Dec. 9, 1969 R. W. ESHBAUGH 3,483,055

METHOD FOR FORMING A FIBER GLASS RACKET FRAME

Filed March 28, 1966 5 Sheets-Sheet 1

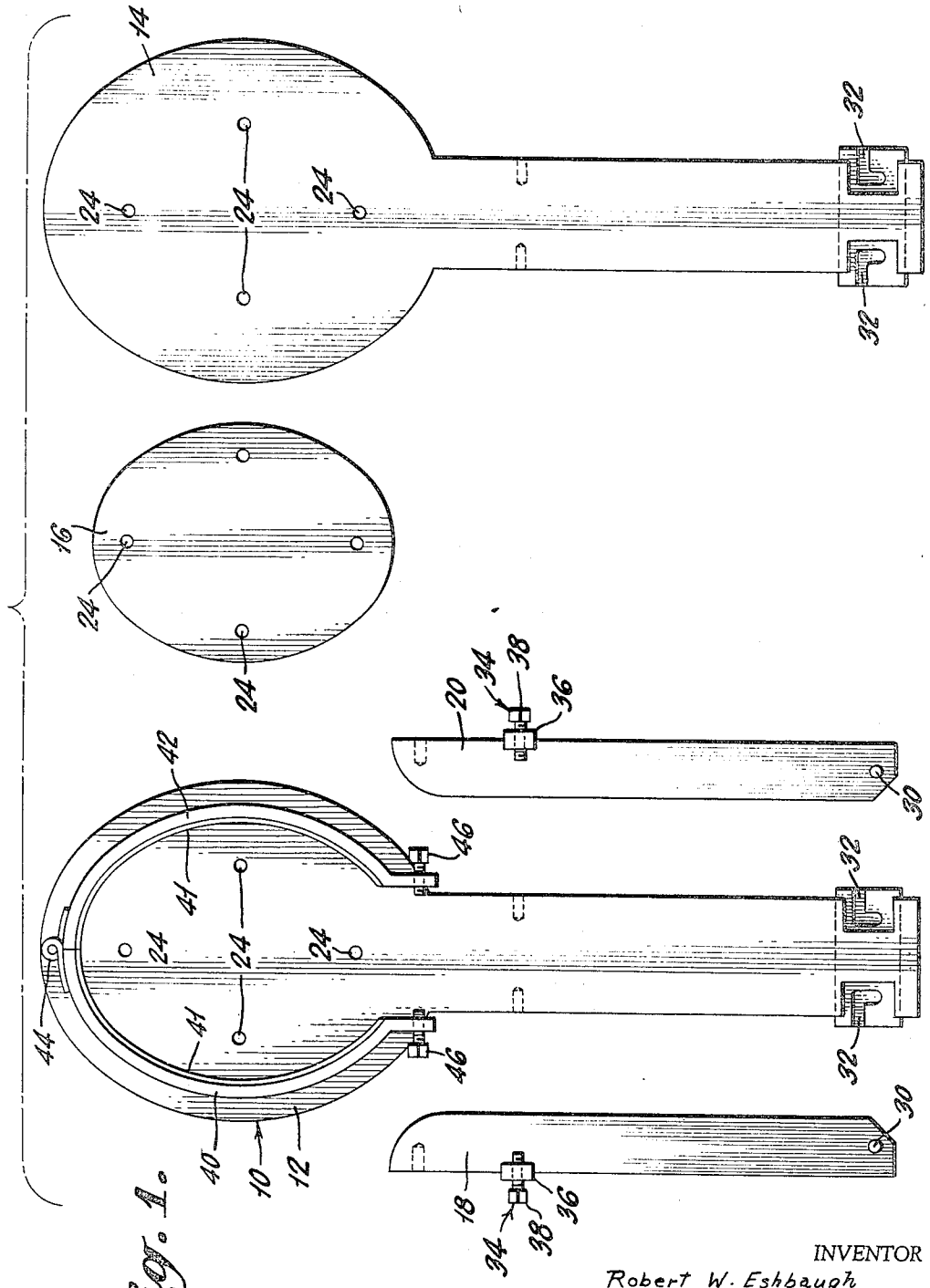

Fig. 1.

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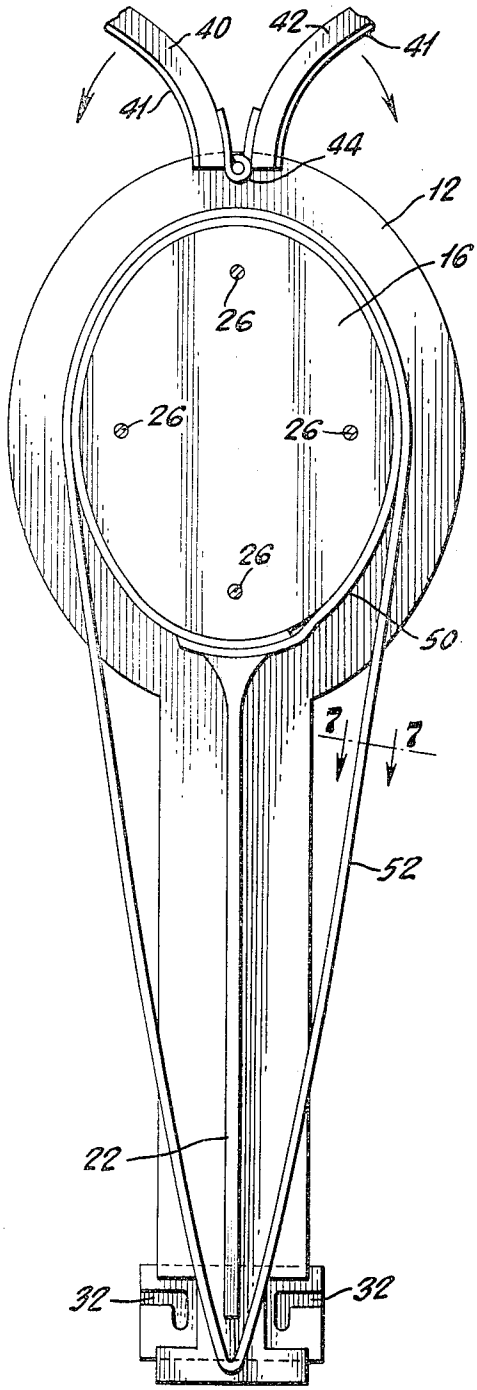
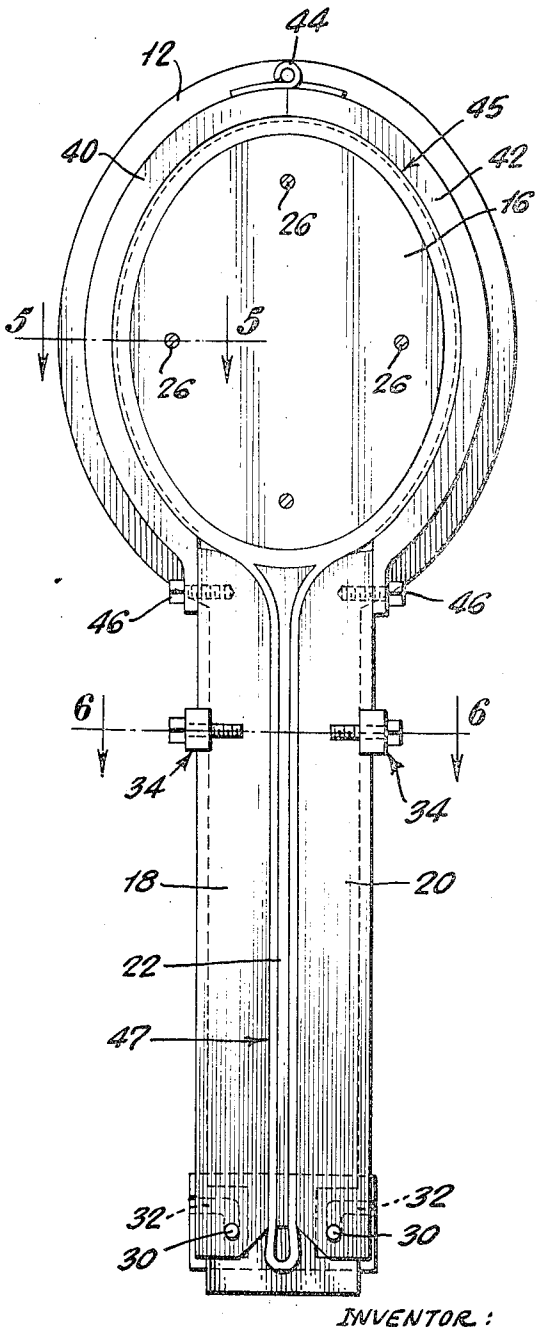


Fig. 2.

Fig. 3.



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METHOD FOR FORMING A FIBER GLASS RACKET FRAME

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Fig. 4.

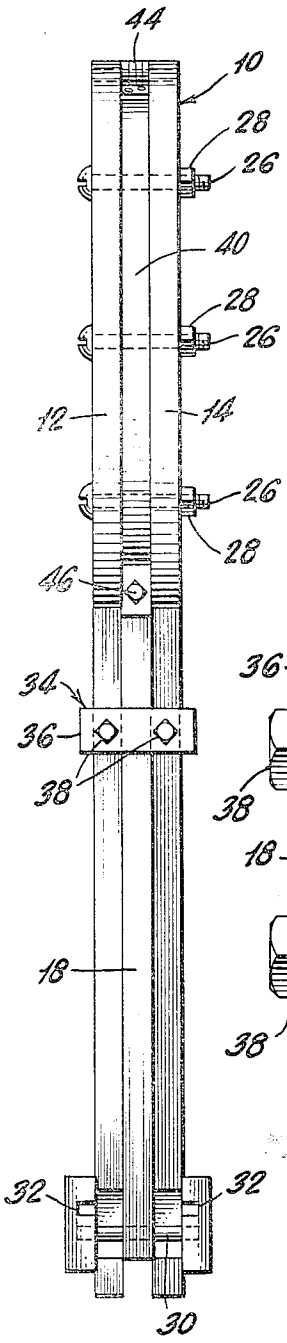


Fig. 5.

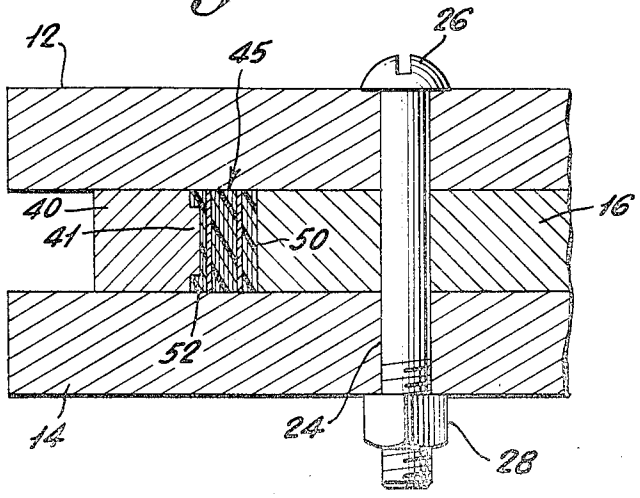


Fig. 6.

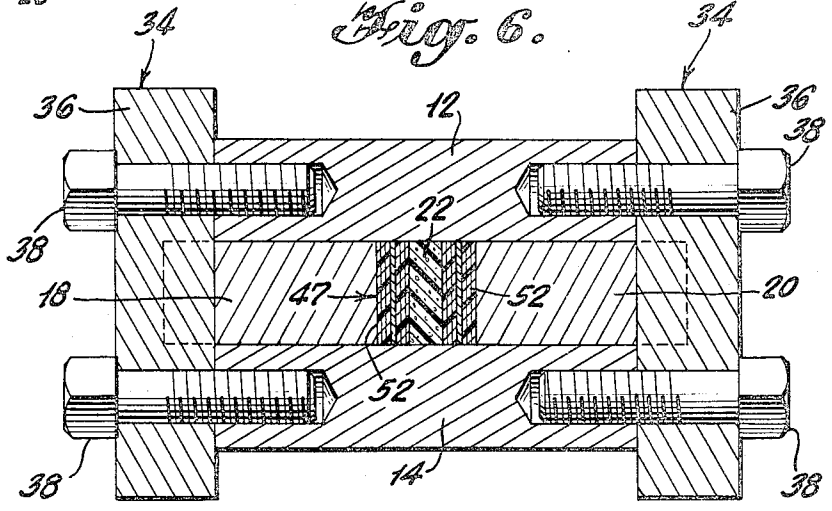
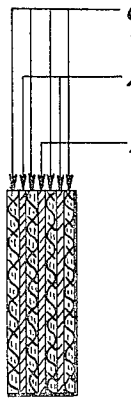


Fig. 7.



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METHOD FOR FORMING A FIBER GLASS RACKET FRAME

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Fig. 8.

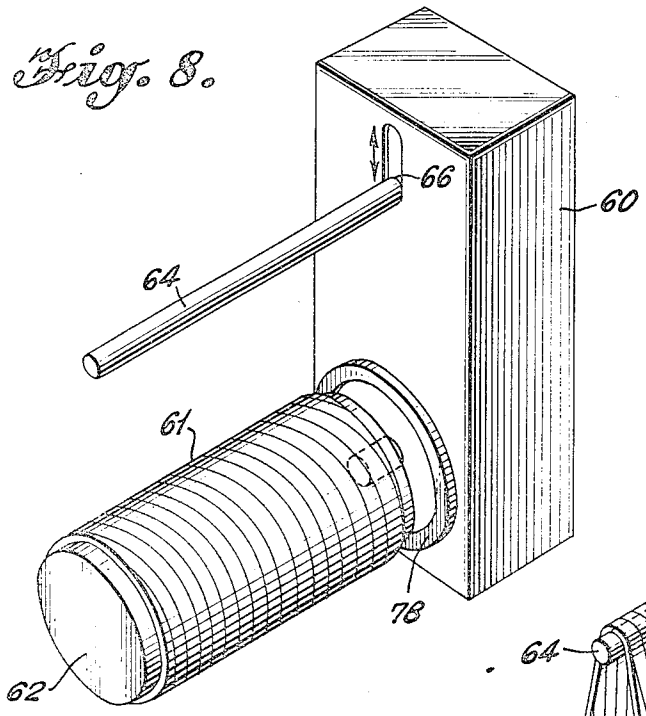


Fig. 9.

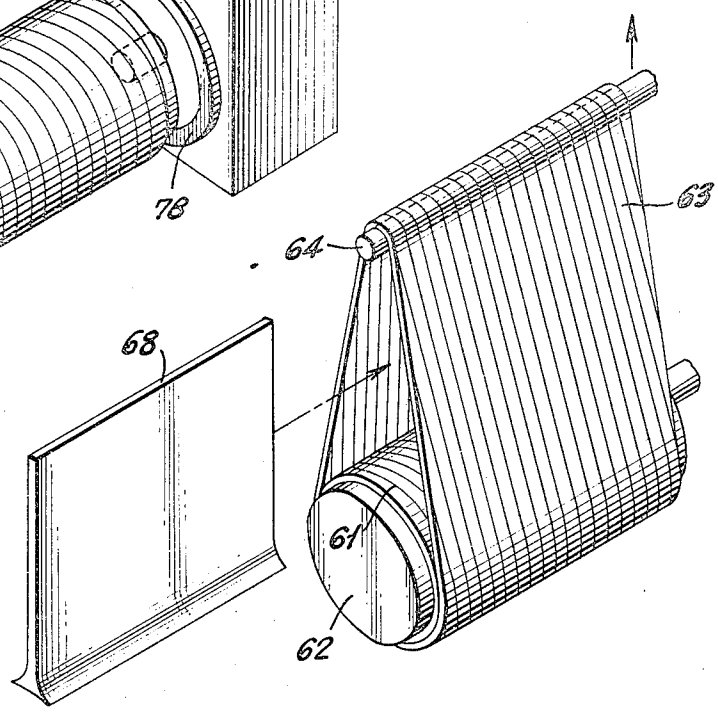
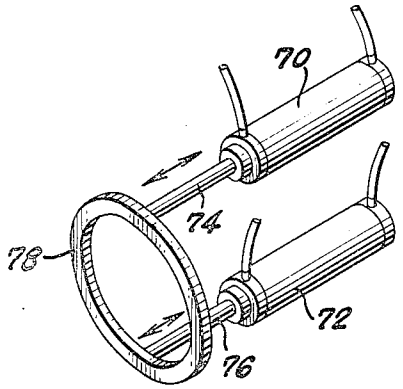


Fig. 10.



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METHOD FOR FORMING A FIBER GLASS RACKET FRAME

Filed March 28, 1966 5 Sheets-Sheet 5

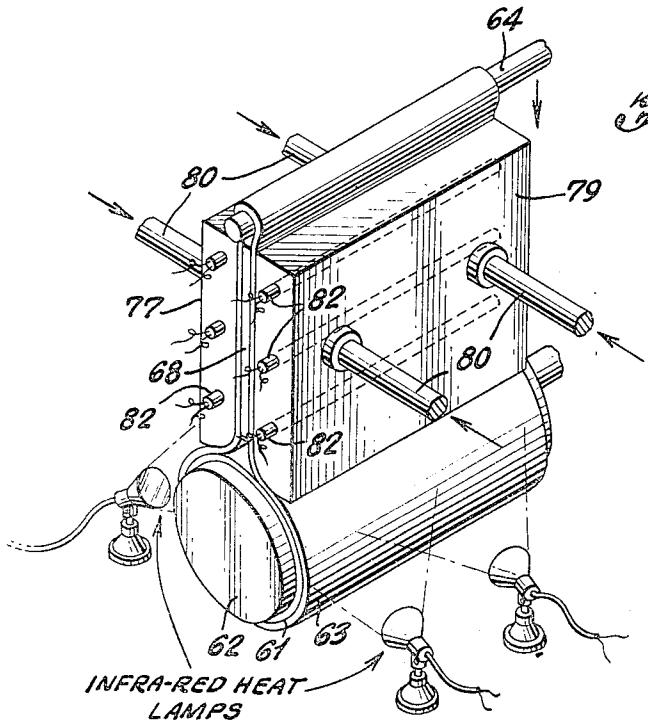
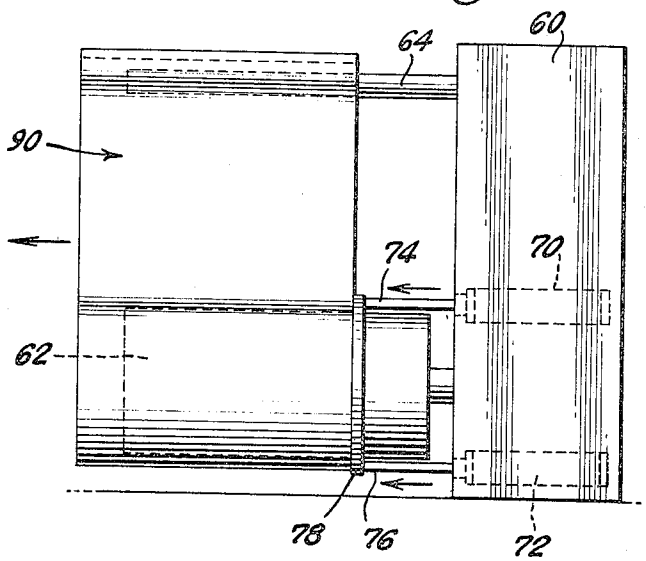


Fig. 11.

Fig. 12.



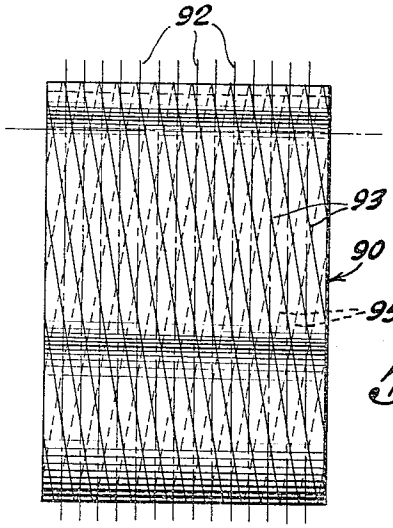


Fig. 13.

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METHOD FOR FORMING A FIBER GLASS RACKET FRAME

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Int. Cl. B29d *12/00*
U.S. Cl. 156—189 25 Claims

ABSTRACT OF THE DISCLOSURE

A method for producing racket frames (tennis, etc.) essentially from only flexible windable materials involving the winding of same about a suitable form defining means and then heat curing said materials to a rigid condition conforming to the desired frame configuration.

This invention relates to a fiber glass racket frame and, more particularly, to a fiber glass racket frame which enables the user to control the flight of a tennis ball or the like with a maximum uniformity and minimum effort for a long period of time.

It has been the custom, when providing a means to propel a ball in the games of tennis, badminton, squash, and so forth, to utilize a racket frame of wood, the head of which is provided with a nylon or "gut" string which contacts the ball to propel it. However, these wooden rackets suffer from many disadvantages, which include relatively low tensile and compressive strengths, susceptibility to warpage, scuffing, and the like. Furthermore, these wooden rackets tend to lose their color and, therefore, attractiveness, over a period of years along with their flexible properties, resulting in a relatively short fatigue life. In addition, these wooden frames must be of a certain relatively large cross section to provide the necessary strength, resulting in a relatively high wind resistance. Also in wooden frames, it is extremely difficult to manufacture a uniform product in regard to weight, balance, density and other mechanical properties since wood is a heterogeneous material, varying in density, moisture content, and modulus of elasticity.

Only recently have attempts been made to provide a racket frame of a generally fiber glass material which, in general, has a higher strength and a greater freedom from warpage, etc. However, these frames have also suffered in several respects, including a relatively high cost and lack of product uniformity, these being due to the fact that there has not yet been proposed any type of apparatus and method of uniformly manufacturing these rackets which result in a relatively efficient utilization of materials in order that the cost of each individual racket can be reduced to a competitive level with those of the wooden rackets. Nor has there yet been proposed a rapid and simple fabrication technique for the above-mentioned fiber glass racket, which provides an efficient utilization of materials.

It is, therefore, an object of this invention to provide a fiber glass racket frame which exhibits a greater strength than the wooden racket frames; a greater fatigue life; a more advantageous control of degree of flexibility and stiffness; a greater resistance to damage, color and fading; a greater resistance to warpage, moisture, flame and chemicals.

It is a further object of this invention to provide a distinct improvement over known fiber glass designs by providing an apparatus and a rapid, simple fabrication technique which permits a more efficient utilization of materials, thus resulting in a racket frame which is more economical and easier to produce.

Briefly summarized, the present invention features a racket frame formed by a mold which consists of several component parts, including a front and back plate, a pair of clamping members, a pair of flanged arcuate arms, and a mandrel shaped according to the desired shape of the finished racket frame. In the manufacture of the frame of the present invention, an inner loop or ring of uncured, substantially fiber glass, heat curable, flexible material is wound or placed over the mandrel between the two side plates and an outer loop or ring of the same material as above, but of a considerably larger diameter is wound or placed over the inner material in an abutting relation, the lower portion of the outer material hanging down to the bottom of the mold. A pair of clamping members are then clamped over this lower portion of the outer material to form the frame handle and the mold itself is secured together. The inner material together with the upper portion of the outer material forms the frame head, and the flanged arcuate arms may then be pivoted downwardly over this head to form a groove along the head to aid in the subsequent stringing of the frame. The materials are then cured in the mold to form a single racket frame which is then subjected to several finishing treatments.

According to another embodiment of the invention, an elongated stock piece which is substantially thicker than the normal width of the average racket is formed and subsequently sliced into a plurality of individual rackets. The apparatus for forming this stock piece includes an elongated lower mandrel about which an inner loop of substantially fiber glass heat curable, flexible material of considerable width is wound or placed, preferably in a helical manner. Also provided is a rod extending parallel to the lower mandrel; and an outer loop of a similar material is wound or placed around the rod and mandrel with the upper portion of each material being in an abutting relationship over the upper portion of the mandrel. The rod is then moved in a direction away from the lower mandrel to stretch the lower portion of the outer material. A pair of clamping members are then clamped between the rod and the mandrel which forms a portion of the outer material into the frame handle. A pair of arms substantially similar to those discussed above may then be utilized to form the grooves in the racket heads. In this embodiment the stock piece is removed from the mold after curing and then sliced in a direction so that a plurality of individual frames are formed.

Reference is now made to the accompanying drawings for a better understanding of the nature and objects of the present invention, which drawings illustrate the best mode presently contemplated for carrying out the objects of the invention and its principles and are not to be construed as restrictions or limitations on its scope.

FIG. 1 is a plan view of the major components for forming a single racket frame according to the subject invention;

FIG. 2 is a plan view illustrating the preliminary step in the assembling of the mold and the forming of the racket frame;

FIG. 3 is a plan view with the mold assembled, but with the front plate omitted for the sake of clarity;

FIG. 4 is a side elevation of the assembled mold;

FIGS. 5 and 6 are sectional views taken along lines 5—5 and 6—6 respectively of FIG. 3;

FIG. 7 is a sectional view of a typical ply of the racket frame taken along line 7—7 of FIG. 2;

FIG. 8 is a perspective view of an apparatus used in the forming of a stock piece from which a plurality of rackets may be formed, showing the inner ring which forms a portion of the racket head wrapped about a lower mandrel;

FIG. 9 is a fragmentary perspective view of the device of FIG. 8 showing a further step in the assembly of a stock piece from which a plurality of frames may be formed;

FIG. 10 is a perspective view of a device for ejecting the finished stock piece from the apparatus of FIGS. 8 and 9;

FIG. 11 is a perspective view showing the arrangement of FIGS. 8 and 9 during the step of curing the stock piece;

FIG. 12 is a side elevation of the stock piece being ejected from the machine;

FIG. 13 is a side elevation of a completed stock piece with phantom lines indicating lines through which the stock piece may be cut to form separate racket frames.

Referring now to the drawings in general and specifically to FIGS. 1–4 thereof, there is shown, in general, a mold **10** which is formed of various component parts, including a back plate **12**, an elliptical shaped mandrel **16** and a front plate **14**. Also provided are a pair of clamping members **18** and **20** and a center piece **22** which does not form a portion of the mold, but rather is included in the final cured racket frame. After the materials to be cured are placed in the mold in a manner to be discussed in detail later, the mold is tightened, the means for effecting this being seen by a reference to FIG. 4. As shown, back plate **12** and front plate **14** each have a plurality of holes **24** through which is inserted bolts **26**. Mandrel **16**, which is inserted between the plates, also is provided with holes **24** through which the bolts **26** extend. Nuts **28** are then tightened over the bolts **26** in order to lock the parts together.

Clamping members **18** and **20** are provided to form the frame handle and are seen in a disassembled condition in FIG. 1 and, as shown in FIG. 3, are secured to the side plates **12** and **14** by means of a pair of pins **30** extending outwardly from the lower portion of each of said clamping members. Each pin engages in a corresponding L-shaped slot **32** formed on each side of back plate **12** and front plate **14**, the L-shaped slot being provided to lock the clamping members in this operative position as seen in FIG. 3. To secure the upper portion of each clamping member to the side plates, there is provided a securing means shown generally at **34** in FIGS. 1, 3 and 4 and more particularly in FIG. 6. As seen in FIG. 6, these clamp securing means **34** comprise a plate **36** extending through a portion of each clamping member and abutting the side edges of each of said front and back plates **12** and **14** respectively. Plates **36** are secured to the mold by means of bolts **38** which extend through the plates **36** and are threaded into the back and front plates **12** and **14** as shown in FIG. 6.

In order to provide a groove extending around the outer surface of the finished frame head **45**, there may be provided, on the mold, a pair of arcuate shaped arms **40** and **42** which may be pivotally connected to plates **12** and **14** as seen in FIG. 2 by means of a hinge **44**. In their operative position these arcuate arms extend substantially around the head portion **45** of the racket frame and are secured to the clamping members **18** and **20** respectively by means of a bolt clamp shown generally at **46** in FIG. 3. Each of the bolt clamps extending through the respective arcuate arms are threaded into a hole formed in the clamping members **18** and **20**. As better seen in FIG. 5, a flange **41** is provided on this arm **40** which engages the material to be cured as shown to form a groove in the outer surface of the cured frame. It is to be understood that a similar flange is provided on arm **42**.

Finally a center piece **22** is provided which is of a plastic, plastic foam, or light wood and which serves as a spacer and filler in that it retains the limp uncured composite rings in proper position in the mold and provides a means against which clamping members **18** and **20** may act.

The material used in forming the racket frame of the present invention is better seen in FIG. 2 which shows the mold in a partially assembled state. This material includes an inner loop or ring **50** extending around the mandrel **16** which may have its ends cut and overlapped near the bottom end of the mandrel as shown; and an outer loop or ring **52** which is of a considerably larger diameter than the inner loop so that when the outer loop is placed over the inner loop as shown, the lower portion of the outer loop will extend downwardly through the entire length of the mold to form the handle portion **47** of the racket frame. The rings may be individually wound over the mandrel or manually placed thereon after being formed on a separate mandrel.

FIGS. 5, 6 and 7 all show portions of the cured material in a cross-sectional view and FIG. 7 identifies each component of the material before it is cured, it being understood that it is within the scope of the invention to vary the components as desired. Since FIG. 5 is taken along a portion of the cured frame head **45**, the structure of the inner loop **50** and the outer loop **52** will be molded together while, since FIG. 6 depicts a cross section of the frame handle **47**, the outer loop **52** is shown between the sides of which a center piece **22** extends. It should be emphasized that each individual layer of material subtends the width of the racket and extends from the bottom portion of the frame handle upward around the frame head and then downward back towards the handle.

The inner loop and outer loop may each be separately formed by applying a thermos-setting adhesive to a plurality of glass rovings and winding the rovings onto the mandrel **16** or onto a separate mandrel along with absorbent paper and foil, the weight of the frame being, of course, determined by the number of wraps or plies present in each ring. If a separate mandrel is used, the limp uncured loops which are thus formed are then placed on the mandrel **16** as discussed above.

The thermo-setting adhesive may be in the form of an epoxy or polyester resin blended with an appropriate amount of a suitable type of curing agent. The absorbent paper is included to absorb this adhesive and thus provide an even distribution thereof throughout the frame and may be in the form of stands, tapes, or sheets of cellulose, asbestos or plastic foam. The foil is utilized to act as a barrier between adjacent layers of the glass and paper as well as to provide added strength to the finished frame. In the event added strength is not deemed necessary, plastic tape or paper tape may be utilized in place of the foil.

It is to be understood that variations of the type and amount of these materials may be made within the scope of the invention. For example, it has been found that it is highly desirable to use a glass cloth in place of the glass rovings in the outer surface of the racket since the former provides added shear strength in the transverse direction of the frame.

In the steps of forming the racket frame according to the present invention, the mandrel **16** may be initially coated with a release agent and an uncured or "B-staged" loop of the above mentioned materials directly wound or manually placed around the mandrel. The free ends of this loop may then be cut and overlapped adjacent the lower portion of the mandrel as seen in FIG. 2 in order to provide additional material for the throat portion of the frame, or the loop may be left on the mandrel in its original form. Then the outer loop **52** is either directly wound or manually placed over the inner loop **50** on the mandrel **60**, this outer loop being of a larger diameter than the inner loop and of the same materials. Side plates

12 and 14, which may be also coated with a release agent, are then secured adjacent each face of the mandrel by means of the bolts 26 as discussed above and the side plates are then tightened to the desired degree and locked by tensioning nut 28 on the bolts. The outer loop is then stretched downwardly by means not shown so that the lower portion thereof extends at least to the lower end of the mold which removes wrinkles, air or resin pockets from the material and minimizes slippage. An elongated spacer 22 may then be inserted within the lower portion of this outer loop and adjacent the lower portion of the mandrel as seen in FIG. 2.

The lower portion of the stretched outer loops 52 is then clamped inward by the clamping members 18 and 20 so that it will abut the center piece, thus densifying the laminate by squeezing out the excess resin while forming the frame handle. It should be understood that the stretching means discussed above must "give" slightly in a direction towards the mandrel against the action of the clamping members while still maintaining the requisite degree of tension. Arms 40 and 42 which are hinged between the side plates, may then be pivoted downwardly and clamped by means of bolts 46 to the upper portion of the clamping members 18 and 20, the flange 41 on each arm extending into the outer surface of the outer loop in order to form a groove therein which is utilized to protect the racket strings from scuffing.

The materials are then cured by any known method, such as by use of an electrical heating element or steam pipes attached directly to the mold plates or by simply placing the mold inside an oven. The time, temperature and conditions necessary to polymerize the material depend on its chemical nature, it being understood that production and economy considerations dictate the choice of a fast curing system with a heat cure. For example, it has been found that a typical initial curing time for a thermo-setting adhesive such as epoxy resin blended with an amine curing agent is for one hour at 200° F.

The cured racket frame is then removed from the mold by simply disassembling the mold in reverse order as discussed earlier and knocking out the mandrel from within the frame head. The frame then may be subjected to an additional heat cycle to insure complete polymerization. For a typical system it could be post cured at 250–275° F. for two hours. This may be performed either with the frame on or off the mold, the latter being more economical as it permits resue of the mold earlier in the production cycle.

A series of final finishing steps are then performed on the cured racket frame which may consist of removing any flash present, cutting the shaft to the proper length, drilling the string holes, adding any necessary labels and decorative decals, buffing and polishing, forming any type of handle, and spraying a glossy sealer varnish or the like over the frame.

The string holes are drilled within the groove formed in the outer surface of the frame head, so that the string will not extend outward from the outer surface of the frame head, the string thus being less susceptible to being frayed in actual use.

Referring now to FIG. 8–13 which relate to another embodiment of the present invention, an elongated stock piece is formed which has a cross section corresponding to the shape of the finished racket frame. This stock piece, of course, is considerably wider than the finished frame and after it has been molded it is sliced into a plurality of individual frames. The apparatus for forming the frame stock piece includes a base 60 in which is journaled a lower mandrel 62, means being provided in base 60 for rotating mandrel 62. As in the first embodiment the mandrel 62 may be shaped according to the frame head, and is preferably elliptical. As seen in FIG. 8 tension rod 64, the longitudinal axis of which is parallel to that of mandrel 62, is mounted in base 60 at 66 in a manner so that it can move in a direction toward and away from the mandrel 62, for reasons that will be explained later, it being understood that any known means are provided in base member 60 for permitting this movement.

The stock piece is formed by winding or placing an inner layer 61 of substantially fiber glass material directly around the mandrel 62. This material may be of the same composition as set forth in the first embodiment with one exception. The glass rovings may be helically wound around the mandrel to provide a shear strength in all directions and thus eliminating the need for glass cloth or the like, which is a desirable component in the forming of a single frame, as described earlier. The helical windings are shown by the lines 93 and 95 in FIG. 13, it being understood that the absorbent paper and foil may be also be wound similarly, or applied as a sheet extending the entire width of the mandrel.

After the inner loop has been wound around mandrel 62, an outer loop or ring 63, which may be of the same material as the outer loop of the single frame, is placed around the mandrel and the tension rod 64, the outer loop, of course, extending over a portion of the inner loop as shown in FIG. 9. As in the first embodiment, each loop may be directly wound around the mandrel and rod or formed on a separate mandrel and then manually placed over mandrel 62 and rod 64. The tension rod is then moved in a direction away from the mandrel in order to place a predetermined tension on the outer loop 63. After center piece 68 has been inserted within the outer loop 63 and adjacent mandrel 62, a pair of clamping members 77 and 79 are clamped adjacent each side of the outer loop 63 as shown in FIG. 11 to form the frame handle. Rams 80 or the like may be provided to exert an inward clamping force on members 77 and 79, as shown in FIG. 11, it being understood that rod 64 will have to "give" a little to accommodate this inwardly directed force. Infrared heat lamps, or the like, along with electrical heating elements 82, which extend through clamping members 77 and 79, may be utilized to effect the curing of the stock piece.

It should be understood that means may also be provided to form a series of grooves in the stock piece before it is cured, which correspond to the grooves which protect the strings, as discussed in relation to the first embodiment.

Means are also provided to eject the cured stock piece from the mandrel and tension rod after the clamping members 77 and 79 have been retracted, this means being shown in FIGS. 10 and 12. A pair of cylinders 70 and 72 are provided which are mounted in base member 60 and which have a pair of piston rods 74 and 76, respectively slidably mounted therein. Attached to the free end of the piston rods 74 and 76 is an elliptical yoke shown at 78 which, in the assembled condition shown in FIG. 12, extends around the mandrel 62. When the finished stock piece 90 has been sufficiently cured, it is ejected from the mandrel and tensioning rod by action of the pistons 74 and 76. The pistons may be actuated by means of a fluid or the like being forced into the cylinders 70 and 72 in any known manner.

The temperature and time conditions used in the curing of the inner and outer loops may be the same as discussed earlier.

It is to be understood that the curing operation is normally performed while the inner and outer loops are still in the mold and that the cured stock piece also may be subjected to a post curing at temperatures which correspond to those in the first embodiment, said post curing occurring before or after the ejection of the stock piece from the mold. Then the stock piece is sliced along lines 92 in FIG. 12 to form a plurality of individual frames which, of course, then may be subjected to finishing operations as discussed in relation to the first-mentioned embodiment.

It is within the scope of the instant disclosure to add color pigments to the resin for the different layers of the racket frame. The different colored layers so formed may be separated by a substantially impermeable material such as foil, paper or tape, as discussed above. For example, a

black pigment could be added to the resin binding the materials to the left of the foil in FIG. 7, and a red pigment added to the material to the right.

The racket frames formed by the method and apparatus of the present invention have many advantages. For example, they will exhibit tensile and compressive strengths in excess of 80,000 lbs. per square inch, which is over three times the strength of a typical laminated wooden racket. Also, a greater fatigue life is present in the racket frame of the present invention, since the stress level during use is a smaller percentage of the ultimate strength than that of a wooden frame, resulting in a greater reserve strength in the frame of the present invention. Another advantage of the frame of the present invention is that it can be given a controlled degree of flexibility and stiffness through a selection of several parameters, such as type of material, amount of material, degree of curing, etc. Furthermore, the surface of the fiber glass racket of the present invention is much harder than that of wooden rackets and is, therefore, more scratch and damage resistant. Also, the racket of the present invention maintains its original permanent color, and will not warp because it is inert.

Of course variations of the specific construction and arrangement of this type of apparatus and method herein disclosed may be made by those skilled in the art without departing from the invention.

What is claimed is:

1. A method of manufacturing a plurality of racket frames comprising the steps of placing a first loop of a combination of heat curable flexible materials around an elongated mandrel, positioning an adjustable tensioning rod in a spaced position from said mandrel so that their respective longitudinal axes are parallel, placing a second loop of similar type materials around said mandrel and said rod so that a portion of said second loop abuts a portion of said first loop, moving said rod in a direction away from said mandrel until a predetermined tension is placed on said second loop, clamping another portion of said second loop inward to form the racket handles, curing said material, removing the cured material from said mold, and slicing said cured material into a plurality of individual racket frames.

2. The method of claim **1** further comprising the step of coating said mandrel and said rod with a release agent before said materials are placed thereon.

3. The method of claim **1** further comprising the step of inserting a spacing means within said second loop between said rod and said mandrel before said clamping step.

4. The method of claim **1** further comprising the step of adding a color pigment to the adhesive of at least one of said loops before said curing step.

5. The method of claim **1** further comprising the step of finishing said frames after said slicing step.

6. The method of claim **1** wherein at least one of said loops is formed by the steps of applying a thermo-setting adhesive to a plurality of glass rovings and winding same along with an absorbent material and foil onto said mandrel at predetermined intervals.

7. The method of claim **6** wherein at least said rovings are helically wound on said mandrel.

8. The method of claim **1** wherein at least one of said loops is formed by the steps of applying a thermo-setting adhesive to a plurality of glass rovings and winding same along with an absorbent material and foil onto a separate mandrel at predetermined intervals before placing the formed ring around said first mentioned mandrel.

9. The method of claim **8** wherein at least said rovings are helically wound on said separate mandrel.

10. A method of manufacturing a racket frame consisting of a head and handle portion, comprising the steps of:

(a) laying an inner layer of flexible, windable material which is heat curable to a rigid condition contiguously along at least a portion of a continuous surface which defines the desired head shape of a racket frame;

(b) laying an outer layer of flexible, windable material, which is heat curable to a rigid condition, between two spaced apart points along a portion of the longitudinal extent of said inner layer which is contiguous with said surface, and convergingly extending straight spaced apart sides of said outer layer from said points towards a point along the desired axis of the frame handle;

(c) pressing the converging straight sides towards each other to contact them along a remaining portion of said inner layer and to conform them to the desired frame handle configuration;

(d) curing said layers to a rigid condition.

11. The method of claim **10**, wherein said inner layer of material is wrapped around said continuous surface to form a closed curvilinear loop therearound, and wherein said straight sides extend tangentially from respective points along the curvilinear extent of said closed loop.

12. The method of claim **10**, further including the step of inserting a spacer element between said converging sides and then pressing said sides against said spacer element and curing said layers so as to permanently embed said spacer element between said sides.

13. The method of claim **10**, further including prior to the curing step, the step of forming a groove along the extent of the outer peripheral surface of said outer layer which conforms to the frame head portion.

14. The method of claim **10**, wherein said inner layer is wrapped around said continuous surface to form a closed loop therearound.

15. The method of claim **14**, wherein said inner layer is made longer than said continuous surface and the ends of said inner layer are circumferentially overlapped to form said closed loop.

16. The method of claim **10**, wherein said outer layer sides are made to converge and meet up to and at a point corresponding to the end of the desired frame handle and wherein said sides are tensioned to a wrinkle free condition while being pressed towards each other.

17. The method of claim **16**, including the step of applying a pigment of a different color to respective ones of the heat curable agents which impregnate respective ones of said strata of impregnated material.

18. The method of claim **10**, wherein said outer layer is itself a closed continuous loop of material which is conformed to a portion of said inner layer and extended therefrom as said converging straight sides to form a corner along the desired axis of the frame handle.

19. The method of claim **18**, including the step of gripping said corner and tensioning said sides to a wrinkle-free condition while pressing said sides towards each other.

20. The method of claim **10**, wherein at least one of said layers is formed by laying a first strata of absorbent material over a strata of a material impregnated with a heat-curable agent and by laying a second strata of such impregnated material over said absorbent strata.

21. The method of claim **20**, wherein said impregnated material comprises a plurality of glass rovings impregnated with a thermosetting agent, which rovings are wound together with said absorbent material separately from said surface into the form of a ring which is then laid around said surface to form said one layer.

22. The method of claim **20**, wherein a strata of metal foil is laid along said second strata of impregnated material and thereupon the strata sequence of claim **20** is repeated.

23. The method of claim **22**, which includes the step of applying a pigment of a different color to respective ones of the heat curable agents which impregnate respective ones of said strata of impregnated material.

24. The method of claim **20**, wherein said impregnated material is a glass roving.

25. The method of claim 24, wherein said roving is in the form of a glass cloth.

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