ture of those suitable for plastics and some that are not. Means of separating them have not yet been found.

The neutral oils are of the hydrocarbon type. Part of them may prove suitable for lubricating purposes, and all as fuels.

The proportions of these three types of chemicals formed in the process may be varied with the hydrogenating conditions.

Wood may also be hydrogenated in aqueous alkaline suspension. The lignin forms compounds of the types just described. When the hydrogenation conditions are mild, the cellulose left is a pulp residue; when severe, the cellulose is broken down into sugars and glycerine. The industrial possibilities of such a glycerine-forming process must await further research.

Before the hydrogenation of either lignin or cellulose can become an industrial reality, methods for carrying on the process in continuous-flow equipment will have to be developed. The possibilities of commercial hydrogenation, however, are promising. One is to hydrogenate the lignin residue from a wood-hydrolysis ethyl-alcohol plant to obtain an optimum yield of neutral oils. Such a plant, it is estimated, could produce, by the combined methods, from a ton of dry wood about 110 gallons of liquid fuel consisting chiefly of ethyl alcohol and neutral oils, together with some methyl alcohol and furfural.

With all these possibilities, the chemical processing of wood residues may well be expected to expand rapidly in the next few years.

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PUTTING UNUSED WOOD TO WORK

C. V. SWEET

Every time a saw chews through a log, it spits aside sawdust. Whenever a planer dresses the roughness off a board, it throws off shavings. Square-edged lumber is made only at the cost of slabs, edgings, and trims. For every log put through the sawmill a considerable tonnage of wood fiber is left in the forest. Even the digesters of pulp mills disgorge as unusable sizable quantities of the wood fed into them. And so it goes with nearly every operation concerned with harvesting and converting trees into useful things.

Those unused materials generally have been called waste, not in the sense that they signify neglect or carelessness but in the sense that they are not economically usable. If there is use for them, the margin of profit may be discouragingly narrow, the necessary investment for equipment may be prohibitive, or the expense of handling and hauling the raw material to one point may be excessive.

Theoretically, there is a use to which practically every type of unused wood is or can be put. The problem is in finding profitable ways of doing it on an adequate basis.

Only in relatively recent years have we come to regard those unused forms as important to our national economy.

Without quite yet realizing it, we have become so desperately dependent upon our forests that failure to get the maximum use from the annual timber harvest becomes increasingly vital.

Is this unused wood close to locations where it can be put to use? Just why does a waste occur? Are we making any headway in efforts to use it?

RESIDUE occurs everywhere that wood is utilized to make things, but much of it is in remote and scattered locations. It happens for various reasons. One of the most basic is that nature did not design trees wholly, or even primarily, for man's use. Nature made them round, partially defective usually, with buttressed butts and with much of their content in branches and tops. We use only the round trunk, as a rule, and for the most part saw it into strips with squared edges to remove the bark, although veneer is peeled off like paper from a roll and the pulp-mill chippers swallow the whole barked log. But even the trunk has knots and some other defects which, for many purposes, must be cut out.

The most obvious accumulations of material discarded in processing occur at small sawmills, although back in the woods there may be even more. To the layman, the great heaps of sawdust and other scrap at the sawmills loom as an impending evil and a bad waste. The fact is, however, that those piles of refuse are in large part unavoidable even with the most efficient sawmill equipment. The finest saw inevitably chews up some of the wood as it bites through the log.

At sulfite pulp mills, only the cellulose in wood is extracted for manufacture of high-quality book and magazine paper, rayon textiles, plastics, and other chemical products. Roughly, a third of the chemical constituents of wood, known as lignin, are discarded because there is no good use for them. Lignin has thus far defied the efforts of a small army of chemists to make much profitable use of it. Not only is it unused; it pollutes the stream into which it is dumped. Some cellulose fiber is lost with the lignin.

At first glance, rotary-cut veneer, from which most softwood plywood is made, looks like an efficient way to utilize logs. Veneer bolts are mounted on a lathe that rotates them while a stationary knife cuts off a continuous ribbon of veneer. But logs are not perfect cylinders of perfect wood. A good deal of veneer has to be removed piecemeal before the log becomes a cylinder that yields a continuous sheet of veneer as it revolves against the cutter blade. Knots, cross grain, and other defects take a heavy toll, and, finally, there is the unused core of the bolt, which is too small for veneer cutting. By the time the veneer is clipped, trimmed, graded, patched, and otherwise readied for the plywood presses, some 40 to 50 percent of the log has been lost.

These and related products—including railroad ties, cooperage, mine timbers, shingles, and on down to tongue depressors and pencil slats—make up the output of the wood-using industries. In total, the discarded material from these industries bulks almost fantastically large each year.

Follow the lumber from the sawmill and you find still more loss. There are, for example, the cut-offs and degrade that result from seasoning. As lumber dries, considerable amounts are checked, warped, split, and honeycombed. Knots loosen and fall out. Some of the lumber becomes infected with decay. At the planing mill, more sawdust and shavings; at the building site, discarded ends, broken pieces, and warpage and splitting due to faulty handling and piling. In the furniture factories and millwork plants, the same processing residues occur.

A hundred million tons of unused wood each year—60 million tons of cellulose in a cellulose-hungry world—constitutes an almost untouched backlog of raw material that challenges the ingenuity of Americans.

After the piles have been out in the weather for a short time they become practically useless except where they can be used in mixture with poisons to control grasshopper plagues. Ultimately they may find usefulness in some areas as soil-conditioning materials to improve the physical make-up of soils.

Sawdust fresh from the log has present and potential values as fuel for specially designed furnaces and burners. Hickory, oak, maple, and birch can frequently be shipped over long distances for use in smoking meats at packing plants.

If the sawdust is from dry wood cut at factories, it has a larger range of use possibilities.

Obviously, this unused wood occurs in comparatively small rivulets all along the harvesting and production lines. But the rivulets never run into one big reservoir that can be conveniently tapped. There is tremendous variation in the kind and form of the residues that occur, and this diversity complicates the task of utilizing them.

The task, of course, starts in the woods. More efficient harvesting methods are constantly being devised. New, fast-working, labor-saving equipment for cutting, skidding, loading, and even bundling has speeded forest operations to the point where it often has become profitable to relog after primary logging and to salvage much cull timber for lumber and pulpwood that would not pay its way with the ordinary logging equipment.

In ordinary logging, only the trunk of the tree is taken out. Tops, branches, and stumps are left behind to be burned or eventually to decay. Sometimes the woods operators can find markets for a part of this refuse. Tops of felled trees can sometimes be sold for pulpwood along with defective trees, thinnings, and the noncommercial species. Some refuse can be used to make charcoal where markets exist. Short logs of good material can be sawed into boards, squares, barrel staves, and numerous other small products. Some short lengths cut from between branch whorls may be suitable for box veneer and paper cores. Stumps, crotches, and other parts of some species provide figured veneer. Forest litter finds markets with local nurseries as mulching material. Branches can be used in such items as rustic furniture and fencing.

Everything that can be used in the form of sawed and solid wood products should be recovered first. Recovery for pulpwood and fiber products is next in order for areas near established mills.

Sawmills, too, have undergone extensive changes. In the older forest regions, many of the big stationary sawmills have shut down and have been supplanted by smaller portable mills that can be moved from one locality to another. Previously looked upon as a headache to lumbermen and foresters, portable mills are undergoing revolutionary development and are playing an increasing role in our forest economy; they require less investment, they can be moved easily, and they can operate economically where timber resources are thinner and more scattered. The design and operation of small sawmills are being studied for ways in which to make them more efficient.

Sawmills vary widely in the efficiency with which they cut up logs into lumber. Some sawdust is inevitable. Slabs, edgings, and trim wastes vary widely in quantity, however, depending on the efficiency of the mill, the type of logs being sawed, and the extent of salvage operations. The more efficient mills cut lumber accurately to size, reducing waste. With large logs, the proportion of slab and edging offal is reduced. And at some mills this slab material is cut into a great variety of secondary products and sold.

Most of the markets for sawmill refuse are specialized and either local or regional in character. In many of the larger cities, dealers handle sawdust and shavings, supplying makers of floor-sweeping compounds, the fur workers, metal finishers, toy makers, and others that use small quantities. Considerable amounts go as wood flour into linoleum, explosives, and plastics. Probably the largest use, however, is as fuel—at the sawmill to furnish power and heat, in public buildings and power plants, as well as in domestic sawdust burners. Briquets of sawdust and shavings compressed at high temperatures are a fuel product of growing interest.

A great variety of things are or can be made of slabs, edgings, and trims, depending on the species and dryness. Seasoned material has a wider market range than green wood. At the sawmill it may be cut to rough size or to finished dimensions. If softwood, such material is called "cut stock"; if hardwood, "dimension stock." Typical uses are various building materials—flooring, molding strips, sash and frame stock—and furniture flat stock, squares for bed slats, upholstery frames, chair backs and posts, core stock, core blocks, glue blocks, box and crate stock, handle squares, toys, stepladder stock, tent pegs, washboard parts, and a long list of other articles. This material is also used for fiber products, including building boards, container board, roofing felt, and even various grades of paper. Its biggest single use, however, remains as fuel, usually in mixture with sawdust but sometimes bundled or bagged for retail sale; as a processing fuel, it is used by bakers of some types of pastries and breadstuffs, in the drying of tobacco, and to heat brooders.

In the pulp and paper mills, much the same development is going on.

The enigma of lignin is being attacked by Government and privately financed research in the hope of finding uses for it. As knowledge of this complex substance grows, it is recognized as a potential source of valuable industrial chemicals. It is now used as a dispersing agent for portland cement, in the negative plates of storage batteries, and for the production of vanillin and tannins. The evaporated sulfite liquor in which it occurs is used as a binder for foundry cores, in linoleum cement, and as a road-surface binder.

As a source of valuable chemicals, wood is winning greater interest year by year. Chemists are gradually devising new methods of extracting those chemicals at economic cost levels, with their eyes trained primarily on the scrap piles now completely unused.

Sawdust can be transformed into grain alcohol, vitamin-rich yeast, and molasses for stock feed, and, along with small percentages of pulp binders, into serviceable building boards. Alcohol is being manufactured from the spent liquors of sulfite pulp mills. Molasses produced from wood residues at the Forest Products Laboratory is being fed experimentally to cattle, hogs, and chickens to establish its feed value.

But the task of utilizing wood residue does not end in the laboratory with the discovery of new ways of using it. Commercially feasible processes must be developed, financing obtained, then plants built where steady supplies are assured at practical costs, technical skills developed, and markets found. All those steps are necessary to translate research findings into commodities available for purchase and use at a profit to the manufacturers and distributors. Unless the many problems of production and distribution can also be solved, research findings are likely to remain curiosities of the laboratory.

The attack on the problem of unused wood residues has to be from many sides. It has to meet local as well as regional and national needs. A single large, centralized plant in the Pacific Northwest can perhaps make yeast, molasses, alcohol, and other industrial chemicals profitably, because of the vast supplies of raw material nearby. In the Lake States and New England, however, where supplies of wood residue are more scattered, the need is for smaller plants set up perhaps as auxiliaries to sawmills and similar primary converters.

Such small plants have a special significance for farmers, who own about 36 percent of the timber-growing land of the United States—more than is held by any other single group of owners. Much of this acreage is not producing at anything like its capacity, largely because profitable utilization and management are not practiced. If, however, new markets for low-grade timber become available—as, for example, new processing plants for fabricating, laminating, fiber processing, and converting to fodder, molasses, and yeast—farm wood lots in the locality will become more profitable.

An example of what waste-utilization measures have in store for concerns too small to run individual recovery operations is a recent step toward the organization of a wood-waste cooperative in one of the Central States. The prime movers are a number of woodworking plants in a metropolitan area. Each member company proposes to contribute capital in proportion to the weekly tonnage of scrap wood it will ship to a central conversion plant for making pressed board and other products from sawdust, shavings, and other residues. Each member will take out finished converted products for use or sale, paying to the State, as required by State law governing agricultural cooperatives, a restocking fee, in this case a fee sufficient to plant trees calculated ultimately to produce a volume of wood equal to the wood residue handled.

Regardless of whether the proposals are carried out, the plan represents a new approach to the utilization of wood wastes by means of which small concerns can do together what they cannot do alone.

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THE FOREST PRODUCTS LABORATORY

GEORGE M. HUNT

The Forest Products Laboratory, which is maintained in Madison, Wis., as a unit of the United States Department of Agriculture, conducts research to help conserve the Nation's timber supply and make it serve more satisfactorily the needs of the people for wood products of all kinds.

For nearly 40 years the Laboratory has been doing this work. Today virtually every use of wood known to man is directly affected by it.

Hardly a day passes without visits from representatives of forest-products industries seeking information about wood: What is the correct temperature and relative humidity to use in drying magnolia for venetian blinds? Can the new resin glues be used in piano production? What is the best type of wood sheathing for house construction? What grade of plywood is best for outdoor use? How do you bag mold a plywood boat? What will happen if I apply white paint to my red barn? Am I entitled to the free use of the Laboratory's patents on the semichemical process of paper making? How does the Laboratory make molasses from wood? And many other questions about the thousands of uses to which wood is put.

Each day brings fresh batches of letters, telegrams, and telephone calls from every State—from great corporations and Government agencies, home owners, farmers, and operators of small sawmills, woodworking establishments, and factories. The questions range from the complex problems of aerodynamic design to paint peeling off a house or lumber warping in the seasoning pile. But fundamentally they are alike in that they generally involve the basic problem of wood use—an understanding of its fundamental properties, such as strength, wood-moisture relations, and the physical and chemical structure of this common but highly complex substance. It is toward a better understanding of those fundamental properties that the Laboratory has aimed its scientific inquiries, on the