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BY A. P. C.

M. J. LYON ET AL
METHOD AND APPARATUS FOR FABRICATING OBJECTS FROM PLY-WOOD AND PRODUCTS THEREOF
Filed Feb. 19, 1941

Serial No.
379,694

6 Sheets-Sheet 1

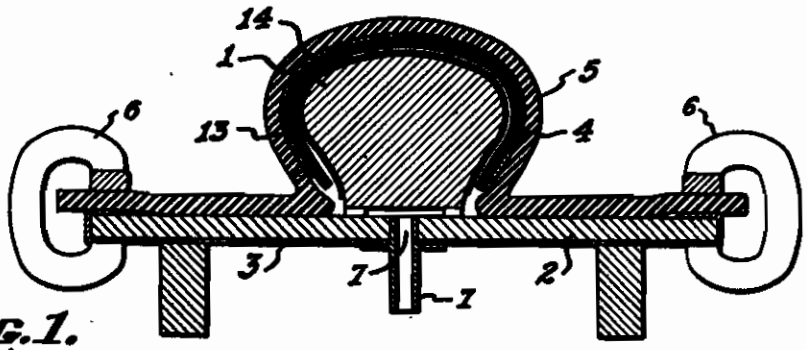

FIG. 1.

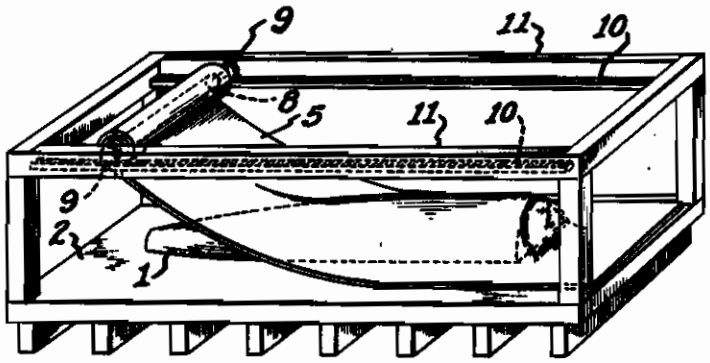

FIG. 2.

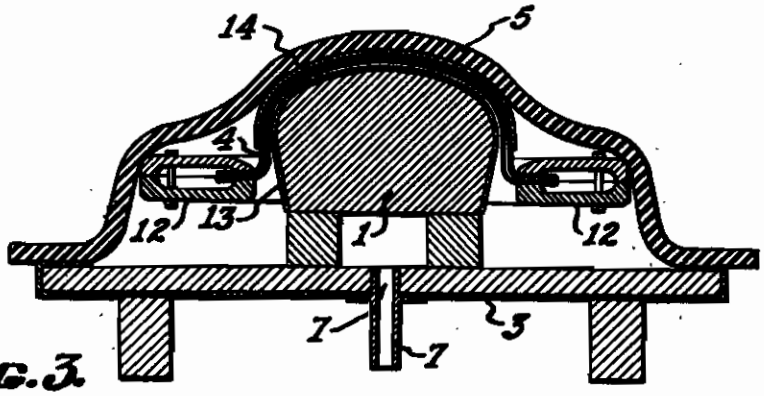

FIG. 3.

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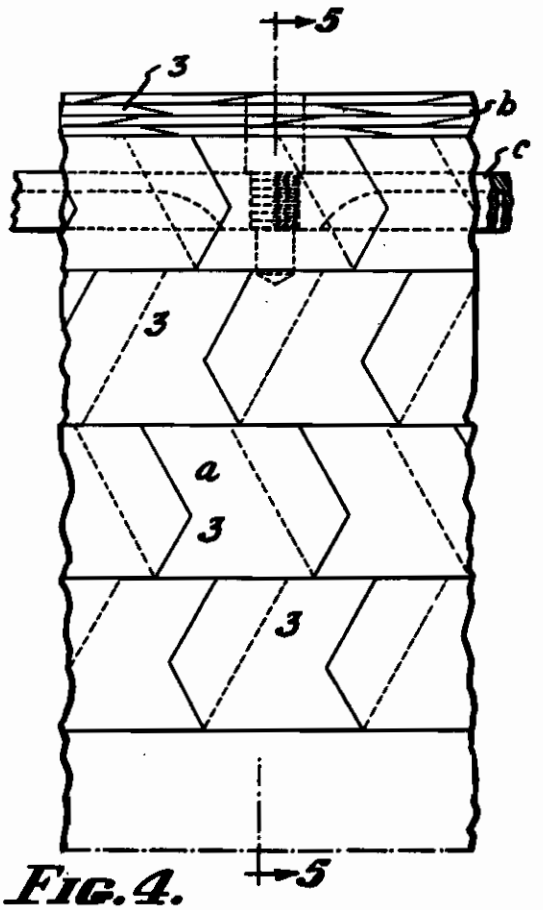

FIG. 4.

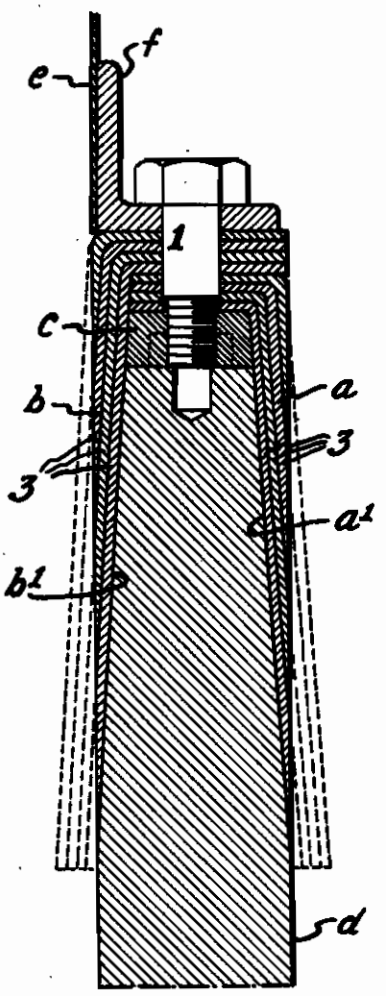

FIG. 5.

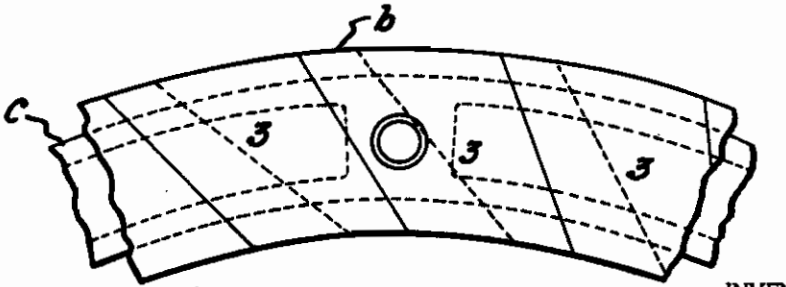

FIG. 6.

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6 Sheets-Sheet 3

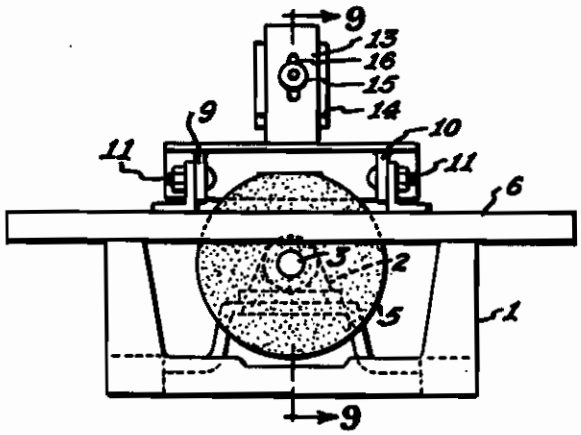

FIG. 7.

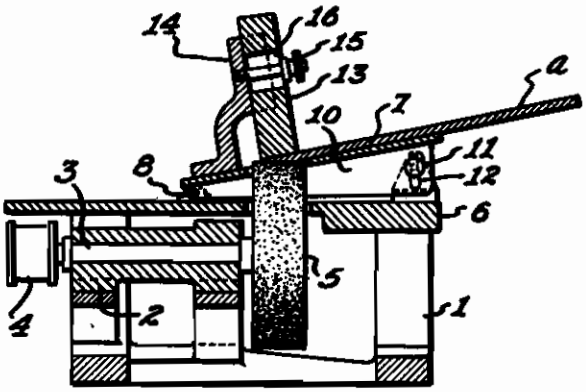

FIG. 9.

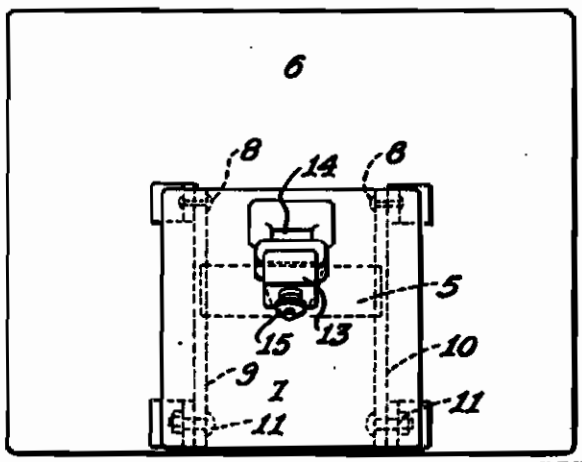

FIG. 8.

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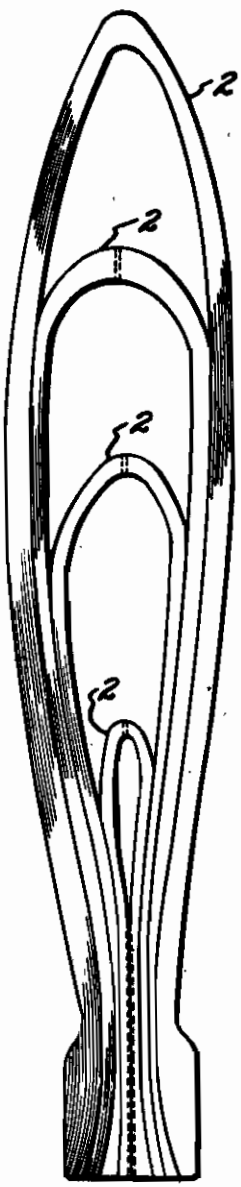

FIG. 10.

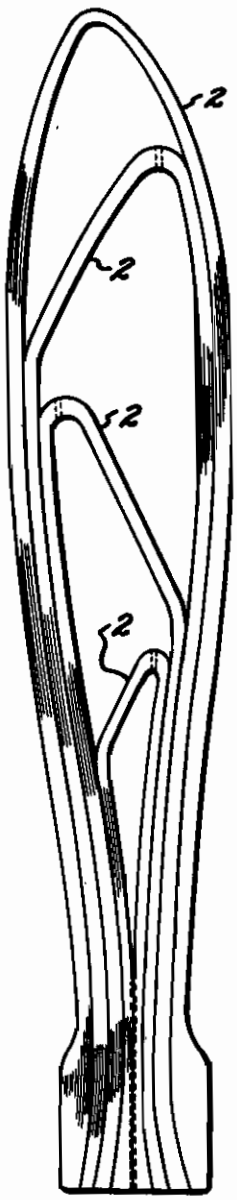

FIG. 11.

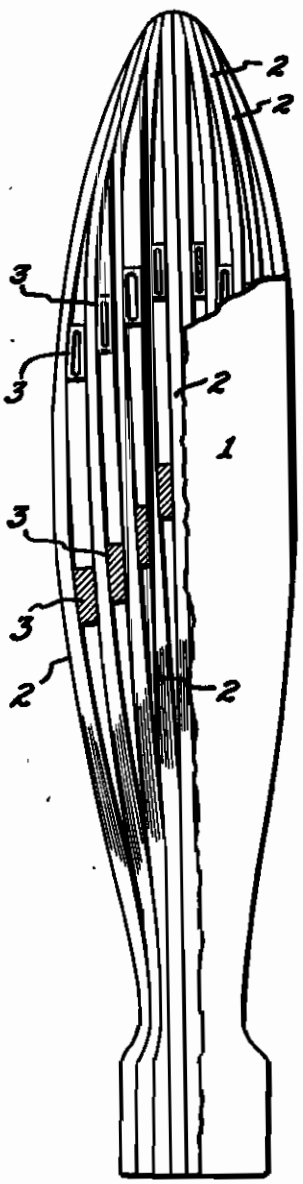

FIG. 12.

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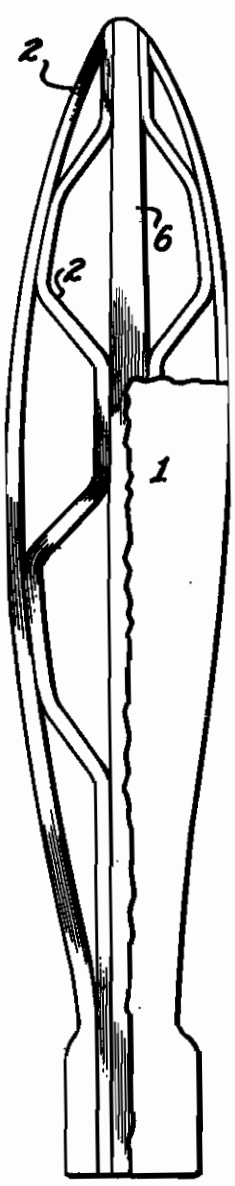

FIG. 13.

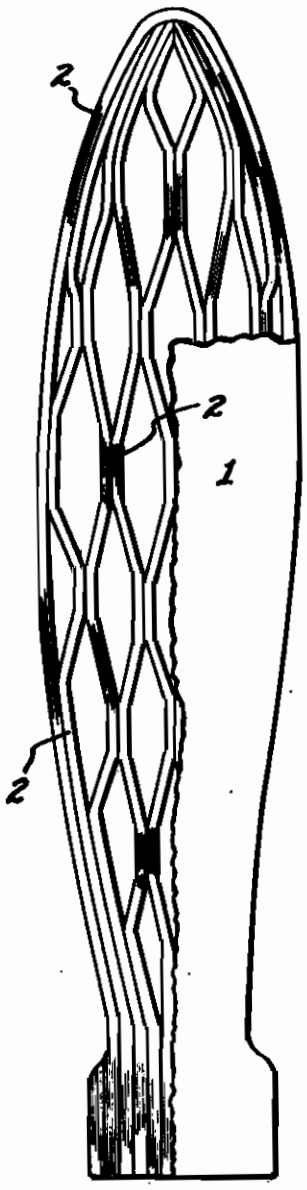

FIG. 14.

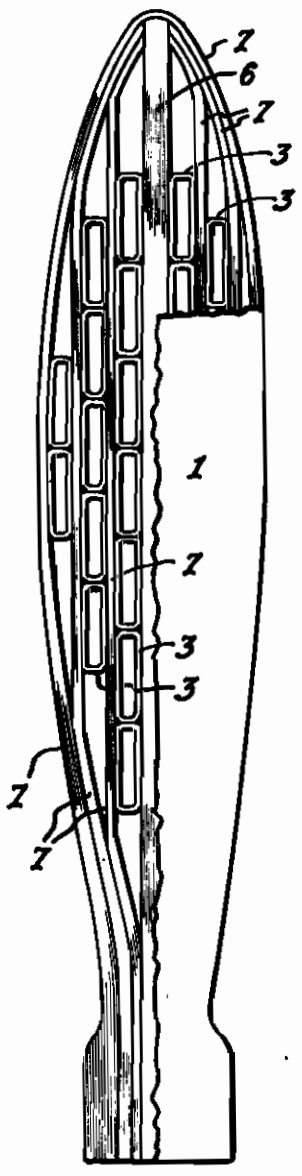

FIG. 15.

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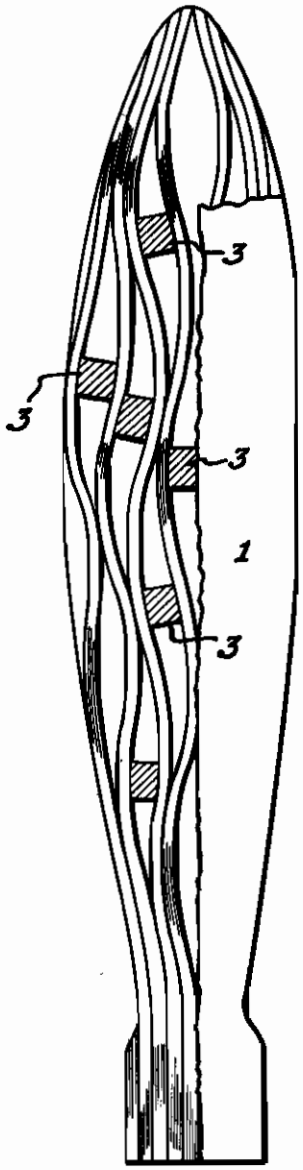

FIG. 16.

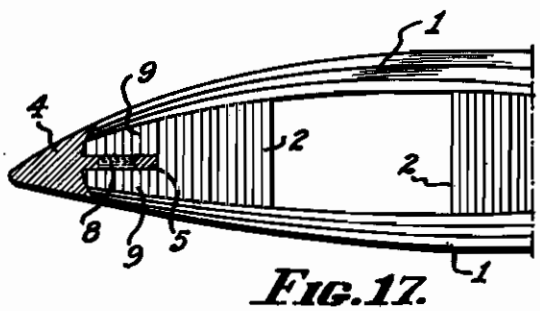

FIG. 17.

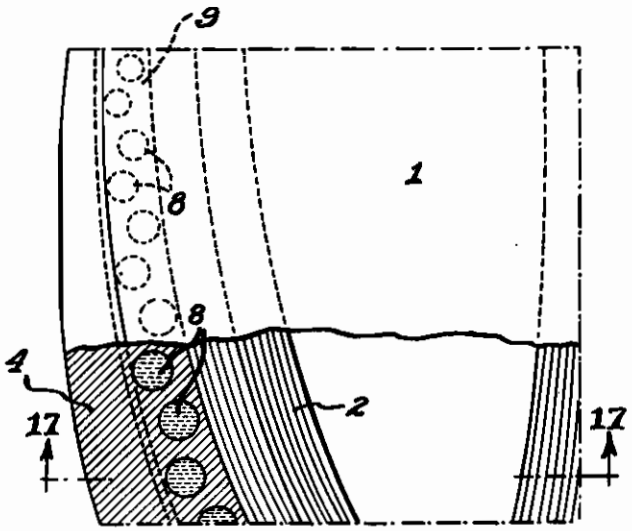

FIG. 18.

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ALIEN PROPERTY CUSTODIAN

METHOD AND APPARATUS FOR FABRICATING OBJECTS FROM PLY-WOOD AND PRODUCTS THEREOF

Marcelle Jeanne Lyon, Paris, Maurice Louchard, Pantin, and Gaston Guillotel, Paris, France; vested in the Alien Property Custodian

Application filed February 19, 1941

This invention relates to the fabrication of objects of all kinds from ply-wood, and more particularly to objects moulded under pressure from sheets of ply-wood associated with an appropriate binder. It relates more particularly, although not exclusively, to those objects which are adapted to be built up of a relatively large number of layers of very thin wood sheets, ranging in thickness, for example, from 0.05 down to 0.02 inch. While considerably thicker material may be used in our process without overstepping the limits of our invention, we prefer to use thin sheets when possible and have generally obtained better results therewith, both in mechanical strength and in ease and perfection of moulding. A very large variety of objects may be fabricated by our method, such, as by way of example, boats of moderate size, parts of automotive vehicle bodies, airplane bodies, etc.

One object of our invention is to provide an inexpensive method of fabricating objects which, on the basis of equal mechanical strength, will be no heavier, cheaper, of simpler construction and generally more lasting, than similar objects fabricated from metals such as steel or aluminum alloys.

Another object is to provide a method of fabricating moulded objects from ply-wood which lends itself to the most efficient use of the material, allowing the latter to be distributed at will so as to give maximum strength at those points of said moulded objects which will be subjected to the maximum stresses, and in such manner that the lines of maximum strength, that is, the grain of the wood, may be made to coincide substantially with those of said maximum stresses.

Another object is to provide a method of fabricating moulded objects from ply-wood which requires a minimum of capital investment and is therefore readily adaptable to a considerable variation in the volume of production.

A further object of our invention is to provide inexpensive and simple means for fabricating moulded articles from ply-wood, which may be operated by relatively unskilled labor and can be adapted to a wide variety of products.

Yet another object of our invention is to provide objects moulded from ply-wood which possess considerable mechanical strength combined with lightness, of extremely simple construction and requiring a minimum of reinforcing, such as internal bracing, ribs, etc. By way of example, small boats produced by our method require no internal ribbing of any kind, and remain moreover completely water-tight throughout the entire length of their useful life. Likewise, while airplane bodies made of aluminum alloys require a very complex and delicate system of internal bracing which may be rendered unsafe by the breaking of a single strut, such bodies made of ply-wood by our method may be designed so as to derive their entire strength from their walls and to require no bracing whatsoever.

A special object of our invention is to provide composite structures, meaning thereby structures comprising at least two associated parts, said associated parts being either all fabricated from ply-wood according to our method, or some being of ply-wood and some of metal, said parts being joined together according to a special method invented by us which comprises the step of embedding metallic members in the edges of ply-wood parts to be assembled to other parts, said metallic members being moulded in said ply-wood and adapted to engage means of fixation such as screws also engaging appropriate portions of adjacent associated parts, either of ply-wood or of metal.

Another special object of our invention is to provide an airplane propeller blade moulded from ply-wood, which is as strong as one made of aluminum alloys, yet lighter and cheaper, and which is moulded to substantially its final shape, requiring practically no subsequent machining to be ready for service.

These and other objects of the invention will be made clear to a man skilled in the art by the following description of certain embodiments thereof with reference to the appended drawings, it being understood that said description and drawings are exemplary only, and are not to be construed as limiting the invention to anything short of the fullest scope of the appended claims.

In the drawings:

Figure 1 is a general diagrammatic view in cross-section of the preferred form of equipment used in applying our method to the fabrication of a small pleasure boat.

Figure 2 is a view in perspective of the equipment used for effecting one step of our method.

Figure 3 is a diagrammatic view in cross-section of a variant of the equipment shown in Figure 1.

Figure 4 is a view in elevation of our method of making a butt-end joint between a moulded object and a metallic member, in order to build up a composite structure comprising associated ply-wood and metallic parts.

Figure 5 is a cross-sectional view of said butt-end joint.

Figure 6 is an end view of a portion of the edge

of a ply-wood object to be joined with a metallic structure.

Figure 7 is a front elevation of a device for accomplishing one of the steps of our method, that is, grinding a bevel on the edges of sheet-wood sections to be associated in building-up said ply-wood objects.

Figure 8 is a plan view of the same.

Figure 9 is a cross-sectional view thereof.

Figures 10 to 18 inclusive are views of various constructions of airplane propeller blades fabricated by our method.

According to our preferred method of fabricating moulded objects of ply-wood, the wood duly seasoned, is cut according to methods known in the art, into very thin sheets which may, for example, have a thickness ranging from 0.05 down to 0.02 inch. Greater thicknesses may be used without overstepping the bounds of our invention; but we prefer to use thin sheets.

Said sheets are then cut into sections, the outlines of which vary according to the final shape of the object to be fabricated, and are chosen so that, when said sheet-wood sections are assembled, as described below, they cooperate to form said final shape of the moulded object.

In determining the correct outlines of the different sheet-wood sections, their position and the number of layers in the different parts of said moulded objects, we are guided primarily, on one hand, by the shape of the moulded object, and, on the other hand, by the magnitude and direction of the stresses to be imposed in service on the material in said parts of said moulded object.

If the object is simple, of rectilinear and substantially constant cross-section, such as a straight or curved angle or channel, said sheet-wood sections may be cut to rectangular or parallelogrammic outlines. If the moulded object has surfaces presenting a compound curvature, the sheet-wood sections may have suitably curved outlines.

In cutting said sections to the required outlines, we prefer to form a pack of a suitable number of sheets, such as 50 or 100, and cut the different shaped sections by means of a band saw.

The next step is to grind at least one edge of said sections, and preferably two or more of said edges, to a bevel of less than 15°, and preferably of the order of 2° to 5°. This operation may be performed by means of the device illustrated in Figure 7, which will be described later. Said sections are next covered on one or both faces with a binder of suitable physical properties. In general, glues of vegetable origin are sometimes unsuited to this purpose, and we prefer to use binders comprising synthetic resin, which, when set, have the advantage of being substantially insoluble in water. The sections are next assembled, layer by layer, with their bevelled edges substantially overlapping. For this operation we provide a rigid form 1 having a moulding surface presenting the final shape required for one surface of the moulded object. For example, if said object is a canoe, said rigid form may be a wooden pattern, the outer surface of which reproduces exactly the final shape of the inside of said canoe. Said outer surface, which is the moulding surface, we usually form with a thin sheath 13 of lead sheet or other plastic metal closely fitting said pattern, which metal sheath will subsequently be heated, as by means of an electric current, for the purpose of accelerating the setting of the binder. Said rigid form we place on a wooden platform or table 2, which is rendered air-tight by any suitable means, for example by applying to the lower surface thereof a sheet of lead 3, which we fold around the edges of said platform, as shown in Figure 1. Said platform has one or more orifices 7 suitably formed therein, in which orifices are inserted nipples 7 for connection to a vacuum pump. Suitable spacing blocks should be inserted between the rigid form 1 and the platform 2, in order to provide free passage for the air around said form.

In assembling the sheet-wood sections, we use either of two methods of procedure, the first indicated in Figure 1 and the second in Figure 3. According to the first, we lay the sections directly on the moulding surface of the rigid form, with their bevelled edges substantially overlapping, forming the required number of layers to make a multi-ply wall 4, until the whole moulding surface of the rigid form 1 is covered.

According to the second method, illustrated in Figure 3, we lay the sheet-wood sections on a flat surface, with their bevelled edges substantially overlapping, until the multi-ply wall has the required thickness and area. We then clamp the edges of said multi-ply wall by means of longitudinal clamps 12. We next lift the wall and clamps bodily onto the rigid form 1, and gradually draw said wall down to conform with the moulding surface of said rigid form, the sheet-wood sections sliding over each other during this operation, to adjust themselves to said moulding surface.

In the course of the operation of building-up the ply-wood wall, we generally prefer to form alternate layers of ply-wood with the grains of the wood crossed at least at a small angle, the general direction of the grains of said alternate layers, at different points of said moulded object, substantially coinciding with the general direction of the stresses to be subsequently imposed in service upon the material at said points, and the number of layers being proportioned to the magnitude of said stresses. At such points exposed to sudden variable and concentrated loads, such as the floor of a boat, we prefer to provide stiffening members such as longitudinal ribs, which may be of wooden lath or built up from ply-wood, said longitudinal ribs being placed on said rigid form 1 in suitable recesses formed therein, so that, when the multi-ply wall is subsequently moulded thereon, said stiffening ribs will be cemented to and become an integral part of the multi-ply wall at said points.

In the next step, we use a mat 5 of rubber or other plastic and air-tight material. Said mat may be laid directly onto the outer surface of the multi-ply wall 4, or if a smooth outer surface is desired, a flexible form 14 may preferably be interposed between said mat 5 and said multi-ply wall 4. Said flexible form 14 should be built so as to be locally rigid, in order to eliminate local surface irregularities, but should be generally flexible, so as to conform perfectly with the surface to be moulded. We generally build said flexible form 14 out of thin ply-wood, and sometimes cut slits in suitable parts of its surface, in order to increase its flexibility, said slits being covered internally with strips of canvas or thin sheet metal, in order to prevent their leaving traces on the outer surface of the moulded object. The inner surface of said flexible form 14 is the moulding surface for the outer surface of the moulded object, and should have approximately the final shape of said moulded object.

When the flexible form 14 has been fitted over the multi-ply wall and the rigid form 1, the metal sheath 13 of the moulding surface of the rigid form is connected to the terminals of the secondary of a step-down transformer, designed to deliver very low voltage and very high current. Said connection is usually made through the platform 2, by air-tight means. The plastic mat 5 is then laid over the flexible form, so as to completely cover the latter, and its edges are clamped, by means of clamps 6, to the edges of the platform 2, so as to form an air-tight seal therewith. Nipples 7 are next connected to a vacuum pump (not shown) and the air is exhausted from the inside of the inclosure formed between the plastic mat 5 and the platform 2. When the pressure has been lowered to such an extent that the mat exerts a powerful pressure on said flexible form, thus compressing the multi-ply wall 4 between the rigid and flexible forms, the primary circuit of the transformer is closed and a heavy current flows through the metal sheath 13 of the moulding surface of the rigid form 1 and heats said sheath to a predetermined temperature, which should be sufficient to polymerize the binder and cause it to set rapidly. This usually takes 15 to 20 minutes. The current is then broken, the vacuum is relieved, the mat is removed and the moulded object may be unmoulded.

In fabricating large objects, we have found the weight of the plastic mat to be too great to be readily handled manually. We have therefore found it convenient to use a device illustrated in Figure 2. The mat is rolled on a small diameter drum 8, supported by end gears 9 engaging racks 10 supported above the platform 2, on a suitable supporting framework 11, which may either be supported from the floor or the platform or suspended from above by any convenient means. As the mat is rolled on or unrolled from said drum 8, it travels lengthwise over the surface of the platform 2, and may easily be laid over the moulded object.

According to the procedure illustrated in Figure 3, the clamping means 12 remain imprisoned under the mat until the vacuum is relieved, and are removed afterwards.

It frequently happens that, in the fabrication of objects of complex design, such as airplane bodies, it is necessary to build the object in separate associated parts, and to assemble said parts in such manner that they may be disassembled, if necessary. Said different parts may be all made of ply-wood, according to our method or any other appropriate method, or some may be of ply-wood and others of metal. The junction of two ply-wood parts, or of one ply-wood and one metallic parts, presents no difficulty when they may be assembled laterally as in a lap-joint. But in all cases requiring a butt-end joint, the problem presents considerably more difficulty, because the use of means of fixation such as screws directly in the thickness of a ply-wood wall does not give sufficient strength to insure a secure joint.

In these cases, we have devised a method of making a butt-end joint presenting the same guarantees as to strength as a metal-to-metal joint. Such a butt-end joint is illustrated in Figures 4, 5 and 6, the first in side elevation, the second in cross-section and the third in end elevation. According to a preferred form of this method, we proceed to embed in the thickness of the ply-wood part and at the edge thereof, a metallic member *c* adapted to be drilled and tapped to engage means of fixation such as screws which will serve to join said ply-wood part with the associated part. In order to embed said metallic member *c* in said ply-wood wall *d*, we generally taper the wall as shown in Figure 5. We then build up from sections of sheet-wood 3 two bands of ply-wood *a* and *b*, with which will be formed two angles with unequal legs. The longer leg of angle *a* is cemented to one face a_1 of the ply-wood wall *d*. The metallic member *c* is then placed in position, and the shorter leg of angle *a* is then folded at right angles so as to cover said metallic member *c*, pressed down onto said metallic member, held until the binder has set and then cut off flush with the far edge of member c. The longer leg of angle *b* is next cemented to the face b_1 of ply-wood wall *d*, the shorter leg of angle *b* is folded over and pressed down onto the shorter leg of angle *a*, maintained thus until the binder has set, then cut off flush with the outer face of the longer leg of angle *a*. Finally the lateral legs of the two angles are planed down flush with the faces of the ply-wood wall *d*. Holes are then drilled through the shorter legs of the angles into said metallic member c and tapped.

If the ply-wood part is to be joined with an associated metallic part, such as an angle *f* fixed to a plate *e*, screws such as 1 may be used. If said ply-wood part is to be butt-ended with a similar ply-wood part, studs may be used as joining means, with right and left threads on the opposite ends, while recesses are formed in the ply-wood wall through which means may be inserted to tighten up the studs.

By the above method, robust and thoroughly secure butt-end joints may be made between ply-wood parts or between ply-wood and metallic parts.

The method described above must be modified to a greater or less extent in certain cases, depending on special features of the object to be fabricated. For example, it frequently happens that said object comprises an inner rigid framework covered over on all faces with multi-ply wooden walls. Specific examples of such objects are the different forms of airplane propeller blades illustrated in Figures 10 to 18. All of said forms of propeller blades consist of a rigid framework and of ply-wood outer walls formed on and cemented to said framework, the latter fulfilling in the manufacturing process a function closely similar to that of the rigid form 1 in the general method, with the exception that the framework remains an integral part of the final moulded product and inclosed therein. Optionally, the propeller blade may be provided with metallic reinforcing around the tip and/or leading and trailing edges, as indicated in Figures 17 and 18.

The rigid framework may be built up in a variety of ways. For example, Figure 10 shows one solution comprising a series of enveloping looped members 2 with their ends extending into the hub-engaging root of the blade and moulded together into a rigid block therein. Multi-ply wooden walls 1 are then formed on and moulded with both faces of said framework and the blade is given its final shape and pitch during the moulding operation, so as to require practically no subsequent machining or finishing.

Figure 11 shows a type of blade differing from that of Figure 10 in that some of the longitudinal members 2 instead of being looped, are bent to approximately triangular shapes, so as to pro-

duce cross-bracing effects which add considerably to the rigidity of the blade in the plane of rotation.

Figure 12 shows a different type in which the framework is built up of a plurality of longitudinal rib-members 2, moulded together in the hub-supported root and at the tip of the blade and flared out between these points and separated by spacing blocks 3, to form the body of the blade.

The type shown in Figure 13 has a heavy central longitudinal rib member 6 extending from the tip down into the root, said rib member being cross-braced by lateral members 2 bent and moulded alternately to the edge member and to the central member 6. In the type shown in Figure 14, the longitudinal ribs 2 are bent and moulded together at such points as to form a honeycomb structure. In Figure 15, we have still another type comprising a heavy longitudinal member 6, as in Figure 13, lighter longitudinal members 7, and elastic spacing members 3 formed into a flattened ring shape, said spacing members 3 being moulded with the longitudinal members on each side of them. Figure 16 shows still another type in which the longitudinal members are given a sinuous shape and assembled in out-of-phase relation, spacers 3 being inserted between them at suitable points.

Figures 17 and 18 illustrate, the first in cross-section, the second partly in elevation and partly in broken section, a portion of a propeller blade of ply-wood provided with metallic reinforcing around its edges. The multi-ply surface walls 1 are moulded with the frame ribs 2. The outer frame ribs 9 are made in two parts forming between them a deep slot. The reinforcing metallic member 4 is cast with a rib or fin member 5 which is machined to fit into said slot between said frame ribs 9. In order to provide safe anchorage between said fin member 5 and the frame ribs 9, the fin 5 has holes 8 formed in it which are filled with binding glue. When the binder has set, the metallic reinforcing fin 4 is securely held between the frame ribs 9.

Our invention also covers the apparatus used in the application of our method, which apparatus has been described in the foregoing pages, with the exception of the device used to grind the edges of said sheet-wood sections to an angle of less than 15°, and preferably of the order of 2° to 5°.

Such an operation is delicate and requires special care to avoid tearing the sheet-wood sections. One embodiment of the device used is illustrated in front elevation in Figure 7, in plan in Figure 8 and in cross-section in Figure 9. In its preferred form, this device comprises a frame 1 supporting a table 6 and a bearing 2, in which is journaled a shaft 3 bearing a grinding wheel 5 and a driving pulley 4. The upper portion of said grinding wheel 5 projects through an aperture formed in table 6. A work support 7 is hinged at 6 to the table 6 and may be fixed at any desired small angle with said table 6 by means of bolts 11 slidable in grooves 12. An abutment guide 13, with its lower bearing surface substantially parallel to said work support 7, may be clamped adjustably by means of a screw and nut, 15 and 16, to a support 14 bolted to said work support 7. Said work support 7 comprises an aperture through which the grinding wheel 5 projects just enough to have one circumferential edge flush with the upper surface of said work support 7.

With this device, the operation of bevelling the edges of the sheet-wood sections is very simple. Said sheet-wood section *a* in Figure 9, is held flat on the work support 7 and fed longitudinally, in the plane of the grinding wheel 5, between the periphery of said grinding wheel and the abutment guide 13. The operation lasts a few seconds.

The grinding wheel may be a relatively coarse-grained emery wheel, or a wooden wheel upon which is fixed a band of sand paper or similar abrasive.

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