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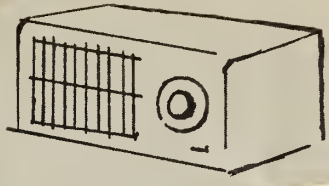
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PRODUCTS OF AMERICAN FORESTS

MISCELLANEOUS PUBLICATION NO. 861

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE



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Contents

	<i>Page</i>
Importance of forest resources	1
Wood—the material	2
Solid and composite wood products	4
House construction	4
Veneer and plywood	7
Insulation board, hardboard, particleboard, and sandwich materials	8
Furniture	9
Laminated timber construction	11
Dimensionally stabilized wood	12
Railroad uses	12
Poles, piling, mine timbers, and posts	13
Pallets and packaging	13
Wood chemical products	14
Pulp and paper	14
Other cellulose derivatives	17
Wood and charcoal fuel	18
Seasonal crops and extractive materials	19
Naval stores	20
Canada balsam and other resins	21
Maple sirup and maple sugar	22
Tannins and dyes	23
Nuts	23
Pharmaceuticals	25
Volatile or essential oils	26
Christmas trees and foliage products	27
Fruits	27
Future demand for forest products	27

Frontispiece—the Forest Products Laboratory at Madison, Wis., where research is in progress to make the products of the forest serve the Nation better.

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Products of American Forests, Importance of Forest Resources

F. J. Champion, Information Specialist, retired. Forest Products Laboratory, Madison, Wis.

Our forests are 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 material 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

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, about 60 cubic feet of wood in a year. This is approximately 50 percent more than the citizen of timber-rich Russia uses and about 2½ 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 one out of every 13 employed persons in 1969 obtained his living from some phase of timber production and fabrication. In that year the timber industries accounted for about 1 dollar in every 16 of manufactured goods—a total of about \$35 billion.

Lumber used for housing is one of the most vital forest products. The success of builders in their efforts to provide over two million 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

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

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

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The farm woodlot is an important source of forest products. More than a third of all commercial forest land in the United States is owned by farmers.

total industrial effort.

The normal economic and cultural activities of the United States also require large amounts of wood fiber pulp. The average American now uses over 600 pounds of paper products annually, five times as much as 50 years ago. Europe now uses 135 pounds, and Asia uses 23 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 attractive 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



M-118208

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

new as well as older uses.

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 often 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 about 500 million acres, about one-fourth of the continental United States, that is either in forest or suitable for growing timber for commercial use. This includes land in the National Forests, land owned by industrial companies, and the vast number of woodlands owned by farmers and other individuals.

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 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 $(C_6H_{10}O_5)_n$. This symbol little indicates the complexity of the cellulose molecule or the variety of ways in which it can be transformed into useful materials. Through chemical alteration, for example, 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.

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 2 inches by 2 inches in cross section can sustain end-wise pressure of as much as 40,000 pounds before failing.

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.

Wood has high strength under a wide range of conditions. In most strength properties, dry wood is stronger than wet wood but wet wood may be 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 the heat flow 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 $\frac{3}{4}$ of an inch actual thickness as is a brick 4 inches thick.

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

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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 temperature. 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. Furthermore, wood is a renewable resource, compared to many of our other natural resources that are not.

Solid and Composite Wood Products

House Construction

The majority of all houses erected in the United States are of the wood-frame type. The traditional frame house has a record of long service, with thousands of houses in the United States 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. About three-fifths of the new houses are one-story houses, and

more than half are without basements. Most of these are built on concrete slabs rather than old-style foundations. The average living space per house has also increased one-third in recent years.

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.

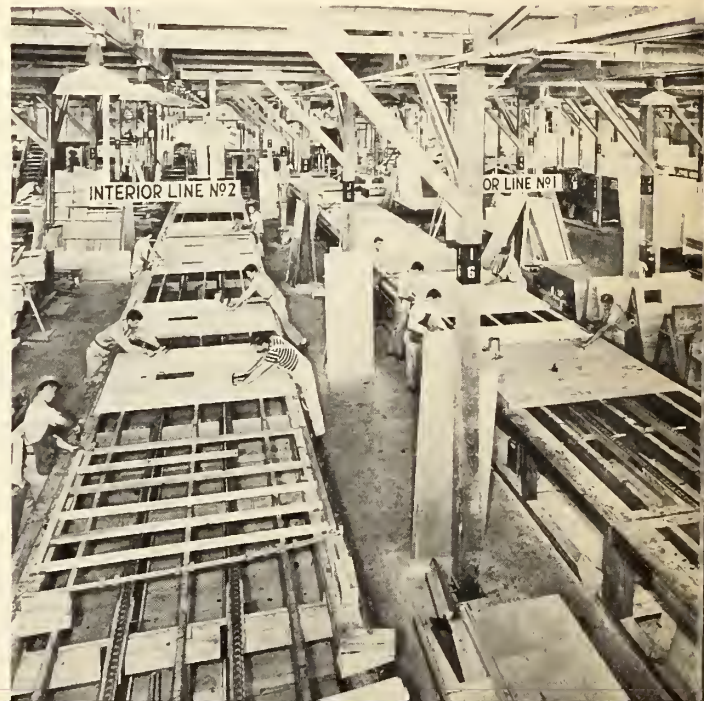
Factory manufacture of houses and house components has become established to a degree. This type of production offers the possibility of carefully engineered design, although methods vary from

A reminder of wood's service in homes. Ralph Waldo Emerson's house was built more than a century ago in Concord, Mass. Well planned, built, and maintained, it has served well through the years.

In a house fabrication plant, mass production techniques are used.

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

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plant to plant. In addition, large quantities of mobile homes are being produced.

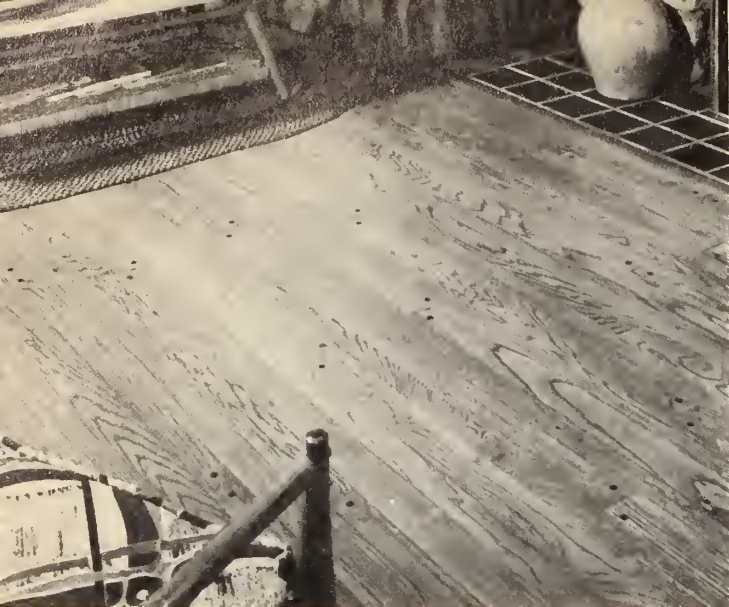
Related to the trend toward complete factory production is the use by local builders of more and more standardized and prefabricated items that save time and effort in the custom-built house. The use of ready-built paneling and roof trusses is typical of this trend. Roof trusses can be erected more quickly 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 finish 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, non-wood 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 and wood-based paneling is increasingly used in interiors of American houses. Wood interior surfaces are serviceable and 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. New technology has resulted in production of a new generation of wood-based products.

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 illustrate their distinctiveness. 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 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 baskets and boxes for fruit and vegetables. The greater part is glued to other veneer to make thicker sheets or is glued to wood or wood-base panels 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 alternate sheets usually laid crosswise. The resulting material has distinct advantages for many uses. The natural tendency of one ply to swell or shrink as moisture conditions change is restrained by the adjoining plies. 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 more economical 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 as raw material for pulp and particleboard.

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 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, casein glue, soybean glue, and blood albumin glue, were not sufficiently waterproof to be used outdoors. However, the phenol-formaldehyde ad-

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 cabinet-work 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.

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M-118235

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M-118240

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



M-118227

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

hesives 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.

An average of more than 5,000 square feet ($\frac{3}{8}$ -inch thickness basis) of plywood per unit is used annually in the construction of one- and two-family housing units. Of this amount, about 41 percent is used for exterior wall and roof sheathing, 33 percent for subflooring, and the remainder for cabinets, doors, paneling, millwork and trim applications, floor underlayment, and siding.

Between 1960 and 1973 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 many as 7,100 square feet ($\frac{3}{8}$ -inch thickness basis) by the year 2000. To 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, Particleboard, 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 particleboard are in this class. These materials now compete with plywood in residential and industrial construction. In contrast, early American housing had no insulating board for sheathing wood-framed walls, no hardboard siding or paneling, and no particleboard for counter tops, door and furniture cores.

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. 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. One use is to reduce sound transmission through walls and floors. Among the hardboards is the hard, dark-brown, smooth-surfaced materials, 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. The newest hardboard is medium-density siding.

Particleboards 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 particleboards, however, have a pleasing surface of large wood flakes that covers an internal structure of smaller and less regular wood particles.

To illustrate the quantities of these boards produced, 1973 figures were: Hardboard, 6.5 billion square feet; insulation board, around 4 billion; and particleboard, 3.5 billion square feet. These figures are based on $\frac{1}{8}$ -inch thickness for hardboard, $\frac{1}{2}$ inch thickness for insulation board; and $\frac{3}{4}$ -inch thickness for particleboard. Particleboard use particularly has been rising, with 1973 showing 14 times as much particleboard being used as 15 years earlier.

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 plastic, grid-patterned

wood latticework, wood fiber, or paper honeycomb. The chief characteristic 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.

Furniture

People used wood for furniture before history was recorded 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.

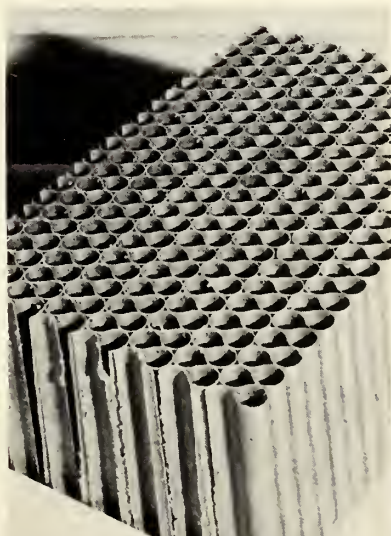
A refinement in the parts of furniture that is still in progress began when metal tools for cutting wood were created. Round wood posts bound with thongs gave way to hewn and then to sawn posts.

Left: Particleboards, made of varied forms of wood residues, provide a new group of sheet materials for building, a 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, hardwood, or other thin but rigid facings. Right: Attic room finished with structural

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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 to please the nobility. For more practical reasons, the thin sheets of veneer were combined to make 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 particleboards 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 overlay-

ing 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 always 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.

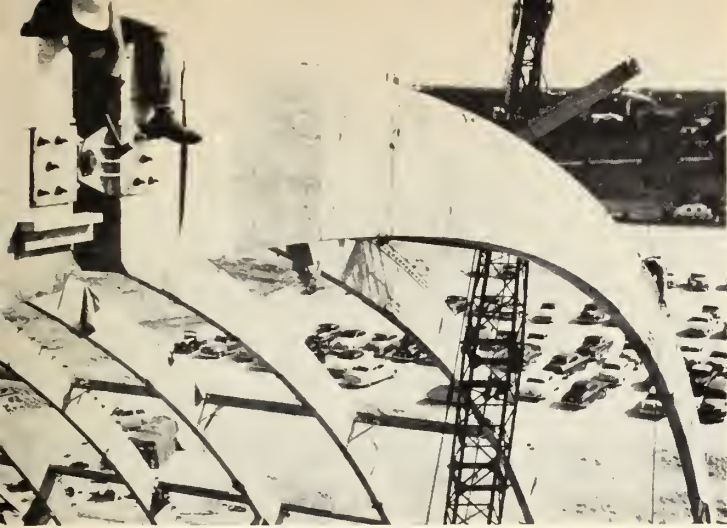
The whole field of composites—combinations of wood with paper, metal, ceramics, and plastics—offers almost unlimited possibilities for more attractive, more serviceable furniture. Knowledge of wood is greater and more freely available than ever. With all of the resources of solid wood, veneers, straight and molded plywood, and composites at his disposal and with the added advantage of being

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.

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M-33077-F





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.

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

Advancing technology of glued laminated timber has made it one of the major structural building materials. This material is glued up from 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.

Structural members made of parallel-laminated materials give excellent performance. These range in size and shape from small straight beams to giant laminated timber 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 semi-cylindrical curve and be large enough to span 350 feet or more of unobstructed space in an athletic arena. Longer spans are feasible. These arches are made in two or more sections that are mechanically spliced at the job site. 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 are



M-106014

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

shop fabricated in standard sizes for a mass market. Custom-built beams and 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 glued laminated timber members is to explain part of their great versatility. In the fabrication of the members, standard lumber sizes may be used. The 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. Wood volume is greatest, therefore, where stresses are most concentrated. Because of this, 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,



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.



M-96073-F

Impreg, a form of resin-treated laminated wood, is used in the making of die models by the auto industry.

thus building up an insulating coating of char. They do not become plastic and fail suddenly under high temperatures. 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. Very large ones are difficult to ship by common carriers but can be made in sections and joined at the job site.

Glued laminated timbers are probably most commonly seen in the modern church building, but also in auditoriums, supermarkets, and dancehalls. Perhaps their 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 (poly-

merized) 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 saved more than \$5 million on each year's new model change-over 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, to reduce volume and increase density, to 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 vehicles, the standard freight or boxcar, used to be made primarily of wood, although less wood is now used in the freight car. The outstanding use of wood in railroads today is for crossties.

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 movement. 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.

To maintain the track millions of railroad crossties are used, with an average life of 33 years considered good for a preservative-treated crosstie.

In the midsixties the railroads used about 4 percent of 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 a quarter-million pole-miles of line, and telephone companies far more, to say nothing of electrical transmission. The total is difficult to arrive at, since miles of wire are not easily interpreted into miles of poles. Currently, sales of poles amount to approximately 6 million per year. Extending powerlines to meet national needs 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 a third of a century of service when properly used. Electrolysis and corrosion never affect the wood

pole below the ground. Effective preservatives protect it against decay and insects.

In recent years, preservative-treated poles have found use in 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 now being used for houses as well as 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 pilings 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.

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.

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.

Production of all miscellaneous industrial round-wood products is estimated at around 500 million cubic feet.

Pallets and Packaging

Nowhere is the versatility and durability of wood more apparent than in packaging and handling

the materials of commerce. Currently around 9 percent of the timber cut is needed to supply the requirements of the pallet and container industries.

Biggest change in recent years has been the tremendous use of pallets. More and more of the products of the Nation are being handled, in bulk, on these rugged wood platforms. This sharp increase in pallets has gone far to offset the decline

in wood for conventional wood crates and containers. Corrugated fiberboard, another wood-based product, has of course taken over heavily in the container field. Meanwhile, considerable quantities of wood and wood products are also used for dunnage to block and brace items during shipment and storage.

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.

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

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. Because 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.

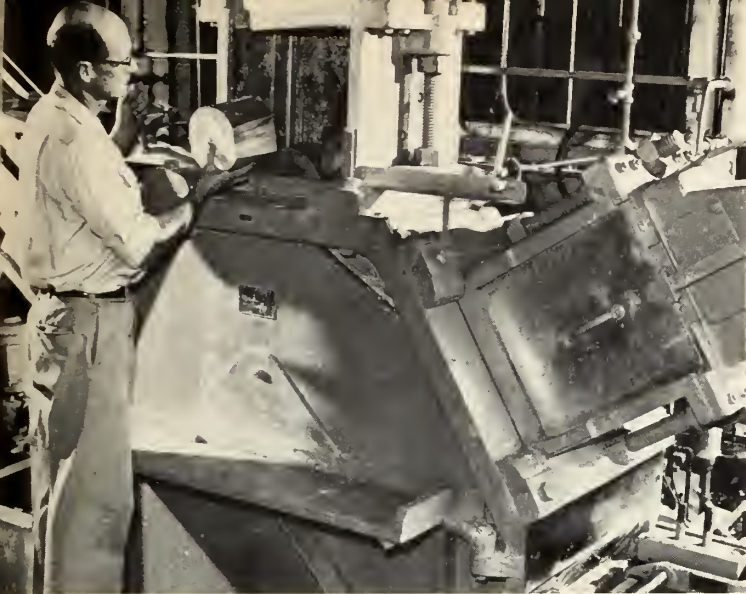
The chemical pulping processes—sulfite, sulfate, and soda—depend on the dissolving action of chemicals to remove practically all of the constituents of the wood except the cellulose fibers, which remain in a fairly pure state. This is accomplished by

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

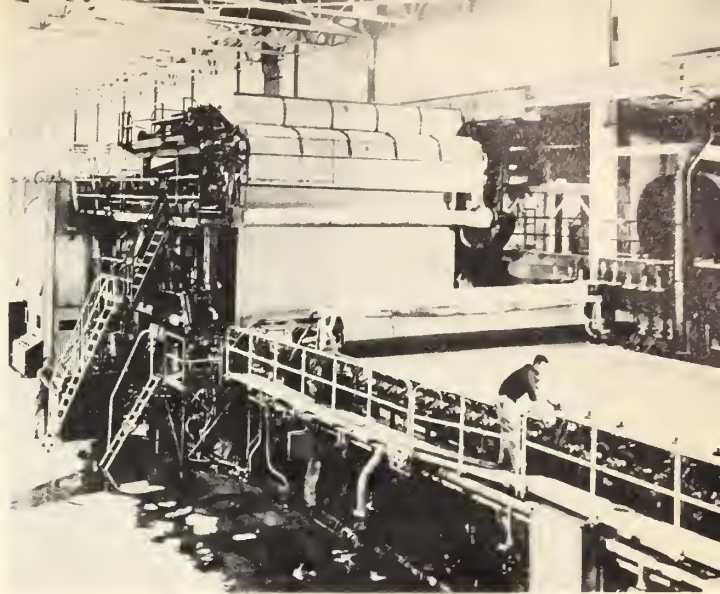
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Left: The simplest method for pulping wood is the groundwood process, in which short bolts of wood are held against a spinning grindstone in the pockets of a grinder such as the three-pocket grinder shown here. The fibers come off the stone into a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

“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 southern 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 percent 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 sul-

fate 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 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 (lightly treated) 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 semi-



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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.

chemical 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. The semichemical process has reached a yearly production of well over 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.

Currently pulpwood for pulp, paper, and allied products account for over a third of all industrial wood, which does not include fuelwood. In 1900, only 2 percent of industrial wood was pulp-

wood. Including round pulpwood and chips, over 7.5 million cords of wood are consumed annually to produce pulp. Some of the wood pulp included in this total is used in manufacturing products other than paper. It is perhaps easier to visualize the paper and board consumption by considering the fact that currently we are consuming over 600 pounds 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. Almost a third of all pulp produced is manufactured from residues.

Some general percentages of our consumption of paper and paperboard by types include:

	<i>Percent</i>
Container boards -----	28
Bending board -----	16
Book and fine paper -----	14
Coarse and industrial paper -----	14
Building paper and board -----	9
Sanitary and tissue paper -----	7
Newsprint -----	5
Other board -----	5
Groundwood paper -----	2
	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.

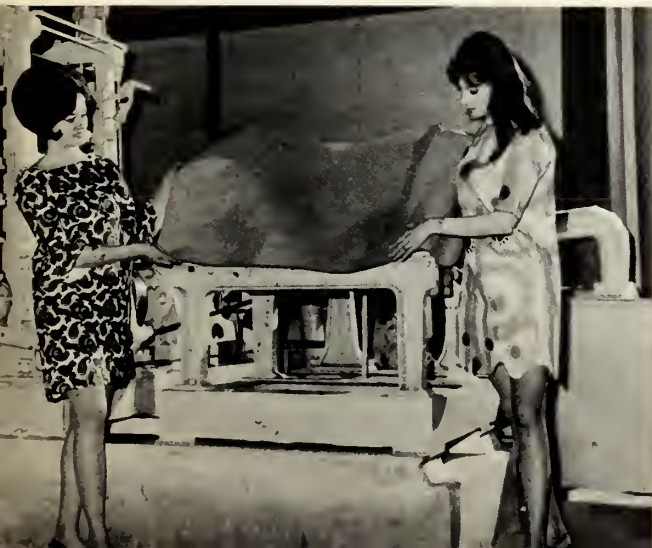
The coarse and industrial papers include brown paper bags, punch card stock, electrical material, file folders, and similar items. Among the building papers are sheathing papers, roofing felts, felts for asphalt tile, and asbestos-filled papers. Sanitary and tissue papers include toilet paper, napkins, toweling, and similar products. The groundwood items include stock for telephone directories, catalogs, wallpaper, 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 overlays 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.

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



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

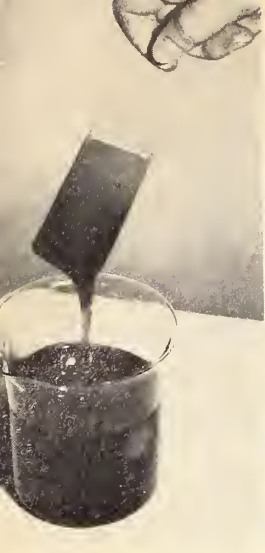
Dissolving grades of woodpulp, including sulfite and special "alpha" pulps, have been used as a basic raw material for an ever-growing list of products—cellophane, nitrocellulose, cellulose acetate plastics, photographic film, smokeless powder, tire cord, cellophane tape, telephone parts, and plastic 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. 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.

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

M-129128





M-33006-F

Dissolved cellulose ready for spinning into textile filaments.



M-32656-F

Rayon fabrics.



M-115608

Spectacle frames of cellulose derivatives from wood.



M-11560

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

Cellulose textile fibers took over a major part of the market for true silk and have competed keenly with cotton and wool. In turn nylon and other synthetics have 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 properties such as wrinkle resistance and wash-and-wear qualities. It is likely that cellulose textiles will continue to be improved and find use in products for which they are suitable.

Nontextile plastic products consume considerable tonnages of woodpulp in their manufacture. Cellulose acetate is familiar in toys, lamp shades, vacuum cleaner parts, combs, and cigarette filters. 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 the principal ingredient of smokeless powders and some rocket propellants.

In general, cellulose plastics 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 acetate propionate. The lightweight black pipe beside the road ready for installation in an underground utility may have been cellulose acetate butyrate.

Wood and Charcoal Fuel

Although the use of wood for fuel accounts for about 5 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 roundwood 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, particularly during the first decades of this century. The change has been attributed to a reduced use of charcoal for heating in cities, 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. The future of the domestic use of charcoal presumably depends on whether back-

yard cooking proves to be a fad or a permanent custom. 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. Around 400,000 tons of charcoal briquettes, as well as quantities of lump charcoal, are produced annually.

Seasonal Crops and Extractive Material

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 an-

nually. 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.



M-115738

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

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 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 longleaf 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.

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 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 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 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 trend is to process 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 are still operating in the South.

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 treat-

ment 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.

Current production is around 30 million gallons of turpentine annually, as well as nearly a billion pounds of rosin.

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 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 increas-

ing 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

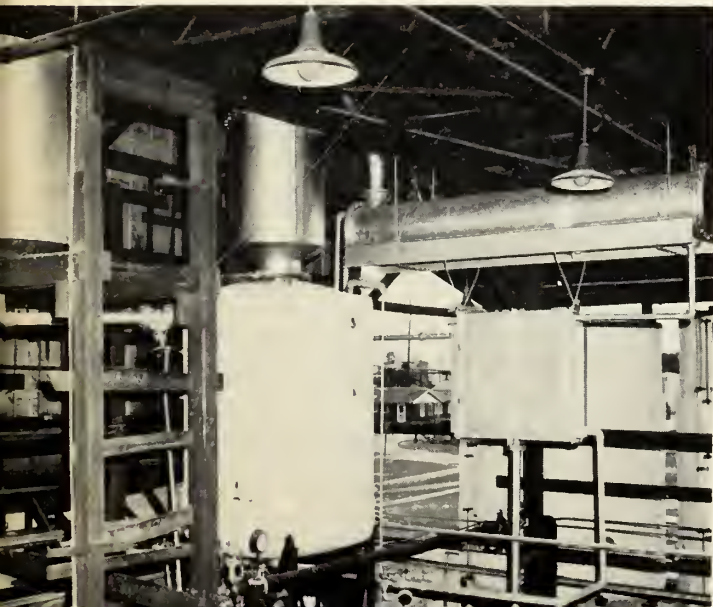
From blisters that form in the bark of the balsam fir comes Canada balsam, a resin that has long been used for cementing optical lenses and for microscopic slide mounts. This resin is suited to optical work because its refractive index is in the range of that of optical glass. At one time Canada balsam 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 fragrant cinnamic acid. This acid can be used in porous plasters, flypaper, chewing gum, ointments, and salves.

Left: The 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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M-115629

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

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, the Indians evaporated the water by dropping hot stones into the maple sap. 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



M-115739

The maple sap flows through long lines of plastic tubing to collecting tanks from which it is pumped into large trucks and hauled to a sugar house for boiling down to maple sirup and sugar.

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. 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 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, new 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 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 drawing a sap tank on a stoneboat.

In the sugarhouse the sap is concentrated and processed for the particular product desired.

The quantity of maple sirup and maple sugar produced annually is around 2 million gallons. 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 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 were 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.

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 piñon 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. Many pecans, however, still come from wild trees growing along the river bottoms of Texas, Oklahoma, Louisiana, and other States south of the Ohio River.

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 area has done much to facilitate marketing, since a substantial share of the crop is sold at roadside and off the trucks.

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 often cracked as a family enterprise.

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. 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*, 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.

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 blight of the chestnut trees 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 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

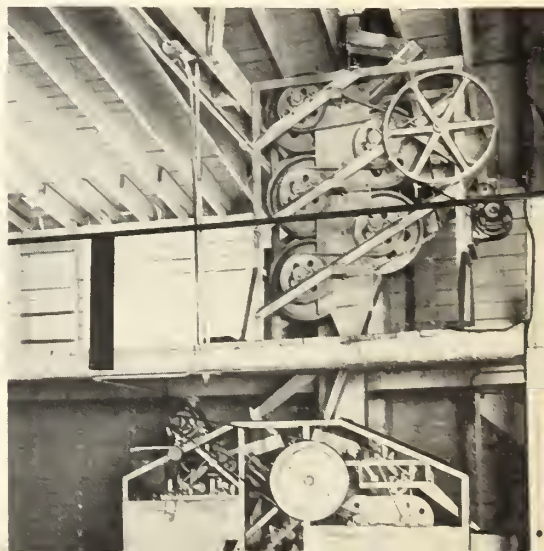
The black walnut, unpleasant to hull and hard to crack, but with kernel rich and full of flavor, is found on the supermarket shelf in vacuum-sealed cans or cellophane packages.

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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.

M-115700



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.

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



M-115743

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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Christmas Trees and Foliage Products

The 60-odd million households in the United States use more than 45 million Christmas trees annually. 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. More than 50 percent of all U.S.-produced trees come from plantations and this percentage is increasing rapidly. Tree farmers own about 70 percent of the Christmas 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 \$225 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.

The leading Christmas tree species are Douglas-fir, balsam fir, eastern redcedar, black spruce, Scotch pine, and red pine. These species make up 80 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 crab-apple, 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 purposes. 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. In addition, new and improved forestry practices can be expected to

provide additional new materials for forest products manufacture.

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 215 million by 1975 and to about 280 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.

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