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Vaughn et al.

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[54] **TENNIS RACKET HAVING IMPROVED STRENGTH FACTOR**

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Related U.S. Application Data

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[52] **U.S. Cl.** ..... **273/73 C;** 273/73 H

[51] **Int. Cl.** **A63b 49/12**

[58] **Field of Search** .... 273/73 R, 73 C, 73 D, 81 R, 273/DIG. 8

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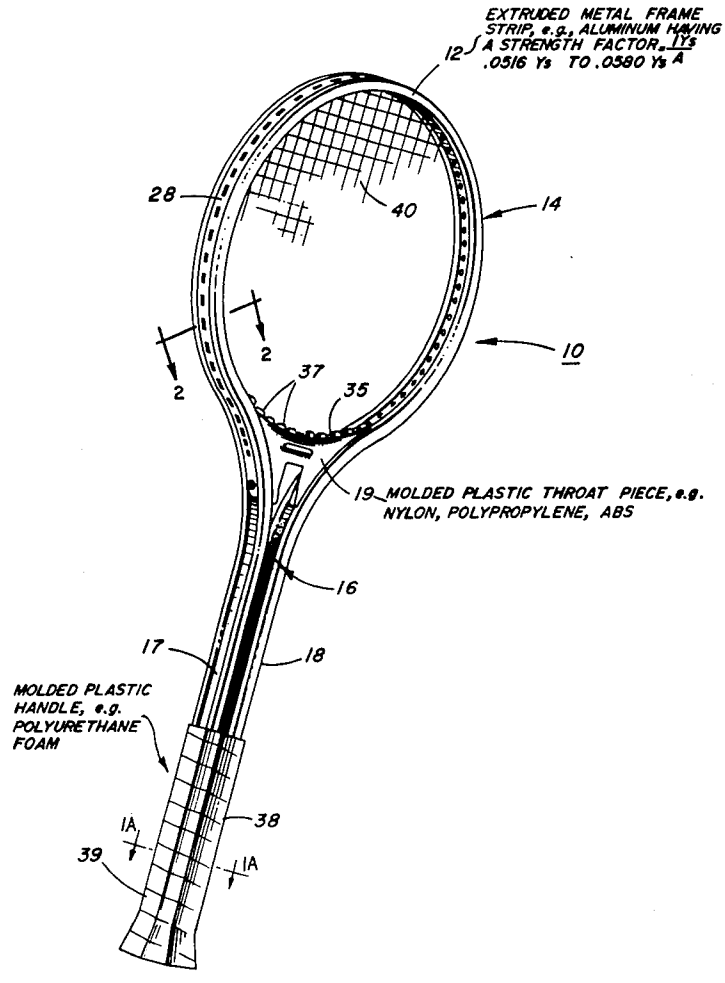
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[57] **ABSTRACT**

A novel tennis racket structure is set forth. The combination of novel frame strip, plastic throat piece structure, grommet means and handle structure provide an improved racket having improved strength characteristics, reliability and durability. A novel frame strip structure provides an improved racket strength factor. The frame strip comprises an extruded metal member having a pair of opposed tubular sections connected by a web and having a cross-sectional configuration for defining a strength factor (IYs/A) in the range of 0.0516 (in^2) Ys to 0.0580 (in^2) Ys.

1 Claim, 7 Drawing Figures



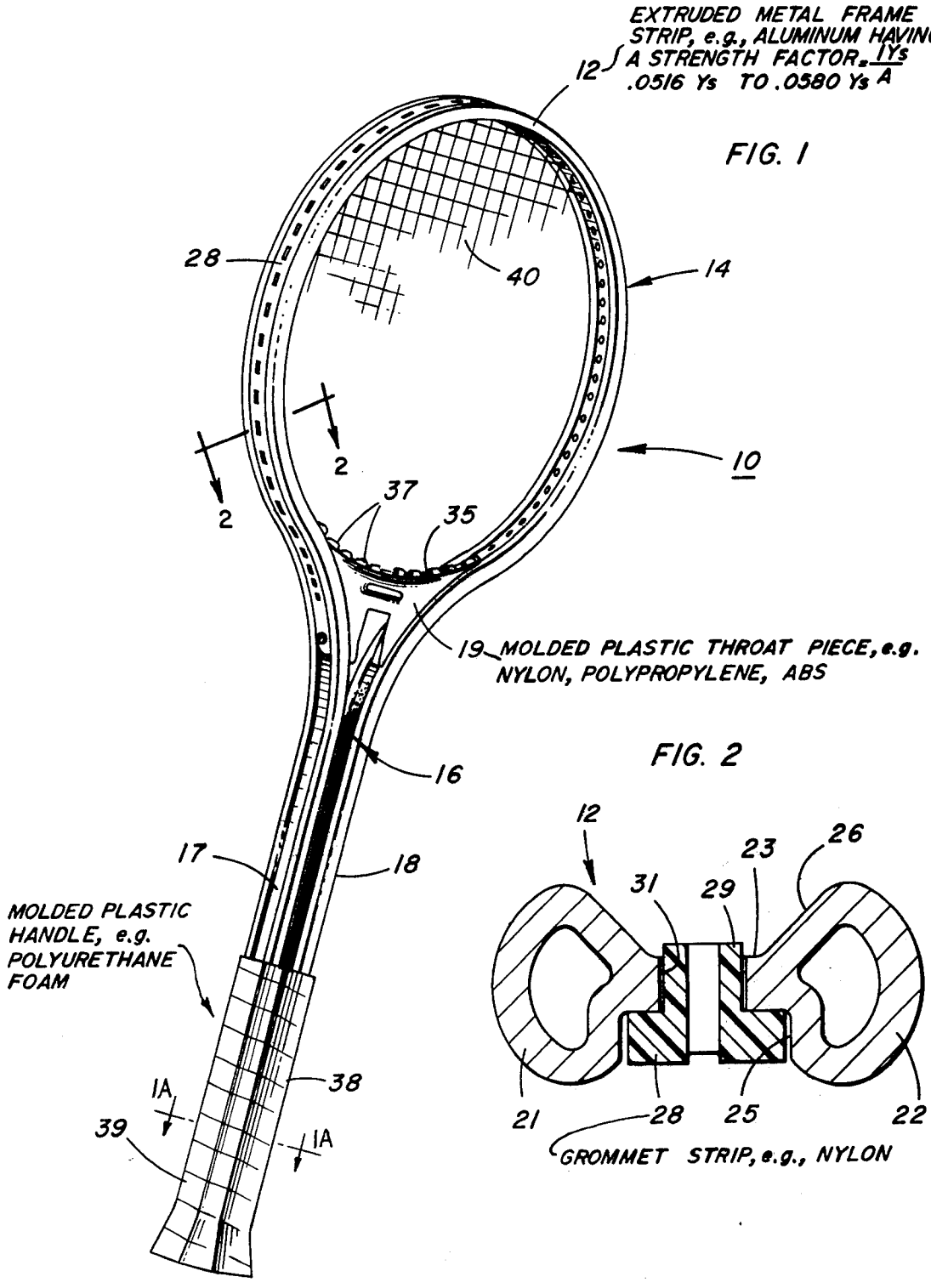

EXTRUDED METAL FRAME STRIP, e.g., ALUMINUM HAVING A STRENGTH FACTOR, $\frac{Ys}{A}$ .0516 Ys TO .0580 Ys
12
28
40
14
10
2
2
37
35
19 MOLDED PLASTIC THROAT PIECE, e.g. NYLON, POLYPROPYLENE, ABS
16
17
18
MOLDED PLASTIC HANDLE, e.g. POLYURETHANE FOAM
1A
1A
38
39

FIG. 1

FIG. 2

12
31
29
23
26
21
28
25
22
GROMMET STRIP, e.g., NYLON

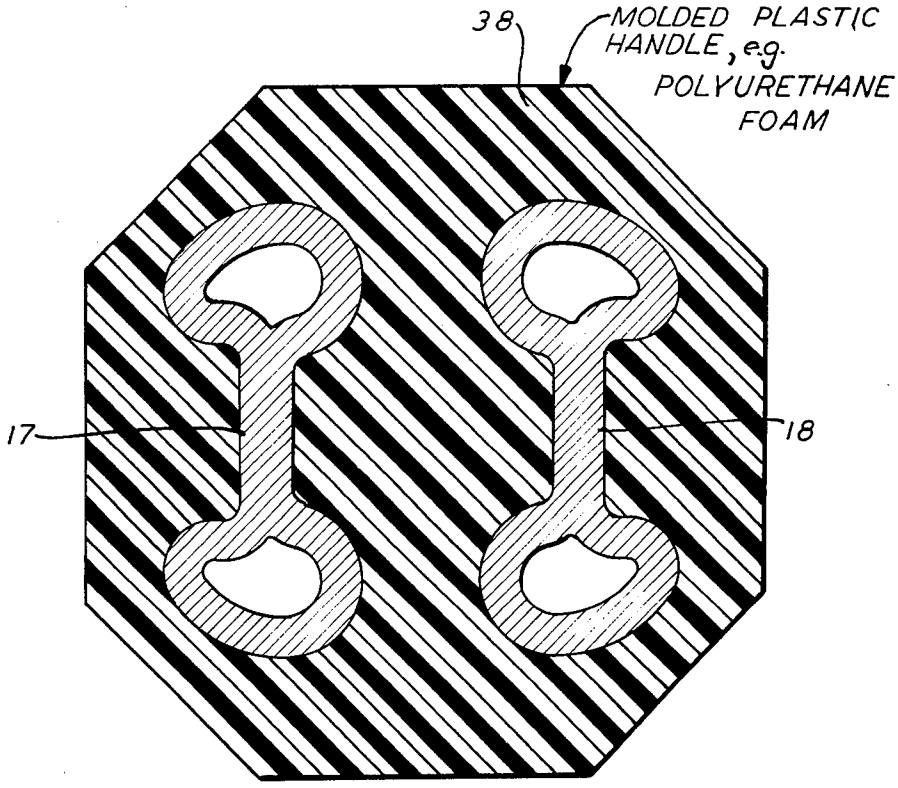
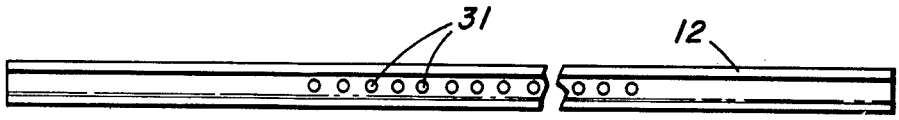


FIG. 1A

FIG. 3A



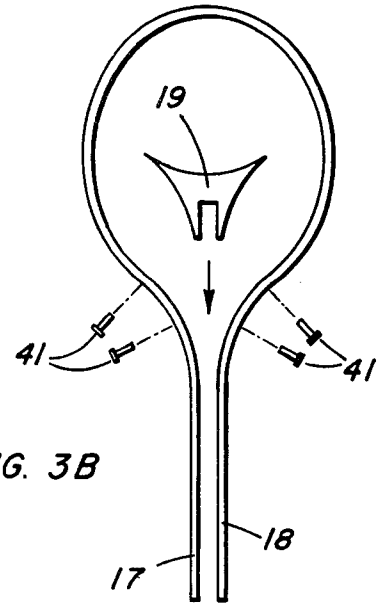
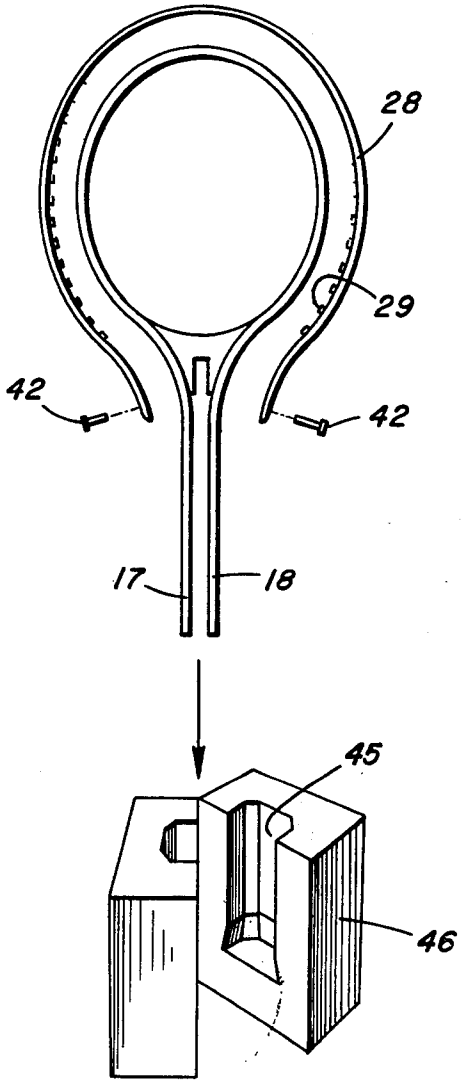


FIG. 3B

FIG. 3C



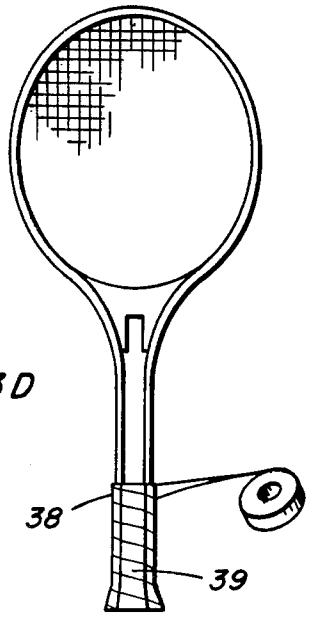


FIG. 3D

TENNIS RACKET HAVING IMPROVED STRENGTH FACTOR

This is a division of application Ser. No. **853,676** filed Aug. **28, 1969,** and now U.S. Pat. No. **3,702,701.**

BACKGROUND OF THE INVENTION

This invention relates to tennis rackets and methods for their manufacture.

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 strip. Typical of the results of these efforts are the racket disclosed in the U.S. patent to La Coste, originally U.S. Pat. No. **3,086,777** and reissued as U.S. Pat. No. Re. **26,128,** and the racket disclosed in the U.S. patent to Allward, U.S. Pat. No. **2,742,289.**

Notwithstanding the efforts expended toward the development of a satisfactory metal frame strip 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 critized 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 frame strips 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 provided 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 grommets provided therethrough. In this regard, even the provision of grommets has not satisfactorily overcome this problem since the shapr edges are equally destructive of the grommet 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 **0.030** to **0.040** inches), 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. Heretofore, 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 shape 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 invention, 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 $0.0516Y_s$ to $0.0580Y_s$.

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 is crosssection to provide a strength factor in the range of $0.0516Y_s$ to $0.0580Y_s$.

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. 1A is a transverse cross-sectional view of the handle in FIG. 1;

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.

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 opposed 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.

Throat piece 19 comprises 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 in enhanced. The inner surface 35 of throat piece 19 is provided with a plurality of raised portions 37 adjacent the surface openings of passages (not shown) provided in throat piece 19 to accommodate the passage of racket strings therethrough. Raised portions 37 define fillets 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 shape 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 self tapping 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 inches 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 davity 45, a charge of suitable foamable 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. 20 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. 24 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 susceptible of slight deformation during stringing so that the string material can make a custom impression on the support 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 for approximately three hours or in room temperature water for approximately 24 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 IY_s/A where I is the moment of inertia of the frame strip shape around its longitudinal axis, Y_s is the yield stress of the material being used and A 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 $0.0442Y_s$ 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 less 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 for 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 $0.0516\ Y_s$ to $0.0580Y_s$, 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 cirtical range is a strip manufactured from 6061-T6 aluminum alloy with the following dimensions:

- Transverse width — 0.750 inches
- Overall thickness — 0.341 inches
- Web thickness — 0.110 inches
- Major radius of outside tubular portions — 0.188 inches
- Transverse width of channel 23 — 0.193 inches
- Transverse width of channel 25 — 0.312 inches
- Thickness of tubular wall — 0.055 inches
- Transverse cross-sectional material area — 0.111 square inches

This strip has been found to be unexpectedly strong, durable and, inter alia, because of the resulting capability 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 of the invention 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 1,400 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 torsion 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 tennis racket structure comprising:

a frame strip for defining a stringing section and a handle section;

said frame strip comprising an extruded metal frame strip having a pair of opposed outer tubular sections connected by a web and being shaped to partially define a generally oval section and a pair of spaced apart generally parallel handle end sections and said web cooperating with said pair of tubular sections to define on one side thereof a generally rectangular channel and on the other side thereof a generally trapezoidal channel;

said frame strip having a cross-sectional configuration for defining a strength factor (IY_s/A) in the range of $0.0516(in^2)\ Y_s$ to $0.0580\ (in^2)Y_s$ wherein

the strength factor is the ratio of the moment of inertia $I(in^4)$ of the frame strip around the longitudinal axis thereof to the transverse cross-sectional area $A(in^2)$ of the strip material, and Y_s is the yield stress of the strip material;

a throat piece consisting solely of plastic and including a pair of opposed surfaces shaped complementarily to conform to the shape of said generally trapezoidal channel of said frame strip and wherein said plastic throat piece possesses such flexibility and resiliency as to prevent deformation in torsion in the throat area of the tennis racket frame in normal play; and

handle means.

* * * * *