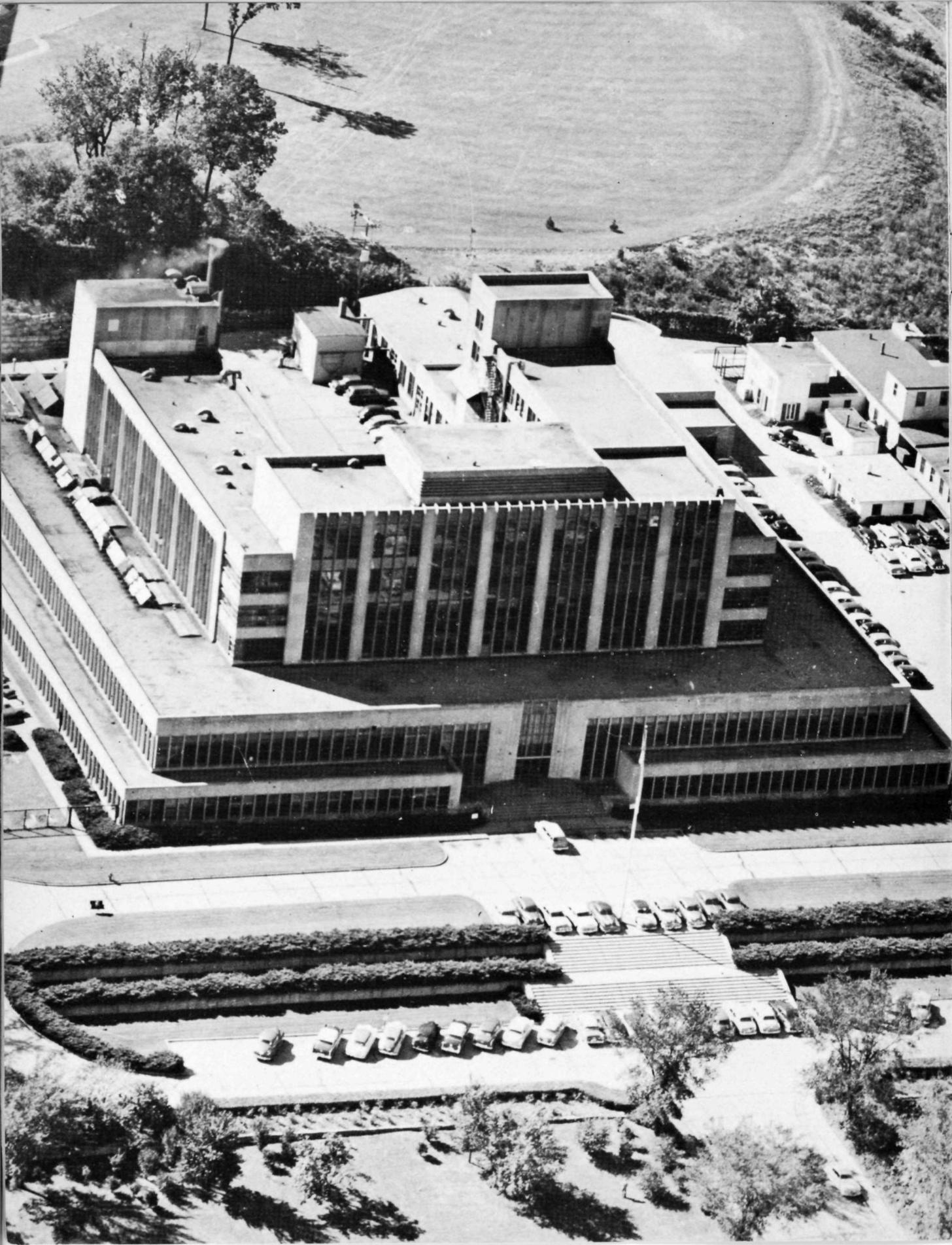


# PRODUCTS OF AMERICAN FORESTS

MISCELLANEOUS PUBLICATION NO. 861

U.S. DEPARTMENT OF AGRICULTURE  
FOREST SERVICE

PRODUCTS OF  
AMERICAN FORESTS



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With the University of Wisconsin

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## Importance of Forest Resources

The forest is a perpetual source of wood and other tree products that are vital to American well-being. The forest collects and regulates the flow of water needed for domestic and industrial uses. It provides a home for fish and game, and offers outdoor recreation to those who wish to retreat from city pressures. Within and about the forests are open areas where livestock can be grazed.

This publication deals only with wood and other crops that come directly from trees. It describes the forest materials in general groups and points out their many uses. While the account is far from complete, particularly with regard to fabricated and manufactured articles of wood, the examples presented are intended to outline the major types of utilization and throw some light on groups of products that are often overlooked. Accordingly, familiar products such as lumber and plywood, which are fully described in numerous books and trade publications, are mentioned but briefly, whereas walnuts, maple sirup, and essential oils are treated in more detail.

From an early day the use of forest products in this country has been on a scale that probably has never been equaled elsewhere. Forests provided the pioneers with most of their basic necessities, even when the trees were being cleared away as obstacles

The American housebuilding industry, based on wood, is fundamental to the market for important classes of manufactured goods such as furnishings and appliances.

to agriculture. They continue to pour out a great tide of fiber without which our present high standard of living could not be maintained.

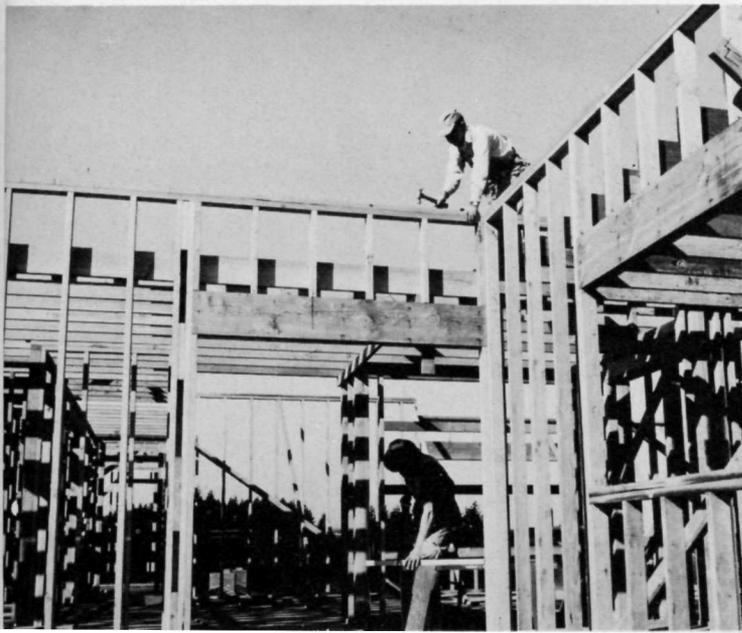
In this pattern of comfortable living the average American uses, one way or another, 65 cubic feet of wood in a year. This is 50% more than the citizen of timber-rich Russia uses and 3½ times as much as the Englishman. Not all of this wood is in the form of lumber, of course, but lumber is the largest item. About 1 out of every 20 employed persons in 1958 obtained his living in some phase of timber production and fabrication. In that year the timber industries accounted for about 1 dollar in every 18 of the national income—a total of about \$25 billion.

Lumber used for housing is the most vital forest product. The success of builders in their efforts to provide about 1½ million or more new houses per year will depend largely on a continuing use of wood. Wood will continue to be used because it is highly efficient as a construction material, craftsmen are familiar with it, and houses built of wood can be repaired and remodeled at a low cost. Closely related to plentiful housing is the use of forest products in the manufacture of house furnishings, which also make up a large part of our total industrial effort.

When the homeowner uses imagination in designing a fence of lumber, a feeling of privacy is created without a shut-in atmosphere.

M-115745

M-118238





M-118208

The importance of the farm woodlot as a source of forest products cannot be overestimated. More than a third of all commercial forest land in the United States is owned by farmers.

The normal economic and cultural activities of the United States also require large amounts of wood fiber pulp. The average American now uses 514 pounds of paper products annually. Fifty years ago he used 93 pounds. Europe now uses 84 pounds per capita. Latin America now uses 18 pounds per capita. Asia now uses 13 pounds per capita. Large quantities of woodpulp are used in the distribution and marketing of products—in the form of durable shipping containers and the glamorous shelf package. Outside the market place woodpulp is the principal raw material for the printing and publishing industry with its scores of textbooks, journals, and literary works.

The use of paper and board is almost certain to expand radically with development of its use for structural purposes. Its production and development are aided by much careful research and its products may be depended upon to serve well in new as well as older uses.

## Wood—The Material

Although woody material is found in many plants, wood is produced by nature in its most familiar form in the trunks and limbs of trees. The chlorophyll in the leaves of trees uses the energy of sunlight to make starches, sugars, and cellulose from carbon, hydrogen, and oxygen. The three elements—carbon, hydrogen, and oxygen—come to the tree in the form of carbon dioxide from the air and water and minerals from the soil. As a result of its own chemical processes, a tree is about 50 percent cellulose



M-32606-F

Wood pulp is the raw material for the daily newspaper which, for the average citizen, is his most important source of education.

This is a part of the picture of wood in America—but only a part. Wood is also of great importance as a raw material in industrial construction and in the railroad, mining, and power industries. The American farmer has always been both a great producer and a great user of wood. He benefits from communities based on the forest industry because here he can sell his produce and often find a job in winter.

To meet the great and growing needs for forest products there is a total area of nearly 510 million acres, about one-fourth of the continental United States, that is either in forest or suitable for growing timber for commercial use. These forest lands ought to be managed so that enough timber of high quality is furnished to meet the Nation's needs. Proper management of forests is the responsibility of many ordinary citizens because for every forest owned by an industrial company there are nearly 150 woodlands owned by farmers and other individuals.

and between 20 and 30 percent lignin, a cementing material between the cellulose units. The rest of the wood in a tree consists of extractives and various carbohydrate materials.

Extractives are materials, like those that give the red color to redwood, that can be soaked out with water or other solvents.

The chemist's symbol for cellulose is  $C_6H_{10}O_5$ . This symbol little indicates the complexity of the

cellulose molecule or the variety of ways in which the carbon, hydrogen, and oxygen atoms can be separated and reassembled into useful materials. Chemical conversion offers the possibility of using the edible sugars from wood as food, of using all of the wood-sugar groups to fabricate a wide range of industrial chemicals, and of growing yeasts that might be cultivated as sources of protein, fats, and vitamins. By altering the cellulose molecule to chainlike proportions, it is possible to produce plastics that can be spun into textile fibers for clothing or molded in an almost limitless variety of plastic articles. The wood fiber is also the raw material from which most pulp and paper are made.

The way wood is put together gives the strength that enables it to be used in many familiar articles. Wood fibers are very small. In the needle-leaved trees they are about one-seventh of an inch long and seven-thousandths of an inch thick. In the broad-leaved trees they are even shorter. Every fiber is almost pure cellulose, and the fibers are bound together tightly by a strong, nonfibrous sheath of lignin to make the light, strong, resilient material we know as wood.

Wood is light in weight. A man can easily handle the boards and planks that make up most of the normal units of construction. Modern building panels, factory made for quick erection of houses, can be made to weigh as little as 2 to 6 pounds per cubic foot, complete with insulation.

Lightness would not be important if it were not combined with strength. Weight for weight, wood has a tensile strength—that is, resistance to forces trying to pull the material apart lengthwise—equal to that of steel. This property is not very important

in practice, since it is difficult to take advantage of the full tensile strength of wood because of the limitations of fastenings. But compressive strength is a most useful form of strength, because it can be fully used and it has many practical applications. A piece of wood 12 inches long and 2 inches by 2 inches in cross section will sustain endwise pressure of 40,000 pounds before failing.

Wood has high strength under a wide range of conditions. In most strength properties, dry wood is stronger than wet wood but wet wood is tougher. Wood heats so slowly that it does not change strength rapidly when the surrounding air temperature is raised suddenly, nor does it lose strength at very low temperatures. Tests have shown that wood is stronger at 300 degrees below zero than at 70 degrees above zero.

The special properties of wood make it the favored material for cooling towers, which are employed in air conditioning installations, power generation, and many other industrial activities in which water must be cooled.

The elasticity of wood is important in many uses. Under the loads imposed by severe winds or the shock loads in earthquakes, its elasticity permits wood to bend and then to spring back without breaking.

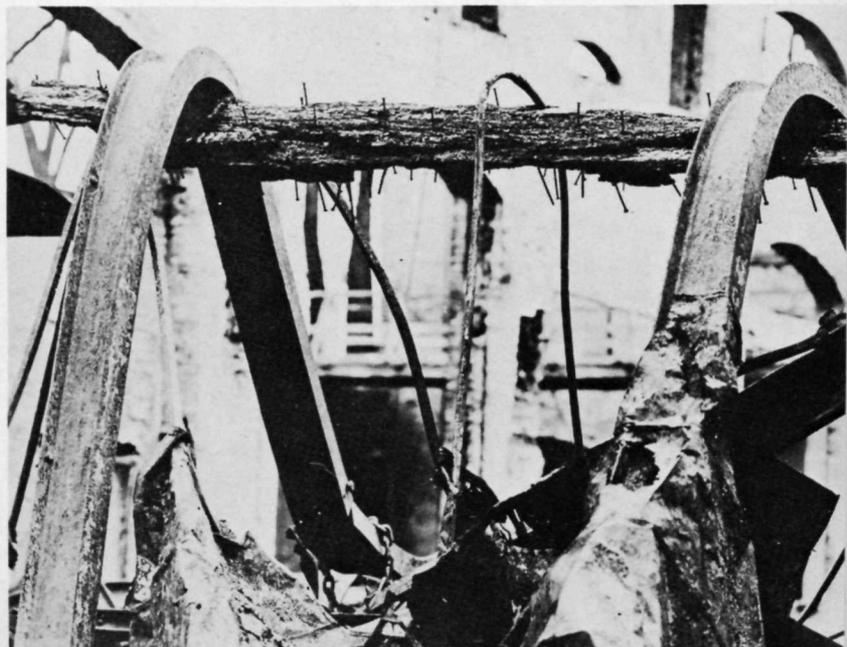
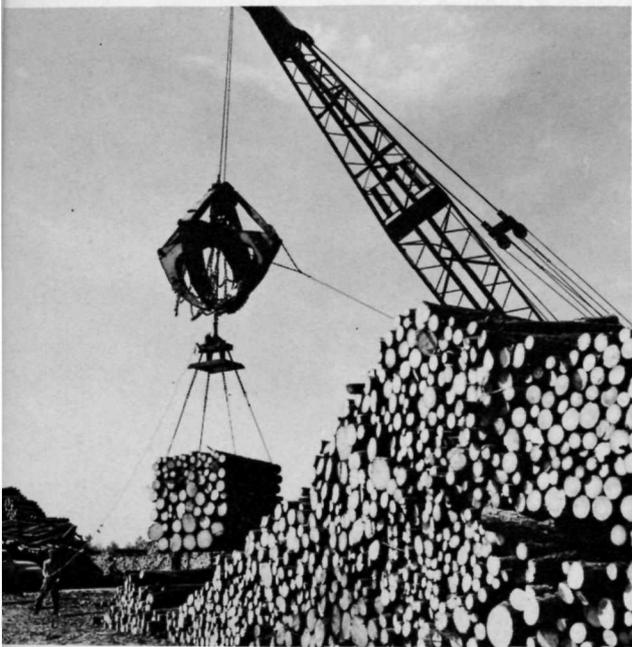
Wood is warm to the touch because it does not quickly conduct heat from the hand; it is a good insulator. In furniture and interior trim in the home, wood invites rather than repels the user's hand. Even in structural uses the insulating quality is an asset, for wood contributes greatly to the heat-retaining quality of any wall of which it is a part. For example, 1 inch of Douglas-fir in a wall resists

Wood, the most abundant and compact source of cellulose in the plant world, is the raw material for the ever-growing pulp and paper industry.

F-497015

Heavy timbers resist fire, sometimes with better load-carrying success than associated materials.

M-95256-F



the loss of heat as well as 12 inches of concrete or stone. The common brick meets its match in the so-called inch board, which is as good a heat retainer with its  $\frac{25}{32}$  of an inch actual thickness as is a brick 4 inches thick.

The resistance of wood to heat transmission is sometimes shown by the behavior of large timbers in a burning building. Large beams or posts char slowly (at an average rate of about 1 inch in 40 minutes). But the char has such a high insulating value that the inner core of wood has some protection from fire temperatures. Heavy wood timbers

fight their own delaying action against fire. They do not soften and deform suddenly at high temperatures.

Wood is readily worked with handtools and can be joined by simple fastenings or by gluing. It can be used in construction by both the skilled amateur and the seasoned craftsman. Because pieces of wood can be joined by common nails, simple construction with wood is within the reach of millions who have none of the skills that are needed for working with other materials.

## Solid and Composite Wood Products

### House Construction

Three-fourths of all houses erected in the United States are of the wood-frame type. The traditional frame house has a record of long service. Many thousands of houses in the United States are over 100 years old. A high percentage of these, adapted to modern living by installation of central heating and other refinements, would be described by the present occupants as affording ample comfort and serviceability, and more room than is usually found in the modern house.

In recent years there have been vigorous new trends in the construction of housing. Over 85 percent of the new houses are one-story houses, and nearly half are without basements and built on

concrete slabs rather than old-style foundations. In 1967 the area of living space per house was reported at over 1,600 square feet, showing that average living space has increased 30 percent in the past decade.

Much housing has been erected on a mass basis; hundreds of houses have been built by a single contractor on a large site. This mass construction has resulted in savings—those from the mass production of standardized units and those from the work saved in erection.

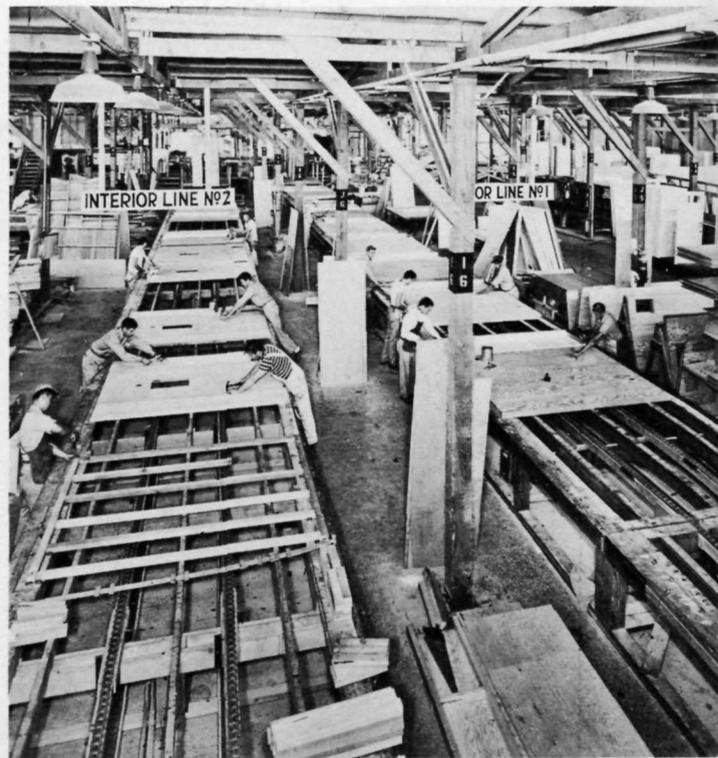
Factory prefabrication of houses and house components has become established to a degree. This type of production offers the possibility of carefully engineered design, although methods vary from

A reminder of wood's great durability. This house in Concord, Mass., was considered old when Ralph Waldo Emerson bought it about 125 years ago.

M-70019-F

In a house prefabrication plant modern mass production technique is used.

M-25643-F





The prefabricated house of today cannot be distinguished from its custom-built counterpart.

M-115747

plant to plant. In addition, over 300,000 mobile homes were purchased in 1968.

Related to the trend toward complete factory prefabrication is the use by local builders of more and more standardized and prefabricated items that save time and effort in the custom-built house. The use of ready-built paneling and roof trusses is typical of this trend. Roof trusses can be erected more quickly than roof rafters, and internal partitions can be omitted until a late stage of construction. This method gives more work room under cover while the house is being completed.

No serious fault has ever been found in the wood-framed house with wood siding if the house has been built according to sound structural principles and the paint on the siding has been wisely selected. The wood house framework that is joined with a proper number of nails will resist all except the strongest winds and floods, especially if the framework is properly bolted to the foundation. Under earthquake tremors the chimneys, glass, nonwood

foundations, and plaster of the frame house may be damaged, but the framework will yield and regain its shape without damage to the general structure.

Wood interior paneling is traditional and is still being used in American houses. Wood interior surfaces are serviceable and they can be beautiful. Some of the most modern decor relies upon the beauty of wood for its effects. This development has been aided by the long-established but newly refined art of cutting fine veneers from American hardwoods.

The wood flooring in the American house gives generations of service with a moderate amount of maintenance. The same is true of stair risers and treads. After 40 years of service hardwood stair treads may be worn enough to suggest replacement, although their appearance is not materially impaired. Probably no other material would retain both esthetic values and serviceability so long as hardwood and be replaceable at an equal or lower cost.



M-118239

Floors of beautifully grained hardwood are in the height of fashion today in view of the new decorative emphasis on display of attractive floor areas. Three major types are shown here. The smart strip style (lower photo), used most extensively, is highly versatile from a decorative standpoint; it harmonizes well with any furnishings, is "at home" in houses of any price class or architectural style. Plank flooring (upper left), which captures much of the charm which distinguished the quaint plank floors of colonial days, is particularly appropriate for colonial and ranch style homes. The unit-block style (upper right), a modern form of conventional parquetry, is especially well adapted to homes where a note of formality is desired.

## Veneer and Plywood

Veneer is wood cut in sheet form. Some of it is used in single thickness for making inexpensive baskets and boxes for fruit and vegetables. The greater part is glued to other veneer to make thicker sheets or is glued to stair wood as a facing. Veneer has been used as an ornamental facing for thousands of years. Egyptian tomb murals, more than 3,500 years old, show veneermakers working at their trade. Veneermaking declined during the disorders of the Middle Ages, but except for this lapse it has persisted and improved and is now an established part of woodworking technology. In modern architectural decoration, veneer is as highly esteemed for decorating the boardrooms of great corporations as it was for embellishing the palaces of ancient Egyptian kings.

Plywood consists of three or more sheets of veneer glued together, with the grain of successive sheets laid crosswise. The resulting material has distinct advantages for many uses. The natural tendency of wood to swell or shrink transversely as moisture conditions change is restrained by the crossing of the grain. To reduce warping to a minimum, an odd number of plies is almost always used. The greater the number of plies, the more nearly the strength of the piece is equalized lengthwise and crosswise. Plywood offers greater resistance than solid wood of the same thickness to shearing, splitting, puncture, and the tearing out of fastenings near the edge. Because plywood can be made in sheets much larger than boards sawed from a log, construction with plywood is rapid and efficient.

Although plywood was under development for centuries, the versatile product of today is essentially a creation of the machine age. The modern plywood industry was made possible by improved and cheap methods of veneer manufacture. Sawing was used at first in making veneer for plywood on an industrial scale. Although it produces excellent veneers, sawing wasted at least half of the log in the form of sawdust. In the 1860's a machine for slicing veneers was developed, and it was followed a few years later by the first rotary cutter. Slicing and rotary cutting create no waste in dividing the wood structure, but they leave a part of the log uncut as slabs or core. In rounding the log to cylinder form, rotary cutting also produces some scrap material. The residues are often usable under modern methods of residue recovery.

The slicing process is often used in cutting veneers from highly figured woods for fine furniture. However, most of the veneer cut to make plywood in the world today is rotary cut. Sliced veneer is made by moving a flitch of wood obliquely across a fixed knife. Rotary-cut veneer is made by rotating a short log, called a bolt or veneer block, against a long heavy blade. The veneer comes off the log like paper being unwound from a roll. Often the logs are first softened by steaming or heating in water so that they will cut easily and produce smooth veneer.

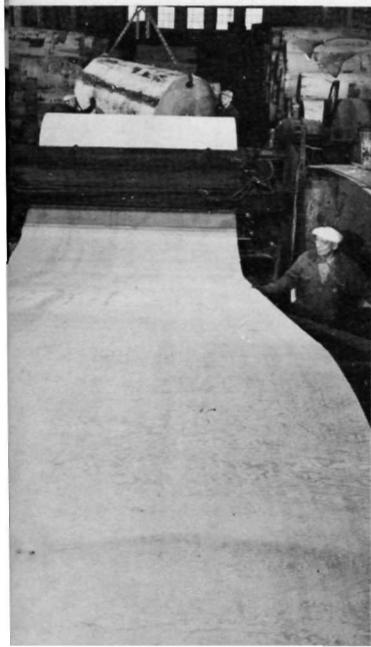
The most important development in the use of plywood is in the residential construction field. The early plywood adhesives, including animal glue,

Left: In making rotary-cut veneer the peeler log or "block" is rotated against a keen cutting edge, which in effect unwinds the log in a continuous strip of veneer. Center: The finer types of hardwood veneers, suitable for high-grade cabinetwork or interior paneling, are produced by slicing on machines of this type. The flitch of wood is moved against a stationary knife. Right: One of the important uses of exterior grade plywood is for sheathing in the house of today.

M-115662

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M-115746





M-118240

Factory-engineered wood cabinets in this modern "dream kitchen" give the rich, warm beauty so popular with homemakers. Units shown here are in beautifully figured American walnut.

casein glue, soybean glue, and blood albumin glue, were not sufficiently waterproof to be used outdoors. In the 1930's, however, the phenol-formaldehyde adhesives made it possible to produce plywood that would stand exposure out of doors. Other synthetic adhesives including urea, melamine, resorcinol, and combinations of these materials came into use. The production of an exterior grade of plywood constantly increased as more and more plywood was used in residences. Other grades of plywood also have increasing use, and substantial amounts of plywood are used for numerous housing applications.

In 1962 an average of more than 3,000 square feet ( $\frac{3}{8}$ -inch thickness basis) of plywood per unit was used in the construction of one- and two-family housing units. Of this amount, about half was used for exterior wall and roof sheathing, 23 percent for subflooring, 20 percent for cabinets, doors, paneling and similar millwork and trim applications, and the remainder for floor underlayment and siding.

Between 1952 and 1962 plywood per one- and two-family housing unit more than doubled. Use per unit in the years ahead is also expected to increase but at a decreasing rate. Use per one- and two-family unit may be as much as 4,500 square feet ( $\frac{3}{8}$ -inch thickness basis) by the year 2000. To



M-118227

This room in the Wisconsin Center Building, Madison, Wis., illustrates the beauty of cherry plywood as an interior finish.

supply the increased demand, ways will be found to use more low-grade veneers, to supplement wood veneers with other sheet materials, and to develop improved manufacturing techniques.

Plywood is highly useful for the maintenance and repair of houses as well as for new construction. The plywood can be put in place at minimum cost, with simple, ordinary woodworking tools. In other kinds of construction plywood is used chiefly for making concrete forms. It is particularly suitable for forms that mold smooth or curved concrete surfaces. The moisture-proof and moisture-resistant types of plywood can often be reused several times.

### Insulation Board, Hardboard, Particle Board, and Sandwich Materials

Any material that covers a large area and can be handled by one or two men as one unit of construction is less expensive to install than a material in many small units put in place by hand. Insulation board, hardboard, and particle board are in this class. These materials now compete with plywood in residential and industrial construction. In contrast, early American housing had no insulating board serving as plaster base, no hardboard counters or cabinets, and no particle board. Par-

ticle board has been produced for more than two decades.

Manufacture and sale of these structural sheet materials affect the entire forest products industry because all these materials are made of wood fiber or particles of various sizes and degrees of refinement. The demand for raw material for these panel products offers outlets for low-grade wood and for the residues of logging, sawmilling, and manufacturing. The profitable sale of sawmill residues to pulpmills and similar users has saved some mills from business failure. Since a large supply of residues is available, it can be expected that more uses and markets will be found for the sheet materials made from them.

Insulation boards in the form of common perforated acoustical tile are commonly installed on ceilings. They are often used also as a base for plaster. Among the hardboards is the hard, dark-brown, smooth-surfaced material, about  $\frac{1}{8}$  inch thick, used in furniture, TV, and radio cabinets. Except on the unfinished back of these cabinets, the hardboard has a gravure grain simulating face wood veneers.

Particle boards are generally used as panel cores on which veneer, hardboard, or plastic faces have been overlaid; hence they are not ordinarily seen and identified. Some particle boards, however, have a pleasing surface of large wood flakes that

covers an internal structure of smaller and less regular wood particles.

In 1967 the quantities of insulation board, hardboard, and particle board produced were as follows: Insulation board, 3.16 billion square feet; hardboard, 3.56 billion square feet; particle board, 1.12 billion square feet. These figures are based on a  $\frac{1}{2}$ -inch thickness for insulation board,  $\frac{1}{8}$ -inch thickness for hardboard, and  $\frac{3}{4}$ -inch thickness for particle board.

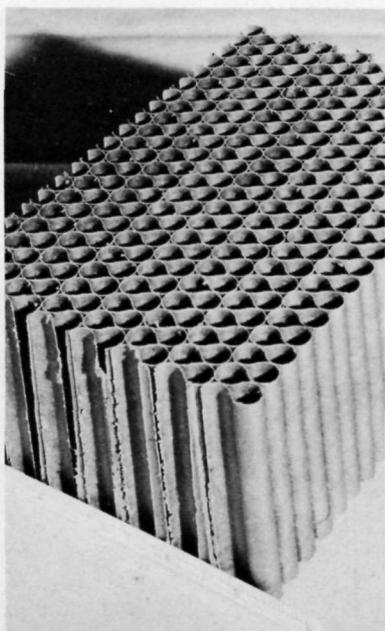
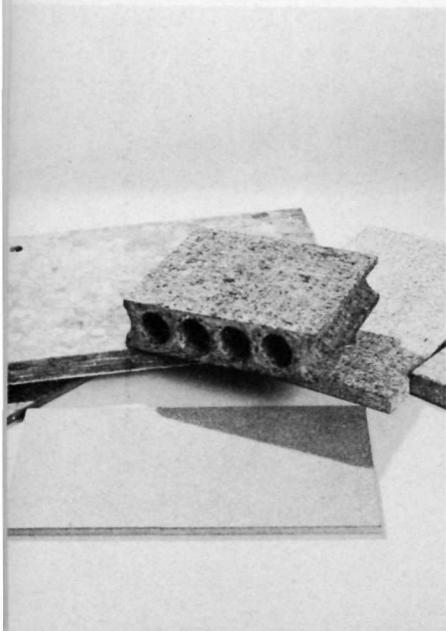
The modern materials called structural sandwiches consist essentially of a lightweight core material to which thin rigid face materials, such as plywood or hardboard, have been glued. The core material generally is foamed cellulose, grid-patterned wood latticework, wood fiber, or paper honeycomb. The chief characteristics of sandwiches is their high ratio of strength to weight. The sandwich panel with a paper honeycomb core has the paper resin treated to resist moisture, and it can be shipped in collapsed form like an old-fashioned paper Christmas bell. Like some of the other sheet materials, sandwich panels have great possibilities because they are light in weight and they save labor in prefabrication for structures and commodities. They may be expected to have increased use in housing structures, in such items as office paneling, and in cabinets and furniture.

Left: Particle boards, made of varied forms of wood residues, are providing a new group of sheet materials for building, a new market for low-grade woods and residues, and a new fringe of profit for many moderate-sized sawmills. Center: The types and kinds of cores and facings in sandwich panel construction vary widely. This is one type of treated paper honeycomb core that might be faced with plywood, hardboard, or other thin but rigid facings. Right: Attic room finished with structural sheet materials made of wood fibers.

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M-118176



## Furniture

Before history began, people used wood for furniture and they have done so ever since. In primitive societies the housewife had only a few simple, useful objects of wood in her household. These articles were either so durable that they outlasted the housewife or they were as readily replaceable as the withes with which she swept her rude hearth.

As society advanced, wooden objects of utility evolved into furniture—benches, tables, stools, bed frames, cupboards. Trial by use eliminated weak design. The simplicity of tools and the demands on the craftsman's time precluded decoration.

A refinement in the parts of furniture that is still in progress began when metal tools for cutting wood were created. Round wood posts bound with thongs gave way to hewn and then to sawn posts. The crudely hewn slabs on benches and tables were replaced by sawn boards. When glues were developed and edge-gluing was perfected, table and bench tops could be made in any width desired.

As refinement continued, decorative woods were sawed into thin sheets (veneer), and the sheets were glued to plain woods so as to please the nobility. For more practical reasons, the thin sheets of veneer were combined to make plywood as noted previously in the story of veneer and plywood. This sheet material was also used in parts of furniture that originally were made of solid wood. Thick single veneers came into use as the bottoms and sides of drawers and for other concealed parts.

In the modern era particle boards and sandwich-type materials are used for central cores on which fancy veneers are laid to produce yet another type of paneling for furniture. Thin hardboard, cost permitting, also has found use instead of single-thickness veneers.

The production of wood furniture creates an important market for forest products. For the foreseeable future a major effort of industry and trade will be to provide shelter and household utilities for an increasing population. The making of furniture will require a large part of this effort. Modern technology provides the materials and the know-how to make furniture that is more attractive and enduring than at any time in the past. Better adhesives than ever before are available for the assembly joints in furniture, and modern freedom of design no longer binds the furniture producer to constructions, like the familiar rung-to-leg connections, that have shown weaknesses at the joints. The adhesives and the techniques used in overlaying of plain woods or inexpensive low-grade woods with attractive veneers have never been better. Great reserves of low-quality hardwoods will have higher value when ways are found to increase their use in the manufacture of furniture. By applying modern wood technology more intensively, the furniture industry can obtain greater acceptance of its products and satisfaction for its customers.

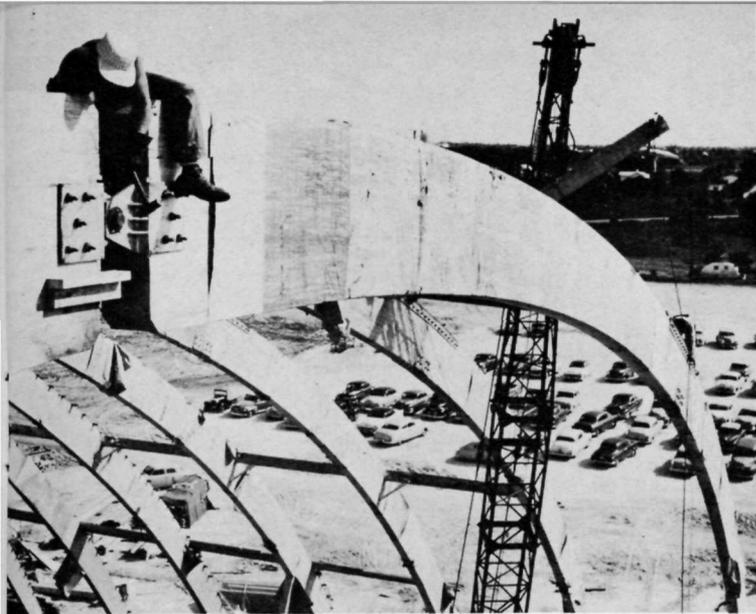
Because it conducts heat slowly, wood furniture is pleasingly warm to touch. Much portable furniture, like chairs, stools, and small tables, has al-

Left: This hotel in Denver has honeycomb-core wall panels faced with steel, and an outside ceramic coating. Right: The beauty and utility of good wood furniture is timeless.

M-115823

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M-108911

Joining glued laminated-wood half-arches in a jai-alai fronton at West Palm Beach, Fla. The unobstructed span of these arches is over 240 feet.

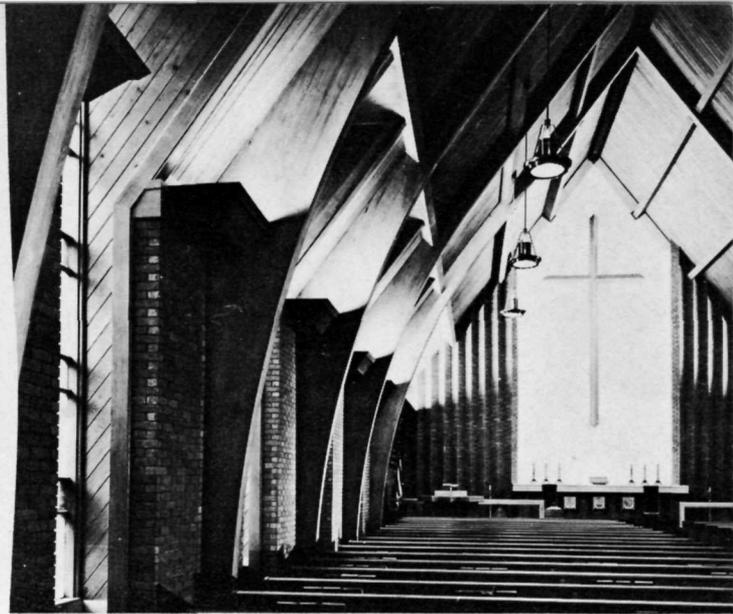
ways been light in weight. The ratio of strength to weight is higher than ever before with sandwich paneling that employs paper honeycomb or similar cores faced with decorative plywood. Portable furniture can be made lighter than before and the weight of larger furniture can be greatly reduced through the use of sandwich panels with light cores.

Surface treatments for furniture in the modern day also have increased possibilities. Both solid members or surface overlays may be made from compreg or semicompreg. Compreg is resin-treated wood that has an attractive finish on which scratches can be dressed out merely by buffing. An underlay of metal foil can be used under the surface veneer to carry off heat and guard against cigarette burns.

The whole field of composites—combinations of wood with paper, metal, ceramics, and plastics—offers almost unlimited possibilities for more attractive, more serviceable furniture. Knowledge of wood is greater and more freely available than ever. With all of the resources of solid wood, veneers, straight and molded plywood, and composites at his disposal and with the added advantage of being able to depart from period design, the modern furniture designer should be able to enjoy new success in providing functional efficiency, beauty, and durability.

### Laminated Timber Construction

Developments in the field of glued laminated wood construction in recent years have launched a new industry. This material is glued up from *Products of American Forests*



M-106014

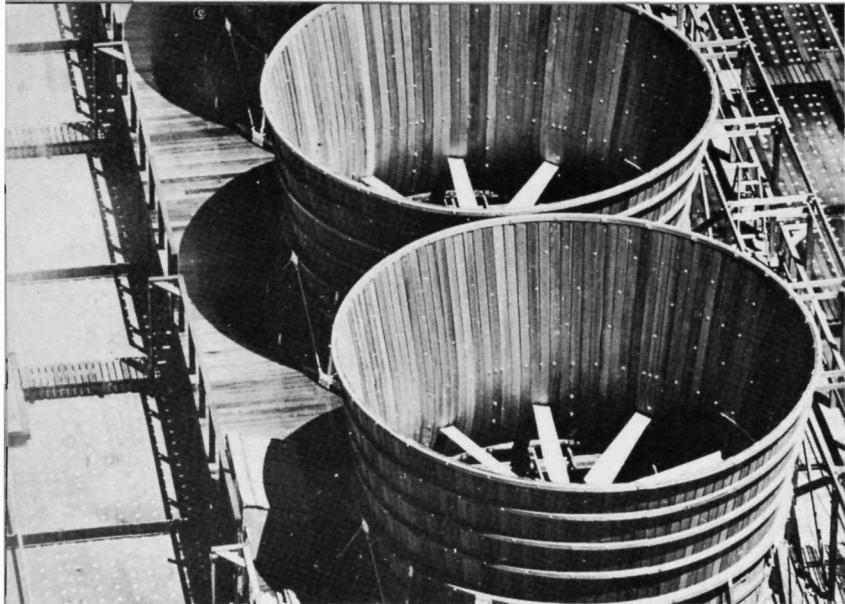
The glued laminated-wood arch shows great diversity in church design.

smaller pieces of wood, either in straight or curved form, with the grain of all laminations generally parallel to the length of the member. It is thus basically different from plywood, in which the grain direction of adjacent plies is usually at right angles.

Many structural members made of parallel-laminated materials give excellent performance. These include barn rafters, and giant laminated-wood arches that support the roofs of auditoriums, churches, and similar buildings. The smallest arches may be circular in sweep and large enough to support only the roof of a small poultry house. The largest arches may also follow a semicylindrical curve and be large enough to span as much as 350 feet or more of unobstructed space in an athletic arena. Longer spans are feasible. These arches are made in two halves. Other giant arches have shapes that range from Gothic to Australian boomerang shapes, thus illustrating the versatility of laminated arch construction.

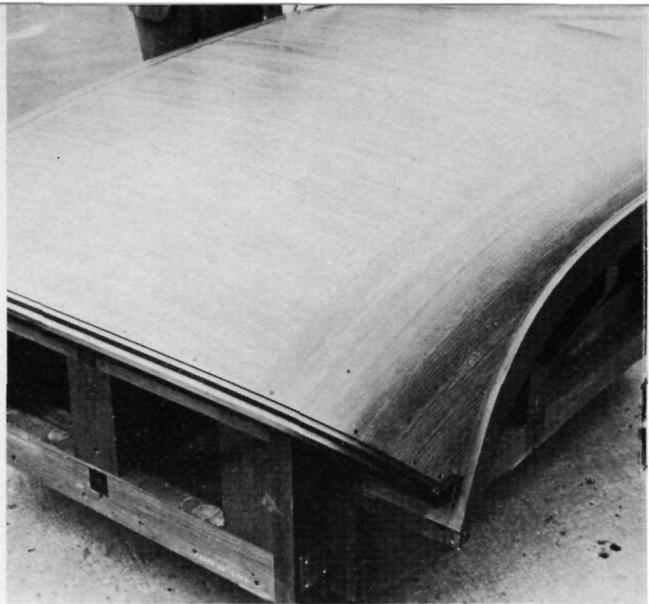
The timber-laminating industry offers a structural medium that is distinctive. Certain shapes, such as those of barn rafters, are shop fabricated in standard sizes for a mass market. Custom-built arches are made to meet the specifications of individual design situations. Thus, the architect is given great scope in providing unobstructed overhead space in buildings ranging widely in area and in architectural treatment.

To outline the advantages of arches and their glued laminated-wood members is to explain part of their great versatility. In the fabrication of the members, standard lumber sizes may be used. The



M-115630

In cooling towers wood is used for the framework and the slats over which cooling water trickles, and for such items as the redwood fan stacks shown here. The huge fans draw air rapidly upward through the cooling towers, much as an automobile fan draws air through a radiator.



M-96073-F

Impreg, a form of resin-treated laminated wood, is used in the making of die models by the auto industry to avoid costly recarving of the model made necessary by shrinking and swelling.

component strips or boards can be readily seasoned before they are glued, thereby eliminating unsightly and weakening surface cracks that often occur when large solid timbers are seasoned. Preseasoning the strips also insures against radical changes in dimensions of the laminated wood member. Shrinkage in drying has already taken place in the individual board.

Since each laminated member is made up of many boards or strips, size of timber is no longer limited by the size of trees or logs on the market. Because the number of laminations is varied to increase or decrease thickness, great engineering efficiency can be achieved. The increased thickness at the "hinges" of laminated arches and the graceful taper to ground-line connection points are related to variations in stress rather than artistic effect. The most wood is applied where stresses are most concentrated. Because of this fact, the timbers can be said to be loaded equally throughout their entire length. There are no areas where loads are concentrated.

The resistance of glued laminated members to fire is distinctly in their favor. They burn slowly, thus building up an insulating coating of char. They do not become plastic and fail suddenly under high temperatures. In areas where their cost is high, the slowburning characteristic may well offset cost disadvantages since other materials may require special protection against potential fire hazard.

There are, of course, some limitations to the use

of glued laminated members. The larger ones are difficult to ship by common carriers. Research has shown, however, that large arches can be cut diagonally and rejoined on the job site without a significant loss in strength.

The glued laminated arch is probably most commonly seen in the modern church building. It is frequently seen in auditoriums, supermarkets, and dancehalls. Perhaps its most spectacular use is in giant sports arenas where soaring unsupported curves give unobstructed space for athletic activity and for spectators viewing it.

Decay-preventive chemical treatment of the wood in glued laminated members makes them suitable for additional uses. There can be greater use of glued materials in unsheltered structures, such as the 2,000 miles of wood bridges and trestles maintained by American railroads.

### Dimensionally Stabilized Wood

Laminates, composites, and treated woods have in recent years greatly increased the efficiency and versatility of wood. One of the more interesting of the modified woods is impreg—wood in which changes in moisture content and hence dimension are greatly reduced by bonding phenolic resins to the cell structure. Thin veneers are saturated with the resin and the resin is dried and cured (polymerized) before the veneers are laid up in a thick laminate.

The most significant current application of impreg is in the making of sculptured models for the huge metal dies from which automobile body parts are stamped. The use of impreg for this purpose has eliminated dimensional changes in the die model during manufacture of the dies. Formerly, shrinking and swelling of the die model caused waste and extremely expensive reworking. It is reported that one manufacturer alone is saving more than \$5 million on each year's new model changeover through the use of impreg.

Compreg is a material that is created when veneers impregnated with phenolic resin but not cured undergo a simultaneous treatment for bonding, curing, and compression. The effect is to increase dimensional stability as in impreg, to reduce volume and correspondingly increase density, to somewhat increase brittleness, and if pressed in a smooth mold, to produce an attractive glossy through-and-through finish. This kind of finish can be restored by buffing if scratched. Compreg has been used in the manufacture of tooling jigs, bobbins and picker sticks for textile looms, cutlery handles, and novelties.

### Railroad Uses

Forest products played a vital part in the building of the American railroads and in their maintenance. They have also made up a large part—as much as 10 percent in some years—of all the freight hauled by railroads. Wood was called into service in enormous quantities by the growing railroads for use in the maintenance of track, the construction of small stations, sheds, and toolhouses, the building of bridges, the erection of snow fences, and the carrying of telephone and telegraph lines. The basic vehicle, the standard freight or boxcar, used to be made primarily of wood, although less wood is used in the modern freight car. With the railroads curtailing their expenses, the use of wood for items other than crossties has been reduced to a minimum.

To maintain the track millions of railroad crossties are used, for the crosstie is one of the vital elements of a roadbed. An average life of 33 years is considered good for a preservative-treated crosstie.

The wood railroad crosstie is so well adapted to its function that it has defied all competition. The American railway track is a flexible mechanism, constructed so that it yields to the terrific impacts and vibrations of the passing trains and yet supports mountainous loads. Ballast, ties, tie plates, spikes, and rails function as a dynamic part of train move-

ment. The tie itself is cheap, strong, elastic, resistant to shock, and easily replaced. In addition to its main task, it is an insulator in the railroad's electric automatic signal system.

In the midsixties the railroads used about 4 percent of all the wood used in the United States. This was chiefly in the more than 17 million crossties laid as replacements and for a minor amount of new trackage.

### Poles, Piling, Mine Timbers, and Posts

Electrical powerlines and telephone and telegraph lines form a veritable web over the country. Approximately one-half of this web is carried on wood poles. Telegraph companies operate more than 250,000 pole-miles of line and telephone companies far more. The total is difficult to arrive at, since miles of wire are not easily interpreted into miles of poles. The vast mileage of power pole lines is partly indicated by the million and a half miles of poles in Rural Electrification Administration projects that did not exist in 1935. Currently, sales of poles amount to approximately 6 million per year. Extending powerlines to meet the needs of a bulging population may require about the same number of poles in years to come. The use of preservative-treated poles, which give longer service, keeps this figure from rising higher.

The strength and elasticity of wood and its good electrical insulating properties make it a satisfactory material for the heavy job of carrying utility wires. It can stand up under the load, resist the stresses of all but the most catastrophic storms, and give as much as a third of a century of service when properly used. Electrolysis and corrosion never affect the wood pole below the ground. Effective preservatives protect the pole against decay below ground line and insects above ground.

In recent years, preservative-treated poles have found use in a revival of an economical type of building in which poles set in the ground form the basic supporting structure. The poles are set 4 to 5½ feet in the ground and 10 to 13 feet apart. This type of construction was recommended first for farm buildings, but it is also being used for warehouses and other industrial buildings.

Wood piling serves important purposes in the structures of civilization. Although many steel and concrete piles are used, towering steel and concrete buildings, piers, breakwaters, dams, bridges, jetties, and channel control works are commonly supported on wood piling driven to bedrock or deep enough

to support their load. Tough and having high resistance to crushing along the grain, wood piles can withstand the heavy blows of the pile driver and, when in place, support enormous loads without maintenance or need for replacement. Where driven below the permanent water table in wet earth, they are sealed by nature against decay and will outlast the structures they support. Where exposed to decay or marine borers, they can be protected by chemical preservatives.

Approximately 1,000,000 pieces of piling are driven in the United States each year.

It is hard to imagine a service performed by wood under more exacting conditions than those where mine timbers are used. Exposed to all degrees of dampness, under continual strain, and subject to corrosive seepage, no other material costing so little could be conceived to replace wood. For longtime

use, mine timbers are frequently treated with wood preservatives. In short-lived workings, untreated timbers can give the desired length of service before decay destroys their safe bearing power. Currently about 50 million cubic feet of wood is used each year in mines.

The common wood fence post, although not used in the numbers formerly required, is still a factor in the American wood harvest. The strength of the wood post and its broad bearing in the earth are inherent advantages in fence building. Nails and staples can be driven into the wood easily with ordinary tools. If properly treated with preservatives, wood posts may serve for as much as 25 years without replacement. More than 300 million wood fence posts are used each year, although competing materials, farm consolidation, and farm abandonment have reduced the demand for them.

## Wood Chemical Products

Useful as wood is in the form of boards and other sawed products, there is a much greater promise of versatility in the products that result from chemical modification or conversion of cellulose, lignin, and extractives. At present the principal products of chemical wood conversion are pulp and paper, the cellulose type of textile fiber like rayon, and cellulose plastics. Of these products, only pulp and paper are showing continuing and aggressive growth. The textile and plastic products are under intense competition from products based on petroleum or inorganic raw materials.

### Pulp and Paper

The various processes for pulping wood are all intended to accomplish a single purpose, namely, to separate the cellulose fibers one from another in relatively pure form so that they can be recombined physically to form sheets or boards, or chemically to form plastics or textile fibers.

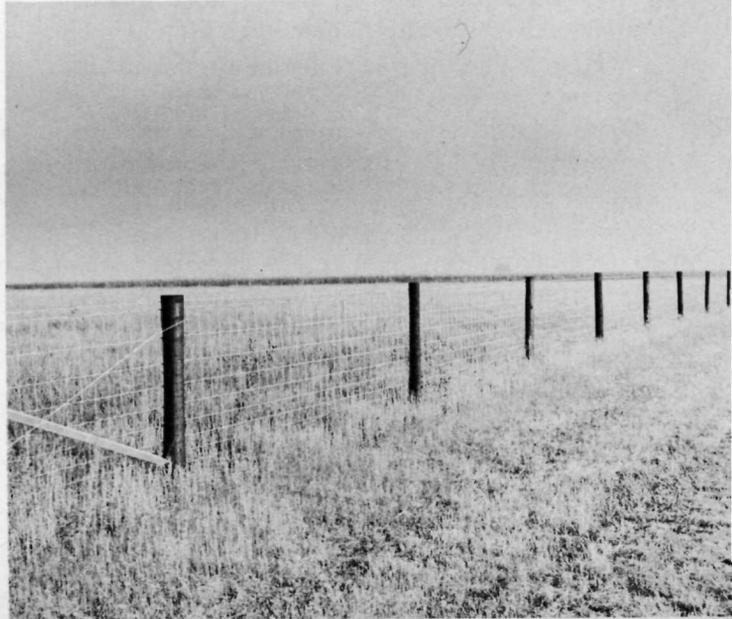
In the mechanical or groundwood process, wood bolts are held against a grindstone and the wood fibers are ground off into water to form the pulp. Be-

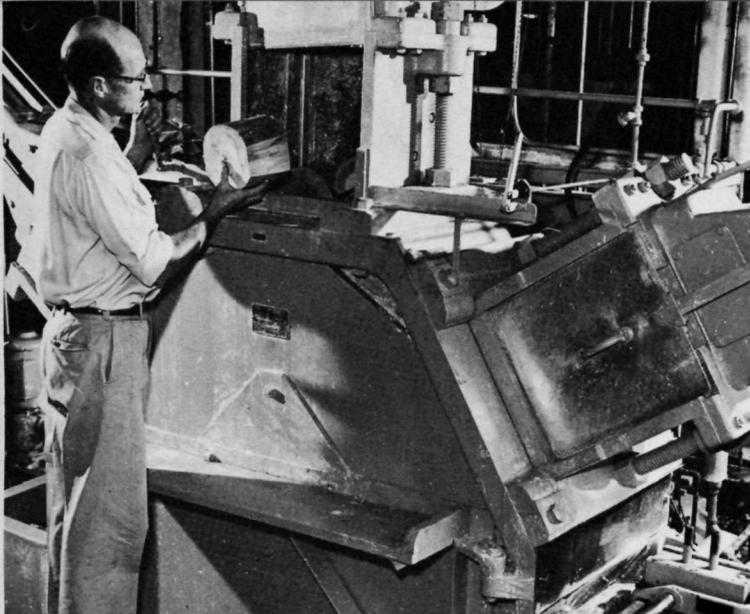
The railroad cross-tie, in spite of numerous attempts to introduce substitutes, still has no equal in providing a durable but yielding surface for trains.

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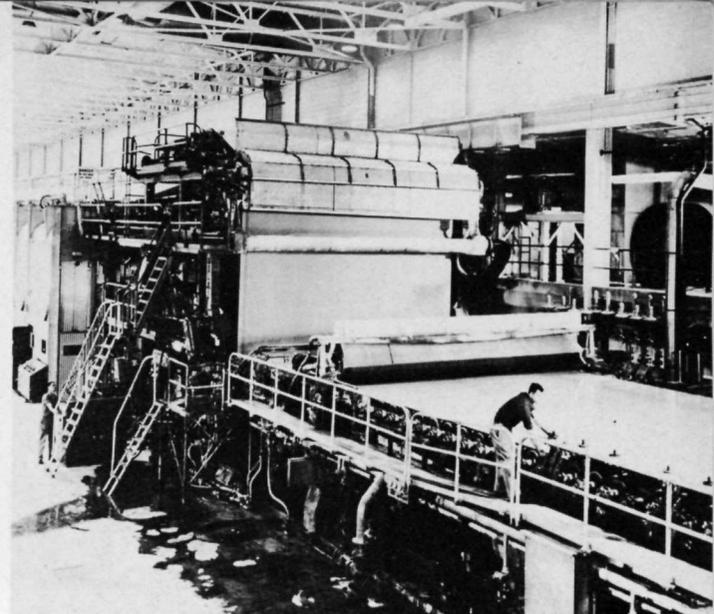
Wood fence posts protect and restrain crops and livestock. In this view creosoted posts support a barrier near a modern highway.

M-118136





M-100673



M-118152

Left: The simplest method for pulping wood is the groundwood process, in which short bolts of wood are held against a spinning grindstone in the pockets of a grinder such as the three-pocket grinder shown here. The fibers come off the stone into a water bath below. Right: Modern paper machines of this type can turn out paper up to 30 feet wide at speeds up to 2,000 feet per minute.

cause of the nature of the pulping process, this pulp is not strong, but it is strengthened to make common newsprint by adding one part of chemical pulp to three parts of the mechanical pulp. The mechanical pulp is cheap and the yield is 90 percent or more of the original weight of the wood. Only a few species of wood are used. The long-fibered, light-colored spruces and balsam are most preferred, although some pines and hemlocks are used in smaller volumes. Only a small amount of the short-fibered hardwoods is used. Groundwood pulp is the principal constituent of all the cheaper printing papers and makes up much of the material in the various paperboards.

The chemical pulping processes—sulfite, sulfate, and soda—depend on the dissolving action of chemicals to remove practically all of the constituents of the wood except the cellulose fibers, which remain in a fairly pure state. This is accomplished by “digesting” the wood chips through the action of a sulfite, sulfate, or soda under steam pressure.

The sulfite process employs an acid chemical (calcium, magnesium, sodium, or ammonium bisulfites plus sulfurous acid). The yield is less than half of the weight of dry wood, but the pulp is much stronger than groundwood pulp. The unbleached pulp is light colored and is readily bleached. The trees most used in producing sulfite pulp are long-fibered softwoods of low resin content such as spruce, balsam, and hemlock, but small amounts of south-

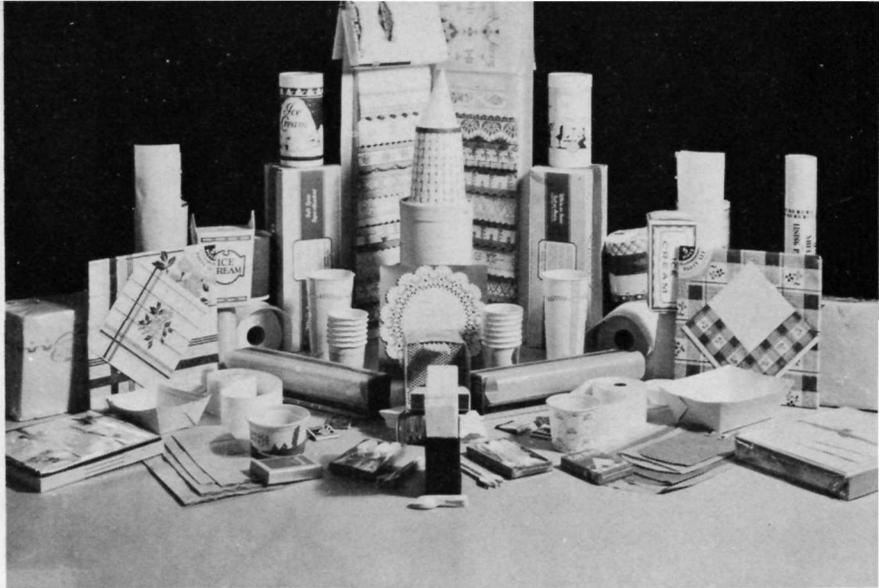
ern yellow pine and some aspen, birch, and a few other hardwoods are also used. Sulfite pulps are suited to a greater variety of uses than the other commercial pulps. They are used in book, wrapping, bond, and tissue papers and are combined with groundwood to form other kinds of paper.

The sulfate process is suited to the use of almost any kind of wood. Since the chemical liquor used is alkaline (a solution of sodium hydroxide and sodium sulfide), resins, waxes, or fats in the wood do not hinder the pulping action. Hence, this is the process used for the conversion of the pines. The sulfate pulping yield is 48–50% and the pulp is the strongest of the commercial pulps. When suitably “cooked,” the pulps can be bleached and made strong and then used to produce high-grade papers, including book, magazine, writing, bond, and specialty papers. The principal uses for unbleached sulfate pulps are kraft wrapping paper, bag paper, and boxboard. Bleached hardwood sulfate pulps are used extensively in printing papers. One modification of sulfate pulp is purified to make rayon textile fiber.

The soda process, alkaline like the sulfate process, employs caustic soda as the pulping agent. This process is used principally for pulping hardwoods, commonly aspen, cottonwood, basswood, beech, birch, maple, tupelo (gum), and oak. The yield varies from 40 to 48 percent, depending on the species of wood and the pulping conditions. Soda



M-118134



M-32449-F

Left: Folded flat to save storage space, 1,500 fiberboard apple boxes arrive at a packing plant. Right: The American housewife is a great user of paper products.

pulp is sometimes used alone in making blotting paper and other bulky papers that have low strength requirements. Book, lithograph, and envelope papers are often made from a mixture of sulfite and soda pulps.

The semichemical processes are more recent in origin than the other processes. They are called semichemical because the wood chips used are first softened and only partly dissolved by chemicals and then are reduced to pulp by mechanical action. In typical mechanical processing the chips are passed between the spinning plates of a disk attrition mill. The chemical solutions used vary. A neutral solution of sodium sulfite is used most, although either alkaline sulfate or acid sulfite liquors are suitable. The yield of pulp is from 65 to 80 percent of the weight of the wood. This semichemical process is applied predominantly to hardwoods, and the pulps are used in corrugating board, newsprint, and specialty boards. By conventional bleaching methods semichemical pulps can be brightened to light shades for use in printing papers or can be bleached to a high white. Yields of pulp used to make the whiter papers are 50 to 60 percent. These lower yields are used to produce printing, glassine, and bond papers and specialty boards like those in food cartons.

The most recently developed process to have significant use is the cold soda process, which is basically semichemical. The process was named cold soda because it was originally expected to operate with treating chemicals at room temperature in non-

pressurized pulping vessels. This too is a high-yield process (about 90 percent) and is best adapted to use with hardwoods.

The high-yield semichemical processes are of special interest because they offer possibilities for more use of hardwoods. Hardwoods of kinds unsuitable for lumber or veneer are overabundant in most second-growth forests; finding uses for them as pulpwoods is very worthwhile. In about 35 years the semichemical process has reached a yearly production of more than 3 million tons of pulp, almost all of which is used to make corrugating board. During this rapid growth little of the hardwood pulp has been used to produce light-colored papers. In the future more diversified use of semichemical pulps may be expected, and this should increase the utilization of hardwoods.

The 1957 consumption of pulpwood for pulp, paper, and allied products amounted to about 30 percent of all industrial wood, which does not include fuelwood. In 1900, only 2 percent of industrial wood was pulpwood. Including the imported pulpwood, about 40 million cords of wood are consumed annually to produce pulp. Some products not classed as paper products are included in this total. It is perhaps easier to visualize the paper and board consumption by considering the fact that currently we are consuming over 500 pounds (512 pounds in 1968) for every man, woman, and child in America. One thousand to 1,500 pounds of wood is required to produce that amount of paper and board per person.

The following tabulation shows the percentages of our consumption of paper and paperboard by types in 1955:

	Percent
Container boards-----	24
Bending board-----	11
Newsprint -----	17
Book and fine paper-----	15
Coarse and industrial paper-----	11
Building paper and board-----	8
Sanitary and tissue paper-----	6
Groundwood paper-----	2
Other board-----	6
	100

In the foregoing classes, container boards include the common corrugated fiberboard containers used in shipping and the shelf packages used for display as well as food wrappers, milk cartons, and similar items. Newsprint is the paper used for newspapers. Magazines and books and the various classes of writing paper are made of the book and fine papers. The coarse and industrial papers include brown paper bags, punch card stock, electrical material, file folders, and similar items. Among the building papers are sheathing papers, roofing felts, felts for asphalt tile, and asbestos-filled papers. Sanitary and tissue papers include toilet paper, napkins, towelling, and similar products. The groundwood items include stock for telephone directories, catalogs, wall-paper, business machine paper. "Other boards" in the list refers to stock used for fiber tubes, drums, and cans, eggcase filler board, and similar items.

The use of container and building boards is expected to increase; fiber containers are expected to be used for increasingly heavy shipping and such items as sandwich honeycomb cores and paper over-

Paper dresses pretty enough for town or travel are modeled by two young women who are examining a sheet of common wrapping paper. The machine is an experimental papermaking machine used at the Forest Products Laboratory to research new techniques in papermaking.

M-136229-8



lays for lumber. To a large degree the fiber container has replaced containers made of resawn lumber and heavy veneer for fruits, vegetables, and similar items. Multi-wall containers made of heavy fiberboard have been designed to support loads of several thousand pounds that might accumulate when the containers are stacked high in warehouses.

In the field of panelized construction one of the most effective of the core materials used between rigid faces is a treated paper honeycomb that is moisture resistant, slow burning, efficient as a thermal insulator, light in weight, and adequately strong when combined with the rigid faces. A 22-story hotel in Denver has an exterior in which paper honeycomb panels are used in combination with light enamelware facings.

Another new development is the use of treated paper overlays on low-grade lumber. Such overlays improve boards or panels by forming smooth exposed surfaces that are free from defects and provide a superior paint base.

Attractive paper party dresses and durable paper bathing suits have been created in the paper industry's laboratories. These items illustrate the increasingly successful efforts that are being made to improve paper products and to diversify their potential uses by making them waterproof, fireproof, stretchable, and stronger.

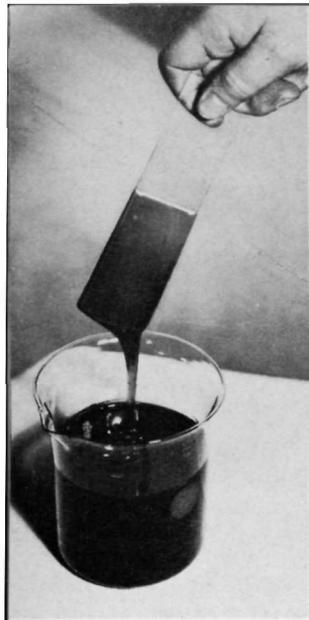
### Other Cellulose Derivatives

Beginning in 1910 with the manufacture of rayon fiber, dissolving grades of woodpulp, including sulfite and special "alpha" pulps, have been used as a basic raw material for an ever-growing list of products—cellophane, nitrocellulose, acetate plastics,

A modern compact automobile is supported on four boxes made from a combination of thin wood veneer and conventional paperboard corrugated box material called Fibreer, developed at the U.S. Forest Products Laboratory.

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M-33006-F

Dissolved cellulose ready for spinning into textile filaments.



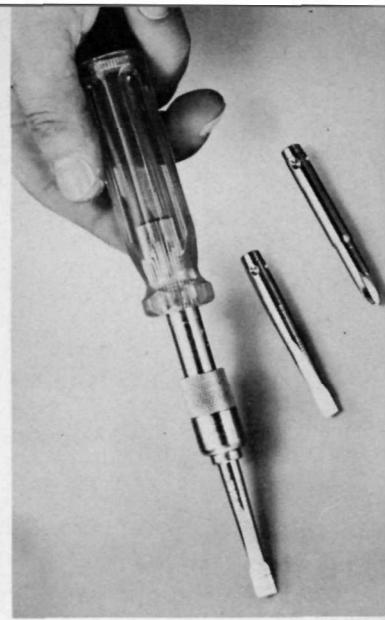
M-32656-F

Rayon fabrics.



M-115808

Spectacle frames of cellulose nitrate from wood.



M-115607

Tool handles of clear, tough yellow plastic are made of ethyl cellulose from wood.

photographic film, smokeless powder, tire cord, cellophane tape, telephone parts, and plastic housewares and toys. Such material has appeared even in foods and pharmaceuticals.

Rayon has accounted for most of the woodpulp consumed in the manufacture of nonpaper products. Consumption climbed from about 45,000 tons in 1930 to 746,000 tons in 1965, within the latter year woodpulp supplied 86 percent of the cellulose used in rayon manufacture. In all the current processes for making textile fibers from cellulose, the original cellulose fibers are changed into a thick, sirupy solution that is pressed through a group of exceedingly fine openings to form long filaments. As these filaments emerge and solidify, either in the air or immersed in a liquid, they are put under tension and formed into strands.

Cellulose textile fibers have taken over a major part of the market for true silk and have competed keenly with cotton and wool. Nylon and other synthetics have in turn given rayon and the other textiles keen competition. The number of new synthetics under development has increased rapidly in the last few years; research effort has been intensified to provide new properties such as wrinkle resistance and wash-and-wear qualities. In the next 10 years even stronger competition for markets can be expected. It is likely that cellulose textiles will be improved and will retain the market for products in which they have special suitability.

Nontextile plastics products used 50 tons of woodpulp in 1965. Cellulose acetate is familiar in toys, lamp shades, vacuum cleaner parts, and combs. Cellulose acetate butyrate is used in portable radio cases, pipe and tubing, and tool handles. Ethyl cellulose is favored for edge moldings on cabinets and in electrical parts and car hardware. Cellulose nitrate is common in spectacle frames, heel coverings, and fabric coatings.

In general, cellulosics are among the toughest of plastics; they retain a lustrous finish under normal conditions, and they may be produced transparent, translucent, or opaque in a wide variety of colors. Their electrical properties are good, and they will withstand moderate heat. One type (cellulose acetate butyrate) can resist outdoor exposure.

The familiar yellow, transparent, and seemingly indestructible handle of the screwdriver in your tool box is probably ethyl cellulose. Your spectacle frames may be cellulose nitrate. The lightweight black pipe that you saw beside the road ready for installation in an underground utility may have been cellulose acetate butyrate.

### Technologically Promising Products of Chemical Wood Conversion

In addition to the materials already described, many other industrial products can be made from chemically converted wood. These products would

provide an outlet for more than 100 million tons of wood residues that are available every year and for low-grade second-growth trees.

The fiber portion of wood, or that apart from lignin, comprises about 70 percent of the wood substance. This fiber is made up of two fractions, hemicellulose and cellulose. The hemicellulose makes up 20 percent of the wood, and the cellulose 50 percent. Hardwood hemicellulose consists of about two-thirds pentose (5-carbon-atom) sugars and one-third hexose sugars. In the softwoods the pentose sugars make up less than half of the hemicellulose. Cellulose, on acid hydrolysis, breaks down to 80 to 95 percent hexose and the remainder pentose. The two sugar fractions are potential sources of a considerable variety of products.

When the technological problems of acid conversion are solved, the pentose might be converted into furfural, a constituent of nylon. Furfural, in addition to its use in nylon, is valuable in petroleum refining, solvent extraction, and in making synthetic resins. Hardwoods, which yield more pentose than softwoods, constitute the chief remaining raw material available for the production of this important organic chemical.

The hexose sugars also have interesting technical possibilities, although they are more difficult to treat with dilute acid in the hydrolysis process than pentose sugars. One possibility is the acid processing of hexose sugars into hydroxymethylfurfural and then into levulinic and formic acids. If available in commercial quantities hydroxymethylfurfural might prove to be even more valuable than furfural and the levulinic acid might also have great value in the synthetic fiber industry. The hexose sugars found in wood can also be used to produce sorbitol, propylene and ethylene glycols, and glycerine.

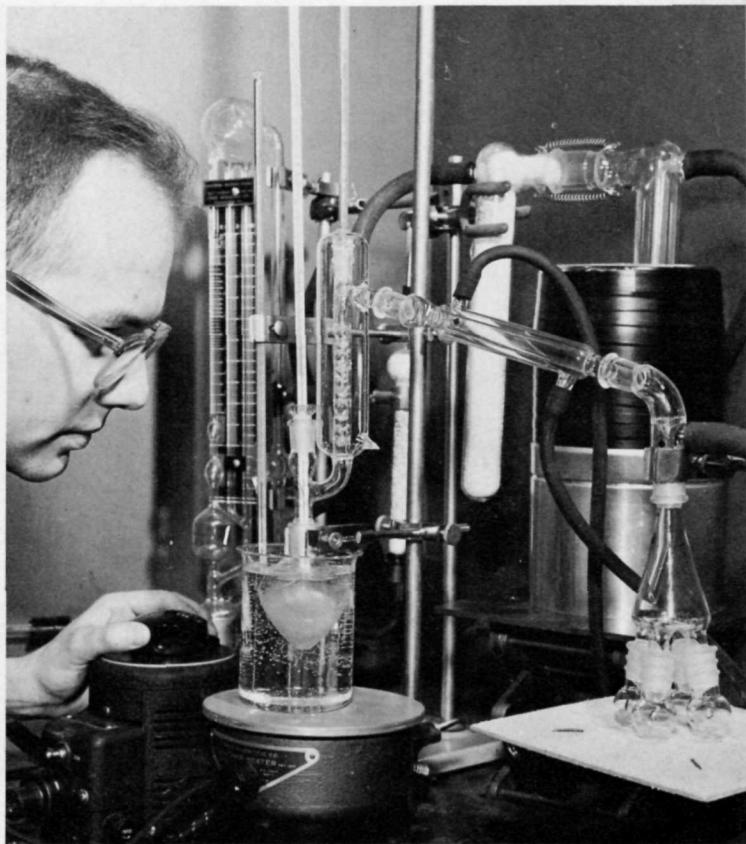
Wood sugars can also be used to grow yeasts that are sources of proteins and vitamins and potential sources of fats. These sugars in the form of crude molasses, not suitable for human consumption, might be profitably used to feed stock if molasses from cane and beet sugar were less plentiful.

Ethyl alcohol, which is the alcohol in alcoholic beverages as well as an important industrial chemical in such materials as synthetic rubber, can be produced by acid hydrolysis of wood sugars and fermentation assisted by yeasts. At present, however, this process cannot compete with processes that synthesize ethyl alcohol from other raw materials.

Some authorities believe that growing population will eventually lead to such general shortages of food from conventional sources that wood may become vastly more important as a source of proteins, fats, and even edible sugars.

From the standpoint of volume of raw material available, lignin should be an important source of useful chemicals because it makes up a fifth to a quarter of wood substance and is a major part of the 12 million tons of residual material that is lost in the pulping liquors of the paper industry. Some use is made of lignin for such purposes as a dispersing agent for concrete, an expander for the negative plates of storage batteries, and in concentrated form as a linoleum adhesive, but this material is not used in proportion to its availability.

For generations chemists have struggled to unravel the complexity of lignin's chemical structure, but progress has been slow. Part of the difficulty could be that known methods of isolating lignin alter



M-100671  
Minute quantities of extractive chemicals are fractionated in a microdistillation apparatus at the Forest Products Laboratory.

the freed material to the point where it may be not quite lignin.

One of the most interesting uses of lignin is the making of vanillin for flavoring ice cream and baked goods from lignin sulfonate in waste pulping liquors. One or two pulp mills, however, can supply enough vanillin to meet the profitable demand. If the total quantity of lignin sulfonate available were converted into vanillin, enough would be made to impart a vanilla flavor to most of the food in the world.

### Wood and Charcoal Fuel

Although the use of wood for fuel accounts for about 8 percent of the total wood used, the amount used for fuel has declined almost without a break for the last half century. Even in rural areas the convenience appeal of fuels such as "bottled" gas and petroleum oils reduces the market for fuelwood. The popularity of a wood fire in the fireplace continues, but it is difficult to obtain seasoned round-

wood at a reasonable price in the city. Besides, in houses of the on-slab type, basements or other facilities for storing wood are lacking. The use of wood for fuel in homes will probably be less and less in the future.

Charcoal has a long history as a fuel for both industrial and domestic uses. At one time it was a product of destructive distillation in kilns, produced simultaneously with wood alcohol, acetic acid, and related chemicals as well as wood tar. All current production is for charcoal alone, because competing materials have made it uneconomical to produce chemicals by wood distillation. About 1900, the iron industry consumed a substantial part of all charcoal. Today coke is used in making all except a few grades of steel and other metal products. Perhaps 35 percent is still used in metallurgy.

As a domestic fuel, charcoal has long been used for both heating and cooking. It still is used in many undeveloped parts of the world for these purposes. In the United States its use has declined,



In this famous Chicago restaurant the premium steaks are broiled over wood charcoal, just as they are the world over.

M-115738

particularly during the first decades of this century. The change has been attributed to a reduced use of charcoal in our slums, probably because of improved living conditions.

The latest phase of domestic use of charcoal is for backyard or barbecue cookery. Charcoal is also popular in restaurants for broiling steaks, and it is used in dining cars. These domestic uses have increased enough lately to hold charcoal consumption about even. The future of the domestic use of charcoal presumably depends on whether backyard cooking proves to be a fad or a permanent custom.

## Seasonal Crops and Extractive Materials

Wood is by far the most important product of the forest, but the forests furnish many other materials that contribute to America's material abundance. A special advantage of these other materials is that, for the most part, they are harvested annually. Year after year the forests can continue to produce them, until finally the mature trees themselves are harvested to make way for the next timber crop.

### Naval Stores

Outstanding in value among crops from the living forest is the harvest of naval stores in the Southeastern States. This crop is valued at many millions of dollars per year. The term "naval stores" is a relic of the days when pitch and tar from the pines were indispensable for calking the seams and lubricating the ropes of wooden sailing vessels. Today it is simply a trade name for turpentine and rosin produced from the southern pines. The turpentine and rosin are produced by distilling the gum or oleoresin that exudes from the longleaf and slash pines after wounding or "chipping" or that is extracted from stump wood rich in resin. They are also obtained by isolating one of the byproducts from sulfate pulping of southern pine for paper manufacture.

The American naval stores industry developed in the virgin stands of longleaf pine in Virginia and North Carolina; it was a fruitful source of income for early colonial enterprise. After the longleaf pine throughout the South was cut, the industry has localized principally in Georgia and Florida. Mississippi, Alabama, Louisiana, and South Carolina share in the total production.

At one time it was feared that cutting the virgin stands of southern pine would end the adequate supply of turpentine and rosin, but this fear has been dispelled. The prompt renewal of slash and long-

leaf pine stands and their rapid growth rate have been of great help in maintaining the supply of these products. Currently supplies of turpentine are more than adequate, but the steadily increased production of rosin is not quite equal to the demand.

Because of their special flavor, barbecued steaks are likely to remain popular in restaurants. From the standpoint of improving American forests and increasing their profitable yield, it is desirable that the market for charcoal hold its own or increase. Charcoal can be made from both low-grade roundwood and residues such as slabwood, edgings, and chips. Its production therefore provides a market for culls and other low-grade timber as well as for residues. About 328,000 tons of charcoal was produced in 1961.

Another important factor in maintaining the supply of naval stores is the change in working methods. These changes are leading to greater gum production and reduced losses by death among the worked trees. In earlier days the woods operator cut a deep recess or box in the base of the tree to catch the flow of gum. This injured the tree and reduced its resistance to windstorms. With a tool called a hack, two downward sloping grooves were cut so as to meet in a V above the box. The V usually took in a third or more of the circumference of the tree. Since the idea prevailed that the bigger the wound the more gum would exude, wide grooves were cut deep into the wood beneath the bark. Since a number of "streaks" were placed one above the other during the harvest year the "face," or working area, reached a height on the tree beyond practical reach of chipping tools. The addition of a second or third face did nothing to improve the vitality of the tree.

The modern trend has been toward wounding the tree less severely, obtaining higher yields of gum per tree, and lengthening the productive life of the tree. One modern way to extract gum is by chemical stimulation. This method consists of spraying a solution of sulfuric acid on the fresh wound to stimulate and prolong the flow of gum. Trees chipped and treated weekly yield 50 to 60 percent more gum than do untreated trees. Trees chipped and treated every 2 weeks yield up to 15 percent more gum per season than those chipped weekly but not treated, and trees chipped and treated every 3 weeks yield only slightly less. By thus extending the interval

between chippings, a laborer can tend more timber and increase his production for the season 70 to 120 percent.

Another method coming into use is a system of bark chipping that is used with chemical stimulation. Bark chipping consists in simply cutting through the bark but not into the wood. Bark streaks treated with acid yield at least as much gum as do similarly treated deep or shallow gouges in the wood. This method requires less physical effort than other methods, is faster, and is much easier to teach new workers. In addition, it leaves the butt log in better condition for use as pulpwood, poles, lumber, and other wood products.

Oleoresin was originally distilled in small, crude, direct-fire stills which turned out products of undependable quality. The modern trend is to processing in centralized plants that use modern methods of gum cleaning and steam distillation. A good market for crude gum in any quantity is provided the small farmer by these plants, and the consumer is supplied a much better and more uniform product. Only a few of the old style direct-fire stills were operating in the South in 1960.

Other ways besides wounding the tree are used to produce turpentine and rosin. From the stumps of longleaf and slash pines comes nearly a third of the turpentine produced in the United States and well over a half of all rosin. From chipped and crushed stump wood, turpentine is steamed out and rosin is removed with solvents.

A complex mixture called pine oil, or tall oil, is also obtained from stump wood. It is used in the flotation process for the concentration of ores of lead,

zinc, and many other minerals; in the treatment of wool, cotton, and rayon fabrics before dyeing; in the devulcanizing and reclaiming of rubber; in commercial laundering; and in the manufacture of soaps, insecticides, and disinfectants.

Still another method is used to produce turpentine. It is recovered as a byproduct in the sulfate process of pulping southern pine for paper manufacture. The turpentine obtained in this way now amounts to considerably more than twice the amount obtained from oleoresin.

For the 1968 crop year, the U.S. Department of Agriculture estimated 656,000 barrels of 50 gallons as the total production of turpentine. This included 135,000 barrels of steam-distilled wood turpentine and 470,000 barrels of sulfate turpentine and 51,000 barrels of gum turpentine. The total rosin production was 1,855,000 drums of 520 pounds, net. Of this total, gum rosin amounted to 170,000 drums; steam-distilled wood rosin, 480,000 drums; and tall oil rosin, 705,000 drums.

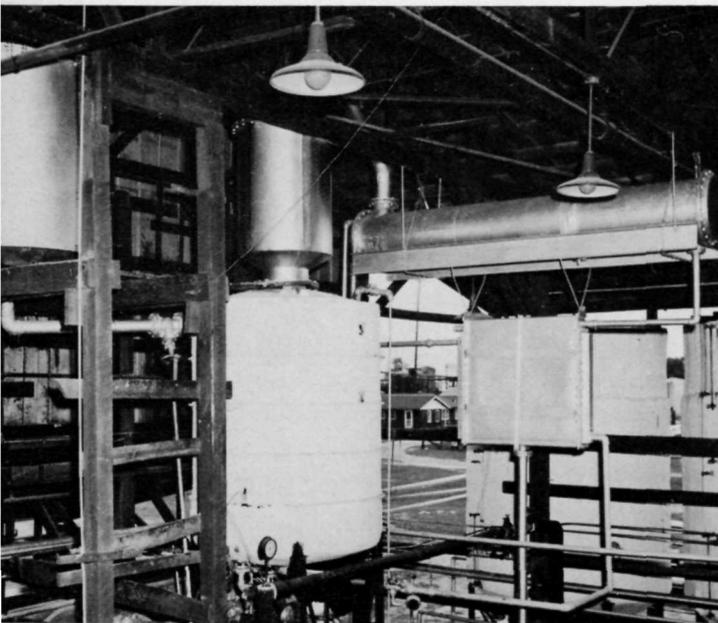
Turpentine has been used for many years as a thinner for ready-mixed paint and varnish, and some is used in making various polishes, waxes, and pharmaceutical items. At one time it was the only source of synthetic camphor. Currently the use of turpentine for thinning paint and varnish is declining steadily. But the turpentine consumed in industrial use, of which 98 percent is in industrial chemicals, is increasing.

Rosin has a somewhat similar story. Hundreds of articles in everyday use contain rosin, although the user may not recognize it. It is, however, recognized when it is used for friction surfacing on

Left: The modern steam still for the production of turpentine is a vast improvement over the old fire kiln. Clean washed gum from the tank at the upper left is still in the middle unit, and condensed in the water-cooled condenser at the right. Right: Gum turpentine goes aboard a ship for export. A deckload of rosin has already been loaded.

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violin bows, machine belts, or on the hands of the baseball pitcher and hitter. But the great quantities of rosin produced are consumed in other uses. The paper industry, for instance, uses nearly 700,000 drums of rosin per year, a use that has been increasing with the rising consumption of paper. In paper, rosin functions as a size that holds the surface fibers of the paper in place, thus giving a firm finish, preventing the spreading of ink, and reducing the pickup of fiber by type in printing. The use of rosin in the manufacture of coarse laundry soaps has decreased because household detergents have largely replaced soaps, but use continues strong in the manufacture of paint, varnish, and lacquers, synthetic rubber goods, paper products, and printing inks.

### Canada Balsam and Other Resins

From blisters that form in the bark of the balsam fir comes Canada balsam, a resin that has long been used for cementing optical lenses and for microscopic slide mounts. This resin is suited to optical work because its refractive index is in the range of that of optical glass. At one time Canada balsam had little competition in its field, except perhaps from Oregon balsam, a Douglas-fir product often used as a substitute. Both products now have competition from a number of synthetic plastics.

No longer important commercially, storax from the sweetgum tree of the South contains the fragment cinnamic acid. This acid can be used in porous plasters, flypaper, chewing gum, ointments, and salves.

The Digger pine and the Jeffrey pine, which grow in the Sierra Nevada and the foothills of the Coast Ranges, yield distinctive resin. These resins produce heptane which was used as a standard in testing the antiknock properties of gasoline. It has since been replaced by petroleum fractions or synthetic materials.

### Maple Sirup and Maple Sugar

No product of the forest is more distinctively American than maple sirup and maple sugar made by boiling down the sap of the maple tree. Only 2 of the 13 native maples have a high enough sugar content in the sap for this purpose. These are *Acer saccharum*, called sugar maple, hard maple, rock maple, or sugar tree, and *Acer nigrum*, called black sugar maple, hard maple, or sugar maple. The latter species grows over a much smaller range than the former. Sugar products were being made by the American Indians when the white man came to this

continent, reportedly by dropping hot stones in the maple sap to evaporate the water. As an item of barter among the Indians of the Great Lakes and the St. Lawrence Valley, this sugar must have been valued highly because there were no other large sources of sugars.

In addition to their exclusively American origin, maple products are distinctive for being among the oldest agricultural commodities and for being crops that must be processed on the farm before they are in suitable form for sale. Where maple groves are sufficiently well stocked, the making of maple sirup and maple sugar offers an excellent rate of profit for the hours invested in the operation of a maple grove and sugar house. This profit is estimated as high as \$5 per hour, including time spent in cleaning the equipment and collecting and boiling the sap. One advantageous aspect of maple products on the farm is that they can be produced in the late winter when other activities are few.

The sugar-making operation, however tedious, is fairly simple. Maple trees are tapped and provided with spouts from which sap drops into suitable buckets. This is usually done in late winter when, although freezing temperatures occur at night, it is warmer during daylight. The sap is boiled down until it becomes sirup, sweeter and more delicately flavored than the sap, and darkened somewhat in the process. The color and the subtle distinctive maple flavor depend on the use of heat in the evaporation process. Evaporation by freezing or vacuum will not produce true maple sirup. The process of making hard or soft maple sugar, maple butters, honey, or creams, depends on further concentration and careful control of crystallization.

The sugar content of the sap in maple trees ranges from less than 1 percent to more than 10 percent but averages about 2 to 3 percent. The prudent operator will, of course, cull trees that give a sap with a low sugar content. The number of tapholes placed on a given tree should be proportionate to the size of the tree. As much as 45 gallons of 2-percent sap must sometimes be processed to yield a gallon of maple sirup or 7.5 pounds of sugar. An exceptional tree with a 10-percent sap would produce the same amount of sirup and sugar from a little more than 8.5 gallons of sap.

Although the first sugarmaking equipment of the maple groves was improvised, modern materials and thinking are making sugarmaking less burdensome and the control over the quality of the end products better. Powered tapping tools have appeared, and



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In some modern sugar orchards, plastic bags have appeared as replacement for the old sap buckets. They keep the sap more sterile and may be rotated readily on the spile for emptying into gathering buckets.



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The sugar bush in some cases has gone very modern, with the maple sap flowing through long lines of plastic tubing to collecting tanks from which it is pumped into large trucks and hauled to a modern sugar house for boiling down to maple sirup and sugar.

plastic tubing has been used to transfer sap all the way from taphole to sugarhouse or from fixed gathering tanks in the grove to the sugarhouse. Pumps have been used where gravity flow is not possible. Plastic bags have been used instead of sap buckets. The truck and tractor are used in the woods—alongside the horse or ox drawing a sap tank on a stoneboat.

In the sugarhouse, oil is replacing wood as the fuel for evaporating water from sap. Thus temperature control at critical stages is improved and the operator's work is made easier.

In the sugarhouse, simple instruments aid control of the operation and diversification. The value of the products is increased by processing on the spot and by making maple creams, pralines, and other confections.

The amount of maple sirup and maple sugar produced in 1967 was 2,024,000 gallons. In any year the quantity produced may be influenced by the availability and cost of labor on the farm. Eleven States, headed by Vermont and stretching westward to Minnesota, have produced most of the product. Producers have joined in associations, have improved their packaging, and to a great extent have sold directly to the consumer. Only a relatively small percentage of tappable trees is being worked in the United States, and substantial quantities of maple sirup and maple sugar are imported from Canada.

Maple sirup is graded to meet certain standards as U.S. Grade AA (Fancy) Table Maple Sirup, U.S. Grade A Table Maple Sirup, and U.S. Grade B Table Maple Sirup. The higher grades are required to be free from cloudiness, relatively light in color, and of a delicate flavor that satisfies connoisseurs' preferences. Individual consumers, however, frequently prefer sirups with a less delicate flavor. A considerable percentage of maple sirup, for which the farm receives around \$5.33 per gallon, is blended with less expensive cane sirup. The best grades of sirup are sold to consumers for table use and to confectioners, and the darker grades to sirup blenders and to tobacco processors for flavoring.

### Tannins and Dyes

The forest is a traditional source of tannins. In general, tannins are able to combine with gelatin to make a solid, insoluble substance. This property makes tannin valuable in processing hides. When animal hides are soaked in a solution of tannin, the so-called collagen, which is similar to gelatin, in the hide combines with the tannin. An insoluble substance is formed that gives to leather its desirable wearing qualities, its durability, and its resistance to wear. Tannin also has been used for reducing the viscosity of mud used in drilling oil wells, as a preventive of steam-boiler scale, as a preservative for fishing nets, and as an ingredient in inks.

The wood of American chestnut and the bark of chestnut oak, western tanoak, and eastern hemlock were at one time the principal sources of tannins for the American leather industry. Subsequently, quebracho imported from South America, Italian chestnut and sumac, and other sources of imported vegetable tannin began to be used increasingly. Extract from the wood of American chestnut was used for tanning until this fine species was exterminated by the chestnut blight. Tanning that used alum, chrome, and various synthetic materials came into use, although these materials, like the vegetable tannins, have distinct characteristics and limitations and are not universally used for tanning all kinds of leather. Currently chestnut and quebracho are the principal sources of vegetable tannin used in this country; much of the chestnut tannin is probably imported in the form of extract from Italian chestnut. Current figures on tannin consumption are not easily obtained, but it is likely that the consumption of all tanning materials is less than 100 million pounds in contrast to 300 million pounds in 1939. A considerable part of this reduction is the result of competition of other materials with leather in many fields.

American forests have enough raw materials in the form of wood, bark, and foliage for the production of tannins, and in an emergency the country's requirements could be met. The problem is harvesting and extracting the material at a cost low enough to make it competitive with imported tannins.

In early days American trees provided dyestuffs that were used by the pioneers. An extract of butternut gave "butternut jeans" their name—a name synonymous with pioneer simplicity and hardship. Yellow and green dyes were at one time made from the coffeetree, which also was used in making soap and coffee substitutes as well as furniture. The Osage-orange is practically identical with the fustic imported from Mexico and Central America for dye purposes. During World War I Osage-orange was in great demand, which was caused by the absence of German chemical dyes. Many American soldiers wore olive drab uniforms dyed with the same Osage-orange used by their forefathers in homespun garments. Black oak bark is a natural source of quercitron, another dyestuff that has ceased to be important only in recent years.

## Nuts

Nuts harvested from the trees of the forest are equal to nuts grown in orchards in nutritive value and in richness and subtlety of flavor. Only the high costs of harvesting, processing, and distributing forest nuts keep the crop from being big business as foodstuffs go. The pecan is the only forest nut that has been domesticated on a large scale, and the sale of this nut grown in the orchards of the South brings in good farm incomes.

Many older Americans are fond of nuts grown wild, partly because of sentimental memories of childhood. Children on the farm and even those in town led a life of high energy and were everlastingly hungry. They enjoyed good things as much as the child today but usually had very little cash. The result was that nuts—black walnuts, butternuts, hickory nuts, pecans, beechnuts, or any of the other forest nuts—gathered on the home farm woodlot, or gathered without thought of ownership from any available tree, represented a worthy prize. Eaten unadorned during the long winter and found in cakes, cookies, and other products on the farm or city kitchen, they were good and they were free.

To a boy, these nuts had and still have in recollection a flavor enhanced by the long tramp in the woods, the good companionship of others of his age, the unpleasant job of removing the husks of some of the nuts, and finally the tedious job of cracking. In black walnut territory, the schoolboy casually displayed fingers blackened for weeks by the stain of black walnut husks as evidence of success afield and of his masculine disdain for the concept of spotless hands. Older people who once lived in the Southwest still praise the pinyon nuts gathered and marketed by the Indians.

*Pecans.*—To most purchasers, pecan probably means the fancy, large thin-shelled varieties of that nut that are a specialty of the holiday trade. This kind of pecan is the cream of the crop; it is mainly harvested in cultivated orchards from budded or grafted trees that were started in nurseries. The bulk of the pecan crop, however, comes from wild trees growing along the river bottoms of Texas, Oklahoma, Louisiana, and other States south of the Ohio River. In 1967 the annual pecan crop was estimated at 207 million pounds, with approximately three-fourths of the crop coming from wild trees. The current trend is toward a larger share of the crop coming from orchard trees.

The wild and cultivated crops are used for different purposes. Having smaller nuts and generally

lower quality, the wild crop is used in candies and baked goods. The cultivated crop, with its larger high-quality nuts, is used on the table and in quality confections.

The first known shipping and marketing of wild pecans was begun about 1900 by Alexander Wooldert, a wholesale grocer of Texas. Wooldert was also the patentee of the original screw device for cracking pecans lengthwise. This device made it possible to extract most of the kernels in full halves that are free from the bitter inside shell membranes. Improved cracking machines, some of the hopper type and capable of operating with a minimum of attention, have greatly increased the supply of shelled pecans and thus the marketing of both wild and cultivated nuts at all levels from the roadside stand to wholesale operations. The growth of the tourist trade in the pecan areas has done much to facilitate marketing, since a substantial share of the crop is sold at roadside and even off the truck tailgate.

*Black Walnuts.*—In recent years the nut of the native black walnut has taken an enhanced position in commerce. But the production of this nut has been handicapped by the demand for the wood of the black walnut tree and by the difficulty of cracking the nut. The wood of the black walnut tree is not equaled by the wood of any other native species in sheer beauty and serviceability for many uses; it has long been in such great demand that cutting for lumber has severely reduced the number of nut-bearing trees. The value of the nut crop, however, is coming to be better understood. The walnut can be propagated rather easily, and in many sections of the Middle West and South there has been consistent planting. Horticulturists have done some successful work in selecting strains for larger yield of nuts.

The primary difficulty with the black walnut from a commercial point of view is that it is one of the hardest nuts to crack. Extracting unbroken kernels from the average black walnut calls for both skill and luck. The price that could be obtained because of the flavor and nutritive value of the meat provided incentives for some home industry for a long time. The nuts were cracked as a family enterprise, and the jobber paid perhaps as much as 80 cents per pound for meats in some years, but much less on the average.

In recent years, improved automatic cracking machinery and laws in some States requiring pasteurization of home-cracked meats have resulted in

a greatly increased harvest of black walnuts. There are now 10 large cracking plants and several smaller ones operating throughout the area where black walnuts are shelled. These plants are in Tennessee, Kentucky, Arkansas, and Missouri; annually they process about 82 million tons of walnuts and market about 9.8 million tons of kernels.

State food and drug laws requiring pasteurization have now practically eliminated the home cracking industry. Nevertheless, most of the nuts used in the processing plants are harvested by farmers from wild trees, and dry hulled nuts are sold for about \$5.38 per ton. Plant processing is by machines, each capable of shelling as much as 2,500 pounds per hour. Kernels are pasteurized and sealed in containers on a production-line basis and reach the consumer in attractive and sanitary packages through foodstores. The nuts flow from woods to consumer much faster than they did when they were shelled at home and marketed through the country store.

The marketing of black walnuts is aided by the fact that the shells can be ground into meal or flour and used in fur and metal cleaners and as extenders in glues and plastics.

*Hickory Nuts.*—Hickory nuts are borne by about 30 recognized species of *Carya* (formerly *Hicoria*), the genus to which the pecan belongs. The nuts of the shagbark hickories have the largest kernels and are considered best for human consumption. Many of the others are so small and thick shelled that they are practically worthless except as food for hogs on open range. Although hickory nuts appear in the market now and then, most sales are local and little is known about the amounts sold.

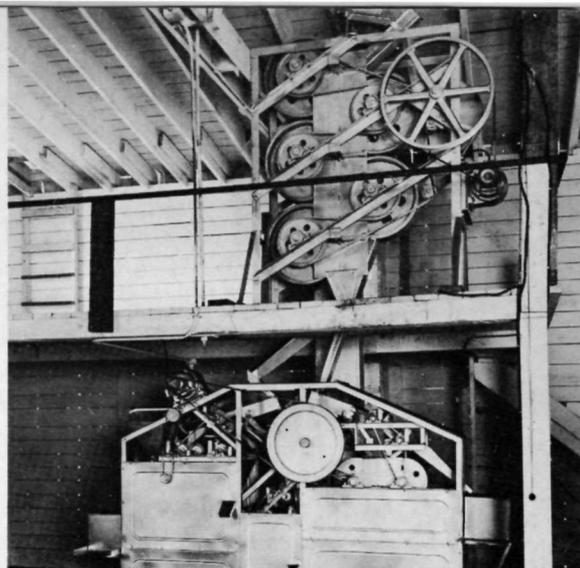
*Butternuts.*—The butternut, a close relative of the black walnut, with the same general type of hard, rough shell but oval in shape, is noted for its richly flavored, oily kernels. Although the butternut is not sold to any great extent, it grows abundantly in some sections of the North and East, where large quantities are gathered for home use. Maple-sugar confections marketed at many roadside stands in New England may contain butternut. By many the butternut is preferred to the black walnut for its flavor and because the shell is not quite so flinty as that of the black walnut, making the recovery of the kernels somewhat less tedious.

*Chestnuts.*—The native American chestnut was commonly sold in stores and "hot roasted" along with imported nuts on big-city street corners. The



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The black walnut, unpleasant to hull and hard to crack, but with kernel rich and full of flavor, is found on the supermarket shelf in modern vacuum-sealed cans or cellophane packages.



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One important link in the marketing of forest-gathered black walnuts is the cracking machine. The machine has supplanted a hearthside activity and has caused a larger marketing of nuts.

incurable blight of the chestnut trees has destroyed all of the native stock throughout the United States and swept the American chestnut from the American market, a fate also shared by the related and once abundant chinkapin of the South and East. For a long period chestnuts imported from Italy and other foreign sources were all that were available. In recent years, however, the blight-resistant Chinese chestnut trees planted around 1940 have begun to bear in Maryland and Georgia, and nuts from these trees are on the market. This is an orchard crop, of course, rather than a product of the forest.

*Beechnuts.*—The sharp-edged three-sided beechnut has never become commercially important. This is because it is very small (improved varieties may have 1,100 to the pound) and because extracting the sweet kernels is difficult. In the Northeast, where it is most abundant, the beechnut has always been gathered in considerable quantities for home use.

*Pinyon Nuts.*—Pinyons are the only nuts produced by an American coniferous tree that have ever had any importance as an article of food or commerce. This nut is the seed of a small pine tree, *Pinus edulis*, and is somewhat egg-shaped, one-half inch or less in length, and, like all pine seeds, is borne between the scales of a cone. Its thin, brittle, brown shell is filled with a rich kernel of distinctive flavor. This nut has held an important place in the diet of Indians and Spanish Americans in the Southwest

and as much as 6 million pounds per year has been marketed. Current crops are estimated at about one-half million pounds. Fortunately, those who used the pinyon nut regularly in their diet have become less dependent on it, but, subject to variations in the harvest, it still provides a good income for local people.

The greatest single market for pinyon nuts is in New York City. Substantial local markets exist around Albuquerque, N. Mex., El Paso, Tex., and Los Angeles, Calif. With the benefit of the continuing demand, gatherers of the pinyon nut have been paid from 50 cents to a dollar per pound. At the higher rate in a good crop year, an enterprising family group has made as much as \$50 for a day's gathering. The retail price of shelled and roasted nuts may go as high as \$3. The Navajo Indians have always harvested the major part of the crop.

### Pharmaceuticals

The early settlers in America became aware of many forest-grown "medicines" used by the native Indians. In time the settlers adopted some of these remedies, and the remedies became professionally recognized. Certain items, such as the bark of the cascara tree because of its laxative effect, had a sound basis for the use. Others were aromatic and convinced the sufferer of their virtue by giving him a temporary pleasure that may have been reflected in the rate of natural recovery. But some brews and

extracts were so bitter and repellent that the sufferer believed the germs could not tolerate them. At any rate, the number of such herbal medicines prescribed by modern physicians has steadily declined, although some are still favored by home practitioners and some are in patent medicines.

Among the pleasing aromatic materials was witch hazel extract, frequently used for healing effects. Sassafras bark, leaves, and root were likewise believed to have fine tonic values, and sassafras tea is still enjoyed without medical consideration by those who grew up in its range.

A quick thumbing over of drug and chemical price lists shows the following forest-derived items still being quoted: Balm-of-Gilead buds, balsam tips and needles, blackhawk bark, cramp bark, dogwood bark, elder flowers, fringetree root bark, elm bark, laurel leaves, prickly-ash bark, sumac leaves, wahoo root bark, white pine bark, wild cherry bark, and witch hazel bark. There are no doubt many others being traded in small quantities and not listed among the higher volume items.

### Volatile or Essential Oils

Volatile or essential oils are aromatic substances derived from crude plant material by distillation or other means. These oils are obtained from leaves, roots, barks, and wood as well as from many whole herbs. They are as diverse in chemical characteristics as are their parent materials.

Dozens of oils from American forest trees have been analyzed, but few have become commercially important. Two oils from conifer leaves that have

been produced in limited quantities are oil of cedar leaf and oil of hemlock. The potential production of oils from the leaves of conifers is enormous, but the profitable production of these oils is seen to be doubtful when labor costs and all operating charges are compared with prevailing prices. The prices, of course, reflect a limited demand for the product. It is not surprising that the already small production of oils is declining.

From the broad-leaved trees at least two commercial oils have been produced. Oil of sassafras was once of some importance as a flavoring and deodorant material, but its importance in this field has declined. The significant ingredient, safrol, can be obtained synthetically. Oil of sweet birch, sometimes substituted for oil of wintergreen as a flavoring material, has also had some irregular production.

### Christmas Trees and Foliage Products

The 60-odd million households in the United States use more than 48 million Christmas trees annually; therefore, Christmas trees are used in 8 out of 10 homes. Of this vast number of Christmas trees, about 40 million are grown and harvested in the United States. The rest come almost exclusively from Canada.

Growing and harvesting Christmas trees are well suited to farm enterprises since land is often available and the harvest comes at a time when farm activity is low. About 87 percent of all trees come from natural wooded areas or pasturelands and the rest from plantations. Farmers own about 70 percent of the more than 225,000 acres of Christmas

Loading Norway spruce Christmas trees in Pennsylvania. In the foreground red pine trees are ready for loading.

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When the trees are decorated, none is so famous as the National Christmas tree in Washington. This one was felled on the Lincoln National Forest in New Mexico.

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tree plantations. On natural forest lands the harvesting of Christmas trees should not be considered detrimental to conservation. Thick stands of young trees normally require thinning to provide space and sunlight so that the remaining trees can grow rapidly to large size. Proper thinning benefits the forest, and at the same time it can produce great quantities of Christmas trees.

The retail value of Christmas trees sold each year is estimated at more than \$140 million. Most of the supply comes from States along the Canadian border. Except for North Dakota, all the northern border States harvest more trees than they can consume. Montana, which has quite complete records of the Christmas tree industry, normally ships trees to 27 other States and to Cuba.

The leading Christmas tree species are Douglas-fir, balsam fir, eastern redcedar, black spruce, and Scotch pine. These species make up 81 percent of the United States production.

In addition to Christmas trees, the wooded areas of the United States provide an undetermined harvest of evergreen boughs and "ropes," holly, ferns, magnolia, mistletoe, Oregon grape, and other natural ornamental materials.

## Fruits

The fruits of the forest are no longer appreciated

as much as they were in pioneer days. As the country became settled, cultivated horticultural species were introduced and no great effort was made to develop the native fruits. Even the wild crabapple, growing in profusion over a wide range, has never been cultivated for its fruit to any extent.

Of the 18 native species of wild plums some have been domesticated and are well established in cultivation. These plums have been derived, for the most part, from the northern wild plum (*Prunus americana*) or the southern or Chickasaw plum (*P. angustifolia*).

The early settlers were familiar with serviceberries, which played an important part in the making of jellies and pies. They also knew the pawpaw, closely akin to the West Indian custard apple and quite tropical in its apparent character, that grew throughout the central and eastern parts of the United States.

The persimmon, a soft, pulpy fruit that is extremely astringent when green and almost equally bland when ripe, was a favored base for breads, puddings, muffins, and cakes in its southern range. It occasionally appears in the modern supermarket, probably from cultivated sources.

Red mulberries, elderberries, wild blackberries, wild raspberries, wild strawberries, and wild grapes formerly contributed to the national larder more than they do at present. Locally they still are of minor importance.

## Future Demand for Forest Products

The volume of forest products used seems likely to increase, because modern research is leading to new technological developments and because the growing population will need more of these products. In the field of technology the trend is to more use of the wood fiber as such or in the form of chips or other easily managed forms. This trend points to the solution of the problem of using wood wastes. In the long run it will aid in the disposal of low-quality material as well.

Outstanding among the increases in forest products utilization is the consumption of pulp and paper. Demand grows along with a rising standard of living and continuing improvement and diversification of paper products. There are indications of an increase in the use of improved papers, moisture-proofed or otherwise fortified, for structural pur-

poses. Paper honeycomb sandwich cores for building panels and paper overlays for improved panel materials are typical of the new uses. If the promise in these materials is fulfilled, the per capita consumption of paper will climb at a more rapid rate than in past years.

The use of veneer and plywood is also expected to increase because of a fast-rising population and because of their convenience and versatility. Large, clear softwood peeler logs, which are the prime raw material of the structural plywood industry, are no longer plentiful; but industrial ingenuity in the use of suitable masking face plies, both of veneer and other materials, should go far to offset the scarcity of inexpensive clear veneers. New skills in using hardwood veneers should help to maintain supplies suited to an increasing market.

The American house is still basically a house of wood and plywood and is comfortable and economical. People will continue to require lumber to make housing, factories, highways, and all of the material appurtenances of living, and people are increasing at an immense rate. The population of the United States is expected to increase to about

220 million by 1975 and to about 305 million by the year 2000. To house and service this population, lumber will be needed in quantities that will tax the capacity of existing forests and call for even more efficient management of forests so that they will yield more logs of high quality.