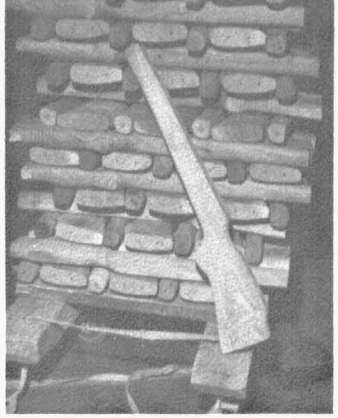
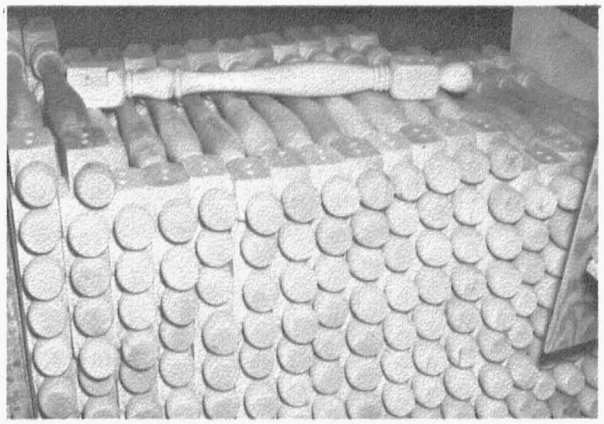
A Survey of

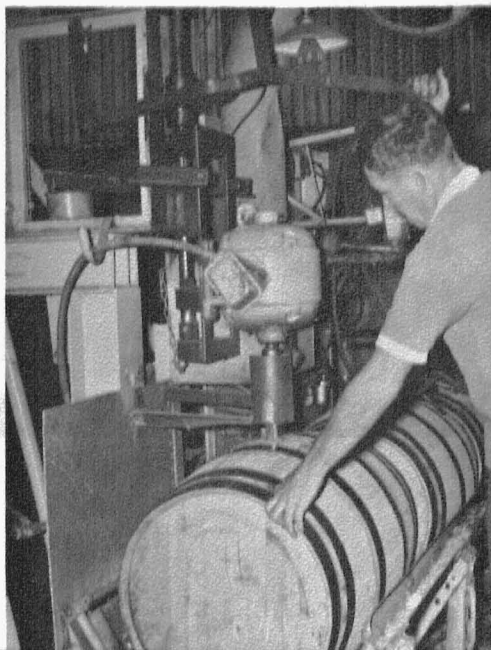
Wood-Using Industries

of Missouri

E. A. McGinnes, Jr.







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Contents

ACKNOWLEDGEMENTS

The following Missouri businesses gave permission for the photographs, taken mostly by Andrew Tau, University Photographer.

Cooperage—Independent Stave Company, Lebanon
Dimension Stock—Himmelberger-Harrison Company, Morehouse
Flooring—Ozark Oak Flooring Company, Bismarck
Furniture and Millwork—Cloud Oak Flooring Company, Springfield
Gunstock—E. C. Bishop and Sons, Warsaw
Handlestock—I. X. L. Handle Company, Bernie and Jackson
Novelty—J. B. Deere Company, Lake Ozark
Post, Pole and Piling—T. J. Moss Tie Company, Winona Plant, Winona
Sawmill (including cross-tie)—Cloud Oak Flooring Company, Vienna mill, Vienna
T. J. Moss Tie Company, Winona plant, Winona
Miscellaneous—Huebert Fiberboard, Inc., Boonville

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Missouri One-Third Forest

Approximately one-third of Missouri's 45 million acres are covered with commercial forests. The bulk of this timber resource is located south of the Missouri river in the Ozark mountains. The majority of Missouri's forests are of hardwood species, and the oak species predominate.

Objective of this study was to gather background information to guide research and extension teaching programs that will help our Missouri manufacturers make the best use of these timber resources in their competition with other states. The bulletin describes some of the many products that are made from wood in Missouri. They have been divided into 12 classifications. Each category is discussed separately but statistics for all operations are included in an Appendix to facilitate comparison of the figures.

From the summary of statistics it can be seen that Missouri's wood-using industries are contributing measurably to the economic stability and growth of our state. It is estimated that 11,343 people are currently employed full-time in the various wood-using industries. This represents an annual payroll of $25,657,000. The gross product value to the manufacturer is estimated at $94,860,000. It takes 522,000,000 board feet of lumber a year to keep these industries operating.

These figures reflect only the importance of industries involved directly in the manufacture of products from wood; they do not include various related industries such as retail lumber yards. Neither are industries frequently associated with wood-using industries incorporated in this presentation. For example, wood preservation industries, manufacturers of paper products, builders of prefabricated homes, and industries engaged in manufacture of paints, varnishes, wood finishes, or wood adhesives have not been included. Some of these are vitally important in a service capacity to the wood-using industries and are excluded only because this discussion has been limited to industries directly engaged in the manufacture of products from Missouri's forests. Most lumber and plywood consumed by businesses engaged in home construction does not come from Missouri's forests.

Mostly Small Businesses

One statistic from which some problems of Missouri's wood-using industries can be inferred is that 1108 out of an estimated 1362 firms employ only ten people or less. One problem associated with such small-scale businesses is the constant struggle to keep abreast of technological and marketing developments. If our wood-using industries are to maintain or improve their status in the state's economy during the expected rapid economic growth in the 1960s, research in wood technology and marketing techniques that will aid the small business man is needed.

What Bulletin Covers

A brief description of each of the 12 selected industries and its contribution to the economy of the state is given. This is followed by a section dealing with production and marketing techinques. Photographs of important stages of production supplement text descriptions. This approach enables more thorough coverage of the manufacture of a given product than verbal description alone. All statistics presented are averages obtained over the period from May, 1960, to September, 1963.

Various problems of the wood-using industries as a whole are discussed. Many industries have similar production and marketing problems. Attention is focused on a particular industry faced with problems of a more or less unique nature.

The problem analysis is followed by a selected bibliography and an appendix presenting tabulated statistics for all industry classes.

Charcoal Industry

Description and Contribution

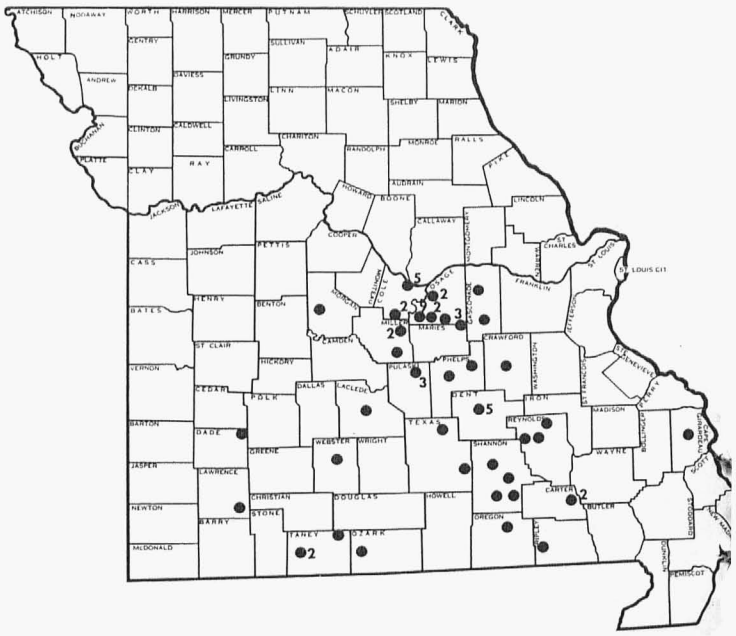
The wood charcoal industry includes both manufacturers of charcoal in bulk or natural lump form and charcoal briquetting operations. Everyone is familiar with the natural lump charcoal and charcoal briquettes packaged in convenient five to 25 pound bags for use in outdoor barbecuing.

The locations of charcoal producers and charcoal briquette manufacturers are shown in Figure 1. The charcoal industry is concentrated mainly in the south and south-central part of the state around a line from Jefferson City southeast to the Arkansas border. This region is heavily forested with oak and hickory, the two preferred species for charcoal manufacture. Charcoal production in Missouri has been significant since the early part of the last century. It first assumed importance with the advent of Missouri's iron industry which was established around Ironton about 1815. Based on 1961 statistics, Missouri accounts for aproximately 20 percent of the national production of charcoal. About 55 million board feet[1] of wood are processed annually. This industry also makes a unique contribution in that the manufacture of charcoal lends itself to the use of low-quality hardwood species which have no other economic use except for fuelwood at present. Charcoal can also be made from logging residue and thinnings as well as from sawmill and flooring mill residue. These conditions provide not only for the removal of otherwise unmerchantable material from the forest land to make way for more productive species but also furnish a source of revenue from residue from other wood-using industries.

There are 64 charcoal or charcoal briquetting operations within the state. These operations employ about 620 people whose total earnings average $1,757,000 annually. The charcoal industry represents a $4,800,000 business expressed as gross to the manufacturers. Charcoal production in Missouri has tripled since 1956. The expected increase in outdoor barbecuing and continuing research to find additional commercial uses of charcoal and charcoal briquettes should allow the charcoal industry to continue as an important wood-using industry.

All wood used in charcoal manufacture in Missouri comes from within the state. Farmers and other producers are paid from $11.60 to $18.80 for their wood on a 1000 board-foot basis.

Fig. 1—Location of charcoal manufacturers.



[1]Throughout this article the term board feet (a piece of wood 12" long, 12" wide, and 1" thick) has been used to describe the quantity of wood processed by each industry type for comparative purposes.

Production and Marketing

Results of studies on the production and marketing of charcoal in Missouri have been reported by Jarvis (see bibliography). Jarvis' article contains a reference list of 62 publications as well as plans for the construction of a kiln suited to Missouri's wood charcoal industry.

The following information on charcoal production was taken directly from Jarvis' publication: "Wood charcoal is made by the partial burning of wood under a reduced atmosphere of oxygen. Should all the oxygen (air is approximately 21 percent oxygen and 79 percent nitrogen by volume, plus moisture that may be present) be allowed in contact with the wood that it could consume, the wood would be reduced to ashes as is the wood in a fireplace or open campfire. By skillfully regulating the air going into a kiln, a high percentage of carbon or charcoal can be formed.

"Once a temperature of 400-500 degrees F. is reached, carbonization may proceed without further burning of the wood. At this temperature the liquors begin to cook out of the wood and an exothermic (or heat generating) process is initiated. The release of liquors, or the chemical reaction which produces these liquors from the wood, generates heat, a limited process of wood burning itself.

"After the carbonization has been completed, the kiln is completely sealed (as a kitchen pressure cooker is completely sealed during cooking). The fire is then smothered and allowed to cool down to near ambient temperature before the charcoal can be removed from the kiln. The cooling time normally takes two weeks or less.

"The charcoal may then be taken to a briquetting plant or bagged for sale as lump charcoal."

During the process of charcoal manufacture roughly three-fourths of the weight and one-half the volume of original wood is lost. Bulk lump charcoal ranges in weight from about six to 12 pounds per cubic foot. As charcoal is sold on a weight basis, it is desirable to use the more dense woods for charcoal manufacture. Fortunately, the two species most used in Missouri for charcoal manufacture, oak and hickory, are quite dense and also yield a premium product.

Most of Missouri charcoal is sold to briquetting plants within the state for further processing and subsequent distribution throughout the United States. It is assumed, based on marketing studies of charcoal briquettes, that the bulk of charcoal manufactured in Missouri is ultimately used for indoor and outdoor cooking.

Cooperage Industry

Description and Contribution

The cooperage industry is divided into two classes: the tight and the slack cooperage operations. The primary difference between the two is the slack cooperage barrels or containers do not have the ability to hold liquids without leakage while tight cooperage containers must have this attribute.

Tight cooperage may be made from most species of soft and hard woods. Various linings, such as wax, liquid glass, and latex rubber stabilize the wood, make porous woods liquid tight, and protect the wood from corrosive contents. In Missouri, tight cooperage production is limited to manufacture of whisky barrels. White oak whisky barrels are ignited on the inside and extinguished, leaving a lining of charred wood. The char lining with the tannin of the white oak mellows and flavors whiskey stored in the barrel.

Only the heartwood of clear quarter-sawed white oak is used in the manufacture of whiskey or bourbon grade cooperage. White oaks are distinguished from red oaks, and many other hardwoods for that matter, by the abundance of gum-like deposits or growths called tyloses in the vessel segments of the heartwood portion of the

Fig. 2—Location of cooperage or cooperage component manufacturers.

Fig. 3—A load of choice white oak bolts prior to processing into barrel staves or heading. Only finest quality heartwood is chosen for tight cooperage containers.

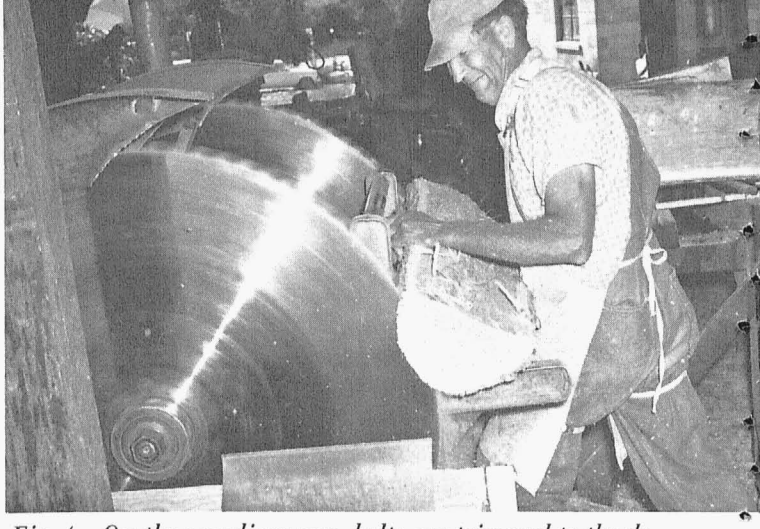


Fig. 4—On the equalizer saw, bolts are trimmed to the desired length. Finished barrel staves range in length from 33 to 37 inches, dependent upon capacity wanted.

tree. These tyloses prohibit or greatly minimize the passage of water and other liquids through the wood.

The wooden barrel is no longer the familiar item in the grocery store that it was several decades ago. A survey, in 1909, of Missouri's wood-using industries indicated that the slack cooperage industry alone consumed 196,000,000 board feet of lumber.

Although packaging containers and methods have changed drastically since that time, the cooperage industry still contributes significantly to the economy of the state. During 1963, when the industry operated at about 60 percent normal, 29 firms employed 630 people in the tight and slack segments of the cooperage industry. These people received wages of $1,757,000. The industry grosses about $8,250,000 annually.

The tight cooperage industry consumes 28,600,000 board feet of various species of white oak per year. The slack cooperage industry, on the other hand, consumes only 800,000 to 900,000 board feet of wood annually. The species used by this segment of the industry are gum, elm, hackberry, bald cypress, sycamore, and others. The cooperage industry pays farmers and other producers from $26 to $93 per thousand board feet for various types of wood. It is estimated that 95 percent of the white oak used by the tight cooperage industry is harvested in Missouri whereas about 60 percent of the wood used by the slack cooperage industry is from within the state.

Locations of the stave mills, which produce the bolts for wooden barrels as well as the barrels themselves, are shown in Figure 2.

The Missouri white oak cooperage industry has operated at approximately half normal output for the last two years. This is attributed to uncertainty of distillers caused by a proposal to change whisky labeling regulations. Current regulations require that whisky produced in the United States be labeled to show the period of storage in reused barrels. In March, 1962, three whisky distillers petitioned the United States Secretary of the Treasury to change whisky labeling regulations so that whisky stored in reused barrels would not have to be labeled differently from whisky stored in new barrels. As a result of this controversy distillers are not purchasing staves or barrels and the Missouri tight cooperage industry has suffered to the extent that many cooperage mills are currently idle.

Information is scanty as to when the cooperage industry became firmly established in Missouri; however, since the barrel is one of the oldest containers known to man, it is reasonable to assume that the cooperage industry was one of the first wood-using industries of the state.

Production and Marketing

As noted previously most of Missouri's production is tight cooperage. White oak is the preferred species for this product. Wood is procured in the form of bolts (Figure 3) that must be 40 inches in length. The length of finished staves ranges from 33 to 37 inches. The additional bolt length is required for end trimming because of seasoning checks and to square the ends.

The manufacture of tight cooperage begins at the stave mill. It is here that bolts are processed into green staves or heading (the circular barrel ends). First operation in the stave mill is to cut the bolts on an equalizer saw which trims them to the desired length (Figure 4). Bolts are then passed through the cylinder stave machine (Figure 5) to produce staves. This equipment cuts bolts into staves which have a slight curvature to correspond to the circular shape around the barrel (see Fig. 5a and 5b). If the bolt is to be used as heading it is passed through a regular circular or band saw. These pieces, of course, require no curvature. After being processed to this point, the green staves are examined for defects which would prohibit their use as either staves or heading (Figure 6).

Fig. 5a—The cylinder stave machine reduces bolts to quarter-sawed staves of specified thickness. The saw, appearing in the picture like a large steel barrel or cylinder with teeth in the end, imparts curved faces to staves as it cuts them from the bolts. In this picture a stave has just been sawn from a bolt and dropped into the center of the cylindrical saw.

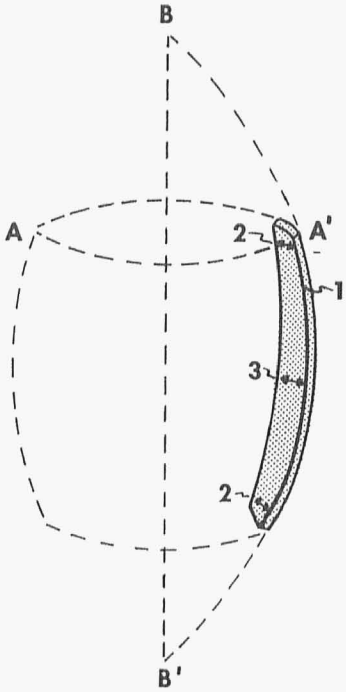


Fig. 5b—Barrels have a "double arch" construction which gives them tremendous strength against crushing. One of the arches referred to is the cylindrical shape of the barrel. (AA' plane) Staves are cut with beveled edges (1) so they will fit together to form a cylinder. The other arch is the bulge in the middle of the barrel. (BB' plane) This is provided by cutting the staves narrower at the ends (2) than in the middle (3).

Fig. 6—The first of a series of inspections of staves for the heartwood content and defects in wood or workmanship which would make them unsuitable for use is done prior to seasoning. Inspection continues at each point of manufacture to assure a high quality product.

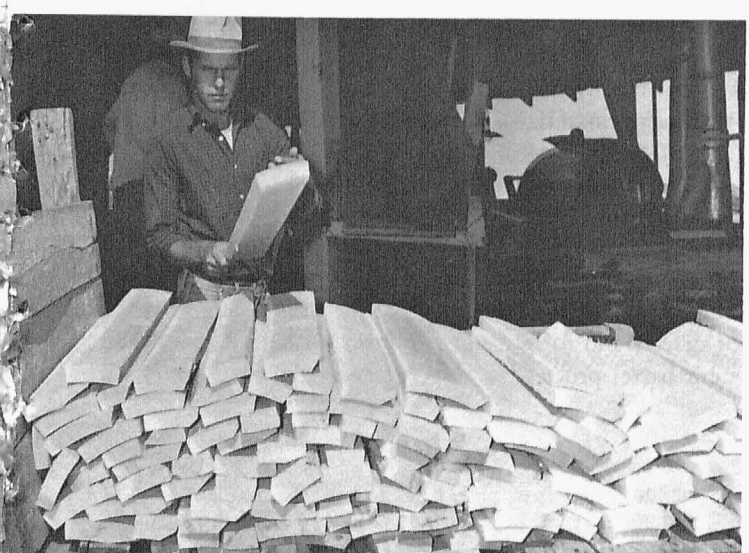


Fig. 7—After being air-seasoned and kiln-dried these neatly stacked staves await further processing. At this point of manufacture, the staves have had their moisture content reduced to about 9½ to 10 percent.

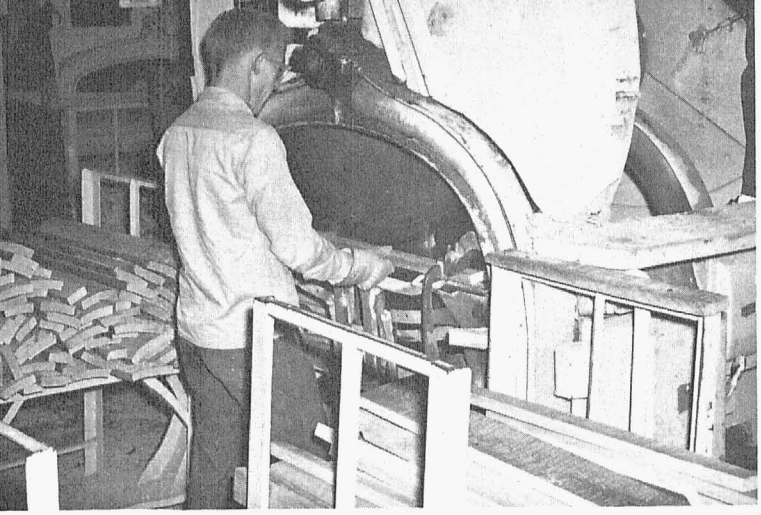


Fig. 8—A jointer in operation. This machine imparts the second curvature to staves. Here, stave width at each end is reduced and stave sides are slightly beveled.

Fig. 9—Staves placed in a special device for formation of the barrel are ready for the next assembly step, steaming and bending together to receive the end hoops.

The green barrel staves are air seasoned for a minimum period of one year. After this time they have usually reached a moisture content of from 12 to 13 percent. Staves used for heading are seasoned for the same length of time.

After yard seasoning, staves and heading may be recut on an equalizer saw to desired lengths. At this time the staves are also planed on the outer convex face. The seasoning process continues; the staves are kiln-dried, usually for about 6 days. In the kiln, moisture content is reduced to about 9.5 percent. Final equilibrium moisture content of stave and heading material is about 10 percent (Figure 7).

After thay have been kiln-dried, staves are jointed. A jointer is a tool in the general shape of a large wheel some three to five feet in diameter with blades set on the periphery. It cuts the proper ratio of width at the middle of the stave to the width at each end (Figure 5b—BB' plane). The staves are wider in the center than at the end, so that when the ends are pulled together there is a bulge in the middle. Each barrel size requires not only a certain length of staves but also a particular set of cutting tools on the jointer to give specific stave center and end thicknesses.

Quality control is essential throughout barrel manufacture. A grader inspects each stave after manufacture. Quality considerations in the inspection of staves are defects, unsound wood, and sap wood. In addition it is mandatory, in proceeding from the inside to the outside of a barrel stave, that at least three to four of the broad rays (that characterize the oaks) be bisected. It is felt that the ray structure, along with the presence of tyloses in white oak, prohibits passage of liquids.

After jointing, the next step in barrel manufacture is the assembly procedure (Figure 9). Barrel staves are segregated into various widths so that an adequate variety of widths is available from which to form a barrel. The number of staves that go into a specific barrel-type is constant. Barrel assembly is done in a jig which has a bottom metal hoop and a circular rack some 12 inches from the floor on which the barrel staves are placed. After the proper number of staves has been set in the bottom of the barrel, a wire hoop is placed over the top of the barrel and drawn tight to give the barrel its initial set and bulge.

Barrels are steamed for approximately one-half hour. This operation increases the flexibility of the staves. After steaming the wire hoop is removed and a top truss hoop is placed on the barrels.

The barrels then go through a pre-heat operation (Figure 10). It is here that they are brought to the proper temperature to insure "setting" of the curve of the stave and to expidite satisfactory charring. Each charring specification has its own preheat time and conditions.

The barrels are then charred (Figure 11). Charring ranges from light to dark as indicated by char numbers from ½ to 4. The lower the char number the lighter the whisky color; for example, char numbers ½ and 1 are used to impart the color of Scotch whisky. Char numbers 3 and 4 produce a darker colored bourbon whiskey. In addition to influencing the final color of the whiskey itself, the amount of char also determines the ratio of esters to organic acids which remain in the whiskey after aging. Although there is considerable interest in reusing whiskey barrels, data are not now available to substantiate that reused barrels may control the final ester-acid ratio of the product as closely as new barrels.

At the time the barrel is charred, an operation that is electronically controlled as to time and temperature, the heading material is also charred (Figure 12).

After they have been charred, the barrel and heading components are machined to insure proper fitting.

Next the heading is placed on the barrel and additional hoops (Figure 13) necessary to impart barrel strength are added. At this time the barrel is given a rough sanding (Figure 14) to aid in the final inspection for defects and to minimize splinter formation in subsequent barrel processing.

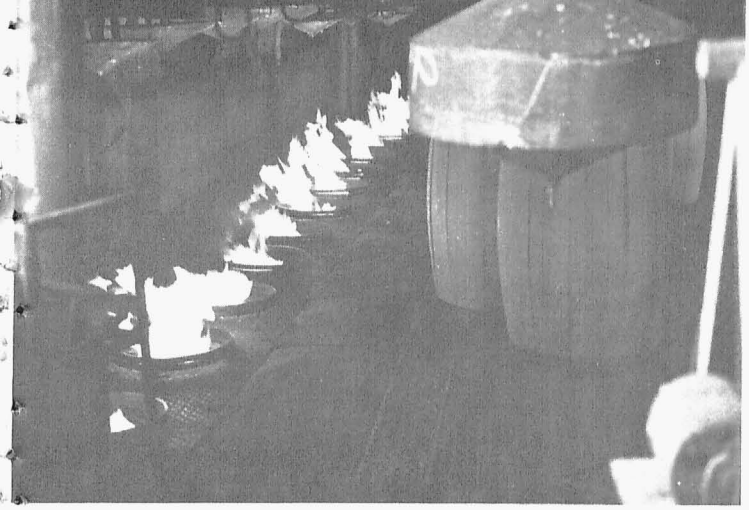


Fig. 10—Here barrels, steam-conditioned and provided with a top hoop, are pre-heated prior to the charring operation. Pre-heating fires are shown at left; barrels in place being pre-heated at right.

Fig. 11—Barrels are charred on their interior to aid in the aging of quality bourbon whisky. This operation is done automatically by specially designed gas burners to ensure rigid control of exacting production standards.

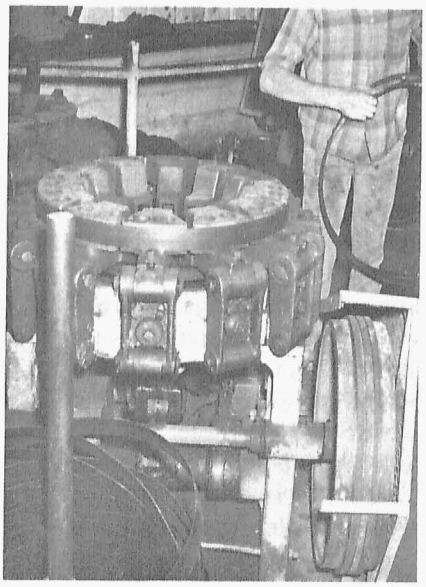


Fig 13—Most barrel hoops today are made of steel. They were originally fabricated from wood (elm the preferred species). Here a machine imparts the correct "set" to hoops providing for a snug fit on the barrel.

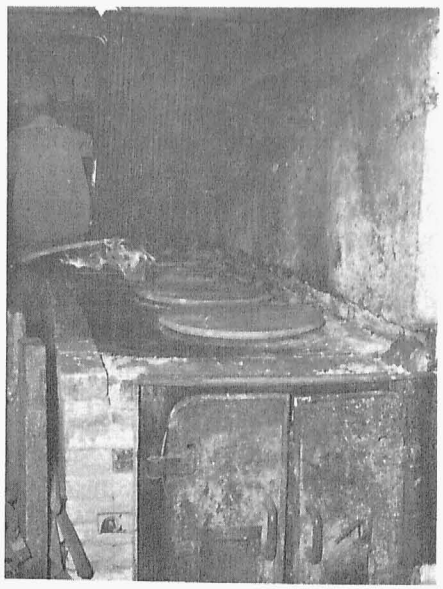
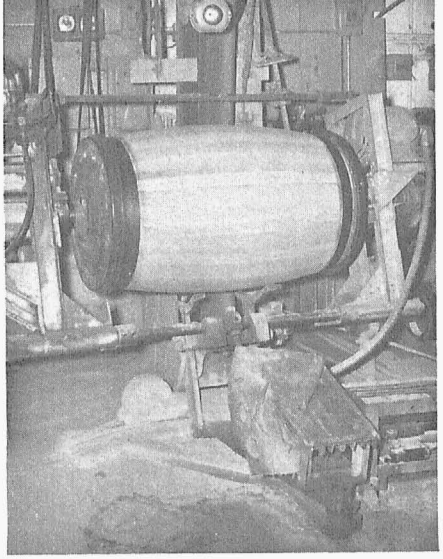


Fig. 12—Heading being charred. Workman (not in picture) is removing one piece of heading from fire; heading is now ready for assembly with charred barrel.



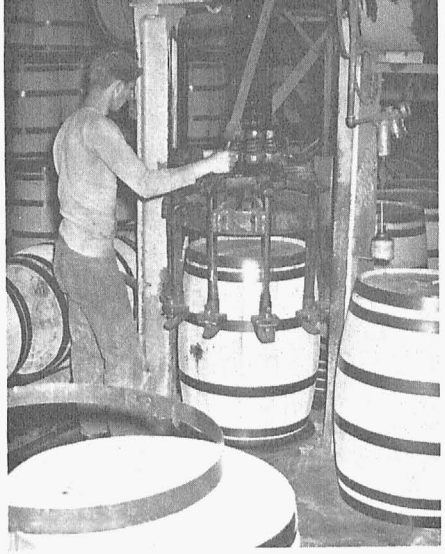


Fig. 14—After staves and heading have been assembled, the barrel is given a rough sanding treatment to facilitate another of many inspections throughout production stages.

Fig. 15—Hoops are forced into place after a "cooling-off" period following charring, barrel assembly, and initial boring of bung stave. Note wet area of wood around initial drilling of bung stave. Higly purified water had been added after drilling to aid "cooling-off" and also to dampen barrel's interior to further insure tight sealing of joints.

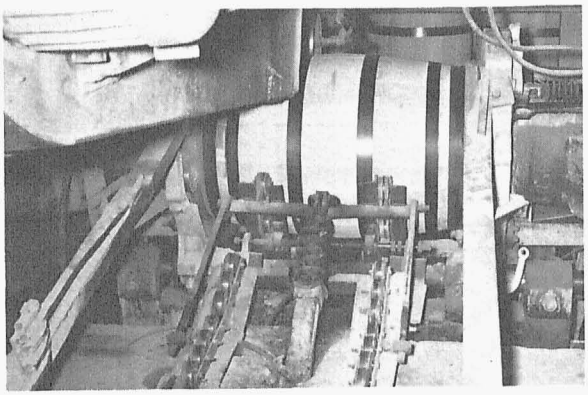


Fig. 16—One of the final operations in barrel manufacture is the reaming of the bung hole. At this time water and air are forced into the barrel to allow inspection for leaks under pressure conditions well in excess of what the barrel will encounter in service.

Fig. 17—Last operation is final sanding. Sanding of sides (pictured) is followed by a similar sanding of barrel heading and the last of many quality-control inspections. Barrel is then ready for delivery to customer.

Liquids are poured into tight cooperage through a hole in the center of the barrel known as the bunghole. Initially, the bunghole is drilled only to a diameter of some 1.5 inches. At this time approximately one gallon of water is added to the barrel to cool it after the charring operation, and also to allow moisture to enter the wood and further seal the barrel joints. The barrels are turned end-over-end two or three times to insure the wetting of the entire inner barrel surface.

After a 24-hour cooling-off, the barrel hoops are forced into place (Figure 15). The bunghole is reamed to its ultimate diameter of 2 inches (Figure 16).

A small quantity of water is added to the barrel under air pressure of 6 pounds per square inch to aid in the final detection of leaks.

After a sanding operation (Figure 17) the barrel is given its final inspection and is then ready for transport to a distiller.

The largest independent tight cooperage manufacturer in the country is located in Missouri. The statistics in this section also include numerous stave mills that sell their product to cooperage manufacturers outside of the state.

Marketing of staves is usually done on a contract basis through the efforts of stave mill manufacturers or buyers from cooperage plants. The marketing of finished cooperage is done by the one manufacturer who delivers his product directly to the customer.

Stave bolts used in slack cooperage manufacture may be sawed or sliced for staves as well as heading. To be sliced, the wood must be quite wet; in some instances it is even steamed. Heading material may be produced from rotary cut veneer as well as from sliced wood.

Hoops used in tight cooperage manufacture are invariably steel; those for slack cooperage are sometimes made out of wood. Elm is the desired species for wooden hoops.

Dimension Stock Industry

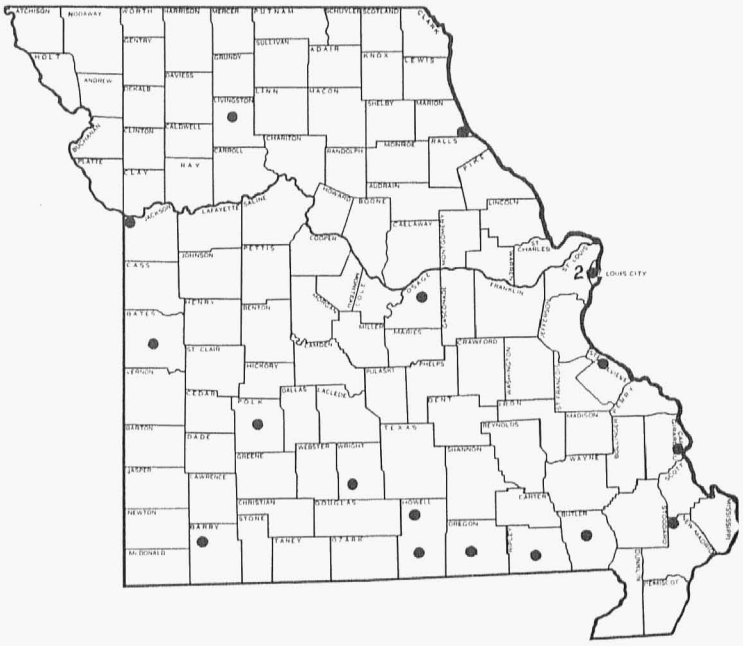


Fig. 18—Locations of manufacturers of dimension stock and related items.

Description and Contribution

This segment of the wood-using industry deals primarily with the fabrication of small clear pieces of lumber from either hardwood[2] or softwood species, to be used for the further manufacture of a variety of products. Examples of the latter are the familiar turnings used for furniture legs, drawer components for desks, table tops and leaves made by gluing together several narrow strips of wood of the same or dissimilar species. The species of wood used for this are almost as numerous as the number of final products made. Southern yellow pine, red and white oaks, gum, hickory, cedar, cherry, walnut, sycamore, soft maple, and mahogany are some of those on the list of preferred species for Missouri manufacturers.

Eighteen of the wood-using operations are classed as dimension stock manufacturers. They employ approximately 440 full-time employees with an annual payroll of $1,130,000. The total consumption of the numerous wood species numerated above is estimated at 16,800,000 feet annually. The gross earnings of the industry are estimated at $4,650,000.

Sixty percent of the wood consumed comes from Kentucky, Illinois, Tennessee, and Arkansas; the remainder is grown in Missouri. Prices paid for raw material by the manufacturer of dimension stock items range from $40 to $250 per thousand board feet of lumber.

Location of these industries, based on the period 1960-1963, is shown in Figure 18. Perhaps no single segment of the wood-using industries has needed to keep pace more with the latest technological developments in order to remain competitive than dimension stock manufacturers. This is one industry where competition from materials other than wood has made substantial inroads in recent years. A dimension stock manufacturer is keenly aware of the necessity to make his product compatible with materials other than wood in both the fabrication and finishing of a final product.

The dimension stock industry is an intermediate one in the sense that usually no final product is made; but instead, rough lumber is fabricated into a few basic forms and sizes inherently adaptable for processing into a wide range of finished products. This system enables subsequent manufacturers to avoid the expenses and problems involved in obtaining a quality starting material. Furniture manufacturers and other producers both within Missouri and elsewhere have been provided with high quality dimension stock from our state since the turn of the century by some firms in existence today.

Production and Marketing

Hardwood dimension stock manufacturing can be a complete business in itself or a side line of some larger wood producing operation. This discussion is limited to the manufacture of dimension stock as the main line of business. Dimension stock may be defined as wood turn-

[2]Hardwood species are those that have broad leaves as oaks, maple, hickory, etc., they usually shed their leaves in autumn. Softwood species are the pines, firs, spruces and other trees with narrow, needle-shaped leaves. The wood of either species may be hard or soft.

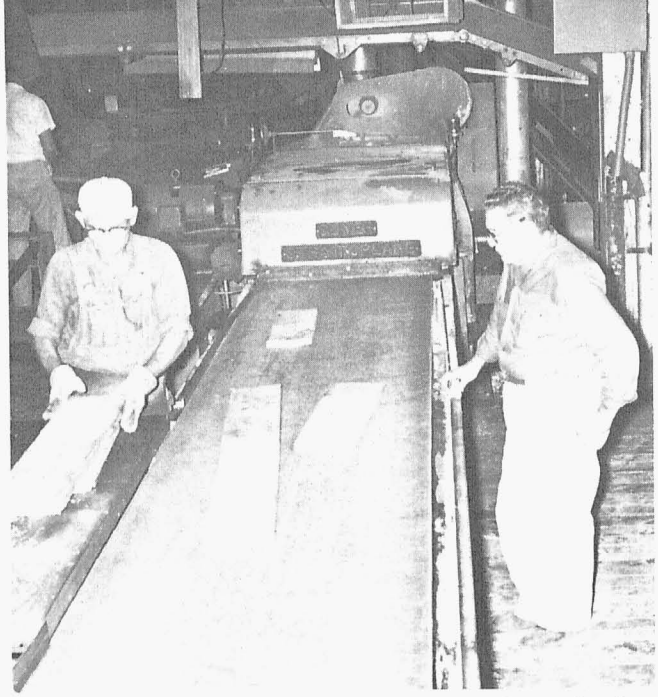


Fig. 19—Rough lumber being fed into a planer for further processing. This dimension plant uses modern conveyor systems throughout the operation for speedy, effective transfer of wood.

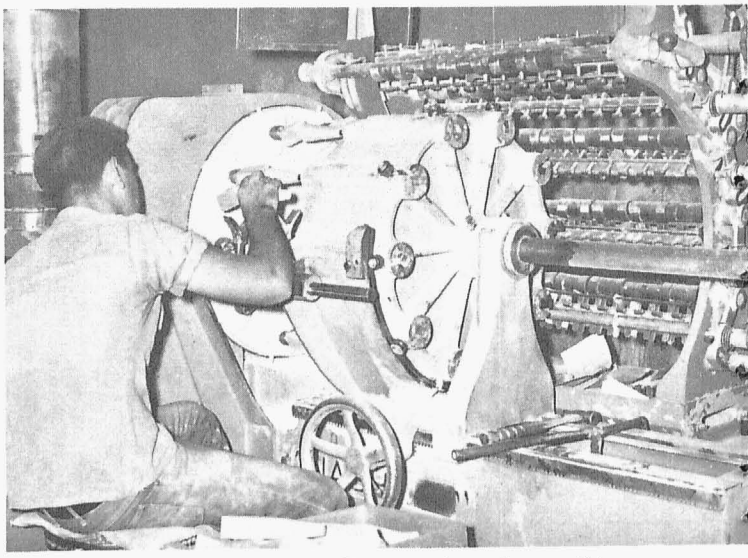


Fig. 20—This operator is sanding turnings for possible use as legs on tables or other pieces of furniture. Turnings and squares comprise the bulk of dimension stock items.

ings, squares, or other parts used in the subsequent manufacture of a finished product such as furniture, handles, tools, and numerous other items by wood working operations. Although softwood dimension stock is also manufactured, the bulk of the business in Missouri centers on hardwood species.

Rough lumber may be purchased by the manufacturer or he may have his own sawmill and process logs himself. In any event, after the manufacture of the lumber, the first operation is grading and subsequent air-seasoning. This is followed by kiln-drying to bring the wood down to a moisture content of from 6 to 12 percent, depending upon requirements of the final wood product.

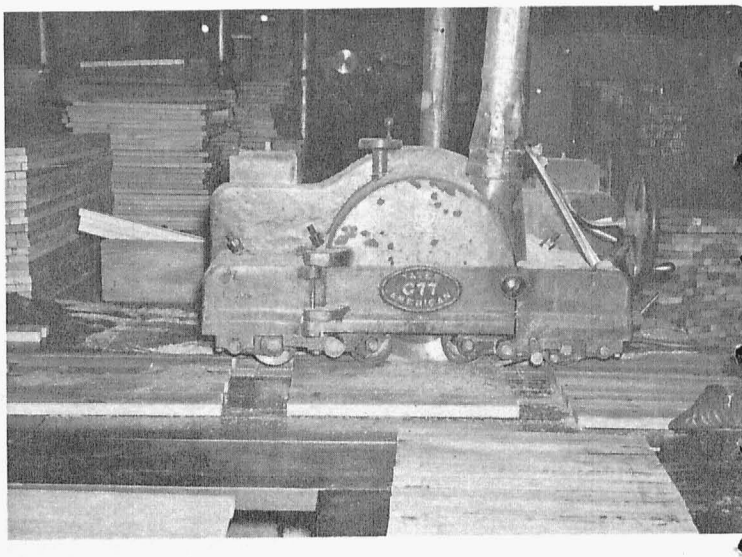
Sequence of manufacture after kiln-drying may follow several courses. The following steps are those employed by one of our larger Missouri manufacturers. The wood is planed (Figure 19) on both surfaces to remove warp, if present, and to enable better visual inspection of defects, such as knots, which may have to be removed.

The term dimension stock, in addition to meaning material of specific sizes, implies all clear, partially clear, or sound material, depending on the purpose for which the item is to be used and its location in certain pieces of furniture. Stock cut for turnings (Figure 20) is usually clear; whereas dimension stock for such items as table tops, dresser tops and drawer fronts are usually specified "clear-one-face."

The fabrication of wood into blanks for turning such items as furniture legs usually involves face-gluing thin pieces of lumber. These pieces have previously been rip-sawed to desired width. In some instances, processing is carried through the finishing operation (Figure 21) and hardware is installed.

The manufacture of wood into panels, or squares, follows a slightly different procedure than that used for turnings or turning blanks. After it is planed, the lumber is edge-surfaced either on a jointer or rip saw to remove defects and prepare edges for bonding. One of the larger plants employs high frequency gluing to perform this operation (Figure 22). High frequency bonding permits

Fig. 23—Minutes after passing through a high-frequency bonding machine, panels are trimmed to desired width, or perhaps reduced to several panels of smaller width, on a rip-saw.



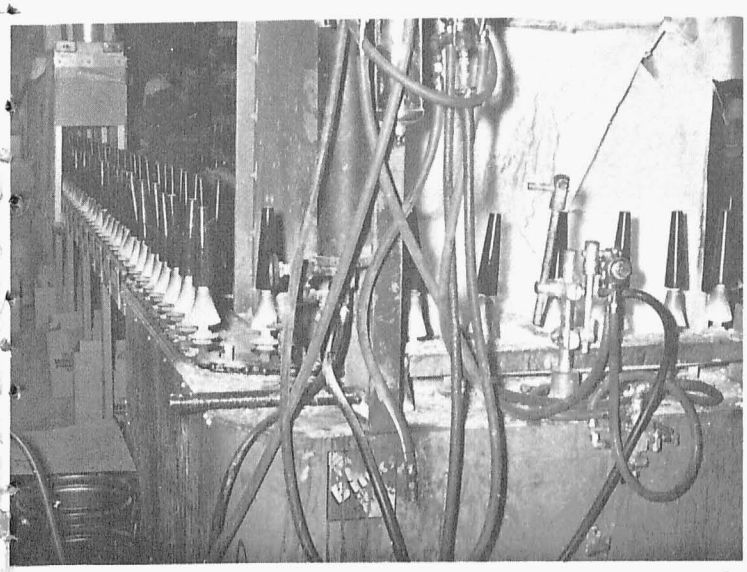


Fig. 21—Some dimension plants process turnings into the final item, including application of finish and hardware. Here a machine automatically applies the final lacquer coat to table legs.

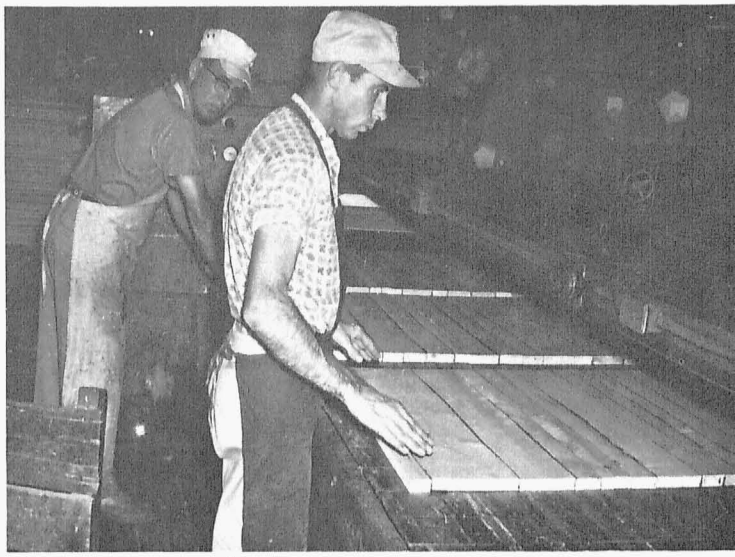


Fig. 22—Here a workman "lays-up" pieces of freshly glued wood to form a panel. The panel will then be fed into a high-frequency glue machine which cures the adhesive in a fraction of a minute.

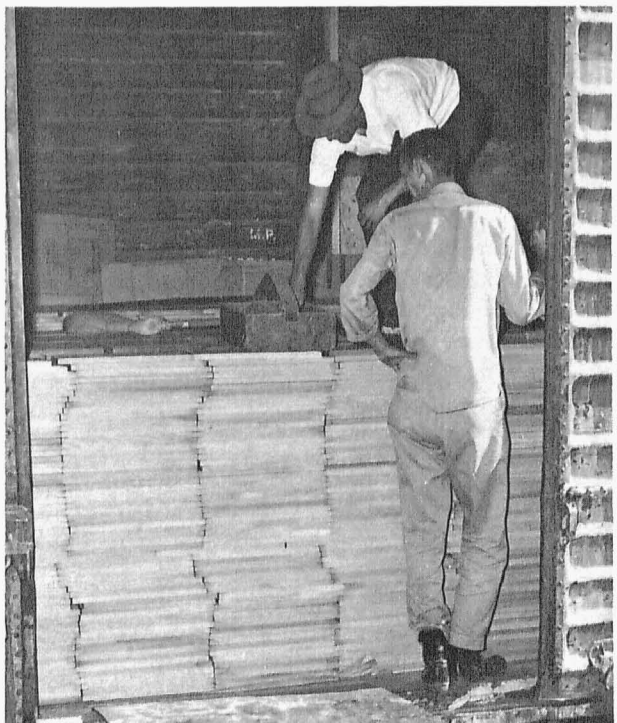
the bonding and curing of wood adhesives in minutes as opposed to hours or days for older, more conventional types of gluing. After assembly, either as a square or block, the wood may again be cross-cut or ripped into specified widths and lengths (Figure 23) prior to planing on all four surfaces and subsequent packaging and pallatizing for shipment.

Finished packaged and pallatized material may be stored in a warehouse (Figure 24) or shipped (Figure 25) directly to waiting customers. The larger factories have their own sales organizations while some small ones rely only on orders from specific industries, such as furniture factories which usually maintain liaison with dimension plants.

Most of the dimension stock manufactured in Missouri is consumed within the state by furniture and allied industries. Some is shipped to other places, primarily in the central and eastern United States.

Fig. 24—Stacks of various shaped panels and squares palletized and ready for shipment to furniture manufacturers and other customers.

Fig. 25—Finished squares, or panels, are loaded into a freight car for delivery to a furniture manufacturer who will make the final product.



Flooring Industry

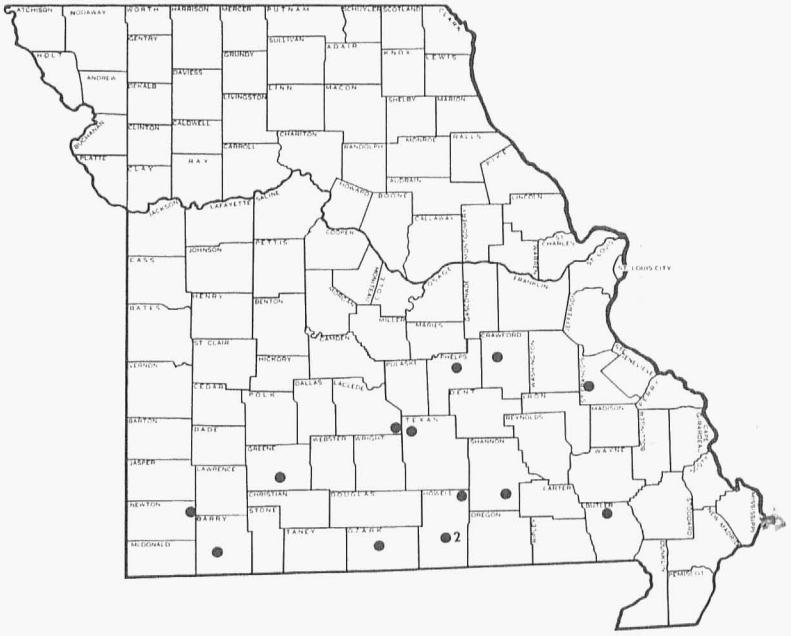


Fig. 26—Locations of hardwood flooring manufacturers.

Description and Contribution

This classification is concerned primarily with Missouri producers who manufacture hardwood flooring from our native red and white oak species. There are, however, several small mills which manufacture both hardwood and softwood flooring. The red and white oak segment of the flooring industry uses approximately 83,500,000 board feet of lumber annually. The softwood flooring industry consumes only 500,000 board feet of shortleaf pine over the same time period. The flooring industry is represented by relatively large firms. Several are integrated in the sense that they produce other products as well as flooring. Information in this bulletin is primarily about firms engaged only in flooring manufacture.

The hardwood flooring industry is often referred to as the backbone of Missouri's secondary[3] wood-using industries.

The hardwood flooring industry assumed prominence in the state of Missouri just prior to or immediately after World War I. The oldest existing operation started production in 1927. The locations of the various hardwood and softwood flooring manufacturers are shown in Figure 26. Most are located in the eastern Ozark region and in the southwestern part of the state. In this area the mills are able to draw on an ample supply of both Missouri and Arkansas oak lumber. Approximately 75 percent of the wood used is Missouri grown.

[3]Secondary wood-using industries are usually defined as those starting with partially processed wood and turning out a finished product. Primary wood-using industries either manufacture rough lumber or process such products as charcoal, posts and poles, which do not involve numerous operating steps. Unfortunately, these definitions are not completely adequate in defining some specific categories and operations.

It is not surprising that the hardwood flooring industry comprises a major wood-using industry of our state. A large percentage of Missouri's forests is composed of red and white oak species, woods in strong demand for flooring because of their excellent wearing qualities and image of warmth and beauty.

In recent years, the hardwood flooring business has suffered from competition with other products for floor covering. Among the competing products are the various forms of asphalt, vinyl, and other plastic tile coverings, which can be laid not only over a wood sub-floor but also over concrete. Since World War II, the increasing popularity of the split-level home design has resulted in partially or completely finished basements, usually with a concrete floor. This means, in essence, that one floor in the typical home has been lost to the hardwood flooring industry, for a concrete sub-floor lends itself to plastic and other tile squares for either the "do-it-yourselfer" or the home builder.

It is estimated that there are nine different operations comprising 14 mills employing approximately 630 people in the flooring industry of Missouri. These people earn $2,050,000 annually. The gross value to the manufacturer is estimated at $7,600,000 annually. Missouri's hardwood flooring industry has been aggressive in adapting new processing and merchandising techniques as well as new types of wood floor covering. One of our larger manufacturers has recently started production of small, flexible squares of oak flooring made up of thin strips of wood stapled together. These squares may be laid over concrete as easily as tile and similar floor coverings and at competitive prices.

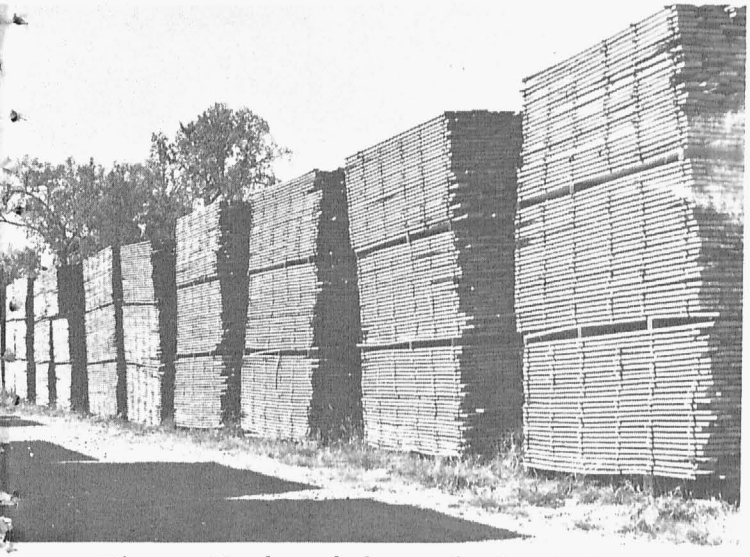


Fig. 27—Neatly stacked rows of red and white oak lumber being air-seasoned on the yard of a flooring manufacturer. Tremendous quantities of oak are processed annually by flooring plants in Missouri.

Fig. 28—A load of air-seasoned oak ready for kiln-drying to assure the proper amount of moisture to be retained in the wood for most efficient service as flooring.

Production and Marketing

The first step in the production of hardwood flooring is seasoning, which usually means air seasoning for four months (Figure 27), followed by kiln drying (Figure 28) for three to five days to a final moisture content of six to nine percent. However, green lumber may go direct to the kiln where it takes from three to four weeks to bring it down to proper moisture content. Following kiln drying, in many instances, selection is made of some of the better lumber for manufacture of other, more profitable products such as molding, stair treads, and special millwork items (Figure 29).

First step in the manufacture of flooring is "ripping to width" with a battery of gang ripsaws (Fig. 30). A 3-inch width is standard for conventional-sized flooring. This step is followed by the use of a battery of knotter saws (Figure 31) where the length of a board may be reduced to nine-inch minimum. Following the knotter saw operation, material goes through the "side" (Figure 32) and then the "end" (Figures 33, 34) matchers. A side matcher surfaces the lumber top and bottom, grooves one side and forms a tongue on the opposite side and usually imprints the mill identification (or company name) upon the wood. Lumber then proceeds to the first of two "end" matchers (one for the tongue and one for the groove). Following this, flooring is graded, stacked, and bundled for warehouse storage or immediate shipment (Figures 35-38).

Flooring opearations use considerable low grade material. The minimum acceptable length for flooring is 9 inches; this permits utilization of material which could not possibly be used in most other wood-processing in-

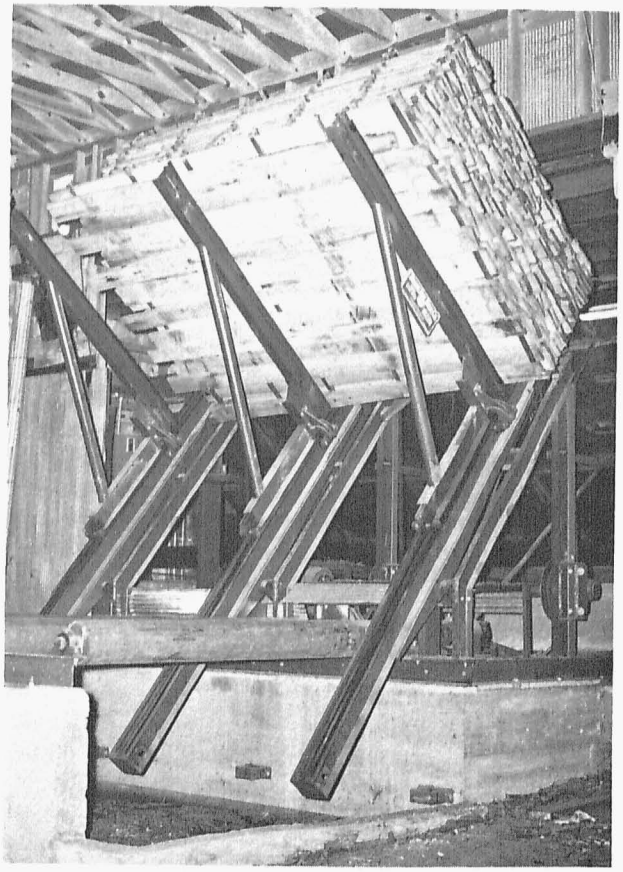


Fig. 29—Stack of kiln-dried oak on a device which automatically allows one row of lumber at a time to fall on a conveyor system for sorting and sawing to width, the start of flooring manufacture.

dustries. Material which does not meet the standard width is put to one side. When a sufficient quantity has been accumulated a narrow width (1½ inches) flooring may be produced. One plant in the state produces a square parquet flooring from strips originally rejected because of insufficient width for standard flooring.

The main market outlets for hardwood flooring manufactured in Missouri are Kansas City, St. Louis, Chicago, St. Paul, and Minneapolis. Other markets include New York, Des Moines, Los Angeles, and Seattle. Many manufacturers ship by rail and in their own trucks. Semi-tractor trailers can carry 18,000 feet or more of finished flooring. Some markets are not pursued at present by Missouri manufacturers because of unfavorable rail freight rates.

Large factories have their own sales forces, whereas, others are dependent upon outside agencies. Missouri hardwood flooring averages an estimated 75 percent number 1 common grade or better. White oak flooring brings about $10 less per thousand board feet than red oak. The price (1960-1963) for red oak flooring ranges from $134 to $155 per thousand board feet to the manufacturer.

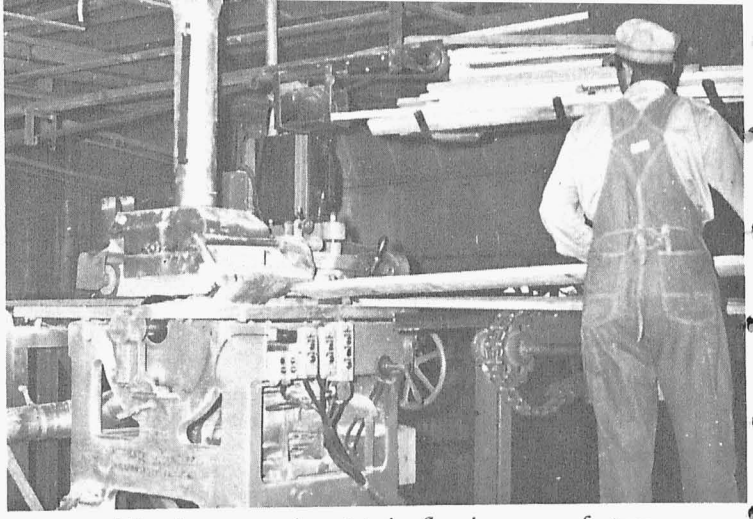


Fig. 30—The first processing step in flooring manufacture is rip-sawing the lumber to proper width. Here the operator prepares to feed rough lumber into a gang rip-saw.

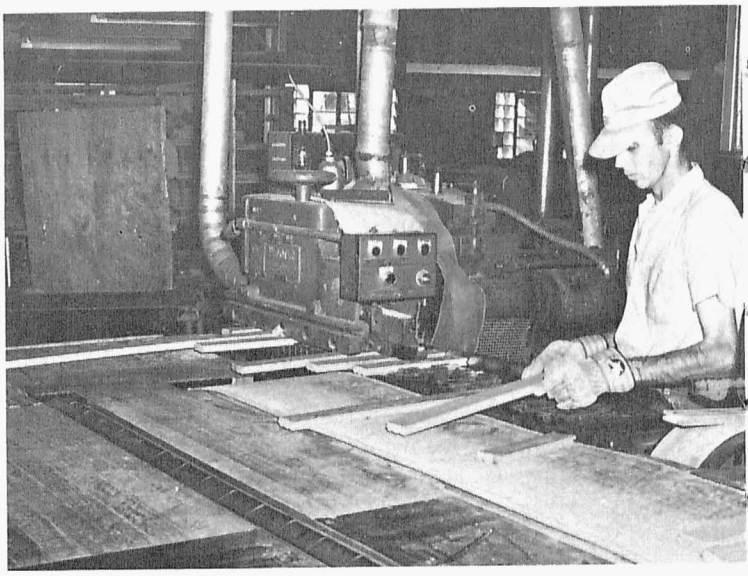


Fig. 33—Here workman is passing pieces of partially processed flooring through one of two end-matchers. These pieces have already been through the side-matcher which cut the tongue and groove pattern seen in the wood. The end-matchers perform the same operation for joining pieces lengthwise. This design enables oak floors to "stay-in-place" and maintain their excellent reputation for stability in service.

Fig. 36—An operator bands a stack of flooring for warehouse storage. Pieces of finished flooring, sorted acording to length, are shown in the background.

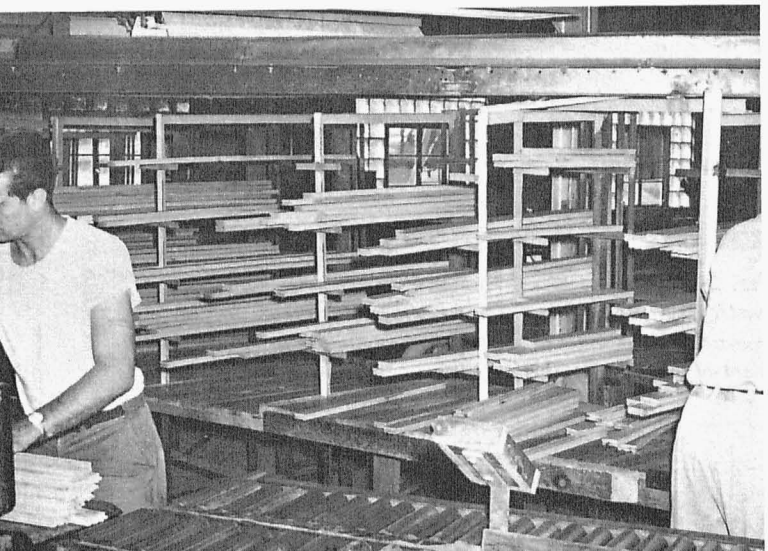
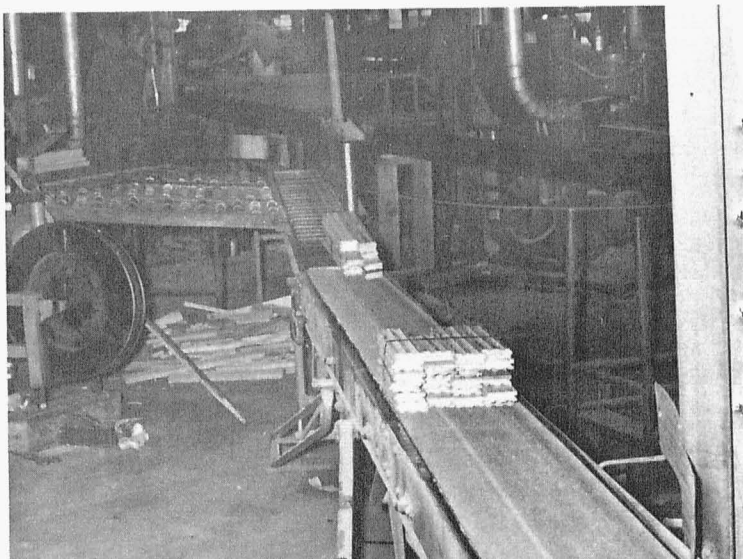


Fig. 37—Banded bundles of flooring on a self-powered conveyor system from plant to warehouse. Here they will be combined into larger bundles, palletized, and eventually shipped.



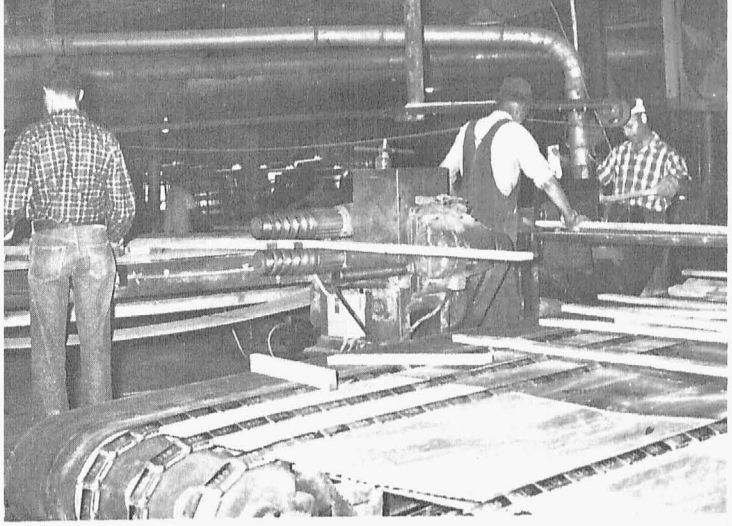


Fig. 31—Operators cutting knots and other defects out of lumber to assure clear pieces of oak for beautiful hardwood floors.

Fig. 32—The side-matcher is an impressive piece of machinery which surfaces the top and bottom of flooring while tongue and grooving the two edges. This is all done in one pass of the wood through the machine.

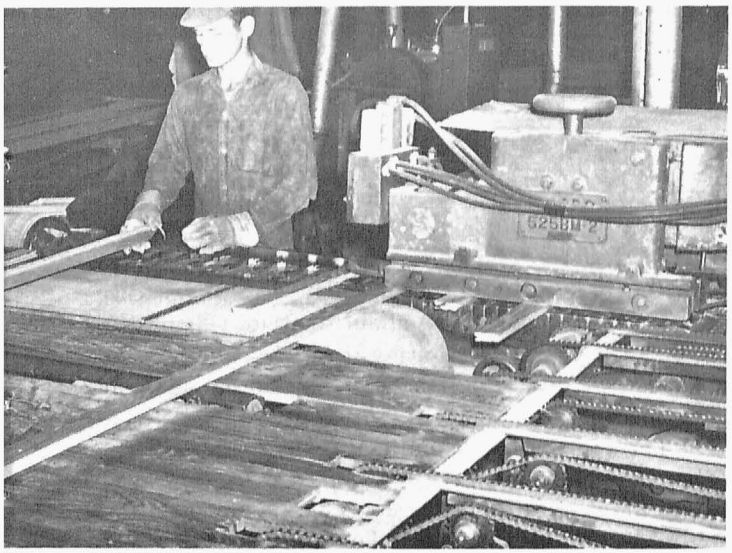


Fig. 34—The other end-matcher cuts the matching pattern in the last end of flooring for subsequent "snug and secure" fabrication in a home.

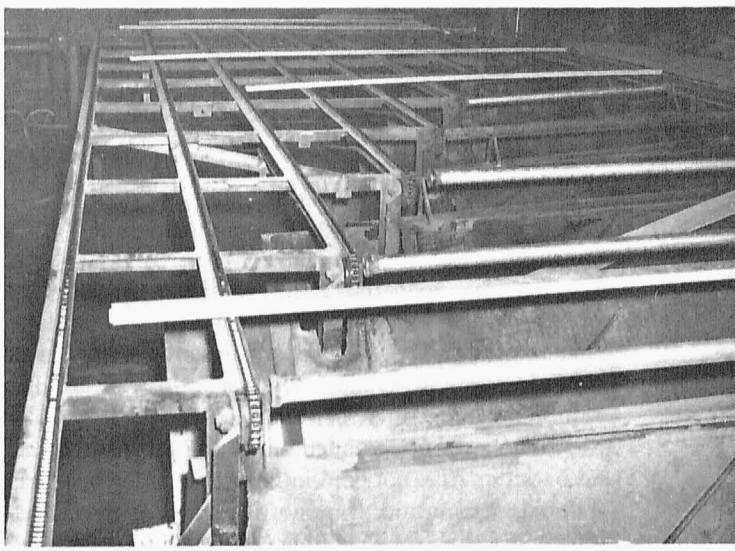


Fig. 35—Finished flooring is automatically sorted according to length. This machine is an example of many efficient and time saving techniques developed by Missouri's modern hardwood flooring industry.

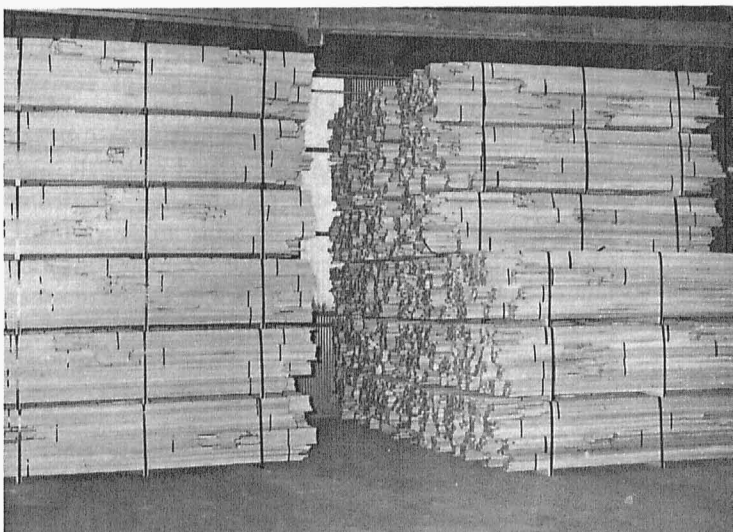


Fig. 38 — Stacks of finished flooring in the warehouse awaiting shipment. Note the neatly palletized bundles which may be handled easily by fork-lift trucks within the warehouse and moved onto truck or railroad car.

Furniture and Millwork Industry

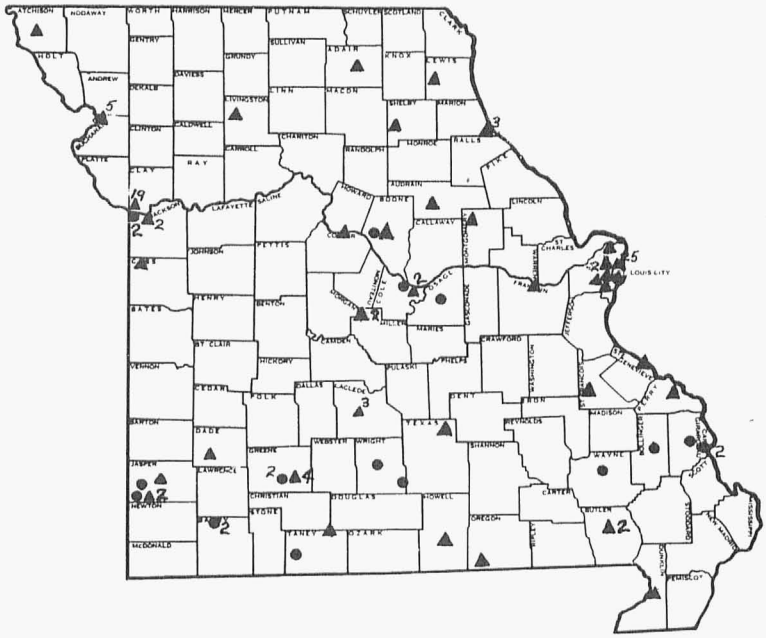


Fig. 39—Locations of furniture (●) and millwork (▲) manufacturers.

Description and Contribution

To qualify in this bulletin at a *furniture manufacturer,* the producer had to process lumber or partially fabricated wooden components into furniture. He might or might not have bought fabricated parts from dimension mills or other furniture plants. This eliminates all manufacturers of furniture whose product is not mainly of wood. For example, manufacturers of aluminum outdoor furniture who frequently use wooden armrests or wooden seats and backrests have not been included here. Manufacturers of upholstered furniture are not included in this discussion.

Millwork operations are businesses engaged primarily in the manufacture of molding and trim and other interior wood fixtures used mainly in the finishing and construction of buildings. Also included are businesses, usually small operations, which do custom cabinet or similar work. At one time it was estimated that 10 percent of all the lumber consumed in the construction of either homes or public buildings went into millwork or related items. Today this amount has been reduced to approximately 3 percent.

A variety of species of hardwood and softwood lumber and dimension stock is used by both furniture and millwork operations. In addition, related materials, such as plywood, hardboard, particle board, etc., are used in the manufacture of furniture and some millwork items. Oaks comprise about 33 percent of the total consumption of wood and wood products used by these industries in Missouri. The total consumption is estimated at 26,800,000 board feet annually. Of this amount approximately 20 percent (the bulk of the oak) is grown in Missouri.

The furniture and millwork industries are old ones. Many of the firms in operation today were in existence in 1910. There are 116 throughout the state (Figure 39). Unlike many of the wood-using industries which are located near the source of raw material, furniture and millwork plants are concentrated in metropolitan areas.

The 116 operations employ 2,208 people. These workers earn about $7,159,000 and gross product value of the industry is the highest for any included in this study, $22,050,000 per year. Furniture and millwork makers pay from $80.00 to $300.00 per 1000 BF for lumber and dimension stock to both local and out-of-state producers.

Although 50 of the 116 operations employ only 10 people or less, the furniture and millwork industries have kept abreast of technological advances. Their growth should keep pace with the over-all expansion of Missouri's economy.

Production and Marketing

Furniture manufactured in Missouri ranges from rustic red cedar furniture (for restaurants, family dens, and even bed-room suites) to conventional maple, birch, and oak household furniture. It includes church furniture and either standard production or custom orders for both solid and veneered walnut. A considerable volume of toy and juvenile furniture also is made in the state. Certain production procedures are, however, more or less common to all operations. The general sequence of process-

Fig. 40—Legs ready for assembly with other component parts into an attractive dining room table made of native hardwoods.

Fig. 41—An operator giving a final sanding to a glued-up hardwood panel which may eventually be fabricated into a table or desk top.

ing steps supplemented with various illustrations of specific operating techniques is described in this section.

Raw material is generally rough, air-seasoned lumber. Lumber may be supplemented with rough (or finished) turnings (Figure 40) and glued-up panels from dimension plants. In recent years chip and particle board have made substantial inroads into the plywood market for core stock. Wood veneers comprise some of the raw materials used.

Of the above items, rough lumber requires further seasoning prior to processing; the other materials usually have moisture contents suitable for use. Seasoning of wood is necessary in furniture manufacture to (1) render the product suitable for efficient service, and (2) enable satisfactory processing of the product from the wood adhesive and wood finish aspects.

For example, the use of hot animal glue (an old-time furniture maker's favorite) requires a moisture content of walnut lumber of about 5 percent. The lower the moisture content the better the glue penetration and hence the glue bond. The length of time it takes green, one-inch walnut at 65 percent moisture to reach 5 percent moisture ranges from 20 to 22 days in the kiln according to one large producer of walnut furniture. Wood finishing—the application of one lacquer coat, or a sequence of sap stains, filler coat, sealer coat, hot lacquer, and wax—requires a specific moisture content range on the wood surface to achieve a pleasing and satisfactory job.

After seasoning, rough lumber is sawn to length, width, and surfaced on the top and bottom. The use of diamond and carboly-tipped saws in the last 15 to 20 years has permitted more efficient sawing operation (kerf is reduced through use of thinner, better-edged blades) which also produces a wood surface smooth enough for gluing.

The wood may then be "conditioned" by bringing the surface temperature to a suitable range for gluing (this may be 95°F. for hot animal glues). High frequency bonding of wood with synthetic adhesives usually does not require this step. After "gluing-up" the wood panels, a curing time is necessary to complete the gluing operation. This ranges from seconds in the case of high frequency bonding to some four hours for hot animal glue, and overnight for cold animal glue and some other adhesives. Slight pressure or pressures to 120 pounds per square inch also is needed.

At this point, panels are sanded (Figure 41). Panels purchased from dimension plants then may have numerous machining and cutting operations performed on jointers, band saws, molders, shapers, and a variety of wood-working machines. Each operation has a pattern (Figure 42), or jig-assembly (Figure 43). At this time rough or semi-processed wood turnings obtained from dimension plants or those processed within the furniture factory itself, are turned into complete legs, braces, or similar items.

Assembly of the parts may be by hand (Figure 44) or by jig. A jig is a device which accepts the parts and draws them together under proper pressure (if glue is used to assemble the parts). Fastening of wood parts is usually by glue but there are some instances (certain rus-

Fig. 42—"Patterns" which form the basic mold for all the intricate and varied shapes of furniture components awaiting use in some future set-up for furniture production.

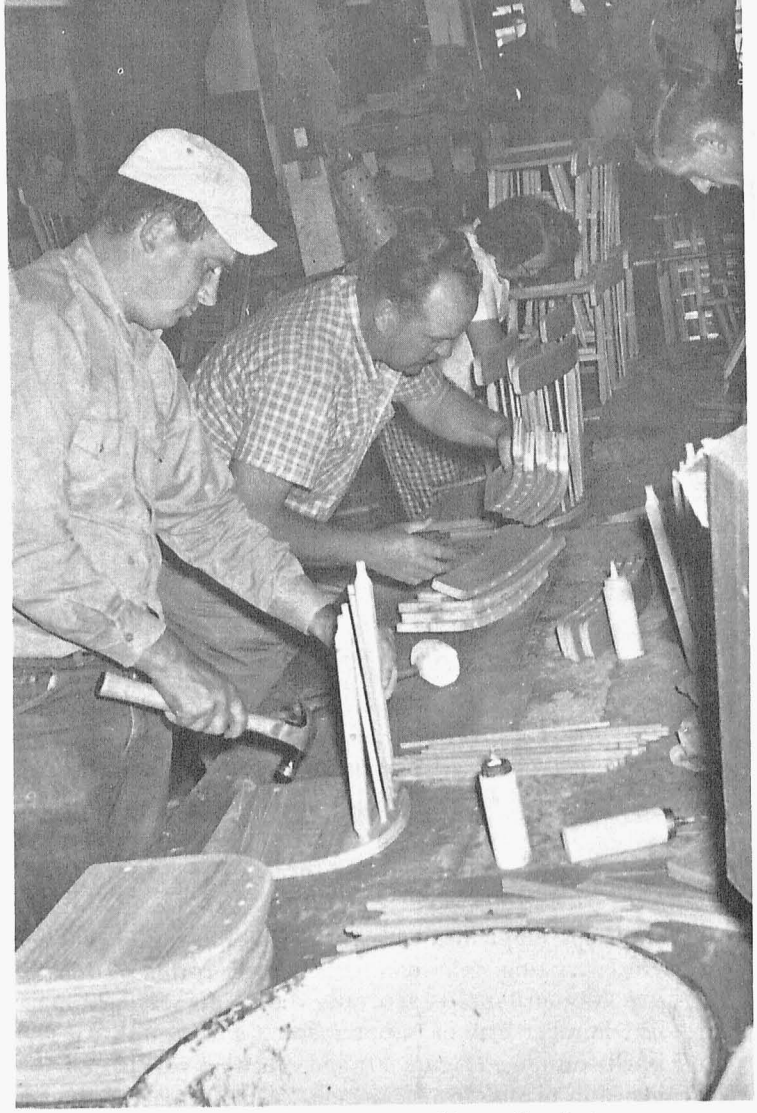
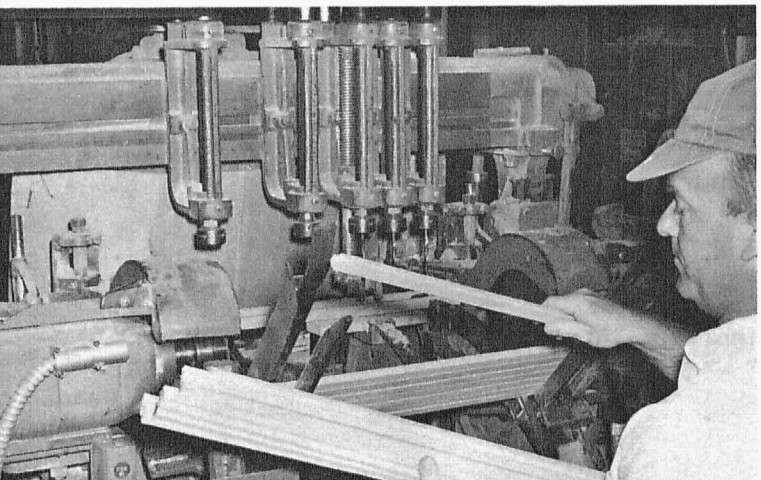


Fig. 44—Various component parts of juvenile chairs are assembled by workers before inspection and application of lacquer or varnish finishes.

Fig. 43—Missouri produces a considerable amount of juvenile and toy furniture. Here an operator prepares to feed a toy baby crib rail into a machine that drills all of the holes to receive the crib slats simultaneously.



tic furniture) where mechanical fastenings such as nails or screws are used.

After it is assembled (Figure 45), the furniture item is ready for finishing. This may be a single coat of lacquer or varnish or a series of applications. Hardware is put on either before or after finishing.

Furniture is inspected, retouched if necessary (Figure 46), and carefully packed for shipment (Figure 47). With the exception of the less expensive items and toy furniture, which are shipped in a knocked-down condition (Figure 48), the bulk of furniture items is shipped ready for the retail display room (Figure 49).

Manufacture of millwork and related items in this article includes many of the small cabinet shops as well as larger operations located, in the main, in metropolitan areas of Missouri.

The larger millwork plants have undergone radical changes in recent years. With the increase in construction of pre-fabricated homes in the last decade, millwork plants have lost almost the entire window frame and

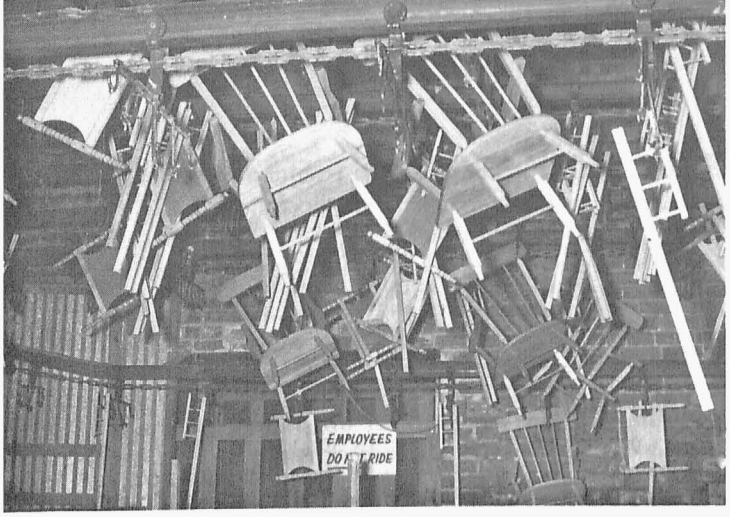


Fig. 45 — Juvenile chairs and other furniture parts suspended from overhead conveyor system which carries them into the finishing room, through the dryer, and on to the next stage of production.

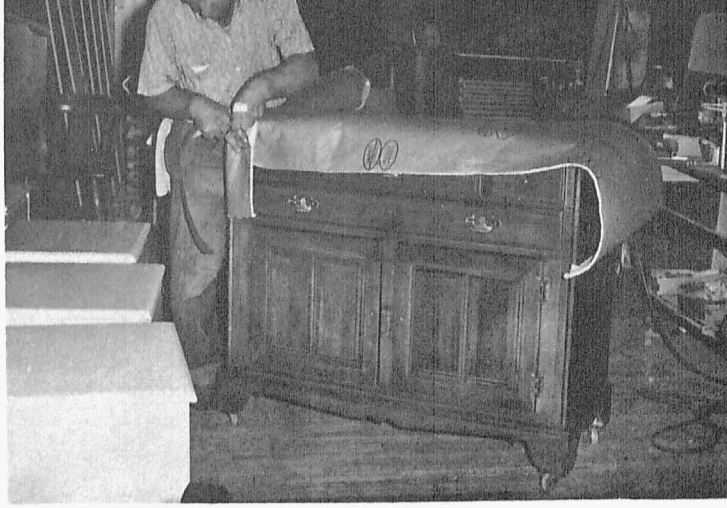
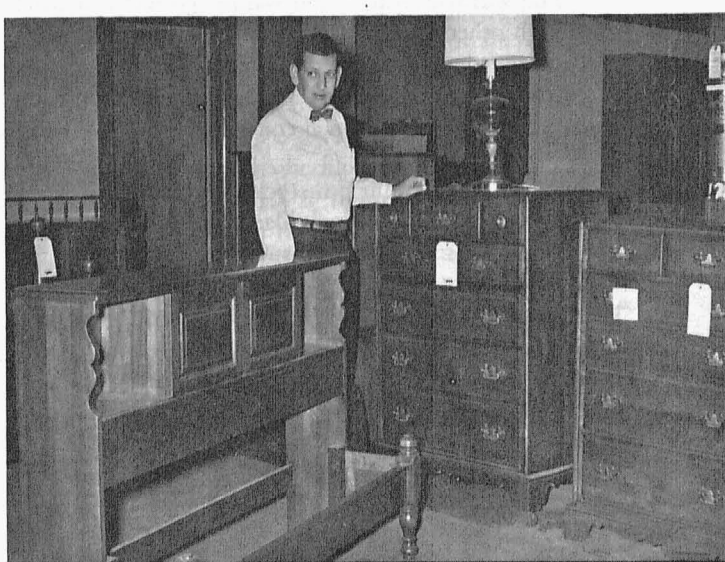


Fig. 47—After rigorous inspection, high quality Missouri furniture is carefully padded and packaged for shipment to furniture display rooms throughout the United States.

Fig. 46—One of the most important jobs in manufacture of fine furniture is the final "touching-up" of small blemishes and imperfections of the wood finish to assure a pleasing product.

Fig. 48—Completed toy crib components, ready for customer assembly pass along this conveyor line for packaging and shipment. This type of furniture is shipped in a "knocked-down" condition to reduce freight costs.

Fig. 49—A salesman in a display room of his company exhibits some beautiful bedroom furniture pieces.



door framing business. Many of the former millwork plants in Missouri now derive the bulk of their business as distributors or, at most, final assembly points for these items produced by large building concerns. Some millwork plants have gone over almost completely to public buildings. In this area, interior trim is still largely custom work for each building. However, even in this category, the amount of wood used for interior trim has been considerably reduced.

The smaller millwork and cabinet shops have not suffered from changes in business methods. They still do the same type of work, usually on a custom basis. Remodeling of homes constitutes a larger percentage of their work than in years gone by.

Production of cabinets or an occasional piece of furniture follows roughly the same steps as outlined in furniture manufacture. Raw material source is of course different due to the smaller quantities of wood used. The cabinet maker relies on his local lumber yard for the majority of his materials. Many of the operators interviewed expressed preference for particle and chip board over plywood as core material. Reasons given for this were: (1) more uniform thickness, and (2) reduction of "show-through" (core material patterns become slightly evident) on the finished veneer face. This was particularly true for some of the newer composition plastic face veneers.

The typical small cabinet maker has a versatile and well-equipped wood shop. He does all of the assembly, gluing, and finishing operations performed by the larger furniture plants. Since cabinet work and trim form the bulk of his business, he has been classed in the millwork category.

The cabinet maker usually charges so much per lineal foot of finished cabinet: for example, a 12-foot (length) of cabinet work on a kitchen wall may run from $25 to $75 per foot depending upon several factors (wood species, both top and bottom cabinets, built-in facilities, etc.). If he receives an inquiry by phone, he is thus able to give a surprisingly accurate cost estimate for his work. This initial estimate is, of course, followed by personal appraisal of the job at which time the cost figure is precisely set.

Gunstock Industry

Fig. 50—Locations of gunstock manufacturers.

Description and Contribution

The words gunstock and walnut go hand in hand. Although other species of wood, such as birdseye maple, Oregon myrtle, and cherry, are used in the manufacture of custom gunstocks, walnut reigns supreme, comprising some 99 percent of the wood consumed for this purpose in Missouri.

Missouri has four gunstock plants; two of these manufacture rough gunstock blanks for further processing by out-of-state concerns such as Winchester and Remington. The other two operations manufacture custom gunstocks for the sportsman. There are other companies within the state which manufacture small quantities of gunstocks as a sideline operation but they are covered under dimension stock or furniture and millwork operations.

The manufacture of gunstocks in Missouri on a commercial scale assumed prominence during World War I. One operation was set-up on a site where a sawmill had been in continuous use since 1890. Figure 50 depicts the four operations for which economic data have been compiled. They produce other products including quality walnut lumber for use in furniture, and the procurement

and sale of prime walnut veneer logs for use by plywood industries in the United States and abroad.

These four operations employ 193 full-time employees who receive a total annual payroll of about $790,000. The amount of walnut handled for gunstocks and other uses is estimated at 7,987,000 board feet annually. Gross product value to the manufacturer, and hence to the Missouri economy as a whole, is placed at $3,550,000 annually. Gunstock manufacturers pay from $120 to $500 per 1000 board feet for walnut. Occasionally high quality wood will bring a higher price. The limited amounts of fancy maple and myrtle usually procured from out-of-state bring a premium price ranging from $1800 to $3000 per 1000 board feet.

To many people walnut is the king of American woods. Its warmth and pleasing appearance coupled with excellent machining qualities, dimensional stability, and strength are the basis for the statement that as long as fine firearms are made for the discerning sportsman, the gunstocks will be walnut. Missouri's manufacturers of custom gunstocks sell their products to a large percentage of the 50,000 retail sporting goods and gunsmith outlets around the country as well as overseas.

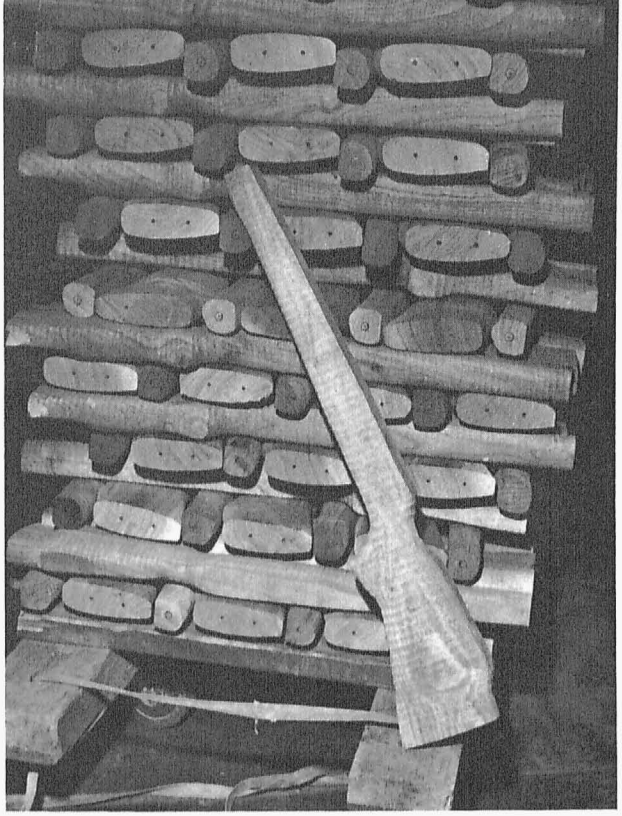


Fig. 51—Rough-turned walnut rifle stocks. The beginning of a series of operations that will produce a custom stock.

Production and Marketing

The finished gunstock mills employ buyers or rely upon local operators for a supply of walnut. Procurement is planned chiefly with this idea of obtaining walnut suitable for gunstock manufacture. Logs suitable for lumber and prime veneer are handled by several plants. Logs stored on the yard of a manufacturer of gunstocks are slightly different in appearance from logs used by a sawmill. This is because: (1) Length is not a prime factor for gunstocks and logs thus may be a minimum of 3 feet long, (2) there is a preponderence of material which contains a complete crotch (fork). This is because it is in the crotches where the bulk of the striking, fancy-grained wood is found.

There is no specified air seasoning time involved in the manufacture of gunstocks. In fact, if possible, the wood is sawed green. There is considerable waste in the sawing of the up to three-inch slices, "cants," or "flitches" of wood. The "cants" are marked, after removal from the head saw, to show the maximum number of gunstock blanks that may be cut.

In general, the man responsible for the laying-out of the patterns on the cant starts with the longest and largest gunstock and fits all of these that he can, and then, of course, goes down to the shorter gunstocks and finally attempts to fit blanks for shotgun fore-arms. In each instance, the man turns the slab with the side that contains the most defects up, and then he traces this with his finger on the top side while simultaneously on the underside marking the defect area with a crayon. He is then able to flip the cant over and avoid defect areas on the hidden face while he is tracing the various patterns. Patterns are then cut out, usually on band saws, and material left over is mostly residue or loss. Some operators utilize this material to make "Preslologs" for fireplaces.

After the blanks have been rough sawed they are placed in a chest or pit below ground level, covered with sawdust, and steamed at a temperature of approximately 120°F. for a period of from 1 to 5 days. Walnut lumber may also be steamed above ground in concrete kilns. Steaming tends to equalize color differences between the heart-wood and sap-wood zones. It also may assure a more uniform distribution of moisture in the wood for subsequent kiln-drying. Actually, the steaming process dries the wood somewhat because heat is present. The only thing lacking is forced air circulation. This has been confirmed by moisture content determinations.

After they are steamed the rough blanks are end-coated, usually with a paraffinic or asphaltic mixture, to eliminate end checking in subsequent seasoning operations. Blanks are kiln-dried from 90 to 120 days. This extensive period in the kiln is necessary to reduce excessive seasoning losses through checking. It is particularly important for the fancy grain of figured gunstocks. These particular blanks have a tendency to check more than straight grained wood.

The manufacturer of rough gunstocks ships his kiln-dried material, either by rail or truck, to the customer engaged in finished gunstock production. Here the rough contour of the stock is formed on a lathe (Figure

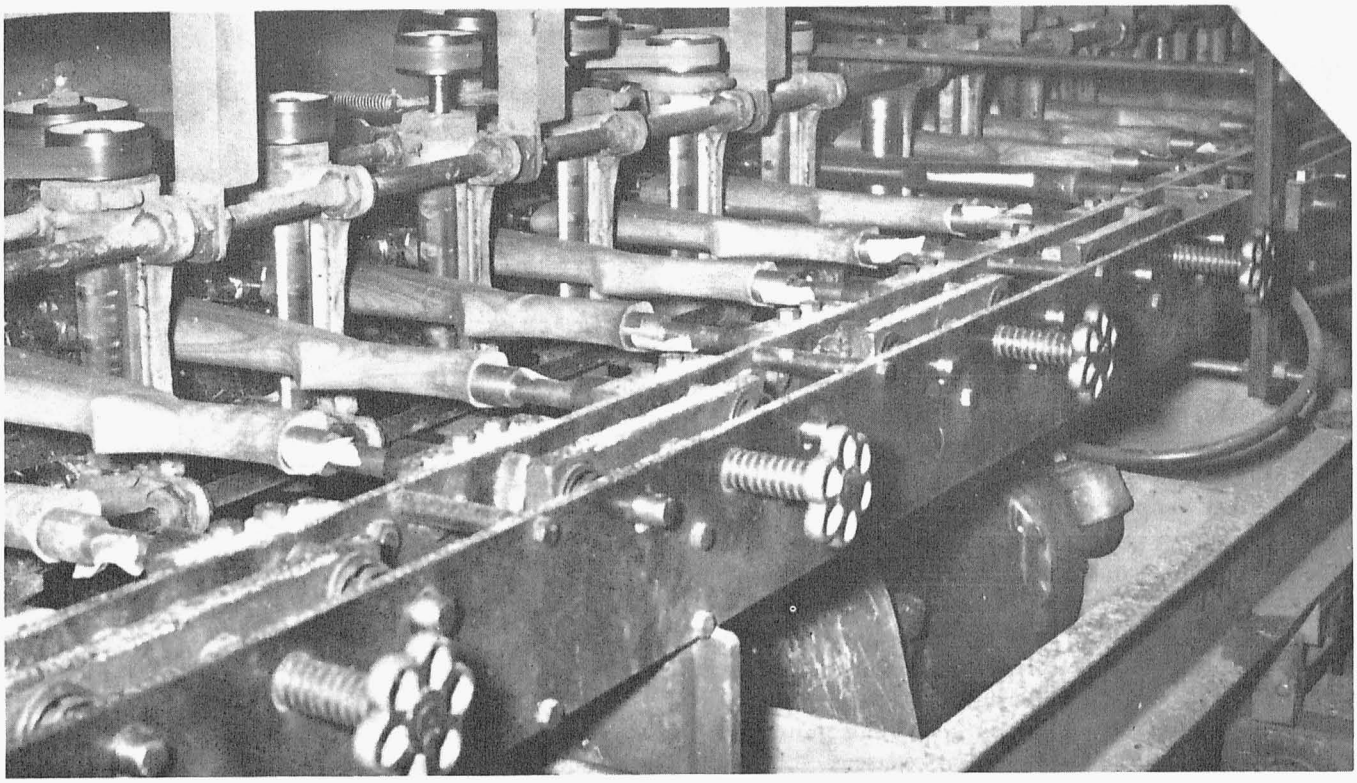


Fig. 52—Shaping walnut shotgun stocks. Notice the metal form in the machine which acts as a guide for cutting operations on the wooden stocks.

51). The final stock contour is machined prior to inletting (drilling, filing, etc.) the stock for the fitting of the gun action. The final machining operation (formation of stock contour) is done in one of two ways: on machines capable of following a gray steel form or a finished wooden "form," turning from 12 to 24 contoured stocks in one operation (Figure 52). The advantage of the gray steel form over the more conventional wood "form" is that tolerances can be more rigidly maintained to ±10 thousandths of an inch.

In some plants, the inletting of the stock is also done on the machine which completes the stock contour. This is accomplished by using a "form" which in addition to having the final contour of the stock also has been inletted for the particular gun action (Figure 53). This operation is done manually by changing the cutter heads on the machine and then tracing the particular inletting cuts by hand.

An alternative is to remove the stocks from the contour machine and place them in a series of routers, each of which follows a definite cutting operation determined by the metal fixtures for the particular router. These machines perform one of perhaps eight to a dozen inletting operations. Gunstocks which have passed this point of manufacture are shown in Figure 54.

Regardless of the route followed to make the final contour (for the outside), and inletting of the stock, the last sequence is sanding, "fitting," and finishing.

It is in these areas where the more skilled or specialized operators are employed. Men in this department do the rough and final sanding operations prior to finishing; and, of equal importance, fitting the gun action to the stock. (Figure 55). Some sanding operations are automatic but the majority of final sanding operations are by hand. Upon completion of sanding and fitting, finishing is done through one of several appropriate means to achieve final high-gloss or dull finish. The high-gloss is a lacquer base and the dull finish is sometimes an oil base and is handrubbed. Hand checkering (Figure 56) of some stocks follows the finishing phase.

It is also in the finishing department where special custom orders are filled. A customer sends in his action and describes the type of stock he wishes and the custom work is done upon roughcut stocks.

Parcel post is used to transport custom gunstocks, since they are made to order and shipped singly as completed.

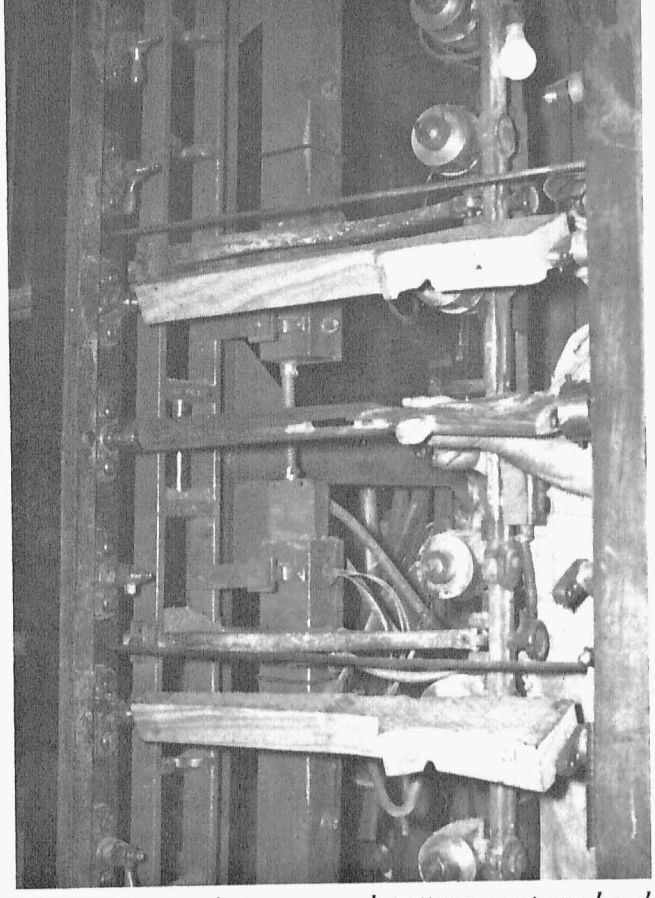


Fig. 53—In some instances, rough patterns are turned and inleted on the same machine. Here an operator supervises this operation. The "form" is of wooden construction in this instance.

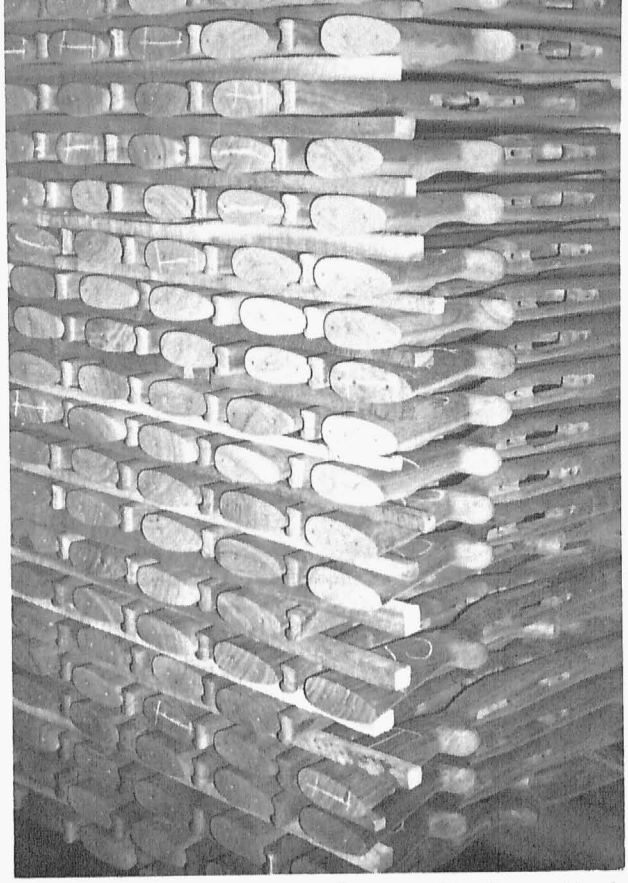


Fig. 54—Rifle stocks that have been machined to rigid tolerance assuring perfect fit of stock and rifle action. These stocks are ready for final sanding and finishing operations.

Fig. 55—A master craftsman makes final adjustments to obtain the perfect fit between stock and rifle for the particular sportsman.

Fig. 56—One of the last operations in the preparation of a custom rifle stock is the special hand work in applying the design specified by the customer.

Handle Industry

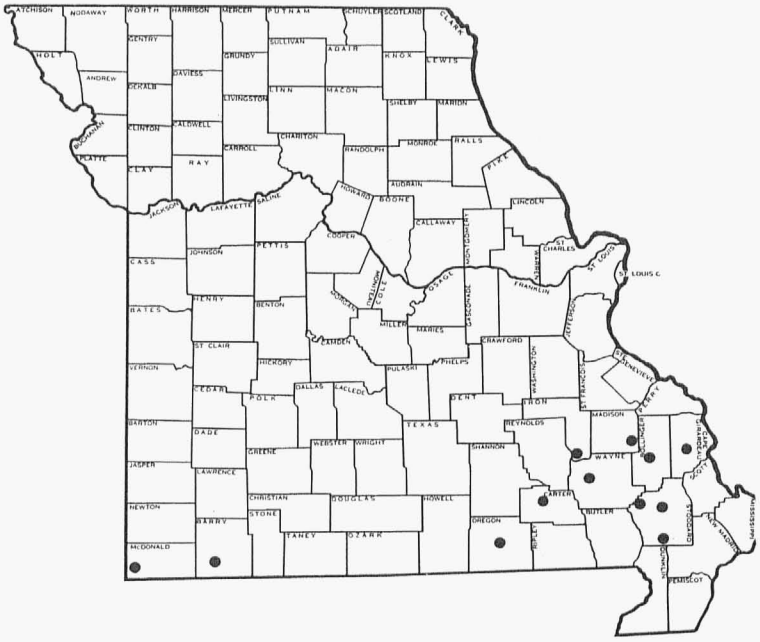


Fig. 57—Locations of handle stock manufacturers.

Description and Contribution

Hickory, which is used primarily for striking tools such as hammers, railroad picks, and axes and ash, which is used primarily for farm implement tools, such as rakes, forks, and shovels are the principal species use. Some firms have recently become engaged in the manufacture of dimension stock in addition to handles.

There are 18 to 20 major hickory handle manufacturers in the United States. Four of these major firms are located in Missouri. Nationally, the hickory handle industry grosses between $6,000,000 and $8,000,000 annually. Seventeen percent of this amount is contributed by companies located in Missouri.

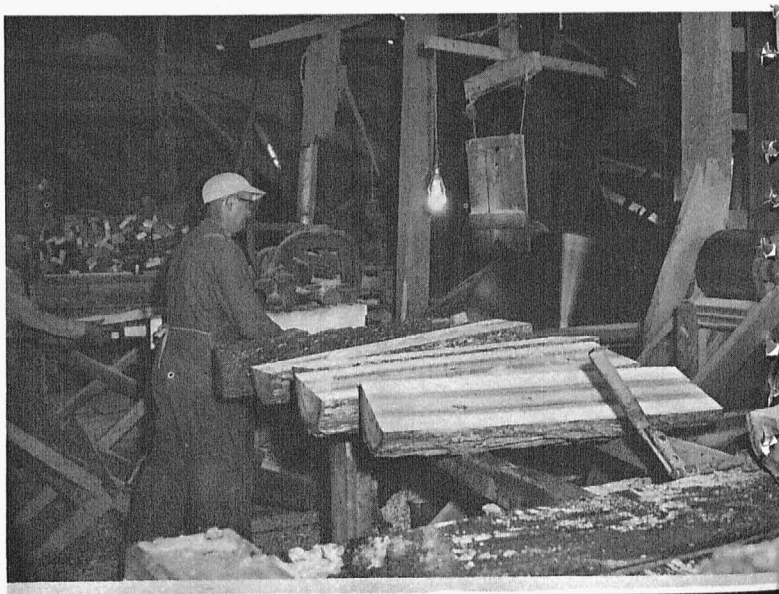
Location of 12 handlestock operations (including the four larger ones mentioned above) is shown in Figure 57. The industry is concentrated in the southeast region of the state with one or two operations in the southwest. The handle industry represents one of the oldest in the state, and one firm visited by the author has been in continuous operation since 1892. Many of the items produced by Missouri's handlestock manufacturers are used nationally and internationally by railroads in roadbed maintenance. It is estimated that between 10 and 15 percent of Missouri's handle production is shipped outside of the continental United States.

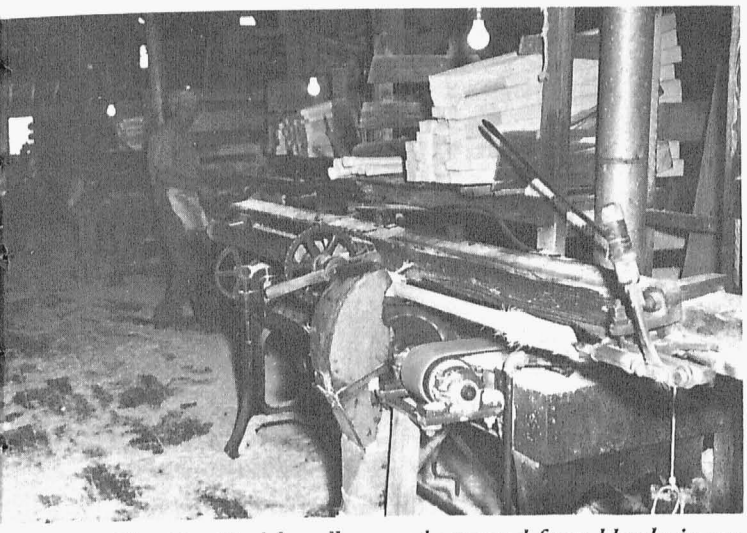
Missouri handlestock operations employ some 251 full-time workers. The annual payroll for this industry is estimated to be $668,000. Gross product value is approximately $1,900,000 annually. Total consumption of hickory and ash plus gum, which is used in some instances, is about 3,700,000 board feet annually. The wood supply is drawn primarily from the states of Arkansas, Kentucky, Illinois, and Missouri. Missouri's forests supply 40 percent of the wood used. Handle manufacturers pay from $50 to $150 per 1000 board feet for the wood they use.

Production and Marketing

Hickory and ash logs or bolts are usually purchased in short lengths running from about 40 (hickory) to 60 (ash) inches. In some instances dimension stock is cut from bolts at another mill and is ready for processing into handles by Missouri plants. In any event, the first operation is to process the wood while still green into rough cants (Figure 58); it is next formed on a lathe employing one of two techniques (Figure 59). The rough formed pattern, still green, is dried to 12 to 15 percent moisture. The wood is seasoned in specially designed kilns.

Fig. 58—First production step in handle manufacture is sawing of hickory or ash bolts into rough blanks for further processing.





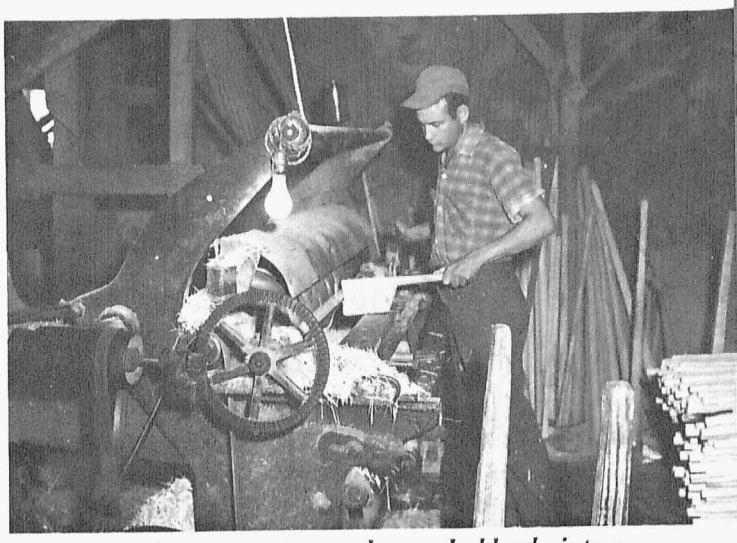


Fig. 59—Tool handles may be turned from blanks in one of two ways: Left, the work is done automatically on a lathe which traces a pattern (left side of picture) and simultaneously cuts the blank (right side) into an axe handle. Right, the operator presses the rough blank into a series of cutting tools which perform the turning directly without "tracing" a pattern to form a sledge handle.

The required moisture content usually takes from two to four days at 100° to 110°F with some forced-air circulation. Special rooms are built in some plants to provide the necessary drying conditions (Figure 60). One operator uses four of the new "Wel-Dri" kilns which are also suitable for dimension stock manufacture (Figure 61). Unlike walnut gunstock kiln-drying, the ends of handle blanks usually are not coated. Several operators have estimated that a maximum of five percent loss due to checking is encountered in the kiln drying operation. The ends of rough-turned blanks are cut off to remove lathe clamp marks in the final processing, so this loss is not considered serious. In some instances, prior to kiln drying, turned stock may be rough sanded.

After kiln drying the blanks are stored until a specific order has been placed. The final sanding operation is done on the handle stock when it is removed from storage. The importance of a smooth surface on tool and implement handle stock is apparent. Splinter formation must be kept to a minimum.

After the material is sanded, it may be dipped in hot lacquer. The material is dry enough to be handled about 30 minutes after the finish coat has been applied. Handles are then placed in a tumbler to insure a final smooth finish (Figure 62). There are other finishing techniques if lacquer is inappropriate. One of these is "burning" the handle which exaggerates the difference between the spring and summerwood zones of annual growth. Another finishing alternative is to paint the handle stock. Usually the lower grade handles are painted to hide defects such as small knots which *do not* impair the utility of the handle but which detract from its appearance.

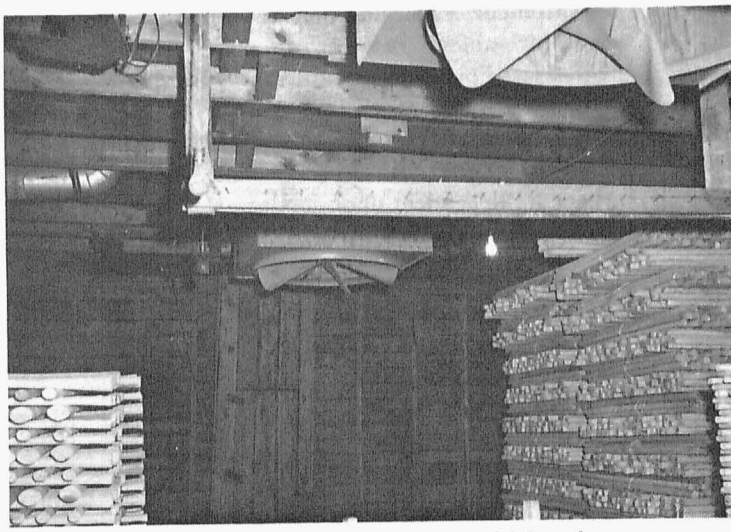
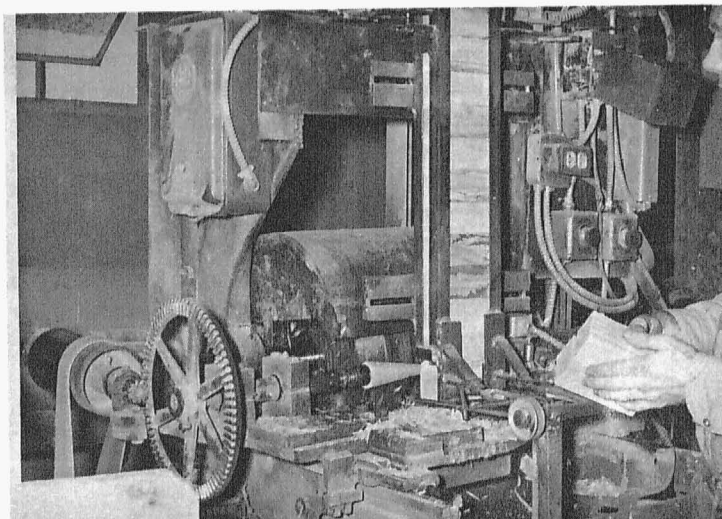


Fig. 60—Turned handle stock in a "kiln" which reduces moisture content of stock to about 15 percent. Handles in lower left and lower right portions of the picture are hickory, the others are ash.

Fig. 61—Some Missouri handle producers also turn out special turned items such as furniture legs. Here an operator feeds squares into a machine which performs the turning operation.



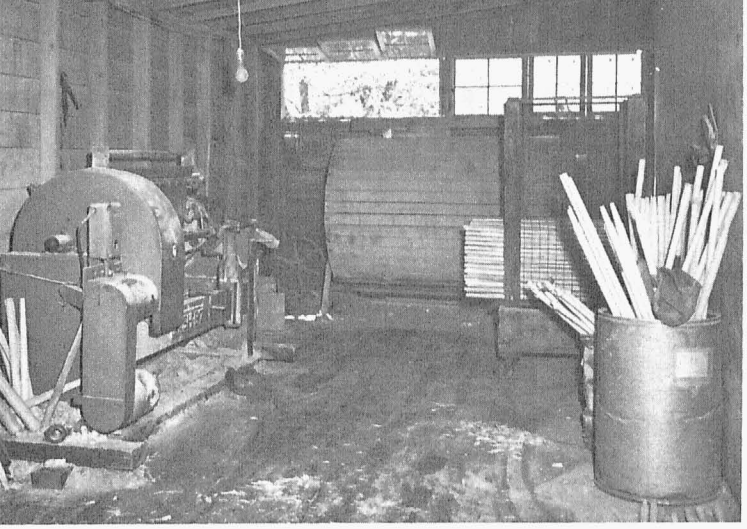


Fig. 62—In the background is a "tumbling" machine which imparts a smooth finish on lacquered handles much the same way one would handrub a wood finish.

Fig. 63—One profitable outlet for hickory sawdust is the meat packing industry. Here bags of screened sawdust are stored awaiting shipment.

When finishing, handles are graded and packaged for shipment. Packaging may be in burlap bags (overseas consignment) or paper cartons.

A large percentage of Missouri's handle production is exported to foreign countries. In addition, outlets in at least 42 states are served by Missouri handle manufacturers. Some operators handle their own sales whereas others are dependent upon jobbers. Handles, like cedar novelty items, are sold by the dozen. The price range per dozen for the manufacturer is quite large. Representative figures range from $1 to $12 per dozen.

Residue includes shavings, dust, slabs, and ends of the rough-turned handle stock. In many instances shavings and dust are hogged and burned to supply steam for mechanical power or heat for the plant. Some hickory is collected and bagged in 45-pound bags for use in packing houses (Figure 63). Some scrap hickory handle ends are collected and bagged for barbecue purposes.

Novelty Industry

Description and Contribution

This industry divides conveniently in two classes: (1) firms which process eastern red cedar products to be sold as relatively inexpensive gifts, and (2) firms which manufacture more expensive functional items such as walnut salad bowls and serving trays.

Missouri firms manufacture an estimated 90 percent or more of the annual production of the red cedar novelties produced in the United States. The oldest existing operation was established near Tuscumbia in 1938 and a majority of firms now in existence were started shortly

Fig. 64—Locations of cedar (●) and walnut (▲) novelty manufacturers.

Fig. 65—Square cedar timbers awaiting the band-saw for start of an eventful transformation into a "catchy" novelty item.

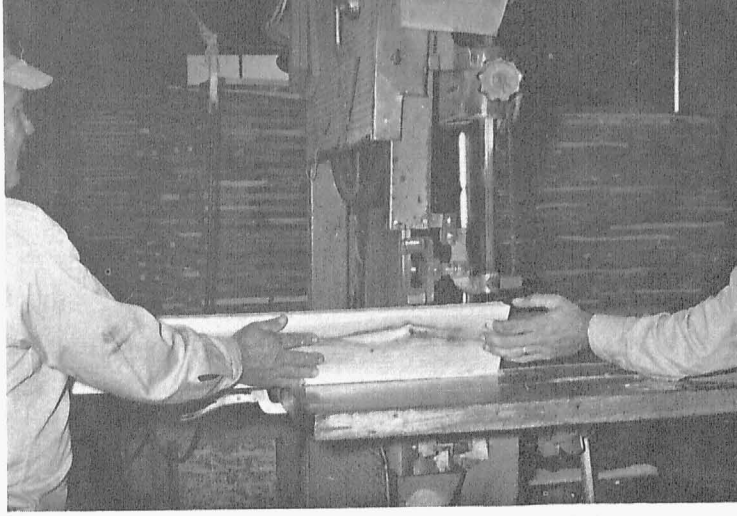


Fig. 66—Squared cedar timbers are band-sawed into boards of suitable thickness for making a novelty plaque.

before or immediately after World War II. Most plants are located in the two main tourist areas of the state, in the vicinity of Bagnell Dam on the Lake of the Ozarks and the other in the region stretching south of Springfield to the Arkansas border. Locations of cedar and walnut novelty operations are shown in Figure 64.

This industry has enjoyed phenomenal growth since its inception around World War II. Several producers of novelty items stated that they doubled or even quadrupled their business for the first five-year period after World War II and present business is excellent, although the period of rapid growth appears to have leveled off somewhat.

Twenty firms are engaged in either cedar or walnut novelty manufacture in Missouri. These operations employ approximately 458 people on a full-time basis. The payroll of this industry is estimated at $963,000 annually. The gross product value of the novelty business is estimated at $3,325,000 annually. The novelty makers pay from $50 to $150 per 1000 board feet for some 2,400,000 board feet of cedar, walnut, and pine they consume annually. Of this amount, 90 percent is grown in Missouri.

The number of cedar novelties is legion. There are a few basic patterns, such as the box, the flatboard (plaque), and the turned items, such as salt and pepper shakers. But the variations on these basic forms result in numerous attractive, eye-catching items. Several manufacturers list from 60 to 200 different items in their catalogues. The manufacturer of novelty items sells his merchandise directly in salesrooms at point of manufacture, or to distributors, wholesalers, and in some instances by mail order catalogue. Novelty items made in Missouri are sold in all 50 states, Mexico, Canada, and Puerto Rico. With the increasing interest in recreation in Missouri and elsewhere, the novelty business will continue to grow, for it is the souvenir and gift shops in recreation and resort areas that are the major outlet for the novelty articles.

With the increasing level of living, exemplified by more attractive home furnishings and luxury items, it is not surprising to find a growing demand for walnut tableware and other household items. Forks, spoons, bowls, lamp bases, book-ends, and other articles fashioned from walnut are popular sellers with a bright future market outlook.

Production and Marketing

As mentioned, the cedar novelties stem from a few basic patterns—the box, the flat board or plaque, and turned items. Manufacturing techniques for these three patterns have many steps in common. For brevity, only the plaque will be discussed in detail.

Cedar arrives at the novelty plant in the form of green logs or lumber (Figure 65). Freshly cut eastern red cedar does not contain as much moisture as most woods. The heartwood of cedar may contain as little as 25 percent moisture. The sapwood, although about 100 to 110% moisture, makes up a small percent of the tree. Thus, the relatively low moisture content of cedar reduces the seasoning time it requires, compared to most woods.

Cedar squares are band-sawed (Figure 66) to boards one-fourth to one-half inch thick, and kiln dried (Figure 67) for about five days to a moisture content of from six to eight percent. The next operation is band-sawing to width, followed by rough and fine sanding operations.

The plaque is now ready for decorative illustrations, phrases, or both. In recent years the silk-screen technique (see Figures 68 to 70) has been found satisfactory for imparting the desired painted lettering and drawings. This process is limited to the application of one color at a time. Therefore, a three-color plaque requires three trips through the machine.

After the illustration is put on the plaque, a lacquer coat (Figure 72 and 73) is applied. Each novelty item is wrapped individually for packing (Figure 74).

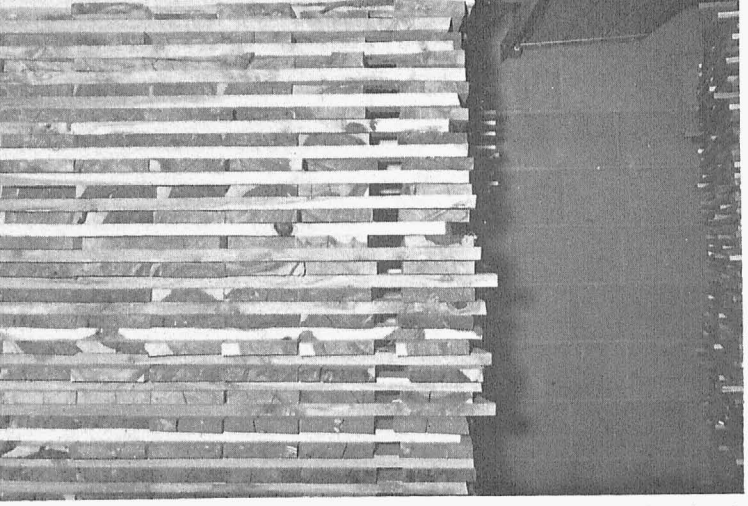


Fig. 67—After the band-sawing operation, cedar lumber is kiln-dried to 6 to 8% moisture content before further processing.

Fig. 68—The operator is using the "silk-screen" technique of applying various color-patterns to the plaque.

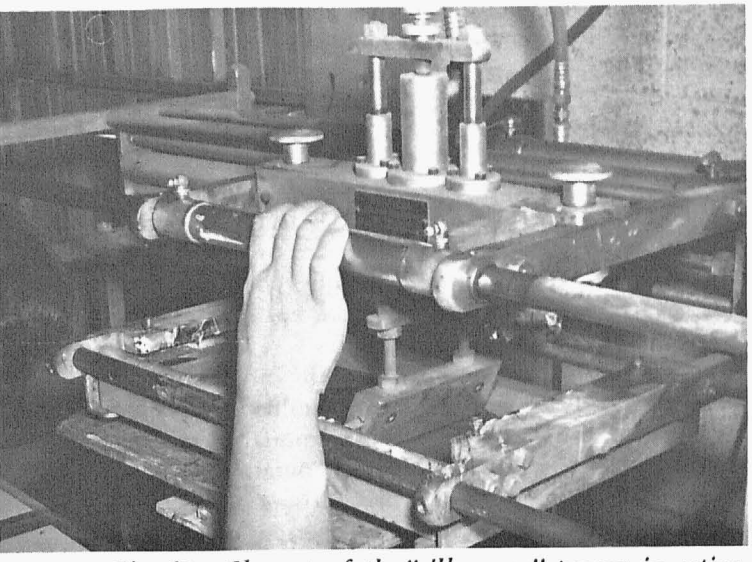


Fig. 69—Close-up of the "silk-screen" process in action. The metal jig acts as a squeegee allowing the color to penetrate to the wood only at designated spots.

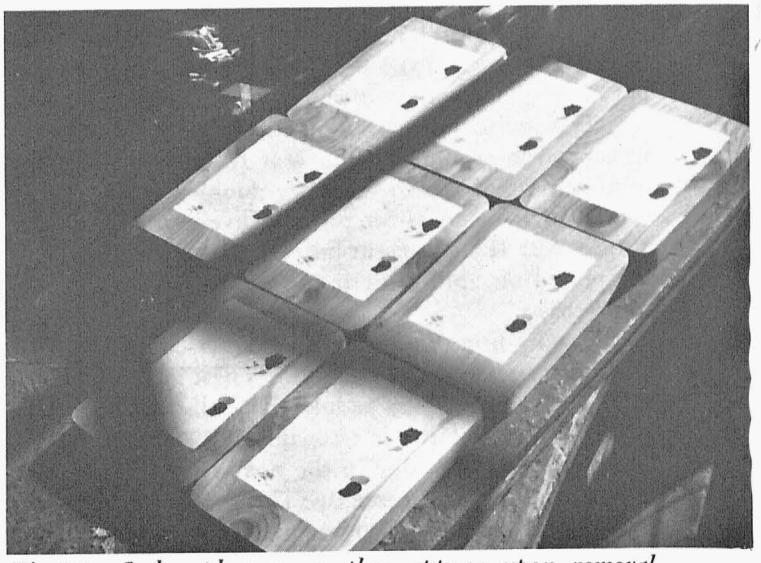


Fig. 70—Cedar plaques, as they appear upon removal from the "silk-screen" operation. Each color requires separate screen pattern.

Fig. 71—Various silk-screen patterns stored for future use. Service life of these patterns exceeds that of conventional stenciling patterns.

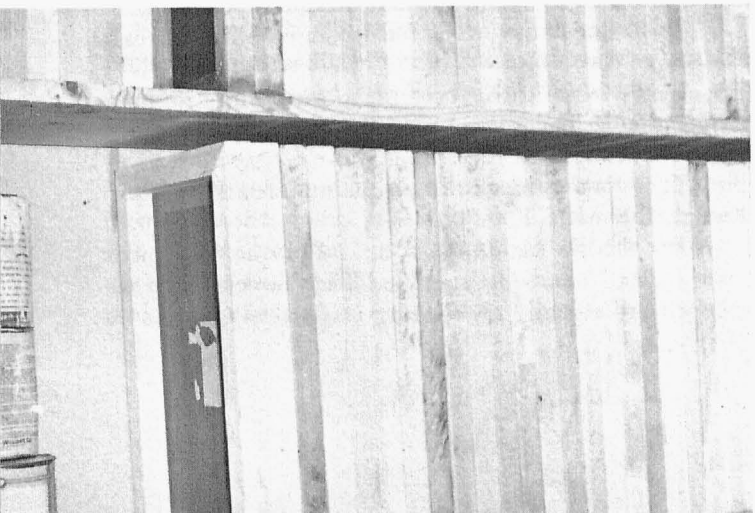


Fig. 72—A hot lacquer spray is applied to the finished plaque to enhance the eye-appeal of cedar's natural coloration, so desired in the novelty trade.

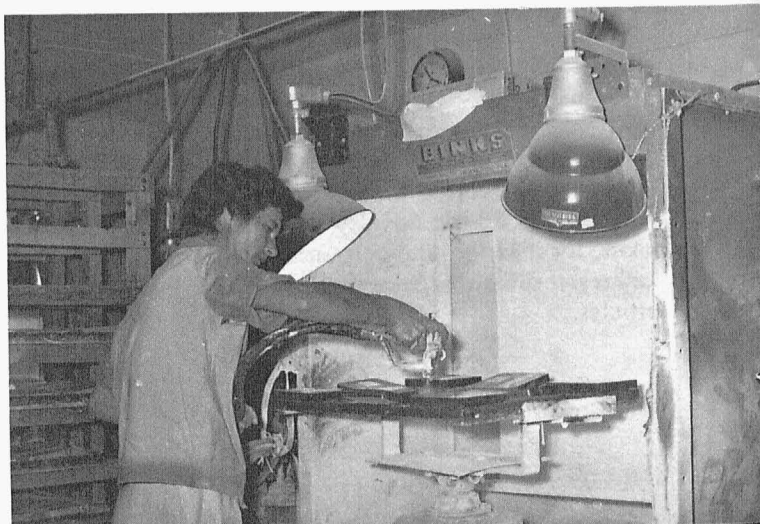


Fig. 73—Freshly lacquered plaques set out to dry prior to inspection and packaging.

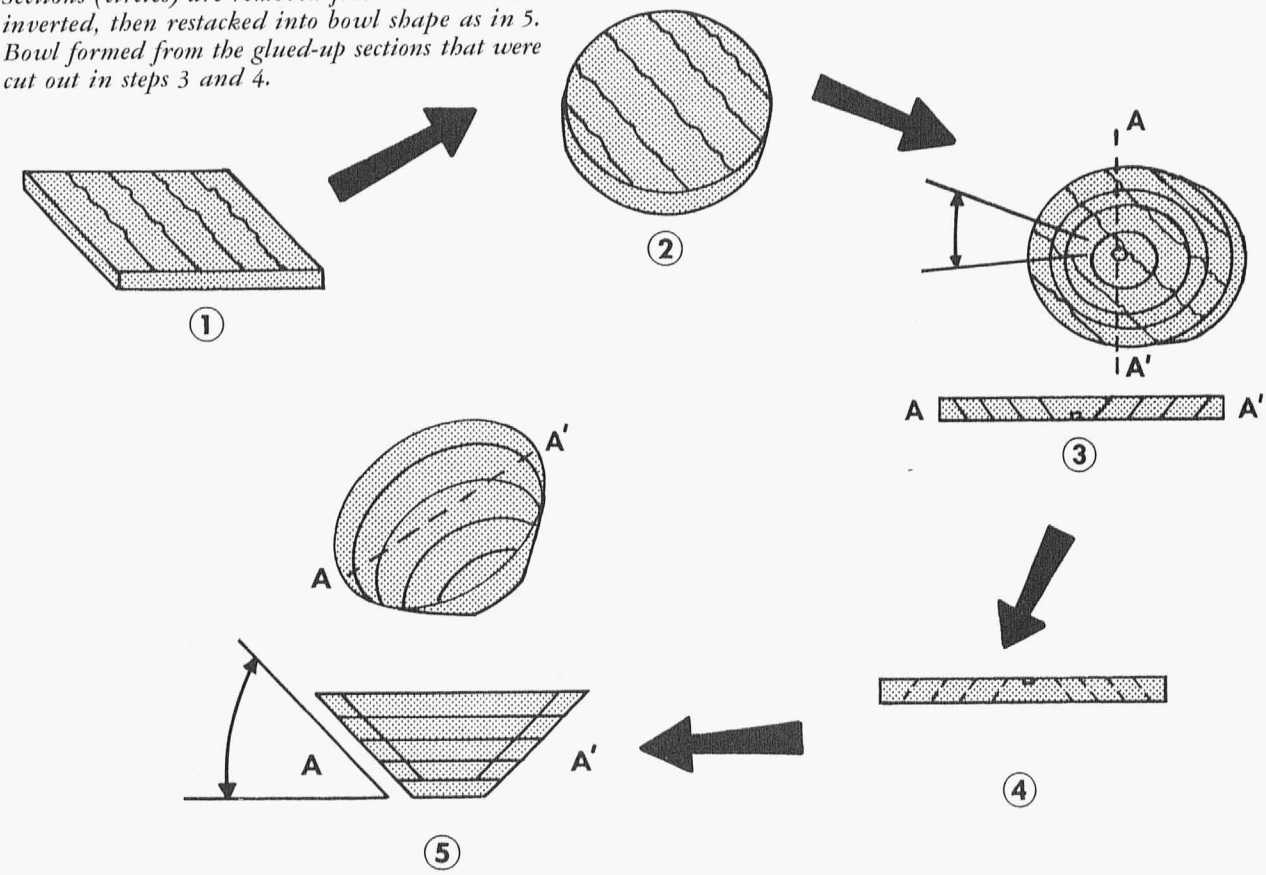
Fig. 74—A group of workers wrapping several types of cedar novelty items in paper. The next step is packaging and then off to the warehouse to await shipment.

Typically, walnut is received by the manufacturer as green lumber one to three inches thick. Walnut requires air-seasoning (sometimes eliminated) and kiln-drying to achieve proper moisture content and distribution.

After it is seasoned, walnut is rip or band-sawed to width, surfaced on top and bottom faces, "glued-up" to boards ranging from 12 to 16 inches in width and then sawn to length to yield square panels from 12 to 16 inches on a side. The squares are then cut on a band-saw to a circular shape of corresponding diameter (12 to 16 inches).

This is followed by various operations (see diagram), such as lathe work, gluing, finishing, and packaging for sale. Walnut items are generally sold through a jobber or distributor.

1. *Glued-up square panel.*
2. *Panel is cut to circular shape on band saw.*
3. *Special lathe cuts concentric circles out of the block. Angle of cut is equal to the angle of sides the bowl will have.*
4. *Sections (circles) are removed from the lathe and inverted, then restacked into bowl shape as in 5.*
5. *Bowl formed from the glued-up sections that were cut out in steps 3 and 4.*



Pallet and Container Industry

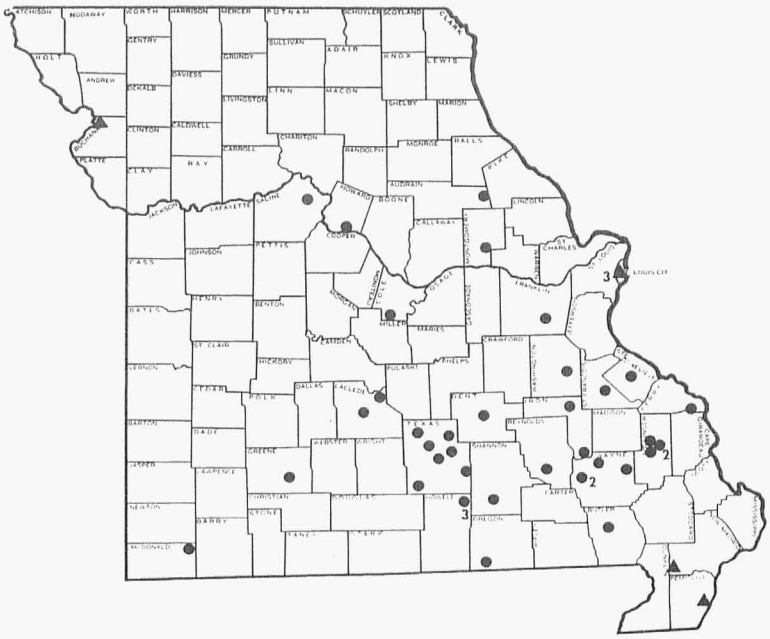


Fig. 75—Locations of pallet (•) and container (▲) manufacturers.

Description and Contribution

The pallet and container industry includes two types of products. One is the familiar wooden pallet in its two main forms, the warehouse (reusable) and the expendable pallets. The container industry in Missouri is restricted to the manufacture of wooden boxes, usually wire bound, for the packaging of fresh fruits, poultry, and eggs. Both pallets and containers are made primarily from wood and not wood-fiber compositions as characterized by paper cartons and bags. Missouri does not have pulp mills that engage primarily in the conversion of wood to chemical pulp used for containers or other purposes.

Although developed in the late 1920s primarily by the United States Navy, the wooden pallet did not assume national importance until World War II. The development and expanded use of fork-lift trucks and the technique of storing boxes or other items on a movable wooden platform, or pallet, was the outgrowth of a pressing need for more efficient handling of wartime commodities. Today, industry uses the wooden pallet for the handling and storage of a large majority of commercial items.

The warehouse pallet has gradually replaced markets formerly belonging to the expendable pallet. This facet of Missouri's wood-using industry has been growing continuously since World War II. The recognition by leading pallet manufacturers of the necessity for quality control and standard production techniques will contribute to the continued expansion of this industry within the state.

The manufacture of wooden boxes and crates in the state of Missouri dates to the turn of the century. Firms in Missouri have kept abreast of modern technological and marketing advances and the market for Missouri wooden boxes, primarily the wire bound type, is a national one. The wooden container industry is, of course, in stiff competition with cardboard and other fiberboard boxes for a large share of the packaging market. In 1910, 112,000,000 board feet of lumber, primarily red gum and cottonwood, were processed in Missouri by the wooden container industry. In contrast about 60,950,000 board feet are now consumed by the combined pallet and container industry.

There are about 45 pallet and container manufacturers within the state. These 45 firms employ 845 workers. It is estimated that the gross sales of the pallet and container industry in Missouri is $5,485,000 annually. The annual payroll for this industry is $1,800,000. Of the 61,000,000 board feet of lumber used in this industry, oak constitutes 70 percent, with cottonwood and other soft hardwoods comprising approximately 20 percent. The wood sources are mainly Arkansas, Kansas, Illinois, and Missouri. Missouri contributes some 70 percent of the total amount of wood used. Location of the pallet and container manufacturers are shown in Figure 75.

It is estimated that Missouri pallet production comprised three to four percent of the national production of warehouse pallets in 1961. Pallet consumption within the state of Missouri accounts for 50 to 75 percent of Missouri's production.

The wooden containers, on the other hand, are

Fig. 76—Dependent upon final usage, pallets may be constructed of rough lumber or surfaced lumber which is allowed some or no defects such as knots and wane. Here a workman selects a piece of lumber for deckboarding.

Fig. 77—Pallets may be bolted, screwed, or nailed together. In this operation (drive-screw) nails and metal straps are used to fasten pallet components together.

usually used outside the state. The markets for containers are mainly on the east coast and in southeastern Texas and California.

Production and Marketing

In Missouri, oak is the major pallet wood. Expendable pallets also are made from cottonwood and other soft hardwoods as well. The pallet manufacturer may buy his raw material in the form of logs, squared timbers (as ties), or as rough lumber.

First step of manufacture is selection and sawing of lumber (Figure 76) for deckboards (the pallet platform) and the stringers or blocks which support the two platforms (sometimes only one). Blocks are really short-length stringers. Stringer construction permits fork-lift trucks to enter on opposite sides only; whereas the block design allows fork trucks to enter on all four sides. The pallets shown in Figures 77 and 78 are of the stringer, two platform type.

After the component parts are sawed, they are air-seasoned to 20 to 25 percent moisture content. This is desirable for better-grade warehouse type pallets. Surfacing of top and bottom faces of lumber may or may not be done.

Final phase of construction is pallet assembly. This is usually done by hand, either individually or on an assembly line basis. In some plants, components are placed in jigs and the assembly steps such as hole drilling and fastening (drive screws, annular ring nails, common wire nails, or nuts and bolts) may be done automatically. The

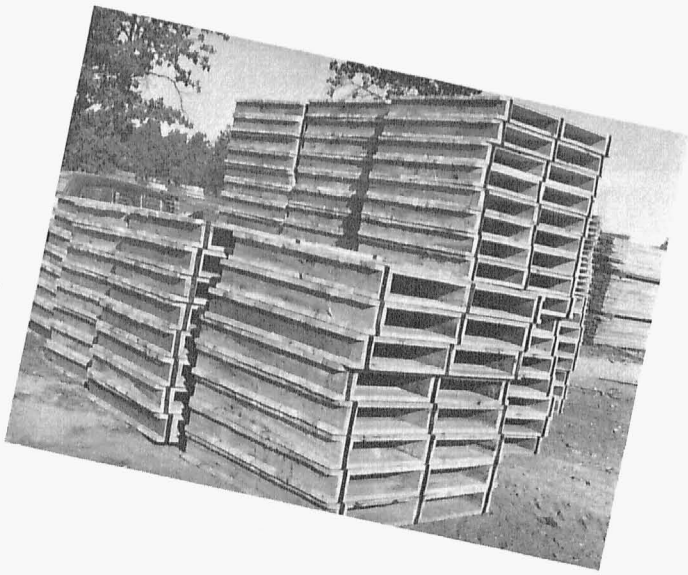


Fig. 78 — A stack of sturdy oak pallets ready for use in handling storage items in some segment of the nation's manufacturing industries.

fastening operation is the most important production step; 80 percent of pallet failures are traceable to improper fastening.

The bulk of Missouri's pallets are transported by the producers on company-owned or commercial tractor-trailers.

The bottomland areas of the Mississippi and Missouri River systems provide cottonwood and related softwood species for the box and container industry. Cottonwood is the preferred species for box veneer because of its light color (ease of painting, printing or other means of identification), lack of odor and because it can be processed into veneer green without steaming. The wood is harvested from shores and islands of the river systems.

Upon arrival (by barge or log boom) at the veneer plant, logs are cut into 42 inch long bolts. The bolts are then cut by a rotary veneer process into sheets up to one-half inch thick.

The sheets are sliced (trimmed) into sizes suitable for construction of wire-bound boxes, passed through a veneer-drier, graded, and either stored for future use or immediately fabricated into one of several types of wire bound containers.

The container veneer industry practices very complete utilization of their raw material. The bark is used for fuel for heat in the veneer-drying process, and the core is sold for pulpwood.

Cottonwood is purchased as lumber and fabricated into beverage cases. Wood ranging from 14 to 18 percent moisture content has been found satisfactory, and in some instances superior to kiln-dried material with a lower moisture content.

While there are other types of container plants in Missouri, all operate along the same general lines. Either veneer (processed at the plant or purchased) or lumber is used with cottonwood being the preferred species.

Wirebound boxes, beverage cases, and other containers made in Missouri enjoy a national market. Shipment is predominantly by truck and rail. Many sales are made directly to the customer.

Post, Pole and Piling Industry

Description and Contribution

Through the efforts of state and federal forestry agencies, shortleaf pine, a native southern pine, has made substantial gains in both quantity and quality of timber since the mid 30s. The post and pole industry has profited most from this trend. Manufacture of piling in Missouri is very limited. Piling is mentioned, however, because it is usually included in post and pole statistics. Because the volume and quality of shortleaf pine has been increasing, post and pole production of this species has increased substantially in the last five years. In contrast, the production of fence posts from oak, cedar, and other durable woods has remained the same or declined in recent years.

It is estimated that there are 31 post and pole operations in Missouri; the plant locations are shown in Figure 79. The annual payroll is about $780,000 and the gross product value is about $6,000,000 annually. This total does not include the value of the large number of fence posts which are cut and used on the farm. In terms of board feet it is estimated that oaks, cedar, pine, locust, and other species cut for posts are used at the rate of 22,500,000 board feet annually. Shortleaf pine alone is

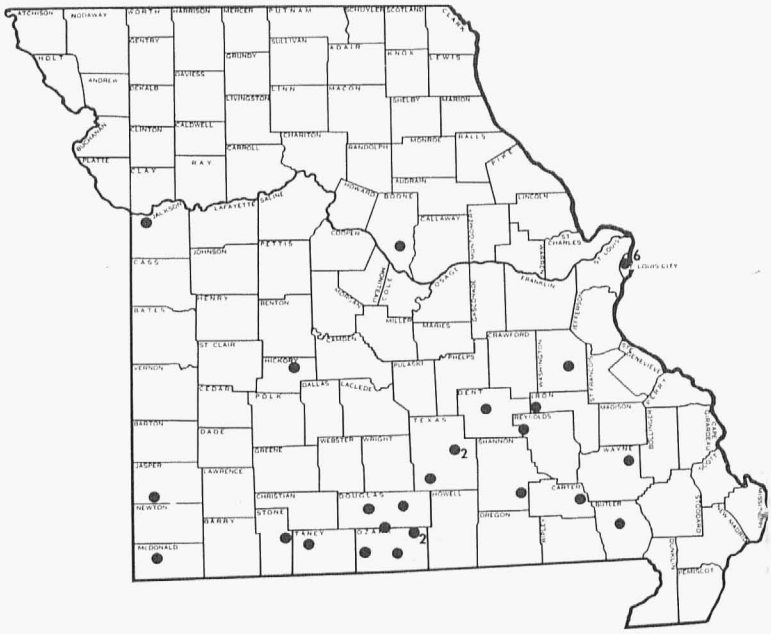


Fig. 79—Locations of post, pole and piling manufacturers.

cut for poles at the rate of 1,300,000 feet annually by Missouri operations. Ninty percent of this wood is harvested in Missouri; the remainder comes from Arkansas.

A large percentage of pine posts and poles are shipped to wood preserving plants where they are treated to increase their longevity and finally shipped out of the state. The bulk of the oak, cedar, and locust posts is consumed within the state. As the southern pine based industry continues to grow, Missouri's post and pole industry will also grow. Conservative estimates are that this business could double in the next five years. However, the number of fence posts cut for farm use will probably remain the same or decline slightly.

Production and Marketing

Production of posts and poles, compared to that of furniture and gunstocks, for example, is not an involved process. The steps in the manufacture of oak, cedar, and locust posts include felling and bucking of logs to desired length, and splitting (or sawing) of the bolt into two or more posts. Bark may or may not be removed. If the posts are to be given preservative treatment, air seasoning is desirable for some commercial processes. Seasoning is not desired for techniques used by the farmer. The heartwood of white oaks, cedar, and black locust is durable, and posts made from these species need little or no preservative treatment (dependent upon amount of sapwood present) to give years of satisfactory service. Red oak posts must be given preservative treatment if a reasonable service life is to be expected.

Manufacture of pine posts and poles follows a somewhat different pattern. Shortleaf pine logs are delivered to a concentration yard where they are peeled, sorted into sizes, and palletized. This sequence of operations is shown in Figures 80-82. Wood preserving facilities may or may not be present at this location.

Pine posts and poles are sold by the concentration yard to treating plants if the two operations are not under the same management.

Fig. 80—Future shortleaf pine fence posts prior to removal of the bark in a peeling machine.

Fig. 81—Workman operating the post and pole bark peeling machine. Notice how efficient the operation is in removing the bark and yet not harming the wood.

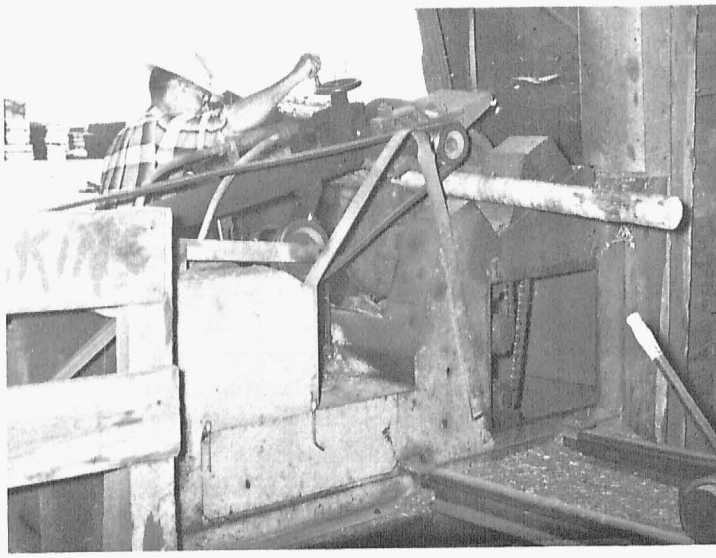
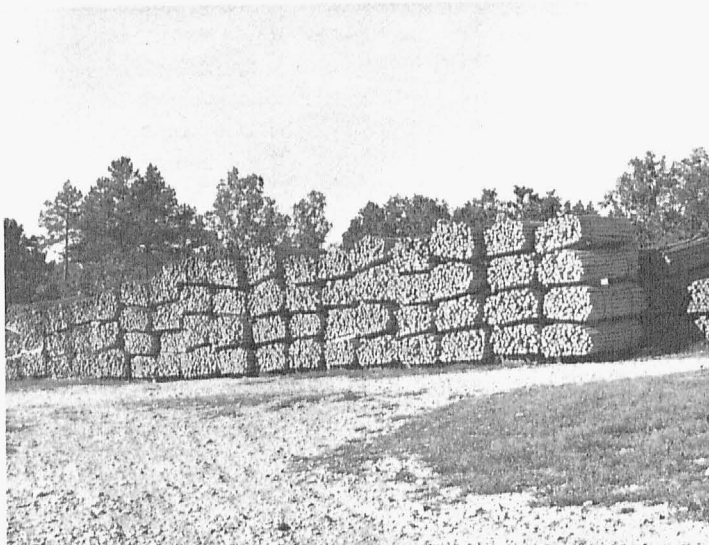


Fig. 82—Peeling posts and poles of shortleaf pine, palletized and ready for shipment to a wood preservation plant where they will be given the treatment necessary to assure many years of useful service without fear of rot or decay.



Sawmill Industry

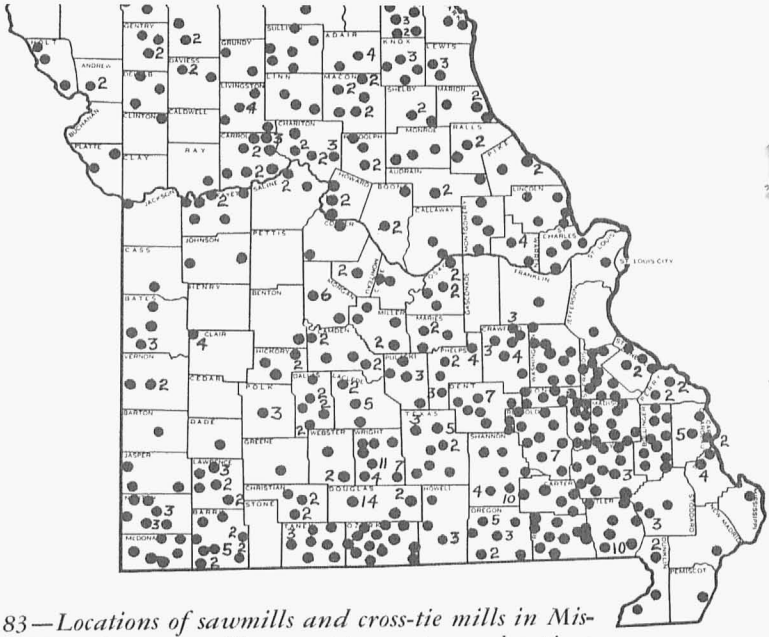


Fig. 83—Locations of sawmills and cross-tie mills in Missouri. More than one mill may appear at some locations.

Description and Contribution

The sharp ring of the axe, the rasp of the crosscut saw, and now the high pitched buzz of the power saw, coupled with the familiar cry of "timber" are symbols of the logging operation that goes hand in hand with the sawmill industry. Logging and milling are the main primary wood-using industries. Here the trees are felled, bucked into log lengths, and cut into rough lumber that goes to the numerous secondary wood-using plants.

The locations of some 1,000 active sawmills in Missouri are shown in Figure 83. The manufacture of railroad cross-ties is included with that of rough lumber for both are products of the sawmill. The industry is concentrated in the southeast portion of the state, excluding the bootheel. This region has been the center of the sawmill industry since Missouri was settled. The only difference between operations at the turn of the century and now is that sawmills located in the south central Ozark region were harvesting more shortleaf pine then. Today, the bulk of the species cut consists of hardwoods, mostly oaks, but includes some cottonwood and other species.

Of the 1362 wood-using plants covered in this bulletin, 1,000 are sawmills. Of the 1,000 sawmills, 917 employ 10 people or less. In fact, the total number of workers for the 1,000 sawmill operations is estimated to be only 4520. The annual payroll of part or full-time workers is estimated to be $4,550,000. The sawmill industry is largely seasonal, thus an accurate differentiation between part-time and full-time employees is impossible.

The amount of wood, including cross ties, handled by the sawmills in the state is approximately 206,725,000 feet. This amount excludes the wood reported for the other wood-using industries. Of this amount, hardwood species comprise 182,300,000 board feet. The remainder is comprised of softwood species, primarily shortleaf pine and some cedar. Gross product value for the industry is estimated at $20,000,000 annually Most of the lumber produced from Missouri timber by Missouri sawmills is consumed within the state.

Plants engaged in production of railroad ties are actually sawmills that produce quality side lumber while "squaring-up" a log suitable for cross tie (Figure 84) use. The cross tie industry in Missouri is an old one. It dates back to the start and subsequent phenomenal growth of railroading in America during the last century. Today Missouri's production equivalent to 40,000,000 BF of lumber annually represents 20 percent of the national cross tie output.

Production and Marketing

The sawing of logs or bolts into lumber is a familiar process to many. One sequence of techniques used to transform logs to lumber is discussed and illustrated in this section. A circular head-saw is used to square-up logs into "cants" (Figure 85). These "cants" (Figure 86) are then processed into lumber using a gang-saw (Figures 87-88). The use of a gang-saw for reducing squared logs, or "cants," into lumber has certain advantages over the use of more conventional band or circular saws; among these are a more rigid control of uniform thickness and, in some instances, a reduction is saw kerf and, hence, waste.

Other mills employ either circular (most prevalent) or bandsaws for reducing the log directly to lumber.

After logs are reduced to lumber, the boards are edged, trimmed, graded (sometimes), and stacked for air seasoning. The sorting and grading operation is shown in Figure 89. Air seasoning of rough (unsurfaced) lumber usually terminates sawmill operations; but in some instances, lumber may be kiln-dried and subsequently surfaced.

The annual quantity of lumber produced by sawmill operations in Missouri, not including that produced by secondary wood-using industries and that used in cross-tie production, is estimated to be 166,725,000 BF. The bulk of this is sold directly to the consumer with some going to wholesalers and retailers.

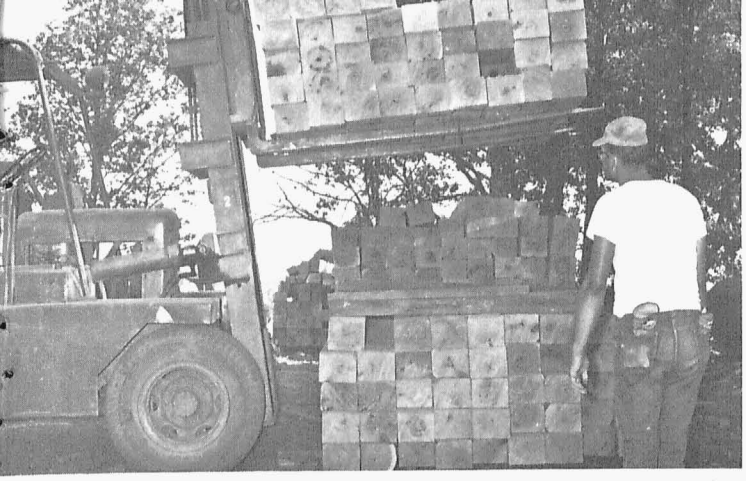


Fig. 84—A load of cross ties is stacked for air-seasoning prior to shipment to a wood preservation plant for final processing prior to seeing service somewhere on our nation's railroads.

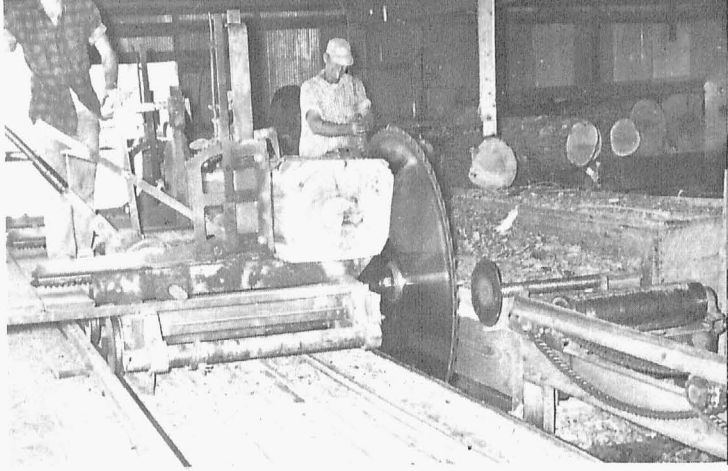


Fig. 85—A large oak log is squared-up on the circular head saw of a Missouri sawmill. The squared log, called a "cant," will be further processed into lumber on a gang-saw.

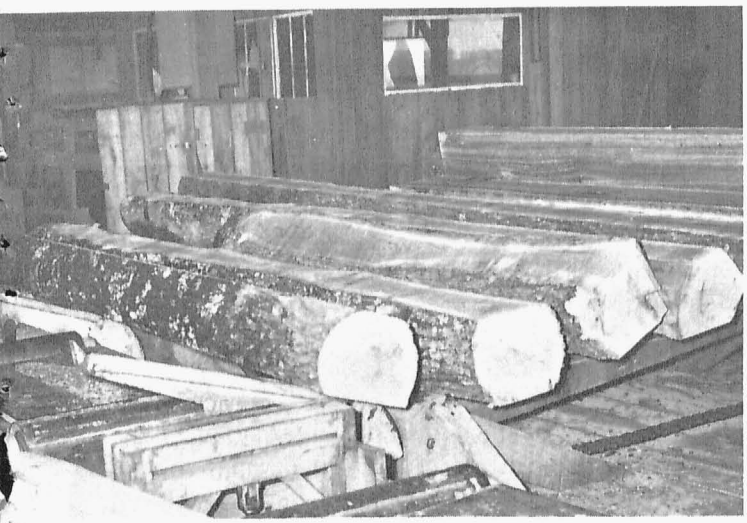


Fig. 86—"Cants" of high-grade oak awaiting processing into lumber on the gang-saw.

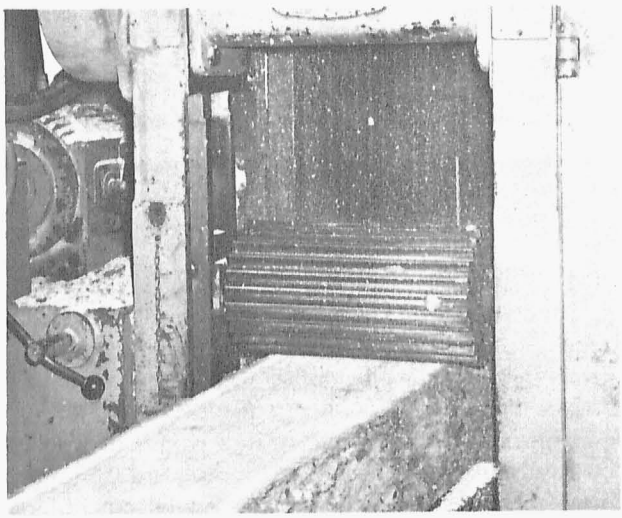


Fig. 87—Cant of block oak being fed into a gang-saw. In one pass through this machine the cant is sawn into one-inch lumber of uniform thickness.

Fig. 88—The cant emerges from the gang-saw as one-inch lumber. Note that the cant has been sawn into eight one-inch boards in a single operation.

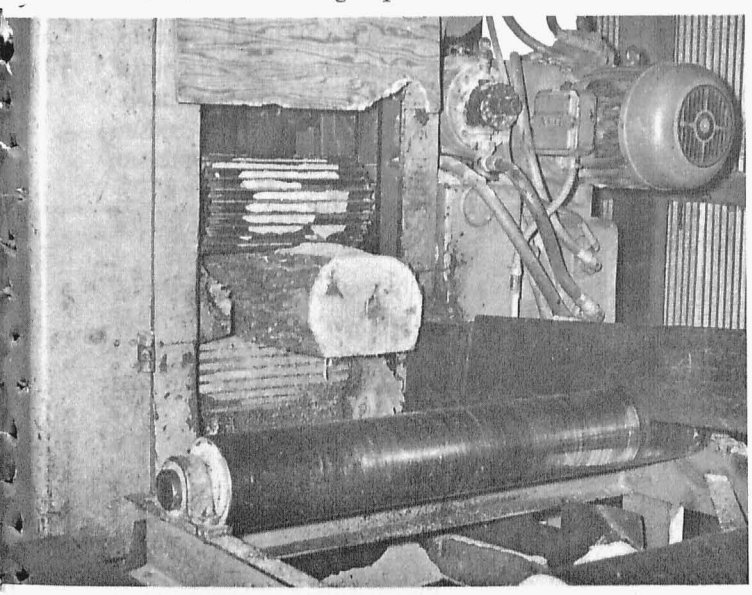
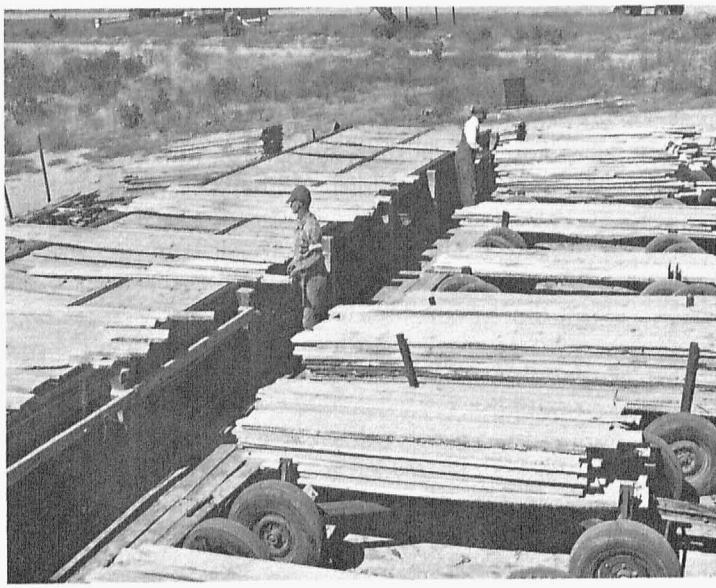


Fig. 89 — The final operation is sorting of freshly sawn green lumber by length, or other category, for a period of air seasoning on the yard.



Miscellaneous Wood-Using Industries

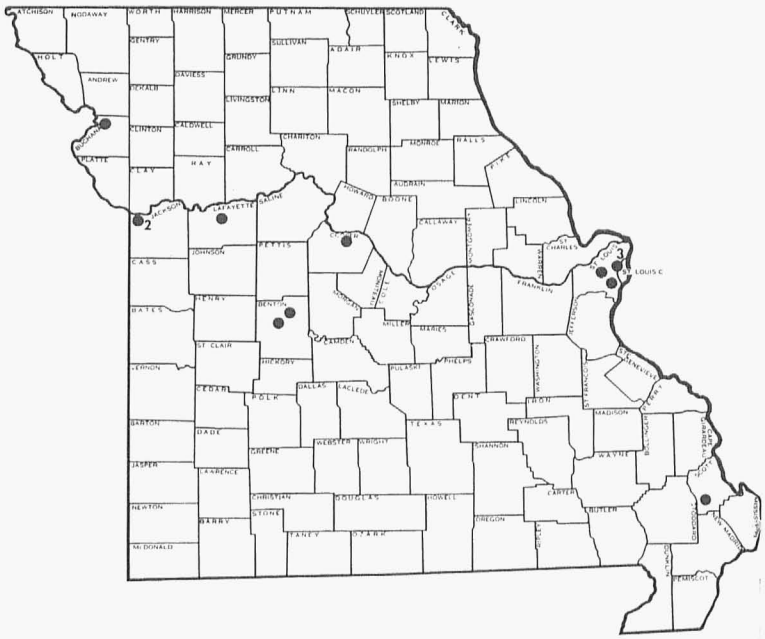


Fig. 90—Locations of miscellaneous manufacturers in Missouri.

Description and Contribution

Industries which did not fit the foregoing classification system were grouped in the miscellaneous category. Firms that were the only ones of their kind were included to prevent publication of their statistics.

Included are pulp mills, manufacturers of wooden boats, manufacturers of shoe lasts, hardboard fabricators, manufacturers of bee keeping supplies, producers of hickory and oak chips for meat processing and aiding in the fermentation of wine and other alcoholic beverages and several other operations. Locations of these industries are shown in Figure 90.

It is not known exactly how many miscellaneous wood-using industries there are. The following statistics are based on visits to 13 known operations. These 13 operations employ 713 people on a full-time basis. The payroll is estimated at $2,200,000 annually. The amount of wood consumed as pulpwood, lumber, or plywood is estimated at 5,600,000 board feet annually. This figure does not include some special uses of particle board, hardboard, and related items by some manufacturers. The gross product value of this segment of the wood-using industries is estimated at $7,875,000 annually. Of the total amount of wood consumed only 30 percent comes from the state of Missouri. The remainder comes from adjoining states or elsewhere and depends upon the type of product. Markets for products are local, national, or international. For example, most of the oak chips used in the aging and fermentation of wine are shipped abroad. Both production and custom made boats are produced in Missouri for national and international markets. On the other hand, the market for shoe lasts is mainly Missouri's shoe industry.

Production and Marketing

Production details on plants included in this category are beyond the scope of this bulletin. Only the details of the production of building or insulation board are discussed and illustrated in this section.

At present the pulping industry in Missouri is limited to manufacture of fiber or insulation board. Processing of this type of pulp is not as involved or costly an undertaking as the manufacture of conventional, more purified, chemical pulps (i.e., sulfite or sulphate). The operation starts with hardwood bolts (Figure 91) which in some instances must be split (Figure 92) prior to chipping (Figure 93). Chips are reduced, along with waste paper and board usually composed of coniferous fibers. After wax and asphalt are mixed in, the stock proceeds to wire (Figure 94). The mat of fibers (Figure 95) is pressed, cut (Figure 96), and dried. The board is packaged (Figure 97) and either stored or shipped (Figure 98) to the consumer.

Conventional pulpwood chippers are used to produce oak or hickory chips from lumber or reject staves. Oak chips used in the fermentation process are "toasted" in automatic gas-fired ovens. "Toasted" chips, like charred barrels, absorb unwanted esters and organic acids given off during the fermentation of wine or whiskey.

Hickory chips are used by meat processors in curing and smoking operations.

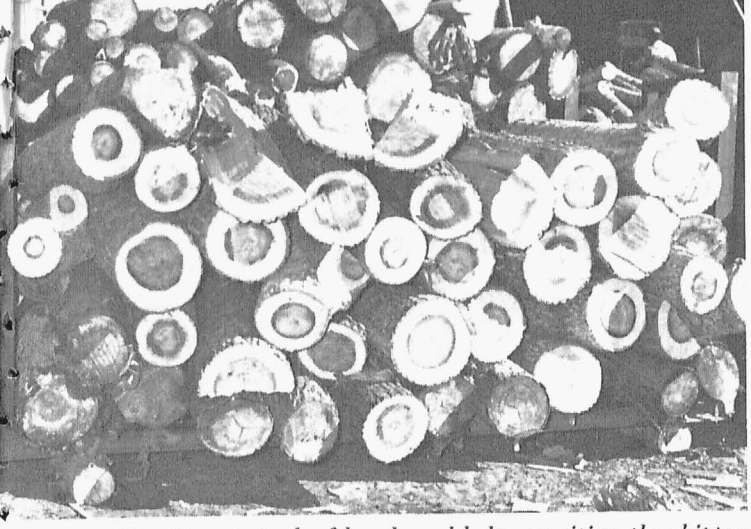


Fig. 91—A stack of hardwood bolts awaiting the chipper in a wood pulp operation. Notice the metal jig which permits easy storage and handling of the wood.

Fig. 92—Some bolts, too large for the chipper, are split on this machine into two or more pieces.

Fig. 93—An operator throws a bolt of wood into the chipper. In a matter of seconds the bolt is reduced to chips and conveyed to the next step in pulp manufacture.

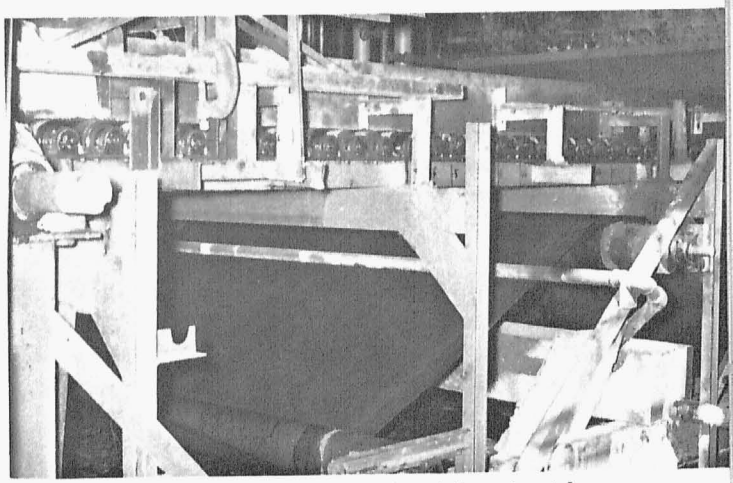


Fig. 94—The start of board formation. The wire (shown more clearly at the bottom of the picture) accepts pulp stock (slurry), retains the pulp fibers, and allows the water to pass through and drain off for reclaiming or sewage disposal.

Fig 95—A freshly formed mat of fiber board immediately after formation on the wire. The board now passes through a series of rolls to remove a large portion of water prior to being cut into lengths and dried.

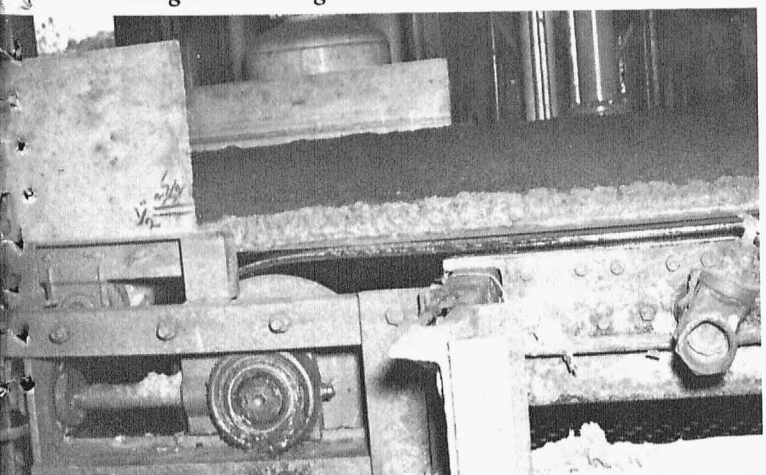
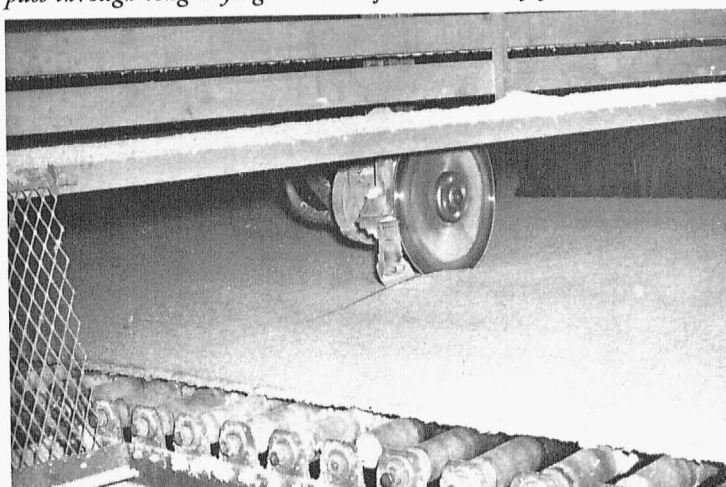


Fig. 96—The continuous mat of wet pulp is cut into desired lengths by this automatic cut-off saw. The pulp mat of this stage contains large quantities of water and must pass through long drying tunnels before it is ready for use.



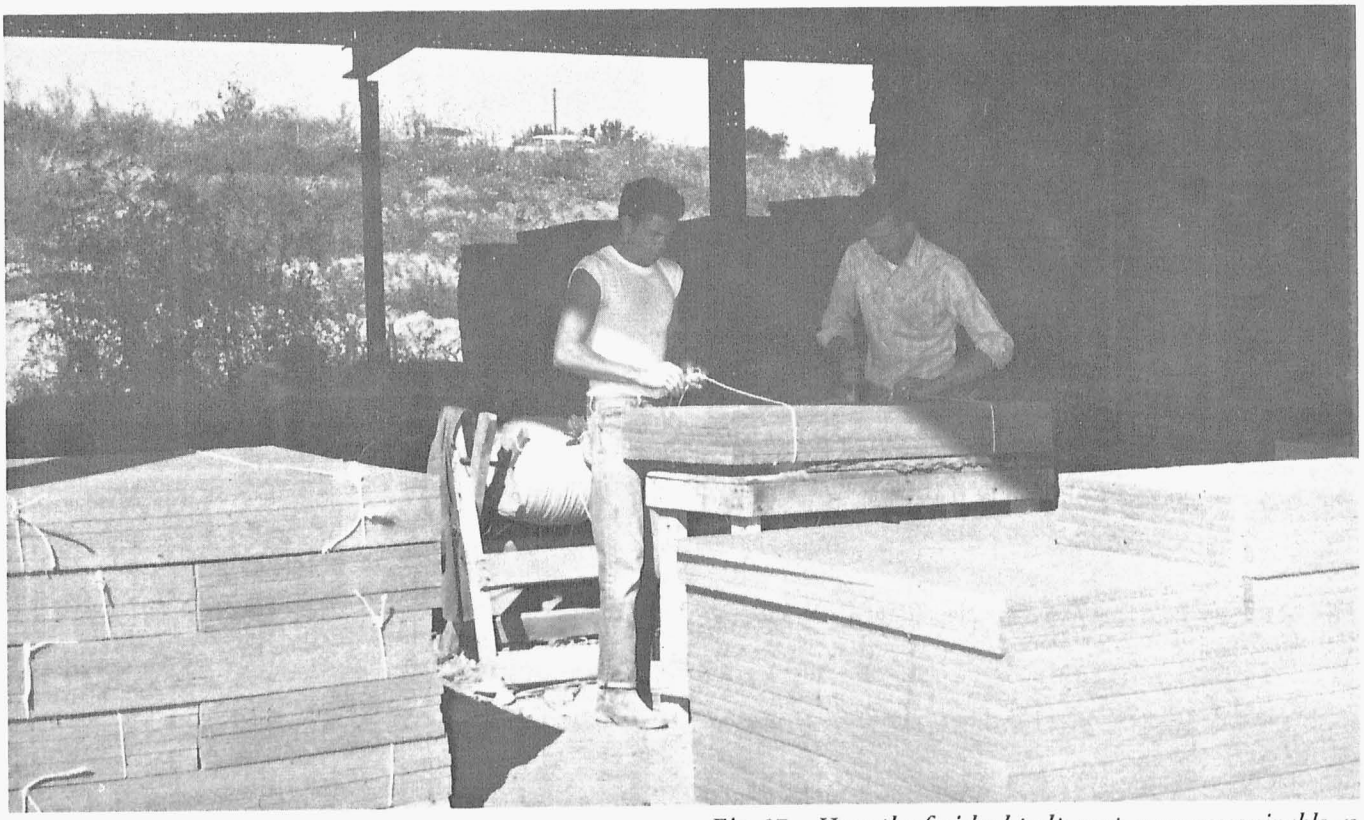


Fig. 97—Here the finished pulp mat, now recognizable as building or insulation board, is packaged and palletized for shipment.

Fig. 98—A truck-load of board being readied for shipment. Output from this mill is used in building construction both within and adjacent to Missouri.

Industry Problems and Suggested Areas of Research

From the foregoing data on Missouri's wood-using industry, from numerous discussions with industry leaders and personnel of state and federal agencies and other people interested in Missouri's economy, a number of challenging problems that confront our wood-using industries have become apparent. The solution of these problems could increase both efficiency of use of Missouri's forest resources and profits of industries which rely on the forests for their raw materials.

These problems may be attacked through three general channels: (1) Extension efforts of the University of Missouri Forestry School, U. S. Forestry Service, and Missouri Conservation Service, which may be defined as the process of alerting industry to practical research results and assisting industry to use these research results, (2) technological research on the physical and chemical properties of wood itself or research on production techniques to effect a higher quality product or more efficient wood utilization, and (3) the improvement of existing marketing techniques to achieve more efficient and profitable sale and distribution of Missouri's forest products.

Extension

The logical starting point to achieve more profit and better utilization of our timber resources is through extension work. Of Missouri's 1362 wood-using operations, 1108 employ only 10 people or less (Table 1). Only four categories of manufacturers do not have such small scale operations. All other industry classifications had many small operations and this "10 employees and under" size-class was the largest (as far as number of operations) for 10 of the 15 industry classes.

Many small operations need assistance in such problem areas as increased efficiency in plant layout, information on where and how to buy their raw materials, adequate technical knowledge of their raw material, and knowledge of marketing techniques and market possibilities for their finished product. The dissemination of information on research practices based on research is primarily the role of extension workers trained in wood products. The School of Forestry, the U. S. Forest Service, and the Missouri Conservation Commission are all aware of this problem and have men on their staff who devote full time to extension work in wood technology and wood products, including marketing.

It is not implied that extension work should be limited to small-size operations. Large businesses could benefit from extension efforts aimed at increasing employee efficiency through short courses or related programs. Modern production and marketing techniques, new research in these areas, and related subjects can best be transmitted to the industry through such programs. Production techniques have never been subject to more changes and evaluations than they are today.

Large businesses are usually able to absorb the cost of sending key personnel to short courses conducted at the University or elsewhere. Small businesses may find this a hardship. Short courses provide operators with the opportunity to exchange thoughts on production or marketing as well as expose them to a concentrated and thorough educational program. The small businesses may be served best through individual visits by extension personnel.

Research

Research can be subdivided into applied research and basic research. Applied research is the use of existing techniques or methods to solve a particular problem. The techniques are the result of past research and experience.

Basic research may be defined as work on a problem which has not been successfully solved before, primarily due to the lack of adequate methods or techniques available to conduct the work.

Examples of Applied Research

The following is an example of applied research, of a short-term nature, done by the School of Forestry. The problem was concerned with measuring a given amount of substance "X" in a manufacturer's finished product. As procedures for the measurement of this substance had been reported in publication of past research, existing techniques were adapted to the manufacturer's problem. A procedure suitable for analysis of his product along with information on the cost, procurement, and operation of equipment necessary to conduct his own quality control work was prepared and given to the manufacturer.

For an example of long-term applied research, the following is taken from an area of work which has not yet been completed. A manufacturer needs a suitable finish

for his wood product. The problem is complicated by the quantity and properties of extraneous substances present in the species of wood he processes. Since his plant is not large and is unequipped for research he has turned to the University staff for help. Since the work concerns not only the application of various wood finishes but also their evaluation in service, this project may be defined as applied research of a long-term nature. The School attempts to maintain flexibility in its program to accomodate research of similar nature when contacted directly by industry or through other agencies.

Basic Research

The definition of basic research implies that a minimum of five years of work are usually necessary to yield significant results. Research methods must be explored and developed and suitable data obtained for analyses. It is desirable that any basic research undertaken by the School of Forestry be designed for Missouri's forest problems, as well as to supplement work by other states or research agencies of the Federal Government. The research should not duplicate work of these agencies. Certain examples of basic research which might benefit Missouri's forest economy are discussed in the following paragraphs.

Although statistics describing the wood-using industries and the timber resources of the state are available, data on growth-quality relations for Missouri's more important commercial species are lacking. Growth-quality studies measure and interpret certain physical and chemical properties of wood structure in terms of various end uses of wood or wood fiber. Most of the data on the physical and strength properties of black and white oak species were obtained when the science of wood technology was young. No attempt was made to relate wood properties to the conditions of tree growth or possible future wood uses. This also prevails for chemical analyses of amounts and distribution of cellulose, lignin, and other chemical components of wood.

Since World War II, emphasis in wood technology has broadened to include the influence of factors of tree growth on various wood properties. It follows that research in this area is not limited to the field of wood technology; in fact, a desirable research program would embrace the fields of tree genetics, silviculture, forest pathology, tree physiology and other disciplines. Information gathered from such integrated research would have many applications, not the least of which would be the establishment of a firmer foundation for scientific forest management. The end result would be an improvement in the quality of the growing forest resources and improved utilization. Such research is especially needed for the hardwood species which comprise the bulk of Missouri's forest resource. Among the hardwood species which need particular attention are various members of the red oak group such as black and scarlet oak which comprise the largest percentage of Missouri's oak resource. Research, along a similar vein, is needed for the coniferous species such as shortleaf pine and eastern red cedar.

Wood-moisture relations data for the various commercial tree species is another type of information that basic research can yield. The long-term objective of such research would be to improve seasoning practices. Perhaps the development of new seasoning techniques could provide for more uniform moisture control, decrease in the seasoning time, or reduction in amount of loss caused by seasoning practices, which in some instances is reported to run as high as 15 to 20 percent.

Determining the cause of shake which may be related to seasoning practices and wood structure is another field for basic research. The red oak group is particularly plaqued by this defect, particularly in some areas of the state. Shake also occurs in black walnut, but it is believed to be less extensive in walnut than in the red oak group. The high value of walnut makes any loss through defect serious, however. The first phase of this work would be to determine the extent of shake. The second phase of research would be to determine its cause(s). Finally, protective and preventive measures would be sought.

The foregoing areas of investigation—growth-quality studies of the commercial species, wood-moisture relationships, and cause and occurrence of shake—are examples of basic research needed to aid Missouri's wood-using industries.

Investigation of wood-residue utilization, involving both basic and applied research, could yield results of great significance to Missouri's economy. This has long been a favorite area of research everywhere. Wood residue, in its broadest sense, can be defined as defective tissue in the growing stock such as decay, firewounds, shake, spiral or twisted grain, and other abnormalities not associated with sound wood, plus material currently left as a result of manufacturing processes. Examples of this latter form of residue are excessively knotty tissue, sawdust, edging and reject items (result of mis-manufacture).

During this study describing Missouri's wood-using industries, data were collected on the amount and form of wood residue for the various industry categories. It soon became apparent, however, that incorporation of these statistics would be meaningless because of their inaccuracy. Only a few operations have sufficient data to characterize the waste involved in their operation. In addition, numerous forms of waste were encountered. The range in volume of waste reported by firms manufacturing similar products was too great to allow the inclusion of such over-all statistics on the amount of wood residues

in Missouri. Certain statements are in order, however, and will be made to clarify this problem.

The charcoal industry enjoys relative freedom from waste. However, losses in this business through handling and transportation reportedly range up to five percent.

Another industry relatively free of the wood-residue problem is the post and pole industry where waste is limited primarily to bark (as far as processing is concerned). The gunstock industry, on the other hand, may have losses ranging from 30 to 85 percent, depending upon the type of operation. The smaller figure is associated with the preparation of walnut gunstock blanks; the larger figure is representative of the manufacture of the semi-finished or finished stock. Industries in which a large amount of waste or loss is unavoidable compensate for this problem by increasing the price to the customer.

The greatest range of wood residue volume was reported by the miscellaneous firms. Since this category included many different industries, it is not surprising that the amount of waste reported ranges from 2 to 75 percent of raw material consumption, dependent upon the operation.

Technological research has provided a number of uses for various wood residues. Examples include debarking of slabs from sawmill operations for use in pulpmills, the use of chips in the formulation of various particle boards, and the exploitation of the beauty of certain natural wood defects for use in wood paneling and trim (wormy cypress and knotty pine). The establishment of a large chemical plupmill in Missouri and/or an increased need for particle and composition board products could alleviate some of the wood residue problems.

Marketing

To improve marketing practices for Missouri's wood-using industries more detailed knowledge is needed of local marketing procedures and techniques as used by the various industries. Marketing techniques have been mentioned briefly in descriptive sections of this bulletin but data are insufficient to adequately describe the over-all marketing structure of Missouri's wood-using industries.

The data we have indicate that some industries have formed more or less informal cooperatives among themselves to handle the sale and distribution of their products. Such techniques are beneficial to the operations involved and it is quite possible that other groups of industries could benefit from such marketing techniques.

One stumbling block in the effective use of informal cooperatives is the lack of general quality control standards for various segments of the industry. This condition results in a wide range of product quality. It is possible that extension and research efforts could alleviate this situation, resulting in a firmer basis for the formation of either formal or "loose" cooperative marketing practices.

The foregoing suggestions for improvment of marketing conditions are based primarily on the size-distribution of the wood-using industries. Such small-size operations tend to benefit most through formation of workable marketing cooperatives.

Summary of Problem Analysis

Managers of wood-using industries can improve the quality of the product they produce and their profits if they will apply more fully the information already available from research. The extension program in timber utilization and marketing can help to solve this problem by teaching improved plant layout and efficiency in production techniques.

Research must continue to provide information not now available. Emphasis should be placed on growth-quality relationships, wood-moisture relationships, utilization of wood residue, and marketing techniques. With limited personnel and facilities, major emphasis should be placed on basic research, but the opportunity to use the knowledge gained from basic research to develop some limited areas of applied research should not be overlooked.

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Appendix

Survey Methods and Extent of Industry Coverage

Statistical data presented were obtained from a variety of sources and through the efforts of many people in private industry and agencies of the state and federal governments. Of the 1362 operations for which data are given, 476 were studied through each of the following means: Questionnaire, correspondence, and personal contact. For the 1000 sawmills in Missouri, 357 were evaluated by Richard C. Smith, of the School of Forestry, and his graduate students. The author contacted 20 of the larger sawmills in the state. Of the remaining 361 plants, exclusive of sawmills, the author visited 98.

The time period for the above work was from 1960 through September 1963; many operators were contacted two or more times and changes in the industry were noted. Data given, in all instances, are estimates of the averages for the industry over this three-year period. Among operations visited two or more times, the range in quantity of wood used and annual gross product value over the three-year period varied from five to 15 percent. On the other hand, the number of employees and number of firms in any given industry remained more or less constant.

Statistical Summary

Statistical data presented in this bulletin have been combined and tabulated for comparative purposes in Tables I, II, III. Quantities of wood consumed by all industries are expressed in units of 1000 board feet despite the fact that several industries do not normally employ this unit of measure. Board feet was used to facilitate industry comparisons. The use of annual gross sales for estimating the contribution of a given industry to Missouri's economy is a conservative mea-

TABLE I - ESTIMATES OF THE TOTAL NUMBER OF OPERATIONS, NUMBER OF EMPLOYEES, AND DISTRIBUTION OF SIZE OF OPERATIONS BASED ON NUMBER OF EMPLOYEES FOR THE INDICATED CLASSIFICATION OF WOOD-USING INDUSTRIES OF MISSOURI

Industry Classification (with subclassification where used)	Number of Operations	Number of Employees	Distribution of Operations Based on Number of Employees				
			0-10	11-25	26-50	51-100	101-300
Charcoal	64	620	38	20	3	2	1
Cooperage	29	630	19	4	3	1	2
Dimension Stock	18	440	8	6	3	-	1
Flooring	9	(14 mills) 650		1	3	3	2
Furniture & Millwork							
Furniture	20	295	13	5	1	1	-
Millwork	96	1,713	50	30	5	11	-
Gunstock	4	193	--	2	2	--	-
Handlestock	12	251	7	-	3	2	-
Novelty							
Cedar	17	395	6	5	4	2	-
Walnut	3	63	-	1	2	-	-
Pallet & Container							
Pallet	39	610	22	11	5	1	-
Container	6	235	-	2	2	2	-
Post, Pole & Piling	31	285	25	2	4	-	-
Sawmill (including cross-tie manufacture)	1,001	4,250	917	77	3	4	-
Miscellaneous 1/	13	713	3	1	5	1	3
TOTALS	1,362	11,343	1,108	165	48	32	9

1/ This category does not necessarily include all operations that could be so classified; data apply to only the thirteen contacted manufacturers and no data have been projected for entire state estimates as was done for some other classifications.

sure. However, to estimate value of a given product at the retail level appeared unrealistic, if not impossible, for many industries.

The number of firms, number of employees, and size of plant based on number of employees are presented in Table I. Table II shows the total number of employees, annual payroll, and annual product value expressed as gross to manufacturer. Annual payroll estimates were made prior to the increase in minimum wage effective September, 1963. The kinds of wood used, amounts of wood used, amount estimated as being grown in Missouri, and the range of purchase prices paid for wood by the various industries are given in Table III. The wide range of purchase prices for raw materials in most industries prohibited the use of meaningful average values.

TABLE II - ESTIMATES OF NUMBER OF EMPLOYEES, ANNUAL PAYROLL, AND PRODUCT VALUE EXPRESSED AS ANNUAL GROSS TO MANUFACTURERS FOR VARIOUS CLASSES OF WOOD-USING INDUSTRIES OF MISSOURI

Industry Classification	Number of Employees	Annual Payroll (thousand dollars) 1/	Product Value Expressed as Gross to Manufacturer (thousand dollars)
Charcoal	620	1,810	4,800
Cooperage	630	1,757	8,250
Dimension Stock	440	1,130	4,650
Flooring	650	2,050	7,600
Furniture & Millwork	2,008	7,159	22,025
Gunstock	193	790	3,550
Handlestock	251	668	1,090
Novelty	458	963	3,325
Pallet & Container	845	1,800	5,485
Post, Pole & Piling	285	780	6,060
Sawmill (including crosstie)	4,250	4,550	20,150
Miscellaneous	713	2,200	7,875
TOTALS	11,343	25,657	94,860

1/ Estimates based on data taken prior to increase in minimum wage effective September, 1963.

TABLE III - ESTIMATES OF DIFFERENT WOOD SPECIES USED, ANNUAL QUANTITY OF WOOD USED, PERCENT OF WOOD FROM MISSOURI, AND RANGE OF PURCHASE PRICES PAID FOR WOOD BY CLASSES OF WOOD-USING INDUSTRIES OF MISSOURI

Industry Classification (subclassification if used)	Wood Species Used	Quantity (Expressed as 1000 BF) 1/	Amount from Missouri (percent)	Range of Purchase Price (dollars/1000 BF) 2/
Charcoal	Oak, hickory and most other hardwoods	54,950	100	11.60 - 18.80
Cooperage				
tight	White oak	27,750	95	87.00 - 93.00
slack	gum, elm, ash, sycamore and other hardwoods	850	60	26.00 - 58.00
Dimension stock	Pine, cedar, oaks, hickory, gums, cottonwood, walnut, cherry, ash, maple, others	16,800	40	40.00 - 285.00
Flooring	Red oak, white oak, pine	83,375	75	52.00 - 60.00
Furniture & Millwork	Oaks, walnut, maple, gum, cedar, cottonwood, pines, and others	26,800	20	80.00 - 300.00
Gunstock	Walnut	7,985	60	120.00 - 500.00
	Maple	1		1800.00 - 2000.00
	Myrtle	1		2500.00 - 3000.00
Handlestock	Hickory, gum, ash	3,711	40	50.00 - 150.00
Novelty	Cedar, walnut, pine	2,339	90	100.00 - 150.00
Pallet & Container	Oaks, cottonwood, maple, pine, hickory, sycamore, gum, and others	60,939	70	30.00 - 70.00
Post, Pole, & Piling	Oaks, pine, cedar	23,850	90	6.75 - 35.00
Sawmill (incl. cross-tie)	native softwoods	24,420	100	5.00 - 45.00
	native hardwoods	182,305		
Miscellaneous	Oak, pine, maple, and most other species	5,568	30	15.00 - 275.00
TOTALS				
Including sawmill		521,769	83.8	
Excluding sawmill		315,044	73.1 3/	

1/ Many industries do not use Board Feet (BF) as their unit of measure; for example charcoal manufacturers buy wood by the cord, posts and poles are bought by the piece. For comparative purposes all data have been translated into board feet.

2/ Variation in price prohibits establishment of an average price figure; again data have been translated into cost per 1000 BF for comparative purposes.

3/ Exclusion of sawmill and cross-tie data give fairer picture of the amount of Missouri wood used b y secondary wood-using industries.