Dec. 14, 1943. E. L. VIDAL ET AL 2,337,007

VENEER STRUCTURE

Original Filed June 30, 1938 7 Sheets-Sheet 1

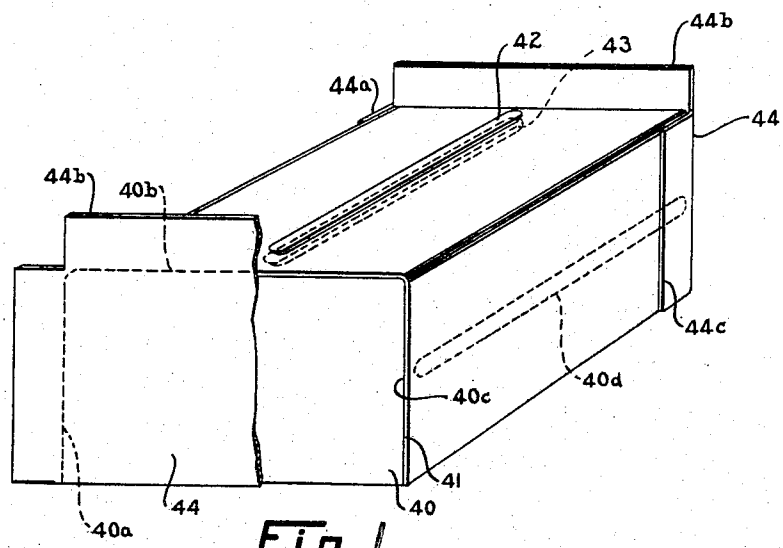

Fig. 1

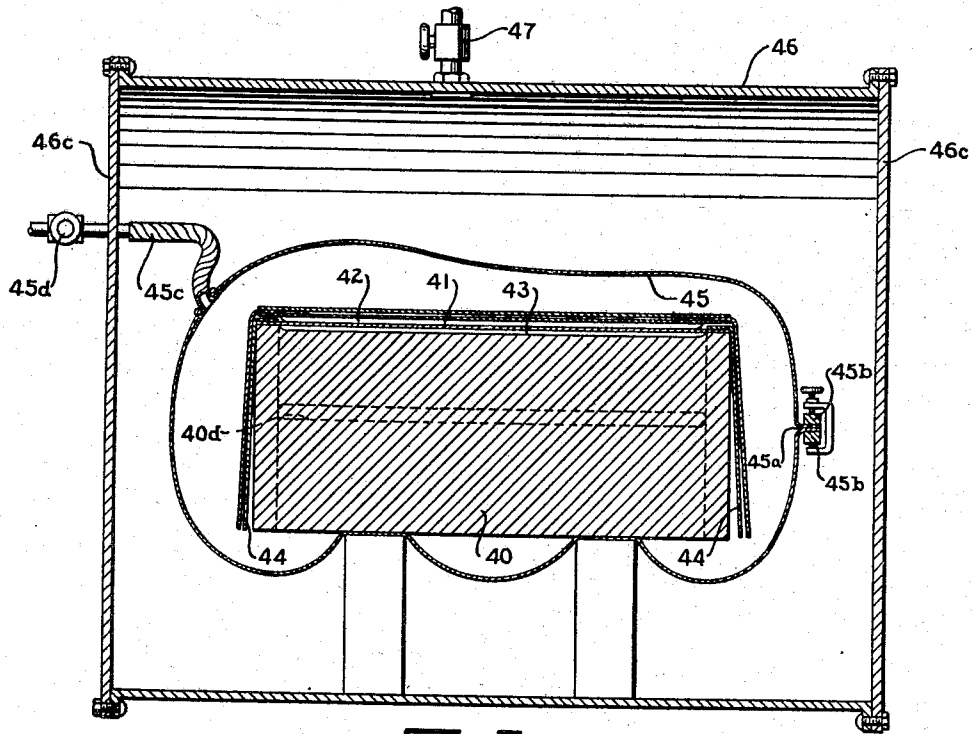

Fig. 2

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VENEER STRUCTURE

Original Filed June 30, 1938 7 Sheets-Sheet 2

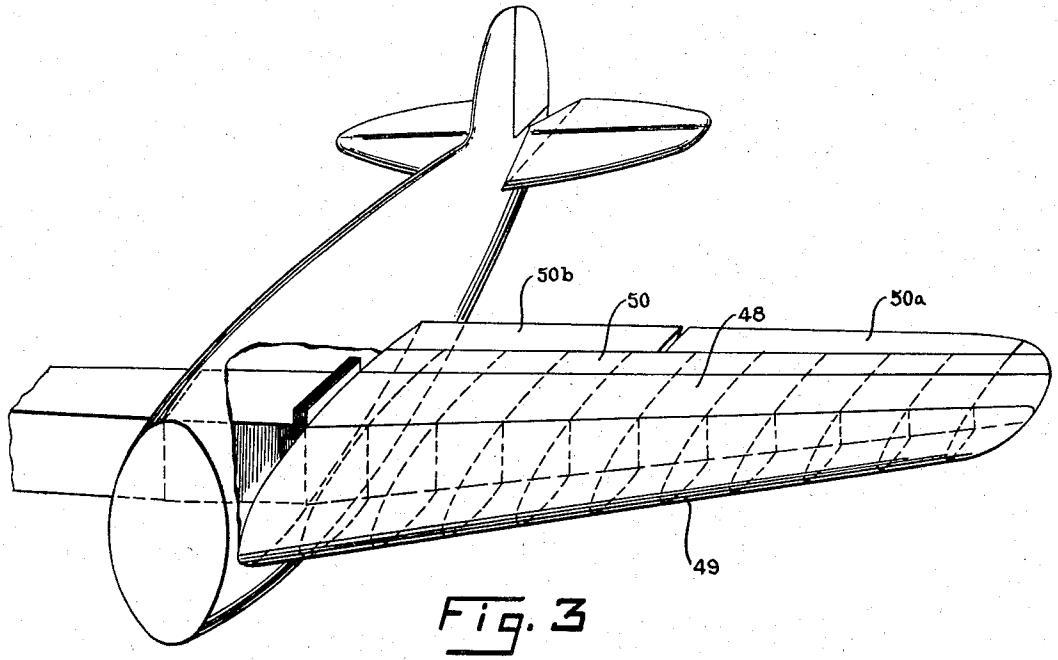

Fig. 3

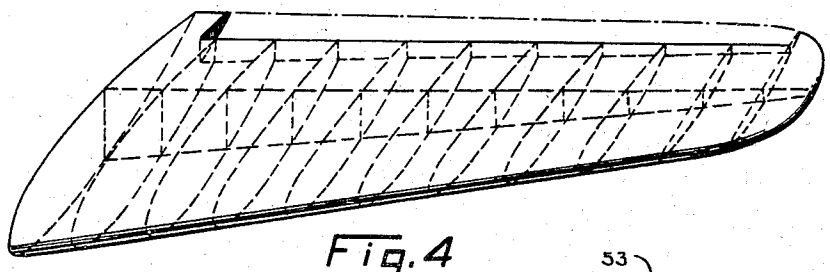

Fig. 4

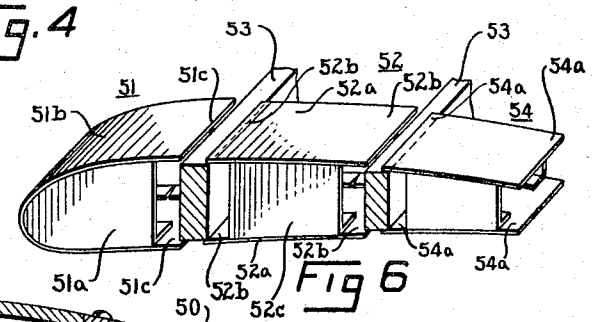

Fig 6

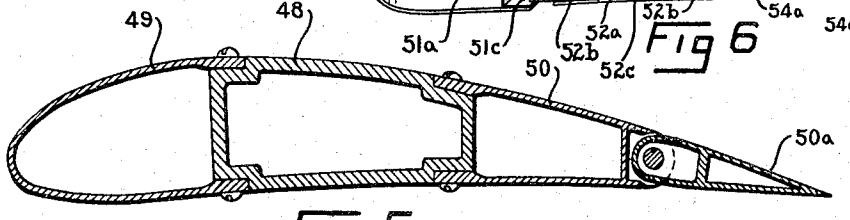

Fig. 5

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Dec. 14, 1943. E. L. VIDAL ET AL 2,337,007

VENEER STRUCTURE

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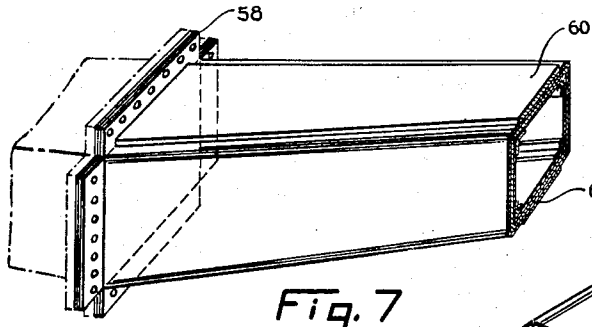


Fig. 7

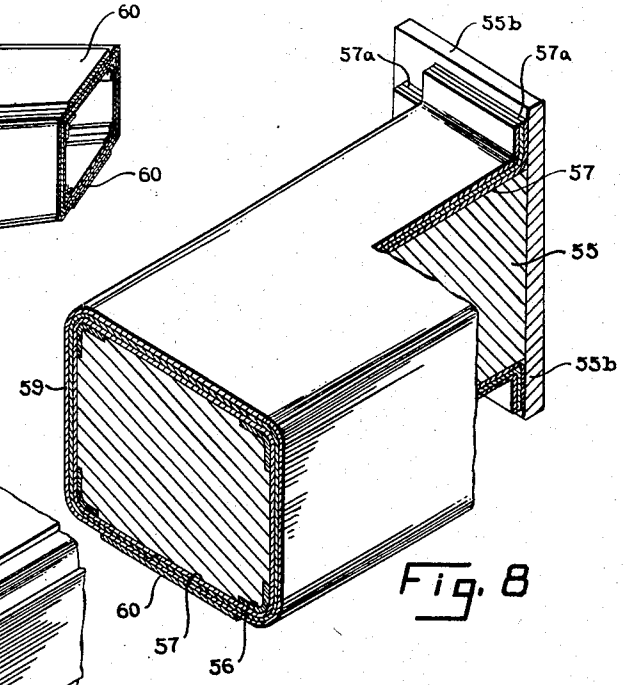
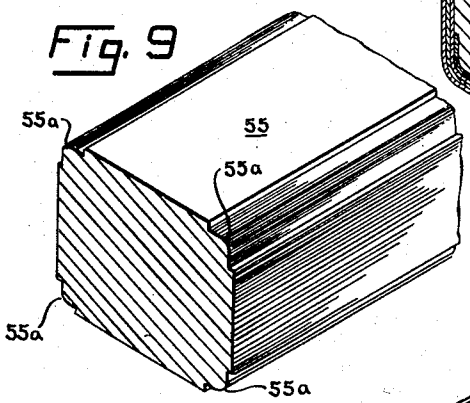


Fig. 8

Fig. 9



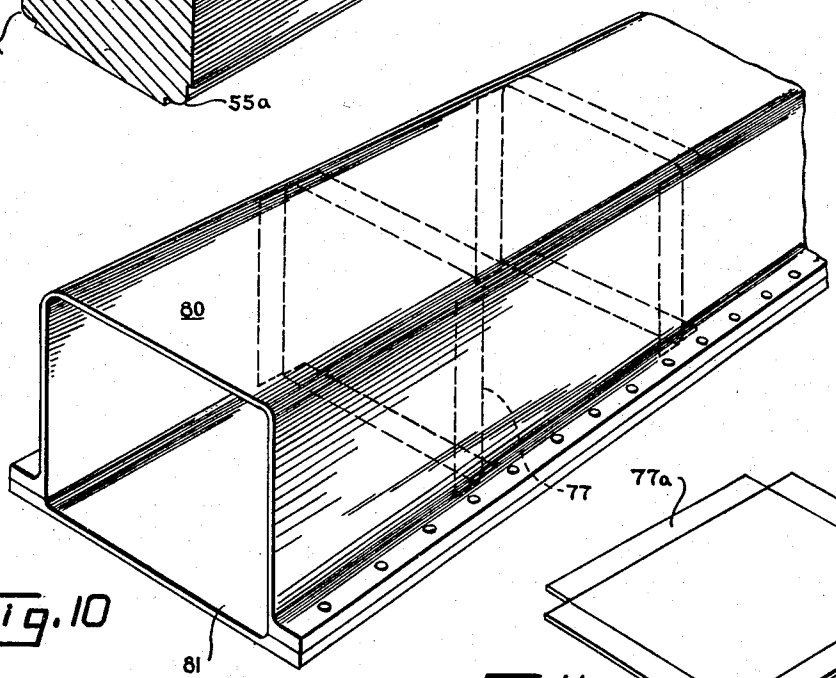


Fig. 10

Fig. 11

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VENEER STRUCTURE

Original Filed June 30, 1938 7 Sheets-Sheet 4

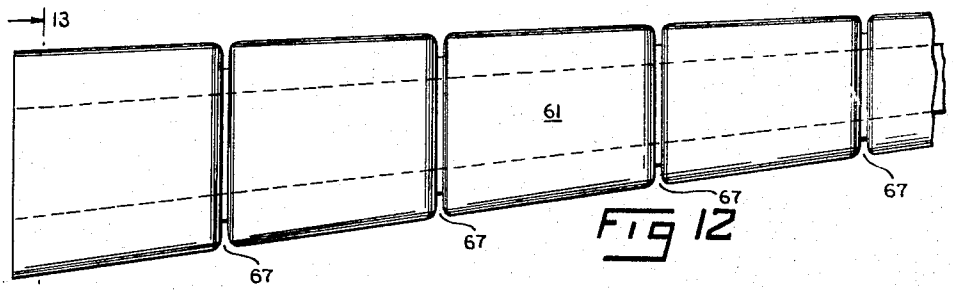


Fig 12

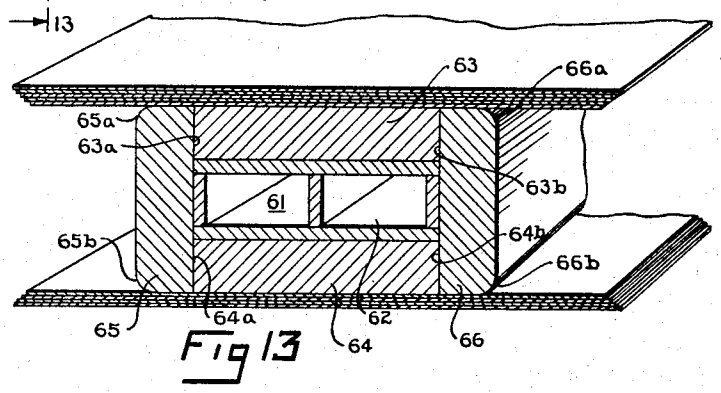


Fig 13

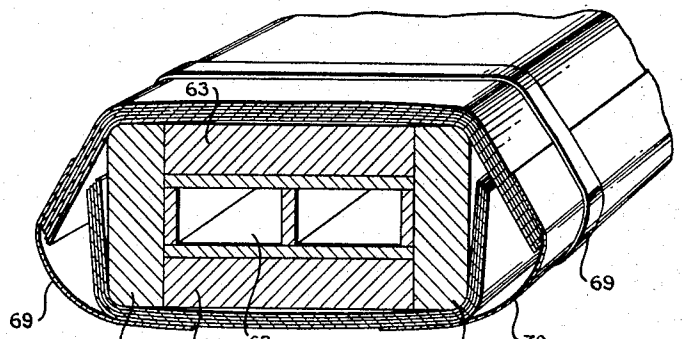
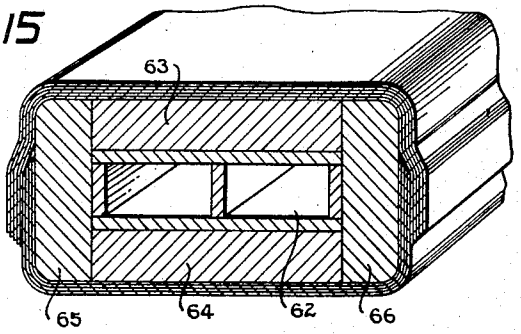


Fig 14

Fig 15



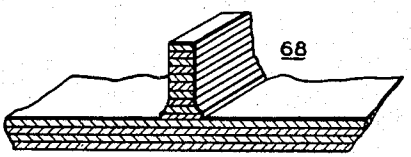


Fig 16

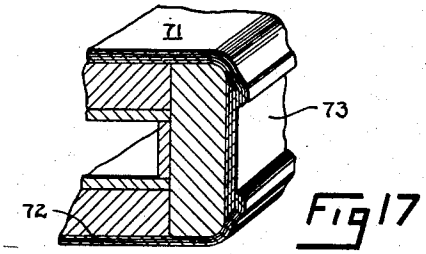


Fig 17

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Dec. 14, 1943. E. L. VIDAL ET AL 2,337,007

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Fig 18

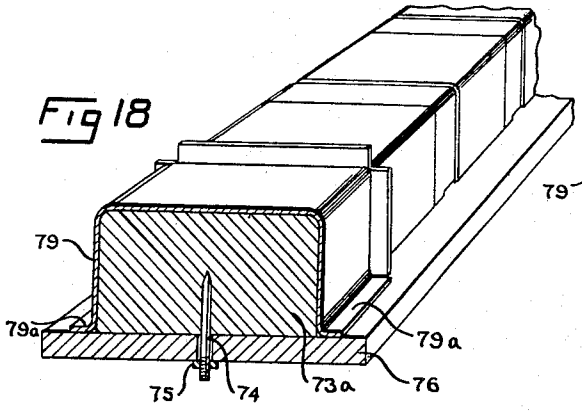
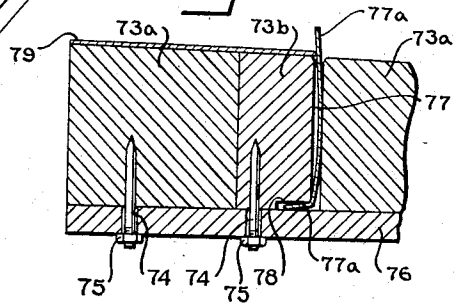


Fig 19



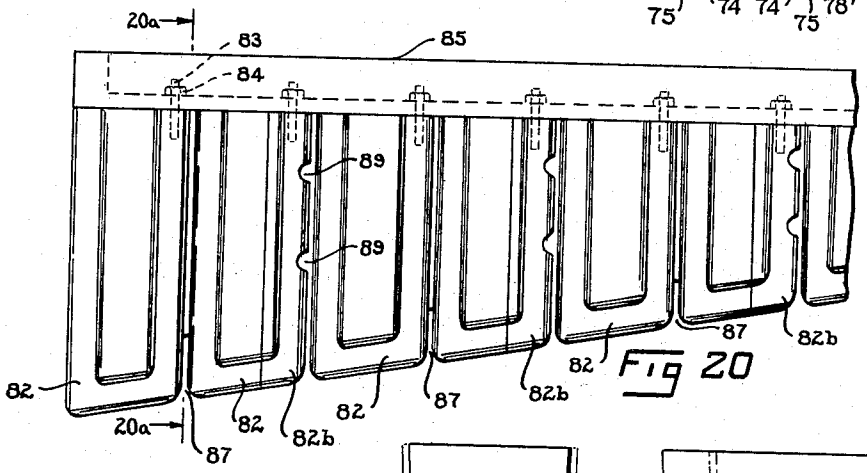


Fig 20

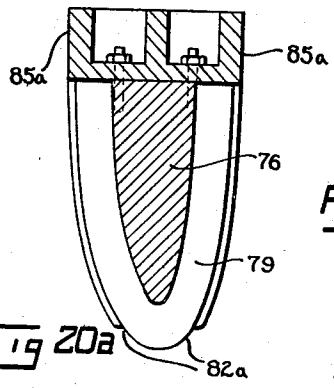


Fig 20a

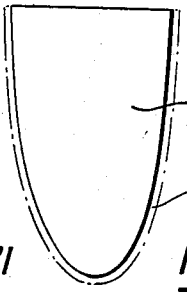


Fig 21

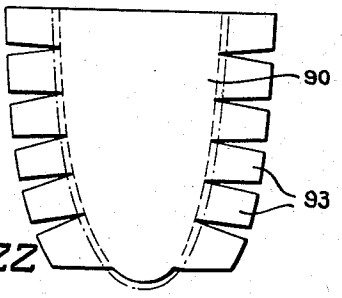


Fig 22

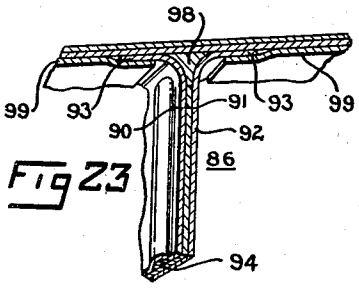


Fig 23

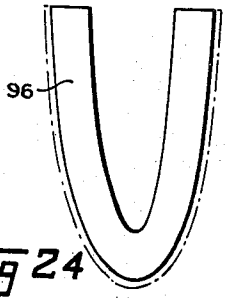


Fig 24

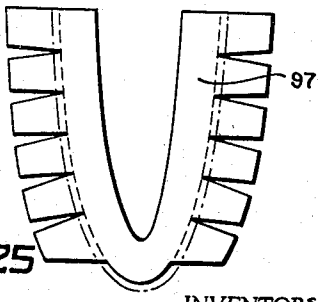


Fig 25

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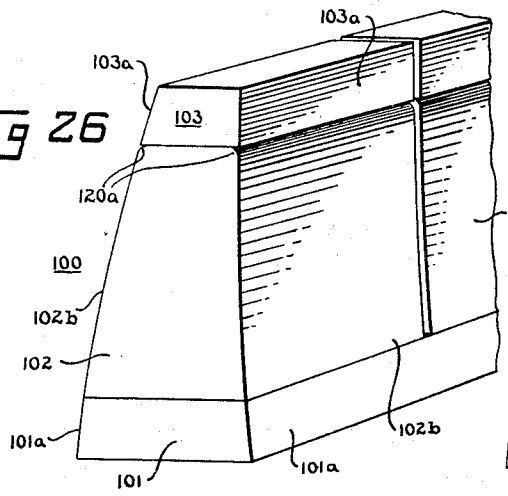
Fig 26



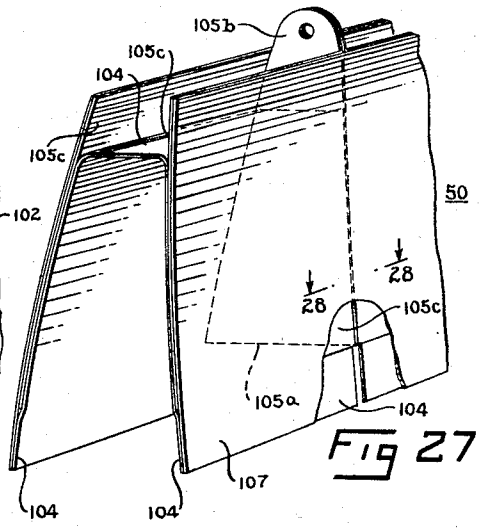


Fig 27

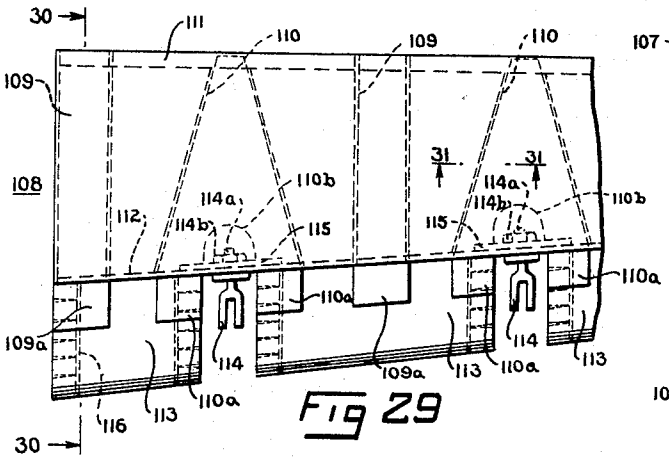


Fig 29

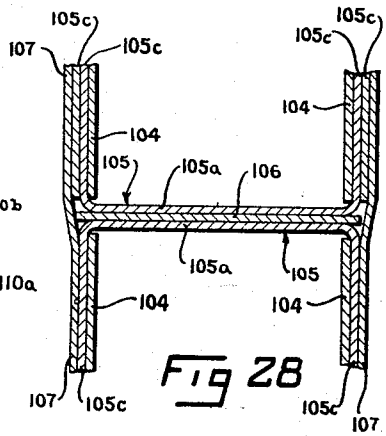


Fig 28

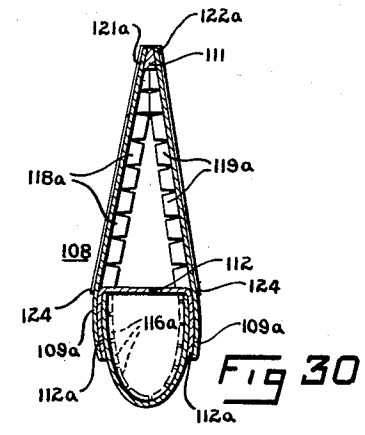


Fig 30

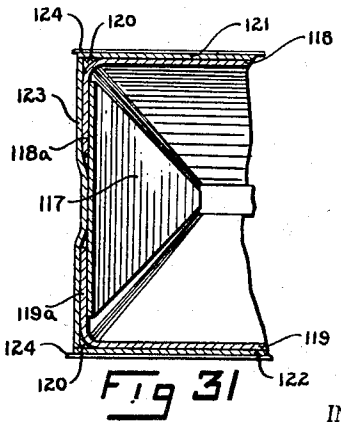


Fig 31

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VENEER STRUCTURE

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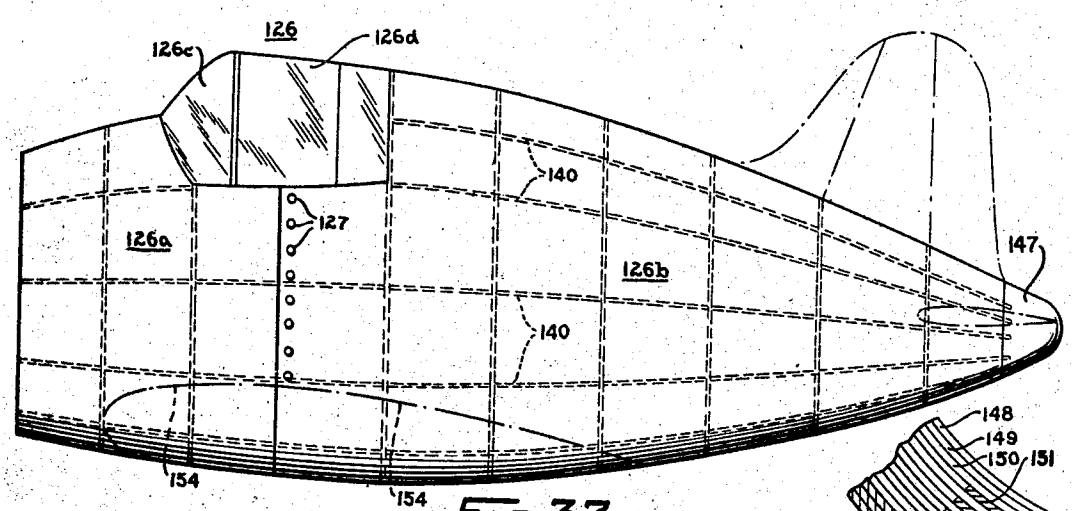

Fig 32

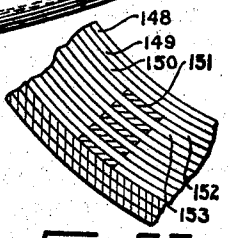

Fig 37

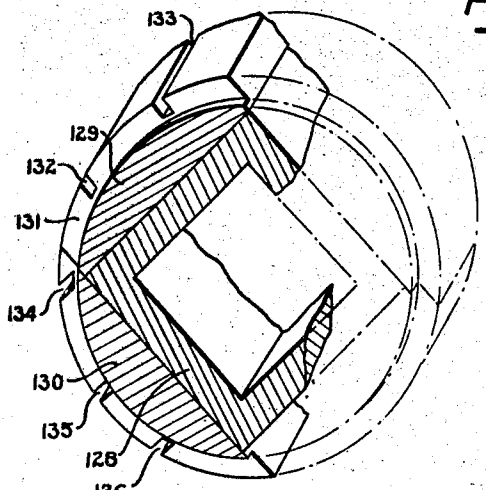

Fig 33

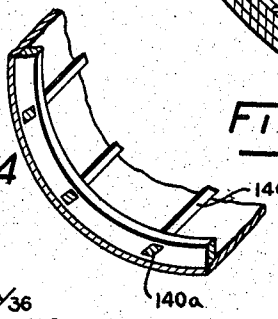

Fig 34

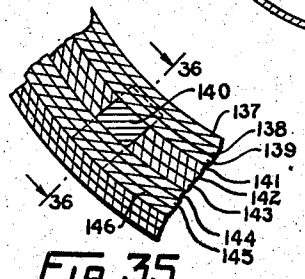

Fig 35

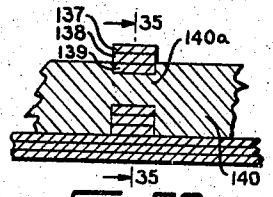

Fig 36

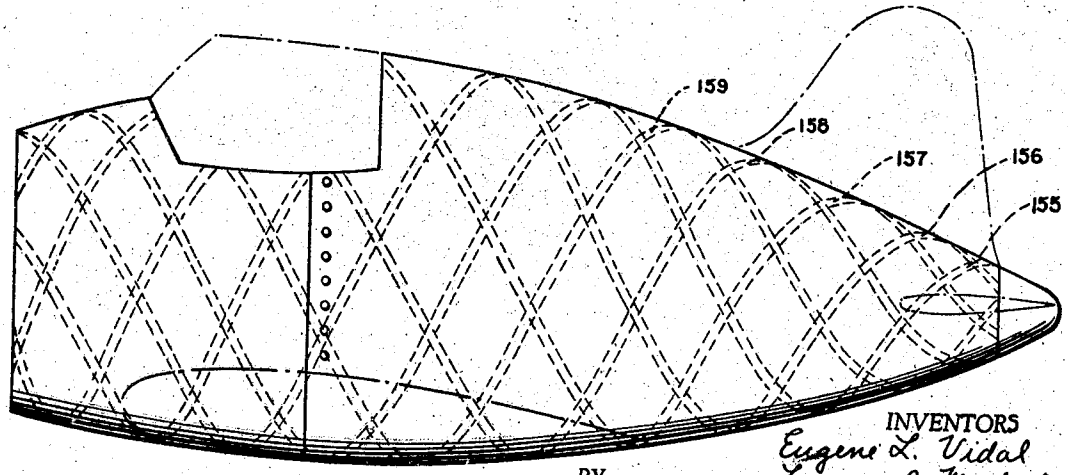

Fig 38

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Patented Dec. 14, 1943 2,337,007

UNITED STATES PATENT OFFICE

2,337,007

VENEER STRUCTURE

Eugene L. Vidal, New York, N. Y., and Laurence J. Marhoefer, Woodridge, N. J., assignors, by mesne assignments, to Vidal Corporation, a corporation of Delaware

Original application June 30, 1938, Serial No. 216,704. Divided and this application April 18, 1940, Serial No. 330,300

8 Claims. (Cl. 244—117)

This invention relates to structures made of veneer, and more particularly to molded structures formed from veneer impregnated with a thermoplastic.

This application is a division of our copending application, Serial No. 216,704, filed June 30, 1938, for Veneer structures and method for forming such structures.

One of the objects of the present invention is to provide novel structural units formed from wood veneer which are impervious to moisture and temperature changes, and which have a proper amount of elasticity, and a satisfactory strength-weight ratio.

Another object is to provide a structure of wood veneer laminations impregnated with polyvinyl butyral or other suitable polyvinyl acetal resins, said laminations having the contacting faces thereof united and securely bonded together over the entire areas thereof, the structure being of such a nature as to permit remolding whereby repairs may be quickly and inexpensively made.

A further object is to provide a novel aircraft which may be quickly and inexpensively made from readily available material, such as wood veneer strengthened by metal or wooden parts bonded to form a unitary structure.

Another object is to provide a novel aircraft having low skin friction and light weight.

A further object is to provide a novel method for constructing an airplane and/or structural units therefor.

A still further object is to provide a structure of the above character which is reinforced in a novel manner.

The above and other objects and novel features will more fully appear from the following detailed description when the same is read in connection with the accompanying drawings illustrating embodiments of the novel method and means constituting the subject matter of the invention. It is to be expressly understood, however, that the drawings are for purposes of illustration only and are not intended as a definition of the limits of the invention, reference for this purpose being had to the appended claims.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is a perspective view of a mold carrying a layer of wood veneer and illustrating one step of the novel process of the present invention;

Fig. 2 is a sectional view, somewhat diagrammatic, of a pressure chamber of the type which may be employed in carrying out the novel method of the invention;

Fig. 3 is a perspective diagrammatic view illustrating the principal units of an airplane structure made in accordance with the present invention;

Fig. 4 is a perspective view of one form of wing which may be employed in the present invention;

Fig. 5 is a cross-sectional view of the main wing as shown in Fig. 3;

Fig. 6 is a perspective view with parts disassembled of a second embodiment of a main wing;

Fig. 7 is a perspective view, in section and with parts broken away, illustrating one type of wing beam which may be employed in carrying out the present invention;

Fig. 8 is a perspective view in section and with parts broken away of the beam shown in Fig. 7 mounted upon a mold therefor;

Fig. 9 is a perspective view with parts broken away illustrating one form of mold which may be employed in forming the beam of Fig. 7;

Fig. 10 is a perspective view, partly in section and with parts broken away, illustrating a second form of beam which may be employed in carrying out the invention;

Fig. 11 is a perspective view of one form of reinforcing bulkhead which may be used in connection with the beam of Fig. 10;

Fig. 12 is an elevation of a second type of mold which may be employed in forming a wing beam;

Fig. 13 is a perspective cross-sectional view of the beam mold taken on line 13—13 of Fig. 12 with laminations superposed upon the upper and lower surfaces thereof;

Fig. 14 is a view of the parts shown in Fig. 13 with the superposed laminations held by suitable means, in the position for vulcanization;

Fig. 15 is a perspective cross-sectional view with parts broken away of a third form of a beam member;

Fig. 16 is a perspective sectional view of one form of reinforcing rib for a beam member;

Fig. 17 is a perspective sectional view with parts broken away of a fourth form of a beam member;

Fig. 18 is a perspective view, with parts broken away, of a third type of wing beam mandrel which is preferably employed in forming the beam shown in Fig. 10;

Fig. 19 is a longitudinal sectional view with parts broken away of the parts shown in Fig. 18;

Fig. 20 is a top plan view, with parts broken away, of a mold for a nose section of a wing;

Fig. 20a is a section taken on line 20a—20a of Fig. 20;

Fig. 21 is a side view of a wing rib lamina to be used with the mold of Fig. 20;

Fig. 22 is a side view of a second wing rib lamina for use with the lamina of Fig. 21;

Fig. 23 is a sectional view of a group of veneer layers interlocked with a rib formed with the laminae of Figs. 21 and 22;

Fig. 24 is a side elevation of a wing sub-rib lamina;

Fig. 25 is a side elevation of a wing sub-rib lamina for use with the lamina of Fig. 24;

Fig. 26 is a perspective view, with parts cut away, illustrating one form of mold which may be used to form the member shown in Fig. 27;

Fig. 27 is a perspective view, with parts cut away, of the trailing portion of a wing made in accordance with the present invention;

Fig. 28 is a sectional view, with parts cut away, taken along the line 28—28 of Fig. 27;

Fig. 29 is a top plan view of one form of control surface which is preferably employed;

Fig. 30 is a section taken on line 30—30 of Fig. 29;

Fig. 31 is a section taken on line 31—31 of Fig. 29;

Fig. 32 is a side elevation of a completed fuselage which may be employed in the present invention;

Fig. 33 is a perspective sectional view, with parts broken away, of a collapsible mandrel which may be employed in forming the fuselage of Fig. 32, the section being taken through a transverse groove in said mandrel;

Fig. 34 is a perspective sectional view, with parts broken away, illustrating a transverse fuselage frame member and associated longitudinal ribs;

Fig. 35 is a detailed sectional view, with parts broken away, taken through a transverse frame in a plane perpendicular to the longitudinal axis of the fuselage illustrating one method of interlocking a frame member with a longitudinal rib;

Fig. 36 is a detailed sectional view taken on line 36—36 of Fig. 35;

Fig. 37 is a detailed sectional view illustrating a second method of interlocking a transverse frame member with a longitudinal rib; and,

Fig. 38 is a side elevation of a second form of fuselage employed in the invention.

In carrying out the novel method disclosed herein, wood veneer sheets of suitable width and thickness are first treated with a thermoplastic medium, preferably polyvinyl butyral. For the most part, it has been found desirable to employ wood sheets approximately .022 inch thick, although, as will be understood by those skilled in the art, sheets of greater thickness up to one-eighth inch, may be employed. The polyvinyl butyral is applied to these sheets by means of a brush or spray or by passing the sheets through a liquid bath with or without pressure, and in certain instances it may be necessary to press thin sheets of polyvinyl butyral upon the wood veneer. A seasoning period of approximately twelve hours is desirable to permit the resin to dry on the sheet. At the present time it is found preferable, after said twelve hour period, to subject the sheet to a second treatment of the resin. The seasoning period may be accelerated by subjecting the treated sheets to hot, dry air currents.

If the structure to be formed embodies bends of very small radius, a suitable plasticizer, such as dibutyl phthalate, is employed to thin the resin, the smaller the radius, the greater the percentage of plasticizer used. For example, if sheets of 0.22 inch are employed for making a structure embodying a curve having a radius of one-half inch, it has been found desirable to add 10% by weight of dibutyl phthalate to the polyvinyl butyral.

The seasoned sheets are cut to the desired dimensions, depending upon the size of the structure to be formed, or the mold to be used, and are then laid one upon the other on said mold, adjacent layers being so positioned, that the grain of the wood in two adjacent sheets is angularly disposed, when it is desired to obtain maximum strength.

Preferably, a sheet of Cellophane or other suitable material, such as metal foil, is interposed between the mold and the inner treated sheet. After the desired number of sheets have been positioned on the mold to obtain a desired thickness of the finished product, the sheets are made to conform temporarily to the mold as by means of clamps, elastic bands, cleats or sheet metal wrappings. Close conformation of the sheets thus positioned is not essential. To further assist in holding the sheets in position, they may be spot welded to each other by means of a hot iron. Alcohol, which will dissolve the thermoplastic, may be applied by hand to various spots for temporarily securing the sheets together, a light pressure being applied to portions treated with the alcohol. The outer surface of the laminations covering the mold is now covered with a non-adhesive material, such as Cellophane, in order to prevent said surface from adhering to pressure transmitting means which will be in contact therewith.

A sharp-pointed tool is now employed for making perforations through the loosely assembled sheets whereby the formation of air blisters during the vulcanizing step is prevented.

While mechanical means, such as heated pressing elements, may be employed for rendering the thermoplastic tacky and for applying pressure to the sheets assembled on the mold to secure adhesion and to press the sheets into substantially a homogeneous mass, it is preferable, except for flat pieces, to place the mold and assembled veneer sheets within a fluid-tight container formed of flexible or resilient material, such as a rubber bag. The bag containing the mold and treated sheets secured thereon is placed in an air-tight drum which may be heated, as by means of steam heat, and which will withstand a substantial fluid pressure, it being understood that the mouth of the bag is tightly closed in a manner to be described hereafter. The fluid-tight bag is connected by means of a suitable conduit to the exterior of the heated container. The air pressure within the outer container is now raised to from fifty to seventy pounds per square inch, and the temperature therein is raised to from 200° F. to 210° F., for example. The air within the flexible bag is thus forced out through the conduit by the pressure within the heated container, and this pressure is effective to cause the walls of the bag and the tough and yieldable sheets to conform to the outline of the mold, whereby the thermoplastic which is now tacky is rendered effective to cause the sheets to adhere one to the other throughout the whole.

The temperature and pressure may be varied

within reasonable limits, depending upon the complexity of the structure and the number of layers of wood veneer. Another variable factor is the time during which the sheets are subjected to heat and pressure. If the veneer structure is composed of three thin layers of veneer, for example, it has been found satisfactory to subject the same to heat and pressure for a period of approximately ten minutes. On the other hand, if sufficient sheets of veneer are employed to make a finished product having a wall thickness of one-half inch, the heat and pressure should be maintained for a period of approximately thirty minutes. At the end of this period the heat is shut off and the flexible container, mold and structure are permitted to remain within the pressure chamber until the structure has been reduced to approximately room temperature.

Thereupon, the metal container is opened, the flexible bag is removed therefrom, opened, and the molded structure and mold are removed. It will now be found that the molded structure can be readily removed from the mold, and that the surfaces thereof will be smooth and glossy. Polyvinyl butyral is normally amber transparent and it will be found that the molded structure presents a very pleasing appearance with the natural appearance of the wood grain preserved. If desired, however, coloring matter may be introduced into the resin.

In forming a simple structure, such as a five-sided radio cabinet, a suitable mold **40** (Fig. 1), preferably formed of one or more wooden blocks, is employed. The mold is first covered with a layer of non-adhesive material, preferably Cellophane. If desired, however, the Cellophane may be spot welded by a hot iron to the inner surface of the first wood veneer sheet. A seasoned sheet of veneer **41**, after being cut to size, is bent over the three sides **40***a*, **40***b* and **40***c* of the mold and may be temporarily held in place by hand, or if desired, by a loose rubber band passing substantially around the center of the sheet and mold. If it is desired to reinforce, for example, the upper surface of the cabinet, a reinforcing member comprising a resin treated rounded wooden strip **42** may be placed during assembly upon layer **41** above a channel **43** cut in the mold. The channel is provided to prevent the formation of a bulge upon the outer surface of the cabinet over strip **42** when other wood layers are added. The strip and veneer will be forced into the channel during the application of pressure, thereby insuring a smooth outer surface after vulcanization is completed. A second treated sheet **44**, having ears **44***a*, **44***b* and **44***c*, is then placed against the end of the mold and the ears are bent over and spot welded by means of a hot iron or by the use of alcohol. A sheet similar to sheet **44** is placed over the opposite end of the box and the ears thereof are secured to sheet **41** as previously described. Another sheet similar to sheet **41** is now positioned on the mold and is spot welded to sheets **41** and **44**. This positioning of sheets is continued to secure the desired wall thickness and strength, any desired number of sheets being employed and each new sheet similar to sheet **41** being slipped under the rubber band, if the same is used.

In wrapping a number of veneer layers about the mold, a certain amount of slack or play will exist between each of the layers and between the layers and the mold which will produce numerous wrinkles in each individual layer. In order to overcome this condition, i. e., to flatten the wrinkles and take up the slack, it has been found desirable not only to strap the veneer layers as tightly as possible upon the mold, but also to cut grooves at certain locations in the mold whereby the play may be taken up by pressure during vulcanization, which will force the veneer in the grooves. A groove **40***d* having this function is shown in mold **40** (Fig. 1).

There is thus formed a loose covering of a plurality of sheets around five sides of the mold. A sharp-pointed tool, such as an awl, is now employed to punch small air holes at intervals throughout the entire area of the superposed sheets in order to prevent the formation of air blisters.

Instead of interposing a rounded wooden reinforcing member, as above described, it is possible to reinforce the cabinet by placing sheets of resin treated metal or fabric between the wood laminations, it being pointed out that the polyvinyl butyral is effective to adhere closely to and to produce an intimate bond between these materials and the wood when subjected to heat and pressure.

If it is necessary that a bolt extend through the laminations of the cabinet whereby the area adjacent the bolt will be subjected to excessive stresses, it is possible to distribute the stresses and to reinforce said area by placing a resin treated metal washer to receive the bolt between the wooden laminations during the assembly of the cabinet. The washer during assembly of the cabinet may be temporarily secured in position upon a desired lamination by spot welding as above described.

In order to provide hinges for a cover for the sixth side of the radio cabinet, suitable hinges (not shown) which have been treated with the polyvinyl butyral may be inserted before vulcanization between the laminations at an edge of the cabinet. The hinges instead of being inserted after the laminations are assembled may be positioned during assembly and temporarily secured in place by spot welding. The outer layer of veneer covering the mold is covered with Cellophane, which may be tacked in place by spot welding. The mold, layers of veneer, and Cellophane are then placed in a fluid-tight flexible container **45** (Fig. 2), for example, of rubber, having an opening **45***a* in one extremity thereof for the insertion of the material to be vulcanized. The lips of the opening may be tightly closed by clamping same between two rigid strips **45***b*, **45***b* which may be drawn together by a suitable clamp. The assembled material and bag **45** are placed within a metal drum **46** having removable end plates **46***c*. A suitable non-collapsible conduit **45***c* having a valve **45***d* therein permits communication between container **45** and the atmosphere external to the drum.

A vulcanizing process then follows wherein a fluid pressure is applied to the veneer, for example, air controlled by valve **47** is forced into the drum to a predetermined pressure, i. e., from 50 to 70 pounds per square inch. The air within the elastic container **45** is forced therefrom through conduit **45***c* and the container is pressed closely against the veneer and mold. Simultaneously with the application of pressure the drum is heated, for example, by steam in pipes (not shown) to a temperature sufficient to cause the polyvinyl butyral to become tacky, i. e., from 200° F. to 210° F. As soon as the resin has become sufficiently tacky, and the pressure great enough to press the veneer sheets firmly together

and to force them to conform perfectly to the mold, the temperature is reduced to normal. However, the pressure is not removed until the material is completely cooled because of the necessity for holding the veneer in close contact with the mold during the cooling process.

During the vulcanizing process, the thermoplastic fills the interstices between the wood fibers and imparts a greater elasticity and tensile strength thereto, and hence improves the impact-withstanding qualities of the structure. Since a thermoplastic medium is employed, the structures formed as above-described may be remolded, thus facilitating repair to damaged or defective parts.

In the construction of an aircraft as shown, for example, in Fig. 3, the method employed in treating the veneer layers is analogous to that in forming the above-described cabinet. After completion of a vulcanizing process, the component parts of the wings, for example, are so closely associated and interlocked that they may be considered to have blended into a substantially homogeneous piece. For example, it is possible to mold a plurality of wood veneer layers into an entire aircraft wing structure comprising one piece. This single piece is constituted by a wing-shaped shell, as shown in Fig. 4, having a longitudinal rib and a plurality of transverse ribs which may be interlocked with the inner surface of the shell after vulcanizing the latter upon a suitable mold. However, the inspection, testing and repairing of such a single piece is more difficult than if the structure were made in several sections; consequently, the wing is subdivided (Fig. 3) into a central wing beam member **48** which comprises a main support for a nose or leading section **49**, and a trailing section **50**. Suitable control surfaces or ailerons **50***a* are pivotally mounted upon the trailing section. A stationary flap member **50***b* similar in construction to ailerons **50***a* is rigidly secured (Fig. 3) to trailing section **50** along the trailing surface of the latter between the aileron and the fuselage. These sections may be mechanically fastened to one another (Fig. 5) or joined by vulcanization. The joints, however, as above mentioned, are for facilitating inspection and repair.

In the subdivided form of the wing shown in Fig. 5, the nose section, beam and trailing section each comprises a complete unit and each is equal in length to the length of the wing. However, in the second embodiment of the wing shown in Fig. 6, these members are subdivided into a series of separable cells or compartments each of which may be formed upon a separate mold. For example, the nose section of the embodiment is constituted by a plurality of cells or subdivisions **51** each of which preferably is equal in size to a corresponding portion of the nose section **49** which is included between two ribs. Each cell **51** comprises suitable vulcanized laminated side ribs **51***a*, **51***a*, which reinforce a skin **51***b*. The ribs are formed and provided with suitable ears upon the outer edge thereof and are attached to the skin **51***b* in a manner analogous to that to be described later in connection with nose section **49**. A portion of the skin **51***b* extends beyond the after edge of the ribs **51***a* and forms an overlapping sheet **51***c* at the upper and lower trailing edges thereof which are to be secured to a supporting member. The vertical after face of each of the cells **51** remains uncovered.

A supporting member for this embodiment of the wing comprises a series of box-shaped cells or subdivisions **52**, each of which may be formed upon a suitable mold in a manner analogous to that of the above-described radio cabinet, with the exception that the forward and after faces of each cell **52** remain uncovered, and the laminations **52***a* which constitute the upper and lower surfaces thereof are provided with portions **52***b*, which extend beyond the forward and after edges of suitable side ribs **52***c*. In combination with the cells **52** there are employed a pair of resin-treated beams **53**, **53**, preferably of a wood such as spruce, which extend the full length of the wing and serve as the main strength or supporting members therefor. Beams **53** are preferably equal in height to the vertical distance between the overlapping portions **52***b* and are adapted to be secured between said portions by vulcanization.

The trailing member for the wing is similarly subdivided into a series of cells **54**, each of which is formed upon a suitable trailing section mold in a manner analogous to subdivisions **52**. The cells **54** are therefore similarly provided with both forward and rear overlapping sheets **54***a* at both upper and lower surfaces thereof. The forward overlapping sheets provide means for securing the trailing subdivisions to the supporting member, whereas the after sheets **54***a* are provided for overlapping an aileron and for preventing eddy currents therebetween.

In assembling the above parts to form a completed wing, adjacent faces of the side ribs of the nose, beam, and trailing sections are vulcanized together, for example, by plate presses, to form rigid bonding engagements therebetween. Following this, the beams **53** are interposed each between two of the overlapping sheets **52***b* and there secured by plate pressing. The overlapping sheets **51***c* of the nose cells and forward sheets of the trailing cells **54***a*, are next plate pressed to the assembled supporting member and the wing is formed. In Figs. 5 and 6, the cross-sectional area of the superposed laminations is shown as if it were a single piece without representing the individual laminations.

In forming the supporting beam **48**, there is first constructed a suitable mold **55** (Fig. 9) comprising, for example, an oblong wooden mandrel, having a cross-section with a proper "curvature," "washout" and "taper" which conforms to the airfoil section of a desired wing. The mandrel **55** of Fig. 9 is shown as a single piece of wood, tapering longitudinally from the inboard extremity or butt to the outboard extremity or tip. The four longitudinal edges of the mandrel are rounded and carved or kerfed to provide longitudinal convex channels **55***a* for a veneer strip constituting a reinforcing inner corner piece to be positioned in a manner to appear later. A butt flange **55***b* (Fig. 8) is secured to the inboard extremity of the mandrel for a purpose to appear later.

In forming a wing beam over this mold, for reasons above explained, a non-adhesive material, such as Cellophane, is placed thereover and caused to cling closely thereto, for example, by means of wax placed on the mold. Sheet-reinforcing corner strips **56** (Fig. 8) having been treated with polyvinyl butyral are next placed in the longitudinal channels **55***a* and there retained by rubber bands or suitable straps (not shown). A primary layer of wood veneer **57** (Fig. 8) is then slipped beneath the rubber bands and wrapped about the mandrel with its grain, for example, extending parallel to the longitudinal

axis of the mandrel. Ear portions 57*a* are cut in sheet 57 so as to abut the mandrel flange 55*b*, and additional layers are similarly placed over the primary layer until the beam shell has a desired thickness, each added layer having its grain substantially perpendicular to or at an angle relative to the grain of the preceding layer, and also being provided with ears similar to those of layer 57 which collectively comprise a beam flange 58 (Fig. 7) for securing the beam to a fuselage or to another beam. The collective thickness of the veneer layers may progressively diminish toward the beam tip, i. e., each layer may terminate at a predetermined distance from the tip. Reinforcing strips (not shown), for example, of rounded wood construction analogous to the strip 42 shown in connection with Fig. 1, may be placed upon any desired layer and temporarily held in place by means of glue or by spot welding, while the next or succeeding layer is placed thereover. Upon the central upper and lower surfaces of a final layer 59, longitudinally extending strips 60 (Fig. 7) are positioned in order to form a suitable step upon each of said upper and lower surfaces to form a flush surface with an overlapping portion of a nose piece and a trailing section to be described hereinafter.

The mandrel, with the outer veneer layers having been covered with Cellophane, is then placed within a flexible fluid-tight bag similar to bag 45 employed in connection with the cabinet shown in Fig. 2. The bag and its contents are then placed within drum 46 and subjected to a vulcanizing process as above described.

The beam mandrel, instead of comprising a single member, may be constituted by a plurality of fitted pieces which are so associated that one piece functions as a key wedge portion, enabling the easy extraction of the remaining pieces from a wing beam after the removal of said key. A beam mandrel 61 of this character is shown in Figs. 12, 13 and 14 wherein, for example, a member 62 comprises the key wedge portion and is surrounded by four longitudinal side members 63 and 64 upon the top and bottom surfaces, and members 65 and 66 upon the forward and after surfaces, respectively. The latter two members extend above and below the upper and lower surfaces of wedge 62 and cover sides 63*a*, 63*b* and 64*a*, 64*b* of members 63 and 64, respectively. The outer edges of members 65 and 66 are rounded as at 65*a*, 65*b* and 66*a*, 66*b*, respectively. The key wedge 62 is rectangular in transverse cross-section and is preferably of hollow reinforced construction. When the side members 63, 64, 65 and 66 are assembled upon the key wedge 62, channels 67 encircling the entire mandrel are cut therein at predetermined intervals along the mandrel axis, the plane of said channels being perpendicular to the mold's longitudinal axis. The outer edges of these channels are filleted in order that ribs which are to be placed therein may be of a desired cross-section.

One of the most difficult problems met in forming a structure of superposed laminations about a mandrel such as the one shown in Fig. 12 concerns the cutting of the laminations to suitable dimensions and the positioning of the laminations in such a manner upon the mandrel that any wrinkles which may be in said laminations will be smoothed and flattened by the action of the fluid pressure in the vulcanizing process.

In forming a beam about the mandrel of Fig. 12, a novel method for meeting the above-mentioned problem is employed. Before positioning veneer sheets upon the main surfaces of the mold according to the novel method, suitable ribs 68 must be formed in channels 67. In the form shown (Fig. 16), the ribs comprise a plurality of superposed strips of resin treated veneer, each having a width preferably slightly less than that of the channel. The strips are wound about the mold in the channels until flush with the outer surface of said mold. Each strip may be spot welded to the strip therebeneath in order to hold it in position. The outer strips which are placed in the filleted portion of the channel are sufficiently wide to fit snugly therein.

Following the positioning of the veneer strips in channel 67, several superposed sheets of wood veneer, for example, four, having a length equal to that of the mandrel, are positioned upon the lower face of the latter. These sheets are of such a width that they extend beyond the longitudinal edges of the mandrel preferably a distance equal to from 75% to 90% of the width of the mandrel side members 65 or 66. The sheets are then temporarily attached to the mandrel, for example, by readily extractable nails which are driven along the longitudinal centerline of the group of laminations.

A second group of laminations is next placed upon the upper surface of the mold. This group comprises a greater number of laminations than the first-described group, and in the form shown, is constituted by five laminations, which extend beyond the edges of the mandrel (Fig. 13) a distance preferably equal to approximately 50% to 65% of the width of side members 65 or 66. These laminations are temporarily secured to the mandrel as above described. The air holes may be formed in one or more of the sheets before assembly on the mold, if desired, or the same may be formed after all sheets are assembled on the mold.

The outwardly extending portions of the lower group of laminations are then bent towards the side members 65 and 66, and the overlapping portions of the upper group are bent thereover and temporarily held in overlapping relationship by adjustable bands 69, as shown in Fig. 14. In order to prevent parts of the flexible bag used in vulcanizing from becoming interposed between the upper and lower groups of laminations, a sheet 70 of suitable material, such as tin, is positioned to cover the gap between said groups and is held in position by the bands 69.

The assembled material is covered with Cellophane and placed within the flexible bag 45. The air is now preferably exhausted from the bag, causing the laminations to be pressed closely against the mandrel. The step enables an inspection of the overlapping laminations before the vulcanizing process by noting the contour of the bag, and any desired rearrangement can be made before the parts are placed in the vulcanizer.

Following this, the evacuated bag and its contents are introduced into the pressure chamber and subjected to heat and pressure, as above described. The fluid pressure acting upon the laminations is effective to flatten any wrinkles therein and to force them away from the longitudinal centerline of the sheets outwardly towards the portions overlapping the mandrel sides. After the pressure within the drum 46 has exceeded 15 or 16 pounds per square inch, the interior of bag 45 may be placed in communication with the outer atmosphere, i. e., valve 45*d* may be opened,

thus destroying the vacuum. Since the fluid pressure in the drum exceeds normal atmospheric pressure, there will be no danger of disarrangement of the superposed laminations. A portion of the molded beam after vulcanizing is shown in Fig. 15.

Another embodiment of a beam formed in an approximately similar manner is shown in Fig. 17. In the previous embodiment, the portions of the laminations which overlap the sides of the mold comprise the sides of the beam. However, in this embodiment the overlapping portions are not of sufficient width to form the sides, the latter being formed by separate groups of superposed laminations. In forming this beam, groups 71 and 72 of treated laminations are positioned on the top and bottom, respectively, of the mandrel, and temporarily secured thereto by means of nails as above described, the former group being constituted by a larger number of laminations than the latter. A third and fourth group of laminations, one of which is shown at 73, are next placed over the mandrel sides and temporarily secured thereto in any suitable manner. The overlapping portions of groups 71, 72 are then temporarily bent over groups 73, and metal sheet 70 (Fig. 14), secured by straps, is placed thereover and the above process is repeated in forming the beam, a sectional portion of which is shown in said Fig. 17.

A third embodiment of the beam mandrel is illustrated in Fig. 18 and comprises a series of segments 73*a* and 73*b* which are removably secured, for example, by means of suitable bolts and nuts 74, 75, respectively, to a base 76. Each pair of segments 73*a*, 73*b* is in contact with each other, but is spaced apart a small distance from the next pair of segments (Fig. 19). Reinforcing bulkheads 77 having ears 77*a* thereon (Fig. 11) are positioned in the space between said pairs of segments. The ear portion 77*a* upon the lowermost edge of each bulkhead is folded perpendicular to the plane of the bulkhead in order to fit into channel 78 which is cut in the lower surface of segment 73*b*. A primary veneer layer 79 of suitable dimensions is next placed over each segment and caused approximately to conform thereto by means of clamps (not shown) whereby longitudinally extending flanges 79*a* are formed abutting the base 76. The outwardly extending ear portions 77*a* of bulkhead 77 are next overlapped upon layer 79 and spot welded thereto by means of alcohol. This temporary adhesion will hold the primary veneer layers in place and will thus permit the removal of said clamps. Successive veneer layers may now be superposed thereupon, each layer, for example, being temporarily held in place over the adjacent layer by spot welding with alcohol along a portion thereof above flange 79*a* or by temporarily spot welding by means of a hot iron. Each successive layer may cover the entire length of the mandrel.

The assembled layers and the mold are now inserted in bag 45 and vulcanized as above described. Upon withdrawal of the mold and vulcanized structure from the bag, nuts 75 are disengaged from bolts 74 and the base 76 is lifted therefrom. Following this, segment 73*a* is lifted from its position, thus making possible the shifting of segment 73*b* along the axis of the beam out of engagement with the overlapping ear piece 77*a* which occupies channel 78 of said subdivision. If the segments were not subdivided, it is seen that the extraction thereof from the vulcanized beam would be impossible, due to said ear piece 77*a* engaging channel 78. A portion of a completed beam 80 thus formed is shown in Fig. 10. The beam is in the shape of a channel and is preferably mechanically fastened to a cover strip 81 comprising superposed wood laminations vulcanized in a manner above described. The ear portion 77*a* adjacent the cover-strip may be glued thereto.

After molding a wing beam upon one of the mandrels in the manner above described, the nose section 49 (Fig. 3) may be formed. The mandrels used for molding the nose section in the form shown in Fig. 20 comprise a series of wooden mandrel segments 82 conforming in cross-section to the nose portion of an airfoil section of a desired wing. The series of segments are mounted, for example, by suitable bolts 83 and nuts 84 to a base 85. The nose mandrel is thus made up of numerous sections in order that ribs 86 (Fig. 23) to be later described may be positioned in the rib channels or spaces between the segments. The base mandrel 85 serves not only as a mounting for the segments 82 but provides surfaces 85*a*, 85*a* (Fig. 20*a*) over which the veneer layers which cover the nose section may overlap and be vulcanized to one another to provide a necessary overlapping sheet for securing the nose section 49 to the wing beam 48. The leading edge of the nose mandrel is kerfed, i. e., an outer layer of the wood thereon is removed to provide a kerfed area 82*a* for an inner reinforcing nose strip to appear later. A shallow channel 87 having rounded outer edges may be cut in each segment 82 beginning at 85, and continuing around the nose to the opposite side of the base, in order to hold a small reinforcing frame or sub-rib analogous to the beam frame shown in Fig. 16.

An end portion 82*b* of each segment is removable therefrom to aid in positioning rib sections, to be later described, said removable portions having suitable kerfed areas or channels 89 upon the side faces thereof adjacent to the spaces between the segments. These channels are provided to accommodate reinforcing strips which may be placed between the veneer layers of said ribs.

Each nose section rib in the embodiment illustrated in Fig. 23 comprises three layers 90, 91 and 92 vulcanized together as above described. The central layer 91 (Fig. 21) is in the shape of an airfoil and conforms to the cross-sectional area of the nose mandrel with the exception that an outer strip 91*a* has been trimmed off to permit the insertion of a wooden fillet to appear later. The outer layers 90, 92 (Fig. 22) are provided with outwardly extending ears 93 (Fig. 22) which may be bent over to become interlocked between veneer layers forming the nose section proper. In order that the above-mentioned reinforcing nose strip may be positioned upon area 82*a*, no earpieces are provided at that portion of either rib 90 or 92 which will be adjacent area 82*a* when placed upon the mold. The ears 93 extend beyond the airfoil contour of the rib, and beyond the outer surface of mold 82.

As shown in Fig. 23, the nose rib has been constructed with a reinforcing strip 94 between layers 90, 91. The strip is preferably of resin treated wood of semi-circular cross-section. The bulging portion of layer 90 which conforms to the shape of said strip is accommodated by one of the above-mentioned grooves or channels 89

which are cut in the face of each removable end portion 82b.

Suitable sub-ribs are provided which are substantially in the shape of a horseshoe, said sub-ribs being positioned in grooves 87, and are formed from laminations 96 and 97 (Figs. 24 and 25) in a manner similar to that employed in forming ribs 86.

The main ribs 86 and the sub-ribs are placed in their respective channels upon the mandrel after covering the mandrel with Cellophane. Following this, a U-shaped cove molding strip 98 of substantially triangular cross-section is fitted between the ear portions 93 of the two layers 90, 92 (Fig. 23) to provide a fillet therebetween. The above-mentioned reinforcing nose strip (not shown) which extends longitudinally over the full length of the nose mandrel, is next placed in the longitudinal kerfed area 82a along the leading edge of the mandrel. Veneer layers 99 (Fig. 23) are then placed between each rib and sub-rib and cover the mandrel and overlap each side 85a of base 85. The outwardly extending ears upon each rib are bent over against these adjacent veneer layers 99 and tacked thereto by means of alcohol as above set forth. Additional veneer layers are applied to the mold, each of which is separately positioned thereupon and held in place by one of the methods above described, i. e., by spot welding or by slipping same beneath rubber bands placed around the mold.

For a purpose above explained, the outer veneer layer of the nose section is next covered with a non-adhesive substance. Perforations are made in the material to prevent air locks. In order to prevent wrinkling of the veneer sheets while undergoing vulcanization, the nose section preferably is covered with a metal sheet, for example, sheet tin, which is strapped tightly thereto. This sheet, when subjected to fluid pressure, causes wrinkles in the veneer to be forced towards, and flattened upon, the base 85. The entire section is then placed in a rubber bag and vulcanized as above set forth.

The trailing section 50 is formed upon a mandrel 100 (Fig. 26) the cross-section of which conforms to an after portion of the airfoil section of the desired wing. Both the forward and after surfaces of the section are flat. Mandrel 100 is constituted by a base portion 101 and a plurality of segments 102 which are removably secured thereto at predetermined intervals, each segment being provided with a removably secured cap member 103 having rigid side faces 103a, 103a. The upper edges 102a, 102a of the segments are rounded to protect the laminations placed thereover from fracture.

The base 101 of the mold serves a purpose analogous to that of the base portion 85 of the nose mold, i. e., to provide two rigid faces 101a, 101a over each of which a series of superposed laminations may be vulcanized into suitable overlapping sheets for attachment to the beam member, as shown in Fig. 5. The rigid faces 103a, 103a of the cap members 103 are also employed for forming laminated sheets thereover which are to overlap the forward longitudinal portion of an aileron or control surface, and thus to prevent eddy currents which might otherwise occur in the space between the trailing section and the aileron.

In forming the trailing section upon the mandrel, the cap members 103 are removed from their corresponding segments. The cap members and the segments 102 and base 101 are then covered with a non-adhesive sheet material. An initial veneer lamination 104 is placed over each segment, said lamination being of such dimensions that it will cover the top face of each segment, i. e., the face adjacent cap 103, and in addition side faces 101a, 101a, 102b, 102b, the latter two comprising the side faces of the segments 102. Lamination 104 is held temporarily in position upon the mold by suitable clamps (not shown.) Caps 103 are next secured to the segments 102, for example, by wood screws. A second lamination 105 is next placed upon the mold comprising a sheet having a central portion 105a (Figs. 27 and 28) which conforms in shape to the combined cross-section of the segment 102 and cap 103. An integral upwardly-extending ear 105b, having a central perforation therethrough, is provided surmounting the central portion 105a, the ear serving to reinforce a rib member to appear later. Integral with this central portion are flaps 105c, 105c, each of which is adapted for covering the combined pair of faces 102b, 103a on one side of the mold. Lamination 105 is initially positioned upon the mold so that the central portion 105a is in the gap between segments 102. Flaps 105c are next bent to overlap those portions of lamination 104 which cover faces 102b, the above-mentioned clamps are removed, and said flaps are spot welded to the adjacent lamination, thereby holding the latter in position adjacent the mold. This process is repeated for each segment, there being two laminations 105 (Fig. 28) positioned in each gap between the segments, each lamination having the flaps 105c thereof folded over the faces 102b, 103a of the adjacent segments and caps, respectively. This will therefore place two of the flaps 105c upon each of said faces, as shown in the upper compartment of the trailing section illustrated in Fig. 28. For the sake of clarity, only one flap 105c is illustrated upon each of said faces in the lower compartment of the trailing section. A rib 106 is next interposed in the gap between central portions 105a (Fig. 28). The rib corresponds in shape to said central portion combined with ear 105b and is provided with a central perforation which registers with the perforation in ear 105b. A shaft may be inserted in said perforations to pivotally secure an aileron to appear later.

An outer lamination 107 equal in length to the length of the mold and of sufficient area to cover the combined faces 101a, 102b and 103a upon one side of the mold is next positioned upon said faces and spot welded in position or held in place by suitable clamps (not shown). The assembled material is covered with a sheet of non-adhesive material and vulcanized as above described.

A control surface for the above described wing may be constituted by an aileron having an outer surface of wood veneer laminations. However, in order to damp possible vibrations in this member, it may be desirable to construct an aileron framework having suitable ribs and to secure a fabric thereover. Such a fabric covered aileron 108 is illustrated in the embodiment of Figs. 29 and 30. The aileron is constituted by a plurality of hollow ribs of vulcanized laminated construction of two distinct shapes, i. e., ribs 109 and 110, the former of which is in the shape of a wedge having a triangular longitudinal cross-section, and the latter in the shape of a frustrum of a pyramid having a rectangular base. These ribs are alternately disposed along the longitudi-

nal axis of the aileron with the tapering portions extending aft, and are all secured in a manner to later appear to a common fillet member 111 which comprises the trailing edge of the aileron. The bases of the ribs which constitute the leading faces thereof are each secured to a longitudinally extending strip 112 also of laminated vulcanized construction by means of ears 112a (Fig. 30), which engage superposed ears 109a, 110a of ribs 109 and 110, respectively. A plurality of aileron nose pieces 113, each having a U-shaped cross-section, is positioned over said strip 112 and secured to ribs 109, 110 by the overlapping ears 109a, 110a and 112a. Nose pieces 113 are distributed along said strip 112 in such a manner that a gap occurs between the pieces over the central portion of the rectangular bases of ribs 110. This permits the positioning in said gaps upon strip 112 of a bifurcated member 114 for engaging the ribs of the trailing section and thus for pivotally securing the aileron to the wing. Member 114 is provided with an after extending bolt 114a which passes through a perforation in strip 112 and through a reinforcing lamination 115 which may be vulcanized to said strip. A suitable nut 114b secures said bolt in position. Suitable nose rib members 116, having ears 116a, are positioned in said nose pieces in a manner to later appear.

In forming, for example, the aileron rib 110 (Fig. 31), a suitable mold (not shown) is covered with a non-adhesive material. Vertical side laminations 117 are positioned on the mold and are held in position, for example, by elastic bands. Laminations 118, 119, covering the top and bottom mold surfaces, respectively, and overlapping a part of the side laminations 117 by means of ears 118a, 119a, respectively (Figs. 30, 31), are next slipped beneath said bands, if used. Resin treated fillet members 120 of substantially triangular cross-section are positioned at each of the four edges of the rib which extend from the base thereof to the tip. Flat laminations 121 and 122 (Figs. 30, 31) covering the laminations upon the top and bottom surfaces, respectively, of the mold, are next positioned thereon and either spot welded thereto or slipped beneath said elastic bands. Laminations 123 are next placed over those laminations covering the vertical sides of the mold. The above-mentioned overlapping ears 110a (Fig. 29) are constituted by portions of the superposed laminations 118 and 119. At the trailing edges of laminations 121 and 122 there are provided suitable overlapping pieces 121a, 122a for attachment to fillet member 111. Suitable rigid faces of the rib mold (not shown) are provided for sustaining these overlapping laminations during the vulcanizing process, and for preventing the fluid pressure from molding same in an incorrect position. The assembled laminations are vulcanized to form the completed rib 110. A hole 110b is cut in laminations 118, 121 above bolt 114a to give access to the nut 114b.

The ribs 109 are formed in an analogous manner upon a wedge-shaped mold. Following the extraction of the rib molds from the ribs, the common fillet member 111 is interposed between the after overlapping portions of the ribs and there vulcanized, for example, by hand irons.

The members 113 having the U-shaped cross-section are initially formed as a single continuous piece upon a suitable mold having a D-shaped cross-section. After vulcanizing a desired number of superposed laminations thereon, the mold is withdrawn and slices are cut from the completed member to form the gaps in which members 114 are placed. The mold is replaced within the members 113, each subdivision assuming its former position upon the mold. Sheet 112, having ear portions 112a integral therewith which are so located as to fit directly beneath ears 109a and 110a, is next placed upon the flat longitudinal face of the above mold. Ears 112a are bent thereover and spot welded in position. The assembled material is then inserted between the overlapping ears 109a and 110a, and vulcanized in position by hot irons. The mold is then withdrawn. Following this, fabric 124 may be plate-pressed to the completed structure over the ribs.

The nose ribs or plugs 116 having ears 116a, which serve as ribs for the members 113, are next inserted in each open extremity of each of said members with the ears 116a extending outwardly toward the opening. The ears then are plate-pressed to the adjacent laminations.

In forming the fuselage of the present invention, it is desirable that this structure comprise one piece, i. e., one piece constituted by a plurality of laminations vulcanized together upon a single mold. However, due to the shape of a fuselage 126 as shown in Fig. 32, it is impractical to use a single collapsible mold because of the difficulties accompanying the extraction of portions of the mold. Furthermore, it may be desirable to divide the fuselage into two sections in order to facilitate assembly and disassembly for repair, and also to facilitate the securing of the wings in such a manner that they may be easily dismounted. Consequently, in the form shown, the fuselage comprises a forward section 126a, and an after section 126b, the two being preferably mechanically joined in a telescopic engagement by means of detachable bolts 127 at the point of substantially maximum cross-sectional area. The fuselage is formed with a conventional cockpit having forward windows and side windows 126c and 126d, respectively.

Sections 126a and 126b are each formed upon a collapsible mandrel. Such a mandrel for the after section is shown in Fig. 33, and is analogous in construction to the collapsible beam mandrel, as shown in Fig. 13, in that it comprises a central tapering wedge 128 having a cross-section in the shape of a parallelogram, and having removably secured thereto members 129 and 130 which cover two sides of the wedge, the other two sides being covered by similar members (not shown). The side members are grooved both transversely and longitudinally in order that suitable frames and stiffeners, respectively, may be positioned thereon. A vertical face 131 of a transverse groove is shown in Fig. 32, the section comprising this view being taken through one of said grooves.

In order to facilitate the extraction of members 129 and 130 from a completed fuselage, the longitudinal grooves in each member are cut in such a manner that their sides are parallel. Such grooves 132, 133 in member 129 and 134, 135, 136 in member 130 are shown (Fig. 33).

In forming, for example, the after section 126b of the fuselage, the side members of the mold are mounted upon the wedge 128 and the mold is then covered with a non-adhesive material. Strips of veneer 137, 138, 139 (Figs. 35 and 36) are next wound in the transverse grooves until the grooves are approximately thirty per cent filled, and there held in position in a manner similar to that described in connection with the transverse frames shown in Fig. 16. A longitudi-

nal stiffener 140 comprising a member preferably of flexible solid wood is then placed in each of the longitudinal grooves. At the point of intersection of each stiffener with each transverse frame, a portion of the stiffener is cut away (Fig. 36) in such a manner that a neck 140a is formed which will permit an interlocking therewith of the laminations comprising the transverse frames, i. e., the frames' laminations fit closely between the shoulders adjacent the neck. The latter necessarily interrupts several of the laminations comprising said frames, and in the form shown interrupts laminations 141, 142, 143. Added laminations 144, 145, 146 may then be wound in the transverse grooves until flush with the outer surface of the mold.

The trailing tips of each of the longitudinal stiffeners may be positioned in a suitable groove in the conical face of a trailing cone member 147.

Following this, a series of laminations in the shape of triangular tongue pieces with rounded tips are positioned upon the mold comprising the skin of the fuselage. Each tongue piece is placed upon the mold with the rounded tip extending aft. The inner laminations may be temporarily held in position prior to vulcanization by spot welding the same to the longitudinal stiffeners and transverse frames. Succeeding laminations may be temporarily held in place by spot welding to the laminations therebeneath. The assembled material is vulcanized in a manner above described.

A second manner of interlocking the longitudinal stiffeners to the transverse frame members is illustrated in Fig. 37 wherein the stiffeners, instead of being constituted by solid flexible members of wood, comprise a plurality of veneer strips which are interposed between alternate strips of the transverse frames. In assembling these strips upon the mold, for example, three laminations 148, 149, 150 are first wound in the inner portion of the transverse grooves and held in position as above set forth. A longitudinal strip 151 is next positioned in a longtudinal groove. Strip 151 interrupts the succeeding transverse laminations 152 upon which a continuous strip 153 is next placed. The alternate interposition of the longitudinal strips continues in this manner until both longitudinal and transverse grooves are filled. The laminations comprising the skin are superposed and vulcanized thereon as above described.

The forward section of the wing is formed in an analogous manner upon the forward section of the mold and the two sections are joined in telescopic engagement by means of the bolts 127.

In associating the fuselage and the wings, in the form shown in Fig. 32, the completed fuselage, comprising sections 126a, 126b, is joined as illustrated and a section is cut from the under surface thereof which corresponds in longitudinal cross-section to the cross-section of the wings. This section is represented by the broken line 154.

A complete port and starboard wing, each, for example, having a beam member provided with a flange 58, are assembled by bolting said flanges to one another. The connected port and starboard wings are then positioned in the cut-away section of the fuselage such that said flanges are centrally disposed therein. A strip (not shown) having a cross-section substantially in the shape of an L, said strip being of metal or of heavy resin treated vulcanized wood laminations, is placed within the fuselage adjacent the intersection of said wing and fuselage, with one face of the strip contacting the fuselage and the other the wing. Suitable bolts may be employed for joining the faces of the strip to the wing and fuselage, thereby forming a rigid connection between the latter two members.

A second embodiment of the reinforcing means for the fuselage is illustrated in Fig. 38. This fuselage is formed in two sections, each upon a collapsible mold which is analogous to that shown in Fig. 33, with the exception that the grooves for the reinforcing members are cut as spirals in the outer surface thereof. Although this fuselage is formed in two sections as above mentioned, the spiral grooves are cut in such a manner that when the completed sections of the fuselage are assembled, corresponding spiral ribs upon the after section will abut corresponding ribs upon the forward section, with the exception of those ribs which are interrupted, for example, by the section comprising the windows covering the cockpit.

A mold (not shown) for forming the fuselage of Fig. 38 has cut therein, for example, two left-hand spirals for the ribs 155 and 156 and three right-hand spirals for the ribs 157, 158 and 159, the direction of the spirals being determined when viewed looking forward. The pitch of the spirals, in the form illustrated, is approximately forty per cent of the length of the fuselage, the pitch, of course, being determined by the number of spiral grooves desired and by the length of the fuselage.

The right and left-hand spirals intersect at various points making it necessary that the strip laminations filling the left-hand spirals be interposed between those of the right-hand spirals in a manner similar to that described in connection with the longitudinal stiffeners and transverse frames as shown in Fig. 37.

The skin laminations are superposed, held in position and vulcanized upon the mold sections as described in the former embodiment.

The wings may be associated with this fuselage in a manner similar to that described in connection with Fig. 32.

A mounting (not shown) for an aircraft engine may be constituted by a metal tubular structure which is bolted to strengthened portions of the wing beams adjacent their butt extremities.

A tail wing (Fig. 3) with stabilizing surfaces and vertical rudder are formed in a manner analogous to that described above.

There is thus provided a novel method for fabricating aircraft from veneer layers impregnated with a thermoplastic such as polyvinyl butyral. The fuselage and wings and the component parts thereof, because of the vulcanization process, become so closely associated that a substantially homogeneous structure is formed which may be entirely without mechanical fastenings between any of the parts thereof. The novel method is also adapted for producing furniture, and the hulls of marine vessals, or any of their parts. The product of this method is extremely light, strong and very inexpensive relative to similar products made by other methods. Furthermore, polyvinyl butyral renders the product impervious to the atmosphere, thus precluding warping or separation of the veneer layers due to moisture entering between the layers. Air bubbles are prevented by piercing the veneer sheets, and during vulcanizing, the air holes are closed by the thermoplastic, or a final spray of

thermoplastic may be applied to insure a smooth finish.

Although the present novel method has been described in reference to only two particular structures, i. e., a radio cabinet and an aircraft, it is to be expressly understood that the same is not limited thereto. Furthermore, the method of vulcanization is not limited to an application of heat and of fluid pressure to veneer layers within a flexible container, since mechanical pressure by means of suitably formed heated presses may be applied instead. Also, the method is not limited to the use of a polyvinyl butyral, since a suitable thermoplastic having similar qualities may be employed. Also, instead of wood veneer layers, suitable fabric or sheet metal layers may be used. Various changes may be made in the design and arrangement of the parts of the structures described herein and also in the method for producing these structures without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art. For a definition of the limits of the invention, reference will be had primarily to the appended claims.

What is claimed is:

1. A hollow structural unit of a plurality of laminae of wood veneer which is normally frangible, said laminae being impregnated with a resin adhesive and bonded together to form an integral structure, the wood being permanently molded into shapes beyond the angle of bending without fracture of said wood in its normal state.

2. A hollow structural unit of a plurality of laminae of wood veneer which is normally frangible, said lamir ae being impregnated with a thermoplastic binding material comprising polyvinyl butyral and bonded together thereby to form an integral structure, the wood being permanently molded into shape beyond the angle of bending without fracture of said wood in its normal state.

3. In a structure for aircraft, a hollow member comprising a plurality of sheets of wood veneer bonded together with a resin adhesive, said sheets being molded into shapes beyond the angle of bending without fracture of said wood in its normal state and into several planes to form walls about a hollow space and at least some of said sheets being turned into a plane extending transversely to said walls, thereby to form a reinforcing flange integral with the sheets forming said walls.

4. A structure for aircraft composed of several hollow units, each such unit comprising a plurality of sheets of wood veneer bonded together with a resin adhesive, said sheets being molded into shapes beyond the angle of bending without fracture of said wood in its normal state and into several planes to form walls about a hollow space and at least some of said sheets being turned into a plane extending transversely to said walls, thereby to form a reinforcing flange integral with the sheets forming said walls, and means uniting the adjacent flanges of the several units to form an integral structure.

5. A structure for aircraft composed of several hollow units, each such unit comprising a plurality of sheets of wood veneer bonded together with a thermoplastic adhesive, said sheets being molded into shapes beyond the angle of bending without fracture of said wood in its normal state and into several planes to form walls about a hollow space and at least some of said sheets being turned into a plane extending transversely to said walls, thereby to form a reinforcing flange integral with the sheets forming said walls, and means uniting the adjacent flanges of the several units to form an integral structure.

6. A molded laminated structure comprising thin normally frangible laminae of fibrous material forming a hollow shell of larger area than any of the individual laminae, and geodetic type reinforcing members at the inner surface of said shell, said members and said laminae being united and securely bonded together over the entire contacting areas thereof by a resin adhesive which sets at a temperature below that at which burning of the material in its thin laminar form would normally occur.

7. The structure of claim 6, said shell having a double curved surface.

8. A molded laminated airplane fuselage comprising thin normally frangible sheets of fibrous material forming a hollow shell having a double curved surface, intersecting reinforcing members at the inner surface of said shell, said members being intercalated, and said members and said sheets being united and securely bonded together over the entire contacting areas thereof by a resin adhesive which sets at a temperature below that at which burning of the material in its thin sheet form would normally occur.

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