency to bend and eventually break off altogether. Swage-set is now considered more satisfactory, and there are on the market two or more eccentric swages made especially for use on cylinder saws, any one of which will give good results if properly used. After the saw is swaged, a swage shaper should be used, as no side file will work on this type of saw. Give a little lead to the carriage by measuring from saw to inside edge of carriage while saw is in motion; 1/16 inch will likely be enough. Use a tightener on belt and see that the speed is maintained at 1,800 revolutions per minute.

SWING CUT-OFF SAW

A swing cut-off saw of the type illustrated in Fig. 77 is a good, handy rig for a stave mill, and should always be considered as part of an outfit. There are uses innumerable for a machine of this class, the most important of which is the equalizing to shorter lengths the cull staves which come from the stave cutters. The frame of the saw here shown consists of wrought-iron pipe securely held together and braced by cast-iron braces. The standard distance from ceiling to centre of saw is 8 feet, which length is suitable for an 11-foot ceiling,

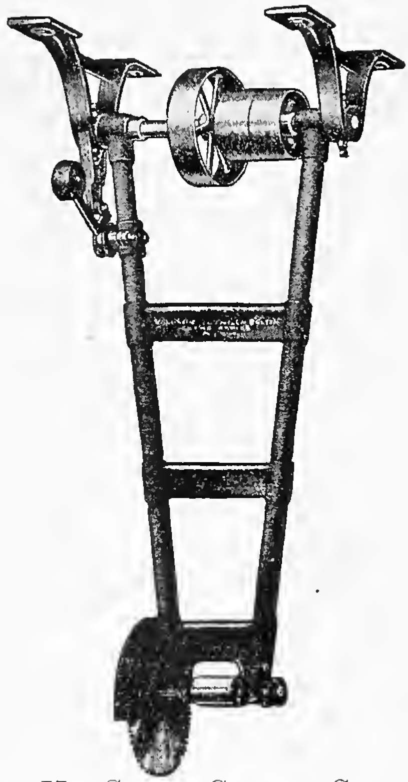


Fig. 77. Swing Cut-off Saw.

but they are made in longer or shorter lengths, as desired. Generally a saw 16 inches in diameter is used. The tight and loose pulleys are 8 inches diameter by 4½-inch face, and should travel 625 revolutions per minute.

STAVE PILING AND AIR-SEASONING

In a great majority of stave mills, after the staves are cut or sawn they are piled on the yard or under open sheds to season, called air-drying, while others put the staves direct from the knife into dry kilns. (This subject will be found more fully presented in Section IX of this work.) In piling stock in the open or under sheds built for this purpose (see Fig. 78) considerable care and attention are necessary, in order to insure that the

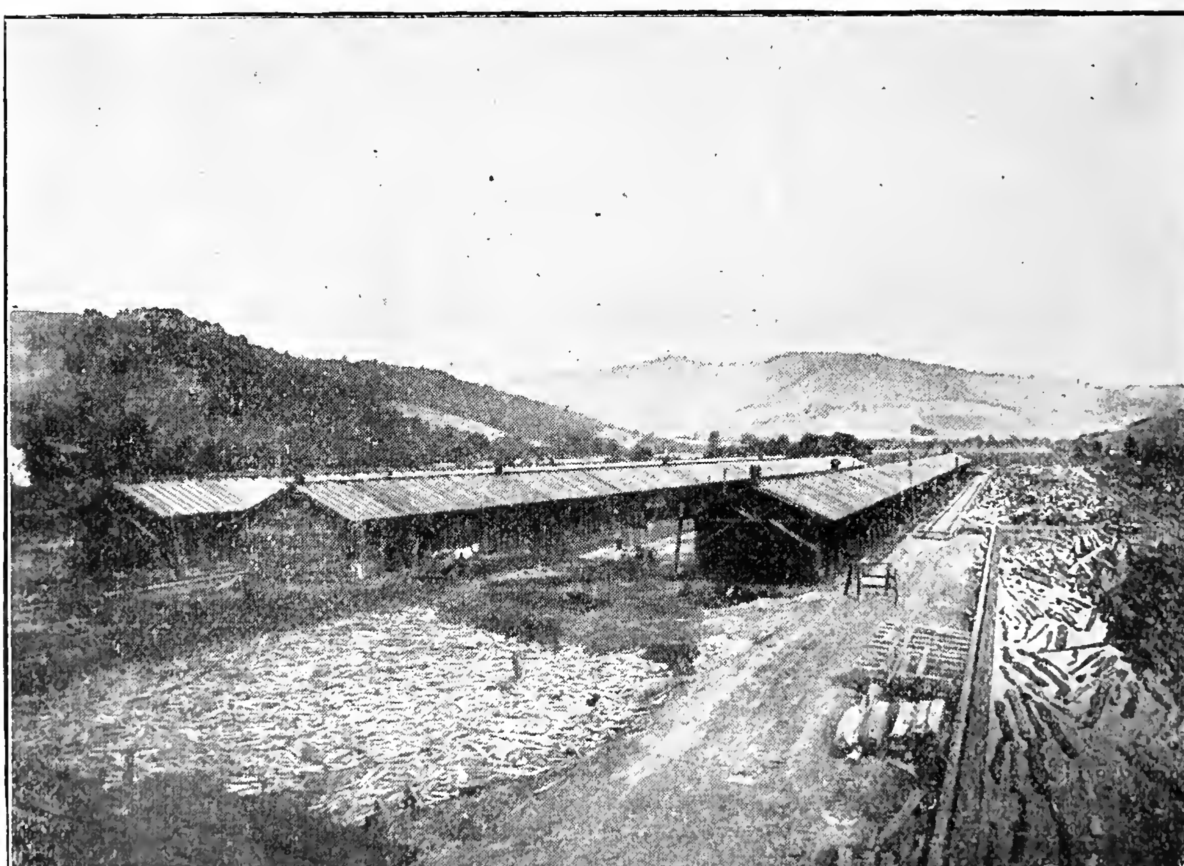


Fig. 78. View of Stave Piling Sheds and Log Pond.

work be properly done. Some manufacturers are of the opinion that after staves are made, the important part has been accomplished and that they can be piled in any old place and in almost any shape or manner which suggests itself to the sometimes inexperienced piler. This is a very grave error, as by improper piling valuable timber is liable to be wasted, and this is not the stage in the manufacture where waste should occur. If there must be waste, let it occur in the woods or before so much time and labor have been expended upon it. It appears to be the most difficult problem for some manufacturers to realize and appreciate the value of expending a little more time and labor in raising their stave piles sufficiently clear of the ground.

On a visit to the yards of some mills where staves are piled for air-seasoning, one will find many cases of gross carelessness, where good, well-manufactured staves are piled so nearly flat on the ground that the grass and weeds growing up around not only hide the poorly laid foundation, but obstruct and retard the proper circulation of air through the several layers on the bottom of the pile. Eventually, when these staves are taken to the jointers, it will be found that the majority of them are stained or have turned black and sour from moisture and lack of proper air circulation incident to being kept close to the ground. Not infrequently some are found to be so rotten and worm-eaten as to be entirely worthless. A great deal can be done toward facilitating the drying of stock if the staves are piled on pieces of timber and kept away from the ground as far as possible, with the piles separated as far as the binders will reach, or at least 14 inches, to allow of good air circulation between the piles, and with a tunnel about 18 or 20 inches square running crosswise throughout the centre of the piles, and at the bottom, directly opposite one another, so that where there is a series of piles this opening makes a continuous tunnel throughout them all. This opening or tunnel has a tendency to create air currents in and about the piles, and considerably facilitates drying or seasoning, and should not be omitted.

If there is nothing near at hand suitable to pile upon, which will furnish a good foundation, why not get something? There are generally a lot of saplings or something of the kind in the stave woods that can be had and used to advantage in making a pile foundation. If something of this kind was secured, and the bark removed, one or two sides flattened if thought necessary, and then take some of those cull stave bolts, and, instead of laying them flat on the ground, dig a small hole and set them on end to form posts, on which the saplings could be placed in the shape of stringers, it would make a pile foundation that would be clear of the ground and would let the air currents circulate freely through and under the piles and prevent moisture coming up into the pile, and so insure staves in the bottom of the pile being as dry and bright as those up toward the top.

It matters not just how these details are carried out, as one should naturally be governed in this by local conditions, but it looks as if there should be an awakening to the necessity of getting stave piles clear of the ground. What is needed is more active steps in the work of spending a little more time and energy in piling staves to save trouble and loss of stock and profits on some of the stock, because of deterioration in the piles for lack of this attention. We have often seen a good rick of staves spoiled by undue exposure, being practically neglected after they were on the yard. Open sheds are now considered by the progressive manufacturers as being the most economical and the only method by which staves should be piled for proper air-seasoning. The sheds should be built to suit the location, but where practicable should be made about 20 feet wide and 100 to 150 feet long. (See Fig. 78.) They are not very expensive, as no floor or sides are required; then the staves should be piled crosswise of this shed, making short and substantial piles, and when

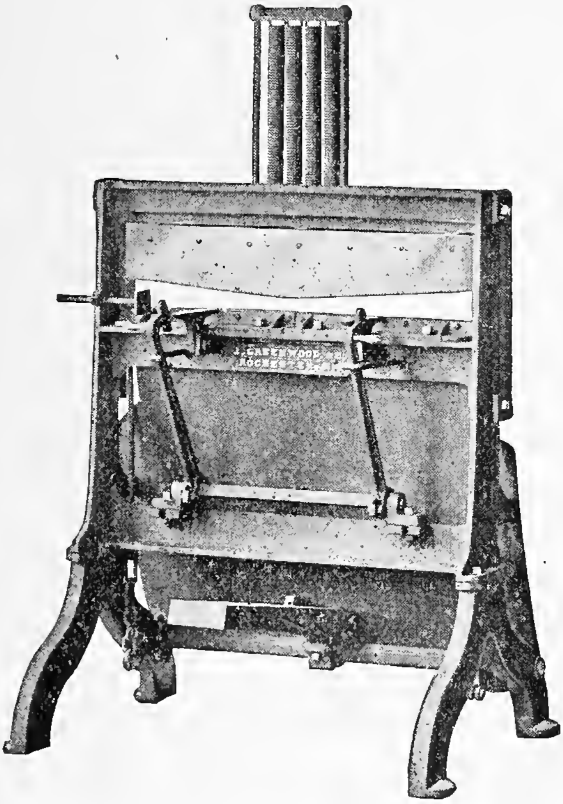


Fig. 79. Slack Stave Foot-power Jointer.

jointing out, the oldest or the ones subjected to air-seasoning the longest should always be taken first; in this way one is always shipping the best-seasoned stock, and the staves will not be liable to rot on account of remaining on the yard too long. Stave piles should be at least 8 inches off the ground, and the grass and weeds kept cleaned away, as any sort of vegetation has a tendency to draw dampness; and in piling, the staves should be laid flat, with the least amount of lap possible, in order to allow of good circulation, and the piles kept straight and orderly. It is also considered good practice to leave a small opening on the bottom and in the centre of each pile, say, 18 or 20 inches square, so that each opening is

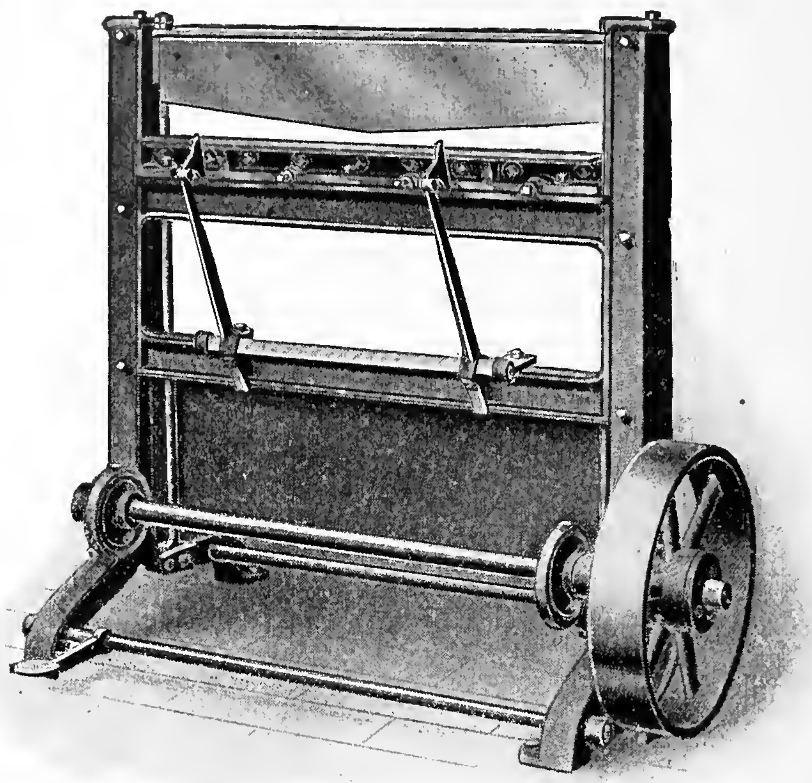


Fig. 80. Slack Stave "Power" Jointer.

directly opposite the one in the next succeeding pile, making a continuous air duct through the entire lot, which facilitates drying considerably.

STAVE JOINTING

Next in order, and of much importance in slack stave manufacture, is the jointing; for this purpose the machine illustrated in Fig. 79 is largely used, and where the jointer can be made stationary, the power jointer, as shown in Fig. 80, is generally used, as it is much easier to operate, and when in the hands of an experienced operator considerably more staves can be jointed than by the foot-power machine. In the process of jointing staves, too little attention is often given to this branch of manufacture. A jointing outfit is practically a little factory in itself, operating off in one corner of the yard, where you place full confidence in the ability of the jointer. His machine does the work poorly or well, depending upon its condition, and he often uses his own discretion in grading. With his helper he operates all day long, and if the superintendent of the plant does not visit him regularly every two or three hours one very important part of the manufacture of good staves is being neglected. Unless the jointer is a reliable and thoroughly experienced man, he should be watched constantly and coached properly in the work and the grading, as it lies in his power to make a poor grade of stock out of well-cut staves and good timber. The superintendent, foreman, or a competent jointer should inspect each and every machine's work at least once an hour, to determine whether the men operating these machines are jointing their staves properly, and at the same time are not wasting valuable timber by cutting off an unnecessarily heavy listing. These listings should be the least amount possible, in order to insure a perfect joint, and where an operator is using an extremely dull or blunt knife which necessitates two or more cuts before a good joint is secured, the waste of timber is enormous. A careless or inefficient jointer can easily waste more timber in a day's work than his wage amounts to. Take a slack stave jointer with a capacity of 10,000 staves per day, and supposing for illustration that he only cuts off just 1/16 inch more than is necessary on each joint (and 1/4 inch is often wasted), there being two edges to each stave, would make ⅛ inch in waste, or about 1,250 inches of valuable timber being sent to the boiler room each day, to be eventually used as fuel. This would be equal to a little over 300 staves per day, and on the basis of what might be termed an average price f. o. b. mills, would amount to something like $2.00 for each jointer. With four slack stave jointers working, which is about the usual crew, the loss on this waste of only 1/16 inch would amount to $7.00 or $8.00 per day. But supposing each operator cuts off ⅛ inch more than is necessary from each edge of a stave, and this will be found to be more probable than only 1/16 inch, it would make this one item of unnecessary waste amount to about $16.00 each day. This is worth looking after, is it not? Apparently it would pay to engage a competent man, or one upon whom you could rely, simply to watch this particular point, in an endeavor to guard against such unnecessary extravagance. Some manufacturers make the serious mistake of telling their jointers just what per cent. they want the stock to run, and demand that this proportion shall be maintained. If the jointer happens to come to a part of a rick of staves which was manufactured from an unusually poor lot of timber, the results would be very unsatisfactory should he mechanically adhere to the instructions given him, while later, when the stock ran better, he would be wasting good timber. Instances have occurred where staves, well cut and made of excellent timber have been ruined in the grading at the jointer's, causing considerable loss to the manufacturer; and, again, manufacturers in their eager desire to forward material or to get it on the market, ship stock that is wet or not thoroughly seasoned, causing considerable trouble to the consumer. This is a serious error, and the stave manufacturer would have done better had he purchased stock at a loss, rather than forward his own stock in poor condition. In caring for the jointing machine, the knife should be kept ground thin (Fig. 81, as at *a*), with a long bevel, and the point of the knife in the centre kept prominent and well sharpened. (Fig. 81, as at *b*.) A thick and naturally round point on the knife is the primary cause of failure to obtain a good, clean joint at the first stroke, and particularly is this so with gum or soft maple timber. The point of most makes of knives is generally 2 inches long, and should the knife be ground thick, it goes through the stave nearly two inches before the ends of the knife complete the cut. This is where the trouble lies, as it acts as a wedge and splits

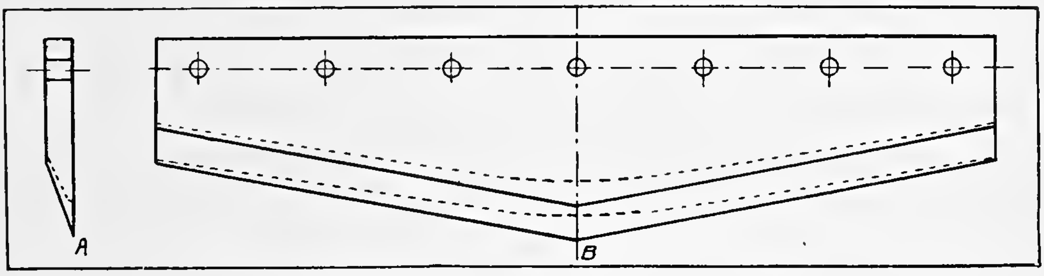


Fig. 81. Jointer Knife.

out the wood ahead of the cut, and is one of the chief causes of poor workmanship and considerable waste in stave jointing. This round or thick bevel on the jointer knives, as shown by the dotted lines in Fig. 81, is caused by the knife not being ground often enough. Instead of taking the knife out and properly grinding it on the grindstone, they merely rub it up with a file and then whet it; of course, in this operation the extreme point is taken off, and eventually the knife becomes thick and round and loses its shape, as shown by the dotted lines in Fig. 81. Where gum staves are jointed, it has been found that a straight knife gives better satisfaction than the pointed knife, from the fact that it does not break out the ends of the staves, but the knife must be thinner than the old style and the bevel kept long and the edge sharp. In adopting this style of knife, the leverage on the treadle shaft will have to be changed, as this straight knife is harder to force through the wood, but with this adjusted properly the knife goes through the wood just as easy as the old style jointing knife. To keep a stave jointer in proper condition to perform good work requires also that the sash works freely in the slides, with no play; that the chains pull evenly on each end of the sash; that the bearing plate be placed close up to the knife, with a square, true edge, as if the bearing plate is allowed to become worn round on the edge or is set too far away from the knife, it will not make a smooth joint, and especially is this true where dry stock is jointed. The rests should be in exact alignment in order to produce proper and equal bevel, the knife set so as to make the bilge exactly in the centre of the stave, and the quarter exactly the same distance from each end. As to the proper bilge and quarter to put on the staves, it appears that manufacturers in different sections of the country vary as to this point. On the regular 30-inch stave for sugar products, experience has proven that a full ¾-inch bilge joint with 7½-inch quarter is the proper thing; this means that when two staves are held together on the joint, that the joint will hold tight from the ends of the stave up to a point 7½ inches from the ends. That is the proper joint for the modern machine shops, as the sugar refiners require a large barrel, and with a shorter quarter the packages do not head up well in the machines, or by hand labor for that matter. On 28½-inch flour barrel staves, opinion seems to vary, but on tests made a ⅝-inch bilge joint with a 9-inch quarter seemed to produce the best results, and as figures show that three-fourths of all the flour barrels made are manufactured with ⅝-inch bilge joint, this should be considered standard. As to style of joint, whether it should be square or bevel, from past experience the bevel joint has easily proven the best.

In order that the term "quarter" be fully understood, it may be well to state that the original practice in making staves that developed this term "quarter" was to have the stave joint run straight from the end back to a point one-quarter of the length of the stave, then the bilge raised from that point gradually to the centre and then return to the other quarter on the opposite end. Now, in the case of a 30-inch sugar barrel stave, this rule works to perfection. As stated before, a 7½-inch

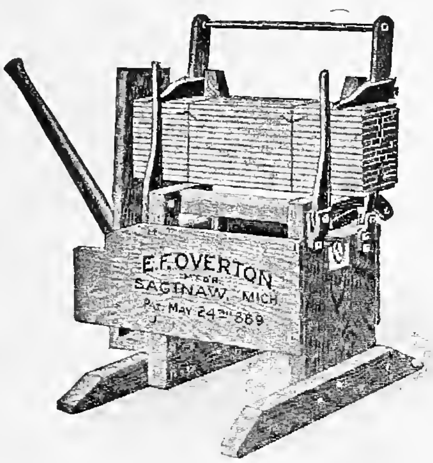


FIG. 82. STAVE PACKER OR BUNDLING MACHINE.

quarter has been found to give the best satisfaction, and 30 inches divided by four equal parts gives you 7½ inches, which is one-quarter the length of the stave; hence the term "quarter." In the case of flour barrel or 28½-inch staves, it has been found that a 9-inch quarter gives the best results. Naturally, therefore, nine inches from the end of a 28½-inch stave would not be the quarter, but coopers making this class of barrel prefer the bilge to start at a point nine inches from the ends of the stave, which is called the quarter point. Different lengths of staves, naturally, should have a different quarter, and care should be exercised in changing from one size to another that the proper quarter is observed.

STAVE BUNDLING OR PACKING

For the packing of staves into bundles subsequent to shipment, the stave press is used. There are several different types of these on the market, and they all work on about the same principle. The one illustrated in Fig. 82 appears to be as good as any, and where used has given entire satisfaction. In the use of this machine the staves should be packed alternately wide and narrow ones, and so arranged that each and every bundle will contain as nearly 200 inches as possible; this is figured as 50 staves averaging 4 inches per stave to each bundle, and is the standard method of packing.

INSPECTION

This matter of inspection is the one important link in slack stave manufacture which should be given much more attention than the average mill has applied to it. Herein lies the usefulness, reliability and quality of the barrel eventually manufactured from it, and the future success of the trade is more or less dependent upon this one point. A manufacturer uses very poor judgment when he will permit stock to leave his factory that is not up to the grade at which he has sold it. The one thing, undoubtedly, that contributes more to a mill turning out poor stock than any other is lack of properly trained and skilled labor, and more particularly so in the matter of inspection, and it is an economic necessity, both to the manufacturer and to the consumer, that effective steps be taken to secure better quality in material. This grading of material is supposed to be carefully done by a process of inspection and selection at the jointer's, and instead of having a boy perform this work, as is often the case in the majority of mills, a competent man should be engaged—one that is thoroughly conversant with the business and the proper grading of staves. This may appear somewhat more expensive at first glance, but in the long run will prove much more economical. Right at this point is where the greatest care and attention is required, as this man, or sometimes boy, is expected to stamp the value or grade of each stave, as, for instance, "No. 1," "meal barrel," or "No. 2," and can easily in the course of a day's work throw away more than his weekly wage by improper inspection. Material which is not good enough for No. 1 stock can still be of service in a lower grade, but if staves of a lower grade happen to be included in a bundle of No. 1 grade, serious injury results. A few bad staves which have crept into the bundles first opened by the purchaser cause him to engage either in a long examination of every bundle, or more usually to assume that the imperfections run all through, and to demand adjustment and rebates accordingly, or to reject the shipment altogether. One of the most vexatious matters in grading cooperage stock, and one which has caused considerable difficulty and loss, is the fact that some consumers require and demand standard quality, while others do not and are not so particular. Staves that ordinarily will pass inspection and be accepted as No. 1 stock in one locality will be questioned and probably rejected in another. It is a well-known fact that there are consumers who use and accept what they consider a No. 1 stave, although it is not up to the specifications of the National Association or the general average of No. 1 stock as manufactured. About the only remedy for this difficulty would be not to joint out and inspect stock until one is fairly positive as to which locality shipment is intended, for if one man is satisfied with a lower grade others should not be expected to accept the same. The National Association rules and specifications on the proper grading of staves are intelligently and plainly set forth. The difficulty lies in the fact that the party who actually does the grading and sorting has probably never seen these rules and is working solely upon instructions as handed him from the foreman, who also may never have given them any study or attention and relies solely upon his ideas as to what constitutes a No. 1, meal barrel, or No. 2 stave. These rules and specifications as adopted by the Association should be thoroughly committed to memory by each and every employee in and about a stave mill, and the manager or superintendent should see to it that they are supplied with a copy of same, and advised promptly of any changes or alterations. It pays immensely to educate your employees in the proper fulfilment of their duties, and employees in a stave mill cannot work intelligently unless kept posted in the Association's doings in regard to proper grading.

STANDARD SPECIFICATIONS AND GRADES

The standard specifications and grades, as acted upon and adopted by the National Slack Cooperage Manufacturers' Association as regards the proper grading of slack barrel staves, follows:

Elm staves 28½ inches and longer shall be five staves to 1⅞ inches in thickness.

Elm staves 24 inches and shorter shall be six staves to 2 inches in thickness.

Gum, cottonwood, and basswood staves 28½ inches and longer shall be five staves to 1¹⁵⁄₁₆ inches in thickness.

Gum, cottonwood, and basswood staves 24 inches and shorter shall be six staves to 2 inches in thickness.

Hardwood staves, oak, beech, and maple 28½ inches and longer shall be cut six staves to 2⅛ inches in thickness.

Hardwood staves, oak, beech, and maple 24 inches and shorter shall be cut six staves to 2 inches in thickness.

No. 1 staves shall be cut full thickness, uniform throughout, free from knots, slanting shakes, dozy wood, badly stained with black and blue mildew, or any other defects that make the stave unfit for use in an A No. 1 barrel.

Meal barrel staves shall be free from slanting shakes over 1½ inches long, knot holes, and unsound knots (but sound knots not over ⅜ inch in diameter shall be allowed), and shall consist of good, sound, workable staves.

Mill-run staves shall consist of the run of the knife, made from regular run of stave logs, all dead culls thrown out.

No. 2 staves shall be free from dead culls.

Standard bilge, unless otherwise understood, shall be ⅝ inch on all staves up to and including 28½ inches in length, and ¾-inch bilge on staves 30 inches in length.

Standard quarter shall be 9 inches for flour barrel stock and 7½ inches for sugar barrel.

No. 1 staves shall not be less than 2½ inches nor exceed 5½ inches across the bilge.

Unless otherwise specified, all staves shall be thoroughly dried.

All barrel staves to be well seasoned when jointed and to average in measurement, after being jointed, 4 inches per stave, or 4,000 inches per 1,000 staves.

Half-barrel staves 23 inches, 23½ inches, or 24 inches to average in measurement when jointed 3½ inches to the stave, or 175 inches to the bundle of 50 staves.

Keg staves to measure 160 inches to the bundle of 50 staves.

All staves to be measured across the bilge.

SPECIAL STOCK

White ash staves shall be cut five staves to 2⅛ inches in thickness and be graded same as elm.

Mill-run apple barrel staves shall be cut six staves to 2 inches in thickness, and shall consist of the run of the mill from regular run of stave logs, all dead culls thrown out.

Cement barrel and all other staves not specifically mentioned should be sold according to the local custom, or by special agreement. Same will apply as well to the bilge of these staves.

All stock not specifically mentioned should be bought and sold on terms and specifications agreed upon between the buyer and seller.

When staves shall be specified to be made of a certain kind or kinds of timber, in any deal or contract, any timber other than that specified, if found mixed in with the timber specified, shall be classified as off-grade.

DEAD CULL STAVES

Dead cull staves are staves containing knot holes of over ½ inch in diameter; staves with coarse knots or badly cross-grained near quarter, that prevents staves being tressed in barrels; staves under ¼ inch thick; staves with bad slanting shakes exceeding 6 inches in length, or with rot that impairs strength.

The above specifications do not touch upon the subject of wormholes, but where two or more wormholes are together in the bilge of a stave, this stave will, eight times out of ten, crack or break at that point; other than that, they are no disadvantage to a 30-inch stave when used for a sugar barrel, as these barrels are lined with paper, which would prevent sifting through such small holes; but in the case of 28½-inch flour barrel staves, where these wormholes go clear through the stave, it should not be classed as a No. 1 stave, and a limit should be placed on the percentage of stock allowable containing such holes, where staves are to be used for sugar.

SECTION IX

SLACK HEADING MANUFACTURE

SLACK HEADING MANUFACTURE

GENERAL REMARKS

In the report of the United States Forest Service on the production of slack barrel heading for the year 1908, which will be found in detail in Section VI, these figures indicate that pine ranks first among the woods chiefly used, followed by gum, beech, maple, and basswood, in the order of their importance. These five different kinds of wood furnish nearly two-thirds of all the heading manufactured. One noticeable feature in connection with this report is the rapid rise in favor of both red and tupelo gum as a heading wood, and confirms the impression had in mind the past few years that this species is destined to be the chief wood used in the future for the manufacture of this article. The chief and most discouraging problem experienced in the past with gum wood has been caused by the inexperience of manufacturers in the seasoning and kiln-drying of this particular species of wood. But this problem now seems to have been solved with satisfaction, as little difficulty appears from this source. In one of the experiments of the Forest Service in this line, heading was dried in from six to seven days, direct from the saw. It probably takes from one to two weeks in practice, depending on the construction of the kiln and the methods used in drying. Different makes of kilns probably require varying lengths of time in drying.

BOLTING OUT

In the getting out of heading bolts, the reader is referred to Section VIII, Slack Stave Manufacture, where, under the following heads, Bolting Room, Cut-Off Saw, Drag-Saw, Drop-Feed Circular Saw, The Bolting Saw, and Stave and Heading Bolts, the preparation of same is thoroughly explained. Heading bolts, when properly prepared, do not require equalizing before being sawn into heading pieces or blanks, as a slight difference in their length one way or another does not affect the head before being turned or circled. But care should be taken that the bolts are not cut too long, as this creates a waste of timber which can easily be avoided, as one inch leeway between the finished size of the head and the rough heading blank is generally considered sufficient by careful heading manufacturers, and if the blanks are properly centred in the heading turner by the operator, it will be found to be quite enough.

THE HEADING SAW

When the heading bolt has been properly prepared it is taken to the heading saw, or, as styled by some of the trade, an upright, pendulous-swing saw (Fig. 83). This saw should be as large in diameter as the machine will allow, in order to secure the extra rim travel, which insures ease in cutting and admits of increased capacity. Kind of timber regulates the gauge of saw and number of teeth it should have. It would be impracticable to attempt to run a 60-inch saw, 20 gauge on the rim, in gum, ash, sycamore, or cottonwood, but perfectly so in white pine or cypress. Where beech, maple, and like hardwoods are sawn, a 50-inch saw with 86 teeth, 15 gauge at the rim and 6 gauge at eye or mandrel hole, running 1,500 revolutions per minute, has been found to give best results. By not having too many teeth, you can secure more clearance for the sawdust, which will prevent the saw from running in and out of the timber when crowded, and it is also much easier for the man that operates the saw. And, again, too much speed will cause the machine to vibrate more or less, no matter how firm the foundation may be; therefore, 1,500 revolutions per minute

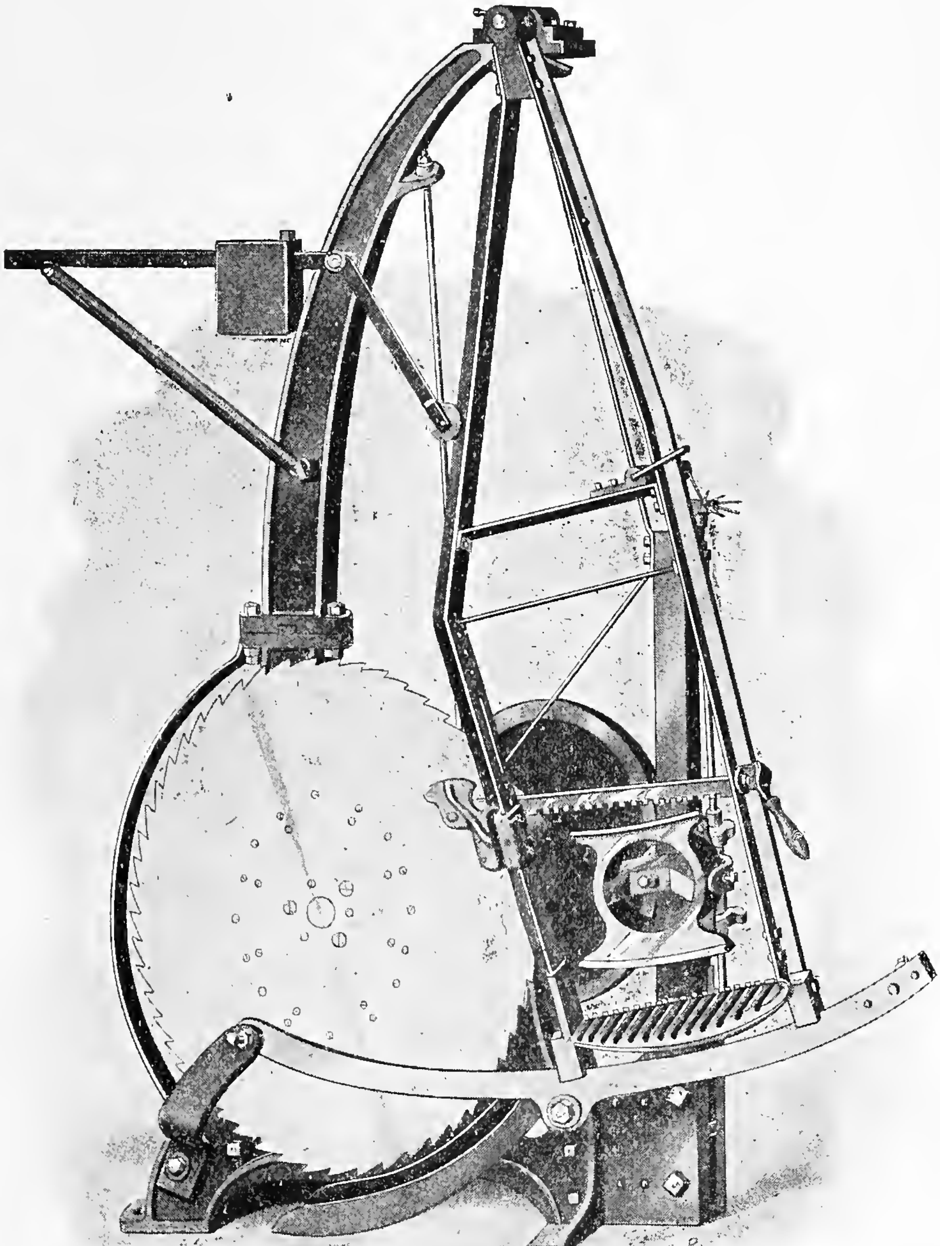


FIG. 83. PENDULOUS SWING HEADING SAW.

should be the maximum at which a heading saw should be run, and an endeavor made to maintain it at that speed. The heavier the gauge of the saw, the more power is required to drive it and maintain it at its proper speed, and there is also a waste of timber, as it takes out a much larger saw kerf. Where gum, cottonwood, and woods of like nature are sawn, it has been found that a 50-inch saw with 64 teeth, 15 gauge on the rim, 10 gauge at eye or mandrel hole, and maintained at a speed of 1,500 revolutions per minute has given excellent results. A good sawyer with this saw properly fitted should saw out 16,000 pieces of gum heading averaging 10 inches wide in 10 hours' work. In fitting heading saws, it must be kept in mind that they are subject to the same treatment as other saws receive, and must be kept in order by the same process. They will need to be taken off the collar frequently and hammered. No one who is not a careful man or who has not a fair and clear knowledge of saw-fitting should attempt to put one of these saws in order, as they are straight on one side and bevelled outside the collar on the other, which makes them very difficult to get straight. Besides, the extra weight in the centre makes it almost impossible to determine the amount of tension you have. It is best where one has not a full knowledge of saw-fitting, to only attempt to straighten them. This can be easily done by removing the collar and placing the saw on the end of a wooden block, which should be slightly oval, and by light blows smooth up the rim and true the plate, using the straight-edge on the straight side of saw only, leaving it slightly hollow on face side. This work will not expand the saw and will invariably put it in good condition, or enable the saw to be used until it can be hammered properly. On account of the position of the grain of timber to be sawn, the pitch of the teeth should be much greater than on the bolting saw. In fitting the teeth of this saw it has been found that a spring-set for gum and cottonwood and a half swage for beech, maple, and like hardwoods has given the best results. Cottonwood is one of the most difficult woods to saw, and when working on this class of timber the points of the saw tooth should be almost needle points and the teeth given full set. The bottom of the swing carriage on this machine should be adjustable, so as to raise or lower it quickly when occasion requires it, in order to bring the centre of the block on a line with the centre of the saw, as a short block will be jerked into the saw, with the probable danger of buckling it, while an extra long block will be very hard to feed if not placed in the centre; but very few of these machines have this adjustment. In setting the

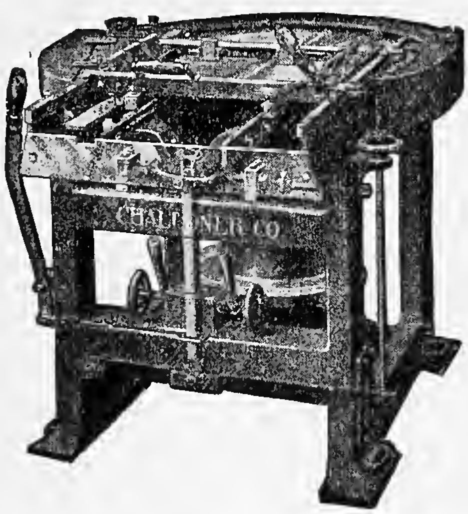


FIG. 84. HORIZONTAL HAND-FEED HEADING SAW.

gauge for thickness, place a long straightedge across the face of the saw and set the gauge to it, letting the dish in the saw provide the lead. About ¼ inch lead is considered ample for hardwoods; for softwoods a little less may be used. Leave the gauge set to thickness; continually moving the gauge one way, then another, will not insure even thickness heading. No one can make good lumber by using the guide to regulate the saw, nor can you saw good heading by manipulating the gauge. If the saw runs unevenly something is wrong, and the filer or saw-fitter should remedy the trouble. But if the saw is kept straight and true, the teeth all made of equal length, the saw gullets kept round, with just enough set to clear the blade of the saw, every tooth filed square across on face and bevelled on back, with plenty of hook, there should be no difficulty and it will run equal to any self-feed machine.

THE HORIZONTAL HAND-FEED HEADING SAW

The horizontal hand-feed heading saw, as illustrated in Figs. 84 and 84½, is sometimes used, and the saw

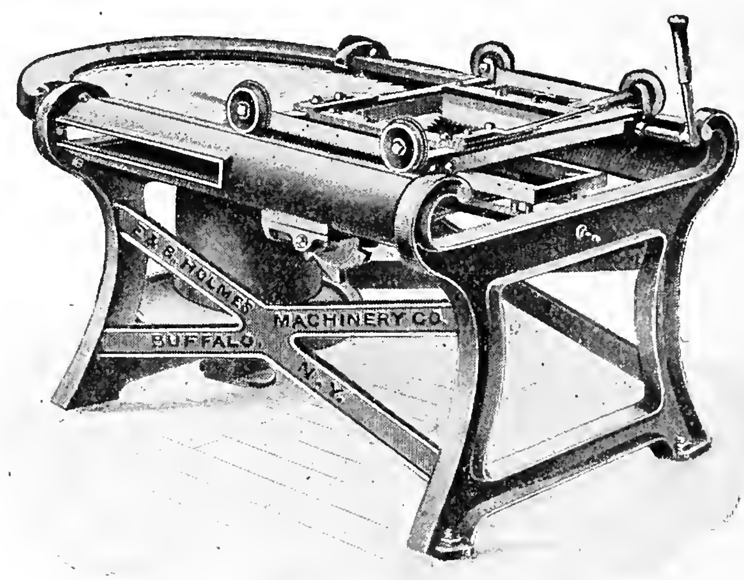


Fig. 84½. Horizontal Hand-feed Heading Saw.

requires the same treatment as the upright heading saws, except this one point: The saw, by the nature of its position, is affected by gravity, as it expands by centrifugal force. It is also acted upon by the attraction of gravitation and the rim of the saw is drawn down, and in this shape has the appearance of an inverted saucer; and as the block is fed into the saw, it strikes a point on the saw generally opposite the collar and causes the carriage to rise against the upper guides, making it hard to feed and also causes the saw to run down and make thin-edged heading. To avoid this, remove the saw from the collar and hammer it on the straight side until it is fully 1/16 inch lower in the centre; it will then not fall at the rim below the level and will perform better work. This is especially necessary where high-speed power feed machines are used. It has also been found beneficial to carry a trifle more set on the upper side of these saws, as it has a tendency to hold the rim up while in the cut and does not wear off the swage of the teeth as the block is drawn back. Special care should be given the mandrel on these machines, all end play should be taken out and it should be kept plumb and level; the flywheel and pulley should be in good running balance. Use as large a belt as the pulley will take, making it endless, and set the machine a good distance from the driving shaft. This will allow the use of a slack belt, which is always desirable, as it takes considerable strain from the bearings.

SEASONING

WHAT SEASONING IS

Seasoning is ordinarily understood to mean drying. When exposed to the sun and air, the water in green wood rapidly evaporates. The rate of evaporation will depend on the kind of wood, the shape of the timber, and the condition under which the wood is placed or piled. Pieces of wood completely surrounded by air, exposed to the wind and the sun, and protected by a roof from rain and snow will dry out very rapidly, while wood piled or packed close together so as to exclude the air, or left in the shade and exposed to rain and snow, will probably dry out very slowly and will be subject to mould and decay. But seasoning implies other changes besides the evaporation of water. Although we have as yet only a vague conception as to the exact nature of the difference between seasoned and unseasoned wood, it is very probable that one of these consists in changes in the albuminous substances in the wood fibres, and possibly also in the tannins, resins, and other incrusting substances. Whether the change in these substances is merely a drying out, or whether it consists in a partial decomposition is as yet undetermined. That the change during the seasoning process is a profound one there can be no doubt, because experience has shown again and again that seasoned wood fibre is very much more permeable both for liquids and gases than the living, unseasoned fibre. One can picture the albuminous substance as forming a coating which dries out and possibly disintegrates when the wood dries. The drying out may result in considerable shrinkage, which may make the wood fibre more porous. It is also possible that there are oxidizing influences at work within these substances which result in their disintegration. Whatever the exact nature of the changes may be, one can say without hesitation that exposure to the wind and air brings about changes in the wood, which are of such a nature that the wood becomes drier and more permeable. When seasoned by exposure to live steam, similar changes may take place; the water leaves the wood in the form of steam, while the organic compounds in the walls probably coagulate or disintegrate under the high temperature. The most effective seasoning is without doubt that obtained by the uniform, slow drying which takes place in properly constructed piles outdoors, under exposure to the winds and the sun and under cover from the rain and snow, and is what has been termed "air-seasoning." By air-seasoning oak and similar hardwoods, nature performs certain functions that cannot be duplicated by any artificial means. Because of this, woods of this class cannot be successfully kiln-dried green from the saw. In drying wood, the free water within the cells passes through the cell walls until the cells are empty, while the cell walls remain saturated. When all the free water has been removed, the cell walls begin to yield up their moisture. Heat raises the absorptive power of the fibres and so aids the passage of water from the interior of the cells. A confusion in the use of the word "sap" is to be found in many discussions of kiln-drying; in some instances it means water, in other cases it is applied to the organic substances held in a water solution in the cell cavities. The term is best confined to the organic substances from the living cell. These substances, for the most part of the nature of sugar, have a strong attraction for water and water vapor, and so retard drying and absorb moisture into dried wood. High temperatures, especially those produced by live steam, appear to destroy these organic compounds and therefore both to retard and to limit the reabsorption of moisture when the wood is subsequently exposed to the atmosphere. Air-dried wood, under ordinary atmospheric temperatures, retains from 10 to 20 per cent. of moisture, whereas kiln-dried wood may have no more than 5 per cent. as it comes from the kiln. The exact figures for a given species depend in the first case upon the weather conditions, and in the second case upon the temperature in the kiln and the time during which the wood is exposed to it. When wood that has been kiln-dried is allowed to stand in the open, it apparently ceases to reabsorb moisture from the air before its moisture content equals that of wood which has merely been air-dried in the same place and under the same conditions.

MANNER OF EVAPORATION OF WATER

The evaporation of water from wood takes place largely through the ends, i. e., in the direction of the longitudinal axis of the wood fibres. The evaporation from the other surfaces takes place very slowly out of doors, and with greater rapidity in a dry kiln. The rate of evaporation differs both with the kind of timber and its shape. Slack barrel staves and heading dry faster than tight barrel stock, from the fact that they are much thinner. Sapwood dries faster than heartwood, and pine more rapidly than oak or other hardwoods. Tests made show little difference in the rate of evaporation in sawn and hewn stock, the results, however, not being conclusive. Air-drying out of doors takes from two months to a year, the time depending on the kind of timber and the climate. After wood has reached an air-dry condition it absorbs water in small quantities after a rain or during damp weather, much of which is immediately lost again when a few warm, dry days follow. In this way wood exposed to the weather will continue to absorb water and lose it for indefinite periods. When soaked in water, seasoned wood absorbs water rapidly. This at first enters into the wood through the cell walls; when these are soaked, the water will fill the cell lumen, so that if constantly submerged the wood may become completely filled with water. The following figures show the gain in weight by absorption of several coniferous woods, air-dry at the start, expressed in per cent. of the kiln-dry weight:

ABSORPTION OF WATER BY DRY WOOD

	White Pine	Red Cedar	Hemlock	Tamarack
Air dried	108	109	111	108
Kiln-dried	100	100	100	100
In water 1 day	135	120	133	129
In water 2 days	147	126	144	136
In water 3 days	154	132	149	142
In water 4 days	162	137	154	147
In water 5 days	165	140	158	150
In water 7 days	176	143	164	156
In water 9 days	179	147	168	157
In water 11 days	184	149	173	159
In water 14 days	187	150	176	159
In water 17 days	192	152	176	161
In water 25 days	198	155	180	161
In water 30 days	207	158	186	166

DISTRIBUTION OF WATER IN WOOD

As seasoning means essentially the more or less rapid evaporation of water from wood, it will be necessary to discuss at the very outset where water is found in wood and its local and seasonal distribution in a tree. Water may occur in wood in three conditions: (1) It forms the greater part (over 90 per cent.) of the protoplasmic contents of the living cells; (2) it saturates the walls of all cells, and (3) it entirely or at least partly fills the cavities of the lifeless cells, fibres, and vessels. In the sapwood of pine it occurs in all three forms; in the heartwood only in the second form it merely saturates the walls. Of 100 pounds of water associated with 100 pounds of dry wood substance in 200 pounds of fresh sapwood of white pine, about 35 pounds are needed to saturate the cell walls, less than 5 pounds are contained in living cells, and the remaining 60 pounds partly fill the cavities of the wood fibres. This latter forms the sap as ordinarily understood. It is water brought from the soil containing small quantities of mineral salts, and in certain species (maple, birch, etc.) it also contains at certain times a small percentage of sugar and other organic matter. All the conifers (pines, cedars, junipers, cypresses, sequoias, yews and spruces) contain resin. Both resin and albumen, as they exist in the sap of woods, are soluble in water; and both harden with heat, much the same as the white of an egg, which is almost pure albumen. These organic substances are the dissolved reserve food stored during the winter in the pith rays, etc., of the wood and bark; generally but a mere trace of them is to be found. From this it appears that the solids contained in the sap, such as albumen, gum, sugar, resin, etc., cannot exercise the influence on the strength of the wood which is so commonly claimed for them. The wood next to the bark contains the most water. In the species which do not form heartwood the decrease toward the pith is gradual, but where this is formed the change from a more moist to a drier condition is usually quite abrupt at the sapwood limit. In long-leaf pine the wood of the outer one inch of a disk may contain 50 per cent. of water; that of the next or second inch, only 35 per cent., and that of the heartwood only 20 per cent. In such a tree the amount of water in any one section varies with the amount of sapwood, and is therefore greater for the upper than the lower cuts, greater for limbs than stems, and greatest of all in the roots. Different trees, even of the same kind and from the same place, differ as to the amount of water they contain. A thrifty tree contains more water than a stunted one, and a young tree more than an old one, while the wood of all trees varies in its moisture relations with the season of the year. Contrary to the general belief, a tree contains about as much water in winter as in summer. The fact that the bark peels easily in the spring depends on the presence of incomplete, soft tissue found between wood and bark during the season and has little to do with the total amount of water contained in the wood of the stem. Even in the living tree a flow of sap from a cut occurs only in certain kinds of trees and under special circumstances; from boards, felled timber, etc., the water does not flow out, as is sometimes believed, but must be evaporated. The seeming exceptions to this rule are mostly referable to two causes: Clefts or "shakes" will allow water contained in them to flow out. And water is forced out of sound wood, if very sappy, whenever the wood is warmed, just as water flows from green wood when put in the stove.

RAPIDITY OF EVAPORATION

The rapidity with which water is evaporated, that is, the rate of drying, depends on the size and shape of the piece and on the structure of the wood. An inch board dries more than four times as fast as a 4-inch plank and more than twenty times as fast as a 10-inch timber. White pine dries faster than oak. A very moist piece of pine or oak will, during one hour, lose more than four times as much water per square inch from the cross-section, but only one-half as much from the tangential as from the radial section. In a long timber, where the ends or cross-sections form but a small part of the drying surface, this difference is not so evident. Nevertheless, the ends dry and shrink first, and being opposed in this shrinkage by the more moist adjoining parts, they check, the cracks largely disappearing as seasoning progresses. High temperatures are very effective in evaporating the water from wood, no matter how humid the air, and a fresh piece of sapwood may lose weight in boiling water, and can be dried to quite an extent in hot steam. In drying chemicals or fabrics, all that is required is to provide heat enough to vaporize the moisture and circulation enough to carry off the vapor thus secured, and the quickest and most convenient means to these ends may be used. While on the other hand, in drying wood, whether in the form of standard stock or the finished product, the application of the requisite heat and circulation must be carefully regulated throughout the entire process or warping and checking are almost certain to result. Moreover, wood of different shapes and thicknesses is very differently affected by the same treatment. Finally, the tissues composing the wood, which vary in form and physical properties and which cross each other in regular directions, exert their own peculiar influence upon its behavior during drying. With our native woods, for instance, summer-wood and spring-wood show distinct tendencies in drying, and the same is true in a less degree of heartwood, as contrasted with sapwood. Or, again, pronounced medullary rays further complicate the drying problem.

EFFECTS OF MOISTURE ON WOOD

The question of the effect of moisture upon the strength and stiffness of wood offers a wide scope for study, and authorities differ in conclusions. Two authorities give the tensile strength in pounds per square inch for white oak as 10,000 and 19,500, respectively; for spruce, 8,000 to 19,500, and other species in similar startling contrasts. Wood, we are told, is composed of organic products. The chief material is cellulose, and this in its natural state in the living plant or green wood contains from 25 to 35 per cent. of its weight in moisture. The moisture renders the cellulose substance pliable. What the physical action of the water is upon the molecular structure of organic material, to render it softer and more pliable, is largely a matter of conjecture. The strength of a wooden block depends not only upon its relative freedom from imperfections, such as knots, crookedness of grain, decay, wormholes or ring shakes, but also upon its density, upon the rate at which it grew, and upon the arrangement of the various elements which compose it. The factors affecting the strength of wood are therefore of two classes: (1) Those inherent in the wood itself and which may cause differences to exist between two pieces from the same species of wood or even between the two ends of a piece, and (2) those which are foreign to the wood, such as moisture, oils, and heat. Though the effect of moisture is generally temporary, it is far more important than is commonly realized. So great, indeed, is the effect of moisture that under some conditions it outweighs all the other causes which affect strength, with the exception, perhaps, of decided imperfections in the wood itself. In the Southern States it is difficult to keep green timber in the woods or in piles for any length of time, because of the rapidity with which wood-destroying fungi attack it. This is particularly so during the summer season, when the humidity is greatest.

SHRINKAGE OF WOOD

Since in all our woods, cells with thick walls and cells with thin walls are more or less intermixed, and especially as the spring-wood and summer-wood nearly always differ from each other in this respect, strains and tendencies to warp are always active when wood dries out, because the summer-wood shrinks more than the spring-wood, and heavier wood in general shrinks more than light wood of the same kind. If a thin piece of wood after drying is placed upon a moist surface the cells on the under side take up moisture and swell before the upper cells receive any moisture. This causes the under side of the piece to become longer than the upper side, and as a consequence warping occurs. Soon, however, the moisture penetrates to all the cells and the piece straightens out. But while a thin board of pine curves laterally it remains quite straight lengthwise, since in this direction both shrinkage and swelling are small. If one side of a green board is exposed to the sun, warping is produced by the removal of water and consequent shrinkage of the side exposed. As already stated, wood loses water faster from the end than from the longitudinal faces. Hence the ends shrink at a different rate from the interior parts. The faster the drying at the surface, the greater is the difference in the moisture of the different parts, and hence the greater the strains and consequently also the greater amount of checking. This becomes very evident when freshly cut wood is placed in the sun, and still more when put in a hot kiln. While most of these smaller checks are only temporary, closing up again, some large radial checks remain and even grow larger as drying progresses. Their cause is a different one and will presently be explained. The temporary checks not only occur at the ends, but are developed on the sides also, only to a much smaller degree. They become especially annoying on the surface of thick planks of hardwoods, and also on peeled logs when exposed to the sun. So far we have considered the wood as if made up only of parallel fibres all placed longitudinally in the log. This, however, is not the case. A large part of the wood is formed by the medullary or pith rays. In pine over 15,000 of these occur on a square inch of a tangential section, and even in oak the very large rays, which are readily visible to the eye, represent scarcely a hundredth part of the number which the microscope reveals, as the cells of these rays have their length at right angles to the direction of the wood fibres. If a large pith ray of white oak is whittled out and allowed to dry it is found to shrink greatly in its width, while, as we have stated, the fibres to which the ray is firmly grown in the wood do not shrink in the same direction. Therefore, in the wood, as the cells of the pith ray dry they pull on the longitudinal fibres and try to shorten them, and, being opposed by the rigidity of the fibres, the pith ray is greatly strained. But this is not the only strain it has to bear. Since the fibres shrink as much again as the pith ray, in this, its longitudinal direction, the fibres tend to shorten the ray, and the latter in opposing this prevents the former from shrinking as much as they otherwise would. Thus the structure is subjected to two severe strains at right angles to each other, and herein lies the greatest difficulty of wood seasoning, for whenever the wood dries rapidly these fibres have not the chance to "give" or accommodate themselves, and hence fibres and pith rays separate and checks result, which, whether visible or not, are detrimental in the use of the wood. The contraction of the pith rays parallel to the length of the board is probably one of the causes of the small amount of longitudinal shrinkage which has been observed in boards. The smaller shrinkage of the pith rays along the radius of the log (the length of the pith ray) opposing the shrinkage of the fibres in this direction becomes one of the causes of the second great troubles in wood seasoning, namely, the difference in the amount of the shrinkage along the radius and that along the rings or tangent. This greater tangential shrinkage appears to be due in part to the causes just mentioned, but also to the fact that the greatly shrinking bands of summer-wood are interrupted along the radius by as many bands of porous spring-wood, while they are continuous in the tangential direction. In this direction, therefore, each such band tends to shrink, as if the entire piece were composed of summer-wood, and since the summer-wood represents the greater part of the wood substance, this greater tendency of tangential shrinkage prevails. The effect of this greater tangential shrinkage affects every phase of wood-working. It leads to permanent checks and causes the log to split open on drying. Sawed in two, the flat sides of the log become convex; sawed into timber, it checks along the median line of the four faces, and if converted into boards the latter checks considerably from the end through the centre, all owing to the greater tangential shrinkage of the wood. Briefly, then, shrinkage of wood is due to the fact that the cell walls grow thinner on drying. The thicker cell walls and therefore the heavier wood shrinks most, while the water in the cell cavities does not influence the volume of the wood. Owing to the great difference of cells in shape, size, and thickness of walls, and still more in their arrangement, shrinkage is not uniform in any kind of wood. This irregularity produces strains, which grow with the difference between adjoining cells and are greatest at the pith rays. These strains cause warping and checking, but exist even where no outward signs are visible. They are greater if the wood is dried rapidly than if dried slowly, but can never be entirely avoided. Temporary checks are caused by the more rapid drying of the outer parts of any stick; permanent checks are due to the greater shrinkage, tangentially, along the rings than along the radius. This, too, is the cause of most of the ordinary phenomena of shrinkage, such as the difference in behavior of entire and quartered logs, "bastard" (tangent) and rift (radial) boards, etc., and explains many of the phenomena erroneously attributed to the influence of bark or of the greater shrinkage of outer and inner parts of any log. Once dry, wood may be swelled again to its original size by soaking in water, boiling, or steaming. Soaked pieces on drying shrink again as before; boiled and steamed pieces do the same, but to a slightly less degree. Neither hygroscopicity, i. e., the capacity of taking up water, nor shrinkage of wood can be overcome by drying at temperatures below 200° Fahr. Higher temperatures, however, reduce these qualities, but nothing short of a coaling heat robs wood of the capacity to shrink and swell. Rapidly dried in the kiln, the wood of oak and other hardwoods "caseharden"; that is, the outer part dries and shrinks before the interior has a chance to do the same, and thus forms a firm shell or case of shrunken, commonly checked wood around the interior. This shell does not prevent the interior from drying, but when this drying occurs the interior is commonly checked along the medullary rays, commonly called "honeycombing" or hollow-horning. In practice this occurrence can be prevented by steaming or sweating the wood in the kiln, and still better by drying the wood in the open air or in a shed before placing in the kiln. Since only the first shrinking is apt to check the wood, any kind of lumber which has once been air-dried (three to six months for 1-inch stuff) may be subjected to kiln heat without any danger. Kept in a bent or warped condition during the first shrinkage, the wood retains the shape to which it has been bent and firmly opposes any attempt at subsequent straightening. Sapwood, as a rule, shrinks more than heartwood of the same weight, but very heavy heartwood may shrink more than lighter sapwood. The amount of water in wood is no criterion of its shrinkage, since in wet wood most of the water is held in the cavities, where it has no effect on the volume. The wood of pine, spruce, cypress, etc., with its very regular structure, dries and shrinks evenly and suffers much less in seasoning than the wood of broad-leafed trees. Among the latter, oak is the most difficult to dry without injury. Desiccating the air with certain chemicals will cause the wood to dry, but wood thus dried at 80° Fahr. will still lose water in the kiln. Wood dried at 120° Fahr. loses water still if dried at 200° Fahr., and this again will lose more water if the temperature is raised, so that absolutely dry wood cannot be obtained, and chemical destruction sets in before all the water is driven off. On removal from the kiln, the wood at once takes up water from the air, even in the driest weather. At first the absorption is quite rapid; at the end of a week a short piece of pine 1½ inches thick has regained two-thirds of, and in a few months all, the moisture which it had when air-dry, 8 to 10 per cent. and also its former dimensions. In thin boards all parts soon attain the same degree of dryness. In heavy timbers the interior remains moister for many months, and even years, than the exterior parts. Finally an equilibrium is reached, and then only the outer parts change with the weather.

With kiln-dried woods all parts are equally dry, and when exposed the moisture coming from the air must pass in through the outer parts, and thus the order is reversed. Ordinary timber requires months before it is at its best. Kiln-dried timber, if properly handled, is prime at once. Dry wood when soaked in water soon regains its original volume, and in the heartwood portion it may even surpass it; that is to say, swell to a larger dimension than it had when green. With the soaking it continues to increase in weight, the cell cavities filling with water, and if left many months all pieces sink. Yet after a year's immersion a piece of oak 2 by 2 inches and only 6 inches long still contains air; i. e., it has not taken up all the water it can. By rafting or prolonged immersion, wood loses some of its weight, soluble materials being leached out, but it is not impaired either as fuel or as building material. Immersion, and still more boiling and steaming, reduce the hygroscopicity of wood and therefore also the troublesome "working" or shrinking and swelling. Exposure in dry air to a temperature of 300° Fahr. for a short time reduces but does not destroy the hygroscopicity, and with it the tendency to shrink and swell. A piece of red oak which has been subjected to a temperature of over 300° Fahr. still swells in hot water and shrinks in the kiln. In artificial drying temperatures of from 150° to 180° Fahr. are usually employed. Pine, spruce, cypress, cedar, etc., are dried fresh from the saw, allowing four days for 1-inch stuff. Hardwoods, especially oak, ash, maple, birch, sycamore, etc., are usually air-seasoned for three to six months to allow the first shrinkage to take place more gradually, and are then exposed to the above temperatures in the kiln for about six to ten days for 1-inch stuff, other dimensions in proportion. Freshly cut poplar and cottonwood are often dried direct from the saw in a kiln. By employing lower temperatures, 100° to 120° Fahr., green oak, ash, etc., can be seasoned in dry kilns without danger to the material. Steaming and sweating the lumber is sometimes resorted to in order to prevent checking and "case-hardening," but not, as has been frequently asserted, to enable the wood to dry. Air-dried stock is not dry, and its moisture is too unevenly distributed to insure good behavior after manufacture. Careful piling of the stock, both in the yard and kiln, is essential to good drying. Since the proportion of sap and heartwood varies with size, age, species, and individual, the following figures must be regarded as mere approximations:

POUNDS OF WATER LOST IN DRYING 100 POUNDS OF GREEN WOOD IN THE KILN

	Sapwood or outer part	Heartwood or interior
(1) Pines, cedars, spruces and firs	45–65	16–25
(2) Cypress, extremely variable	50–65	18–60
(3) Poplar, cottonwood, basswood	60–65	40–60
(4) Oak, beech, ash, elm, maple, birch, hickory, chestnut, walnut and sycamore	40–50	30–40

The lighter kinds have the most water in the sapwood, thus sycamore has more than hickory.

DIFFICULTIES OF DRYING WOOD

Seasoning and kiln-drying is so important a process in the manufacture of woods that a need is keenly felt for fuller information regarding it, based upon scientific study of the behavior of various species at different mechanical temperatures and under different mechanical drying processes. The special precautions necessary to prevent loss of strength or distortion of shape render the drying of wood especially difficult. All wood when undergoing a seasoning process, either natural (by air) or mechanical (by steam or heat in a dry kiln), checks or splits more or less. This is due to the uneven drying out of the wood and the consequent strains exerted in opposite directions by the wood fibres in shrinking. This shrinkage, it has been proven, takes place both endwise and across the grain of wood. The old tradition that wood does not shrink endwise has long since been shattered, and it has long been demonstrated that there is an endwise shrinkage. In some woods it is very light, while in others it is easily perceptible. It is claimed that the average end shrinkage, taking all the woods, is only about 1½ per cent. This, however, probably has relation to the average shrinkage on ordinary lumber as it is used and cut and dried. Now, if we depart from this and take veneer, or basket stock, or even stave bolts where they are boiled, causing swelling both endwise and across the grain or in dimension, after they are thoroughly dried there is considerably more evidence of end shrinkage. In other words, a slack barrel stave of elm, say, 28 or 30 inches in length, after being boiled might shrink as much in thoroughly drying out as compared to its length when freshly cut as a 12-foot elm board. It is in the cutting of veneer that this end shrinkage becomes most readily apparent. In trimming with scoring knives it is done to exact measure, and where stock is cut to fit some specific place there has been observed a shrinkage on some of the softer woods, like cottonwood, amounting to fully ⅛ of an inch in 36 inches. And at times where the drying has been thorough the writer has noted a shrinkage of ⅛ of an inch on an ordinary elm cabbage-crate strip 36 inches long, sawed from the log without boiling. There really are no fixed rules of measurement or allowance, however, because the same piece of wood may vary under different conditions; and, again, the grain may cross a little or wind around the tree, and this of itself has a decided effect on the amount of what is termed "end shrinkage." There is more checking in the wood of broad-leaf trees than in that of coniferous trees, more in sapwood than in heartwood, and more in summer-wood than in spring-wood. Inasmuch as under normal conditions of weather, water evaporates less rapidly during early seasoning in winter, wood that is cut in the autumn and early winter is considered less subject to checking than that which is cut in spring and summer. Rapid seasoning, except after wood has been thoroughly soaked or steamed, almost invariably results in more or less serious checking. All hardwoods which check or warp badly during seasoning should be reduced to the smallest practicable size before drying to avoid the injuries involved in this process, and wood once seasoned should never again be exposed to the weather, since all injuries due to seasoning are thereby aggravated. Seasoning increases the strength of wood in every respect, and it is therefore of great importance to protect it against moisture.

UNSOLVED PROBLEMS IN KILN-DRYING

1. Physical data of the properties of wood in relation to heat are meagre.

2. Figures on the specific heat of wood are not readily available, though upon this rests not only the exact operation of heating coils for kilns, but the theory of kiln-drying as a whole.

3. Great divergence is shown in the results of experiments in the conductivity of wood. It remains to be seen whether the known variation of conductivity with moisture content will reduce these results to uniformity.

4. The maximum or highest temperature to which the different species of wood may be exposed without serious loss of strength has not yet been determined.

5. The optimum or absolute correct temperature for drying the different species of wood is as yet entirely unsettled.

6. The inter-relation between wood and water is as imperfectly known to dry-kiln operators as that between wood and heat.

7. What moisture conditions obtain in a stick of air-dried wood?

8. How is the moisture distinguished?

9. What is its form?

10. What is the meaning of the peculiar surface conditions which even in the air-dried wood appear to indicate incipient case-hardening?

These questions can be answered thus far only by speculation or, at best, on the basis of incomplete data. Until these problems are solved, kiln-drying must necessarily remain without the guidance of complete scientific theory.

KILN-DRYING

Drying is an essential part of the preparation of wood for manufacture. For a long time the only drying process used or known was air-drying, or the exposure of wood to the gradual drying influences of the open air, and is what has now been termed preliminary seasoning. This method is without doubt the most successful and effective seasoning, because nature performs certain functions in air-drying that cannot be duplicated by artificial means. Because of this, hardwoods, as a rule, cannot be successfully kiln-dried green or direct from the saw. Kiln-drying, which is an artificial method, originated in the effort to improve or shorten the process by subjecting the wood to a high temperature or to a draught of heated air in a confined space or kiln. In so doing, time is saved and a certain degree of control over the drying condition is secured. With softwoods it is a common practice to kiln-dry direct from the saw or knife. This procedure, however, is ill adapted for hardwoods, in which it would produce such checking and warping as would greatly reduce the value of the product. Therefore, hardwoods, as a rule, are more or less thoroughly air-dried before being placed in the dry-kiln, where the residue of moisture may be reduced to within three and four per cent., which is much lower than is possible by air-drying only. It is probable that for the sake of economy, air-drying will be eliminated in the drying process of the future without loss to the quality of the product. The kiln-drying of staves and heading is one of the most important items in the manufacture of cooperage, and to do it properly requires constant care and attention. Where staves are kiln-dried, they should be piled in the kiln or on the trucks lengthwise, allowing the ends only to lap, and this should be the least amount possible. By this method it reduces the quantity of staves per truck, but facilitates drying, as they dry faster, more uniformly, and with better results. By cross-piling, the staves become flat and lose their proper circle. As to the time required in drying staves, this depends on three things: the species of wood to be dried, the condition of the staves when they enter the kiln, and the intensity of the drying process. This generally varies from three or four days to about two weeks; probably a safe average would be one week on stock that is comparatively easy to dry, or that has been well steamed before cutting. It is well, where staves are kiln-dried direct from the knife, to get them into the kiln while they are still warm from the steaming, as they are then in good condition for kiln-drying, as the fibres of the wood are soft and the pores open, which will allow of forcing the evaporation of moisture.

It is the practice among slack stock manufacturers to abide by the decision or judgment of their foremen as to when the stock in the dry-kilns is sufficiently dry, and this decision is generally based entirely on observation. This practice is no doubt a good one, providing the party thus deciding is well versed in the drying subject and has had considerable experience in the matter; but there are a great many who have not this knowledge or experience and who have never made a study of this subject, and who operate their dry-kilns in a haphazard sort of way, either by subjecting all their stock to a given number of days, regardless of the condition of same when entering the drying room, or else entirely by their own judgment, which, in the majority of cases, is found to be unsatisfactory. System is as indispensable in this operation as at any other point in manufacture, and one should be guided somewhat by figures, indicating "about" the proper weight of the stock when leaving the kiln. This in itself will not guarantee properly dried stock, but will cause investigations to be made, and will materially assist those upon whom this responsibility rests. It is quite a difficult matter to give specific or "absolutely correct" weights of slack staves when thoroughly or properly dried in order that one may be positively guided in these kiln operations, as a great deal depends upon the species of wood to be dried, its density, and upon the thickness which it has been cut. Elm will naturally weigh less than beech, and where the wood is close-grained or compact it will weigh more than coarse-grained wood of the same species. But from numerous experiments and investigations made at one of the largest slack barrel plants in this country, it has been found that when No. 1 30-inch staves cut from the different species of wood and of the thicknesses as shown in the table below conform to the weights as specified that they are entirely satisfactory, and that for guidance in this matter can be safely relied upon.

Beech, maple, etc., cut 6 staves to 2⅛ inches should weigh about 940 pounds and not exceed 1,040 pounds per 1,000 staves.

Gum, cottonwood, etc., cut 5 staves to 1$^{15}/_{16}$ inches should weigh about 880 pounds and not exceed 980 pounds per 1,000 staves.

Elm cut 5 staves to 1⅞ inches should weigh about 800 pounds and not exceed 900 pounds per 1,000 staves. Other sizes in proportion.

In the kiln-drying of heading blanks considerable importance attaches to the piling on trucks in such a manner as to avoid moulding, warping or checking, and this is especially so with gum. To obviate the first difficulty, a space of not less than six or eight inches should be left between the ricks. The uneven lapping of the heading blanks either at the ends or sides is sure to cause warping, and the general preference is given to cross-sticks rather than interlocking the heading blanks. These cross-sticks should be not more than 1¼ inches wide by about ¾ or 1 inch in thickness, and when used have a tendency to prevent warping; whereas, if the heading blanks are simply interlocked, any tendency of some one piece to warp or twist may communicate itself to another, but where the cross-sticks are used they will exert a restraining influence. The heading blanks of the upper layer, being subjected to the greatest amount of heat and ordinarily without weight to hold them in shape, should have planks or some device superimposed to put the upper course under conditions similar to those lower in the pile; otherwise these topmost layers will warp. As to the time required for drying heading blanks, this also depends on the species of timber, condition when entering kiln, and the intensity of the drying method. No set rules can be laid down, as good judgment only should be used, as the quality of the drying is not purely one of time. Sometimes the comparatively slow process gives excellent results, while to rush a lot of stock through may be to turn it out so poorly seasoned that it will not give satisfaction when worked. The mistreatment of the material in this respect results in numerous defects, chief among which are warping and twisting, checking, case-hardening, and honeycombing, or, as sometimes called, hollow-horning. Many woods, as, for example, tupelo and red gum, will warp and twist in drying unless special care is taken. This difficulty is not alone confined to kiln-drying, but is quite as great in air-seasoning. In fact, drying in the open with exposure to the sun often develops the worst examples, especially so with the top layers of each pile. If the kiln-drying is too rapid the stock may open up at the ends, which is termed checking. Frequently checks which appear after kiln-drying were originally formed during previous air-drying and are merely reopened in the kiln. These may readily be distinguished from fresh checks formed in the kiln, since their inner surfaces have been filled with dust and darkened by the weather. Case-hardening occurs when the kiln-drying is pushed too rapidly without proper precaution; the surface of the wood becomes dry and impervious, while the interior remains almost as moist as before, and thorough drying is thus quite prevented, and an effort to secure it produces honey-combing or hollow-horning. Honeycombing can occur only together with case-hardening. It is, in effect, internal checking in which the checks, following the medullary rays, may run nearly from end to end of the piece, but do not except in extreme cases show upon the surface. In piling heading blanks on the yard for air-seasoning, care should be taken to keep the piles or ricks well clear of the ground. At least eight inches should be the minimum, in order to allow of good air circulation. There are different methods of piling: some pile in large, hollow, circular piles; others use smaller ones, while some pile in long, hollow, rectangular or square piles. Either method will bring good results if care is taken that the heading blanks are not given too much lap and the ricks kept well separated. The least amount of lap gives the best results. The long, hollow, rectangular or square piles are the most acceptable form of piling, from the fact that more space can be utilized and the foundations more easily laid. The piles or ricks can then be bound together, and the whole becomes a stanch and rigid mass.

THE HEADING ROOM

HEADING PLANER

The heading blanks being thoroughly air-dried or kiln-dried, as the case may be, are then brought to the heading room for finishing and turning. Where heading pieces have been kiln-dried, they should at all times be left standing under cover, subject to the atmosphere for at least 48 hours before turning to size, in order that the timber may become thoroughly acclimated, as this will materially lessen the possibility of the finished heading swelling beyond size while en route to destination, or if kept in storage for future use. When heading pieces that have been thoroughly kiln-dried are taken direct to the jointer from the dry-kilns, they are generally drier than the surrounding atmosphere, and after being jointed and circled they immediately begin to absorb this moisture, and naturally will do so through the ends. This causes the ends of the pieces to swell, and the original joint is altered or lost, making heading joint "much more open in centre" than is desired, while if the heading pieces were allowed to become thoroughly acclimated before jointing or turning this would not occur. And, again, if the heading pieces are taken to jointer before they are properly or thoroughly dried, they naturally contain more moisture than the surrounding atmosphere, and immediately begin to throw off this excessive moisture, with the result that the heading joint is again altered or lost. But these conditions being the reverse to the former, the joint becomes open on the ends, and the finished head is eventually much smaller than originally intended. Considerable care should be given to this point in heading manufacture, as this is one of the chief causes of difficulty with finished heading, and has been the means of considerable expense and anxiety both to the consumer and the manufacturer. Considering that the heading pieces have been properly dried and then thoroughly acclimated, they are then taken to the heading planer, Fig. 85. These surface planers accommodate two knives 24 inches long on the cylinder and should be run at 4,500 revolutions per minute. Considerable care should be taken in grinding that these knives are kept evenly balanced as regards one another, and also each knife should be evenly balanced in relation to itself; that is, it should be of same weight at one end as at the other. This can be easily determined by the use of a knife-balancing scales, as shown in Fig. 39½; for, should these knives be out of balance, the knife cylinder running at such speed would cause them to jump and rattle, putting considerable strain on the machine, and particularly on the cylin-

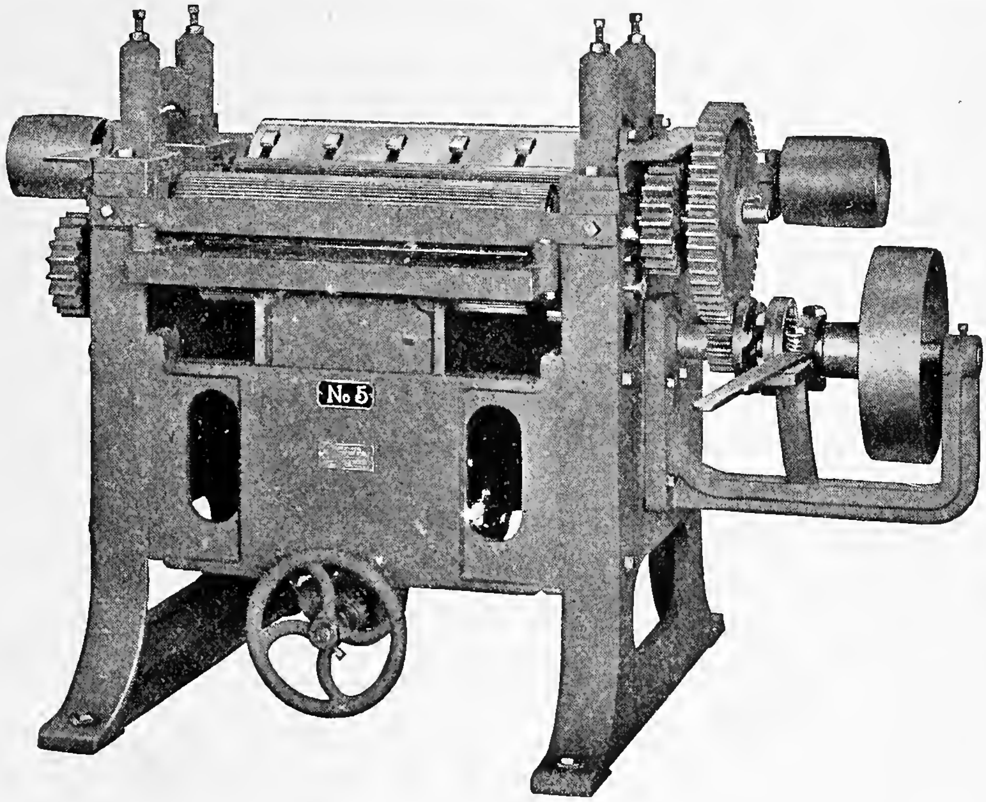


Fig. 85. Heading Planer.

der bearings, which in time would wear them oblong, causing the knife cylinder to rise or jump up and down while in motion, giving the finished head, or the stuff planed, a rough, wavy surface. Particular attention should also be given that the knives have the proper bevel, so that while revolving the heel of the knife will clear the material being planed, keeping the cutting edge prominent. A good rule to observe in this respect is to always make the bevel of the knife a trifle less than twice its thickness, and this rule will apply in all cases where knives are used. A great many operators, when these planer knives get dull, instead of taking them off the machine and grinding them properly, merely use a hand file, and after one or two applications of this method of sharpening the bevel is round, does not clear the material, and turns out very unsatisfactory work, at the same time

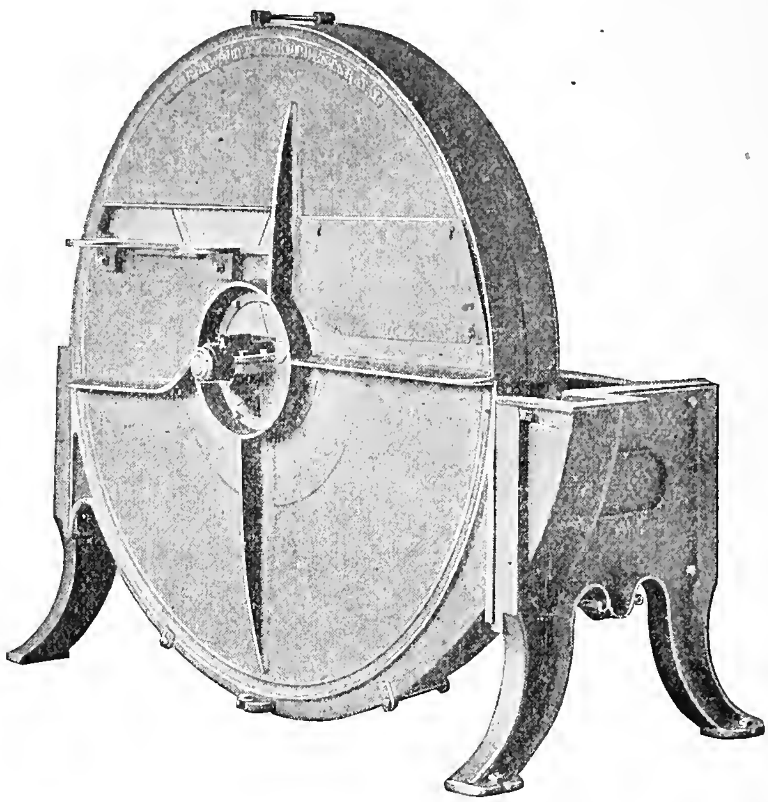


Fig. 86. Heading Jointer.

subjecting the machine to unnecessary strains. This surface planer should be set about 8 or 10 feet from and on the right hand side of the heading jointer. A table should then be built the same height and width of the discharge end of the planer and attached thereto, leading toward the jointer, so that the heading pieces when planed are fed directly to the operator on the jointer. This method insures capacity, as a good operator on the heading jointer should easily in this manner joint as many heading pieces as can be put through the planer.

THE HEADING JOINTER

Next in order in the process of manufacture is the heading jointer. (Fig. 86.) Experience has proven that a 5-foot wheel jointer running at a speed of 650 revolutions per minute is easily the best for this purpose, as with a jointer of this class the knife, which is 21 inches long, has good shearing qualities and cuts as much at the point of the knife as at the heel, and, consequently, wears away evenly from end to end of knife edge. In a wheel jointer of smaller diameter, the heel or end of knife nearest the centre of the wheel has to do much more cutting than the point or upper end, and naturally will require grinding or sharpening more often to insure good joints. Also, it has been found that an operator can joint more heading pieces with less labor on a 5-foot wheel than on a wheel jointer of smaller diameter, from the fact that the larger wheel cuts more freely. Some manufacturers use a saw jointer for this purpose, but while these saw machines turn out a very satisfactory joint, they are not to be compared with a wheel jointer for speed or capacity, as an experienced operator can easily joint from 3,500 to 4,000 sets heading in a day's work of ten hours on the wheel jointers, while a little more than half of this amount would be the limit on a saw jointer, as more time is consumed in determining the necessary cut. Where hardwoods or timber that is more or less cross-grained is being worked, smoother joints and much better results can be obtained by using caps on the knives of these wheel jointers. These caps should be filed to same gauge as the jointer knife and about 1/16 inch flat on the under side where it lies adjacent to the cutting edge of knife, so that when tightened down it will have a good bearing surface and will prevent shavings from getting under or between knife and cap. These knives and caps should also be kept well balanced in relation to one another. It is always a good rule to mark these knives and caps consecutively from 1 to 6 with a centre punch, that is, putting one mark on the first knife and cap and marking the slot or opening in jointer wheel the same; two marks on the next, three on the third, and so on. Then these knives and caps which have the same marks should always travel together and always be put in opening on wheel of same number. For instance, knife and cap marked 4 should be put in slot 4 on jointer wheel, etc. In balancing, these knives and caps should be of same weight as knife and cap directly opposite in wheel; for instance, knife marked 1, travelling directly opposite knife 4. These should be of same weight, likewise knives 2 and 5, and knives 3 and 6. By balancing in this manner it insures equal weight on opposite sides of the jointer, and the wheel will run smooth and true when at its full speed.

In grinding or sharpening these jointer knives, care must be exercised that they are all ground alike or of the same shape on the cutting edge. For this purpose a gauge should be used, one made of steel is the best, and as a straight joint has been found to be the most desirable for slack barrel heading, this steel gauge should be made in the manner of a straightedge, and each and every jointer knife ground in like manner. In setting these knives in the jointing wheel, care should also be taken that they are all set alike; that is, each knife must protrude just so far from or through the face of the wheel. Quality and kind of timber jointed determine this to a certain extent, but where hardwoods are jointed less knife is desirable than if the timber was of the softwood or coniferous species. In practice it will be found that about 1/32-inch set will produce the better results, and for this purpose a small gauge should also be made of steel, with a small notch filed in the centre to the desired depth, so that in setting these knives the heel and toe of each knife is brought out from the face of the wheel to the depth of this notch in the gauge. In this manner each and every knife will be set alike. It is also advisable occasionally to stop the wheel and go over each knife with the gauge to satisfy one's self that they are properly set or that none of them have slipped, which happens quite frequently.

In operation, the heading piece should be held firmly up to the face of the wheel and not allowed to chatter, as this produces a poor joint; and in feeding, the blank should be fed evenly, that is, there should be the same amount of pressure applied to one end as to the other and an effort made to joint "with the grain" of the wood, otherwise the grain may be crossed, and this will have a tendency to cause rough joints. And, again, if the operator does not feed the heading blank evenly, but feeds it to the wheel, first one end and then the other by a sort of rocking motion, it will produce a joint that will be high in the centre and cause the joints on the finished heads to be open on the ends, sometimes leaving the impression that the heading blanks were not sufficiently dry and that they had shrunk after being turned to size. Care should also be taken that too much timber is not wasted by unnecessary jointing. The heading blank should not be held up to the face of the wheel too long. It is a good plan occasionally to take about 50 or 75 pieces or heading blanks, measure them carefully across their width, allowing sufficient margin for jointing properly, and then without the knowledge of the operator on the wheel send them through the planer, and after he has jointed them measure them again, and you may be surprised at the amount of timber your operator at the jointer is wasting. The operator on this machine should be schooled in economy, and not permitted to waste unnecessarily timber which is valuable by sending it through the shaving pipe to the boiler room to be eventually used as fuel.

MATCHING OR ASSEMBLING

After the heading pieces or blanks have been properly jointed they are matched, or the pieces assembled for the size head to be turned. Here is where too much care and attention cannot be given, as a careless operator at this position can easily and without much exertion cause more waste of timber, with its consequent lessening of profits, in one day than the total value of his wages will amount to in one month. As stated before, all economical heading manufacturers consider that a leeway of one inch is amply sufficient, considering that the operator at the heading turner properly centres the heading pieces; and any heading pieces or blanks that have been assembled or matched up larger than this amount, the surplus may be considered as a wilful waste of timber. This point can be easily checked up by a careful watch on the "bats" or waste wood sawn from each head that is being continually wheeled out to the boiler room. And, again, it makes quite a difference which way these blanks are matched up; narrow pieces should always be placed in the centre of the head and the wider ones on the "cant," as small, narrow cants are extremely difficult to hold in the bundle and also more or less difficult to put into the barrel. And then where one of these small cants happens to drop out of the bundle before it has reached the cooper, the balance of the head is useless until it has been rematched. It is generally the rule to assemble these heading pieces in piles up to a convenient height on a bench or short skid, and as the operator on the heading turner finishes one pile the next one is shoved up to within easy reach.

THE HEADING TURNER

These heading turners (Fig. 87) are designed for circling all sizes of heading or square-edge covers, and are

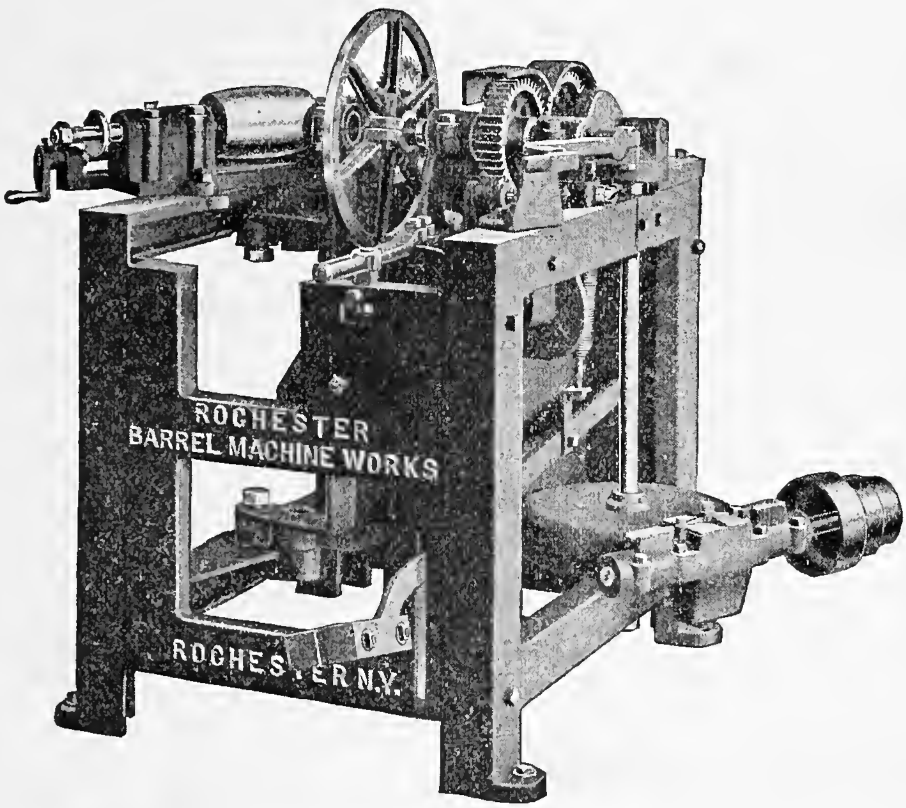


FIG. 87. HEADING TURNER.

almost automatic in their operation. Aside from placing the heading blanks in between the clamps, all that is necessary of the operator is to tread upon a foot lever, and by this one operation the heading pieces are clamped, then immediately brought in contact with the saw, and the machine put in motion. When the head has been turned the machine throws itself out of gear, discharges the finished head, and is in position to receive another. The operator, having no need to touch the machine with his hands, can have the next head ready to drop into

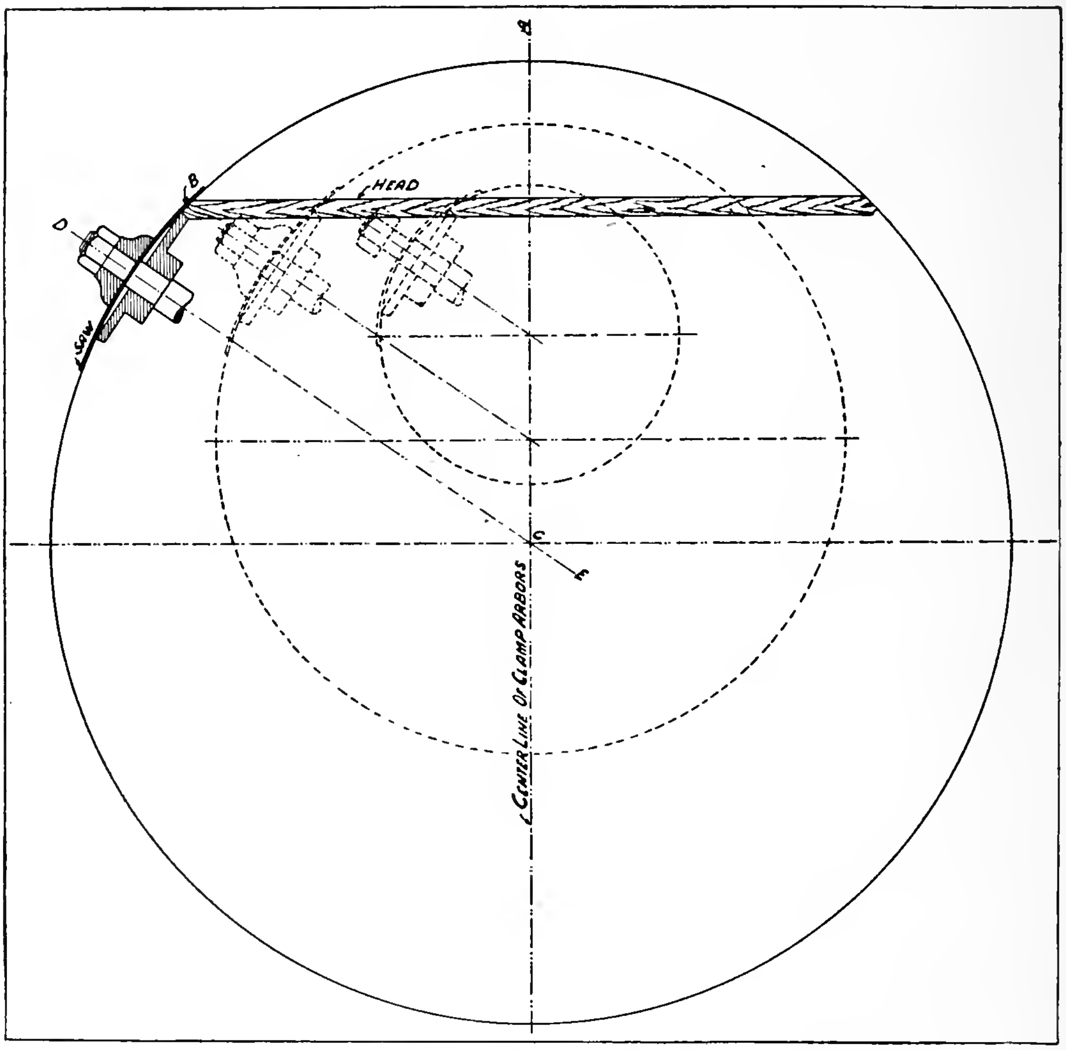


FIG. 88. SKETCH SHOWING METHOD OF DETERMINING PROPER CONCAVE OR CIRCLE OF HEADING SAWS.

the machine the moment the finished one has been discharged. The speed of these saws should be 5,000 revolutions per minute, and the machine placed about 6 or 8 feet from the matching bench. The heads should be matched in piles of 20 set each and slid along a small runway or skid to the heading turner. These heading turners are equipped with a chamfering saw, i. e., a flat steel cutter head of varying thickness, which turns the outside bevel on the head, and a small, concaved, circular saw. These concave saws are made right and left hand. By holding the saw so that the teeth point toward you, if the saw concaves to the right it is a left-hand saw, and if it concaves to the left it is a right-hand saw. These saws are also made to concave to different circles. The size of the head to be turned determines the circle saw necessary to be used in order that the proper bevel may be sawn on the head or that the saw will not bind in the cut, which will cause it to overheat on the rim, and the unequal expansion will invariably result in the saw cracking. The smaller the diameter of the head to be turned, a relatively smaller circle or dish of the concave saw should be used. This can best be explained by referring to Fig. 88, where it will be readily seen that the head represents a segment of a given circle. The size of this circle corresponds to the dish or concave that is necessary in the saw in order properly to turn the size head desired. To determine this circle, it is necessary first to sketch the head, as shown, or one-half of it; then divide it equally and draw a vertical line, as shown at *A*, representing the centre of the head; then trace on the head the bevel desired, as at B, and inscribe a circle with the point of radius on the vertical line as at C, to correspond to the bevel as already drawn; then the diameter of this circle will represent the proper dish or circle saw required for this particular size head. Of course, the same circle saw can be used for different size heads where the variation is not too great, but it is not practicable to use the same saw where the variation in size is greater than one inch. If a concave saw of the proper dish or circle corresponding with the diameter of the head to be turned is used, the centre line of the saw arbor, as shown from *D* to *E*, will intersect the vertical line *A*, as at *C*. This vertical line represents the centre of the bearings on the clamps which hold the head while it is being turned. This being the case, the blank head will swing into the concave saw on a circle concentric with the circle of the saw, and therefore will not bind either on the inside or the outside of the saw, the set of the saw teeth giving the necessary clearness. If, however, the centre line of the saw arbor, as shown, does not intersect the vertical axis of the heading clamp, the head will bind, causing the saw to heat on the rim, as stated; and this unnecessary heating will cause unequal expan-

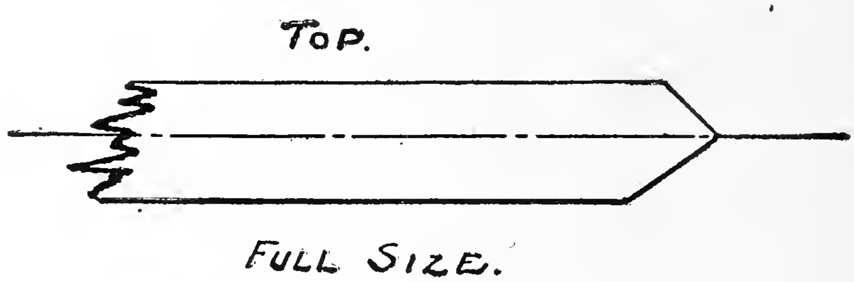


FIG. 89. PROPER BEVEL FOR SLACK HEADING.

sion, which, in its turn, will invariably result in the saw cracking. To keep these concave saws in order so that they will produce satisfactory results, set the teeth alike on both sides of the plate. To do this, where these saws are set by hand, use a small piece of steel plate filed on one edge, concave, so that it will fit the convex side of the saw; the other edge convex, to fit the concave side of the saw. Then file a notch on each side to the proper depth, and spring each tooth to this gauge. As these saws are called upon to cut with the grain as well as across the grain, they require less bevel on the teeth than a regular cut-off saw. They should be, therefore, filed straight across in front and bevelled on the backs of the teeth. Keep the same amount of hook on the front of each tooth and file the gullets or sawdust chambers round by the use of a round-edge file or emery wheel, and do not run the saw when dull, as it is much easier to keep a saw in shape by frequent filing than it would be if the saw was kept at work until the points of the teeth

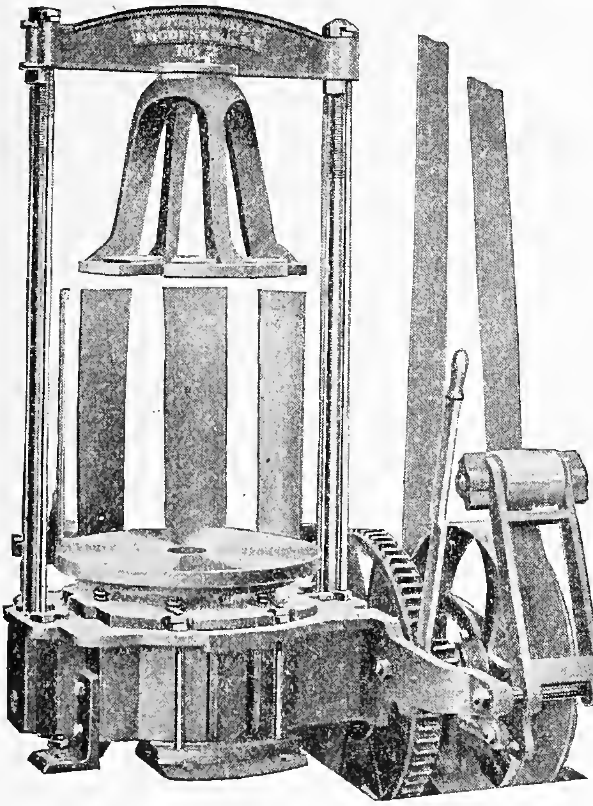


Fig. 90. Heading Press.

were rounded and the shape of the tooth practically lost. As to the proper bevel for a slack barrel head, Fig. 89 shows the style which is full size, that has been considered as correct by some of the largest consumers of heading in this country. The bevel on slack heading should not be made too sharp, as when it is put into the package "stiff" it has a tendency to cut into and weaken the chime. And, again, should the bevel be made too blunt, it does not enter the croze properly, and the head is liable to fall out should the package receive a sharp, sudden jolt. This matter of bevel is quite as important as any other point in heading manufacture, and should be given its proper share of attention.

BUNDLING OR PACKING

After the heading has been properly turned it is packed in bundles and bound with wire or flat steel bands. This bundling is accomplished by the aid of the heading packer, as shown in Fig. 90. It is the general custom to pack these heads 20 set to the bundle, but it is the opinion of the writer and others that a standard of 15 set per bundle would be much more satisfactory. With this number in each bundle and the bundles bound

Fig. 91. View Showing Results of Poor Bundling.

with three wire ties of 11-gauge wire would produce a package more acceptable to the cooper, and one that could be shipped any distance without the contents arriving at its destination resembling a carload of kindling wood, as shown in Fig. 91. This shipment was actually unloaded by the writer, and is only one of many which have been received in like condition. Twenty set to a bundle is too heavy a package to handle economically and with any satisfaction, as they are difficult to store and equally as difficult to take down from the pile, and fully 15 per cent. are more or less broken or in bad condition before they are in the hands of the cooper. And, again, the writer has observed that shipments of heading arrive at destination in much better condition when the bundles are piled in the car in a standing position instead of being laid down, as shown in Fig. 91. This is another point that will bear investigation.

STANDARD SPECIFICATIONS AND GRADES

The standard specifications and grades, as acted upon and adopted by the National Slack Cooperage Manufacturers' Association as regards the proper grading of slack heading, follows:

No. 1 basswood, cottonwood, or gum heading shall be manufactured from good, sound timber, thoroughly kiln-dried, turned true to size, and shall be ½ inch in thickness after being dressed on one side; of such diameter as is required, well jointed, and free from all defects making it unfit for use in No. 1 barrels, with straight joints unless otherwise specified.

No. 1 hardwood or mixed timber heading shall be of same specifications as above, excepting that the thickness after being dressed shall be 7/16 inch.

Mill-run heading shall be the forest run of the log, or bolt, well manufactured, of standard thickness and kiln-dried; all dead culls to be thrown out.

No. 2 heading shall be heading sorted from the No. 1 and to be put up so that it is workable and free from dead culls.

Dead-cull heading is classified as anything not useful nor serviceable, such as knot holes of over ½ inch in diameter, bad slanting shakes, rotten timber, or other bad defects that make it unworkable.

All heading to be well bundled; number of pieces to the head not to exceed the following:

No. 1 and mill-run grades, 13½ to 15½ inches, inclusive, four-piece.

No. 1 and mill-run grades, above 15½ to 17⅛ inches, inclusive, three and four-piece; at least 50 per cent. to be three-piece.

No. 1 and mill-run grades, 18 to 19⅛ inches, inclusive, three, four and five-piece; at least 50 per cent. to be four-piece or less.

All stock not specifically mentioned should be bought and sold on terms and specifications agreed upon between the buyer and seller.

When heading shall be specified to be made of a certain kind or kinds of timber in any deal or contract, any timber other than that specified, if found mixed in with the timber specified, shall be classified as off-grade.

SECTION X

SLACK BARREL HOOP MANUFACTURE

THE MANUFACTURE OF HOOPS

GENERAL REMARKS

Since elm timber has become so scarce and the first quality high in price, manufacturers of hoops in the northern parts of the country are facing a serious problem. It is generally conceded that hoops, as well as all other cooperage stock, should be marketed at a reasonable price, and manufacturers interested in the permanent trade desire to keep the values consistent with those of staves and heading, especially since the wire and flat-steel hoops have made such serious encroachments of late years upon their trade. With the exception of a few manufacturers in Michigan, there are no concerns holding large quantities of elm timber or timbered lands, and it is commonly admitted that small factories temporarily located where tracts of elm timber can be found are better propositions than more permanent institutions.

In the South, conditions are somewhat different. The amount of elm found to the acre is small, and in some localities the timber is very brash, and if the best quality of stock is made, large quantities of defective hoops must be thrown away during the process of manufacture. The most advantageous locations for hoop mills in the South seem to be river points, so that a large area can be covered. Starting with the purchasing and cutting of the timber, there are many opportunities for mistakes and losses before the manufactured hoop is loaded into the car. In the first place, timber must be bought of the right quality. Though some trees show green leaves and are apparently in good condition, many are, at the same time, so old that they are not a profitable investment for hoop timber. Dry rot has set in, and especially near the heart the wood is a total waste. Second-growth hard elm generally makes a very poor hoop. In the sawmill such timber cannot be separated into stave bolts and hoop plank, as can many logs having common defects, but the entire piece is often unfit for hoops, and had better be left in the woods. Raw material purchased for the purpose of making flat or coiled hoops should be, if possible, sound timber, free from knots, wormholes, splits, and wind-shakes, and must be a kind of wood that will coil easily when steamed or boiled without undue breakage.

THE PATENT HOOP

What is known as "the patent hoop" is a thin strip of tough wood, principally elm, between 1 and 2 inches wide and 4 to 7 feet long. It is made with one edge thick and the other edge thin. The thick edge should be nearly twice the thickness of the thin edge, and this difference in thickness should be entirely on the inside of the hoop, forming a bevel to conform to the shape of the barrel or package, while the outside of the hoop should be straight. (See Fig. 92.) The standard barrel

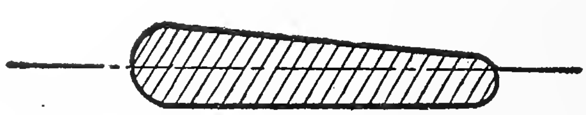


FIG. 92. END SECTION OF PATENT HOOP.

hoop should be 1⅜ inches wide, with the thick edge $\frac{5}{16}$ inch and the thin edge $\frac{3}{16}$ inch in thickness. One end of the hoop is pointed, while the other end is thinned down like a wedge and forms what is termed the lap. Both the thick and thin edges of the hoop are rounded.

METHODS OF MANUFACTURE

There are two distinct methods of manufacturing the coiled elm hoop and several systems for doing the work that differ somewhat in detail, but for commercial purposes we can divide it into the two general methods of cutting and sawing. In the former method, that of cutting, the timber is sawn into planks at the sawmill of a thickness that will make the width of a hoop, then crosscut to proper length, after which it is put into a boiling vat, and when the wood fibres are properly softened by the hot water the planks are taken to the hoop cutter and sliced by a large knife into thin strips or hoops, and then pointed and lapped.

Where sawn hoops are made, the timber is also sawn into planks at the sawmill, but instead of being boiled and cut with a knife, the plank is run through a gang ripsaw, which saws it into bars that are of sufficient thickness or size to split and make two hoops. By this it can be readily seen that it requires more timber to make a given amount of sawn hoops than it does to make the same number of cut hoops, because a certain amount of the wood is wasted in sawdust. In fact, it is estimated that there is a difference of about 1,000 hoops in every 1,000 feet of logs. In other words, it has been found that 1,000 feet of elm logs of hoop grade will make approximately 4,000 cut hoops, while it has been found that 3,000 is nearer the average if the timber is put into sawn hoops.

With this great difference in favor of cut hoops, it appears there would never be any sawn hoops made, especially since elm timber is becoming so scarce; but there are other factors which enter into the matter and make the sawn process the favorite in some cases. One thing in favor of the sawn hoop is the portability of the machines, enabling them to be moved more readily from one locality to another at a nominal cost. And, again, it has generally been conceded that the sawn hoop is really superior to one that has been cut. No doubt there is a lot of truth in this assertion, for if the planks are not properly boiled, the knife in forcing its way through shatters the timber more or less, and this materially weakens the hoop. Another advantage in favor of the sawn hoop is that it requires less capital to equip a plant for sawing hoops and a smaller degree of skill for maintenance and operation. The sawn hoop offers many little advantages to make up for the disadvantage of the waste from saw kerf.

The machinery necessary to equip a hoop plant for either cut or sawn hoops depends somewhat on what system is used. The general plan, however, for cut hoops is to have a hoop cutter—that is, a long, heavy knife that cuts the hoop from the plank—a jointer or lapper, a hoop planer, and a coiler. For sawn hoops one generally requires a sawing outfit which consists of a machine that contains both a planer and a jointer or lapper, a self-feeding rip or gang saw for preparing the bars or strips, and a coiler. As to output, it is a well-known fact that the cutting machines have the largest capacity. The average machine for making sawn hoops will turn out about 15,000 hoops a day, while some of the cutters will run as high as 40,000 to 60,000 hoops per day. In comparing the producing machines with the subsidiary machines, including coilers, we find that the average coiling machine will coil about as many hoops as one hoop-sawing machine will make—that is, about 15,000 hoops a day. It is hardly fair, probably, to say that this is an average. There are some hoop-coiling records in which these figures have been materially exceeded, some special occasions on which men have coiled as high as 66,000 hoops in one day. Usually, however, it takes about three coilers to take care of the output of a plant making from 40,000 to 60,000 hoops a day, and the general practice is to have about three hoop coilers, and sometimes four, to each hoop cutter. A good hoop-cutting machine will cut from 40,000 to 60,000 hoops a day, running full capacity. Much, of course, depends upon the quality of the timber as well as the skill of the operator, and 40,000 hoops is probably a fair day's output. And three coilers to the hoop cutter would no doubt make a well-balanced equipment. The question of selection, however, for method or system to manufacture hoops naturally depends somewhat on local conditions, and they have to be considered in each case separately. Still, notwithstanding the fact that the odds are against the sawn system as a timber economizer, it is, as a rule, about the best method for a sawmill man who desires to enter into the manufacture of hoops as a side line.

MANUFACTURE OF HOOPS

Elm has been principally the standard hoop timber, but other woods lately have come into the market. Oak, ash, birch, and hickory make good hoops and are used quite extensively. Some beech and maple have also been used with varying results. In the South, pine, gum, cypress, and even magnolia hoops are very often used. This class of timber should be worked in the green state, otherwise the breakage will be excessively high. In the manufacture of hoops, the proper sawing of the plank is essential in order to get out the timber to the best advantage, and a great waste, which is caused by uneven planks, is often noticed. Through carelessness, some planks often will vary from 1⅛ to 1⅝ inches instead of being sawn true and to proper size, which should be 1$\frac{7}{16}$

inches and kept to within $\frac{1}{16}$ of an inch of the proper thickness. A variation of more than this amount is not necessary if the saw is properly adjusted and the operators are experienced and attend strictly to their duties.

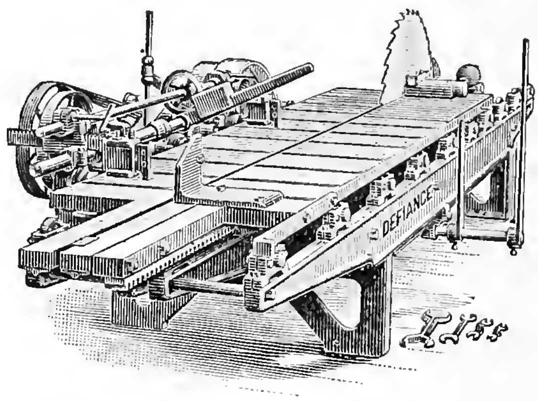


Fig. 93. Short Log Saw Mill.

The planks being sawn $1\frac{7}{16}$ inches thick allows $\frac{1}{32}$ inch on each side for planing, which is ample, the finished hoop then being $1\frac{3}{8}$ inches wide, which is the standard width. Some hoop manufacturers cut their own planks,

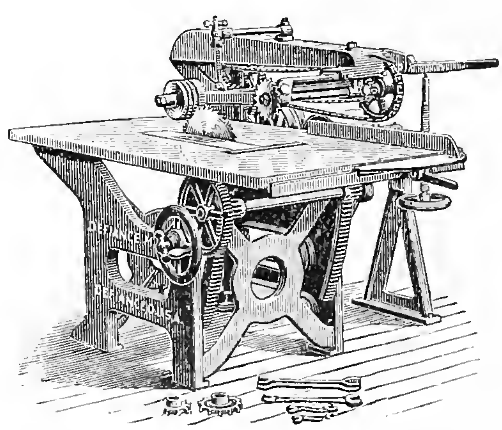


Fig. 94. Self-feed Gang Ripsaw.

while others purchase them already cut to size from the sawmills. When the planks are sawn at the hoop mill, the short log sawmill, as shown in Fig. 93, is generally used.

THE SAWN PROCESS

In the manufacture of hoops by the sawn process, the plank is not steamed as in cutting. Instead, it is taken to a self-feed gang ripsaw (Fig. 94 or 95), where the planks are sawn or ripped into hoop bars $1\frac{7}{16}$ x $\frac{11}{16}$ inches. Each bar then contains sufficient material for

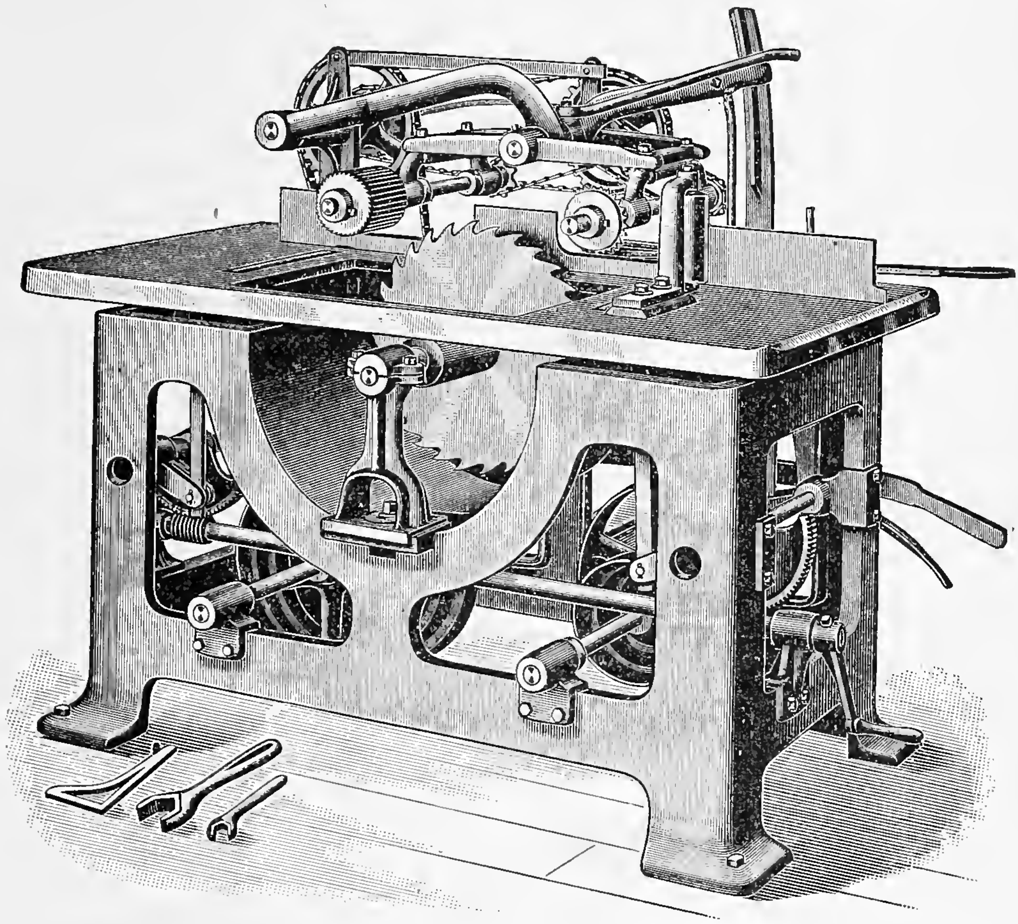


FIG. 95. SELF-FEED GANG RIPSAW.

two hoops. These bars are then passed through the hoop machinery proper, after which the hoops are steamed and coiled. On the gauge ripsaws illustrated, saws 16 inches in diameter should be used and maintained at a speed of 3,000 revolutions per minute. After the plank has been ripped into hoop bars of the proper dimensions, these bars are taken to the machine illustrated in Fig. 96, known as "the Trautman." This machine makes two complete hoops from each bar fed into it, as it saws the bar in two, planes, points and laps each hoop. In operation, one end of each bar is first pointed by a revolving cutter head at the front end of the machine, and is then fed into the feed rolls. These carry it between two cutter heads, which plane opposite surfaces of the blank, while at the same time a saw, set at the proper angle to give

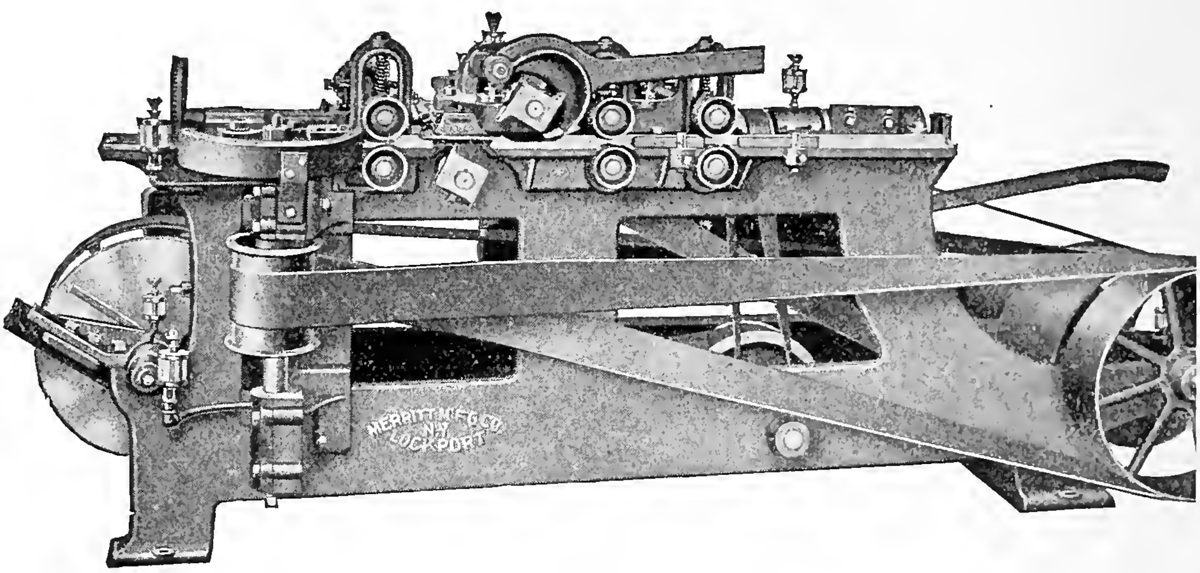


FIG. 96. THE "TRAUTMAN" SAWN-HOOP MACHINE.

the correct bevel, divides the blank into two hoops. As they pass out, each hoop is lapped by an assistant at the rear end of the machine. These two operators, generally a man and a boy, should obtain the rated capacity of 15,000 hoops per day. The speed of the countershaft for this machine should be 1,000 revolutions per minute. This will give the proper speed to the cutters and saws on the machine. Saws used should be 10 inches in diameter, 15 gauge. The hoops are then taken to a boiling vat. These tanks are generally made up of 2 x 4-inch stuff, nailed or bolted securely together, preferably bolted, and are about 7 feet long, 5 feet wide and 3 feet deep. The hoops are softened by dropping them into this tank of hot water, which is heated by exhaust steam, and then coiled. Another excellent sawn-hoop machine is illustrated in Fig. 97, and is known as "the Kettenring."

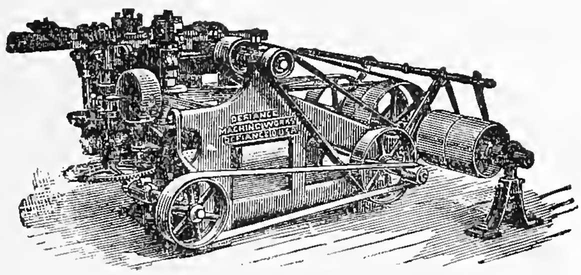


FIG. 97. THE "KETTENRING" SAWN-HOOP MACHINE.

This machine also makes two hoops from each bar fed into it, as it saws the bar in two and planes each hoop at the same operation. In practice, the hoop bar is first pointed on the hoop bar chuck pointing machine (Fig. 98), which should be located convenient to the front end

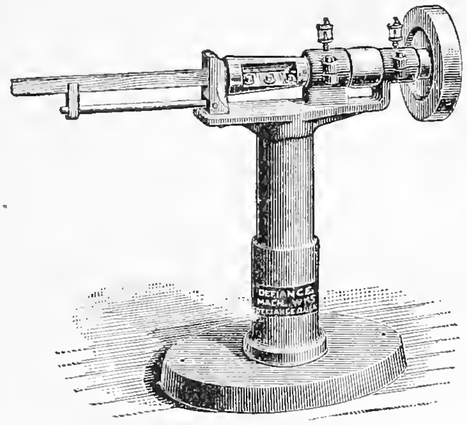


FIG. 98. HOOP-BAR CHUCK POINTING MACHINE.

of the Kettenring machine, and then fed by the same operator into the hoop machine (Fig. 97), where the hoop bar is planed and sawn into two hoops, after which they are lapped by an assistant on the machine shown in Fig. 99, known as the hand-feed hoop-lapping machine, which should be placed convenient to the discharge end of the hoop-sawing machine (Fig. 97). These two operators, generally a man and a boy, should attain the rated capacity of 15,000 hoops per day. The speed of the counter-

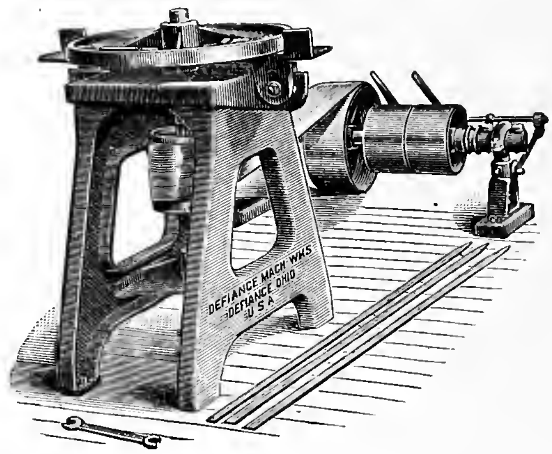


FIG. 99. HAND-FEED HOOP LAPPING MACHINE.

shaft on the Kettenring machine should be 1,000 revolutions per minute. This will give the proper speed to the cutter heads and saws on the machine. Saws used should be 10 inches diameter, 15 gauge.

THE CUTTING PROCESS

In this process, as in manufacturing staves, many of the defects in hoops can be directly traced to improper steaming or boiling. There has been much discussion as to whether steaming or boiling the plank is the more advantageous. Either process, it has been found, if properly carried out, will bring good results, but the most essential feature is to have the plank thoroughly cooked and the hoop-cutting knife sharp; otherwise the timber will be more or less shattered and, of course, will not work or coil with as low a percentage of breakage. The disadvantages of steaming the plank are several. For instance, it costs much more to erect and maintain an efficient and effective steam-box than it does to construct an ordinary boiling vat, where no pressures are to be maintained. Also, where steam-boxes are used it requires a high and almost uniform steam pressure, with consequent increased firing of the boiler; and it has also been found that a steamed plank cools much quicker when exposed to the atmosphere, and that when once cooled off it gets very hard and becomes almost impossible to work with any degree of success. Also the labor incident to effective steaming of planks is much greater than that of boiling. Therefore, considering the above disadvantages, and they will at least bear investigation, the boiling of planks appears to be the more efficient, economical, and practical method of treating the timber before cutting into hoops.

THE BOILING VAT

The boiling vat is as important to the hoop mill as the steam-box is to a stave mill. It should be given its proper share of care and attention, and should be thoroughly cleaned at regular intervals. The dimensions of the vat depend mainly on the capacity of the mill, but a plant with a contemplated capacity of from 40,000 to 50,000 hoops per day of ten hours should provide a cooking vat not less than 50 feet long, 8 feet wide and 6 feet deep. This tank or vat may be constructed of concrete or pine. Where timbers are used, a good construction can be made by using 2 x 4-inch stuff for the sides and ends, planed on the flat or larger side and nailed or bolted firmly one on top of the other. The floor should be of 2-inch stuff, running lengthwise of the vat, with tongue and grooved flooring running crosswise, and held in place with screws. This construction, if properly carried out, will make an excellent cooking or boiling vat.

Where boiling vats are constructed of concrete, care should be taken that they are built on firm foundations; otherwise the side walls will crack from the uneven settling of the walls, and this will cause leaks, making a very unsatisfactory and troublesome vat. A good foundation may be made, where the ground is fairly firm, by digging down below the surface for about 2 or 3 feet and putting in a layer of crushed stone about 18 inches deep; then on top of this pour the concrete. The side walls should be tapered, with the thickest part at the base, making the base about half as thick again as the top, and at intervals throughout the construction there should be reinforcements, in the shape of rods or band iron, in order to hold the mass firmly together and lessen the liability of cracks. It has also been found necessary to put an extra wooden bottom in concrete vats, as by continually dropping the plank into them, if care is not exercised, they will strike the bottom and eventually produce large holes or cracks that will in time cause leaks. This can be overcome by placing anchor bolts in the bottom at regular intervals, which can be used for fastening down a layer of 3-inch planks. This method of protecting the bottom is also necessary on top of the side walls, so that the concrete work will not be broken or worn away by the continual sliding or scraping of the planks while the operator is placing them in or taking same from the vat. These planks can then be renewed as occasion requires, and the boiling vat kept in good condition. The mixture for this construction may be the same as that given for concrete steam-boxes for stave bolts in Section VIII. With boiling vats carefully constructed on this plan they should give excellent satisfaction and last for a considerable period, with little or no expense for repairs.

Opinions differ as to whether the best results are obtained by cooking the plank standing edgewise or placing in tank on the flat side. The objections to boiling hoop plank flat are, that in order to secure good results the plank must be kept apart or separated. This necessitates the use of cull hoops or strips between the plank, which eventually fall to the bottom of the vat, causing difficulty in removing the plank by getting tangled with the hook, and makes frequent cleaning and emptying of the tank an absolute necessity. Also, it has been found that very frequently additional labor is required, from the fact that it is more difficult to remove the plank from the vat when laid flat. Considering the above facts, some of the largest hoop mills have adopted the method of boiling the plank edgewise, and for this purpose they put a 4 x 4 or 4 x 6-inch timber in the centre on the bottom of the tank the full length, and suspend another about 12 inches above the top of the tank, directly over and in line with the one on the bottom. In these timbers they bore holes from 2 to 2¼ inches apart, and put in ¾-inch round iron rods or 1-inch pipe, giving the appearance of an iron fence through the centre, lengthwise of the tank. The planks are then placed in these spaces on edge, one on top of the other. By this method the boiling hot water has free access to the planks on all sides, which are thoroughly cooked in less time than if lain flat, and are easily removed from the tank by means of a hook. In boiling hoop planks, as in steaming stave bolts, care should be exercised that they are not subjected to too much boiling. All that is required is "merely" to soften them up, or, in other words, to produce the highest possible degree of sponginess, without loosening the fibres of the wood from each other to cause woolly or fuzzy cutting. The secret in turning out a good hoop is in the preparation of the stock, and a part of the secret of preparation is letting it soak thoroughly, putting in more time preparing it than is the practice in most places, not using quite so much heat. It is really doubtful if there is need to raise the water above the boiling point to properly prepare planks for cutting, as when we go above the boiling point there is a remarkably strong tendency on the part of the heat, and the boiling incident thereto, to disintegrate the wood. If the stock is in excellent condition for cutting, that is, duly softened without being rendered woolly and difficult to cut, then half the battle is won, and not only will the stock cut much easier and faster, but it will be much easier to keep the knife in shape.

The condition of the plank when entering the mill should be considered, as planks cut from green or newly

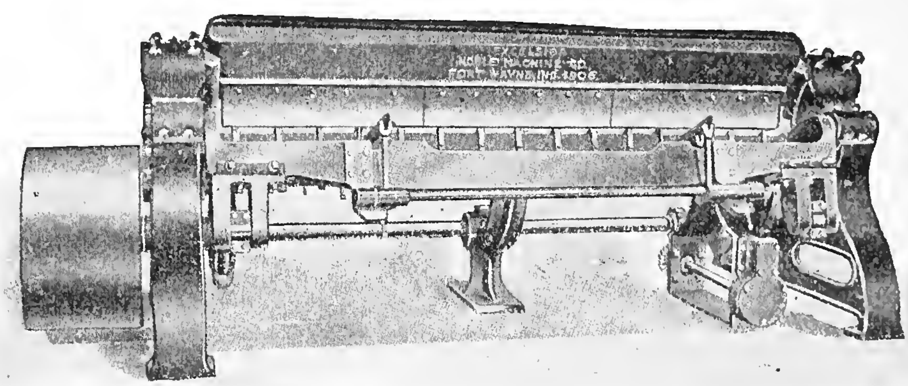


Fig. 100. The Hoop Cutter.

felled trees require less boiling than those cut from logs which have lain on the yard or in the woods for a considerable period. Hoops vary in quality more than any other stock manufactured, and this can be traced mostly to improper softening of the wood fibres before cutting.

THE HOOP CUTTER

The planks after having been prepared properly by boiling are then taken while hot to the hoop cutters, as shown in Figs. 100 and 101, where they are cut into hoops. Care should be taken that the stock is cut so that the hoops will go to the planers $\frac{1}{32}$ inch full, heavier than the specifications call for when finished, on both the thick and thin edges, so that the hoops will leave the planers about $\frac{1}{64}$ inch scant, or plump, $\frac{3}{16}$ and $\frac{5}{16}$ inch. This allowance should be made for the shrinkage of the timber while it is being seasoned in the yard. Quite a number of hoops are placed on the market that are not finished properly. Some manufacturers evidently do not place much importance on the fact that a hoop should be well finished. If enough timber is fed into the planer

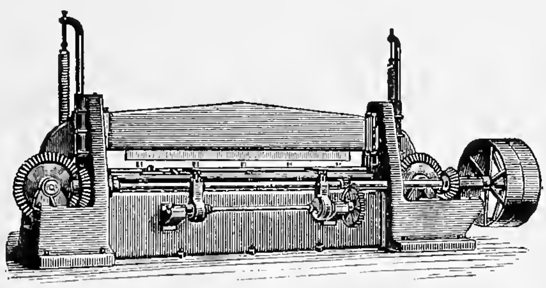


FIG. 101. THE HOOP CUTTER.

so that the cutters can do their work well there should be no difficulty in finishing up the hoops properly and in a workmanlike manner, providing, of course, that the machine is kept in good repair, the knives on the cutter-heads sharp and well balanced, and the bearings properly adjusted. These hoop-cutting machines should be run at a speed of 200 revolutions per minute on the tight and loose pulleys, and if maintained at this speed, with the knife properly cared for, the tilting mechanism and other working parts carefully looked after, should turn out about 70,000 perfectly cut and bevelled hoops in a day's work.

THE HOOP PLANER

The illustration (Fig. 102) represents the automatic triple hoop planer, which is considered one of the best on the market for the purpose of planing wood hoops. When properly cared for this machine is accurate and rapid, it being so arranged as to plane three hoops at one time, and should perform this work at the rate of 35,000 hoops per day of ten hours. The proper planing and finishing of a hoop determines its general appearance and often its ultimate value, and is a part of hoop manufacture frequently given too little attention. In hoops

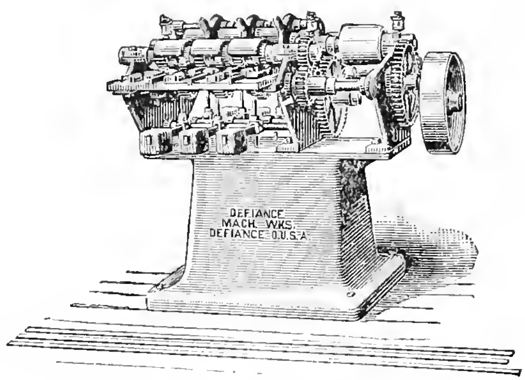


FIG. 102. THE AUTOMATIC TRIPLE HOOP PLANER.

that are well finished or planed, the breakage will be considerably less, both at the hoop coiler's and later in the cooper shop when they are finally used. When the cutter-head spindles are allowed to jump or rattle, it gives the finished hoop a wavy appearance, and in some instances, where the wood is slightly cross-grained, this jumping of the cutter-head spindle has a tendency to dig into the wood or break it out at that point, and it will be found to weaken considerably the hoop, and that a great many will break at the coiler's or afterwards in the coil, and is caused by this inattention of the spindle bearings. In babbitting these bearings it is always preferable to "line" them with several pieces of thin cardboard, instead of using one or two pieces of thick leather belting, as is generally the custom. Then, if the bearings need adjusting, all that is necessary is to take out one of these thin pieces from each side of the cap and tighten it down again. If this is done properly, the bearings can be run for a considerable period before rebabbitting. The bits used should be 1$\frac{7}{16}$ inches, and should always be kept sharp and in running balance. And if the stock fed into it is cut so that the planer can perform its work properly, no difficulty should be experienced in turning out a well-finished hoop, and the breakage would be considerably lessened. It has

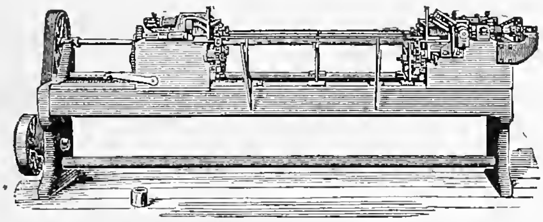


Fig. 103. The Automatic Hoop-pointing and Lapping Machine.

been proven that at least forty per cent. of the breakage of hoops at the coiler's is caused by faulty workmanship at the planer.

THE HOOP-POINTING AND LAPPING MACHINE

After the hoops have been cut properly and planed, they are then passed through the machine, as illustrated in Fig. 103. This engraving represents an automatic hoop-pointing and lapping machine, which is considered one of the best machines for this purpose, and is used by the large hoop manufacturers for equalizing, pointing, and lapping hoops, all these operations being done at one time, and at the rate of 60,000 hoops per day of ten hours. In operation, the hoops are placed upon the chain feed of the machine, which automatically feeds them forward to the equalizing and pointing knives, where they stop just long enough for the cutters to ac-

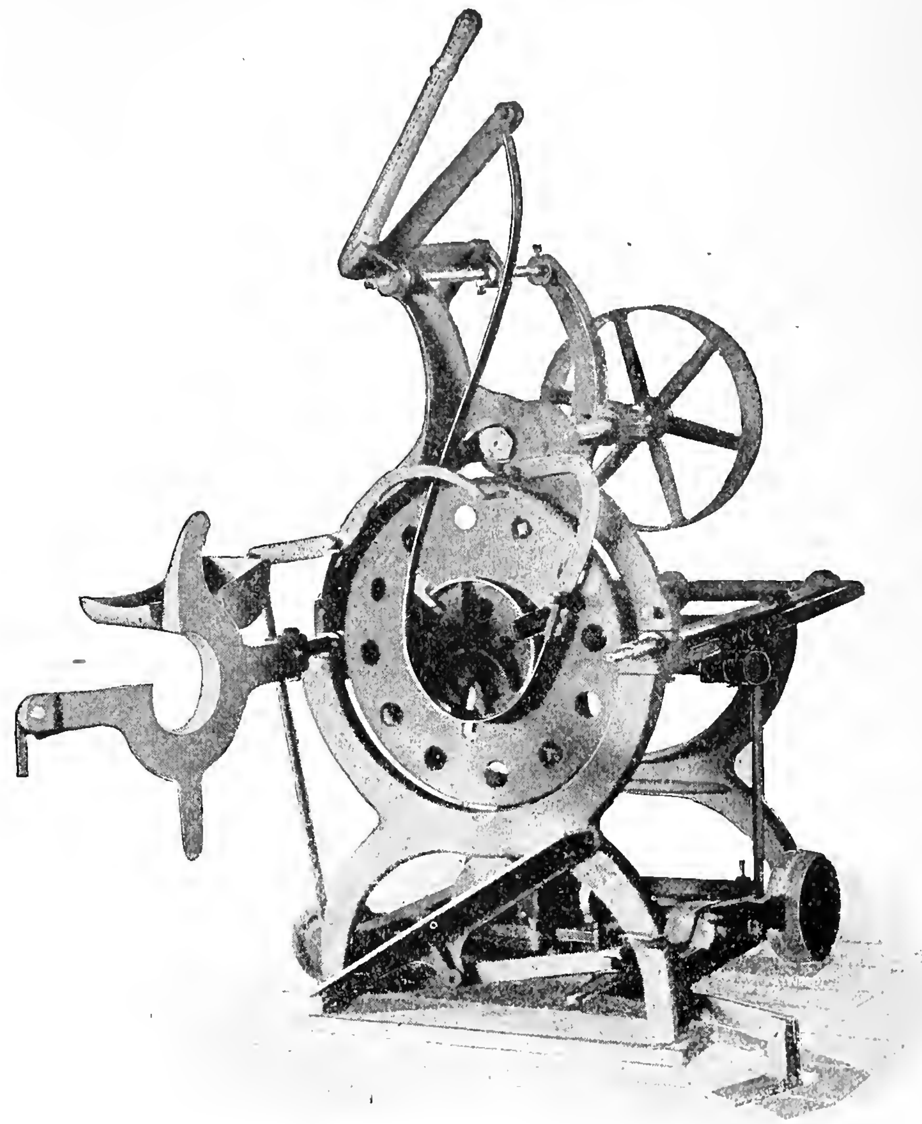


FIG. 104. "THE WARD" HOOP-COILING MACHINE.

complish their work, when they again move forward to the lapping cutters, which complete the work, and the finished hoop is discharged at the rear side of the machine. The speed of this machine should be 700 revolutions per minute on the tight and loose pulleys, which are 12 inches in diameter. There are no saws on this machine, and the fact that it works automatically insures that each and every hoop will be alike. A great many hoops are often put into the coils which are defective on account of not having a properly thinned lap, or in some cases with no semblance of a lap at all. The proper lapping of a hoop is a very essential feature, and care should be exercised at all times that this point is not neglected, as when the lap is not made properly or thinned down sufficiently, the hoop with the defective lap when put into

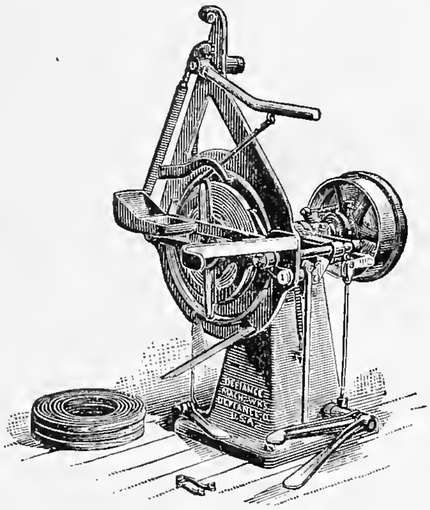


Fig. 105. "The Defiance" Hoop-coiling Machine.

the coil will often cause the hoop next to it to be weakened and break, on account of the "dent" or short crook put into it by coming in contact with this blunt end. Even though damage on this account is not common, coopers prefer a hoop that is properly lapped, and very often rejections are made by the consumer on this particular point.

THE HOOP-COILING MACHINE

The hoop-coiling machine illustrated in Fig. 104 is known as "the Ward," and in the hands of a skilful operator should turn out from 16,000 to 20,000 hoops per day, according to the skill of the operator. The speed of the driven pulley on this machine should be 330 revolutions per minute. Another excellent hoop-coiling machine is illustrated in Fig. 105, and is known as "the Defiance." Its rated capacity is also from 16,000 to 20,000 hoops per day. The coiling of the hoop, after having been manufactured, is more of an important feature of hoop-making than is generally accredited to it, as a hoop well manufactured but improperly coiled easily will lose a large percentage of its quality. It is often the practice of the coilers to use a stick or an iron bar, placing it across the boiling vat, and then take out a large quantity of hoops at one time, allowing them to rest on this support while being coiled. This method of working is not altogether a bad one, provided, of course, that a few hoops are taken out of the vat at one time; but where a large amount is taken out, a great many of the hoops get cold or cool off considerably before the operator succeeds in coiling them, and, therefore, materially increases the percentage of breakage in the coils. This breakage may not altogether appear while the hoops are being coiled, but will eventually materialize later on, when the coils are opened. Hoops should always be placed in the coils while they are hot; otherwise, if coiled cold, the fibres of the wood are strained or broken entirely, and hoops coiled in this condition are also more liable to mould and rot than when put into the coils when hot. Broken or unsound hoops in the coils are the primary causes of a great many rejections or claims for reductions by the cooper. Care must be taken also with the inspection. Many hoop manufacturers have boys to do this work, and it is very often done in a very careless manner. This position is really an important one, and should not be intrusted to an incompetent workman. The smaller sizes, as well as the larger ones, should be inspected carefully, and if every hoop that shows a damaging defect is thrown out enough will remain that cannot be seen or that will develop in seasoning to amply cover the two or three per cent. allowed for breakage and loss. When the mill is running on a particularly bad lot of logs, or logs that have lain too long on the yard before working, and the breakage is found to be excessive, even for only a short time, assistance should be given the regular coiler, or the hoops piled to one side, to be worked over at odd times. It is in such instances as this that particularly bad hoops succeed in getting into the coils, and eventually to the consumer, that causes considerable trouble, and the shipper eventually gets the reputation for poor quality that will remain with him for some time. Also, the cooper becomes suspicious of his stock and subjects it to a very rigid and careful examination or inspection. On the other hand, if a more careful inspection is made at the mill, more hoops will probably be thrown out, but the shipper gains a reputation for good quality of stock, can demand and will secure better prices for his product, and a great many defects will at times pass unnoticed by the cooper.

PILING ON YARD

Hoops to be properly piled on the yard should be placed on platforms not less than one foot above the ground and the grass and weeds kept close cut, in order that they will not obstruct or retard the proper circulation of air through and around the several piles. When properly seasoned they should be taken in and placed under cover or shipped, and not allowed to remain exposed to the rains and sun until they become over-seasoned, often becoming brash as well as unduly discolored. This piling of hoops to the weather is fully as important as that of staves, and should be treated with the same care and attention.

STANDARD SPECIFICATIONS AND GRADES

The standard specifications and grades, as acted upon and adopted by the National Slack Cooperage Manufacturers' Association as regards the proper grading of slack barrel hoops, follows:

Standard dimensions of coiled elm hoops from 5 feet 6 inches to 6 feet 9 inches in length shall be made so as to measure when finished and seasoned not less than 5/16 inch in thickness on the top or thick edge, and 3/16 inch in thickness on the bottom or thin edge, and not less than 1⅜ inches in width.

Hoops less than 5 feet 6 inches in length may be made same width and thickness as longer hoops, unless otherwise agreed upon by buyer and seller.

Dimensions of standard keg hoops, 5 feet and shorter, to be, when finished and seasoned, not less than ¼ inch in thickness on the top or thick edge, and ⅛ inch in thickness on the bottom or thin edge, and not less than 1¼ inches in width.

No. 1 hoops shall be of good, sound timber, up to the specifications, well finished, and free from breakage and other defective hoops that make them unfit for use on a barrel, to be dry or well seasoned when shipped.

HEAD LINERS

The demand for head liners of various sizes, lengths, and shapes, such as are used to secure the heads in slack barrels, has increased in the past few years to such an extent that special machinery with large capacity has been made to produce them. The machine shown in Fig.

106 has been constructed especially for this branch of the industry, and is considered the most complete machine for the purpose. It is simple in construction, automatic in its operation, and can be operated by a boy. It produces three head liners crimped and complete at a time, having a capacity of 50,000 liners per day. The making of head liners is a good side line for a hoop or stave mill,

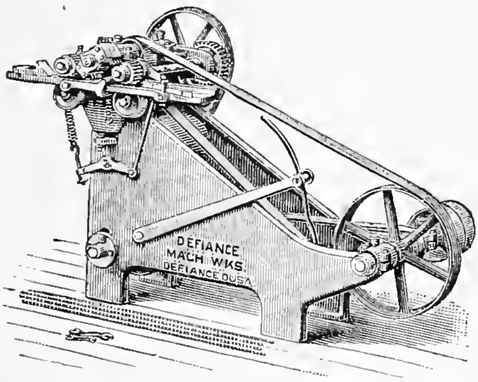


Fig. 106. The Head-liner Machine.

as it considerably reduces the waste problem, as the material from which liners can be made consists of defective and undersized hoops, staves, slabs, etc., and the surplus which collects about the mill or factory and is of no value other than for purposes of this character. It is equally well adapted for making barrel hoops, hoops and handles for fruit and other baskets, and trunk slats, by simply using suitable knives and removing the crimping attachment. Speed of countershaft on machine 1,180 revolutions per minute.

SECTION XI

MODERN SHOP MANAGEMENT

MODERN SHOP MANAGEMENT

In this article I propose to deal more particularly with the commercial or financial aspect of the management of mill or factory, as distinct from the practical side of the manufacture, although in a sense the one is as practical a subject as the other. I shall therefore aim to bring forth a few of the leading principles of successful management as practised by the modern factory manager or superintendent. This is undoubtedly an era of keen and sharp competition, and in order to keep up with the fast-moving procession we must keep in close touch with all the details of the business, lest there be a small leakage somewhere that eventually will grow to harmful magnitude. Many a concern to-day is struggling under a load imposed upon it by bad and inefficient system, both of management and of details of factory and office work. Some will not awaken to a full realization of the situation until some finely organized competitor drives them to the point where an investigation of "what is wrong" is absolutely necessary. Then they will become enlightened of the fact that, instead of profits, the concern has been steadily on the down grade through its dilatory and unprogressive methods, and that it will take strenuous efforts on the part of every one concerned to place it on a proper basis again.

Modern commercialism not only demands the finest and best machinery, the most capable and skilful men, working at the highest possible pitch, but also renders it imperative that all component parts be knit together by modern methods of organization and that product, processes, departments, and workmen be checked up and their efficiency gauged by the most thorough methods of accounting and system. The one thing, undoubtedly, that contributes more to a mill turning out an inferior quality of stock than any other is lack of properly trained and skilled labor. There is hardly a position about a mill where the efficiency might not be improved through careful and proper training. It would almost seem as though some of the manufacturers thought any unskilled and uneducated tramp was competent to perform the duties attached to any of the several positions in and about a stave, heading, or hoop mill; but experience has proven that help of this class is a detriment to the mill. The workman who takes pride in his knowledge and experience in the trade, and who knows much more than is required of him to perform properly the duties set before him, is the help that performs the task with the greatest ease and skill. Investigation will prove that the manufacturer who has the reputation of turning out the best quality of stock to-day, in the absence of an industrial or training school, is using the old apprentice system modernized to suit his requirements and to meet the present industrial and domestic conditions in training the help properly to perform the various duties about the plant. The help must be thoroughly instructed in the operation and care of the various machines and be well versed in the requirements of the user of the class of stock he is manufacturing, and also be familiar with the standard specifications and grades of this article.

How often has it occurred that a firm, prosperous in the early days of its existence, failed utterly after it had grown to such size as to make it impossible for the heads to retain that "personal touch" with its details which was exercised previously. The factory superintendent or manager of to-day must retain that vital touch with the internal working of his organization in this era of close competition, small profits, and intense activity of production; and in order to do this, he must necessarily be a practical man, knowing minutely all the smallest details of the business, in order to distinguish the inefficient portions from the strong parts, and able to assign unerringly the cause for such inefficiency, in order that he may throw all of his power, knowledge, and years of experience into the strengthening of such weak points. He must be able to remove immediately any increase in expenses or deterioration in working efficiency in any of the different departments of the business. He must seek to avoid the employment of unnecessary non-productive labor, and unless he can see very clearly into the future, he must be very careful about employing or engaging straight-time help, because whenever production becomes dormant the expenses necessarily must be cut to a minimum. He must satisfy himself that the costs are calculated upon a correct basis, that they are compiled in such a manner as to show in detail any unnecessary increases in operating expenses, as well as to render it possible to make intelligent examinations and comparisons, with a view to the effecting of economies. This cannot be accomplished unless a complete and accurate set of records are judicially and systematically kept and rigidly adhered to. It will greatly aid the always busy and usually overworked man "at the helm" to a more comprehensive and accurate survey of the entire workings of the plant and to the location of the responsibility for good and bad results.

In an established factory the manager may have many difficulties to contend with if the works have not been carefully planned in view of all circumstances, and the most he can do in such cases is to minimize the consequent disadvantages by judicial internal economies and by structural modifications when possible. The ideal factory is that in which there is no unnecessary handling of raw material and in which everything when received at the works is stored so as to be readily available for use when needed. The buildings should be provided with all the daylight available, and should be so arranged that the respective foremen can readily see all that is going on, as when they have to supervise a number of workmen widely separated much time is lost and the supervision is less effective than when the foreman is, so to speak, on the spot.

In a great many cooperage concerns, and especially so amongst the smaller mills, the foreman is, so to speak, the whole show. He is expected to fill all the important positions in and about the plant, keep the machinery up, and in some cases, after working long hours, devote his spare time to the keeping of the accounts. You can rest assured that in such cases they are few and those of a very brief nature. I have often marvelled at the tenacity of such concerns in holding on to business life, considering the meagre accounts and records kept and the lamentable lack of detailed information of costs. Consideration must be given to the question of securing the full efficiency of the foreman, usually high priced; it is certain that he is one of the most important links in the chain. As he is, so will his workmen be. As the workmen are, so will the quality and cost of the product be. And on the quality, quantity, and cost of the product hangs the success of the business. Do not load him up with detail work. That is one of the gravest errors of many if not most of the concerns to-day. His chief aim should be to improve the quality, increase the quantity, lower the cost, if possible, and investigate and devise improved methods of manufacture, machinery, etc. And if he is an exceptionally good and conscientious man, he should be permitted to make occasional visits to establishments in other and nearby towns or cities, in order that he may not "grow stale" from continuous and uninterrupted association with the same surroundings. It would be an encouragement to him and would assist materially toward brightening up his ideas. It is also an employer's duty to look after the comfort and improvement of his workmen, as far as is possible, and it is imperative that the risk of accident be minimized by all possible precautions for the protection of life and limb; but having done all this, it will also be advisable to insure against the monetary risk of accidents. It will be obvious that where an employer has the interest of his workmen at heart, and the relationship between them is satisfactory, production will be increased greatly and waste relatively minimized, as a result of voluntary effort on the part of the workmen.

Frequently waste arises through thoughtlessness or of not being instructed properly. This is especially noticeable in the operations of jointing staves and heading and in the matching up of heading pieces. Too great importance cannot be attached to the co-operation of employees in regard to the different operations of manufacture. Many intelligent workmen could suggest improvements, but because of lack of encouragement they feel it no business of theirs to do so. Such a state of affairs operates against the interests, and the sooner it is altered the better will it be for all concerned. For inventive genius should be at all times encouraged and suitably recognized, for if it is not, the employer may lose not only the benefit of his workmen's suggestions, but may find that their ideas have been carried to his competitors, with the result that often valuable suggestions, ideas, or inventions are developed and monopolized by others.

To remedy this, an employer should have frequent consultations with his men, and especially with his foreman.

He should be taken into his confidence. A great many costly mistakes could be avoided by the simple matter of organization, whereby an employer would derive the benefit of the experience of others. In the first place, meetings or consultations should be held regularly, and the foreman and the men of importance in and around the plant should be assembled together. Here should be discussed openly and freely the best methods of manufacture, the mistakes that are commonly made, and suggestions made for improvements, both in the machinery and the work in general. Criticism should be sought for and encouraged. These men should be brought into sympathy with the aims and purposes of the business, and, if necessary, instructed and trained in the best methods of handling men for the purpose of increasing their working efficiency, increasing their interest in their work, and using the most effective methods of securing the best general results for both the workmen and the company.

A firm is adopting a very short-sighted business policy when it refuses to acknowledge the fact that decisions based upon free discussion and deliberation with men of long experience, no matter how humble, are wiser, stronger, and much more effective than those of any one man.

It is also an advantage to retain workmen in as regular employment as possible. Otherwise the services of good, skilled workmen may be permanently lost to the firm. As a matter of course, skilled workmen should be the last to be laid off when there is a business lull. Old employees should always be encouraged, having generally a greater interest in their employer's business than new hands. At the same time, the infusion of new blood into the ranks at various times is desirable, as one cannot afford in these days of keen competition and progressive industrial methods to be too conservative of old ideas which may be capable of improvement. Inefficient workmen, like poor tools, are dear at any price; and it is therefore essential that only capable and skilled workers be employed, and that they receive good wages for such services.

Regularity and punctuality should also be insisted upon, for it is a source of loss to operate a factory where a number of workmen are constantly absent or systematically late in arriving at their work. In introducing a system of good wages for their workmen, the management should have many aims in view. The most important of these are as follows: The possibility of shop economies and cheaper production; the forcing of the factory to its maximum capacity quickly; the attraction of expert and more skilful workmen and their encouragement to use their skill and wits to the utmost; the singling out of the slovenly, slow workers for either development or discharge; the cultivation of a feeling on the part of the men that the company is firm in its determination to be just and fair and that its insistence on a high rate of production is justified by the rate of wages paid. To this feeling must be added the knowledge that the company will insist upon a full day's work.

To accomplish these aims, the one important factor—"the man at the machine," with his human prejudices and his capabilities—must be carefully considered. It is, however, surprising to note how little attention is usually paid to this. Policies and systems vitally affecting the workman's welfare are put into force with a total disregard both to his willingness and his ability to improve himself and his product under proper conditions and his power to increase costs and cause other even more serious troubles in the shop when the conditions are not as they should be. These facts should not be lightly considered. It is difficult to overestimate the value of having your mill or factory full of skilled, alert, and contented workmen, who will give you a maximum of production with a minimum of expense. The advantage is not alone in the fact that costs of production are lower, but the feelings of mutual confidence and contentment in this day of labor difficulties are in themselves of great value to both employer and employee. The men's suggestions, given as a consequence of this feeling, and their endeavor to better themselves and their product, will not only lead to many improvements, but, reacting on them, will make them stronger men and better workmen.

The mechanical and general arrangement of a slack stock mill is such that one operator or employee must depend upon another for the proper performance of his duties. The most effective practice would suggest that one employee be not allowed to avoid the responsibility of his faults by charging them to other employees, and where the workmen are charging others with their own faults or "tattling" on each other there is faulty management indicated.

While in all commercial enterprises the cost of production should be minimized by all legitimate means consistent with the maintenance of quality, it is no less important and necessary that a complete system of cost-keeping be adopted. Many firms are satisfied with more or less approximate cost, because at the end of the year they find that there is a fair margin of profit over all; but without accurate costs they cannot tell whether on some of their product they are not losing money. The time books should be analyzed carefully, in order to obtain accurate costs; and if the weekly or bi-weekly wage totals are compared in relation to output, it will facilitate the detection of error or mismanagement. The question of working expenses has a most important bearing on the profits, for as the expenses of conducting a business are high or low, so will the earnings be affected.

For a minimum output, certain charges, such as rent, taxes, insurance, management, supervision, salaries of clerks, etc., are necessarily incurred each year, and will vary but little with any output between that minimum and a certain maximum. For example, say that the annual sales amount to $250,000 and the working expenses to $30,000. It is conceivable that if such sales were increased to, say, $300,000, the expenses might not greatly exceed the above figure, or, at all events, would not increase in proportion, simply because the same establishment is equal to the increased trade. Or, in other words, the resources of the factory are not in the first instance fully employed. If the output be only three-fourths of the factory's capacity, it is clear that these three-fourths are bearing, say, one-fourth more of the establishment expenses than might otherwise be chargeable, and that being so, it is equally clear that if the output be increased to the full capacity the profits will increase, even though the additional business be less remunerative, provided that the selling price is not bare cost, but carries with it a margin for working expenses.

But before advocating any policy that might suggest itself on arriving at this conclusion, it is first assumed that the output has been and under ordinary conditions is likely to remain stationary. Contracts on a large scale are sometimes taken at prices which would not pay on smaller business, but which, as bringing additional grist to the mill, keep the factory fully employed and earn a profit however small. The fact that the manufacturer has generally no monopoly reminds us that he runs the risk when selling cheaply to large buyers of having to reduce his prices to smaller consumers. He has, however, in that event the advantage of a factory fully employed, enabling him to compete successfully with others, should they compel him to reduce his prices generally. Even if he does not accept large contracts at low prices, but leaves it to other manufacturers, he will still run the risk of competition without having the advantage referred to. In other words, competition on the part of a few affects the many by lowering prices, and it is therefore advisable to be early in the field and to take the advantages offered by a good going concern to minimize the rate of working expenses. The percentage of working expenses may also be minimized by an established factory which is only partially employed by branching out into another line of business more or less allied to its own and for which it may be adapted.

While the foregoing remarks indicate the possibility of increasing the output without a proportionate increase in the working expenses, it is often possible to reduce the actual working expenses without affecting the efficiency of the production. Too often working expenses are allowed to eat into the profits of a business without a due appreciation of the fact. It is therefore very desirable to scrutinize all expenditure under this head, for which purpose an analysis of the periodical accounts should be made. Each item of expense can be worked out as a percentage on the sales, or some other convenient basis, and compared with previous years' figures. If the total of sales is taken as the basis, allowance may have to be made for fluctuations in selling price, and for this reason some fixed unit is to be preferred for comparison. The amount of capital employed in any business should not exceed the safe minimum necessary for the efficient and economical working of the business, as a superfluous capital can only entail loss of interest, if not more serious consequences. While an inflated capital is an evil to be avoided, it will be evident that insufficient capital is also a source of danger and loss. The amount of liquid capital necessary will depend upon (among other things) the turnover and output and the facilities for obtaining the raw material on reasonable credit. When labor, requiring, as it does, ready money for wages, forms a considerable proportion of the manufactured article, the liquid capital required will be necessarily high, especially if the output be large; and as that output increases, further capital will be required to pay additional wages and to provide larger stocks to keep pace with the increased demand.

Fixed capital, consisting of buildings, machinery, plant, etc., being subject to depreciation, should be written down periodically, and there should be no division of profits without first making a safe provision for this important item in regard to all wasting assets. All repairs and maintenance should be scrupulously charged to revenue or against reserves previously created for that purpose. The rate of depreciation will necessarily vary according to circumstances in different and even in similar businesses, and as deductions for depreciation are more or less estimates, it is wiser to err on the safe side than to make an insufficient provision. The probable lifetime of each item of capital which is subject to deterioration is generally the basis of depreciation, although this is not always a safe one, even with former experience as a guide. This is especially true in the case of machinery.

There are many firms to-day using machinery of antiquated type, the output capacity of which is only a fraction of that of the more up-to-date machines; but because the normal lifetime of their plant has not been reached they will not discard it, oblivious or indifferent to the fact that their policy is "penny wise and pound foolish." They therefore continue to deduct, say, 5 or 10 per cent. per annum, but would find it infinitely more profitable to write 100 per cent. from the book value, less its scrap value, if it cannot otherwise be disposed of, and to install the more modern machine. I am a strong believer in scrapping old machinery when new and improved types appear on the market. Of course, consideration must be given to the interest on the cost of the old and new machines, and the amount gained in economy by the increased output or the better quality of manufacture. Machines should be forced as much as possible and worn out quickly. The depreciation will be high, but the product will be cheaper, profits larger, and the sooner the old machines will make way for the new and improved ones that will give increased output and better results at the same expense for time and labor. Many successful concerns, however, appreciate this fact, and will throw machinery on the scrap heap or sell it long before its natural life has expired simply because of its inefficiency as compared with later inventions.

In order to preserve the capital intact, buildings, machinery, plant, and stocks must of course be fully insured against the risk of fire. In the case of factories having a number of separate compartments or buildings, between which stocks are constantly passing to and fro, it is an expensive matter to insure the stock in each building for separate sums, because it is always desirable to have a margin on each for any possible increase that may arise during the year, especially as the inventory values forming the basis of insurance may not fully represent the value of stock at the busiest period of the year. These margins would amount in the aggregate to considerably more than would be sufficient as a margin if the whole stock was insured in one sum. To obviate this, however, the stock throughout the works can be insured for one sum, subject to the "average clause," which will in no event adversely affect the insured so long as the total stock is fully covered. Needless to say, fire insurance should be supplemented by the employment of night and day watchmen, and it is also desirable to have sufficient fire-fighting appliances throughout the works and to train a number of employees in their use.

In the factory office, even more than in the shop, is the question of discipline as regards time a difficult one. In the latter men can be, and usually are, held pretty closely to their hours by a system of checking out for a part of the day and a consequent loss of pay. In the office such a plan is impossible, but, nevertheless, discipline and punctuality are quite as necessary as in the shop. In office work there always must be a certain amount of give and take, and, fairly treated, the average clerk will be disposed to act fairly. As in the shop so in the office, except under exceptional circumstances, any advantage gained by working overtime is more apparent than real. When it is necessary, however, clerks will usually be ready and willing to put in the extra time, provided they know that the management see and realize that it is an extra effort that is being called for. Where clerical work is not kept up to date, nine times out of ten it is the fault of those in charge, not of the clerks; and in the majority of cases the cause is neglect of thought and care in distributing the work and planning the details.

As a general rule, it may be said that anything that tends to make a workman or a clerk more interested in his work, more comfortable in his surroundings, or more in harmony with his fellows tends to lessen the cost of the workman's product or of the results obtained by the clerk's labor; in other words, to reduce the cost of production. Even in such a small matter as the location of the desks of the various employees, convenience should be studied, and as a result time saved. These and similar matters, admittedly small in themselves, may collectively affect the question of time and therefore of cost of production to a greater extent than will readily be believed.

In all industries plans of future courses of action are very essential to any large degree of success. Of course, a slipshod way of maintaining the interests of nearly any business is in vogue in many cases, but the general unsatisfactory results of such maintenance is well known. A large percentage of plans undoubtedly prove to be flat failures when acted upon, but, nevertheless, a certain amount of theoretical foresight is necessary to all practical enterprises, even though they may not always "work out" entirely up to expectations. The chief foundation upon which the majority of plans and future projects rests is known by the name of "system." In a commercial sense the meaning of the word combines the results of experience and the consequent education received, with the most advantageous method of pursuing business from a profitable standpoint. It is nothing more than a very simple type of machine; however, each cog in the make-up must be kept thoroughly oiled in order to obtain a maximum amount of power. "System" has several meanings attributed to it when poor judgment is used. An insufficient quantity is generally designated as "haphazard dealing," while too much is commonly called "red tape"; both definitions going to prove the fact that common sense must determine the necessary amount to be applied.

Especially in cooperage manufacture, systematic and regular methods must be observed. The size of the plant required and the production handled naturally entails a careful survey and consideration of the best application to be employed. Consequently, that application is reached only through actual experience in the trade, circumstances and location of business having a good deal of bearing on the subject. Of one thing there is no question—the general importance of regular, concise, and brief reports. It is as much a necessity to have a detailed, comprehensive statement of what is taking place in all parts of the working section of a factory as it is important to keep a set of books in the office. According to the size and facilities of the plant, the statement should be prepared daily, weekly, or monthly. In this way progress or backsliding is easily discovered and guidance as to encouragement or remedy is obtained. While yearly reports are undoubtedly valuable in summing up past business and laying future plans, yet the varying trade conditions of the cooperage business demands a more frequent perusal of all accounts incurred. This is also true of the relation that expenses bear to gross profit, this being a matter that requires attention both daily and monthly.

Expenses, of course, govern the profits made, high prices by no means always meaning large net returns; and therefore it will be seen that, in tabulating expenses and in making provision for expected charges, carefulness and conservatism in preparing reports must be kept constantly in mind. Carelessness and lax methods of procedure would not only be misleading, but would in all probability result in a temporary demoralization of accounts as well.

The average cooperage concern does not find it necessary to have a daily cost statement made up in detail, but when reports are prepared from day to day it is of great value to specify the number of men employed, working hours of the factory, quantity of raw material received, production of the plant in its several different departments, and a cash summary, together with general remarks on the day's work. It would seem to any one unfamiliar with the preparation of such a statement that a large force of men and considerable expenditure would be required in order to show in such a short space of time a lucid, clear review of the operations of the mill or factory and miscellaneous branches of the plant. As a matter of fact, a little adjusting and rearranging of the existing methods of accounting and a proper style of bookkeeping are the chief factors. A certain amount of extra work is without doubt requisite, but the practical and monetary value of the influence obtained in handling the working staff engaged and in directing the use of capital greatly overbalances any objections on that score. Furthermore, when the expenditure question is considered, actual cost and accomplishment of results bear no comparison.

The monthly report must be considered as being midway between the daily and yearly summaries, and should contain the past month's statistics, and, equally important, totals covering the period since the last taking of inventory and closing of books. The average cost sheet should always be devised in as compact a manner as possible, for, owing to the fact of a larger scope being contained in a monthly than in a daily statement, better ideas can be gained of the state of business when monthly totals are reviewed. The latter, under such conditions, may oftentimes be profitably dealt with in a number of different ways. Sales and expense tabulating is valuable, inasmuch as sizes are condensed while all information is retained. Also, and in this the necessity for being conservative again becomes apparent, approximate profit to date may be shown. In preparing all mill or factory reports, no matter should be stated that does not give definite, valuable, complete and accurate information. The average management does not usually wish to measure the conditions of their business by millimetres or ounces, but desires a sort of bird's-eye view of the most prominent features of plant operation. In opening up new departments, segregating sales, taking inventories, classifying and arranging expenses and costs, maintaining balance sheets, and other methods of handling business too numerous to mention, no cooperage manufacturer or like concern can afford, provided that proper and necessary attention be given, to be without such reliable maps with which systematically to plan or project future courses of action.

The foregoing remarks will suggest to the manager numerous details having a bearing on the subject, which he can critically investigate for himself with at least one good result—that if he is unable to economize (and surely he will find *some* room for economy) he will have the satisfaction of knowing that nothing has been overlooked in the administration of his business. Finally, he will bear in mind the necessity of providing, as far as possible, against the exigencies of strikes, fluctuating markets, and any risk likely to bring his works to a standstill, and he will seek to cultivate that kindly interest in his employees which goes far to secure faithful and profitable service.

SECTION XII

USEFUL RULES AND INFORMATION

WEIGHTS OF SLACK COOPERAGE STOCK

THE following weights are of cooperage stock, taken from different sections of the country, and in the usual shipping conditions.

The heading is kiln-dried, staves are thoroughly air-dried, and the hoops are in the usual air-dried condition for shipment.

Staves that are kiln-dried would weigh some less, but as most of the staves are shipped in an air-dried condition, comparatively few being shipped kiln-dried, the weights are for air-dried staves only. It is expected that in every instance staves and heading will be shipped in condition fit for use on receipt of same.

Mixed timber staves will vary, because there are no stave rules as to what the timber shall be nor of what quantities of each species, but, as a rule, it can be probably safely classified the same as gum staves for weight.

These weights are sufficiently high to warrant the railroads in using them as a basis in adjusting of claims for overweight. Experience has proven conclusively that cooperage stock will not vary over two per cent. in weight for the same species of timber, and that, should the variation be greater than this, the stock is not in merchantable condition, which possible variation of two per cent. has been taken into consideration in formulating this table of weights.

ELM STAVES, NORTH OF THE OHIO RIVER

Length Stave	How Cut	Average Width	Weight per 1000 Staves
20 inch	cut 6 staves to 2 inches	3½ inches	450 lbs.
22 inch	cut 6 staves to 2 inches	3½ inches	485 lbs.
24 inch	cut 6 staves to 2 inches	3½ inches	525 lbs.
20 inch	cut 5 staves to 1⅞ inches	4 inches	570 lbs.
21 inch	cut 5 staves to 1⅞ inches	4 inches	595 lbs.

Length Stave	How Cut	Average Width	Weight per 1000 Staves
22 inch	cut 5 staves to 1⅞ inches	4 inches	620 lbs.
24 inch	cut 5 staves to 1⅞ inches	4 inches	670 lbs.
28½ inch	cut 5 staves to 1⅞ inches	4 inches	780 lbs.
30 inch	cut 5 staves to 1⅞ inches	4 inches	830 lbs.
32 inch	cut 5 staves to 1⅞ inches	4 inches	885 lbs.
33 inch	cut 5 staves to 1⅞ inches	4 inches	915 lbs.
34 inch	cut 5 staves to 1⅞ inches	4 inches	945 lbs.

ELM STAVES, SOUTH OF THE OHIO RIVER

Length Stave	How Cut	Average Width	Weight per 1000 Staves
28½ inch	5 staves to 1⅞ inches	4 inches	800 lbs.
30 inch	5 staves to 1⅞ inches	4 inches	840 lbs.
32 inch	5 staves to 1⅞ inches	4 inches	925 lbs.
34 inch	5 staves to 1⅞ inches	4 inches	1,000 lbs.

HARDWOOD STAVES

Length Stave	How Cut	Average Width	Weight per 1000 Staves
28½ inch	6 staves to 2⅛ inches	4 inches	950 lbs.
30 inch	6 staves to 2⅛ inches	4 inches	1,000 lbs.

GUM STAVES

Length Stave	How Cut	Average Width	Weight per 1000 Staves
23½ inch	5 staves to 1 15/16 inches	4 inches	600 lbs.
28½ inch	5 staves to 1 15/16 inches	4 inches	800 lbs.
30 inch	5 staves to 1 15/16 inches	4 inches	840 lbs.
32 inch	5 staves to 1 15/16 inches	4 inches	925 lbs.
34 inch	5 staves to 1 15/16 inches	4 inches	1,000 lbs.
23½ inch	6 staves to 2 inches	3½ inches	500 lbs.
24 inch	6 staves to 2 inches	4 inches	525 lbs.
36 inch	5 staves to 2 inches	4 inches	1,100 lbs.
40 inch	5 staves to 2 1/16 inches	4 inches	1,200 lbs.

COTTONWOOD STAVES

Length Stave	How Cut	Average Width	Weight per 1000 Staves
28½ inch	5 staves to 1 15/16 inches	4 inches	650 lbs.

COILED ELM HOOPS

Length Hoop	Dimensions	Weight per 1000 Hoops
3 feet 8 inches	¼ inch × ⅛ inch × 1¼ inches	275 lbs.
4 feet 0 inches	¼ inch × ⅛ inch × 1¼ inches	300 lbs.
4 feet 4 inches	¼ inch × ⅛ inch × 1¼ inches	350 lbs.
5 feet 0 inches	¼ inch × ⅛ inch × 1¼ inches	400 lbs.
5 feet 6 inches	5/16 inch × 3/16 inch × 1⅜ inches	460 lbs.

Length Hoop	Dimensions	Weight per 1000 Hoops
6 feet 0 inches	5/16 inch × 3/16 inch × 1 3/8 inches	500 lbs.
6 feet 6 inches	5/16 inch × 3/16 inch × 1 3/8 inches	545 lbs.
6 feet 9 inches	5/16 inch × 3/16 inch × 1 3/8 inches	570 lbs.
7 feet 0 inches	5/16 inch × 3/16 inch × 1 3/8 inches	600 lbs.
7 feet 6 inches	5/16 inch × 3/16 inch × 1 3/8 inches	650 lbs.
8 feet 0 inches	5/16 inch × 3/16 inch × 1 3/8 inches	700 lbs.

GUM HEADING

Diameter	Thickness	Weight per 100 Sets	Diameter	Thickness	Weight per 100 Set
15½ inches	½ inch	360 lbs.	21 inches	½ inch	650 lbs.
17⅛ inches	½ inch	435 lbs.	22⅝ inches	½ inch	725 lbs.
18½ inches	½ inch	500 lbs.	23⅝ inches	½ inch	825 lbs.
19⅛ inches	½ inch	550 lbs.	24 inches	½ inch	875 lbs.
20 inches	½ inch	600 lbs.			

COTTONWOOD HEADING

Diameter	Thickness	Weight per 100 Sets
19⅛ inches	½ inch	450 lbs.

BASSWOOD HEADING

Diameter	Thickness	Weight per 100 Sets	Diameter	Thickness	Weight per 100 Sets
14½ inches	½ inch	240 lbs.	16½ inches	½ inch	300 lbs.
15 inches	½ inch	250 lbs.	17⅛ inches	½ inch	340 lbs.
15½ inches	½ inch	260 lbs.	19⅛ inches	½ inch	400 lbs.

HARDWOOD HEADING

Diameter	Thickness	Weight per 100 Sets	Diameter	Thickness	Weight per 100 Sets
14½ inches	7/16 inch	310 lbs.	16½ inches	7/16 inch	440 lbs.
15 inches	7/16 inch	340 lbs.	17⅛ inches	7/16 inch	500 lbs.
15½ inches	7/16 inch	360 lbs.	18½ inches	7/16 inch	600 lbs.
16 inches	7/16 inch	400 lbs.	19⅛ inches	7/16 inch	675 lbs.

CAPACITY OF CARS

When slack cooperage stock is bought by carload lots, and quantity is not specifically stated, the following shall be standard car-lots, as recommended by the Committee on Grades of the National Slack Cooperage Manufacturers' Association. The idea of this is to have some guide where disputes arise through shipping enormous carloads on a falling market, and miniature carloads on a rising one; but in any case there must be stock enough in the car to make a minimum carload weight, as required by the railroads.

STAVES

From 18 inches to 24 inches	75,000 staves
From 24 inches to 26 inches	65,000 staves
From 26 inches to 30 inches	55,000 staves
From 30 inches to 34 inches	40,000 staves
From 34 inches to 40 inches	35,000 staves

COILED ELM HOOPS

From 3 feet 6 inches to 4 feet 4 inches	100,000 hoops
From 4 feet 4 inches to 5 feet 0 inches	80,000 hoops
From 5 feet 0 inches to 5 feet 6 inches	60,000 hoops
From 5 feet 6 inches to 6 feet 9 inches	50,000 hoops
From 6 feet 9 inches to 7 feet 6 inches	48,000 hoops
From 7 feet 6 inches to 8 feet 6 inches	45,000 hoops

HARDWOOD HEADING

From 11 inches to 12½ inches	18,000 sets
From 12½ inches to 14½ inches	15,000 sets
From 14½ inches to 15½ inches	10,000 sets
From 15½ inches to 16½ inches	9,000 sets
From 16½ inches to 17⅛ inches	8,000 sets
From 17⅛ inches to 18¼ inches	7,000 sets
From 18¼ inches to 19⅛ inches	6,500 sets
From 19⅛ inches to 21 inches	6,000 sets
From 21 inches to 24 inches	3,500 sets

PINE AND SOFTWOOD HEADING

From 11 inches to 12½ inches	20,000 sets
From 12½ inches to 14½ inches	18,000 sets
From 14½ inches to 15½ inches	12,000 sets
From 15½ inches to 16½ inches	11,000 sets
From 16½ inches to 17⅛ inches	10,000 sets
From 17⅛ inches to 18¼ inches	9,000 sets
From 18¼ inches to 19⅛ inches	7,500 sets
From 19⅛ inches to 21 inches	7,000 sets
From 21 inches to 24 inches	4,000 sets

LEGAL FRUIT BARREL IN NEW YORK STATE

A RECENT act of the New York Legislature has fixed the size and shape of the legal fruit barrel by adding to Article B of the agriculture law, Section 188, which says that a fruit barrel shall equal 100 quarts, 12½ pecks, or 6,720 cubic inches, dry measure, and shall be of dimensions as follows: Head diameter, 17½ inches; length of stave, 28½ inches; and the bilge not less than 64 inches, outside measurement. If the barrel is made straight up and down, or without any bilge, it shall contain the same number of cubic inches as is described in the foregoing. Any person or party making, manufacturing, or causing to be made or manufactured barrels for use in the sale of apples, pears, quinces, or any other fruit, or selling such fruit in barrels containing less than is above specified, shall be compelled to brand such barrels, "upon each end and upon the side," with the conspicuous letters at least one and one-half inches in length, "Short barrel." The penalty for violation is not stated in the section, but it may be provided for in the general law.

LEGAL FRUIT BARREL IN THE STATE OF INDIANA

THE legal fruit barrel in the State of Indiana shall not contain less than 12 pecks, 96 quarts, or 6,451 cubic inches, an act having been passed by the Legislature of that State to that effect.

NOTES ON BELTING

A BELT transmits power solely through frictional contact with the surface of the pulley.

The lower side of the belt should be made the driving side when possible, as the arc of contact is thereby increased by the sagging of the slack side. By this method belts may be run much slacker and with less strain or friction on the bearings than otherwise, and a greater horsepower transmitted.

Increase of power will be obtained by increasing the size of the pulleys, the same ratio being retained.

Wide belts are less effective per unit of sectional area than narrow belts, and long belt drives are more effective than short ones.

The proportion between the diameters of two pulleys working together should not exceed 6 to 1.

Convexity or crown of pulleys should equal ⅛ to ¼ inch in the width up to 12 inches wide; for larger sizes, ⅛ to ¼ inch per foot of width.

The convexity or crown of driving and driven pulleys should be alike in amount.

The pulley always should be from ½ to 1½ inches wider than the belt, according to the width of face.

The driving pulley is called the "driver," and the driven pulley is called the "driven" or follower.

The horsepower of a belt equals velocity in feet per minute, multiplied by the width, and this sum divided by 1,000.

A 1-inch single belt, moving at 1,000 feet per minute, equals one horsepower.

A 1-inch double belt, moving at 700 feet per minute, equals one horsepower.

Oak-tanned leather belts make the best belts.

When belts are run with the hair side (smooth side) next to the pulley they have greater adhesion and transmit more power.

The ordinary thickness of leather belts is 3/16 inch, and their weight is about 60 pounds per cubic foot.

Ordinarily four-ply cotton belting is considered equivalent to single-leather belting.

The average breaking strain of single-leather belt is 530 pounds per inch in width; three-ply rubber belt, 600 pounds per inch in width.

"SPEED OF BELTS"

Belts have been employed running over 5,800 feet per minute. Nothing, however, is gained by running belts much over 4,000 feet per minute. About 3,500 feet per minute for main belts is considered good practice.

The life of a belt may be prolonged and its driving power increased by keeping it in good working order.

"To CLEAN BELTS" which are dirty from drop oil and dust, first wash the belts with warm water and soap, using a sharp, stiff brush, and while still moist rub them with a solution of sal ammoniac, which saponifies the oil in them. Immediately thereafter the belt must be rinsed well with lukewarm water and then dried with sufficient tension. While they are still moist the belts are to be rubbed well on the inside and less on the outside with the following: 2 pounds ¾ ounce India rubber, heated to 122° Fahr. and mixed with 2 pounds ¾ ounce rectified turpentine oil. After the solution is complete, 27 ounces of bright resin are added, and when this is dissolved add 26½ ounces of yellow wax. This mixture, by diligent stirring, is mixed with 6 pounds 10 ounces of fish oil and 2 pounds 12 ounces of tallow previously dissolved in the fish oil. In the further treatment of the belt, rub the inside only, and the outside only at the first treatment, as stated. This belt dressing, if properly mixed and applied, will prevent dragging of the belt and imparts elasticity to it.

One of the simplest and best belt dressings is made from 1 part neatsfoot oil and 3 parts castor oil.

The best joint for a belt is the cemented joint. This requires time and patience to shave down properly and about five hours to set.

The worst joint is the ordinary laced joint. It has the merit of being made quickly. Another method is the "hinge plan." The important item in this plan is good lace leather, which should be strong, well tanned, and uniform in thickness.

The annealed nickel wire makes an excellent belt lacing, but care must be exercised in inserting it, for if the wire is crossed or lapped over one another on the pulley side the lacing will not last long. The composition wire made especially for this purpose is better suited for lacing than the annealed nickel wire.

In applying, a single row of holes is used, the holes being no farther from the end than the thickness of the belt, and ⅜ inch apart, and should be cut with a $\frac{3}{32}$-inch belt punch. Cut a depression on inside of belt for the wire, so that it will be clear of face of pulley. Commence lacing at the centre by passing the ends of the wire through the two centre holes to the pulley side of the belt. The lacing should be double on the pulley side; then lace each way to the side, double-lacing on the inside, drawing up tightly all the time without kinks or crossing the wire. When finished, flatten down with a hammer on the pulley face.

A properly wire-laced joint makes the belt appear endless, as there is no jar when the joint passes over the pulley.

RULES FOR CALCULATING SPEED OF PULLEYS

"To determine the diameter of the driver," the diameter of the driven and its revolutions, as also revolutions of driver being given.

$$\frac{\text{Diam. of driven} \times \text{revolutions of driven}}{\text{Revolutions of driver}} = \text{Diam of driver.}$$

"To determine the diameter of the driven," the revolutions of the driven and the diameter and revolutions of the driver being given.

$$\frac{\text{Diam. of driver} \times \text{revolutions of driver}}{\text{Revolutions of driven}} = \text{Diam of driven.}$$

"To determine the revolutions of the driver," the diameter and revolutions of the driven and the diameter of the driver being given.

$$\frac{\text{Diam. of driven} \times \text{revolutions of driven}}{\text{Diam. of driver}} = \text{Revolutions of driver.}$$

"To determine the revolutions of the driven," the diameter and revolutions of the driver and diameter of the driven being given.

$$\frac{\text{Diam. of driver} \times \text{revolutions of driver}}{\text{Diam. of driven}} = \text{Revolutions of driven.}$$

If the number of teeth in gears is used instead of diameter in these calculations, number of teeth must be substituted whenever diameter occurs.

POWER OF BELTING

To calculate roughly the power of belts, the following rules may be used:

To determine the "horsepower" transmitted of a single-leather belt.

$$\frac{\text{Width of belt in in.} \times \text{speed in ft. per min.}}{900} = \text{Horsepower transmitted.}$$

To determine the "proper width" of a single-leather belt to transmit a given horsepower.

$$\frac{900 \times \text{horsepower}}{\text{Speed of belt in ft. per min.}} = \text{Proper width of belt.}$$

HORSE-POWER OF LEATHER BELTS PER INCH OF WIDTH

Velocity of Belt in Feet per Minute	Best Oak Tanned Belts			Best Link or Chain Belts					
	Single Belts	Light Double Belts	Heavy Double Belts	3/8 inch	1/2 inch	5/8 inch	3/4 inch	7/8 inch	1 inch
100	0.15	0.21	0.27	0.13	0.15	0.17	0.20	0.24	0.27
200	0.30	0.42	0.55	0.25	0.29	0.35	0.40	0.47	0.55
300	0.45	0.64	0.82	0.38	0.44	0.52	0.60	0.71	0.82
400	0.61	0.85	1.09	0.51	0.58	0.69	0.80	0.95	1.09
500	0.76	1.06	1.36	0.64	0.73	0.86	1.00	1.18	1.36
600	0.91	1.27	1.64	0.76	0.87	1.04	1.20	1.42	1.64
700	1.06	1.49	1.91	0.89	1.02	1.21	1.40	1.65	1.91
800	1.21	1.70	2.18	0.92	1.16	1.38	1.60	1.89	2.18
900	1.36	1.91	2.45	1.05	1.31	1.55	1.89	2.13	2.45
1000	1.51	2.12	2.73	1.27	1.45	1.73	2.00	2.36	2.73
1100	1.67	2.33	3.00	1.40	1.60	1.90	2.20	2.60	3.00
1200	1.82	2.55	3.27	1.53	1.75	2.07	2.40	2.84	3.27
1300	1.97	2.76	3.55	1.65	1.89	2.25	2.60	3.07	3.55
1400	2.12	2.97	3.82	1.78	2.04	2.42	2.80	3.31	3.82
1500	2.27	3.18	4.09	1.91	2.18	2.59	3.00	3.55	4.09
1600	2.42	3.39	4.36	2.04	2.33	2.76	3.20	3.78	4.36
1700	2.58	3.61	4.64	2.16	2.47	2.94	3.40	4.02	4.64
1800	2.73	3.82	4.91	2.29	2.62	3.11	3.60	4.25	4.91
1900	2.88	4.03	5.18	2.42	2.76	3.28	3.80	4.49	5.18
2000	3.03	4.24	5.45	2.55	2.91	3.45	4.00	4.73	5.45
2100	3.18	4.45	5.73	2.67	3.05	3.63	4.20	4.96	5.73
2200	3.33	4.67	6.00	2.80	3.20	3.80	4.40	5.20	6.00
2300	3.49	4.88	6.27	2.93	3.35	3.97	4.60	5.44	6.27
2400	3.64	5.09	6.55	3.05	3.49	4.15	4.80	5.67	6.55
2500	3.79	5.30	6.82	3.18	3.64	4.32	5.00	5.91	6.82
2600	3.94	5.52	7.09	3.24	3.78	4.49	5.20	6.15	7.09
2700	4.09	5.73	7.36	3.28	3.85	4.66	5.40	6.38	7.36
2800	4.24	5.94	7.64	3.31	3.86	4.73	5.60	6.62	7.64
2900	4.39	6.15	7.91	3.32	3.87	4.78	5.80	6.85	7.91
3000	4.50	6.36	8.18	3.31	3.86	4.75	5.97	7.09	8.18
3100	4.60	6.58	8.45	3.30	3.85	4.73	5.96	7.33	8.45
3200	4.69	6.79	8.70	3.28	3.82	4.71	5.94	7.37	8.73
3300	4.77	7.00	8.86	3.24	3.77	4.70	5.92	7.35	8.88
3400	4.84	7.21	8.96	3.19	3.71	4.64	5.87	7.32	8.85
3500	4.90	7.31	9.06	3.13	3.61	4.50	5.78	7.26	8.80
3600	4.95	7.40	9.16	3.05	3.50	4.37	5.67	7.16	8.73
3700	4.99	7.48	9.24	2.96	3.39	4.26	5.55	7.01	8.58
3800	5.03	7.54	9.29	2.84	3.28	4.15	5.41	6.87	8.41
3900	5.06	7.60	9.34	2.72	3.13	4.02	5.20	6.70	8.27
4000	5.08	7.64	9.37	2.58	2.95	3.84	5.01	6.48	8.04
4200	5.10	7.70	9.38	2.27	2.55	3.37	4.52	5.98	7.51
4500	5.07	7.69	9.27	1.64	1.77	2.45	3.68	5.05	6.55
5000	4.82	7.42	8.75	0.42	0.15	0.61	1.55	2.78	4.32

To determine the "proper speed" a single-leather belt should travel to transmit a given horsepower.

$$\frac{900 \times \text{horsepower to be transmitted}}{\text{Width of belt in inches}} = \text{Proper speed in ft. per min.}$$

To determine "the horsepower" transmitted of a double-leather belt.

$$\frac{\text{Width of belt in in.} \times \text{speed in ft. per min.}}{630} = \text{Horsepower transmitted.}$$

To determine the "proper width" of a double-leather belt to transmit a given horsepower.

$$\frac{630 \times \text{horsepower}}{\text{Speed of belt in ft. per min.}} = \text{Proper width of belt.}$$

To determine the "proper speed" a double-leather belt should travel to transmit a given horsepower.

$$\frac{630 \times \text{horsepower to be transmitted}}{\text{Width of belt in inches}} = \text{Proper speed in ft. per min.}$$

These rules are simple calculations and give good, practical results where there is no great inequality in the diameters of the pulleys. To find the "speed of a belt in feed per minute," multiply the diameter of the pulley by 3.1416. This will give you the circumference in inches. Then multiply this by the number of revolutions the pulley makes per minute, and divide the product by 12. This will give you the speed of the belt in feet per minute.

The "working tension" of a leather belt is generally figured as being from 70 to 150 pounds per inch of width.

BABBITT METAL AND BABBITTING

Nearly half a century ago Isaac Babbitt, of Taunton, Mass., originated the alloy which has since been known as Babbitt metal. It is highly valued for its anti-friction qualities as compared with other metals. Isaac Babbitt was a goldsmith by trade, and made the first Britannia ware that was produced in this country. He was honored with a gold medal for his discovery of his anti-friction alloy and was also presented with $20,000 by the Congress of the United States.

Below are several formulas for preparing Babbitt metal for the different uses as specified:

1.	Copper	10 parts
	Tin	72 parts
	Antimony	18 parts
	Total	100 parts

This alloy is recommended for all high-speed machinery journal boxes.

2.	Copper	1 part
	Tin	48 parts
	Antimony	5 parts
	Lead	2 parts
	Total	56 parts

This alloy is more economical than No. 1, and has a more greasy touch than the first named, but is not so desirable for high-speed machinery.

3.	Lead	32 parts
	Zinc	20 parts
	Antimony	48 parts
	Total	100 parts

This alloy will resist a rapid friction, but it is not suited for high-speed machinery.

4.	Lead	90 parts
	Antimony	100 parts
	Total	190 parts

This is a very cheap alloy, suitable only for slow-moving machinery, etc.

5.	Copper	77 parts
	Tin	8 parts
	Lead	15 parts
	Phosphorus	Trace
	Total	100 parts

This alloy is exclusively for heavy machinery bearings.

6.	Copper	3 parts
	Tin	89 parts
	Antimony	8 parts
	Total	100 parts

This is the original Babbitt metal, is not very expensive, and can be used for all classes of machinery bearings where weight is not excessive.

In babbitting bearings it is always advisable to put a piece of rosin into the Babbitt metal before pouring. After putting in the rosin, stir the metal thoroughly with a pine stick, then skim off any refuse or other matter. It makes poor Babbitt metal run better and improves it, and especially when metal from old bearings is used. It also has a tendency to prevent blowing when pouring into damp boxes. Babbitt heated just hot enough to light a pine stick will run in places with the rosin in where without it it would not.

GLUE TO RESIST MOISTURE

Dissolve 1 pound of clean glue in 2 quarts of skimmed milk.

RECEIPTS FOR SOLDERING FLUIDS

1. One dram each of powdered copperas, borax, and prussiate of potash; ½ ounce powdered sal-ammoniac; 3½ ounces fluid muriatic acid. Let the mixture cut all

the zinc it will, and then dilute with one pint of water. This is something extra for soldering the raw edges of tin or galvanized iron. The above quantity of fluid will cost about fifteen cents.

2. Add granulated zinc or zinc scraps to 2 fluid ounces of muriatic acid, until hydrogen ceases to be given off; add 1 teaspoonful of ammonium chloride; then shake well and add 2 fluid ounces of water.

3. A very good fluid for soldering bright tin can be made by simply adding sweet oil to well-pounded rosin. It was used years ago by the tinners of Great Britain for soldering planished ware made in those days, and is excellent for soldering fine work, silver and plated ware. It can be wiped off with a clean rag and leaves no stain or scratches.

USEFUL RULES AND INFORMATION ON WATER

Doubling the diameter of a pipe increases its capacity four times.

Friction of liquids in pipes increases as the square of the velocity.

The mean pressure of the atmosphere is usually estimated at 14.7 pounds per square inch, so that with a perfect vacuum it will sustain a column of mercury 29.9 inches or a column of water 33.9 feet high at sea level.

"To find the pressure in pounds per square inch" of a column of water, multiply the height of the column by .434. Approximately, we say that every foot of elevation is equal to ½ pound pressure per square inch; this allows for ordinary friction.

"To find the diameter of a pump cylinder" necessary to move a given quantity of water per minute (100 feet of piston being the standard of speed), divide the number of gallons by 4, then extract the square root, and the product will be the diameter in inches of the pump cylinder.

"To find the quantity of water elevated in one minute," running at 100 feet of piston speed per minute, square the diameter of the water cylinder in inches and multiply by 4.

Example: Capacity of a 5-inch cylinder is desired. The square of the diameter (5 inches) is 25, which multiplied by 4, gives 100, which is approximately the number of gallons elevated per minute.

"To find the horsepower necessary to elevate water" to a given height, multiply the weight of the water elevated per minute in pounds by the height in feet, and divide the product by 33,000. (An allowance should be added for water friction and a further allowance for loss in steam cylinder, say from 20 to 30 per cent.)

"The area of the steam piston" multiplied by the steam pressure gives the total amount of pressure that can be exerted.

"The area of water piston" multiplied by the pressure of the water per square inch gives the resistance. A margin must be made between the power and the resistance to move the pistons at the required speed—say, from 20 to 40 per cent., according to speed and other conditions.

"To find the capacity of a pump cylinder" in gallons, multiply the area in inches by the length of stroke in inches. This will give the total number of cubic inches. Divide this amount by 231 (which is the cubic contents of a U. S. gallon in inches), and the product is the capacity in gallons.

"To find the capacity of a barrel" in gallons, to the head diameter add two-thirds of the difference between the head and the bilge diameters, and multiply the area by the inside length in inches; divide this amount by 231, and the product is the capacity in U. S. gallons.

USEFUL RULES AND INFORMATION ON STEAM

One cubic inch of water evaporated under ordinary atmospheric pressure is converted into one cubic foot of steam (approximately).

The specific gravity of steam (at atmospheric pressure) is .411 that of air at 34° Fahr., and .0006 that of water at the same temperature.

27,222 cubic feet of steam weigh one pound.

13,817 cubic feet of air weigh one pound.

Locomotives average a consumption of 3,000 gallons of water per 100 miles run.

The best-designed boilers, well set, with good draft and skilful firing will evaporate 7 to 10 pounds of water per pound of first-class coal.

In calculating horsepower of tubular or flue boilers, consider 15 square feet of heating surface equivalent to one nominal horsepower.

On one square foot of grate can be burned on an average of from 10 to 12 pounds of hard coal, or 18 to 20 pounds of soft coal per hour with natural draft. With forced draft nearly double these amounts can be burned.

Steam engines, in economy, vary from 14 to 60 pounds of feed water, and from 1½ to 7 pounds of coal per hour per indicated horsepower.

Condensing engines require from 20 to 30 gallons of water at an average low temperature to condense the steam represented by every gallon of water evaporated in the boilers, supplying the engine—approximately for most engines, we say, from 1 to 1½ gallons condensing water per minute per indicated horsepower.

Surface condensers should have about 2 square feet of tube (cooling) surface per horsepower for a compound steam engine. Ordinary engines will require more surface, according to their economy in the use of steam. It is absolutely necessary to place air pumps below condensers to get satisfactory results.

RATIO OF VACUUM TO TEMPERATURE (FAHRENHEIT) OF FEED WATER

00 inches vacuum = 212°	25 inches vacuum = 135°
11 inches vacuum = 190°	27½ inches vacuum = 112°
18 inches vacuum = 170°	28½ inches vacuum = 92°
22½ inches vacuum = 150°	29 inches vacuum = 72°

29½ inches vacuum = 52°

25 inches of vacuum is usually considered the standard point of efficiency, the condenser and air pump being well proportioned.

DUTY OF STEAM ENGINES (HIGH GRADE)

TYPE OF ENGINE	Temperature of Feed Water	Pounds of Water Evaporated per Pound of Cumberland Coal	Pounds of Steam per I. H. P. Used per Hour	Pounds of Cumberland Coal Used per I. H. P. per Hour	Cost per I. H. P. per Hour Supposing Coal to be $6.00 per Ton
Non-condensing..........	210°	10.5	29.0	2.75	$0.0073
Condensing..............	100°	9.4	20.0	2.12	0.0056
Compound Jacketed......	100°	9.4	17.0	1.81	0.0045
Triple Expansion Jacketed	100°	9.4	13.6	1.44	0.0036

The effect of a good condenser and air pump should be to make available about 10 pounds more mean effective pressure with the same terminal pressure, or to give the same mean effective pressure with a correspondingly less terminal pressure. When the load on the engine requires 20 pounds mean effective pressure, the condenser does half the work; at 30 pounds, one-third of the work; at 40 pounds, one-fourth, etc. It is safe to assume that practically the condenser will save from one-fourth to one-third of the fuel, and can be applied to any style engine, either cut-off or throttling, where a sufficient supply of water is available.

WEIGHT AND COMPARATIVE FUEL VALUE OF WOOD

One cord air-dried:

Hickory	weighs about 4,500 lbs.	and is equal to about 2,000 lbs. coal.
Hard maple	weighs about 4,500 lbs.	and is equal to about 2,000 lbs. coal.
White oak	weighs about 3,850 lbs.	and is equal to about 1,715 lbs. coal.
Red oak	weighs about 3,250 lbs.	and is equal to about 1,450 lbs. coal.
Beech	weighs about 3,250 lbs.	and is equal to about 1,450 lbs. coal.
Poplar	weighs about 2,350 lbs.	and is equal to about 1,050 lbs. coal.
Chestnut	weighs about 2,350 lbs.	and is equal to about 1,050 lbs. coal.
Elm	weighs about 2,350 lbs.	and is equal to about 1,050 lbs. coal.
Average pine	weighs about 2,000 lbs.	and is equal to about 925 lbs. coal.

From the above it is safe to assume that 2¼ pounds of dry wood is equal to 1 pound average quality of soft coal, and that the full value of the same weight of different woods is very nearly the same; that is, a pound of hickory is worth no more for fuel than a pound of pine, assuming both to be dry. It is important that the wood be dry, as each 10 per cent. of water or moisture in wood will detract about 12 per cent. from its value as fuel.

TO PLACE AN ENGINE ON THE DEAD CENTRE

To place an engine on its dead centre, bring the crosshead to within about half an inch of the end of its travel. Take a pair of dividers and from a point on the guides strike an arc of a circle on the cross-head, and with the engine in the same position, tram from a point on the floor to the rim of the wheel; then move the engine in the direction it is to run until the cross-head has passed the end of its travel and returned to a point where the dividers will coincide with the mark already made on the cross-head. Make another tram mark on the rim of the flywheel, and midway between these two marks make a centre punch mark for a "dead-centre mark." Bring the flywheel to a point, that the point of the tram will just enter the dead-centre mark, and the engine is on its exact centre at that end. Then repeat the operation on the other end. In all cases move the engine in the direction it is to run, and if moved past the dead-centre mark it must be backed up far enough to take up the lost motion before reaching the mark again.

HORSEPOWER OF AN ENGINE

An easy method of figuring the horsepower of an engine will be found in the following formula:

$$\frac{\text{Diam.}^2 \times \text{stroke} \times \text{revs.} \times \text{M. E. P.}}{250{,}000} = \text{H. P.}$$

This is explained as follows: Multiply the diameter of the piston in inches by its diameter (or, in other words, square the diameter); multiply this product by the length of the stroke in inches; then multiply by the number of strokes per minute and this product by the mean effective pressure in pounds per square inch on the piston during one stroke. Dividing this total by 250,000 will give you the horsepower. The result is accurate to within 2 per cent.

Still another easy method is as follows: Multiply the diameter of the piston in inches by itself, then by .4, then by the mean effective pressure, then by the number of strokes per minute, and point off six places. The result will be the horsepower to within 2 per cent.

If an indicator card cannot be obtained, a fair approximation to the M. E. P. may be obtained by adding 14.7 to the gauge pressure, and multiplying the number opposite the fraction indicating the point of cut-off in the following table by the boiler pressure. Then subtract 17 from the product, and multiply by .9. The result is the M. E. P. for good, simple non-condensing engines. If the engine is a simple condensing engine, subtract the pressure in the condenser instead of 17.

CUT OFF	CONSTANT	CUT-OFF	CONSTANT	CUT-OFF	CONSTANT
$\frac{1}{6}$	.566	$\frac{3}{8}$	.771	$\frac{2}{3}$	.917
$\frac{1}{5}$	.603	.4	.789	.7	.926
$\frac{1}{4}$	.659	$\frac{1}{2}$	.847	$\frac{3}{4}$	.937
.3	.708	.6	.895	.8	.944
$\frac{1}{3}$	.743	$\frac{5}{8}$	.904	$\frac{7}{8}$	.951

The fraction indicating the point of cut-off is obtained by dividing the distance that the piston has travelled when the steam is cut off by the whole length of the stroke.

Example: Stroke is 30 inches, and the steam is cut off when the piston has travelled 20 inches. The engine cuts off at $^{20}/_{30} = ^{2}/_{3}$ stroke. For a $^{2}/_{3}$ cut-off and a 92-pound gauge pressure in the boiler, the M. E. P. is

$(92 + 14.7) \times .917 - 17] \times .9 = 72.76$ pounds per square inch.

INDICATED HORSE-POWER "PER POUND" OF MEAN EFFECTIVE PRESSURE PER SQUARE INCH

("HORSE-POWER CONSTANTS")

Diameter of Cylinder in Inches	Speed of Piston in Feet per Minute							
	240	300	350	400	450	500	550	600
6	0.205	0.257	0.3	0.343	0.385	0.428	0.471	0.514
7	0.28	0.35	0.408	0.466	0.525	0.583	0.641	0.699
8	0.365	0.457	0.533	0.609	0.685	0.761	0.837	0.914
9	0.463	0.578	0.675	0.771	0.867	0.964	1.06	1.157
10	0.571	0.714	0.833	0.952	1.071	1.19	1.309	1.428
11	0.691	0.864	1.008	1.152	1.296	1.44	1.584	1.728
12	0.822	1.028	1.119	1.371	1.542	1.713	1.885	2.056
13	0.965	1.206	1.408	1.609	1.81	2.011	2.212	2.413
14	1.119	1.399	1.633	1.866	2.099	2.332	2.565	2.799
15	1.285	1.606	1.874	2.142	2.41	2.677	2.945	3.213
16	1.462	1.828	2.132	2.437	2.742	3.046	3.351	3.656
17	1.651	2.063	2.407	2.751	3.095	3.439	3.783	4.127
18	1.851	2.313	2.699	3.084	3.470	3.855	4.241	4.627
19	2.062	2.577	3.007	3.437	3.866	4.296	4.725	5.155
20	2.285	2.856	3.332	3.808	4.284	4.76	5.236	5.712
21	2.519	3.149	3.673	4.198	4.723	5.248	5.773	6.297
22	2.764	3.456	4.032	4.607	5.183	5.759	6.335	6.911
23	3.021	3.777	4.406	5.036	5.665	6.295	6.924	7.554
24	3.29	4.112	4.798	5.483	6.169	6.854	7.539	8.225
25	3.57	4.462	5.206	5.95	6.694	7.437	8.181	8.925
26	3.86	4.826	5.63	6.434	7.238	8.043	8.847	9.651
27	4.164	5.205	6.072	6.94	7.807	8.675	9.542	10.41
28	4.478	5.598	6.531	7.464	8.397	9.329	10.262	11.195
29	4.804	6.005	7.005	8.006	9.007	10.008	11.009	12.009
30	5.141	6.426	7.497	8.568	9.639	10.71	11.781	12.852
31	5.489	6.861	8.005	9.149	10.292	11.436	12.579	13.753
32	5.849	7.311	8.53	9.748	10.967	12.185	13.404	14.623
33	6.22	7.775	9.071	10.367	11.663	12.959	14.255	15.551
34	6.603	8.254	9.629	11.005	12.381	13.756	15.132	16.508
35	6.997	8.746	10.204	11.662	13.12	14.577	16.035	17.493
36	7.403	9.253	10.795	12.338	13.88	15.422	16.964	18.506
37	7.82	9.774	11.404	13.033	14.662	16.291	17.92	19.549
38	8.248	10.31	12.028	13.747	15.465	17.183	18.902	20.62
39	8.688	10.86	12.67	14.48	16.29	18.1	19.91	21.72
40	9.139	11.424	13.328	15.232	17.136	19.04	20.944	22.848
41	9.602	12.002	14.003	16.003	18.003	20.004	22.004	24.004
42	10.076	12.595	14.694	16.793	18.892	20.991	23.091	25.19
43	10.561	13.202	15.402	17.602	19.803	22.003	24.203	26.403
44	11.058	13.823	16.127	18.431	20.734	23.038	25.342	27.646
45	11.567	14.458	16.868	19.278	21.688	24.097	26.507	28.917
46	12.086	15.108	17.626	20.144	22.662	25.18	27.698	30.216
47	12.618	15.772	18.401	21.03	23.658	26.287	28.916	31.545
48	13.16	16.45	19.192	21.934	24.676	27.417	30.159	32.901
49	13.714	17.143	20.0	22.857	25.714	28.572	31.429	34.286
50	14.28	17.85	20.825	23.8	26.775	29.75	32.725	35.7

This formula is worked out as follows:

Gauge pressure	92	pounds
Atmospheric pressure	14.7	pounds
Total pressure	106.7	
Horsepower constant	.917	
	7469	
	1067	
	9603	
	97.8439	
Less	17	
	80.8439	
	.9	

M. E. P.= 72.75951 or 72.76 pounds per square in.

The "actual horsepower" of an engine is usually approximated as three-fourths of the "indicated horsepower."

USEFUL NUMBERS FOR RAPID APPROXIMATION

(From Hamilton's Useful Information for Railroad Men)

Feet	×	.00019	= miles.
Yards	×	.0006	= miles.
Links	×	.22	= yards.
Links	×	.66	= feet.
Feet	×	1.5	= links.
Square inches	×	.007	= square feet.
Circular inches	×	.00546	= square feet.
Square feet	×	.111	= square yards.
Acres	×	4840.	= square yards.
Square yards	×	.0002026	= acres.
Width in chains	×	8.	= acres per mile.
Cubic feet	×	.04	= cubic yards.
Cubic inches	×	.00058	= cubic feet.
U. S. bushels	×	.046	= cubic yards.
U. S. bushels	×	1.244	= cubic feet.
U. S. bushels	×	2150.42	= cubic inches.
Cubic feet	×	.8036	= U. S. bushels.

Cubic inches	×	.000466	= U. S. bushels.
U. S. gallons	×	.13368	= cubic feet.
U. S. gallons	×	231.	= cubic inches.
Cubic feet	×	7.48	= U. S. gallons.
Cylindrical feet	×	5.878	= U. S. gallons.
Cubic inches	×	.004329	= U. S. gallons.
Cylindrical inches	×	.0034	= U. S. gallons.
Pounds	×	.009	= cwt. (112 lbs.).
Pounds	×	.00045	= tons (2,240 lbs.).
Cubic feet water	×	62.5	= pounds avoirdupois.
Cubic inches water	×	.03617	= pounds avoirdupois.
Cylindrical foot of water	×	49.1	= pounds avoirdupois.
Cylindrical inches of water	×	.02842	= pounds avoirdupois.
U. S. gallons of water	÷	13.44	= cwt. (112 lbs.).
U. S. gallons of water	÷	268.8	= tons (2,240 lbs.).
Cubic feet of water	÷	1.8	= cwt. (112 lbs.).
Cubic feet of water	÷	35.88	= tons.
Cylindrical foot of water	×	5.875	= U. S. gallons.
Column water 12″ high, 1″ diam.			= 34 pounds.
183,346 circular inches			= 1 square foot.
2,200 cylindrical inches			= 1 cubic foot.
French metres	×	3.281	= feet.
Kilogrammes	×	2.205	= avoirdupois pounds.
Grammes	×	.0022	= avoirdupois pounds.

DECIMAL EQUIVALENTS OF FRACTIONAL PARTS OF AN INCH

Fractions	Decimals	Fractions	Decimals	Fractions	Decimals	Fractions	Decimals
$\frac{1}{64}$	0.015625	$\frac{17}{64}$	0.265625	$\frac{33}{64}$	0.515625	$\frac{49}{64}$	0.765625
$\frac{1}{32}$	0.03125	$\frac{9}{32}$	0.28125	$\frac{17}{32}$	0.53125	$\frac{25}{32}$	0.78125
$\frac{3}{64}$	0.046875	$\frac{19}{64}$	0.296875	$\frac{35}{64}$	0.546875	$\frac{51}{64}$	0.796875
$\frac{1}{16}$	0.0625	$\frac{5}{16}$	0.3125	$\frac{9}{16}$	0.5625	$\frac{13}{16}$	0.8125
$\frac{5}{64}$	0.078125	$\frac{21}{64}$	0.328125	$\frac{37}{64}$	0.578125	$\frac{53}{64}$	0.828125
$\frac{3}{32}$	0.09375	$\frac{11}{32}$	0.34375	$\frac{19}{32}$	0.59375	$\frac{27}{32}$	0.84375
$\frac{7}{64}$	0.109375	$\frac{23}{64}$	0 359375	$\frac{39}{64}$	0.609375	$\frac{55}{64}$	0.859375
$\frac{1}{8}$	0.125	$\frac{3}{8}$	0.375	$\frac{5}{8}$	0.625	$\frac{7}{8}$	0.875
$\frac{9}{64}$	0.140625	$\frac{25}{64}$	0.390625	$\frac{41}{64}$	0.640625	$\frac{57}{64}$	0.890625
$\frac{5}{32}$	0.15625	$\frac{13}{32}$	0.40625	$\frac{21}{32}$	0.65625	$\frac{29}{32}$	0.90625
$\frac{11}{64}$	0.171875	$\frac{27}{64}$	0.421875	$\frac{43}{64}$	0.671875	$\frac{59}{64}$	0.921875
$\frac{3}{16}$	0.1875	$\frac{7}{16}$	0.4375	$\frac{11}{16}$	0.6875	$\frac{15}{16}$	0.9375
$\frac{13}{64}$	0.203125	$\frac{29}{64}$	0.453125	$\frac{45}{64}$	0.703125	$\frac{61}{64}$	0.953125
$\frac{7}{32}$	0.21875	$\frac{15}{32}$	0.46875	$\frac{23}{32}$	0.71875	$\frac{31}{32}$	0.96875
$\frac{15}{64}$	0.234375	$\frac{31}{64}$	0.484375	$\frac{47}{64}$	0.734375	$\frac{63}{64}$	0.984375
$\frac{1}{4}$	0.25	$\frac{1}{2}$	0.5	$\frac{3}{4}$	0.75	1	1.0

TABLE OF GAUGES

Gauge Number	American Legal Standard	Brown & Sharp American Standard	Birmingham or Stubbs British Standard	English Imperial Legal Standard	Lancashire one of Holtzapffel's	Warrington or Ryland's	Whitworth's English Standard	Needle Wire	Music Wire
0000000	.500	....	....	.500	....	.500	....	....	....
000000	.468+	....	....	.464	....	.468+	....	....	....
00000	.437+	....	....	.432	....	.437+	....	....	....
0000	.406+	.460	.454	.400	....	.406+	....	....	....
000	.375	.409+	.425	.372	....	.375	....	....	....
00	.343+	.364+	.380	.348	....	.343+	....	....	....
0	.312+	.324+	.340	.324	....	.326	....	....	....
1	.281+	.289+	.300	.300	.227	.300	.001	.045	....
2	.265+	.257+	.284	.276	.219	.274	.002	.042	....
3	.250	.229+	.259	.252	.209	.250	.003	.035	....
4	.234+	.204+	.238	.232	.204	.229	.004	.032	....
5	.218+	.181+	.220	.212	.201	.209	.005	.028	....
6	.203+	.162+	.203	.192	.198	.191	.006	.025	.018
7	.187+	.144+	.180	.176	.195	.174	.007	.022	.019
8	.171+	.128+	.165	.160	.192	.159	.008	.020	.020
9	.156+	.114+	.148	.144	.191	.146	.009	.018	.021
10	.140+	.101+	.134	.128	.190	.133	.010	.016	.022
11	.125	.090+	.120	.116	.189	.117	.011	.014	.023
12	.109+	.080+	.109	.104	.185	.100	.012	.013	.025
13	.093+	.071+	.095	.092	.180	.090	.013	.012	.026+
14	.078+	.064+	.083	.080	.177	.079	.014	.010	.028
15	.080+	.057+	.072	.072	.175	.069	.015	.009	.030
16	.062+	.050+	.065	.064	.174	.062+	.016	.008	.032
17	.056+	.045+	.058	.056	.169	.053	.017	.007	.033+
18	.050	.040+	.049	.048	.167	.047	.018	.005	.035
19	.043+	.035+	.042	.040	.164	.041	.019	.004	.038
20	.037+	.031+	.035	.036	.160	.036	.020	.003	.042
21	.034+	.028+	.032	.032	.157	.031+	.021	.002	....
22	.031+	.025+	.028	.028	.152	.028	.022	.001	....
23	.028+	.022+	.025	.024	.150	....	.023	....	....
24	.025	.020+	.022	.022	.148	....	.024	....	....
25	.021+	.017+	.020	.020	.146	....	.025	....	....
26	.018+	.015+	.018	.018	.143	....	.026	....	....
27	.017+	.014+	.016	.016+	.141	....	.027	....	....
28	.015+	.012+	.014	.014+	.138	....	.028	....	....
29	.014+	.011+	.013	.013+	.134	....	.029	....	....
30	.012+	.010+	.012	.012+	.125	....	.030	....	....
31	.010+	.008+	.010	.011+	.118	....	.031	....	....
32	.010	.007+	.009	.010+	.115	....	.032	....	....
33	.009+	.007	.008	.010	.111	....	.033	....	....
34	.008+	.006+	.007	.009+	.109	....	.034	....	....
35	.007+	.005+	.005	.008+	.107	....	.035	....	....
36	.007	.005	.004	.007+	.105	....	.036	....	....
37	.006+	.004+	....	.006+	.102	....	.037	....	....
38	.006	.003+	....	.006	.100	....	.038	....	....
39	.005+	.003+	....	.005+	.098	....	.039	....	....
40	.005	.003+	....	.005	.096	....	.040	....	....
41	.004+	....	....	.004+	.095	....	.041	....	....
42	.004	....	....	.004	.091	....	.042	....	....

Note: The above represent decimal fractional parts of an inch.

TABLE OF ALLOYS

Name	Approximate Percentage Composition by Weight					Uses and Remarks
	Copper	Tin	Zinc	Lead	Other Metals	
Gun Metal	91	9	..	..	....	Ordnance, Bearings, Castings
Bell Metal	75	25	..	..	....	Bells, Gongs; Rather Brittle
Bronze Coin	95	4	1	..	....	Coins, Medals
Phosphor Bronze	92½	7	..	..	½ Phosphorus	Strong Castings, Heavy Bearings
Manganese Bronze	89	10	..	..	1 Manganese	Propeller Blades, Pumps; It is very strong and Non-corrosive
Aluminum Bronze	90	..	..	..	10 Aluminum	Very High Tensile Strength
Composition Metal	88	10	2	..	....	Also called Best Valve Metal
Valve Metal	83	2	15	..	....	Cheaper Valves, Cocks, Etc.
Heavy Bearing Metal	77	8	..	15	Trace of Phosphorus	For Heavy Bearings
Original Babbitt's Metal	3	89	..	..	8 Antimony	For High Speed Bearings
Babbitt Metal	..	..	..	80	20 Antimony	For Repair Work on Bearings
Common Brass	66⅔	..	33⅓	..	....	Sheets, Wire, Tubes, Pipe Fittings, Etc.
Muntz Metal	60	..	40	..	....	Bolts, Nuts, Etc.; Malleable at Red Heat.
Delta Metal	56	..	42	..	2 Iron	Strong Sheets, Etc.
Soft Brazing Metal	50	12½	37½	..	....	Has Low Melting Point
Medium Brazing Metal	50	..	50	.	....	For Copper Work
Hard Brazing Metal	75	..	25	..	....	Very Strong
German Silver	60	..	20	.	20 Nickel	Ornaments, Resistance Wire
Fusible Plug	..	10	..	86	4 Bismuth	For Safety Valves, Etc.
Common Solder	..	50	..	50	....	
Fine Solder	..	66⅔	..	33⅓	....	
Pewter	..	80	..	18	2 Antimony	Plates, Mugs, Etc.
Britannia Metal	..	90	..	..	10 Antimony	Tableware, Etc.
Type Metal	..	..	..	80	20 Antimony	Type, Etc.
Regulus Metal	..	..	..	88	12 Antimony	Acid Cocks, Valves, Etc.

GOVERNMENT OR TREASURY WHITEWASH

What is known as "Government" or "Treasury whitewash," because the formula was sent out by the Lighthouse Board of the United States Treasury Department, is considered the best that can be made. To make it, slake ½ bushel of unslaked lime with boiling water, and cover it to keep in the steam. Strain the liquid through a fine sieve, and then add to it 1 peck of common salt, previously well dissolved in warm water; 3 pounds of ground rice boiled to a thin paste and stirred in boiling hot; ½ pound Spanish whiting, and 1 pound of clean glue which has also been previously dissolved. Then add to this mixture 5 gallons of hot water. Stir well, and let it stand covered for a few days. Then heat to a boiling point and apply. "It should be applied hot, as this is essential to success." Do not allow the mixture to get lukewarm or cold. It can be kept hot by using a small pail suspended in a large pail of hot water. For neat work, brushes somewhat small should be used, and the whitewash should be applied in thin coats. A pint of the mixture if applied hot will cover about one square yard of surface. This preparation has been found to answer as well as oil paint for wood, brick, or stone, and is much cheaper. It retains its brilliancy for many years, and is equally desirable for inside or outside work. Any color may be added to the mixture except green, which causes the whitewash to flake off. Spanish brown stirred in makes a rose pink, and finely pulverized common clay mixed with Spanish brown makes a reddish stone color. The darkness of the shades is determined by the amount of color used.

"POWER EQUIVALENTS"

One horsepower is equal to:

1,980,000	foot-pounds per hour.
33,000	foot-pounds per minute.
550	foot-pounds per second.
273,740	kilogramme-metres per hour.
4,562.3	kilogramme-metres per minute.
76.04	kilogramme-metres per second.
2,552	British thermal units per hour.
42.53	British thermal units per minute.
0.709	British thermal unit per second.
0.746	kilowatt.
746	watts.

One kilowatt is equal to:

2,654,400	foot-pounds per hour.
44,239	foot-pounds per minute.
737.3	foot-pounds per second.
366,970	kilogramme-metres per hour.
6,116.2	kilogramme-metres per minute.
101.94	kilogramme-metres per second.
3,438.4	British thermal units per hour.
57.30	British thermal units per minute.
0.955	British thermal unit per second.
1,000	watts.
1.34	horsepower.

One watt is equal to:

2,654.4	foot-pounds per hour.
44.239	foot-pounds per minute.
0.737	foot-pound per second.
366.97	kilogramme-metres per hour.
6.12	kilogramme-metres per minute.
0.102	kilogramme-metre per second.
3.4384	British thermal units per hour.
0.0573	British thermal unit per minute.
0.000955	British thermal unit per second.
0.001	kilowatt.
0.0013406	horsepower.

One foot-pound is equal to:

0.0000003767	kilowatt per hour.
0.0000226	kilowatt per minute.
0.001356	kilowatt per second.
0.000000506	horsepower per hour.
0.0000303	horsepower per minute.
0.001818	horsepower per second.
0.0003767	watt per hour.
0.0226	watt per minute.
1.356	watt per second.

One foot-pound is equal to:

1.3825	kilogramme-metres.
0.001288	British thermal unit.

When estimating water power at 75 per cent. efficiency, a flow of 705 cubic feet of water per minute equals 1 horsepower for each 1 foot fall.

HYDRAULIC EQUIVALENTS

One cubic foot of water	=	7.480	U. S. gallons.
One cubic foot of water	=	1,728	cubic inches.
One cubic foot of water	=	6.232	imperial gallons.
One cubic foot of sea water	=	64	pounds.
One cubic foot of water	=	62.42	pounds.
One cylindrical foot of water	=	48.96	pounds.
One United States gallon	=	8.345	pounds.
One United States gallon	=	231	cubic inches.
One United States gallon	=	0.83	imperial gallon.
One United States gallon	=	3.8	litres of water.
One imperial gallon	=	277.3	cubic inches.
One imperial gallon	=	0.16	cubic foot.
One gallon crude petroleum	=	6.5	pounds.
One gallon refined petroleum	=	6.5	pounds.

MENSURATION

Circumference of a circle = diameter × 3.1416.

Circumference of a circle × .31831 = diameter.

Diameter of a circle = circumference × .31831.

Diameter of a circle × 3.1416 = circumference.

Diameter of a circle ×.8862 = side of an equal square.

Diameter of a circle ×.7071 = side of an inscribed square.

Area of a circle = square of radius × 3.1416.

Area of a triangle = base × half of altitude.

Area of a square = base × height.

Area of a trapezium = half the sum of two parallel sides × height.

Area of a parabola = base × height × .6666.

Area of an ellipse = long axis × short axis × 0.7854.

Area of a parallelogram = base × height.

Area of sector of circle = length of arc × one-half of radius.

Square of diameter × .7854 = area of circle.

Square root of an area × 1.12837 = diameter of equal circle.

Side of a square × 1.12837 = diameter of equal circle.

Contents of cylinder = area of end × length.

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