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Haines et al.

[11] **3,809,402**

[45] **May 7, 1974**

[54] **TENNIS RACKETS AND FRAMES THEREFOR**

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[73] Assignee: **Dunlop Holdings, Limited**, St. James, London, England

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[21] Appl. No.: **286,001**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 889,642, Dec. 31, 1969, abandoned.

[30] **Foreign Application Priority Data**

Jan. 30, 1969 Great Britain 367/69

[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, 73 G, 273/73 H

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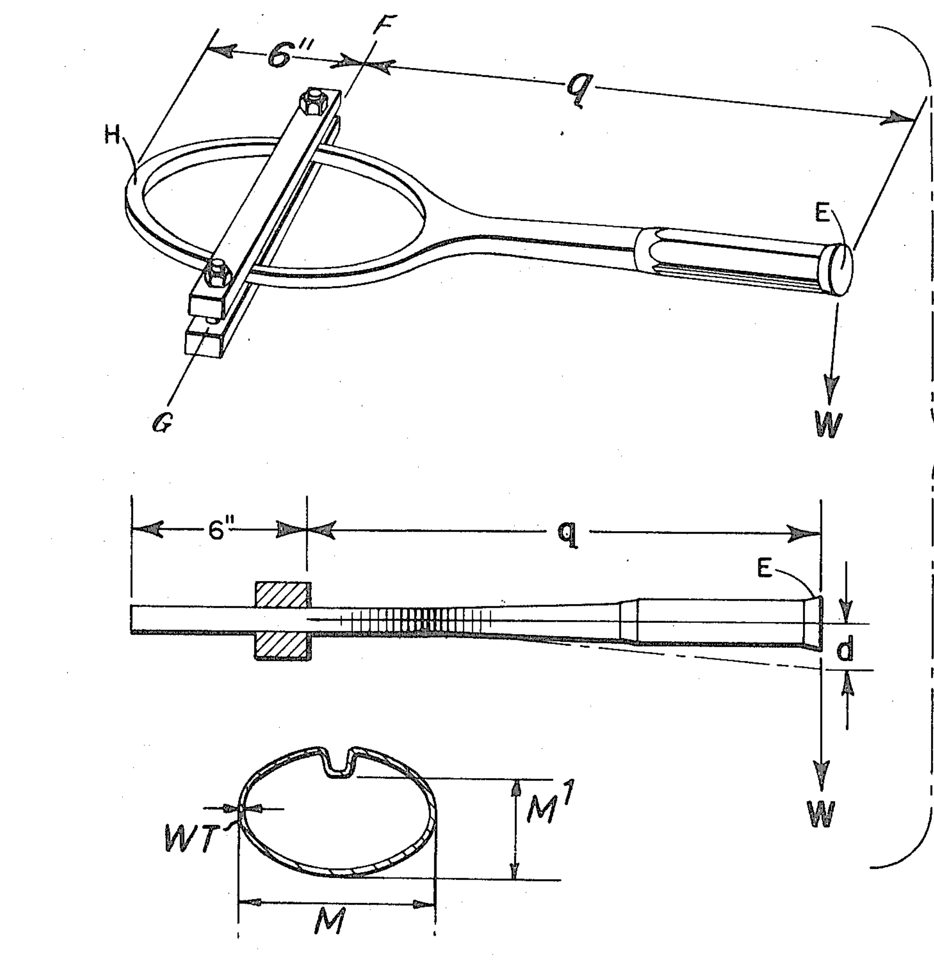
Assistant Examiner—Richard J. Apley
Attorney, Agent, or Firm—Stevens, Davis, Miller and Mosher

[57] **ABSTRACT**

The invention concerns tennis rackets whose frames are formed from steel tube (so called "steel tennis rackets") of enhanced rigidity which gives them superior playing properties. This rigidity can be obtained by choosing steel tube whose dimensions are as follows: (A) the maximum external dimension of the tube cross-section divided by the maximum wall thickness of the tube at the cross-section is at least 26; and (B) the minimum external dimension of the tube cross-section divided by the maximum wall thickness of the tube at the cross-section is at least 13. If the tube is of oval cross-section, the maximum external dimension of the cross-section is preferably in a direction transverse to the plane containing the racket frame, of which the following is a specification.

12 Claims, 11 Drawing Figures



TEST NO. 3

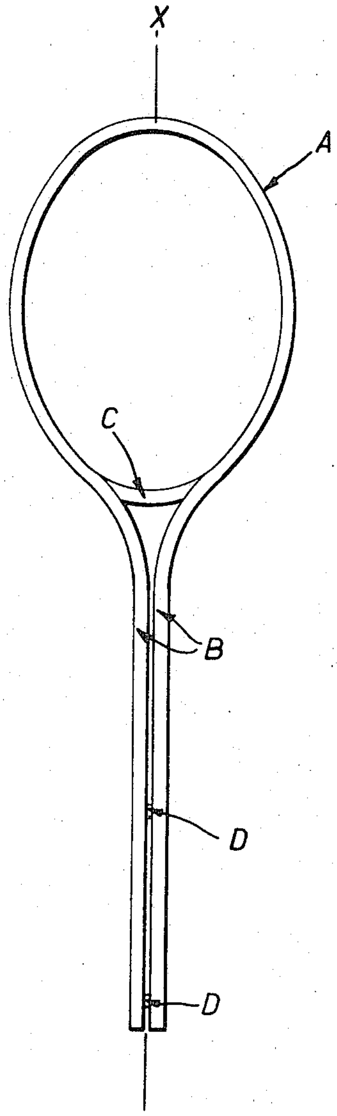


FIG. 1

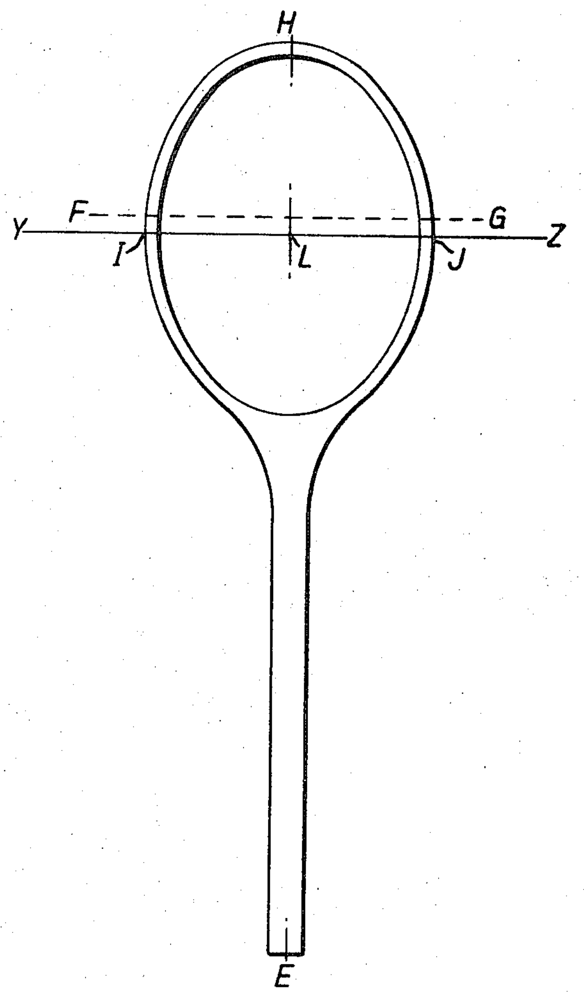


FIG. 2

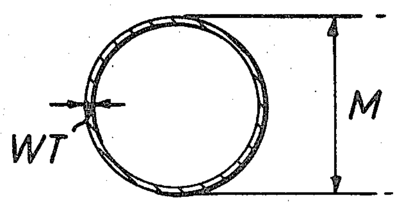


FIG. 3

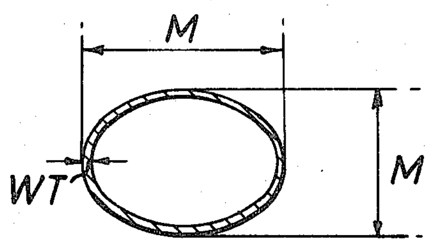


FIG. 4

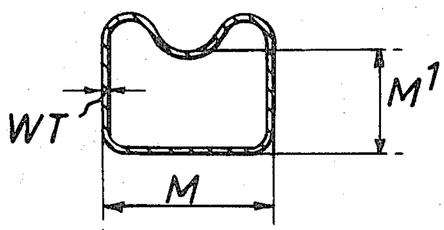


FIG. 5

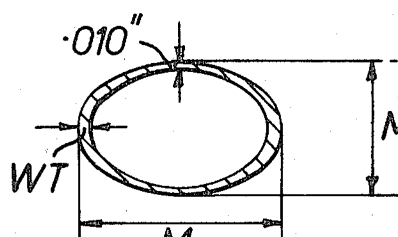


FIG. 6

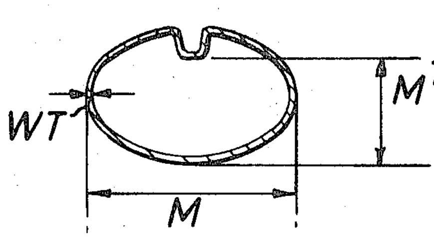


FIG. 7

RELATIONSHIP $A = \frac{M}{WT.} = \frac{\text{MAX. EXT. DIA.}}{\text{MAX. WALL THICKNESS}} \geqq 26$

RELATIONSHIP $B = \frac{M'}{WT} = \frac{\text{MIN. EXT. DIA.}}{\text{MAX. WALL THICKNESS}} \geqq 13$

FIG. 8
TEST NO. 1

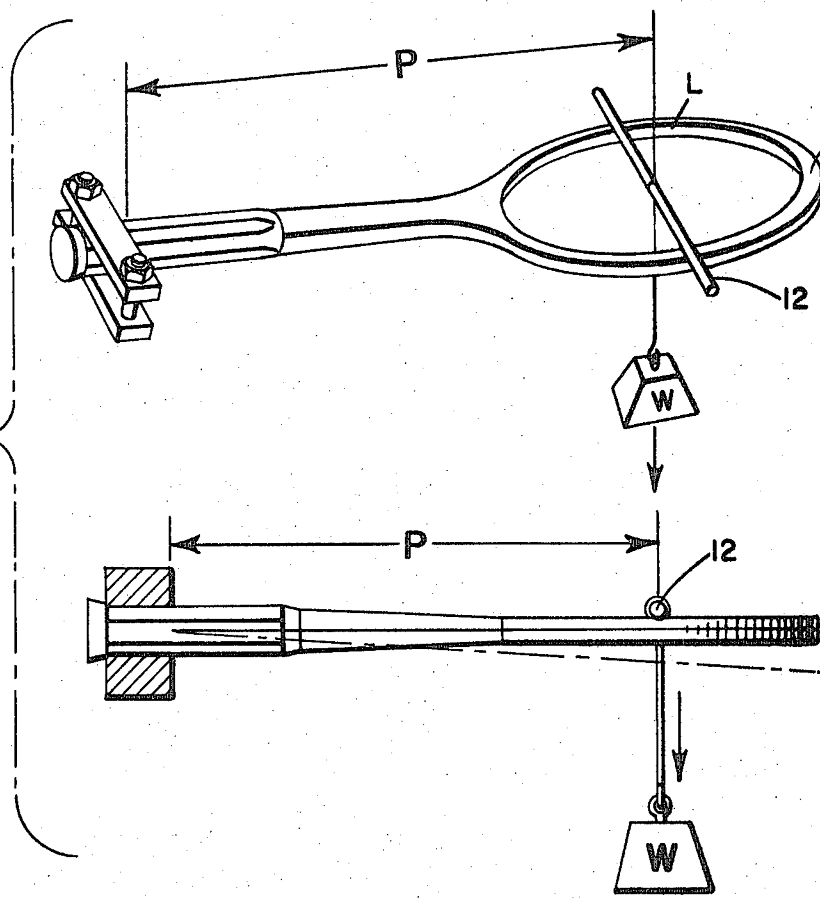
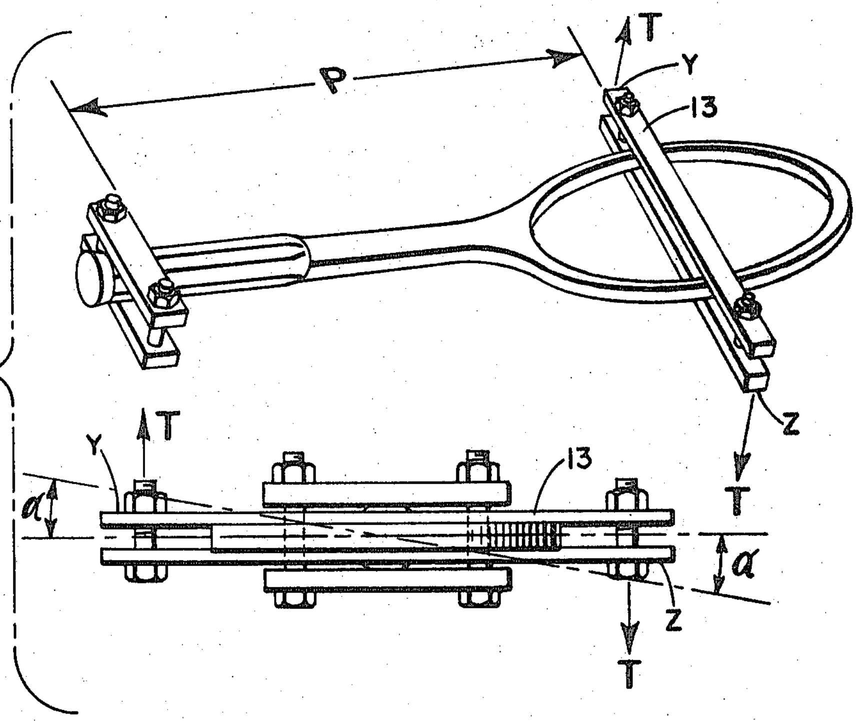


FIG. 9
TEST NO. 2



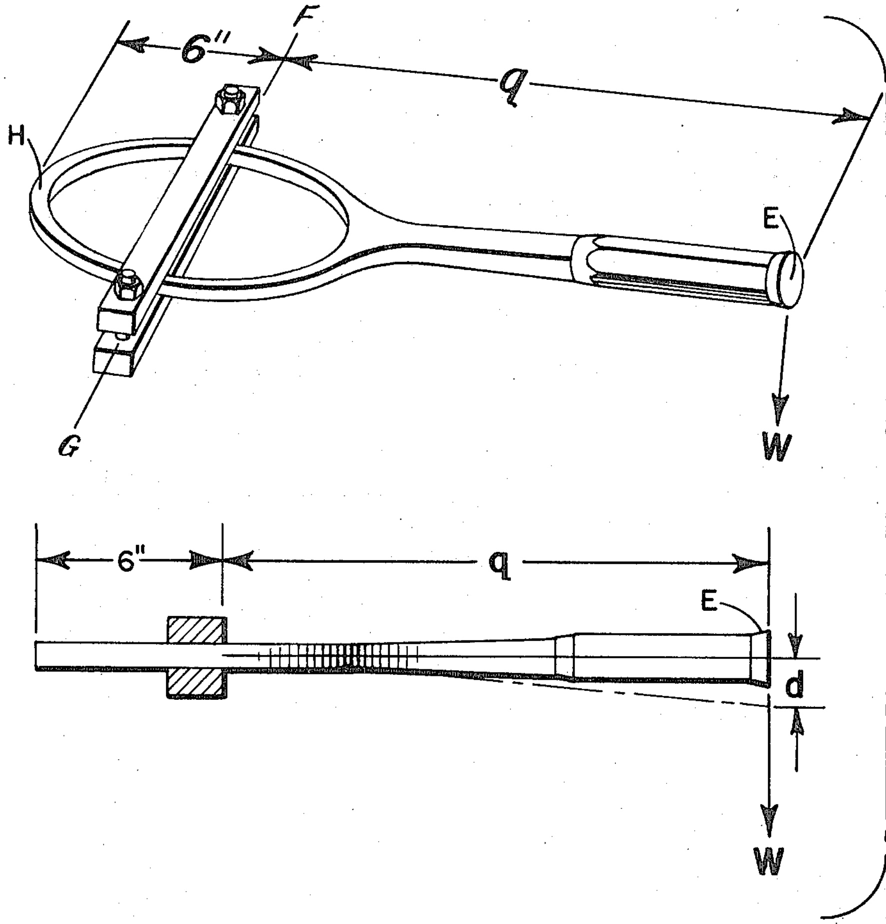


FIG. 10
TEST NO. 3

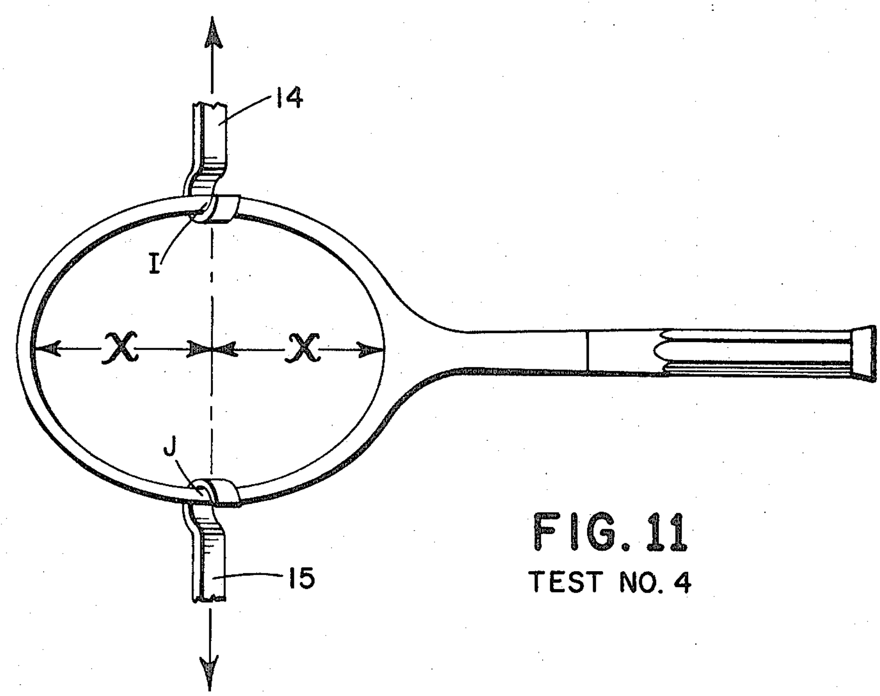


FIG. 11
TEST NO. 4

TENNIS RACKETS AND FRAMES THEREFOR

This application is a continuation-in-part of our copending application Ser. No. 889,642 filed Dec. 31, 1969 and now abandoned.

This invention relates to steel tennis racket frames and rackets made from them.

To illustrate this invention attention is directed to the attached drawings in which:

FIG. 1 is a plan view of a thin shaft tennis racket showing its principal parts;

FIG. 2 is a plan view of a tennis racket showing the location of tests performed thereon;

FIGS. 3 to 7 illustrate cross-sections of steel tubes used for frames of rackets of this invention;

FIGS. 8 to 11 illustrate the positioning and apparatus for a tennis racket while conducting distortion tests 1 to 4, respectively.

DESCRIPTION OF THE INVENTION

During recent years considerable work has been done in the development of tennis rackets having steel frames, usually referred to simply as "steel tennis rackets." These rackets are, for example, often in the form shown in FIG. 1 of the accompanying drawings, in which the head (A) and the twin shafts (B) are made from a length of hollow steel tube, and the frame is completed by means of a bridge-piece (C) and a brace (D) which may or may not be made from the same type of tubing as used for the head and shafts. Hitherto, it has been believed that flexibility in the racket frame was a desirable feature, and indeed "whippy" shafts have been acclaimed as an advantage of steel rackets over wooden rackets.

We have now found that conventional steel rackets are in fact not sufficiently rigid and that considerable improvement is obtained by using frames of increased rigidity. Our experiments have shown that during contact with a ball the conventional racket is distorted, particularly by bending along the longitudinal axis X-X^1 (FIG. 1), and/or by twisting about this axis when the ball strikes the racket asymmetrically. Distortion of the racket in this way results in a reduced amount of energy being imparted to the ball by the racket because the strings are not caused to be elastically distorted to the same degree as would occur if the frame were more rigid. Moreover, in some instances the player experiences difficulty in hitting the ball accurately in the intended direction because the direction of flight of the ball on leaving the racket is effected by the angular distortion of the head of the racket.

However, recognition by us of these deficiencies of conventional steel rackets did not lead to a ready solution. To a large extent the difficulty lay in the need to retain the desirable playing qualities of the rackets and to avoid increasing the weight of the racket beyond what is acceptable by the players. It was also necessary, from a commercial aspect, that the racket should have an attractive appearance which will appeal to players, and this factor alone obviated several solutions to the problem which might otherwise have been possible.

We have now found according to the present invention that rackets of the necessary rigidity can be obtained by the use for the frame of steel tube having a particular cross-section. Thus, we have found that the dimensions of a cross-section of the tube at right-angles to its longitudinal axis should be such that:

a. The ratio of the maximum external dimension of the tube cross-section throughout the frame on the axis perpendicular to the plane containing the racket frame (i.e., the major axis of the cross-section) to the maximum wall thickness of the tube at said cross-section (Relationship A) is at least 26, and

b. The ratio of the external dimension of the tube cross-section throughout the frame on the axis perpendicular to and passing through the midpoint of said major axis (i.e., the minor axis of the cross-section) divided by the maximum wall thickness of the tube at said cross-section (Relationship B) is at least **13.** Relationship A is preferably in the range **26** to **52** and especially in the range 30 to 42; and Relationship B is preferably in the range 13 to 28 and especially in the range 20 to 28.

By way of example, the racket frames of this invention are described hereinafter with reference to the use of twin shafts such as that shown in FIG. **1** of the accompanying drawings, but the invention is not limited to the use of twin shafts and, for example, a single shaft can be used.

A further aspect of the present invention is based on the discovery that a steel racket, if it is to be of a desirable rigidity, should preferably have one or more of the following special characteristics as measured by physical tests described below with reference to FIG. **2** of the drawings and referred to respectively as distortion tests 1, 2, 3 and 4. These tests are illustrated in FIGS. **8-11** respectively. All four tests are made on the frame, that is the racket before stringing; and tests 1, 2 and 3 should be made after the grip has been affixed to the frame. Test 4 may also, if desired, be made after the grip has been affixed to the frame.

DISTORTION TEST 1 — DEFLECTION OF HEAD WITH HANDLE CLAMPED (SEE FIG. 8).

The last 6 inches of the handle end of the frame is clamped firmly with the strings in a horizontal position.

Using a bridge attachment **12** a load W of 50 lbs is applied to the center of the head of the frame at a point "L" 14 inches from the edge of the clamp (i.e., 20 inches from the grip end) so that the head is deflected downwardly in a vertical direction. The displacement d of the head, over length P, at the point "H" is then measured.

DISTORTION TEST 2 — TWIST OF HEAD WITH HANDLE CLAMPED (SEE FIG. 9).

The frame is clamped as in Test 1 and the head is twisted about the longitudinal axis of the handle but with no linear displacement. The twisting couple T is applied on the line YZ by means of a counter weighted beam **13** fastened to the head, 14 inches from the clamp edge. Loads are applied in opposite directions at positions Y and Z in the direction shown by the arrows to provide a torque of 150 inch pound, and the angular displacement α of the frame is measured at line YZ. The test measures torsional stiffness of the frame between the clamps.

DISTORTION TEST 3 — DEFLECTION OF HANDLE WITH HEAD CLAMPED (SEE FIG. 10).

The crown of the racket up to line FG (6 inches from H) is clamped firmly in a horizontal position. A load W of 20 lbs is applied at the end E of the handle and the vertical displacement d of the end of the handle is measured. The stiffness of the racket over length q is measured.

DISTORTION TEST 4 — DISTORTION OF HEAD IN PLANE OF STRINGS (SEE FIG. 11).

The frame without strings is gripped between hooked jaws **14** and **15** in a tension testing machine at I and J.

A load is steadily applied to the frame in a direction opposed to the direction of tension normally exerted by the transverse strings. The deflection X of the frame under the steadily increasing load is plotted in the form of a graph, and the load deflection ratio at a deflection value of one-tenth of an inch is calculated as load (lb)/deflection (inch).

According to a further aspect of the invention, steel rackets preferably have the following properties as measured by the distortion tests:

1. Distortion Test 1.

The vertical displacement of H is not more than 1¾ inches, preferably not more than 1¼ or 1½ inches.

2. Distortion Test 2.

Under a torque of 150 inch pound the angular distortion of the head is not more than 4°, preferably not more than 3°.

3. Distortion Test 3.

The vertical displacement of E is not more than 1¾ inches, preferably not more than 1¼ or 1½ inches.

4. Distortion Test 4.

The load deflection ratio is greater than 450.

The invention is illustrated in the following examples with reference to the accompanying drawings. In the drawings FIG. **1** is a plan view of a tennis racket whose head A and twin shafts B are constituted by a single length of drawn steel tube whose cross-section is uniform along its whole length; FIG. **2** is a diagrammatic representation of a racket of the invention to illustrate the various distortion tests; and FIGS. **3** to **7** are respectively cross-sections of steel tubes used for the frames of rackets of the invention.

EXAMPLES

Examples 1 to 4 refer respectively to four steel tennis rackets constructed in the form shown in FIG. **1** and having a cross-section at right-angles to the longitudinal axis of the tube, (for example on the line X-X¹) as shown respectively in FIGS. **3** to **6**. Thus, for example, the cross-section of the tube of Example 1 (FIG. **3**) is circular whereas that of Example 2 (FIG. **4**) is oval.

The racket of Example 1, being constructed of a steel tube of circular cross-section has the same values for maximum and minimum (i.e., major and minor axes respectively) external dimensions, in each case being 0.625 inch. The wall thickness is 0.023 inch. Thus, both relationships A and B are obtained by the expression: $0.625/0.023 = 27.2$

In Example 2 (see FIG. **4**), where the tube has an oval cross-section and a uniform wall thickness of 0.022 inch the relationships A and B are obtained as follows:

Relationship A = Major axis external dimension/maximum wall thickness $= 0.700/0.022 = 31.8$

Relationship B = Minor axis external dimension/maximum wall thickness

$= 0.500/0.022 = 22.7$

In Example 3 (see FIG. **5**), where the wall thickness is 0.020 inch the major axis external dimension is 0.580 and the minor axis external dimension is 0.350 inch.

Thus Relationship A $= 0.580/0.020 = 29.0$

Relationship B $= 0.350/0.020 = 17.5$

In Example 4 (FIG. **6**) the cross-section of the tube is oval but in this instance the wall thickness varies between 0.025 inch and 0.010 inch. The major axis external dimension is 0.680 inch and the minor axis external dimension is 0.450 inch.

Thus Relationship A $= 0.680/0.025 = 27.2$

Relationship B $= 0.450/0.025 = 18.0$

EXAMPLE 5

There now follows, with reference to FIGS. **1** and **7** of the accompanying drawings, a description of the manufacture of a tennis racket according to a preferred embodiment of the invention from a length of steel alloy tubing of oval cross-section. The major axis (external dimension) of the cross-section was 0.711 inch and the minor axis (minimum external dimension) was 0.497 inch. The wall thickness of the tube was 0.018 inch. A length of this tube 5 feet 1 inch long was first grooved along a length of 21 inches situated symmetrically in the middle of the tube length. This groove was 1/16 inch wide and 3/32 inch deep. The tube was filled with a molten bitumen supporting material which was allowed to solidify, and the tube was then bent into the shape of a racket frame so that the groove in the tube now lay along the outer edge of the loop of the frame (A-FIG. 1). A series of holes were drilled in the loop, the edges of the holes then being deformed by indentation towards the interior of the tube to provide the stringing apertures. The bitumen support material was then melted and drained from the tube.

A bridge piece (C) having appropriate stringing apertures was prepared in a similar way to that described above and then brazed onto the frame loop to provide the head of the racket. Two braces (D) were brazed between the parallel ends (B) of the frame, the upper brace being in such a position that when the wooden handle was subsequently applied, the top of the upper brace coincided with the top of the handle.

The frame was electroplated with chromium and nickel and then two, like wooden handle pieces were glued together about the handle end of the frame and then bound with leather to provide the handle. The racket was completed by the insertion of nylon grommets into the stringing apertures and then strung in a conventional manner.

The racket frame of Example 5, before stringing, was subjected to distortion test 1, 2, 3 and 4, and the following results were obtained:

Test 1: 1.1 inches deflection.
Test 2: 2½ degrees angular distortion.
Test 3: 1.2 inches deflection.
Test 4: 580 load deflection ratio.

The tennis rackets of the invention are preferably made from non-circular — especially elliptical-cross-section tubing because it is desirable to obtain as high a degree of stiffness as possible in a direction perpendicular to the plane containing the strings, that is, the plane containing the head. This is achieved by aligning the larger axis, i.e., major axis, of a tube of asymmetrical cross-section in that direction.

The dimensions of the frames of the rackets of the examples, and their respective relationships A and B are set out in the following Table.

Example No.	Figure No.	Maximum External Dimension (M) (inch) (major axis)	Minimum External Dimension (M') (inch) (minor axis)	Maximum Wall Thickness (WT) (inch)	Relationship A	Relationship B
1	3	0.625	0.625	0.023	27.2	27.2
2	4	0.700	0.500	0.022	31.8	22.7
3	5	0.580	0.350	0.020	29.0	17.5
4	6	0.680	0.450	0.025	27.2	18.0
5	7	0.711	0.497	0.018	39.5	27.6

We claim:

1. A tennis racket frame of greater than conventional rigidity having a head, a throat, a handle portion and a grip at the end of said handle portion, said frame comprising a steel tube having a uniform maximum wall thickness and a cross-section measured at right-angles to its longitudinal axis such that,

a. the ratio of the maximum external dimension of the tube cross-section throughout the frame on a first axis perpendicular to the plane containing the racket frame (i.e., the major axis of the cross-section) to said maximum wall thickness of the tube at said cross-section (Relationship A) is at least 26, and

b. the ratio of the external dimension of the tube cross-section throughout the frame on a second axis perpendicular to and passing through the mid-point of said first perpendicular axis (i.e., the minor axis of the cross-section) to said maximum wall thickness of the tube at said cross-section (Relationship B) is at least 13,

and said frame when subjected to distortion test 3 (as hereinbefore defined) shows a vertical displacement of not more than 1 ¾ inches, said ratios existing uniformly throughout the length of said frame.

2. A frame according to claim 1, in which Relationship A is in the range 26 to 52.

3. A frame according to claim 1, in which Relationship B is in the range 13 to 28.

4. A tennis racket frame according to claim 1, which when subjected to distortion test 3 (as hereinbefore defined) shows a vertical displacement of not more than 1¼ inches.

5. A tennis racket frame according to claim 1, which when subjected to distortion test 1 (as hereinbefore defined) shows a vertical displacement of not more than 1¾ inches.

6. A tennis racket frame according to claim 1, which when subjected to distortion test 1 (as hereinbefore defined) shows a vertical displacement of not more than 1¼ inches.

7. A tennis racket frame according to claim 1, which when subjected to distortion test 2 (as hereinbefore defined) shows (under a torque of 150 inch pound) an angular distortion of not more than 4°.

8. A tennis racket frame according to claim 1, which when subjected to distortion test 2 (as hereinbefore defined) shows (under a torque of 150 inch pound) an angular distortion of not more than 3 degrees.

9. A tennis racket frame according to claim 1, which when subjected to distortion test 4 (as hereinbefore defined) shows a load deflection ratio greater than 450.

10. A tennis racket frame according to claim 1, in which the tube is of circular cross-section.

11. A tennis racket frame according to claim 1, in which the tube is of oval cross-section.

12. A tennis racket obtained by stringing a frame as claimed in claim 1.

* * * * *