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# The Implication of Molded Plywood

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# THE IMPLICATION OF MOLDED PLYWOOD AND WOOD LAMINATES TO INDUSTRIAL ARTS

# THE IMPLICATION

# OF MOLDED PLYWOOD

# AND

# WOOD LAMINATES TO INDUSTRIAL ARTS

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## Introduction

Two industrial processes which are important in the area of design and construction are wood lamination and molded plywood. These processes permit the fashioning of wood objects and wood shapes which could not be created with any other method. These processes of forming wood are not new to the field of design in industry, but they are not commonly used in industrial arts woodworking classes.

It is essential to continually examine curriculum in this "space age" because of our ever changing society. The objectives should be kept constantly in mind, otherwise teachers will be teaching a narrow field which has little to contribute to general education.

Industrial arts teachers must strive to find new materials and processes with which they can better teach their pupils. Pupils should be informed of modern industrial processes so that the pupils can better understand modern industry. If a pupil has a sound knowledge of industrial processes he may have better job opportunities when he leaves high school, and he should become more aware and appreciative of the articles provided society by modern industry.

The purpose of this paper is to thoroughly examine the processes of wood lamination and molded plywood and to explain and discuss how the processes can be used in industrial arts woodworking classes. New types of construction and other new ideas for industrial arts teachers are discussed. This paper will suggest examples of industrial arts programs which have been engaging wood lamination and molded plywood. Pictures are included to illustrate articles which have been constructed.

This paper includes information from the United States Department of Agriculture, furniture manufacturers, and manufacturers of wood laminates and molded plywood. Some material is included from school and professional periodicals.

# CHAPTER I

## Wood Lamination

Man's use of wood for various structural purposes goes back untold centuries. Man first found a use for wood when a fallen tree provided a tree bridge or rude hut, and, as time went on, the hollow-log canoe was used. We have found many uses for wood as time elapsed, and we now have great timber structures of the present day. With progress has come a change in conditions. At one time the timber supplies seemed limitless, there was little reason for concern about the species, size, or quality of the timber used. Therefore, much timber construction was characterized by over-size members, often of very high quality.

As timber became more limited and the prices higher, conservation of use became very important. The development of structural grades was very helpful in the more economical, and efficient use of timber. The prospects for efficient utilization of timber was still further improved when the use of glued laminated lumber was introduced because "this lumber can be made from shorter lengths, lower grades, smaller sizes, and combinations of high and low grades".(1) Laminated lumber usually costs more than solid sawn timber so it should be used wisely and economically.

A definition of laminated timber is needed so that the exact type of timber being discussed will be realized. "Structural glued laminated lumber is any structurally designed member comprising an assembly of wood laminations in which the grain of all laminations is approximately

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[1]A. D. Freas and M. L. Selbo, Fabrication and Design of Glued Laminated Wood Structural Members, Handbook no. 1069, (Washington, D. C.: United States Department of Agriculture, February, 1954), 1.

parallel longitudinally and in which the laminations are bonded with adhesives."(2) The success of laminated wood can be attributed to progress which has been made in the field of wood adhesives.

## Advantages and Uses of Laminated Wood

Pieces of laminated wood can be formed into complicated shapes and curves of practically any degree of complexity, with strength and water-resistance qualities superior to those of solid wood. "This fact, added to the natural versatility of wood, gives the material possibilities limited only by the scope of the imagination."(3)

Some of the advantages of using laminated woods are:

1. Ease of fabricating large structural elements from standard commercial sizes of lumber.
2. Achievement of excellent architectural effects, and individualistic decorative styling in interiors.
3. Freedom from defects associated with large one-piece wood members.
4. The opportunity of designing on the basis of the strength of seasoned wood.
5. The opportunity to design structural elements that vary in cross section along their length in accordance with strength requirements.
6. The use of lower-grade material for less highly stressed laminations without adversely affecting the structural integrity of the member.

There are also certain factors involved in the production of laminated wood which are not encountered in producing solid timbers.

1. The preparation of lumber for gluing and the gluing process usually raise the cost of a laminated product over that of regular timbers.
2. More time is required in making laminated products.
3. The laminating process requires special equipment, facilities and fabricating skills.
4. Great care must be exercised while manufacturing a laminated member.
5. Laminated members are often awkward to handle and ship.

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[2] Hardwood Glued Laminated Lumber, (Oshkowh, Wis.: Northern Hemlock and Hardwood Manufacturers Association, 1952), 1.

[3] George Welch, "Laminating Wood is Made Easier," Industrial Arts and Vocational Education, 17 (November, 1957) 20.

Some of the more common uses of laminated wood are found in the form of laminated wood arches. Many churches, gymnasiums, and theaters use this type of arch. Glued laminated curved rafters are frequently used in farm structures, particularly in barns. During World War II aircraft hangars began using laminated wood arches, and during this time laminated wood was employed in the construction of boats and ships.

Glued laminated structures in exterior applications are less common, but a number of bridge installations have been made on railroads and highways. Laminated wood is also employed in various parts of trainer and glider aircraft. Laminated cross arms for electric power lines have been used to some extent.

## Methods of Manufacturing Wood Lamination

In the manufacturing of laminated wood the glue is very important. There are many types of glues which can be used, and they are classified according to the temperature required to cure them. The four classifications of the glues are hot-setting, intermediate-temperature-setting, room-temperature-setting, and cold-setting.

### Selecting and Preparing the Lumber

Lumber that is used in fabricating a laminated member must be carefully selected and adequately prepared for gluing. Attention should be given to the intended use of the laminated product, the strength, durability, and gluing properties of the species, the dryness of the wood and the quality of the surfaces to be glued. Defects that may impair the quality of the bond, interfere with the bending, or reduce the serviceability of the finished product, should be considered.

Softwood species have been used largely in the laminating of members such as arches or beams. This wood has a favorable cost and meets the strength requirements. White oak is often used when the timber is to be used in water. If a high-strength member is needed it is made of clear and straight grained wood, free of sizeable defects. Sapwood is used in continuously dry conditions, but is quite susceptible to fungi attack in 20 per cent moisture content.

<u>Seasoning and Moisture Content of Lumber</u>

The moisture content of lumber at the time of gluing is very important in laminated products. "The desirable moisture content in the lumber is that which will produce strong glue joints and, as nearly as practicable, approximate the average moisture content the laminated product will attain in service."(4) Strong bonds can be produced when the wood has a moisture content between 7 and 15 per cent. Usually, it is desirable to produce the laminated member at a lower moisture content than that expected in service. The most practical method of seasoning lumber to specific moisture content requirements is by kiln drying.

The moisture content of the lumber should be determined before machine operations are started, and the most accurate means of testing wood for moisture content is by the oven-drying method. Electrical moisture meters may also be used, but they are not as accurate.

When laminated lumber is stored, great care is taken so that the moisture content will not vary.

<u>Rough Surfacing</u>

Preliminary rough surfacing of the lumber to be used helps to obtain uniform thickness of laminations in the final surfacing. In hardwoods the use of a rough planer as the initial step in sorting lumber

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[4] Freas and Selbo, <u>op</u>. <u>cit</u>., 30.

will help disclose natural and seasoning defects. Rough planing will also reduce stock to an approximately uniform thickness. Rough planing should be done on both surfaces with an equal amount of removal on both surfaces.

## Cutting Laminating Stock

When preparing stock for laminating, it is often important that narrow pieces used to produce a lamination the full width of the member be edge glued to increase strength properties. Another reason for using edge gluing is because open edge joints may induce further checking and splitting and cause a decay hazard in damp or exterior service. If added strength is not needed, edge gluing would not be necessary in members used in normally dry conditions.

If it is necessary that laminations be of one piece in width, and lumber of the required width is not available, the desired width may be obtained by edge gluing strips or boards of the desired quality. When edge gluing, proper machining of the edges is necessary to enable the production of maximum strength.

The machined edge should be square and straight to enable a tight fit of the wood surfaces. Tongue-and-groove joints have also been used to yield lumber of a desired width, but these joints involve a greater loss of material and require special equipment.

It is often necessary to produce full-length laminations by end-jointing short boards for the purpose of obtaining better use of raw material, for building into the assembly the required grade, quality, and strength properties, or to enable handling of each full-length lamination in one piece. The plain scarf, hooked scarf, finger, and serrated scarf are commonly used. All joints require a long slope to develop the needed strength of an unjoined piece.

## Final Surfacing

The final surfacing of the stock preparatory to spreading the glue, assembling, and clamping is a very important operation in the fabrication of laminated wood products. The quality of the final product is dependent on the accuracy and care with which this segment of the work is done. If glue joints of maximum strength are to be produced, the wood surfaces to be glued must be cleanly machined and must fit accurately.

"Finish surfacing can best be done on cabinet-type surfacers equipped with well-fitted cutter heads mounted on ball bearings. Knives should be kept well sharpened to prevent compressing or otherwise damaging the wood fibers."(5) Glazed or burnt areas indicate damaged fiber as a result of dull planer knives. Final surfacing should be done just before gluing, and the dressed lumber should be protected from any moisture change.

At times wood surfaces are intentionally roughened by tooth planing or sanding with coarse sandpaper, but tests show that this practice is of no benefit to the glue bond, and it requires the use of additional glue.

## Layout of Laminated Assembly

A plan for the position of laminations in the glued assembly is needed for each gluing operation, especially where the laminations are of different grades or contain edge-glued and end-glued joints or where the member is curved or bent. The strength of the laminated member is greatly effected by the position of such joints.

## Gluing Jigs and Forms

Jigs and forms are used in order to permit assembling the laminations after glue has been applied to them, and then they can be drawn to the

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[5] Ibid., 36.

shape desired in the final product. The gluing form holds them in shape under gluing pressure until the glue is set and cured.

When gluing curved laminated members, the cured assembly essentially retains, upon release from retaining clamps, the curved shape in which it was glued. A curved glued laminated member made of many thin laminations is less likely to develop spring-back when released from its form than one of equal depth that is made of a few thick laminations. It is best to cure members in a jig that is strong enough to hold the desired shape of lamination because less spring-back is likely to develop than when it is necessary to remove the clamped assembly from the jig for curing. A jig is a form in which the laminations, spread with glue, are laid consecutively, and are held and formed into a predetermined shape.

The gluing of curved assemblies may be done on either a male or a female type of jig or form. The jig may be built for one curvature or it may be adjustable to various curvatures. The general laminating procedure with such jigs is to lay the individual laminations in approximately a bent position and hold them by a series of stops, or to draw the entire assembly into bent position at one time by using block and tackle or winch. Then the clamps are drawn to pull the assembly into final shape and to hold it while gluing pressure is applied.

### Gluing Laminated Assemblies

Much of the success in fabricating good laminated members depends on following a correct procedure while gluing the assembly. Much attention must be given to arranging the laminations in the proper order in a convenient place for feeding them to the glue spreader. Mixing and spreading the glue properly, and placing the laminations on the jig, and applying adequate pressure evenly and quickly to avoid any set of the glue before application of pressure is completed, are necessary. A well-planned and quick procedure is especially important when glues having short assembly times are used. If edge gluing and end gluing are necessary, the laminations should first be edge glued, then end jointed, and surface finished just prior to gluing.

To make glue joints, it is necessary to apply the correct amount of glue and to spread it evenly, and with certain glues this must be done within a short period of time.

The moisture content of wood is increased in the gluing process because the wood absorbs the water contained in the glue. "Glues of high water content add more water than those of low water content, and heavy spreads add more water than do light spreads."(6) There are formulas which may be used to determine the percentage of moisture content added to the wood when laminations of equal thickness are used.

The lumber should be at room temperature before the glue is spread, and the surface of the wood should be free of any material that would interfere with good bonding.

The time between the spreading of glue on the first lamination and the application of full gluing pressure is called assembly time. If the pieces of wood are coated with glue and exposed to the air, a much more rapid change in consistency of the glue occurs than if the pieces are laid together as the glue is spread. When the wood is exposed to the air it is referred to as open assembly and when the pieces are laid together as the glue is spread it is referred to as closed assembly. Assembly and pressing must be completed before the glue has begun an initial set, which is the result of both chemical reaction and loss of solvent to the wood and to the air.

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[6]Ibid., 52.

The application of adequate and uniformly distributed gluing pressure is essential to the production of good joints. There must be pressure on the joint during the early stages of setting in nearly all types and forms of gluing. The pressure causes the glue to be smooth, thus forming continuous, uniformly thin film between the wood layers. The pressure also brings the wood surfaces into close contact with the glue and holds them in this position while the glue sets. The amount of pressure needed to produce a strong joint varies within a wide range. For dense woods, such as oaks, good results may be obtained with pressures within the range of 150 to 250 pounds per square inch. For softwood species, pressures of 100 to 200 pounds per square inch are adequate. The minimum pressure that should be allowed is one that will insure close contact of the wood surfaces.

Equipment for Applying Gluing Pressure

There are many means of applying pressure to laminated assemblies. If room-temperature-setting glues are used, hydraulic presses or screw presses may be used in assembling straight members. Retaining clamps serve best in gluing curved members because pressure must be applied progressively along the assembly to permit slippage of laminations. A frame type of retaining clamp with rocker head and a C-type of retaining clamp with rocker head for equal distribution of pressure across the width of the assembly have been used successfully.

It is necessary to use pull-down clamps or other means to pull the laminations to the shape of the jig when laminations are glued into a curved member. Retaining clamps may be used to furnish pressure on the glue joints.

Fire hose that is inflated by air, water, or steam is frequently used to supply gluing pressure. Usually, the hose is placed between a rigid support and a movable rigid caul, and the pressure developed by the inflation of the hose is transmitted to the caul.

Factors Affecting Strength

There are certain characteristics that affect the strength of solid sawn timber that also affect the strength of laminated timbers, and these should be mentioned. Some of the common characteristics are knots and cross grain. These should be considered along with other additional factors which affect the strength of laminated construction.

The bond between the lamination is of primary importance, therefore, an adhesive must be chosen that will provide a bond that will hold over the period of the service of the structure. There are many adhesives available, but the most important to the laminating industry are the resorcinol resins and the mixtures or blends of phenol and resorcinol resins. Resorcinol resins are used in materials which will be used at room temperature, and phenol-resorcinol blends and resorcinal resins on high-density species must be cured at elevated temperatures so that the laminated material may withstand severe service. The glue in laminated wood must have sufficient original bonding strength and durability so that the glued member may perform as a structural unit throughout its service life.

If the glued bond is to be proper it must also have; uniform seasoning of lumber, smooth and uniform surfacing of the laminations, proper mixing and spreading of the glue, adequate and uniform application of pressure, and proper curing of the glue.

Another factor which is an important factor in determining the strength of laminated members is the joining of pieces of lumber end to end properly. This factor has been discussed previously.

## The Finished Product

There are methods for evaluating the finished laminated member, other than by simple visual evaluation. In factories these tests are made by a shear tool, especially when testing the strength of a glue joint. If the laminated member is proven to have sufficient strength, it is ready to be used.

# CHAPTER II

## Molded Plywood

The molding of plywood is an important technique in the precision use of timber. Molded plywood is essentially the same as flat-press plywood, except for variations in shape. Plywood is made by gluing small pieces of wood together with the grain direction of adjacent plies at right angles. Molded plywood is used instead of flat plywood when the pieces needed are too thick to be steam bent from flat plywood. Molded plywood differs from wood lamination in the fact that the grain of all the laminations are parallel to the length of the member.

The molding of plywood was first used to great extent during World War II. During this time many uses of plywood were realized, and the production was greatly increased and perfected. However, it was first introduced in the furniture industry several years ago.

Molded plywood is used in many articles, but few people realize its contribution to our wise use of lumber or the contribution that it makes to the use of design in wood. Because molded plywood can be shaped into various shapes and curves, it has unlimited possibilities in the field of design. It can be shaped into many combinations of single and compound curvatures, cylinders, paraloids, and portions of a sphere. It can, in fact, be fashioned into any curve shape for which a mold can be made and later separated from the finished product.

### Uses of Molded Plywood

The use of molded plywood has been utilized in fabricating plywood parts with various degrees of curvature, ranging from a small aircraft fairing to a complete boat hull. Aircraft parts have been improved by using bag-molded fusilages, wing fillets and fairings. The molded product in aircraft has superior stiffness, is lighter in weight than metal, and it offers less air resistance than parts which contain rivets.

Molded plywood is used extensively in the furniture industry. Nearly every new public building is furnished with chairs which are curved into comfortable shapes and made of molded plywood.

Molded plywood is used to a large extent in the manufacturing of boats, especially for pleasure crafts. Many different shaped hulls can be designed and constructed by using molded plywood.

## Methods of Molding Plywood

Molded plywood can be produced by several techniques; Duramold, Vidal, Aeromold, or vacuum-bag processes. These are shown in figure 1. An inclusive term is "fluid-pressure molding". Today bag-molding methods are used instead of the vacuum-bag method, and the basic differences are the application of heat to the glue during the pressure period; thus, permitting the use of thermosetting and thermoplastic glues with long assembly periods, and the application of 30 to 100 pounds of pressure per square inch, instead of the normal atmospheric pressure used in earlier methods. There are numerous combinations of supplying heat and pressure.

The fundamental procedure is the same for all processes. "The technique consists of attaching temporarily by staples, tape, clips, or some other means, superimposed layers of stripes or sheets of glue-coated veneers to a mold of the desired shape, and molding these into a unit structure by the application of heat and fluid pressure through a flexible, impermeable bag or blanket."(7) All of the processes are

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[7]Bruce G. Heebink, Fluid-Pressure Molding of Plywood, Handbook No. 1624, (Madison 5, Wis.: Forest Products Laboratory, November, 1959) 2.

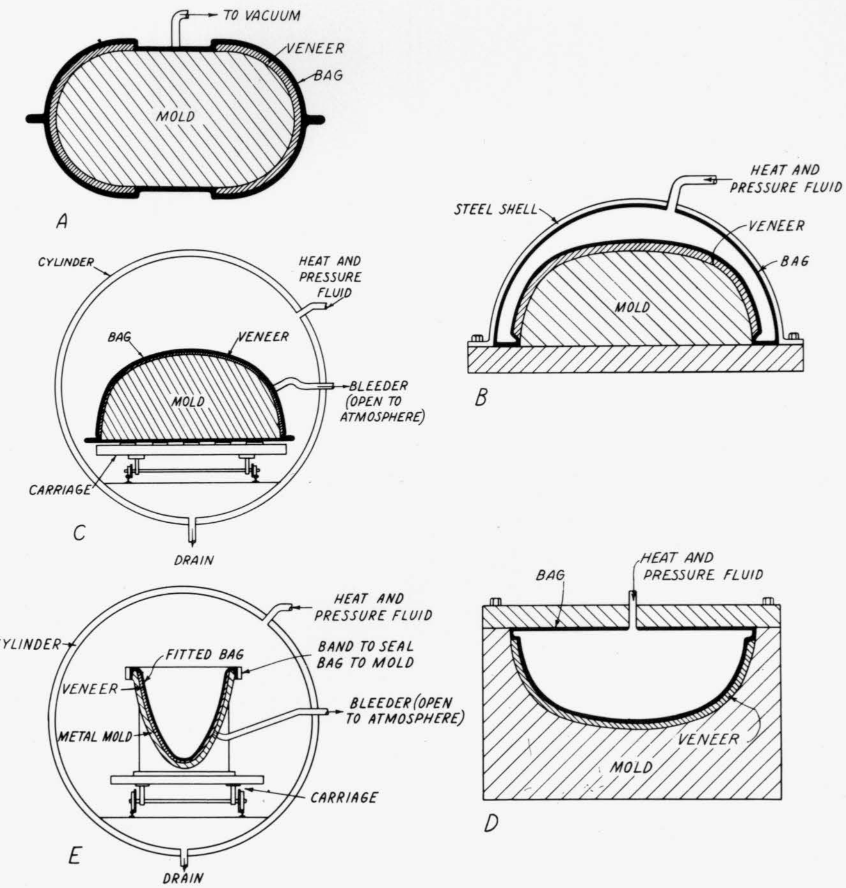


Figure 1.--Five methods of forming bag-molded plywood.

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Bruce G. Heebink, Fluid-Pressure Molding of Plywood, Handbook No. 1624, (Madison 8, Wis.: Forest Products Laboratory, November, 1959).

relatively simple. It should be stated that under certain conditions it is possible to produce bag-molded plywood of durable quality using only the external atmospheric pressure developed by the use of a vacuum within the bag. But when atmospheric pressure alone is used only thin, flat veneers or relatively flat molds should be utilized with certain types of glues.

Equipment for Fluid-Pressure Molding

There must be a mold for all fluid-pressure molding. Molds are classified as male or female. Male molds are the desired shape on convex surfaces, while female molds have the desired shape on concave surfaces.

Some materials which are commonly used for molds are solid wood and plywood, steel or cast iron, metals and low-temperature alloys, plastic materials, and cements. Many factors determine the choice of mold materials, such as the shape of the item to be molded, the quantity needed, availability of the material.

Wood molds are made of softwood lumber cut approximately to the contour of the mold and glued and nailed together. Then the rough shape is marked into stations. Next, it is "worked down" by plane and sander to the desired shape making an allowance for a hardwood skin. The hardwood skin is bonded to the mold by bag molding, and it is then "worked down" to the contour at each station. The direction of the grain in the skin and the mold proper should be given much consideration so that the maximum cross-banding may be achieved.

Exposure to moisture and heat will distort wood molds. A leaky bag will usually destroy the articles being molded. It takes a longer period of time to heat plywood molded in a wooden mold than it does in a steel mold of the same thickness. The steel mold is about twice as quickly heated.

A more stable wooden mold involves the use of thick, resin-bonded plywood instead of solid wood stock. An impregnated skin of veneer should be bonded to the plywood base. Dimensional changes can be limited by laying the plywood in a manner that will minimize shrinking and swelling in thickness. Wood molds are usually male in shape, therefore, strips of veneer may be stapled to the molds to hold them in place.

Metal molds are usually made of sheet steel or cast iron. Molds of slight curvature are made of sheet material one-tenth to one-fourth inch thick, but those of severe curvature are made of cast iron. Metal molds are very stable. Usually, metal molds are of the female type, and the strips are taped together or sprung into place with metal clips.

Metal molds transfer heat rapidly. "The rate of temperature rise in a molded plywood piece on a thin metal mold approaches that of plywood of the same thickness in a hot press. The time in the pressure cylinder can, therefore, be approximated from the hot-press instructions for the particular glue being used by adding the actual pressing time to the time required to bring the pressure cylinder up to operating temperature."(8) The heating medium always affects the rate of heating any mold.

When a cement or concrete mold is used, a wood form is first made to cast the form. Cement molds are very stable towards moisture, but they are difficult to handle because of the excessive weight, and they are damaged by repeated heating.

Plastic molds are in the experimental stage, and, thus far, they have proven practicable in very few cases.

A bag or blanket is used to provide a flexible impervious barrier between the fluid under pressure and the mold. The molded piece is

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[8]Ibid., 6.

pressed between this flexible bag and the rigid surface of the mold. The full fluid pressure is applied at right angles to the bag, whatever the shape. The pressure at certain glue joints may be less than full fluid pressure.

There are two types of bags, full bags and half bags or blankets. "A full bag is a complete envelope of impervious flexible material clamped shut at one end or side and having a connection, usually called a bleeder, to allow the entrapped air to escape to the atmosphere."(9) A bag may be completely closed using a tube for inflation.

A half bag, or blanket, is a sheet, smoothly fitting the mold, and it is temporarily sealed to the edges of the mold. A bleeder is attached to the mold or bag. Usually full bags are used over male molds and half bags are used on female molds. Half bags are used when production is high because they will endure wear longer, since they do not have to support the weight of the mold as do full bags.

The life of a bag is determined by the material used in the bag, the temperature of the cycle, the size of the bag, and the care given in use. Some bags last only for ten hours of operation, while others last two hundred hours. Most bags are made of specially compounded natural or synthetic rubber. Sometimes the rubber will be reinforced with fabric.

Most bags are between one-thirty-second and one-eighth inch in thickness. The thickness of a bag depends on the amount of reinforcing, the severity of handling and the type of bag molding. The thinnest bag which will withstand the pressure needed should be used because it will transfer heat more rapidly, and thin bags will not wrinkle the molded piece.

It is advisable that a layer or two of paper or cloth be used

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[9] Ibid., 7.

between the plywood being molded and the bag. This will allow steam and air to escape to the outside, and it protects the bag against glue squeeze-out. All sharp corners on the plywood should be covered with extra layers of paper or cloth so that the bag will not be injured.

Pressure cylinders that are used with bag-molding should be hydraulically tested to a pressure double the maximum pressure needed. If more pressure is used than that at which the cylinder was tested an adequate safety valve should be installed.

Glues for Bag Molding

Close cooperation between the user and the glue supplier should be practiced when selecting a glue for bag molding. The glue selected is determined by the performance requirements of the product. Bag molding is best adapted to large or severe double curvature. Bag molding requires a long period of time to adjust the strips of veneer in place in the mold. A hand plane and sandpaper block is often used for hand-fitting the veneer strips. Because of these conditions a glue should be used that permits an assembly period of at least thirty hours.

When molding double-curvature parts with thermosetting glues, a glue that will pass through the fluid stage slowly and flow readily should be used. This type of glue will act as a lubricant and will allow the adjacent plies of veneer to slip into their proper place, thus avoiding wrinkles. Most bag molding glues have this property. It is also important that bag molding glues be durable under service conditions.

A consideration should be given to curvatures, thickness and number of plies, species, and arrangement of alternate plies before gluing. The curvature of the piece may determine the thickness of the veneers that should be used.

## Moisture Content

A moisture content of 8 to 12 per cent in veneer is favorable for bag molding, however, the variations within this range will depend on the glue being used. The variation of moisture content between the veneer sheets in one assembly should not exceed 2 per cent. Change in moisture content during manufacture is usually serious, and, if the width of the veneer shapes change much, hand fitting is required. The importance of dimensional stability depends on the size and shape of the molded part. The larger the part, the more important is the stability.

## Assembling the Veneer

The width of the veneer strips is ascertained by the amount of curvature that is desired. It is more economical to use a few wide strips, but the strips must not be so wide as to cause wrinkles as the fluid pressure on the bag presses the flat strips against the double-curved mold. The veneer strips should be tapered carefully to fit the mold in order to obtain a close joint between the adjacent strips. While the strips are put in the mold they must be fastened in place by staples or tacks. The staples are left in the outer layer of veneer during the molding, but the others are removed as another layer is added.

The heating mediums which are used are steam, steam-air mixtures, water, and air. When high temperatures are desired pure steam is used. When pure steam is used, an exhaust valve is left partly open so residual air can be expelled. The steam-air mixture often requires an air compressor in addition to a steam boiler. The use of hot water requires the use of an auxiliary storage tank in which the water is heated and it returns to the tank after being used in the heating cycle.

Usually bag molding is done at pressures from forty to eighty pounds per square inch. Vacuum alone is not recommended for critical work because it provides insufficient pressure. It is somewhat difficult to select a proper heating cycle to be used to cure the glue and bond the veneer into the finished molded part because synthetic resins do not have a definite temperature at which condensation occurs.

Of course, the final check of the finished product is simply whether the glue joints in the finished product meet the requirements which were specified.

# CHAPTER III

## Significance of Wood Lamination and Molded Plywood to Industrial Arts

It appears that many industrial arts programs are not offering wood lamination or molded plywood in their industrial arts program, but because of the great and varied use of these industrial processes it seems that more could be taught in regard to them.

### Advantages of Using Wood Lamination and Molded Plywood in Industrial Arts

Lamination and molded plywood may not be applicable to all industrial arts programs. However, if a teacher is teaching a class which is ready for this type of work some advantages of using wood lamination and molded plywood in the program are:

1. It offers a different method of fabricating a product.
2. Members can be made much stronger with less weight and size.
3. It offers unlimited opportunities for creative design.
4. It offers a challenge for better-or advanced-students.
5. In many cases it saves on materials.(10)

The use of these products offers many opportunities in meeting the needs of better students because they offer so many opportunities for creative design, in fact, the opportunities are unlimited. Many teachers of industrial arts are now using a problem solving method to stimulate better students, and wood lamination and molded plywood also offer many possibilities in this area.

Many woodworking teachers are concerned about the importance of teaching woodworking. Often it is felt that the advantages of teaching

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[10] Warren Thomas, "Laminating, Bending Wood for a Chair," School Shop. 19 (September, 1959), 16.

woodworking are few because "wood construction is becoming of lesser importance in industry because of better and stronger materials available".(11) Therefore, a woodworking teacher may use laminated wood and molded plywood to strengthen the objectives of his course.

The use of this type construction also tends to combat the amateurish look which is so often found in objects made in the school shop.

There are some factors, however, which should be investigated before starting a laminated or molded plywood project. The most outstanding factors seem to be the amount of money available for use in constructing molds and the type of equipment which will be necessary for producing the needed molds.

### Articles made from Laminated Wood

One project which has been used in the Senior High School in Wausau, Wisconsin is rather outstanding. It won the 1958 Ford Industrial Arts Award. The construction is a chair which is made of laminated wood. The design is original, and the molds were constructed by the student. The molds for the chair are illustrated in figures 2, 3, and 4.

#### Procedure for Making the Chair

Free-hand sketches are first made of the chair, and then a mock-up of the chair is made to allow one to study the over-all appearance and make possible any needed variation in design.

A male-female type mold is used for the back of the chair. A masonite pattern may be used to design the sections of the mold. This is shown in figure 4. The two molds must be concentric to each other in the male-female type mold. "It is important to have both sections of the mold machined very accurately to produce good glue joints on the

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[11] Troyce McGovern, "Selecting I A Solids from Industry," Industrial Arts and Vocational Education. 49 (June, 1960), 17.


FIGURE 2

Chair made from wood laminations.

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Warren Thomas, "Laminating, Bending Wood for a Chair," School Shop. 19 (September, 1959).

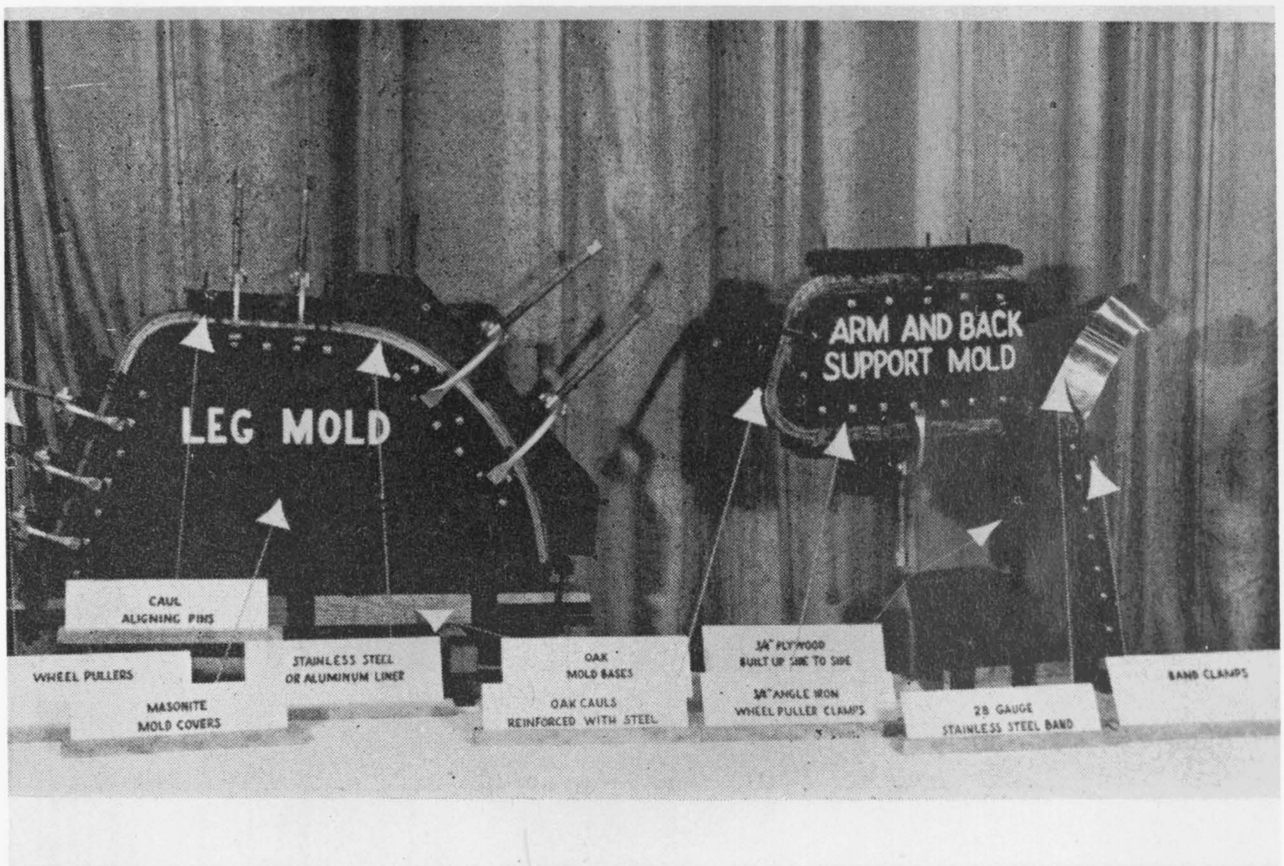


FIGURE 3

Molds used for making chair.

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Warren Thomas, "Laminating, Bending Wood for a Chair," School Shop. 19 (September, 1959).

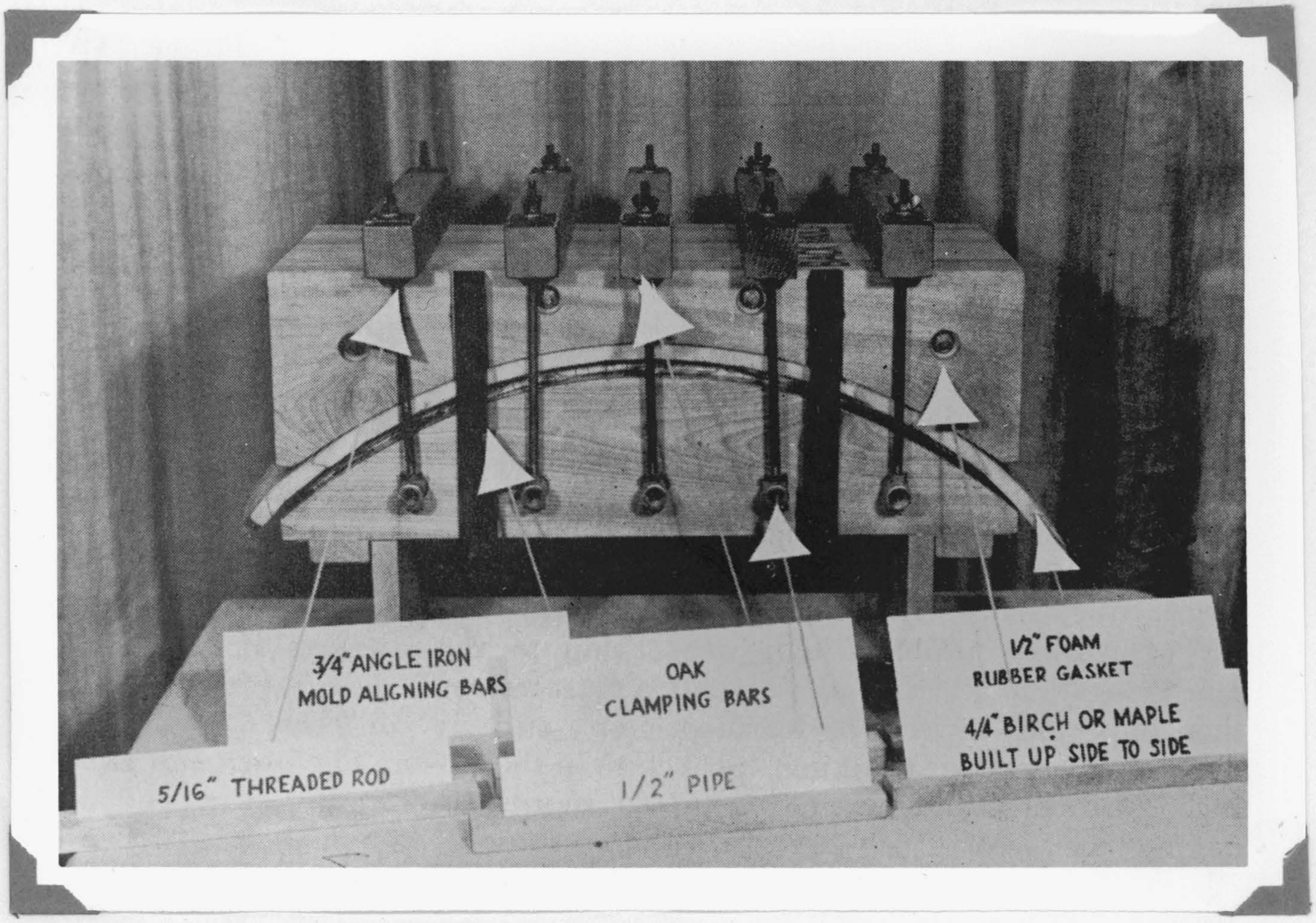


FIGURE 4

Clamping assembly for laminating chair back.

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Warren Thomas, "Laminating, Bending Wood for a Chair," School Shop. 19 (September, 1959).

glued member."(12) Figures 2, 3, and 4 further illustrate how to construct the molds. A urea resin glue is used to glue all the members.

A major problem which must be handled properly in this project is the problem of distortion. Some of the major causes of distortion have been discussed previously.

Shrinkage is a problem which is often caused by water in the glue. The glue-water ratio may be controlled as accurately as possible to the one-tenth of a gram to allow for equal shrinkage of all the members.

After the member is allowed to cure for twenty-four hours, the glue squeeze-out can be trimmed off with a saber saw and hand plane. Safety goggles should be worn during the trimming operation.

The members can be cut to size and shaped by using a combination of operations on the jointer, circle saw, band saw, and saber saw. Special machine guards should be built for some operations. Special jigs and fixtures should also be made to hold some members for making special cuts. This is illustrated in figure 5.

Water Skis Project

An item which has been used in the Altadena, California High School is water skis made of laminated wood. This construction features the principle of pneumatic clamping. The form was designed to facilitate clamping of double or single slalom water skis and also snow skis. The specifications for this project are illustrated in figure 6.

Pneumatic clamping is accomplished by taking a 6.50 X 15, or larger, tire inner tube, cutting it six inches from the valve stem and clamping each end with two pieces of steel which are bolted together and inflating it with air.

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[12] Thomas, Op. Cit., 16.

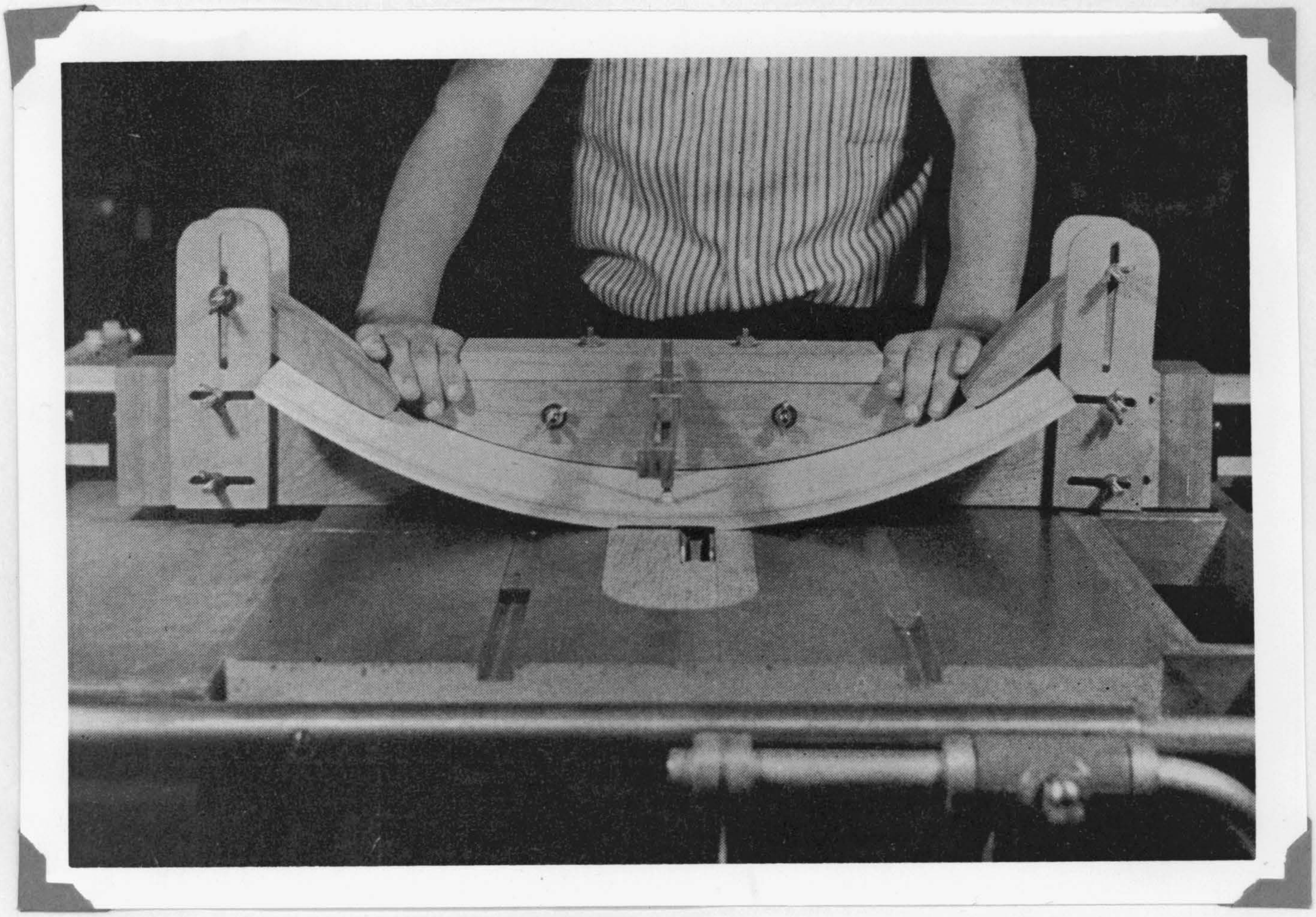

FIGURE 5

Jig used on circular saw.

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Warren Thomas, "Laminating, Bending Wood for a Chair," <u>School Shop</u>. 19 (September, 1959).

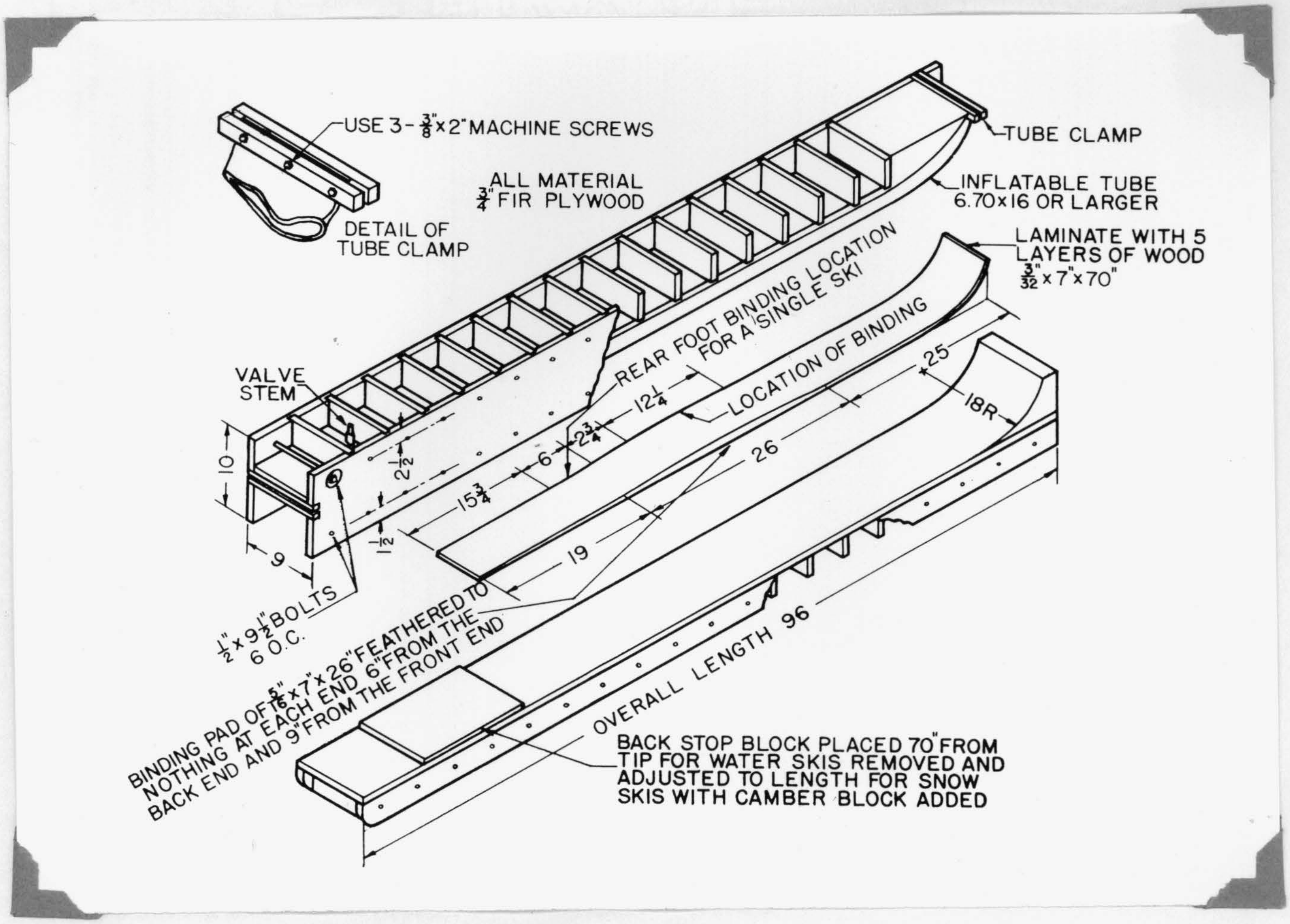


FIGURE 6

Form for making laminated water skis.[1]

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Christen J. Hansen, "Pneumatic Clamping of Laminated Water Skis," Industrial Arts and Vocational Education, 49 (February, 1960).

The veneer pieces may be made by the students using pieces of mahogany, domestic ash or Sitka spruce. The fletches may be planed by placing each on a thicker and a larger piece of surfaced lumber, and it should run with the grain to prevent splitting out. The footpad should be tapered six inches from one end and nine inches from the other end. The tapering should be finished by hand.

The form should be first tested under pressure before gluing. A plastic resin urea formaldehyde type waterproof glue can be used, and it is applied with either a serrated spreader or brayer, as illustrated in figure 7. The bottom fletch should be placed on waxed paper before coating its surface with glue, then the second fletch is placed on the first and coated with glue, also the third and fourth. The footpad is placed nineteen inches from the back of the ski blank with the six inch taper to the back.

Glue is applied to its upper surface. After the top fletch is on, the entire ski should be wrapped with a second sheet of waxed paper. After the assembly is placed in the form, the form is assembled and filled with air to thirty pounds per square inch. The glue should be allowed to set eight hours. After the ski blank is removed from the form it may be finished with the usual woodworking techniques.

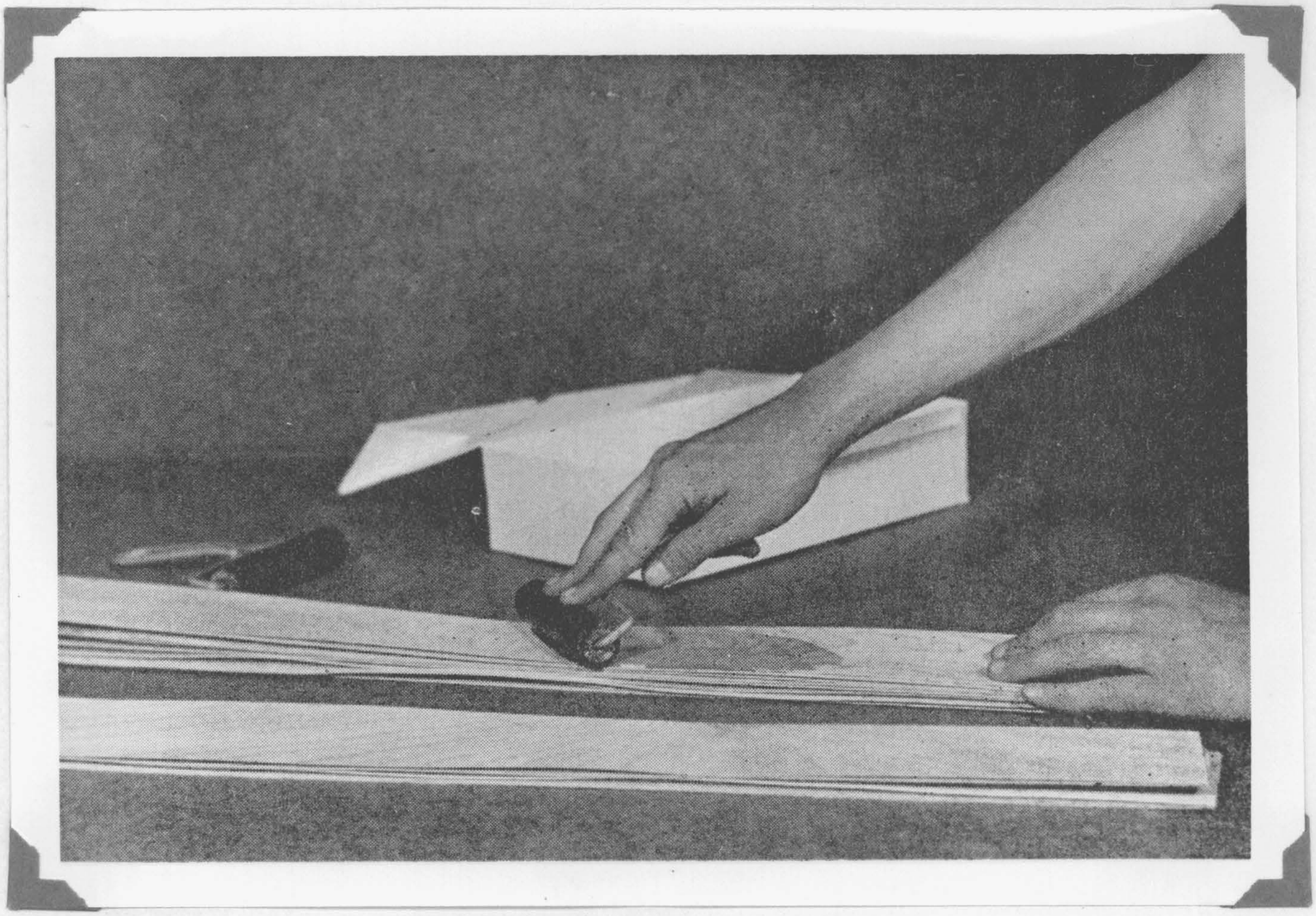

FIGURE 7

Applying glue with a brayer.

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Warren Thomas, "Laminating, Bending Wood for a Chair," School Shop. 19 (September, 1959).

## IV. Conclusion

The use of wood lamination and molded plywood is so important to the use of wood in modern industry that it seems almost essential for teachers of advanced woodworking classes to teach something which pertains to wood lamination and molded plywood.

Teachers of industrial arts are now encouraged to teach more "saleable skills". This means that more skills should be taught which will help students select a vocation or which will help them in attaining employment when they are out of school. One of the most important roles of industrial arts is that of preparing students for employment after leaving school, therefore, it seems very important that industrial processes be used and understood by students, and wood lamination and molded plywood are two processes which can be taught to students.

Because wood lamination and molded plywood offer so many opportunities for creativity, they can be very stimulating for the student that might not be needing the knowledge for later employment.

The teacher will need to be the stimulating force, and he will need to educate himself in regard to how these processes can best be used in his situation. A teacher who wishes to use wood lamination or molded plywood for use in projects will usually be able to improvise materials so that the cost will not be prohibitive. This type of learning situation will require much planning by the teacher and by his students, but a well planned program should result in some very desirable learning experiences.

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