METAL TENNIS RACKET WITH PLASTIC THROAT PIECE AND MOLDED PLASTIC HANDLE

FIG. 1

EXTRUDED METAL FRAME STRIP, e.g., ALUMINUM HAVING A STRENGTH FACTOR, ITs
.0516 YS TO .0580 YS A

FIG. 2

MOLDED PLASTIC THROAT PIECE, e.g., NYLON, POLYPROPYLENE, ABS

INVENTORS
R. D. HARGRAVE
G. A. VAUGHN

MARN & JANGARATHIS
ATTORNEYS
FIG. 4A

FIG. 4B

INVENTORS
R. D. HARGRAVES
G. A. VAUGHN
METAL TENNIS RACKET WITH PLASTIC THROAT PIECE AND MOLED PLASTIC HANDLE

George A. Vaughan and Richard D. Hargrave, Princeton, N.J., assignors to Mauck Corporation
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ABSTRACT OF THE DISCLOSURE
The metal racket is made from an extruded aluminum strip comprising a pair of opposed tubular sections connected by a web, with a strength factor of $IF/A$ in the range of 0.0516Y to 0.080Y. The metal strip has a first channel in its outer periphery and a second channel in its inner periphery. A plastic throat piece is provided with outer surfaces shaped complementarily to the configuration of the inner periphery of the metal strip. The racket further having a solid molded plastic handle made of a foamed plastic material molded to the lower extremities of the metal strip.

BACKGROUND OF THE INVENTION
This invention relates to metal tennis rackets. A long standing and continuing effort by those concerned with the development and manufacture of tennis rackets has been the effort directed to the development of a commercially feasible yet functionally satisfactory tennis racket having a metal frame. Typical of the results of these efforts are the racket disclosed in the U.S. patent to La Coste, originally Pat. No. 3,085,777 and reissued as Re. No. 26,128 and the racket disclosed in the U.S. patent to Allward, Pat. No. 2,742,289.

Notwithstanding the efforts expended toward the development of a satisfactory metal frame tennis racket, difficulties continued to be experienced and acceptance of such rackets by tennis players has been marginal.

The problems attendant to known tennis rackets having metal frame strips have been vexing. For example, rackets having channel or tubular frame strip structure have been manufactured using both steel and aluminum alloys. Steel rackets, although providing satisfactory racket strength characteristics, have been criticized for being excessively flexible. Such flexibility has been complained of for causing the rackets to be "whippy" at the sacrifice of player accuracy. Aluminum rackets, on the other hand, have demonstrated satisfactory rigidity within the limits of their yield strengths but have been subject to criticism for their propensity to permanently deform.

The propensity for permanent deformation has also presented structural difficulties in the manufacture of known aluminum frame strip rackets. More particularly, it has been found that aluminum frames of known configuration tend to deform locally rather than uniformly during shaping to form the racket shape. Ordinarily the lines of localized deformation have been through the holes in the frame strip material to accommodate stringing. Thus, where such localized deformation occurs, the shaped frame strip defines a polygonal figure rather than a generally oval figure having a smooth curve outline.

A further difficulty experienced with known rackets using metal frame strips has been the short string life experienced in their use. This difficulty appears to result from one or more of many possible causes which may include excessive string wear at the point of entry to the frame structure, string wear within the frame structure and string wear caused by subjecting the string to excessively small corner radii. Considering initially excessive string wear at the point of entry to the frame structure, this often occurs where the string bears against a relatively sharp edge and is displaced across the edge by the impact of a ball against the strings of the racket. The resultant rubbing causes early failure of the string at that point of stress concentration and wear. String wear within the frame structure ordinarily occurs with tubular frame strips which have been punched, drilled or otherwise worked to form string accommodation holes. The edges of the holes on the inner surface of the tube are inaccessible to finishing procedures and as such ordinarily present sharp edges which cause failure of the strings or string accommodating grooves provided therethrough. In this regard, even the provision of grooves has not satisfactorily overcome this problem since the sharp edges are equally destructive of the grooves material which, upon failure, exposes the strings to wear. Recognizing this, workers such as La Coste have suggested the elimination of stringing holes and have proposed that the strings be supported by a wire coiled around the racket frame. Such structure, however, has subjected the string material to short radius deflections which generate rapid wear and for this, as well as other reasons recognizable to those in the art, is considered to be unsatisfactory.

With respect to the problems created by deflecting the strings around excessively small radii (e.g. the ordinary radius around which a string may be supported in known racket structures is generally in the range .030 to .040 inch), it will be recognized by those skilled in the art that supporting a string which is loaded in tension on a short radius fillet generates a point of stress concentration. Hence, a solution of the short radius problem by increasing the radius dimensions of support surfaces for the racket strings has been impossible because of the lack of available space resulting from the structural configuration of the frame strip.

A further difficulty with respect to aluminum frame strip rackets has been the relative racket weakness. Such weakness has been found to be caused by the shape of the frame strip cross-sections. Specifically, known aluminum frame strip cross-sections have relatively large concentrations of material along their longitudinal axis. It appears that this may have resulted from attempts to provide a solid web of material through which to provide stringing holes in an attempt to avoid the problem discussed above relating to internal sharp surfaces and the attendant string wear. The strength factor of structural shape, however, is directly related to the moment of inertia of the particular shape and the yield stress of the material in question, and inversely related to the area of material exposed in a cross-section thereof. Thus, while concentration of material in the central or axial section of known frame strips eliminates the incidence of string breakage resulting from sharp inner frame strip surfaces, it also resulted in a general weakening of the racket frame strip material.

A final difficulty experienced in the prior art metal frame strip racket structures has been a lack of strength in the throat of the racket. Specifically, rackets of known structure have been subject to deformation in torsion around the throat, which deformation has often resulted in the permanent deformation of the racket material thus misaligning the racket.

SUMMARY OF THE INVENTION
It is a primary object of the present invention, therefore, to provide a tennis racket having a metal frame strip, which racket overcomes the above-defined disadvantages of the prior art rackets as well as other disadvantages known to those skilled in the art.

This object as well as others which will become readily apparent is accomplished by the tennis racket of the inven-
tion, one embodiment of which may include a racket frame having a frame strip defining a stringing section and a handle section, a throat piece and a handle means, wherein the frame strip has a cross-sectional configuration with a strength factor in the range of 0.516 Y to 0.580 Y.

Another aspect of the invention comprises a novel aluminum frame strip for manufacturing tennis rackets, which strip comprises first and second tubular portions separated by a web portion, and wherein the strip is configured in cross-section to provide a strength factor in the range of 0.516 Y to 0.580 Y.

**BRIEF DESCRIPTION OF THE DRAWINGS**

A more complete understanding of the invention may be had from the following detailed description, particularly when read in the light of the accompanying drawings wherein:

FIG. 1 is a perspective view of a tennis racket according to the invention;

FIG. 2 is a cross-sectional view through the plane 2—2 of FIG. 1; and

FIGS. 3A–D are a schematic presentation of the steps of manufacturing a tennis racket according to the method of the invention.

FIGS. 4A and 4B disclose the throat piece.

**DETAILED DESCRIPTION**

Referring to FIG. 1, a tennis racket according to the invention is designated generally by the reference numeral 10. Racket 10 includes a racket frame comprising a frame strip 12 which is bent to form a generally oval stringing section 14 and a handle section 16 defined by the opposed end sections 17, 18 of frame strip 12 extending from stringing section 14 in parallel spaced relationship.

Rigidly secured in the throat section of oval stringing section 14 is a throat piece 19. Throat piece 19 cooperates with oval string section 14 of frame strip 12 to define the generally oval impact area of the racket 10.

Frame strip 12, as is best seen in FIG. 2, comprises a monolithic strip having first and second outer tubular portions 21 and 22, which tubular portions are separated by a web section 23. Tubular portions 21 and 22, and web section 23 are cooperatively shaped on their one surface to define a generally rectangular channel 25, and on their opposite surface to define a generally trapezoidal channel 26. Rectangular channel 25 accommodates the positioning therein of a grommet strip 28 comprising a base strip of material having formed thereon a plurality of integral grommets 29. Thus, when racket 10 is assembled as shown in FIG. 2, grommets 29 extend through holes 31 formed in the web section 23 of frame strip 12. It is to be recognized that although grommet strip 28 is shown as a single element, more than a single strip can be utilized equally as effectively.

FIG. 3 provides a molded structure having outer curved surfaces which conform in curvature to the desired curve of frame strip 12 in the area of the racket throat so that when assembled, the throat piece 19 and the frame strip 12 are in surface-to-surface engagement. To this end, the outer surfaces of throat piece 19 are also shaped to conform to the cross-sectional configuration of channel 26 in frame strip 12 so that the surface-to-surface contact and therewith the structural integrity of the racket is enhanced. The inner surface 35 of throat piece 19 is provided with a plurality of raised portions 37 adjacent the surface openings of passages 44 as shown in FIG. 4B provided in throat piece 19 to accommodate the passage of racket strings therethrough. Raised portions 37 define flat or curved support surfaces for the strings passing from the throat piece passages to the ball impact area of the racket. Such surfaces are provided to define string support surfaces of relatively large radii so that the problem of excessive string wear discussed above will not be experienced at the passage openings of throat piece 19.

Handle section 16 of racket 10 comprises the opposed end sections 17 and 18 of frame strip 12 which, because of the bending of the frame strip to define oval stringing section 14, extend in parallel spaced relationship. The lower extremities of end sections 17 and 18 are rigidly secured in parallel spaced relationship by being encased in a plastic material such as foamed polyurethane. In this regard, the foamed polyurethane serves the dual function of rigidly securing frame strip end sections 17 and 18 and defining the desired octagonal shape around which a strip of handle material 38 may be wrapped to form a handle 39.

Once the racket frame is manufactured, it may be strung with suitable stringing material such as gut 41 as shown or other materials known to those skilled in the art.

Considering the method of manufacturing the racket 10, and referring to FIGS. 3A–D, a frame strip 12, which has been extruded into the cross-sectional shape shown in FIG. 2 by conventional extrusion methods, is provided with a plurality of holes 31 by punching or similar operations. The frame strip 12 may be formed from an aluminum alloy and, in this regard, 6061–T6 aluminum alloy is the material of choice. Holes 31 are formed through web 23 and as such generate no internal sharp edges as has been experienced in holes through tubular shapes as discussed above.

With holes 31 formed in frame strip 12, the strip is bent to general racket shape such as is shown in FIG. 3B. Thereafter throat piece 19 is positioned in the throat of frame 12, snugly within channel 26, and secured to the frame strip by means of a plurality of screws 41. With respect to throat piece 19, the piece may be manufactured by molding into the desired shape using a material such as nylon. Other materials such as polypropylene and ABS (acrylonitrile-butadiene-styrene) may be used with satisfactory results.

After securing throat piece 19 to frame strip 12, grommet strip 28, which may be a preformed strip manufactured from suitable material such as nylon, may be inserted in channel 25 of strip 12 in such a manner that grommets 29 extend through holes 31 (FIGS. 2 and 3C). With the grommet strip 28 so positioned, its ends are secured to frame strip 12 by securing with screws 42.

Ends 17 and 18 of handle section 16 of the racket are then positioned within the die cavity 45 of a molding die 46 shown schematically in FIG. 3C, so that the lower extremity of the end sections 17 and 18 is spaced from the bottom of the cavity 45. The particular spacing is considered to be a matter of choice, however spacings of 0.5 to 0.75 inch have been found to be satisfactory. The inner surface of die cavity 45 is shaped to define the desired shape of handle 38 which in the racket 10 is octagonal. Thus, the securing of ends 17 and 18 by molding also accomplishes the formation of structure for handle 38. Having positioned the ends 17 and 18 in die cavity 45, a charge of suitable formable molding material such as polyurethane foam is introduced into the die cavity and allowed to expand therein. Upon the completion of expansion, curing is permitted for a suitable period (e.g., twenty minutes) until the handle can be removed from the die 46 without experiencing deformation of the molding material. After a further curing period (e.g., twenty-four hours) for allowing the molding material to take on a greater rigidity, the handle may be wrapped (FIG. 3D) with a suitable handle strip material such as leather which is known to those skilled in the art.

At this point in the manufacture, or prior to the handle wrapping step discussed above, the racket may be strung. In this regard, it has been found to be advantageous, although not necessary, to render the material of the grommet strip and throat piece temporarily more sus-
ceptible of slight deformation during stringing so that the string material can make a custom impression on the throat material thereby providing even smoother contact surfaces therebetween than has been heretofore possible. One mode of accomplishing this has been to soak the grommet strip material and throat piece material, when made of nylon, in a water bath to increase its water content. Thus the soaking of the material in boiling water or in room temperature water for approximately twenty-four hours has been found to increase the deformability of the nylon sufficiently to allow the custom impression of the strings therein during stringing without destroying the structural integrity of the grommet and throat piece.

After stringing is complete, the racket may be finished for sale by the addition of suitable labels, a surface finish or other finishing touches which are both known by and within the skill of those in the art.

It was noted above that one of the primary advantages of rackets according to the invention is their excellent and unexpected racket strength characteristics. These characteristics have resulted from the novel extrusion shape utilized for frame strip 12 as may be best seen in FIG. 2. More particularly, the racket strength factor is equal to \( Y_R/A \) where 1 (in.\(^4\)) is the moment of inertia of the frame strip shape around its longitudinal axis, \( Y = (#/in^2) \) is the yield stress of the material being used and A (in.\(^2\)) is the area of material exposed by a transverse cross-section of the strip shape, e.g. the area of strip material shown in FIG. 2. Known aluminum frame strips have strength factors in the range of 0.044Y\(_R\) which has proven disadvantageous since such a relatively low strength factor results in the utilization of excessive metal thereby precluding the availability of such racket life extending features as the grommet strip because of their weight.

More particularly, tennis rackets range in weight from approximately 12.5 ounces to 14.5 ounces, which range defines the light to heavy range generally accepted in the sport. If, in order to provide racket strength, it becomes necessary to utilize substantially the entire weight allowance over strings and handle weight for structural metal, the use of racket life extending devices such as grommets 29 becomes impossible and the racket must either become too heavy or inferior by reason of racket strength. The novel extrusion shape for frame strip 12, however, defines a shape of such high moment of inertia that structural material is required and devices such as grommets 29 and in particular grommet strip 28, which materially simplifies manufacturing procedures, can be utilized. The moment of inertia defining shape of frame strip 12 thus becomes a critical shape in taking full advantage of the present invention and, in this regard, the criticality of the shape can best be defined by the racket strength factor which it renders possible.

More particularly, the frame strip 12 shown in cross-section in FIG. 2 has enabled the achievement of strength factors in the range of from 0.516Y\(_R\) to 0.580Y\(_R\), which factors have not heretofore been achievable in aluminum rackets.

One example of a frame strip shape such as that shown in FIG. 2 which has provided a strength factor in the above-defined critical range is a strip manufactured from 6061-64 aluminum alloy with the following dimensions:

<table>
<thead>
<tr>
<th>Transverse width</th>
<th>1 inch</th>
</tr>
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<tbody>
<tr>
<td>Overall thickness</td>
<td>do</td>
</tr>
<tr>
<td>Web thickness</td>
<td>do</td>
</tr>
<tr>
<td>Major radius of outside tubular potion</td>
<td>108</td>
</tr>
<tr>
<td>Transverse width of channel 23</td>
<td>do</td>
</tr>
<tr>
<td>Transverse width of channel 25</td>
<td>do</td>
</tr>
<tr>
<td>Thickness of tubular wall</td>
<td>do</td>
</tr>
<tr>
<td>Transverse cross-sectional material area</td>
<td>square inch</td>
</tr>
</tbody>
</table>

This strip has been found to be unexpectedly strong, durable and, inter alia, because of the resulting capacity to employ grommets therewith, has contributed to the extension of string life in rackets according to the invention by as much as 28 times the life of known rackets. In this regard, the racket has been tested to demonstrate structural and string reliability when subjected to as many as 40,000 hits. In the same tests, known rackets have failed in the range of 1400 to 20,000 hits.

It is considered to be clear from the foregoing that the racket of the invention defines a substantial step forward in the art. Among other advantages it is capable of being conventionally strung, i.e. through frame holes, without the incidence of excessive string wear, it provides racket strength factors which are over 20% greater than known first quality aluminum rackets without exceeding the accepted range of total racket weight, it provides a racket which is stronger in tension than known rackets, and it comprises a racket capable of being manufactured by a novel process which is less complicated and less expensive than any others known in the art.

It is considered to be manifest, however, that many modifications and variations to the disclosed invention may be made without departing from the spirit and scope thereof.

What is claimed is:

1. A racket comprising:
   - an extruded metal frame strip comprising a pair of opposed tubular sections connected by a web, said frame strip being formed to partially define a generally oval section and being formed to provide a pair of spaced apart generally parallel handle end sections, and said tubular sections and said web defining a first channel in the outer periphery of said generally oval section and defining a second channel in the inner periphery of said generally oval section, and said web in said generally oval section having a plurality of holes formed therein for receiving string;
   - a plastic throat piece having outer surfaces formed complementary to said second channel, said plastic throat piece being received within said second channel and being secured to said formed frame strip in said second channel and completing in combination with said generally oval section of said formed strip an oval string section for said racket;
   - a grommet strip mounted in said first channel, said grommet strip having a plurality of grommets formed thereon and extending through said holes in said web;
   - a molded plastic handle molded around said spaced apart generally parallel handle end sections, said molded plastic handle for securing said handle end sections in a fixed spaced apart generally parallel relationship and for defining a hand grip area for said racket.

2. A racket according to claim 1 wherein said plastic throat piece is provided with a plurality of passages therethrough for receiving string and each of said passages, at one end thereof, is provided with a raised portion having a curved surface thereon for supporting string.

3. A racket according to claim 1 wherein said handle comprises a solid molded plastic handle made of a foamed plastic.

4. A racket according to claim 1 wherein said web is solid and wherein the thickness of said web is less than the overall height of said opposed tubular sections, and wherein said web cooperates with said tubular sections to provide said first channel with a generally rectangular configuration and to provide said second channel with a generally trapezoidal configuration.

5. A racket according to claim 1 wherein said extruded frame strip is provided with a racket strength factor \( (Y_R/A) \) in the range of 0.0516 (in.\(^2\)Y\(_R\) to 0.580(in.\(^2\)Y\(_R\) wherein the strength factor is the ratio of moment of inertia \( I/(in.\(^4\)) \) of the frame strip shape.
around the longitudinal axis of the strip, divided by the transverse cross-sectional area $A$(in.$^2$) of said web and said opposed tubular sections, and $Y_d$(#/in.$^2$) is the yield stress of the strip material.

6. A racket according to claim 4 wherein said extruded metal frame strip is provided with a racket strength factor ($IY_d/A$) in the range of $0.016$(in.$^2$)$Y_d$ to $0.058$(in.$^2$)$Y_d$, wherein the strength factor is the ratio of moment of inertia $I$(in.$^4$) of the frame strip shape around the longitudinal axis of the strip, divided by the transverse cross-sectional area $A$(in.$^2$) of said web and said opposed tubular sections, and $Y_d$(#/in.$^2$) is the yield stress of the strip material.

7. In a metal racket including an extruded metal frame strip having an inner surface of predetermined configuration and being shaped to partially define a generally oval section and also being shaped to provide a pair of spaced apart handle end sections; and a handle secured to said handle end sections; the improvement comprising:

a plastic throat piece provided with outer surfaces shaped complementarily to said predetermined configuration of said inner surface of said frame strip; said plastic throat piece secured to said shaped frame strip and completing in combination with said generally oval section of said shaped strip an oval stringing section for said racket; and said plastic throat piece being flexible and thereby allowing torsional rotation of said metal frame strip in the throat area of said metal racket.

8. A metal racket according to claim 7 wherein said plastic throat piece is provided with a plurality of passages therethrough for receiving string, and each of said passages, at one end thereof, is provided with a raised portion having a curved surface thereon for supporting string.

9. A metal racket according to claim 8 wherein said plastic throat piece is comprised of nylon.

10. A metal racket according to claim 8 wherein said plastic throat piece is comprised of polypropylene.

11. A metal racket according to claim 8 wherein said plastic throat piece is comprised of ABS (acrylonitrile-butadiene-styrene).

12. In a metal racket including a metal frame strip including a pair of spaced apart generally parallel end sections having lower extremities about which a handle is to be formed, the improvement comprising: a solid plastic handle secured to said lower extremities of said end sections and being continuously and homogeneously solid throughout, and for fixedly securing said lower extremities of said end sections in said spaced apart generally parallel relationship.

13. A racket according to claim 12 wherein said plastic handle is a molded plastic handle molded around said lower extremities of said end sections.

14. A metal racket according to claim 13 wherein said molded plastic handle comprises a solid molded plastic handle made of a foamed plastic material.

15. A metal racket according to claim 14 wherein said foamed plastic material is polyurethane foam.

16. A metal racket according to claim 12 wherein said plastic handle is further provided with a wrapping of leather wrapped around said plastic handle.

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ANTON O. OECHSLE, Primary Examiner
R. J. APLEY, Assistant Examiner

U.S. Cl. X.R.

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