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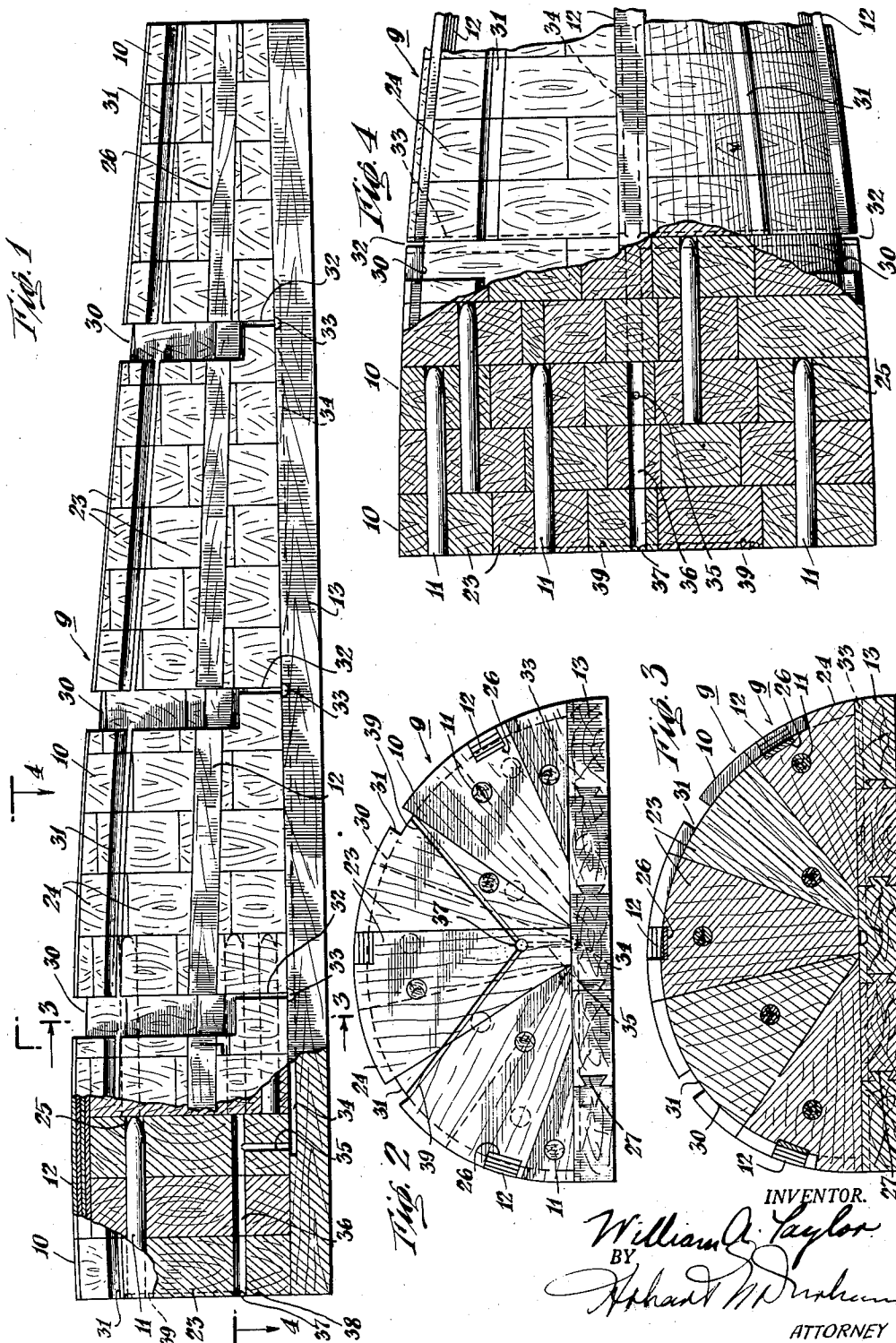
W. A. TAYLOR

2,392,707

MOLDING APPARATUS

Filed Feb. 20, 1943

2 Sheets-Sheet 1



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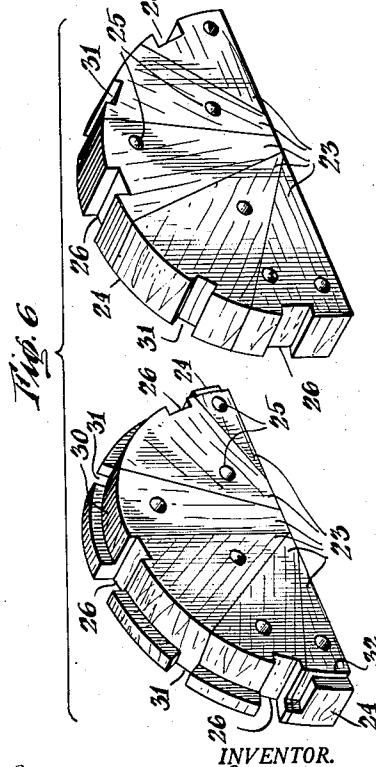
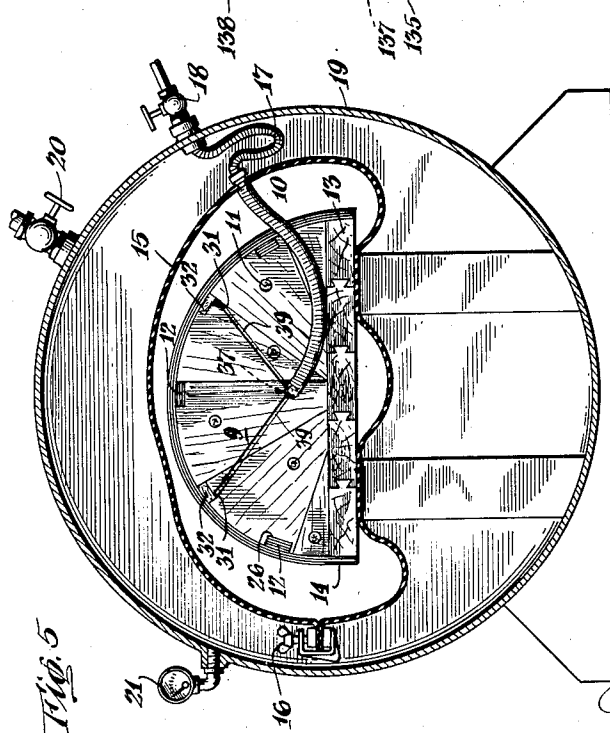
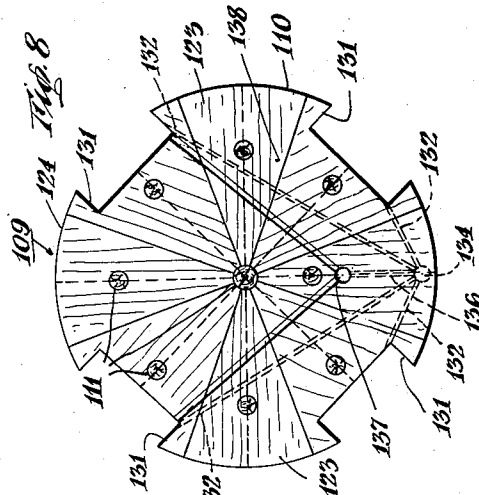
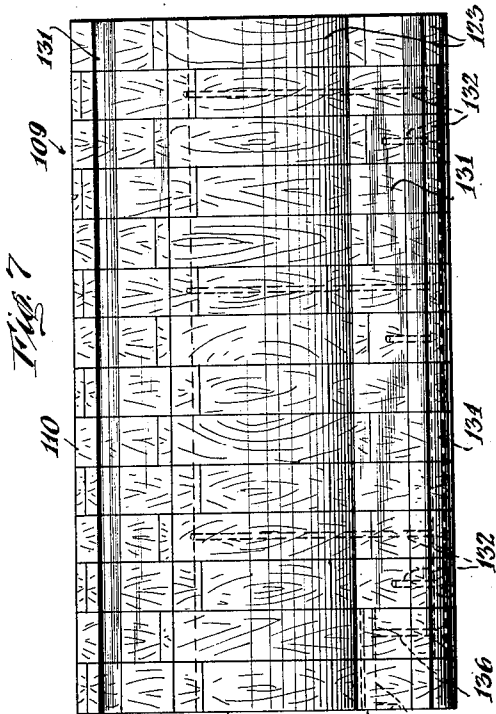
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2 Sheets-Sheet 2



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MOLDING APPARATUS

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3 Claims. (Cl. 144—281)

This invention relates to certain new and useful improvements in fluid pressure molding apparatus.

Objects and advantages of the invention will be set forth in part hereinafter and in part will be obvious herefrom, or may be learned by practice with the invention, the same being realized and attained by means of the instrumentalities and combinations pointed out in the appended claims.

The invention consists in the novel parts, constructions, arrangements, combinations and improvements herein shown and described.

The accompanying drawings, referred to herein and constituting a part hereof, illustrate one embodiment of the invention, and together with the description, serve to explain the principles of the invention.

In the manufacture of laminated molded articles upon a rigid mandrel, the molding pressure is frequently applied to the moldable material through the medium of a fluid under pressure, such, for example, as high pressure steam or air, acting through a fluid-impervious membrane, or membranous container, wholly or partially enveloping the mandrel and moldable material assembled thereon.

In order to obtain the necessary differential molding pressure through the membrane, it is customary to vent or exhaust the membranous container while the molding pressure is being applied. It frequently happens that at the high molding temperatures and pressures employed steam permeates the container, either through the pores of the membrane, or through openings therein created by rough handling, gradual deterioration, rupture in use, or other causes. Condensation within the container follows and water collects therein. When the mandrel is recessed to receive stringers, the water may collect in the stringer grooves, and the stringers wetted with ensuing warping, twisting and other injurious effects.

Success of the molding operation is facilitated if the container is first evacuated. Evacuation is desirable to permit preliminary manipulation of the container on the mandrel. Preliminary manipulation tends to eliminate factors causing tearing and rupturing of the container. Such difficulties often arise when the container is permitted to stretch unduly over sharp corners or gaps in the mandrel or moldable material, as pressure is applied. With large mandrels particularly, evacuation can be a relatively slow operation. The slowness is apparently due to the

difficulty of removing fluid trapped between the mandrel and moldable material as the latter conforms to the mandrel surface.

It is obviously desirable also that the mandrel possess high resistance to warping, crushing, bending and twisting. Wooden mandrels are advantageous in that their construction may be carried out with relatively non-skilled labor and for a given size they are of lighter weight and cost less to fabricate than mandrels of concrete or metal. In large sizes, however, it has been difficult to impart to them the necessary strength factors so that they will retain their exact form with continued usage over long periods of time.

Objects of this invention are: to provide improvements in fluid pressure molding apparatus; to provide a new and improved wood mandrel having an extended useful life and high resistance to crushing, bending, warping and twisting; to provide a mandrel for molding articles by fluid pressure transmitted through a flexible membrane which will minimize the possibility of injury to the mandrel or article consequent upon leakage of the pressure fluid into the space between the mandrel and the membrane; and, to provide a mandrel which will enable said space to be evacuated more rapidly than has heretofore been possible.

Of the drawings:

Fig. 1 is a view in side elevation with parts in section of a fuselage mandrel constituting one embodiment of this invention;

Fig. 2 is a view in elevation of the left end of the mandrel of Fig. 1;

Figs. 3 and 4 are sections respectively taken along the lines 3—3 and 4—4 of Fig. 1;

Fig. 5 is a view in vertical section through fluid pressure molding apparatus showing the mandrel of Fig. 1 with moldable material thereon;

Fig. 6 is a view in perspective of the fifth and sixth contour sections from the left end of the mandrel of Fig. 1;

Fig. 7 is a view in side elevation of a binnacle stand mandrel constituting another embodiment of this invention; the mandrel being in the position it would occupy during a molding operation; and,

Fig. 8 is a view in end elevation of the left end of the mandrel of Fig. 7.

To the accomplishment of the foregoing ends and objects, there is provided in accordance with this invention, a wooden mandrel comprising a strong and rigid assembly of individual units of wood. These units are so constructed and arranged that in their assembled relationship, the

wood grain of each will run substantially normal to the molding surface of the mandrel.

Means are provided for draining water or other liquid from stringer grooves or other recesses in the molding surface into the interior of the mandrel from whence it can be removed by suction through a non-molding surface of the mandrel.

The term "molding surface" as used herein is intended to include all portions of the mandrel surface with which the moldable material, including any and all reinforcing elements thereof, comes in contact or covers. Thus, it will be understood that the bottom and side walls of a groove in the mandrel, adapted to receive a pre-formed stringer, for example, may form part of the molding surface.

The term "non-molding surface" as used herein refers to a surface not contacted or covered by moldable material although it may be, and generally is contacted, or covered by the pressure transmitting membrane, sometimes hereinafter referred to as the container, which covers the molding surface of the mandrel during the molding operation.

The same means is also utilized for effecting the withdrawal of air or other gaseous fluids from such recesses and from the container which envelops the mandrel during the molding operation.

It will also be apparent that through the provision of a drainage system communicating with the space between the molding surface and moldable material, the removal of air, as during evacuation of the container, from between the moldable material and the mandrel is facilitated. In consequence, evacuation of the container can be carried out in considerably less time than is required for the purpose with mandrels of conventional construction.

In accordance with this invention, the mandrel is "built-up" of a number of small wooden members or elements in such fashion as to obtain a structure of superior resistance to deformation by bending, crushing and torsional forces. As embodied, these wooden elements are so constructed and arranged that the grain of the wood of the elements forming the molding surface will be normal or substantially normal to the molding surface throughout at least the major portion of the molding surface area.

Since the direction of action of fluid pressure is normal to the surface to which it is applied, the pressure upon the molding surface in a fluid pressure molding operation will act in the direction of the wood grain. High crushing resistance is thus obtained so that substantially no variation in the contour of the molding surface will occur even after extensive use of the mandrel.

In order to facilitate fabrication of the mandrel and at the same time to impart thereto a greater torsional rigidity, the mandrel comprises a number of side-by-side contour sections of multiple unit construction.

Each unit of a section is so fashioned that when assembled in its section its grain will be substantially normal to the molding surface of its section.

The units of each section are preferably also so fashioned and arranged that the seams or juncture lines of any one section will be in angularly offset relation to the seams or juncture lines of its preceding and/or succeeding section. In consequence, increased shear strength is obtained.

Bonding of the successive sections and the units of each section to each other is obtained by means

of a suitable adhesive, preferably a plastic bonding agent, such, for example, as a synthetic resin adhesive of which Durez, Plaskon and the like are typical.

Means are provided for increasing the longitudinal and torsional stiffness of the mandrel and for structurally integrating the mandrel sections into a unitary rigid structure. As embodied, suitable spanwise stiffeners of which the grain runs in the direction of their length traverse the successive sections at right angles thereto. These stiffeners are preferably adhesively bonded to the sections and also serve to bond them mechanically together.

It will be understood that the foregoing general description and the following detailed description as well are exemplary and explanatory but are not restrictive of the invention. Referring now to the accompanying drawings and more particularly to the embodiment of Figs. 1 to 6 thereof a fuselage mandrel 9 as there embodied comprises a plurality of contour sections 10 joined together in side-by-side relationship by means of dowels 11, inset longitudinal stiffeners 12 and an external longitudinal stiffener or spar member 13. It will be understood that the mandrel of Fig. 1 is adapted for the fabrication of one half of a fuselage, two such halves upon completion being assembled into a unit to form the desired structure.

As will be evident from Fig. 5, material such, for example, as laminae or sheets 14 of wood veneer of which the fuselage is to be constructed, is assembled on the molding surface of the mandrel, layer upon layer, to the desired thickness. This assembly is then enveloped in a membrane 15 of flexible, resilient material such, for example, as rubber, neoprene, etc., forming a bag-shaped container or envelope 15 through the medium of which it is possible to subject the assembly to a fluid molding pressure.

The container 15 is provided with a removable closure member 16 sealing its mouth and is adapted to be vented and/or exhausted through a vent hose 17 which extends through the container 15 in sealing engagement therewith. One end of the hose 17 is removably lodged in a vent opening 37 in a non-molding surface 38 and the other end is connected to a valved fitting 18 of a pressure vessel 19. The fitting may be connected by suitable means to a suction pump (not shown).

The pressure vessel 19 is equipped with a valved fitting 20 for supplying fluid under pressure from a suitable source (not shown) to the interior of the vessel and for releasing the pressure when the molding operation is complete. Suitable devices, such as the pressure gauge 21, may be provided for determining the operating conditions in the vessel.

It will be apparent that as the container 15 is collapsed, either by the building up of pressure within the vessel 19 or by exhausting the container through the fitting 18, fluid within the container will be discharged or educted through the fitting 18 and the mandrel 9 will be subjected to a uniformly distributed fluid pressure acting normal to the periphery of the mandrel.

Each of the contour sections 10 is of suitable configuration providing a desired substantially arcuate molding surface over the area which it is designed to cover and, as embodied, each is so constructed and arranged that the grain of the wood of which it is fashioned is substantially radially arranged and substantially normal to its

molding surface. As embodied in Fig. 1, each of the sections 10 comprises a number of dissimilar wooden units 23, Fig. 6, respectively having a curved molding surface portion 24 to which the wood grain is substantially normal. It will be apparent that each of the units 23 may be cut from a larger unit so as to obtain this result. As embodied in Fig. 6 each unit 23 is of generally "pie-shaped" construction so as to facilitate and make possible the assembly of the units into a section of the desired contour with the desired grain arrangement. The units 23 of a section are adhesively bonded to each other preferably by means of a synthetic resin adhesive applied to the contacting surfaces.

The sections 10 are assembled on the stiffener 13 in side-by-side relationship from right to left as viewed in Fig. 1, the several sections being mechanically bonded together by the dowels 11 traversing adjacent sections.

Apertures 25 are provided in each section 10 for the reception of the dowels 11, the apertures being suitably spaced over the sections so that the dowels will not be axially aligned lengthwise of the mandrel.

In the formation of the sections 10, the units 23 of each section are formed so as not only to obtain the desired grain direction as shown, but also to obtain an angularly offset relationship of the seams or juncture lines between the units of one section and the seams or juncture lines of units of a preceding and/or succeeding section. Such an arrangement is shown in Fig. 6 wherein it will be noted that the sections depicted, which correspond to the fifth and sixth sections from the left in Fig. 1, have different numbers of units, namely, six in the first case and five in the second. A similar arrangement of units is preferably followed in the other sections so as to achieve this angularly offset relationship.

The longitudinal stiffeners 12, as here embodied fit within grooves 26 fashioned in the sections 10 of the mandrel, Fig. 6. The grooves 26 may be formed in the mandrel after the sections have been assembled or they may be formed in the respective units 23 prior to assembly as in Fig. 6.

The stiffeners 12 as embodied may be of solid or laminated construction. As here embodied each is a plurality of strips of thin wood veneer adhesively bonded to the mandrel in the grooves 26 so as to lie flush with and conform to the molding surface of the mandrel. Each of the thin strips of wood veneer has its grain running lengthwise of the strip so as to provide adequate resistance to twisting and bending of the mandrel.

The spar stiffener 13 likewise has its grain running lengthwise of the mandrel for the same reasons. As here embodied, the stiffener 13 is formed of a number of side-by-side sections co-extensive with the mandrel, each joined to the other as by a tongue and groove construction 27, Figs. 2 and 3. Obviously, the stiffener 13 may be a single unit or of multi-piece construction employing short elements joined to each other at their ends and/or at their sides. Various modified forms of stiffener construction will readily suggest themselves to those skilled in the art and such forms are intended to come within the scope of this invention. The stiffener 13, as here embodied, forms part of the molding surface in that the sides of the stiffener form a continuation of the contour of the contour sections 10. The latter are preferably adhesively bonded to the

stiffener 13 over the entire contacting area of the section 10 and stiffener 13.

It will be apparent that the mandrel of Fig. 1 is of a construction providing great strength coupled with light weight. It has high resistance to crushing by reason of the arrangement of the grain of the sections 10 normal to the molding surface. High resistance to deformation under torsional and bending loads is provided by the multiple unit construction and angularly offset units which affords an appreciable amount of cross-graining with its attendant increased strength in several directions. Additional stiffness and strength is contributed by mechanical bonding of the sections 10 to each other by means of the lengthwise stiffeners 12 and 13 and dowels 11, each having its grain running in the same direction and traversing the sections 10 at substantially right angles thereto and substantially parallel to the molding surface.

Means are provided for draining the molding surface of the mandrel; for facilitating exhausting of the container; and, for preventing the accumulation of liquid around removable stringers, both transverse and longitudinal, such as are adapted to be contained wholly or partially within recesses in the mandrel during molding and to form part of the article being molded.

The venting and drainage means, as embodied, comprise a system of ducts through which fluid is adapted to be conducted by both gravity and suction from the molding surface, through the mandrel, to a non-molding surface of the mandrel.

Referring now more particularly to Fig. 1, the mandrel there shown is provided with a number of transverse grooves 30 terminating above the base of the mandrel. Each of the grooves 30 is adapted to receive a preformed transverse stringer (not shown) flush with the molding surface and removable from the mandrel with the molded article, when formed, as a reinforcing element thereof. Longitudinal grooves 31 communicating with the grooves 30 are adapted for the reception of longitudinal stringers 32, Fig. 5, for a similar purpose. It will be understood that it is common in the art to provide such stringer grooves for the purpose aforesaid and that the number, type and arrangement may be suitably varied as may be required. It is to be further understood, however, that the grooves 30, and the grooves 31 communicating therewith, form part of the drainage system and that by reason thereof liquid will tend to course downwardly therein from the upper to the lower reaches of the molding surface.

Each of the grooves 30 is connected at either end by a duct 32 to the opposite ends of one of a number of transverse internal suction ducts 33 in the lower reaches of the mandrel.

The ducts 32, as embodied, may be covered or uncovered so long as they provide a connecting channel between the stringer grooves 30 and the transverse internal ducts 33. As here embodied, the ducts 32 are in the form of open channels which may be conveniently routed out of the sections 10 during fabrication of the latter and of a depth corresponding to that of the grooves 30. Obviously, if an open channel in the molding surface be undesirable, the ducts 32 may take the form of wholly enclosed passageways in the sections 10. In either case, formation of the channels or ducts is obviously facilitated by the sectional construction of the mandrel.

The transverse ducts 33 form laterally extend-

ing arms of a suction manifold of which the header is formed by a centrally located longitudinally extending header duct 34 terminating in a vent opening 37 in the end wall 38 of the mandrel adapted to receive vent hose 17. Both the transverse ducts 33 and the header duct 34 may be routed out of the longitudinal stringer 13 prior to assembly of the sections 10 and spar member 13 and if desired may be lined or coated so as to prevent the absorption of liquid by the wood.

The vent opening 37, in the embodiment of Fig. 1, is located at a considerable height above the bottom of the mandrel in order to facilitate attaching the hose 17 to the mandrel.

The header duct 34 is located preferably at a low level in the mandrel, however, to facilitate drainage of liquid by gravity from the upper to the lower reaches of the mold. The duct 34 is provided with a short high level section 36 extending inwardly from the opening 37, the section 36 being connected to the low level section of the duct by a riser 35.

The duct sections 35 and 36 are preferably drilled in the contour section 10 during fabrication of the latter. It will be understood that, if desired, the opening 37 may be located at a lower level in the mandrel with the header 34 extending directly inwardly therefrom.

Referring now to Fig. 5, it will be seen that by applying suction to the fitting 18 air will be exhausted from the container 15 through the mandrel via the duct 34 and vent hose 17. Any liquid which collects in the stringer grooves 30-31 will drain downwardly by gravity via ducts 32 and be drawn through ducts 33 into duct 34 and from the latter educted through vent hose 17. Ducts 39 in the surface of the end wall 38 provide additional channels through which liquid may course by gravity from longitudinal stringer grooves 31 to opening 37. The vent hose 17 where it enters the opening 37 may be provided with apertures into which such liquid is drawn and by which direct evacuation of the container may be effected.

Thus it will be seen that through the provision of the internal draining and venting system, accumulation of moisture on the mandrel is minimized, the rigidity and resistance to twisting, warping and swelling provided by the multiple unit construction will be preserved, the mandrel life is prolonged and evacuation of the container is facilitated.

It is also apparent that in the event a leak occurs in the container 15, a readily condensable pressure fluid, such, for example, as steam which may condense on the molding surface will drain by gravity through the duct system from the upper to the lower reaches of the mandrel and be educted through the hose 17 to the outside of vessel 19. In this way, there can be no accumulation of liquid in the bottom of the container 15 to be raised by the pressure medium to the top of the mandrel so as to wet stringers, such as the stringers 32, adapted to be contained within the grooves 30 and 31.

Referring now to the embodiment of the invention shown in Figs. 7 and 8, there is depicted a wooden mandrel 109 of generally cylindrical contour such as would be employed in the fabrication of an internally reinforced hollow laminated cylindrical molded structure such, for example, as a binnacle stand.

As there embodied, the mandrel 109 is provided with longitudinally extending stringer grooves

131; gravity drainage ducts 132 and an internal low level header duct 134 having a high level section 135 and vertical section 136.

The header duct 134 terminates in a high level aperture 137 in end wall 138 but it will be observed that the gravity drainage ducts 132 lead directly to the header duct 134, the latter being located in the lower reaches of the mandrel.

It will be understood that the term lower reaches of the mandrel is a relative one since it depends on the position of the mandrel in the pressure vessel during molding. Obviously, however, a mandrel embodying a drainage system in accordance with this invention would be placed in the pressure vessel so that the drainage system would function in the manner intended. In such case, the terms upper and lower reaches are clearly descriptive and it is believed they will be clearly understood by those skilled in the art.

The contour sections 110 are of multiple unit construction. Each section, as embodied, is assembled from a number of segmental units 123 of identical contour, the stringer grooves 131 being routed in the mandrel preferably after assembly of the sections 10 into their final structural relationship.

The units 123 are so fashioned that the grain of each will be substantially normal to its molding surface portion 124. Each section is also preferably angularly offset relative to its preceding and/or succeeding section so that the seams or juncture lines of successive sections are out of alignment with each other.

Longitudinal stiffness and torsional rigidity is enhanced to the desired degree through the provision of the short dowels 111 joining successive sections and successive groups of sections so as to provide a firmly integrated structure. It will be understood that the dowels 111 have their grain running longitudinally of the mandrel, that is, parallel to the molding surface and at right angles to the grain of the successive sections 10.

It will be apparent that with the mandrel 109, liquid which would otherwise tend to accumulate in the upper grooves 131 will drain therefrom through the gravity ducts 132 into the header duct 134. Suction applied to the duct 134 via the opening 137 will educt the fluid therefrom. Eduction of fluid from the container in which the mandrel is located during molding will be facilitated by the drainage system in that by reason thereof, the escape of fluid from between the mandrel and moldable material is made easier.

The invention in its broader aspects is not limited to the specific mechanisms shown and described but departures may be made therefrom within the scope of the accompanying claims without departing from the principles of the invention and without sacrificing its chief advantages.

What is claimed is:

1. A mandrel comprising in combination a series of wooden contour sections in side-by-side relation, each said section comprising a plurality of solid integral wood units substantially radially arranged in side-by-side relationship, each unit having its wood grain extending substantially radially thereof and substantially normal to a surface thereof forming a molding surface portion of the mandrel; an external wooden spar member uniting said sections; and, wooden stiffeners inset in and uniting said contour sections, the wood grain of said spar member and said inset stiffeners running in the same direction substantially parallel to the molding surface of said mandrel and

at substantially right angles to the wood grain of said contour sections.

2. A wooden mandrel comprising a plurality of wooden contour sections arranged in side-by-side relation, each said section comprising a plurality of solid integral wood units substantially radially arranged in side-by-side relationship, each said unit having its wood grain running substantially normal to a surface thereof forming a molding surface portion of the mandrel; the juncture lines between adjacent units of a section being angularly offset relative to the juncture lines between adjacent units of an adjacent section; and, wooden stiffening members uniting said sections to each other, each said member having its wood grain running substantially at right angles to the wood grain of said unit.

3. In a fluid pressure molding apparatus for the fabrication of reinforced molded articles, the combination with a pressure vessel and a pressure transmitting membrane of a wooden mandrel in said vessel to the molding surface of which a

fluid molding pressure is adapted to be transmitted through said membrane, said mandrel having grooves for the reception of reinforcing elements for said articles and comprising a plurality of wooden contour sections arranged in side-by-side relation, each section having its wood grain running substantially normal to a surface thereof forming a molding surface portion of said mandrel, said mandrel having additionally a venting and drainage system for the eduction of fluid from said grooves and areas of the molding surface contiguous thereto, said system comprising gravity drainage ducts leading from said grooves to a suction duct at a relatively low level in said mandrel, said suction duct having a terminus in a non-molding surface of said mandrel, and conduit means coupled to said system at said non-molding surface for conducting fluid from said system through said membrane to the outside of said vessel.

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