The basic material resource of your industry is wood. Needless conversion of the raw material into waste during the furniture fabrication process reduces the number of pieces that can be produced from a thousand board feet of lumber, thereby increasing the forest drain and decreasing your profits.

Only about one-third of the log cut in the forest reaches the ultimate user in the form of a finished wood product; two-thirds of the log is lost along the way. The primary forest industries producing the lumber and dimension stock that you buy contribute much to this enormous waste. The secondary wood-using industries, such as yourselves, also produce considerable quantities of wood waste - a factory by-product with little value for anything but fuel. Reduction of this waste through elimination of the causes coupled with the development of new products that give new value to wood waste can, through research, be made the source of increased profits.

Waste Reduction Through Research

The need for greatly expanded research in forest products utilization by everyone concerned is apparent. We must find ways and means of increasing the utilization of our forest resources by reducing the waste in our wood converting industries. The new business created, the jobs made, the new products and taxes produced from increased utilization of wood that is now wasted are substantial benefits to be derived from successful forest products research; and this research need not be limited to agencies supported by Federal or State funds. Each plant manager in attendance at this meeting should be interested in carrying on research projects whose objectives are to obtain more useable products from each thousand board feet of lumber, dimension stock, plywood, or veneer that is procured for further fabrication.

1Presented at the Annual Meeting of the Southern Furniture Manufacturers' Association at High Point, N.C., October 30, 1946.

2Maintained at Madison, Wis., in cooperation with the University of Wisconsin.
We are now confronted with an inadequacy of wood supply. Everywhere we see extensive areas of forest and wood land, but we still lack timber products of the desired quantities, of the right species, and in accessible locations to meet our demands. With an ever-expanding industrial economy, the demands for raw material from the forests will increase, and alleviation in the near future of the present situation of scarcity of desired sawmill products does not seem likely. Your factories therefore must produce more furniture and less waste from the raw material that you can obtain.

Your own industrial research can accomplish much in gaining this objective. Federal and State research agencies can also be of considerable assistance to you in this utilization program. Every bit of information regarding the physical, mechanical, and chemical properties of wood that research has divulged and that can be economically exploited to reduce waste in your plants should be carefully considered.

The Forest Products Laboratory - Its Obligations and Objectives

The agency which I represent, namely the Forest Products Laboratory, can be of considerable help to you in any research program that you undertake. The immediate purpose of forest products research at the Laboratory is the optimum utilization of the forest crop for the benefit of the grower, the processor, the distributor, the consumer, and dependent communities. The large volume of timber in public ownership is adequate justification for substantial expenditures of public money to retain profitable markets for the wood crop and to increase the efficiency and effectiveness of its utilization to the fullest extent consistent with sustained production.

A well-balanced and properly coordinated program of forest products research will benefit everyone. The use of wood products is so universal and so much a part of the daily life of every individual, and forests are so important in our national existence that no one can escape the beneficial effects that result from research in this field.

The job of the Forest Products Laboratory, as an agency of the Forest Service, is to obtain scientific and technical information on forest products that is needed in the production of timber crops of suitable kind and quality, in economically converting timber crops into useful products, in increasing their serviceability, in broadening their markets, and in their satisfactory distribution to, and use by, the ultimate user or consumer and to disseminate and aid in the application of such information.
Establishment of Forest Utilization Service Units

Since the Laboratory was established at Madison, Wisconsin, in 1910, the results of its research have amply justified its organization. Its work of extending the technological and scientific up-to-date practices of wood utilization has contributed greatly to American leadership in this field. To augment the work of the Forest Products Laboratory, the Forest Service has recently established in the various regions of the country forest utilization service units consisting of technicians, or subject-matter specialists, who keep in close contact with the Forest Products Laboratory but who maintain their regional headquarters at the Forest Experiment Stations. The function of each group is to bring the findings of forest products research to the people within its region. The Forest Utilization Service Unit in your region is established at the Southeastern Forest Experiment Station at Asheville, North Carolina.

The men assigned to the Forest Utilization Service Unit determine locally what needs to be done to meet local problems. They suggest and participate in local activities to expand and improve forest products utilization. They are our immediate contact with your industry. They interpret the information we already have in light of the conditions which exist in your plants to help you solve wood utilization problems. Through them the vast fund of information available at the Laboratory on many wood fabricating problems, such as growth, structure, and identification of wood; logging, manufacturing, and utilization of timber, lumber, and other wood products; mechanical properties of timber; gluing and glued wood products; seasoning, storage and handling of wood; wood preservation and chemical utilization, become applicable to the solution of your specific wood use problems.

Research Accomplishments in Wood Utilization

Since the establishment of the Laboratory in 1910, its contributions to improvements in harvesting, conversion, and utilization of wood have been many. During this period the grading of lumber and structural timbers was standardized; systematic strength data became available on more than 180 domestic species of commercial lumber; marked improvements were made on structural design and stress analysis; definite strides were made in the development of glues for use in the manufacture of plywood, laminated wood, and glued wood.
products; great advances were made in the pulping and chemical conversion of wood; and the technique of kiln drying of wood was developed from a mysterious art to a scientific process.

Glues and Gluing Methods

Development of New Glues.--Perhaps no single factor has been more responsible for significant advance in the field of modern wood utilization in the wood-using industries, such as the furniture industry, than the development of improved glues and gluing techniques. Starting with the development of somewhat moisture-resistant casein glue of World War I, further advances were made in the 1930's with the advent of the more water-resistant urea and phenol synthetic resin adhesives, which extended the opportunities for employing glued wood products. The recent war period was marked by accelerated developments with the introduction of improved types of resin adhesives with varying properties and uses, such as resorcinol, phenolresorcinol, and melamine glues and with improved techniques for applying and setting the adhesives. Included among the advances has been the development of glues for bonding wood to metal and to various plastic materials.

War-time discoveries in the field of synthetic resin glues are already getting special attention by designers and fabricators of wood products and their application is expected to extend to a wide variety of uses, including the manufacture and assembly of fabricated houses. The older glues, such as casein and animal, however, will continue to be used for many bonding tasks in the furniture industry.

Glues for Outdoor Exposure.--Highly water-resistant adhesives and new glue-setting techniques have made possible the use of glued structures for outdoor exposure. Since wood products glued with phenolic-type adhesives take preservative treatment, new opportunities are afforded in the design, construction, and use of wood furniture for outdoor use.

With the development of the new synthetic resin adhesives, plywood has been transformed from a product strictly limited to interior or temporary use to a material of practically universal application, not only in the flat panel form, but also molded to various curvatures as well. The immediate application of these newer plywoods is in the field of prefabricated house construction, but bag molding, or fluid pressure molding, has made possible the rapid and extensive production of parts with compound curvature, which increases the potential post-war use by your industry in producing new furniture designs and products.
Sandwich Construction

In "sandwich" construction various materials are combined in order to take advantage of the best qualities and properties of each material for a given purpose and provide products superior to those made of one material alone. In such construction low density woods, pulpboard, or other light filler substances are faced with relatively dense, strong, durable materials, such as plywood or resin-impregnated compressed wood. Opportunities for such composites appear to exist in the furniture industry. Glass cloth, resin-impregnated fabric, paper-base plastics, and other materials are being developed as face materials for hot-press bonding to plywood. Such materials also promise improved appearance and serviceability of low and medium grade plywood panels.

Thus it may be seen that the study and application of these newer glues and gluing techniques offers unlimited possibilities to increase the utilization of wood and the development of new wood products by your industry.

Modified Wood

During the World War II period a variety of chemical treatments, in some instances combined with the application of high pressures, resulted in a variety of products, some of which have been so changed that it is difficult to realize that they are wood, because their treatment has made them suitable for uses not formerly held by wood. Under this classification are grouped such products as impreg, compreg, staypak, and staybwood.

Impreg.—Impreg is produced by allowing phenolic resin-forming chemicals in a partially polymerized condition to enter the wood substance and bond with the wood constituents when subsequently cured by heat. The resin unites with some of those parts of the wood responsible for the tendency of wood to take up moisture, thereby permanently reducing the tendency of impreg to swell and shrink. The swelling has been reduced to as little as 30 percent of normal with resin-forming phenolic materials used in this way. Urea resins reduce swelling by one-half.

Practically none of the woods can be properly treated with resins in lumber lengths. The process, however, is easily applicable to veneer. By using sheets of impreg veneer for the facing of plywood, face checking can be practically eliminated and the moisture that will pass through the plywood is reduced many-fold. While impreg had very limited war-time use in the United States, it is anticipated that it may find post-war
application, especially as production costs are lowered, in the manufacture of products such as furniture, in which marked dimensional stability and durability are important.

Compreg.--If the plies of wood which were used to make impregn are piled one on the other and subjected to pressure before applying heat to bring about the curing of the resin, sufficient resin is pressed out to bond the plies together as the wood is compressed. Depending on the species and pressure applied, the plies may be pressed to one-half or even to one-third of their original dimension. This compressed product is known as compreg. These resin impregnation treatments of wood, and particularly the compregnated form, are applicable to species which have had restricted use in their natural state because of inherent low strength, lack of resistance to various destructive agencies, or other undesirable features that are overcome in the modified forms of wood.

Staypak and Staybwood.--Staypak, a compressed product, and staybwood, an uncompressed product, are modified wood produced without resin. Resin-treated wood in both the compressed and uncompressed form is more brittle than is the original wood. In staypak the lignin within the wood is caused to flow enough to eliminate the internal stresses produced by pressing. Staypak is not as water resistant as impregn but is tougher and has higher tensile and bending strength. Its special use is in products where high impact strength is needed. In staybwood a 60 percent reduction in swelling and shrinking is attained in wood by heating under conditions that just avoid charring.

Chemical Conversion of Wood

The chemical conversion of wood is accomplished by several different types of processes, chief among which are pulping, destructive distillation, hydrolysis or conversion of carbohydrates to sugars, extraction, and reactions with chemicals such as hydrogen. As most of you probably are not interested in chemical conversion, I shall not describe the significant advances in this field. The utilization of waste through chemical conversion, however, should not be forgotten in your search for increased diversification of wood utilization.

Processing Methods

Research in wood utilization at the Laboratory and other agencies has, during the past 25 years, yielded new and improved methods
for preparing wood for use and increasing its serviceability. Outstanding advances have been made in wood preservatives, fire retardant treatments, and seasoning procedures. One of the newest developments, still largely experimental, is electrostatic or high-frequency dielectric heating.

Wood Preservatives. --Noteworthy progress has been made in developing chemicals and processes for increasing the resistance of wood to deterioration by fungus staining, decay, termites, and other agencies. Wood preservatives and treating methods not only have increased the service life and decreased the ultimate cost of various types of wood construction, but also have made possible the use of species of wood that deteriorate rapidly when exposed without treatment to the ground or other conditions that promote decay.

Fire-Resistant Treatments.--During World War II fire-resistant treatments for wood were intensively developed. Fireproof lumber and plywood were used by the Army and Navy for a variety of products and types of construction and have been incorporated in railroad structures, hotels, hospitals, theatres, and industrial and commercial buildings.

Seasoning Methods. --In the period following World War I the conventional methods of seasoning of wood have been greatly improved. Dry kilns have come into widespread use with improvements in equipment and technique. Much information was acquired on kiln drying schedules for different kinds and thicknesses of lumber. About 1915 the principles governing the accelerated seasoning or kiln drying of wood were worked out by the Laboratory. The essentials of good kiln drying are control of temperature and relative humidity, which is dependent upon several other factors, one of which is ample and uniform air circulation. During World War I the concepts of temperature and relative humidity control in lumber dry kilns were developed. The water spray kiln was invented and later the internal-fan kiln. There are now more than 5,000 internal-fan kilns in the United States. Most of the new and remodelled lumber dry kilns are of this type. It is also extensively used in Australia and to a lesser extent in other countries. Along with the development of better kilns, standard dry kiln schedules were developed for the principal commercial species grown and used in this country and for many foreign woods as well. These advances in dry kiln design and kiln drying schedules have given the United States world leadership in kiln-drying equipment and practices.

High-Frequency Dielectric Heating

High-frequency dielectric current is being intensively investigated as a method for quickly heating wood throughout its entire cross section. Such heating rapidly generates high
temperatures in the interior of even large pieces of wood without requiring conduction of heat from the surface. This method is applicable, in theory at least, to the seasoning of wood in a continuous drying process. Its practicality under existing conditions is doubtful although it is potentially promising where very cheap electric power is available. Its application to the seasoning of wood must still be considered in the exploratory experimental stage.

Of greater significance is the application of high-frequency heating to the gluing of wood products bonded with hot setting synthetic resins. While high-frequency heating has come into use for the commercial production of plywood as well as for edge-and scarf-joint gluing, setting resin glue and dovetail assembly joints, and other purposes, the method is still considered as being only partially successful. One limitation to its widespread application is the high initial cost of the equipment. It appears commercially feasible in mass production of identical units where rapid glue setting will increase the output from costly presses or jigs, release valuable floor space, or significantly affect turnover. In such fields high-frequency heating may have numerous profitable applications.

Increased Utilization Through Improved Drying Practices

Anticipated Loss Due to Improper Drying Practices

Although it is an accepted fact that there is no substitute for properly dried lumber in the fabrication of furniture, the drying process need not cause losses that your industry is now experiencing. During the war tremendous demands for lumber in the face of production shortages necessitated a relaxation of seasoning standards, and we will not know how much material was lost due to the use of green or improperly dried wood. Now the war has been won, but the present sustained demand for lumber for housing, farm buildings, furniture, and wood products of all kinds does not encourage producers and wood fabricators to improve the drying practices that the war emergencies necessitated.

The secondary wood-using industries forced to procure green or partially dried stock often find that their dry kiln capacity is not adequate to carry the increased drying burden, and they must either curtail production of quality products or maintain production by sacrificing quality. Altogether too many plants are adopting the latter procedure, and the drying operation is often based on cut-up plant needs rather than by the physical capacity of the dry kiln equipment and the properties of the wood being kiln dried.
The drying process is not a mysterious or complicated procedure, but when the drying requirements of the species being kiln dried are disregarded excessive seasoning degrade may result. The loss of lumber due to poor seasoning practices, which includes air drying as well as kiln drying, has been estimated as varying from 5 percent at some plants to 25 percent at others. This includes the loss of cuttings resulting from excessive warp, including cup, bow, and twist, which is attributable, in many instances, to poor piling practice, which must be considered a part of the seasoning operation.

It is estimated that furniture production in the South in 1946 will require about one billion board feet of lumber, and an 8 percent loss in footage due to seasoning degrade represents 80,000,000 board feet, or, at an average cost of $65 per thousand, the monetary value is $5,200,000. To this must be added the unknown costs of handling, seasoning, and processing up to the time that the waste is sent to the fuel bins. I suspect that this estimate is on the low side, but even on this basis it appears that your industry loses about $550,000 for each 1 percent of seasoning degrade.

Suggestions for Increased Output

Furniture plants faced with a drying problem can frequently reduce drying time and thereby increase dry kiln output by making better use of their present drying equipment. Two things are usually necessary: first, the dry kiln equipment may need repair and modernization, including a revamp of the lumber stacking methods and practices; secondly, the dry kiln operator needs training so that he can efficiently manage the equipment and turn out the maximum footage of properly dried lumber with a minimum of seasoning degrade. The greener the lumber that is being kiln dried, the more important these two requirements become.

This past fall a program of training of dry kiln operators was started by your industry. Three two-week courses were given in the field by instructors from the Forest Products Laboratory. These courses were sponsored by your association, and the arrangements were established in cooperation with the Forest Utilization Service Unit of your region. I hope that these three training courses are proving helpful to you, but the anticipated benefits may not be derived if you ignore the requests from the men who attended to improve the physical equipment given them to work with. Your industry is known for its willingness to scrap woodworking machinery in favor of more modern equipment which will reduce your production costs. In general your dry kiln equipment is in fair shape, but if our instruction has given your dry kiln operator an idea as to how improvements can be made to increase production...
and minimize losses, I suggest that you seriously consider his proposals.

A good piece of dry-kiln equipment can turn out good work if supervised by a person who is familiar with the drying problem. In fact, a good dry kiln supervisor can get reasonable production out of a poor dry kiln, but an inadequately trained supervisor may botch production of properly dried lumber in the best commercial dry-kiln installation in the country. The men you sent to the three dry-kiln courses were in general a group of high-class men. Upon completion of the short course they were enthused and determined to study and figure out how they could accomplish some of the objectives that you are after. This enthusiasm must be encouraged, and whatever you can do to stimulate a constant study of the drying problem by the dry-kiln supervisor will be beneficial to you in the form of reduced seasoning losses.

Increased Responsibility of Dry-Kiln Operator

In our course of instruction in kiln drying we not only advise the men how to operate their dry kilns better, but we also suggest proper air-seasoning practices, methods of piling for kiln drying, and methods for the storage and handling of dry stocks after kiln drying. All too often we find that the man you sent to the course has no control of the conditions under which lumber stocks are handled prior to or after kiln drying. It seems that the wood moisture control activity in your plants is decentralized to the point where you have difficulty in placing the responsibility for seasoning losses. I suggest that you consider establishing a position in your plants that centralizes responsibility for moisture content control. Such a position would require a trained technician, and he should be invested with the responsibility of seasoning, storage, and handling of your lumber stocks to the end that moisture quality is attained with a minimum of seasoning losses. The job is a much broader position than just operating dry kilns. Air seasoning, kiln drying, and storage of lumber cannot be separate supervisory functions if increased utilization through better seasoning control is to be accomplished.

We would like to see your industry provide a stimulus to keep these men peppe up and on their toes concerning drying problems and their solutions. One way of doing this is to sponsor a competent technician who would serve the needs of the association in much the same manner as your packing engineer.

Conclusion

The developments briefly outlined here are typical of the contributions that research has made in the utilization of R1633
The Forest Products Laboratory has not been alone in this research but in many instances has pioneered the development or pointed out what was needed, and industrial research has responded with excellent products. The application of newer techniques or processes as indicated by these research results provides the opportunity to increase wood utilization at a profit to your industry.

In conclusion I will restate a slogan that points our Laboratory research in seasoning, "There is no substitute for properly dried wood." Improved seasoning practices founded on scientific knowledge will pay outstanding rewards.

The Forest Products Laboratory at Madison and the Forest Utilization Service unit at Asheville are prepared to assist you, within their limits of funds and personnel, in this vital utilization program.