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2017276185 12 Dec 2017

GOLF CLUB HEAD WITH STRUCTURAL COLUMNS

ABSTRACT

A golf club head (10) comprising: a body (20) with a hollow interior (27) comprising: a toe structural connector (52) comprising a body with a crown end (52a), a sole end (52b), a forward surface (52c), a rearward surface (52d), a heel surface (52f) and a toe surface (52e); a heel structural connector (50) comprising a body with a crown end (50a), a sole end (50b), a forward surface (50c), a rearward surface (50d), a heel surface and a toe surface (50e); a striking face section (30) having an exterior surface (30a), an interior surface (36), an upper perimeter (31) and a lower perimeter (33); a crown return portion (32) extending rearward from the upper perimeter (31) of the striking face section (30) a distance ranging from 0.5 inches (10 mm) to 1.5 inches (38 mm); and a sole section portion extending rearward from the lower perimeter (33) of the striking face section (30); wherein the crown end (52a) of the toe structural connector (52) is connected to the crown return portion (32), the crown end (50a) of the heel structural connector (50) is connected to the crown return portion (32), the sole end (52b) of the toe structural connector (52) is connected to the sole section, and the sole end (50b) of the heel structural connector (50) is connected to the sole section; wherein a contact surface area (57a, 57b) between the crown return portion (32) and both of the crown end (52a) of the toe structural connector (52) and the crown end (50a) of the heel structural connector (50) ranges from 1% to 5% of the surface area of the crown return portion (32); wherein the toe structural connector (52) and the heel structural connector (50) are positioned approximately parallel to the interior surface (34) of the striking face section (30) and are parallel to each other, wherein the positioning of the toe structural connector (52) and the heel structural connector (50) improves the normalized ball speed relationship to characteristic time; wherein the toe structural connector (52) and the heel structure connector (50) attenuate movement of the crown return portion (32) and the sole section when the striking face section (30) impacts a golf ball.

2017276185 12 Dec 2017

GOLF CLUB HEAD WITH STRUCTURAL COLUMNS

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application is a divisional application of Australian Patent Application No. 2017201154, which is incorporated herein by reference in its entirety. The following are also incorporated by reference in their entirety herein:

- U.S. Patent Application Number 15/423,347, filed on 2 February 2017;
- U.S. Patent Application Number 15/385,549, filed on 20 December 2016;
- U.S. Patent Application Number 15/051,361, filed on 23 February 2016;
- U.S. Patent Application Number 14/997,199, filed on 15 January 2016;
- U.S. Patent Application Number 14/788,326, filed on 30 June 2015;
- U.S. Patent Application Number 14/794,578, filed on 8 July 2015;
- U.S. Patent Application Number 14/755,068, filed on 30 June 2015;
- U.S. Patent Application Number 14/498,843, filed on 26 September 2014, and issued on 16 February 2016 as U.S. Patent Number 9,259,627;
- U.S. Patent Application Number 14/173,615, filed on 5 February 2014, and issued on 10 November 2015 as U.S. Patent Number 9,180,349;
- U.S. Patent Application Number 14/039,102, filed on 27 September 2013, and issued on 16 September 2014 as U.S. Patent Number 8,834,294;
- U.S. Patent Application Number 13/797,404, filed on 21 March 2013;
- U.S. Provisional Patent Application Number 61/665,203, filed on 27 June 2012;
- U.S. Provisional Patent Application Number 61/684,079, filed on 16 August 2012;
- U.S. Patent Application Number 14/622,606, filed on 13 February 2015, and issued on 24 May 2016 as U.S. Patent Number 9,345,936; and
- U.S. Patent Application Number 13/906,572, filed on 31 May 2013, and issued on 17 February 2015 as U.S. Patent Number 8,956,244.

2017276185 12 Dec 2017

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a golf club head. More specifically, the present invention relates to a golf club head with stress-reducing features connecting a crown portion with a sole portion via a hollow interior and disposed proximate a striking face section.

Description of the Related Art

[0003] The prior art discloses various golf club heads having interior structures. For example, Kosmatka, U.S. Patent Number 6299547 for a Golf Club Head With an Internal Striking Plate Brace, discloses a golf club head with a brace to limit the deflection of the striking plate, Yabu, U.S. Patent Number 6852038 for a Golf Club Head And Method of Making The Same, discloses a golf club head with a sound bar, Galloway, U.S. Patent Number 7118493 for a Multiple Material Golf Club Head, discloses a golf club head with a composite aft body having an interior sound component extending upward from a sole section of a metal face component, Seluga et al., U.S. Patent Number 8834294 for a Golf Club Head With Center Of Gravity Adjustability, discloses a golf club head with a tube having a mass for adjusting the CG of a golf club head, and Dawson et al., U.S. Patent Number 8900070 for a Weighted Golf Club Head discloses a golf club head with an interior weight lip extending from the sole towards the face. However, the prior art fails to disclose an interior structure that increases ball speed through reducing stress in the striking face section at impact, with a minimal increase in mass to the golf club head.

OBJECT OF THE INVENTION

[0004] It is an object of the present invention to overcome or at least ameliorate the above problem.

BRIEF SUMMARY OF THE INVENTION

[0005] The present disclosure relates to a golf club head comprising interior structures connecting a crown section to a sole section to reduce the stress in a striking face section during

2017276185 24 Jan 2019

impact with a golf ball. In some embodiments, the interior structures are hollow tubes or solid rods composed of a titanium alloy.

[0005a] In accordance with an aspect of the present invention, there is provided a golf club head comprising:

a body with a hollow interior comprising:

a toe structural connector comprising a body with a crown end, a sole end, a forward surface, a rearward surface, a heel surface and a toe surface;

a heel structural connector comprising a body with a crown end, a sole end, a forward surface, a rearward surface, a heel surface and a toe surface;

a striking face section having an exterior surface, an interior surface, an upper perimeter and a lower perimeter;

a crown return portion extending rearward from the upper perimeter of the striking face section a distance ranging from 0.5 inches (13 mm) to 1.5 inches (38 mm); and

a sole section portion extending rearward from the lower perimeter of the striking face section;

wherein the crown end of the toe structural connector is connected to the crown return portion, the crown end of the heel structural connector is connected to the crown return portion, the sole end of the toe structural connector is connected to the sole section, and the sole end of the heel structural connector is connected to the sole section;

wherein a contact surface area between the crown return portion and both of the crown end of the toe structural connector and the crown end of the heel structural connector ranges from 1% to 5% of the surface area of the crown return portion;

wherein the toe structural connector and the heel structural connector are positioned approximately parallel to the interior surface of the striking face section and within 1 inch (25 mm) from the interior surface of the striking face, and are parallel to each other, wherein the positioning of the toe structural connector and the heel structural connector improves the normalized ball speed relationship to characteristic time such that the gold club head satisfies the equation $V_{ballnorm} \geq 0.0356x+140.82$,

wherein the variable "x" is the characteristic time in micro-seconds, and

wherein $V_{ballnorm} = \frac{m_h V_{inh} + m_h V_{inh}\left[\frac{V_{cr}}{V_{ctn}}\left(1+\frac{m_b}{m_c}\right)\frac{m_b}{m_c} + \frac{V_{br}}{V_{btn}}\left(1+\frac{m_b}{m_p}\right)\frac{m_b}{m_p} - 0.822\right]}{m_h + m_b}$;

wherein the toe structural connector and the heel structure connector attenuate movement of the crown return portion and the sole section when the striking face section impacts a golf ball.

2017276185 24 Jan 2019

[0005b] In accordance with an aspect of the present invention, there is provided a golf club head comprising:

a body with a hollow interior comprising:

a toe structural connector comprising a body with a crown end, a sole end, a forward arc surface, a rearward arc surface, a heel arc surface and a toe arc surface;

a heel structural connector comprising a body with a crown end, a sole end, a forward arc surface, a rearward arc surface, a heel arc surface and a toe arc surface;

a striking face section having an exterior surface, an interior surface, an upper perimeter and a lower perimeter;

a crown return portion extending rearward from the upper perimeter of the striking face section;

a sole section portion extending rearward from the lower perimeter of the striking face section; and

a hosel section;

a crown body attached to the crown return portion;

wherein the crown end of the toe structural connector is connected to the crown return portion, the crown end of the heel structural connector is connected to the crown return portion, the sole end of the toe structural connector is connected to the sole section, and the sole end of the heel structural connector is connected to the sole section;

wherein a contact surface area between the crown return portion and both of the crown end of the toe structural connector and the crown end of the heel structural connector ranges from 1% to 5% of the surface area of the crown return portion;

wherein the toe structural connector and the heel structural connector are positioned approximately parallel to the interior surface of the striking face section and within 1 inch (25 mm) from the interior surface of the striking face, and are parallel to each other, wherein the positioning of the toe structural connector and the heel structural connector improves the normalized ball speed relationship to characteristic time such that the gold club head satisfies the equation $V_{ballnorm} \geq 0.0356x+140.82$,

wherein the variable "x" is the characteristic time in micro-seconds, and

wherein $V_{ballnorm} = \frac{m_h V_{inh} + m_h V_{inh}\left[\frac{V_{cr}}{V_{cin}}\left(1+\frac{m_b}{m_c}\right)\frac{m_b}{m_c}+\frac{V_{br}}{V_{bin}}\left(1+\frac{m_b}{m_p}\right)\frac{m_b}{m_p}-0.822\right]}{m_h+m_b}$;

wherein the toe structural connector and the heel structural connector attenuate movement of the crown return portion and the sole section when the striking face section impacts a golf ball.

2017276185 24 Jan 2019

[0006] Also disclosed herein is a golf club head comprising:

a body with a hollow interior comprising:

a toe structural connector comprising a body with a crown end, a sole end, a forward surface, a rearward surface, a heel surface and a toe surface;

a heel structural connector comprising a body with a crown end, a sole end, a forward surface, a rearward surface, a heel surface and a toe surface;

a striking face section having an exterior surface, an interior surface, an upper perimeter and a lower perimeter;

a crown return portion extending rearward from the upper perimeter of the striking face section a distance ranging from 0.5 inches (10 mm) to 1.5 inches (38 mm); and

a sole section portion extending rearward from the lower perimeter of the striking face section;

wherein the crown end of the toe structural connector is connected to the crown return portion, the crown end of the heel structural connector is connected to the crown return portion, the sole end of the toe structural connector is connected to the sole section, and the sole end of the heel structural connector is connected to the sole section;

wherein a contact surface area between the crown return portion and both of the crown end of the toe structural connector and the crown end of the heel structural connector ranges from 1% to 5% of the surface area of the crown return portion;

wherein the toe structural connector and the heel structural connector are positioned approximately parallel to the interior surface of the striking face section and are parallel to each other, wherein the positioning of the toe structural connector and the heel structural connector improves the normalized ball speed relationship to characteristic time;

wherein the toe structural connector and the heel structure connector attenuate movement of the crown return portion and the sole section when the striking face section impacts a golf ball.

[0007] Also disclosed herein is a golf club head comprising:

a body with a hollow interior comprising:

a toe structural connector comprising a body with a crown end, a sole end, a forward arc surface, a rearward arc surface, a heel arc surface and a toe arc surface;

a heel structural connector comprising a body with a crown end, a sole end, a forward arc surface, a rearward arc surface, a heel arc surface and a toe arc surface;

2017276185 24 Jan 2019

a striking face section having an exterior surface, an interior surface, an upper perimeter and a lower perimeter;

a crown return portion extending rearward from the upper perimeter of the striking face section;

a sole section portion extending rearward from the lower perimeter of the striking face section; and

a hosel section;

a crown body attached to the crown return portion;

wherein the crown end of the toe structural connector is connected to the crown return portion, the crown end of the heel structural connector is connected to the crown return portion, the sole end of the toe structural connector is connected to the sole section, and the sole end of the heel structural connector is connected to the sole section;

wherein a contact surface area between the crown return portion and both of the crown end of the toe structural connector and the crown end of the heel structural connector ranges from 1% to 5% of the surface area of the crown return portion;

wherein the toe structural connector and the heel structural connector are positioned approximately parallel to the interior surface of the striking face section and are parallel to each other, wherein the positioning of the toe structural connector and the heel structural connector improves the normalized ball speed relationship to characteristic time;

wherein the toe structural connector and the heel structural connector attenuate movement of the crown return portion and the sole section when the striking face section impacts a golf ball.

2017276185 12 Dec 2017

[0008] There is also disclosed herein a golf club head comprising:

a metal body with a hollow interior comprising:

a toe structural connector comprising a body with a crown end, a sole end, a forward surface, a rearward surface, a heel surface and a toe surface;

a heel structural connector comprising a body with a crown end, a sole end, a forward surface, a rearward surface, a heel surface and a toe surface;

a striking face section having an exterior surface, an interior surface, an upper perimeter and a lower perimeter;

a crown return portion extending rearward from the upper perimeter of the striking face section a distance ranging from 0.5 inches (10 mm) to 1.5 inches (38 mm); and

a sole section portion extending rearward from the lower perimeter of the striking face section;

wherein the crown end of the toe structural connector is connected to the crown return portion, the crown end of the heel structural connector is connected to the crown return portion, the sole end of the toe structural connector is connected to the sole section, and the sole end of the heel structural connector is connected to the sole section;

wherein a contact surface area between the crown return portion and both of the crown end of the toe structural connector and the crown end of the heel structural connector ranges from 1% to 5% of the surface area of the crown return portion;

wherein the toe structural connector and the heel structural connector are positioned approximately parallel to the interior surface of the striking face section, are parallel to each other and are each spaced from 0.136 inch (3.45 mm) to 0.210 inch (5.33 mm) from the interior surface of the striking face section, wherein the positioning of the toe structural connector and the heel structural connector improves the normalized ball speed relationship to characteristic time;

wherein the toe structural connector and the heel structure connector attenuate movement of the crown return portion and the sole section when the striking face section impacts a golf ball.

[0009] There is also disclosed herein a golf club head comprising:

a metal body with a hollow interior comprising:

a toe structural connector comprising a body with a crown end, a sole end, a forward arc surface, a rearward arc surface, a heel arc surface and a toe arc surface;

2017276185 12 Dec 2017

a heel structural connector comprising a body with a crown end, a sole end, a forward arc surface, a rearward arc surface, a heel arc surface and a toe arc surface;

a striking face section having an exterior surface, an interior surface, an upper perimeter and a lower perimeter;

a crown return portion extending rearward from the upper perimeter of the striking face section;

a sole section portion extending rearward from the lower perimeter of the striking face section; and

a hosel section;

a crown body attached to the crown return portion, the crown body composed of a carbon composite material;

wherein the crown end of the toe structural connector is connected to the crown return portion, the crown end of the heel structural connector is connected to the crown return portion, the sole end of the toe structural connector is connected to the sole section, and the sole end of the heel structural connector is connected to the sole section;

wherein a contact surface area between the crown return portion and both of the crown end of the toe structural connector and the crown end of the heel structural connector ranges from 1% to 5% of the surface area of the crown return portion;

wherein the toe structural connector and the heel structural connector are positioned approximately parallel to the interior surface of the striking face section, are parallel to each other and are each spaced from 0.136 inches (3.45 mm) to 0.210 inches (5.33 mm) from the interior surface of the striking face section, wherein the positioning of the toe structural connector and the heel structural connector improves the normalized ball speed relationship to characteristic time;

wherein the toe structural connector and the heel structural connector attenuate movement of the crown return portion and the sole section when the striking face section impacts a golf ball.

[0010] In some embodiments, each of the structural connectors comprises a structure selected from the group consisting of a solid rod and a hollow tube. In another, further embodiment, each of the structural connectors is a solid rod composed of a metal material selected from the group consisting of titanium alloy and steel. In an alternative embodiment, each of the structural connectors is located no more than 0.25 inches from the rear face surface along the vertical plane extending through the face center perpendicular to the striking face section.

2017276185 12 Dec 2017

[0011] There is also disclosed herein a golf club head comprising a metal body comprising a striking face section, a sole section extending from a lower edge of the striking face section, and a return section extending from an upper edge of the striking face section, the return section and sole section defining an upper opening, and the striking face section, sole section, and return section defining a hollow body interior, and first and second structural connectors disposed within the hollow body interior and extending from the return section to the sole section, wherein each of the first and second structural connectors is a solid metal rod, wherein no portion of either the first or second structural connectors makes contact with the striking face section, wherein the golf club head satisfies the equation $V_{ballnorm} \geq 0.0356x + 140.82$, and wherein $V_{ballnorm} = \frac{m_h V_{inh} + m_h V_{inh}\left[\frac{V_{cr}}{V_{cin}}\left(1+\frac{m_b}{m_c}\right)+\frac{m_b}{m_c}+\frac{V_{br}}{V_{bin}}\left(1+\frac{m_b}{m_p}\right)+\frac{m_b}{m_p}-0.822\right]}{m_h+m_b}$.

In a further embodiment, the golf club head may comprise a crown insert that may be permanently affixed to the body to close the upper opening. In some embodiments, the crown insert may be composed of a carbon composite material, and each of the first and second stiffening members may be integrally cast with the body.

[0012] There is also disclosed herein a golf club head comprising a metal body comprising a striking face section, a sole section extending from a lower edge of the striking face section, a return section extending from an upper edge of the striking face section, and an aft end opposite the striking face section, the return section and sole section defining an upper opening, and the striking face section, sole section, and return section defining a hollow body interior, first and second structural connectors disposed within the hollow body interior and extending from the return section to the sole section, and a carbon composite crown insert permanently affixed to the body to close the upper opening, wherein each of the first and second structural connectors is located closer to the striking face section than to the aft end within the hollow body interior, wherein the golf club head has a volume of 420 cubic centimeters to 470 cubic centimeters, wherein the golf club head satisfies the equation $V_{ballnorm} \geq 0.0356x + 141.19$, and wherein $V_{ballnorm} = \frac{m_h V_{inh} + m_h V_{inh}\left[\frac{V_{cr}}{V_{cin}}\left(1+\frac{m_b}{m_c}\right)+\frac{m_b}{m_c}+\frac{V_{br}}{V_{bin}}\left(1+\frac{m_b}{m_p}\right)+\frac{m_b}{m_p}-0.822\right]}{m_h+m_b}$.

[0013] In some embodiments, the first structural connector comprises an upper end proximate the return section and a lower end proximate the sole section, the upper end is spaced a first distance from the striking face section, and the lower end is spaced a second distance from the striking face section that is greater than the first distance. In a further embodiment, the first

2017276185 12 Dec 2017

distance is 0.120 inches to 0.150 inches, and the second distance is 0.180 inches to 0.210 inches. In another embodiment, each of the first and second structural connectors has a length of 1.00 inch to 2.50 inches, the first structural connector extends approximately parallel with the second structural connector, and the first structural connector is spaced a distance of 0.75 inch to 1.50 inch from the second structural connector.

[0014] Having briefly described embodiments of the present invention, the above and further features thereof will be recognized by those skilled in the pertinent art from the following detailed description of the invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0015] Preferred embodiments of the invention will be described hereinafter, by way of examples only, with reference to the accompanying drawings, wherein:

[0016] FIG. 1 is a top elevational view of the preferred embodiment of a golf club head with structural connectors.

[0017] FIG. 2 is a sole elevational view of the golf club head shown in FIG. 1.

[0018] FIG. 3 is a cross-sectional view of the golf club head shown in FIG. 1 along lines 3-3.

[0019] FIG. 3A is a cross-sectional view of the golf club head shown in FIG. 1 along lines 3-3 illustrating the surfaces of the structural connectors.

[0020] FIG. 4 is a cross-sectional view of the golf club head shown in FIG. 3 along lines 4-4.

[0021] FIGS. 5is a cross-sectional view of the golf club head shown in FIG. 3 along line 5-5.

[0022] FIGS. 5A is a cross-sectional view of the golf club head shown in FIG. 3 along line 5-5.

[0023] FIGS. 6 is a cross-sectional view of the golf club head shown in FIG. 3 along line 6-6.

[0024] FIG. 7 is a top perspective view of the golf club head shown in FIG. 1 with its crown insert and sole cover piece removed.

2017276185 12 Dec 2017

[0025] FIG. 8 is a sole perspective view of the embodiment shown in FIG. 7.

[0026] FIG. 9 is a flow chart describing how to calculate the normalized ball speed of a golf club head, including the embodiment shown in FIG. 1.

[0027] FIG. 10 is a top plan view of an exemplary calibration plate used to calculate normalized ball speed of a golf club head.

[0028] FIG. 11 is a cross-sectional view of the calibration plate shown in FIG. 10 along lines 11-11.

[0029] FIG. 12 is a graph showing the relationship between normalized ball speed (y-axis) and Characteristic Time (μs) (x-axis) of prior art golf club heads and the golf club head described herein.

[0030] FIG. 13 is a cross-sectional view of a golf club head.

[0031] FIG. 14 is a top plan view of a golf club head.

[0032] FIG. 15 is a top perspective view of a golf club head.

[0033] FIG. 16 is a bottom perspective view of a golf club head.

[0034] FIG. 17 is an isolated internal view of a golf club head.

[0035] FIG. 18 is an isolated internal view of an intersection of the structural connectors and a return section of a golf club head.

[0036] FIG. 19 is a front elevation view of a golf club head with structural columns with a face removed to illustrate the interior of the golf club head.

2017276185 12 Dec 2017

DETAILED DESCRIPTION OF THE INVENTION

[0037] A preferred embodiment of the golf club head 10 with structural connectors is shown in FIGS. 1-8. The golf club head 10 preferably includes a body 20 having a striking face section 30 with a face center 34, a return section 32 extending rearwards away from an upper edge 31 of the striking face section 30, sole section 22 extending rearwards away from a lower edge 33 of the striking face section 30, a hosel 24 for engaging a shaft, a heel end 23, a toe end 25, an upper opening 26, a hollow interior 27, and an aft end 28. A crown section 40 is comprised of the return section 32 and a crown insert 42 that is placed over the upper opening 26 to enclose the hollow interior 27. The body 20 also includes three cutouts 70, 72, 74 in a center area 21 of the sole section 22, which are closed by a cover piece 80 having a density that is lower than the density of the material used to make the body 20. Each of the crown section 40 and cover piece 80 preferably is composed of a carbon composite material, while the body 20 is composed of a metal material such as titanium alloy or steel.

[0038] Within the hollow interior 27, two structural connectors 50, 52 extend from the sole section 22 upward to the return section 32 approximately parallel with the rear surface 36 of the striking face section 30 and with each other. In an alternative embodiment, the structural connectors 50, 52 extend to the crown insert 42 instead; what is important is that the structural connectors 50, 52 connect the crown section 40 to the sole section 22 proximate the striking face section 30, without making contact with any portion of the striking face section 30, even when the striking face section 30 impacts a golf ball. The structural connectors 50, 52 must, in any event, be closer to the striking face section 30 than to the aft end 28 of the body 20.

[0039] As shown in Figure 3, the preferred embodiment has two structural connectors 50, 52, each of which is a solid rod composed of a lightweight, strong metal material such as titanium alloy or steel, though in an alternative embodiment the structural connectors 50, 52 each may be a hollow tube or other hollow structure made of a strong lightweight metal or a composite material. In another embodiment, the golf club head 10 may include both the solid rod and hollow types of structural connectors 50. The structural connectors 50, 52 preferably are co-cast with the body 20 using a wax molding process, though in alternative embodiments may be added after the body 20 is manufactured and secured to the body 20 via welding, brazing, solder, or adhesive, and/or mechanically.

2017276185 12 Dec 2017

[0040] In the preferred embodiment, each of the structural connectors 50, 52 has a diameter of 0.050 inch to 0.200 inch and a length of 1 to 2.5 inches. The structural connectors 50, 52 are both preferably located within 1 inch of the rear surface 36 of the striking face section 30 measured along a vertical plane 60 extending through the face center 34 perpendicular to the striking face section 30. No portion of any structural connectors 50, 52 should be located outside of this 1-inch range; in fact, it is more preferable for each structural connector 50, 52 to be located even closer to the rear surface 36 of the striking face section 30. In the preferred embodiment, the structural connectors are spaced 0.136 inch to 0.210 inch from the rear surface 36, with the upper end 50a, 52a of each structural connector 50, 52 spaced a distance D_1 that is slightly closer to the rear surface 36 than the spacing D_2 of the lower end 50b, 52b. In the preferred embodiment, D_1 ranges from 0.120 inch to 0.150 inch, while D_2 ranges from 0.180 inch to 0.210 inch. The structural connectors 50, 52 are also spaced from one another by a distance D_3 of 0.500 to 2.00 inch, more preferably approximately 0.75 to 1.50 inch, and most preferably approximately 1.00 inch. This positioning of the structural connectors 50, 52 optimizes the normalized ball speed relationship to Characteristic Time (CT), as measured in μs by the U.S. Golf Association (USGA) CT test.

[0041] Normalized ball speed removes the variable effect of a golf club head's mass and loft, and the construction of a particular golf ball, from testing the speed of a golf ball upon impact with any given golf club head, including the golf club head 10 of the present invention; in other words, it allows an apples-to-apples comparison of golf club head performance. Normalized ball speed can be determined for a golf club head using the following steps, which are also outlined in the flow chart of Figure 9.

[0042] First, provide a titanium 6-4 calibration plate 90 with a mass of approximately 190 grams, a diameter D_4 of approximately 4 inches, a minimum thickness T_1 of approximately 0.100-0.150 inch, and a maximum thickness T_2 of approximately 0.200-0.400 inch, as shown in Figures 10 and 11, and strike the center 92 of the calibration plate with a test golf ball moving at approximately 109 mph (step 100). Measure the return velocity V_{br} of the ball (step 110). Then, strike the same test golf ball, again traveling at approximately 109 mph, with the center 34 of the striking face section 30 of the golf club head 10 being assessed (step 120), and measure the rebound velocity V_{cr} of the test golf ball (step 130). Next, measure and record the mass of the plate m_p, golf ball m_b, golf club head 10 m_c, measured head test ball in velocity (109 mph target) V_{cin}, measured plate test ball in velocity (109 mph target) V_{bin}, measured head test ball

2017276185 12 Dec 2017

return velocity V_{cr}, and measured plate test ball return velocity V_{br} (step 140). Finally, calculate the normalized ball speed ($V_{ballnorm}$) using the following equation (step 150):

$$V_{ballnorm} = \frac{m_h V_{inh} + m_h V_{inh}\left[\frac{V_{cr}}{V_{cin}}\left(1+\frac{m_b}{m_c}\right)+\frac{m_b}{m_c}+\frac{V_{br}}{V_{bin}}\left(1+\frac{m_b}{m_p}\right)+\frac{m_b}{m_p}-0.822\right]}{m_h + m_b}$$

In this equation, V_{inh} is 100 and m_h is 200.

[0043] The golf club head 10 of the present invention has a $V_{ballnorm} \geq 0.0356x + 140.82$, and more preferably a $V_{ballnorm} \geq 0.0356x + 141.19$. The positioning of the structural connectors 50, 52 allow the golf club head 10 to satisfy this equation; as shown in Figure 12, prior art golf club heads, which do not include the structural connector structure, fall well short of this performance metric.

[0044] In addition to optimizing the normalized ball speed of the golf club head 10, locating the stiffening members 50, 52 within the region of the golf club head 10 defined above has the greatest stress-reducing effect on the golf club head 10. If any of the structural connectors 50, 52 are placed more than 1 inch away from the rear surface 36 of the striking face section 30, they will not have a noticeable effect on the stress placed on the striking face section 30 when the golf club head 10 is in use, and will use discretionary mass without providing a significant performance benefit.

[0045] FIGS. 13-19 illustrate the contact surface area 55a and 55b between each of the structural connecting 50 and 52 and the return section 32 of the body 20 of the golf club head 10. The cast metal body 20 preferably comprises a toe structural connector 52, a heel structural connector 50, a striking face section 30, a crown return portion 32 and a sole section 22.

[0046] In one embodiment, shown in FIGS. 3A and 19, the toe structural connector 52 comprises a body with a crown end 52a, a sole end 52b, a forward surface 52c (shown in FIG. 19), a rearward surface 52d, a heel surface 52f and a toe surface 52e. The heel structural connector 50 comprises a body with a crown end 50a, a sole end 50b, a forward surface 50c (shown in FIG. 19), a rearward surface 50d, a heel surface 50f and a toe surface 50e. In this embodiment, each of the heel structural connector 50 and the toe structural connector 52 has a radius of curvature preferably ranging from 0.02 inch to 0.1 inch, more preferably from 0.025

2017276185 12 Dec 2017

inch to 0.05 inch, and most preferably 0.0395 inch. The striking face section 30 has an exterior surface 30a, an interior surface 36, an upper perimeter 31and a lower perimeter 33. The crown return portion 32 extends rearward from the upper perimeter 31 of the striking face section 30 preferably approximately 0.5 inch to 1.5 inches, more preferably 0.6 inch to 1.0 inch, and most preferably approximately 0.725 inch. The sole section 22 portion extends rearward from the lower perimeter 33 of the striking face section 30. The crown end 52a of the toe structural connector 52 is connected to the crown return portion 32. The crown end 50a of the heel structural connector 50 is connected to the crown return portion 32. The sole end 52b of the toe structural connector 52 is connected to the sole section 22. The sole end 50a of the heel structural connector 50 is connected to the sole section 22.

[0047] A contact surface area 57a, 57b between the crown return portion 32 and both of the crown end 52a of the toe structural connector 52 and the crown end 50a of the heel structural connector 50a ranges from 1% to 5% of the surface area of the crown return portion 32. The surface area of the crown return portion ranges from 2.5 square inches to 4.0 square inches. The contact surface area 55a between the crown return portion 32 and the crown end 52a of the toe structural connector 52 preferably ranges from 0.02 square inches to 0.1 square inch, more preferably from 0.035 square inch to 0.075 square inch, and most preferably is 0.045 square inch. As shown in FIG. 18, the contact surface area 55b between the crown return portion 32 and the crown end 50a of the heel structural connector 50 preferably ranges from 0.02 square inches to 0.1 square inch, more preferably from 0.035 square inch to 0.075 square inch, and most preferably is 0.045 square inch. As shown in FIG. 17, the contact surface area 57a between the sole section 22 and the sole end 52b of the toe structural connector 52 preferably ranges from 0.015 square inches to 0.1 square inch, more preferably from 0.025 square inch to 0.05 square inch, and most preferably is 0.03 square inch. The contact surface area 57b between the sole section 22 and the sole end 50b of the heel structural connector 50 preferably ranges from 0.015 square inches to 0.1 square inch, more preferably from 0.025 square inch to 0.05 square inch, and most preferably is 0.03 square inch.

[0048] The toe structural connector 52 and the heel structural connector 50 preferably attenuate movement of the crown return portion 32 and the sole section 22 when the striking face section 30 impacts a golf ball.

2017276185 12 Dec 2017

[0049] The toe structural connector 52 and the heel structural connector 50 each preferably have a length from the sole end 50b, 52b to the crown end 50a, 52a ranging from 1 inch to 2.5 inches. As shown in FIG. 3A, the heel surface 52f of the toe structural connector 52 is a distance ranging from 0.75 inch to 1.5 inches from the toe surface 50e of the heel structural connector 50. A contact area 55a, 55b, between the crown return portion 32 and each of the toe structural connector 52 and the heel structural connector 50 preferably ranges from 0.02 square inches to 0.04 square inches.

[0050] As shown in FIG. 5A, the forward surface 50c and 52c of each of the toe structural connector 52 and the heel structural connector 50 is at least 0.120 inch rearward from the interior surface 36 of the striking face section 30 and the rearward surface 50d, 52d of each of the toe structural connector 52 and the heel structural connector 50 is no more than 1.0 inch rearward from the interior surface 36 of the striking face section 30.

[0051] When the golf club head 10 is designed as a driver, it preferably has a volume from 200 cubic centimeters to 600 cubic centimeters, more preferably from 300 cubic centimeters to 500 cubic centimeters, and most preferably from 420 cubic centimeters to 470 cubic centimeters, with a most preferred volume of 460 cubic centimeters. In the preferred embodiment, the golf club head 10 has a volume of approximately 450 cc to 460 cc.

[0052] The volume of the golf club head 10 also varies between fairway woods (preferably ranging from 3-woods to eleven woods) with smaller volumes than drivers. When designed as a driver, the golf club head 10 preferably has a mass of no more than 215 grams, and most preferably a mass of 180 to 215 grams; when designed as a fairway wood, the golf club head 10 preferably has a mass of 135 grams to 200 grams, and preferably from 140 grams to 165 grams.

[0053] In each of the embodiments disclosed herein, the striking face section 30 preferably has a varying thickness such as that described in U.S Patent Number 7448960, for a *Golf Club Head With Variable Face Thickness,* which pertinent parts are hereby incorporated by reference. Other alternative embodiments of the thickness of the striking face section 30 are disclosed in U.S Patent Number 6398666, for a *Golf Club Striking Plate With Variable Thickness*, U.S. Patent Number 6471603, for a *Contoured Golf Club Face* and U.S. Patent Number 6368234, for a *Golf Club Striking Plate Having Elliptical Regions Of Thickness*, all of which are owned by

2017276185 12 Dec 2017

Callaway Golf Company and which pertinent parts are hereby incorporated by reference. Alternatively, the striking face section 30 may have a uniform thickness.

[0054] In each of the embodiments disclosed herein, the body 20 is preferably cast from molten metal in a method such as the well-known lost-wax casting method. The metal for casting is preferably titanium or a titanium alloy such as 6-4 titanium alloy, alpha-beta titanium alloy or beta titanium alloy for forging, and 6-4 titanium for casting. Alternatively, the body 20 is composed of 17-4 steel alloy. Additional methods for manufacturing the body 20 include forming the body 20 from a flat sheet of metal, super-plastic forming the body from a flat sheet of metal, machining the body 20 from a solid block of metal, electrochemical milling the body 20 from a forged pre-form, casting the body using centrifugal casting, casting the body 20 using levitation casting, and like manufacturing methods.

[0055] In other embodiments, the golf club head 10 may have a multi-material composition such as any of those disclosed in U.S. Patent Nos. 6244976, 6332847, 6386990, 6406378, 6440008, 6471604, 6491592, 6527650, 6565452, 6575845, 6478692, 6582323, 6508978, 6592466, 6602149, 6607452, 6612398, 6663504, 6669578, 6739982, 6758763, 6860824, 6994637, 7025692, 7070517, 7112148, 7118493, 7121957, 7125344, 7128661, 7163470, 7226366, 7252600, 7258631, 7314418, 7320646, 7387577, 7396296, 7402112, 7407448, 7413520, 7431667, 7438647, 7455598, 7476161, 7491134, 7497787, 7549935, 7578751, 7717807, 7749096, and 7749097, the disclosure of each of which is hereby incorporated in its entirety herein.

[0056] From the foregoing it is believed that those skilled in the pertinent art will recognize the meritorious advancement of this invention and will readily understand that while the present invention has been described in association with a preferred embodiment thereof, and other embodiments illustrated in the accompanying drawings, numerous changes, modifications and substitutions of equivalents may be made therein without departing from the spirit and scope of this invention which is intended to be unlimited by the foregoing except as may appear in the following appended claims. Therefore, the embodiments of the invention in which an exclusive property or privilege is claimed are defined in the following appended claims.

2017276185 24 Jan 2019

CLAIMS

1. A golf club head comprising:

a body with a hollow interior comprising:

a toe structural connector comprising a body with a crown end, a sole end, a forward surface, a rearward surface, a heel surface and a toe surface;

a heel structural connector comprising a body with a crown end, a sole end, a forward surface, a rearward surface, a heel surface and a toe surface;

a striking face section having an exterior surface, an interior surface, an upper perimeter and a lower perimeter;

a crown return portion extending rearward from the upper perimeter of the striking face section a distance ranging from 0.5 inches (13 mm) to 1.5 inches (38 mm); and

a sole section portion extending rearward from the lower perimeter of the striking face section;

wherein the crown end of the toe structural connector is connected to the crown return portion, the crown end of the heel structural connector is connected to the crown return portion, the sole end of the toe structural connector is connected to the sole section, and the sole end of the heel structural connector is connected to the sole section;

wherein a contact surface area between the crown return portion and both of the crown end of the toe structural connector and the crown end of the heel structural connector ranges from 1% to 5% of the surface area of the crown return portion;

wherein the toe structural connector and the heel structural connector are positioned approximately parallel to the interior surface of the striking face section and within 1 inch (25 mm) from the interior surface of the striking face, and are parallel to each other, wherein the positioning of the toe structural connector and the heel structural connector improves the normalized ball speed relationship to characteristic time such that the gold club head satisfies the equation $V_{ballnorm} \geq 0.0356x+140.82$,

wherein the variable "x" is the characteristic time in micro-seconds, and

wherein $V_{ballnorm} = \frac{m_h V_{inh} + m_h V_{inh}\left[\frac{V_{cr}}{V_{cin}}\left(1+\frac{m_b}{m_c}\right)\frac{m_b}{m_c}+\frac{V_{br}}{V_{bin}}\left(1+\frac{m_b}{m_p}\right)\frac{m_b}{m_p}-0.822\right]}{m_h+m_b}$;

wherein the toe structural connector and the heel structure connector attenuate movement of the crown return portion and the sole section when the striking face section impacts a golf ball.

2017276185 24 Jan 2019

2. The golf club head according to claim 1 wherein the toe structural connector and the heel structural connector each have a length from the sole end to the crown end ranging from 1 inch (30 mm) to 2.5 inches (64 mm).

3. The golf club head according to claim 1 wherein the heel surface of the toe structural connector is a distance ranging from 0.75 inches (19 mm) to 1.5 inches (38 mm) from the toe surface of the heel structural connector.

4. The golf club head according to claim 1 wherein the golf club head has a volume ranging from 420 cubic centimeters to 470 cubic centimeters.

5. The golf club head according to claim 1 wherein the metal body is composed of a titanium alloy.

6. The golf club head according to claim 1 wherein the golf club head has a mass ranging from 185 grams to 215 grams.

7. The golf club head according to claim 1 further comprising a crown portion composed of a carbon composite material.

8. The golf club head according to claim 1 wherein the sole section comprises a plurality of cutouts covered with a plurality of cover pieces, each of the plurality of cover pieces composed of a carbon composite material.

9. The golf club head according to claim 1 wherein a contact area between the crown return portion and each of the toe structural connector and the heel structural connector ranges from 0.02 square inches (10 mm^2) to 0.04 square inches (30 mm^2).

10. A golf club head comprising:

a body with a hollow interior comprising:

a toe structural connector comprising a body with a crown end, a sole end, a forward arc surface, a rearward arc surface, a heel arc surface and a toe arc surface;

a heel structural connector comprising a body with a crown end, a sole end, a forward arc surface, a rearward arc surface, a heel arc surface and a toe arc surface;

2017276185 24 Jan 2019

a striking face section having an exterior surface, an interior surface, an upper perimeter and a lower perimeter;

a crown return portion extending rearward from the upper perimeter of the striking face section;

a sole section portion extending rearward from the lower perimeter of the striking face section; and

a hosel section;

a crown body attached to the crown return portion;

wherein the crown end of the toe structural connector is connected to the crown return portion, the crown end of the heel structural connector is connected to the crown return portion, the sole end of the toe structural connector is connected to the sole section, and the sole end of the heel structural connector is connected to the sole section;

wherein a contact surface area between the crown return portion and both of the crown end of the toe structural connector and the crown end of the heel structural connector ranges from 1% to 5% of the surface area of the crown return portion;

wherein the toe structural connector and the heel structural connector are positioned approximately parallel to the interior surface of the striking face section and within 1 inch (25 mm) from the interior surface of the striking face, and are parallel to each other, wherein the positioning of the toe structural connector and the heel structural connector improves the normalized ball speed relationship to characteristic time such that the gold club head satisfies the equation $V_{ballnorm} \geq 0.0356x+140.82$,

wherein the variable "x" is the characteristic time in micro-seconds, and

wherein $V_{ballnorm} = \dfrac{m_h V_{inh} + m_h V_{inh}\left[\frac{V_{cr}}{V_{cin}}\left(1+\frac{m_b}{m_c}\right)\frac{m_b}{m_c} + \frac{V_{br}}{V_{bin}}\left(1+\frac{m_b}{m_p}\right)\frac{m_b}{m_p} - 0.822\right]}{m_h + m_b}$;

wherein the toe structural connector and the heel structural connector attenuate movement of the crown return portion and the sole section when the striking face section impacts a golf ball.

11. The golf club head according to claim 10 wherein the toe structural connector and the heel structural connector each have a length from the sole end to the crown end ranging from 1 inch (30 mm) to 2.5 inches (64 mm).

2017276185 24 Jan 2019

12. The golf club head according to claim 10 wherein the heel arc surface of the toe structural connector is a distance ranging from 0.75 inches (19 mm) to 1.5 inches (38 mm) from the toe arc surface of the heel structural connector.

13. The golf club head according to claim 10 wherein the golf club head has a volume ranging from 420 cubic centimeters to 470 cubic centimeters.

14. The golf club head according to claim 10 wherein the metal body is composed of a titanium alloy.

15. The golf club head according to claim 10 wherein the golf club head has a mass ranging from 185 grams to 215 grams.

16. The golf club head according to claim 10 wherein the body of each of the toe structural connector and the heel structural connector is hollow.

17. The golf club head according to claim 10 wherein the sole section comprises a plurality of cutouts covered with a plurality of cover pieces, each of the plurality of cover pieces composed of a carbon composite material.

18. The golf club head according to claim 10 wherein a contact area between the crown return portion and each of the toe structural connector and the heel structural connector ranges from 0.002 square inches (10 mm^2) to 0.03 square inches (20 mm^2).

19. The golf club head according to claim 10 wherein the metal body is composed of a steel material.

20. The golf club head according to any one of the preceding claims, wherein the toe structural connector and the heel structural connector are each spaced from 0.136 inches (3.45 mm) to 0.210 inches (5.33 mm) from the interior surface of the striking face section.

Callaway Golf Company

Patent Attorneys for the Applicant/Nominated Person

SPRUSON & FERGUSON

2017276185 12 Dec 2017

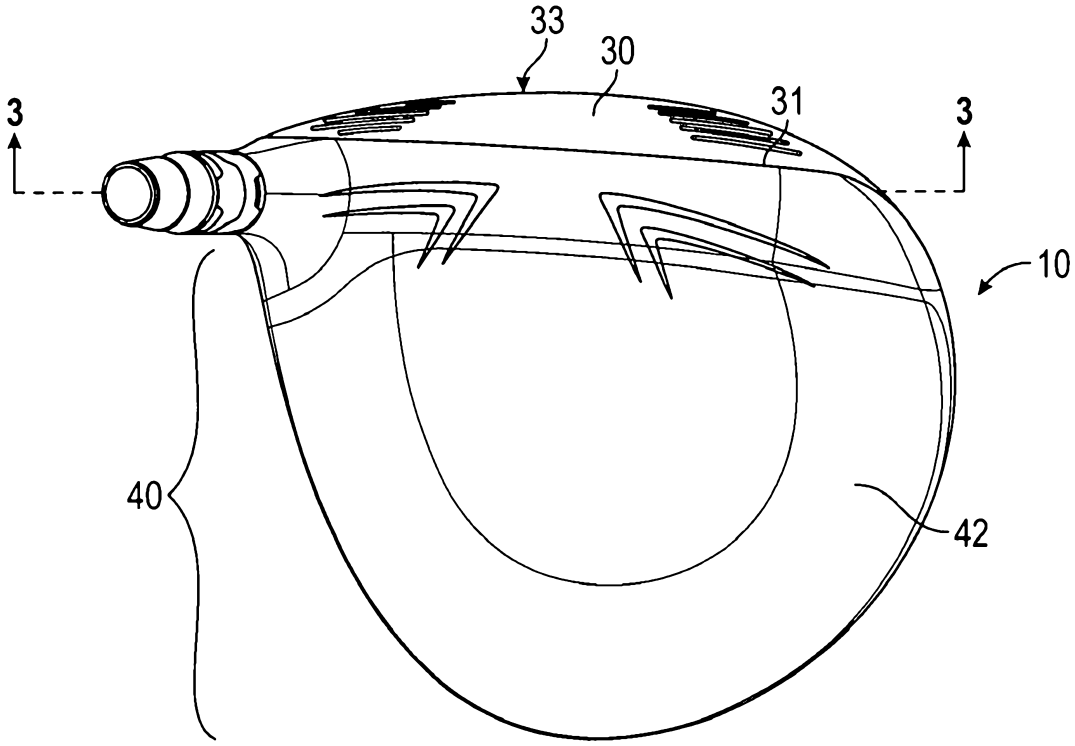


FIG. 1

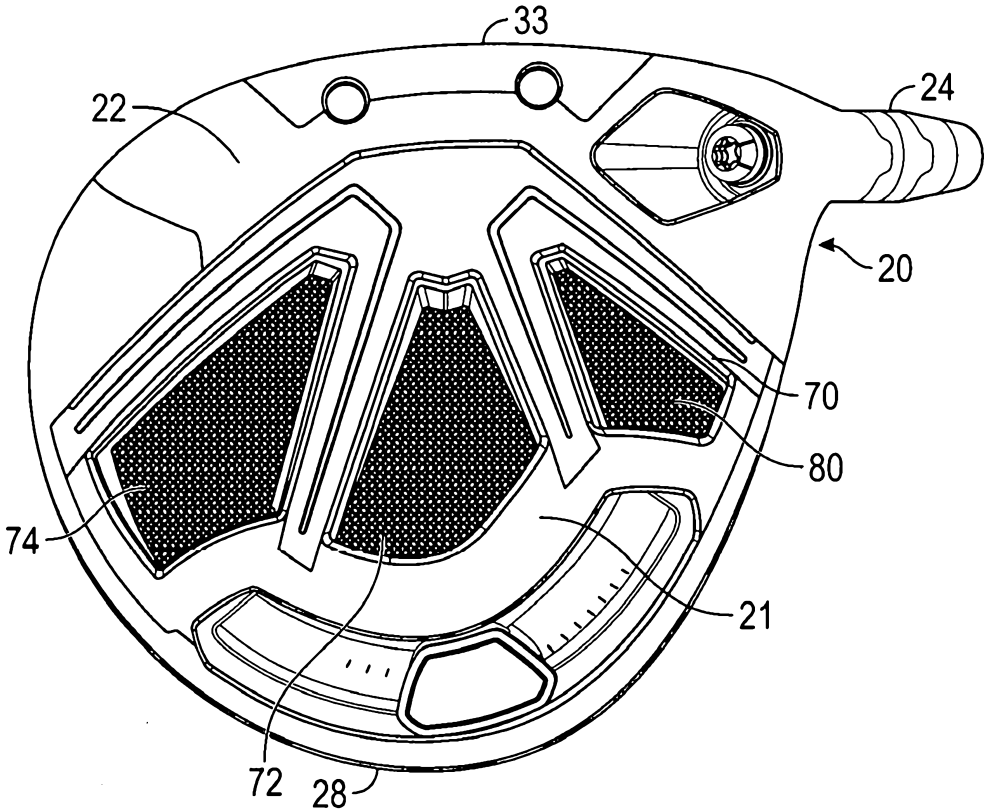


FIG. 2

2017276185 12 Dec 2017

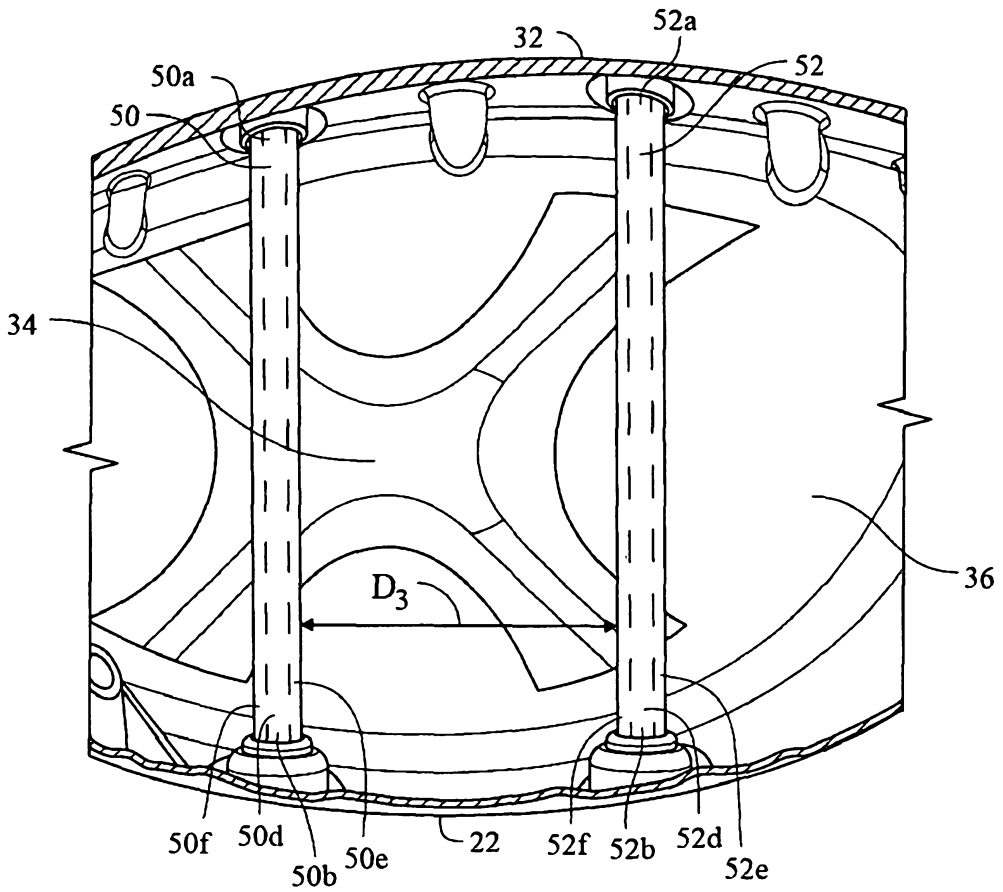


FIG. 3A

2017276185 12 Dec 2017

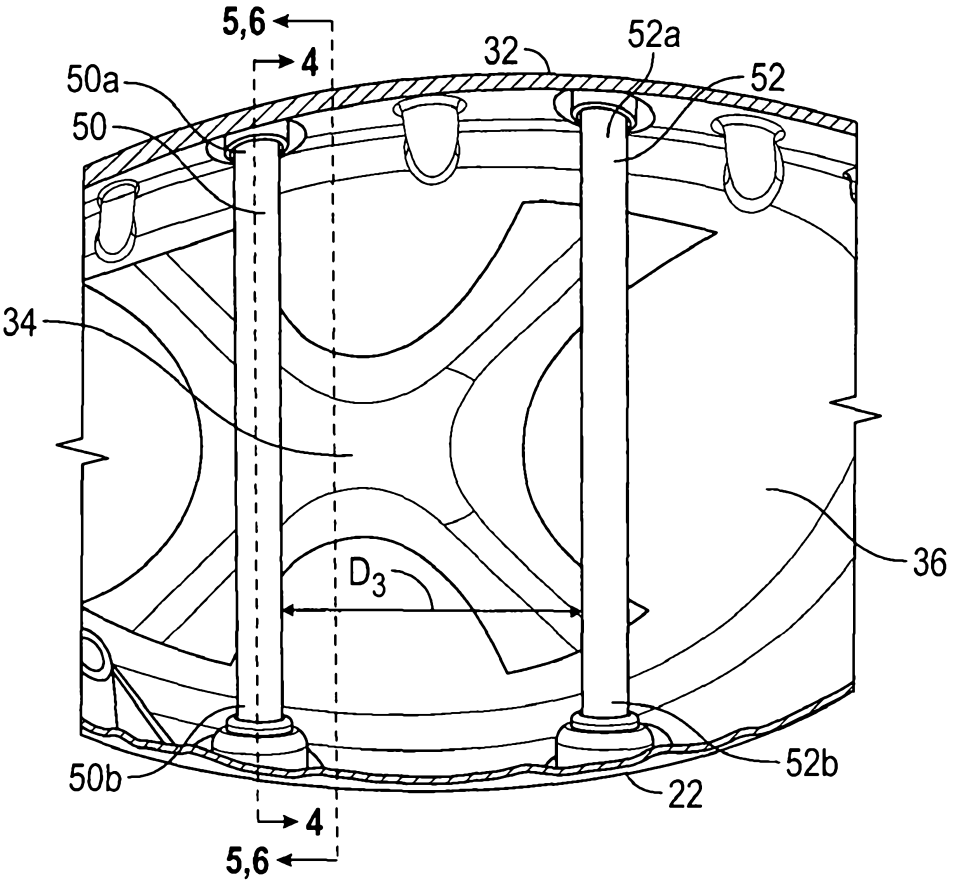


FIG. 3

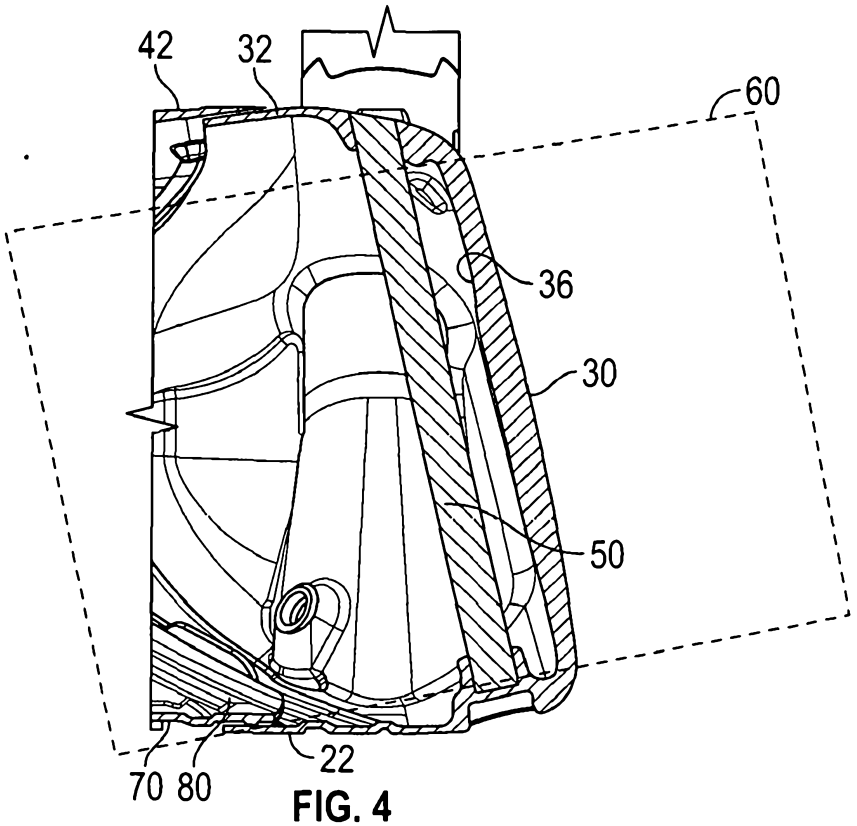


FIG. 4

2017276185 12 Dec 2017

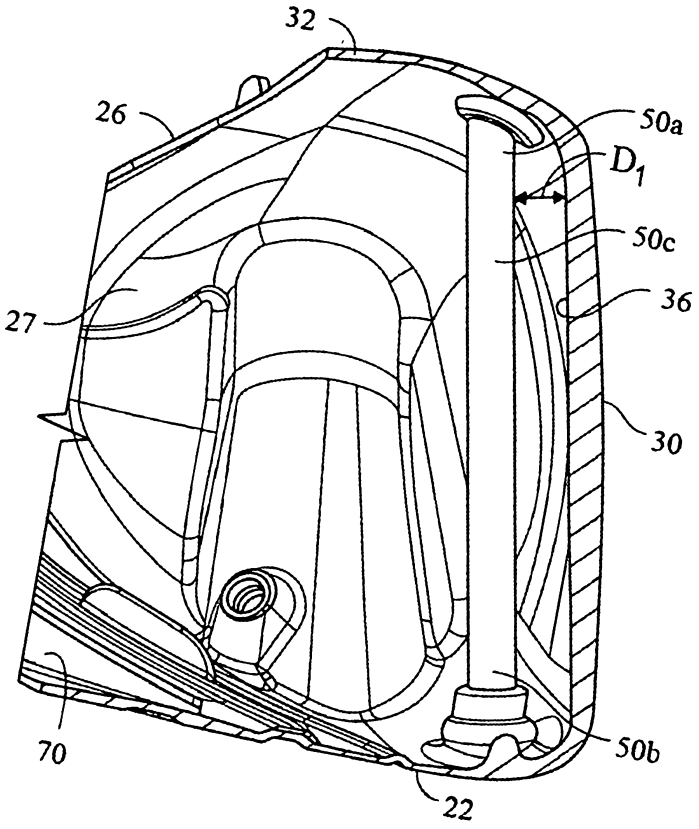


FIG. 5A

2017276185 12 Dec 2017

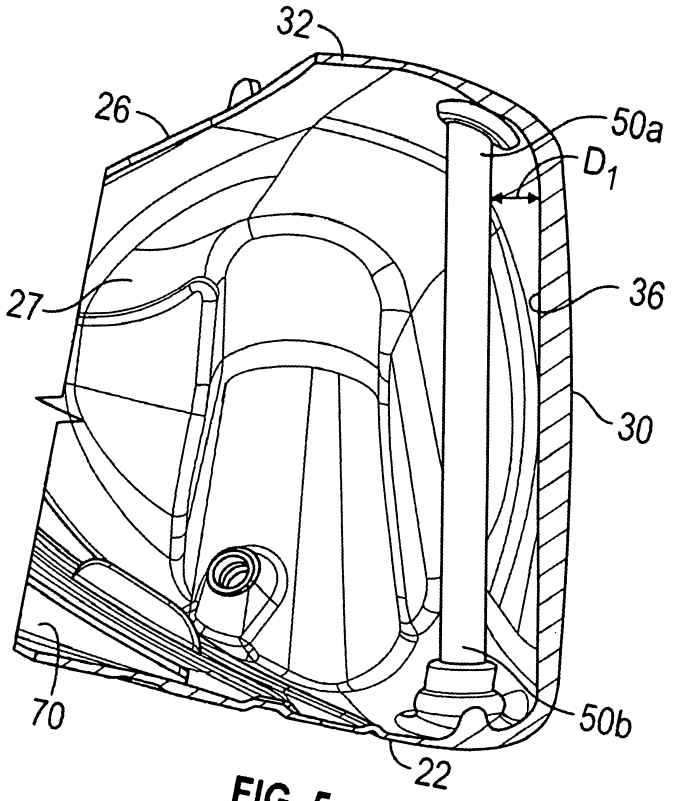


FIG. 5

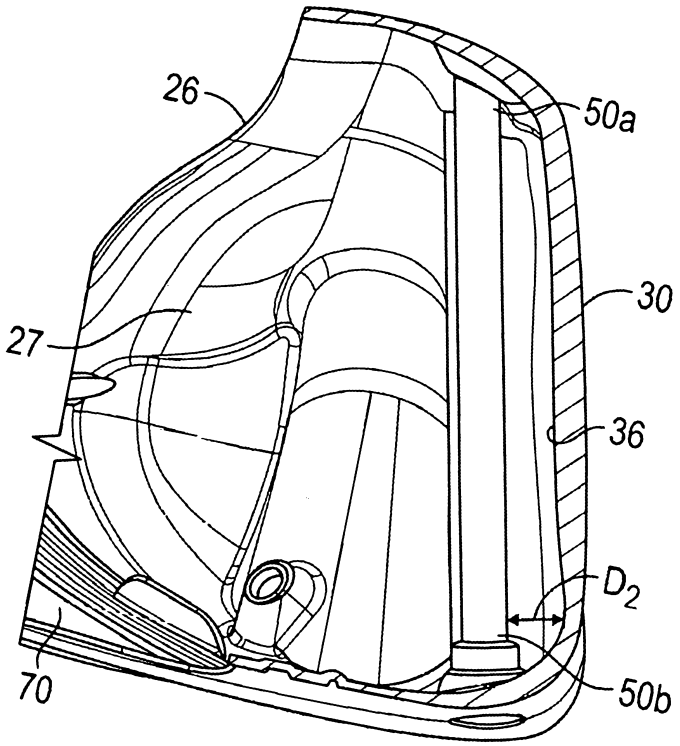


FIG. 6

2017276185 12 Dec 2017

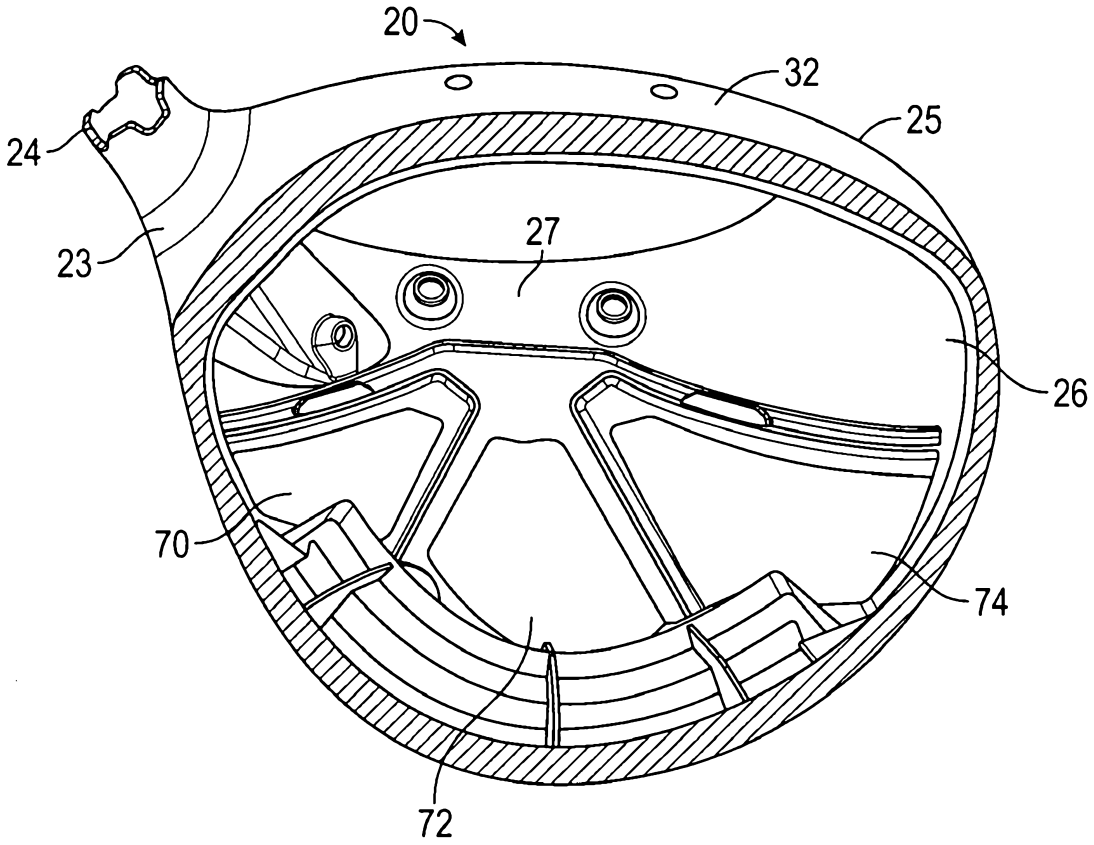


FIG. 7

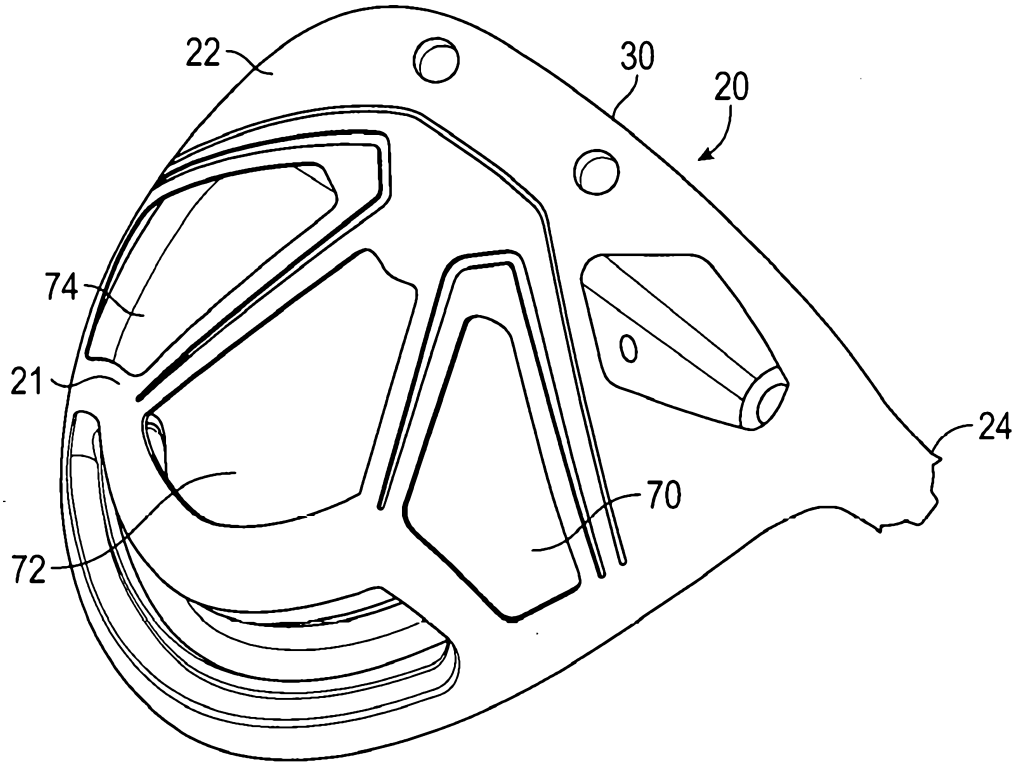


FIG. 8

20172761851 12 Dec 2017

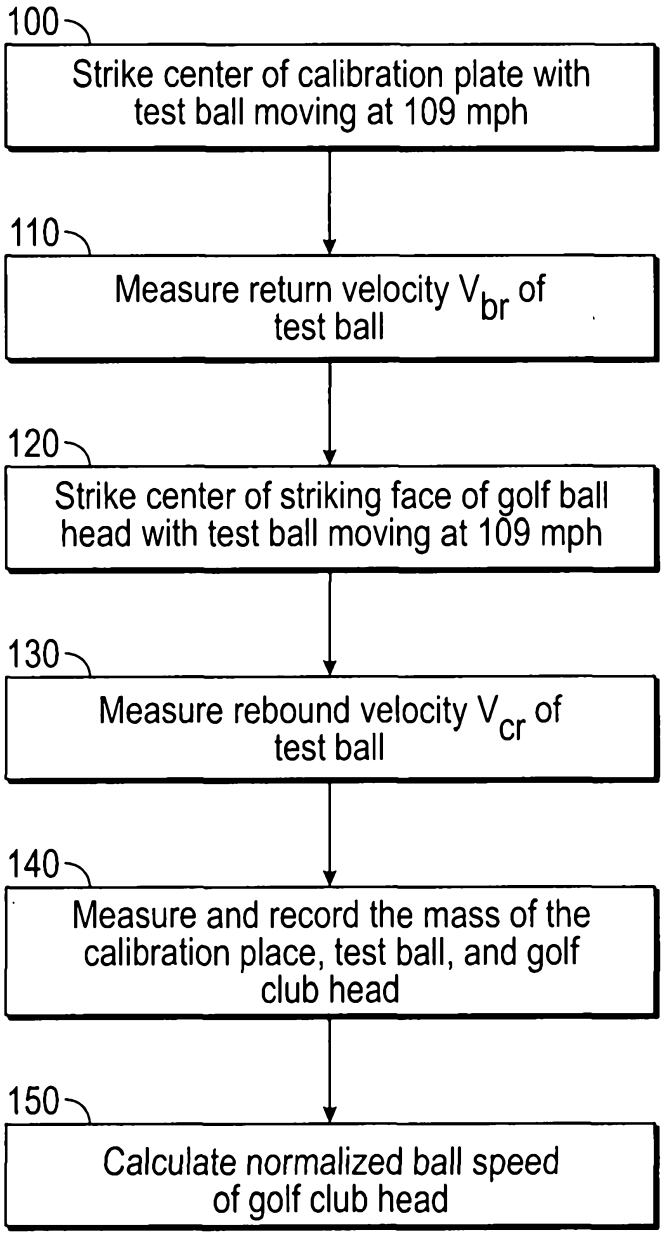


FIG. 9

2017276185 12 Dec 2017

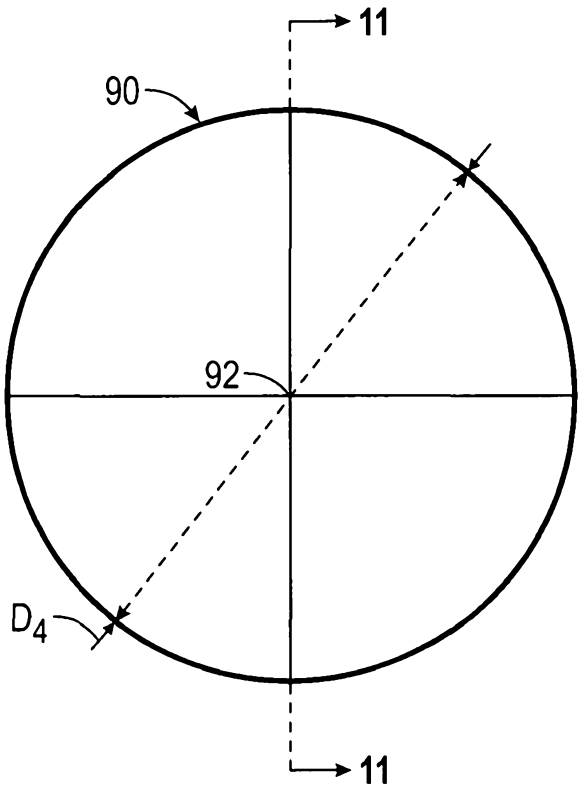


FIG. 10

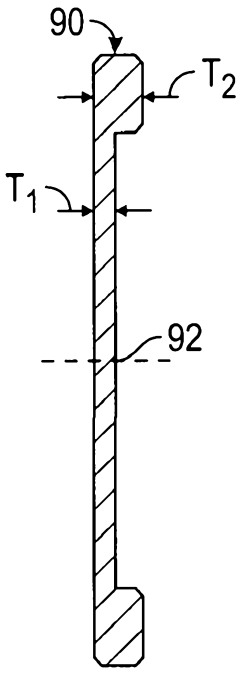


FIG. 11

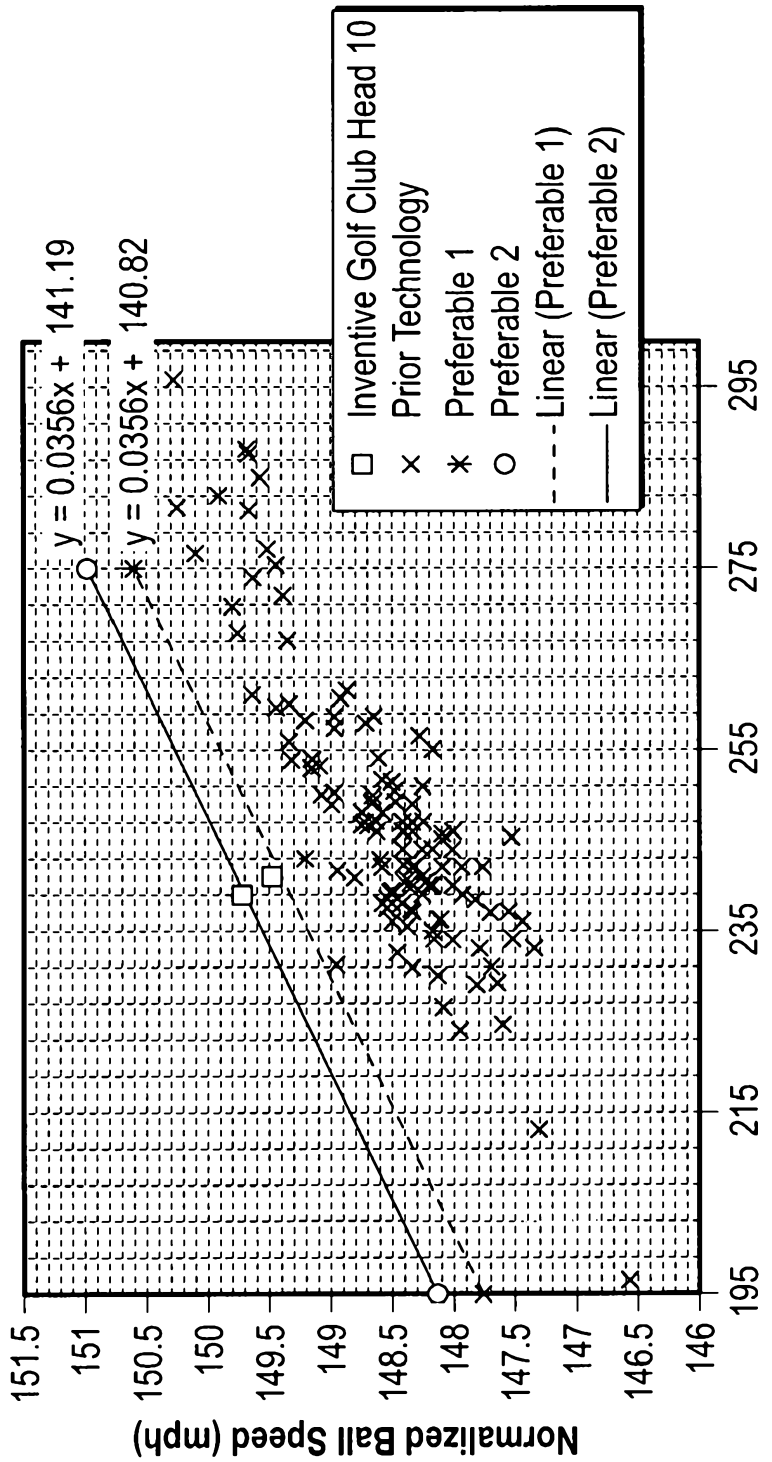

Normalized Ball Speed (mph)
151.5
151
150.5
150
149.5
149
148.5
148
147.5
147
146.5
146
195
215
235
255
275
295
CT (μs)
y = 0.0356x + 141.19
y = 0.0356x + 140.82
Inventive Golf Club Head 10
Prior Technology
Preferable 1
Preferable 2
Linear (Preferable 1)
Linear (Preferable 2)

FIG. 12

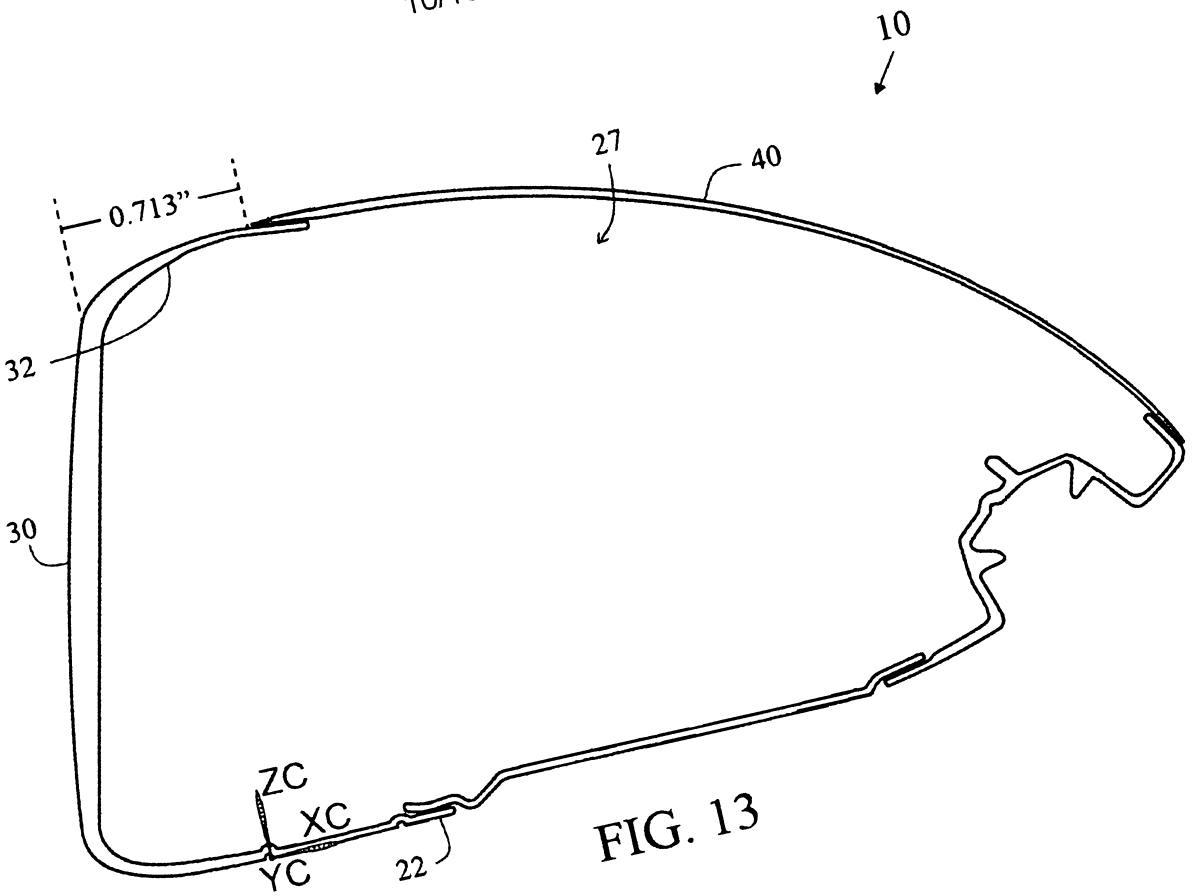


FIG. 13

2017276185 12 Dec 2017

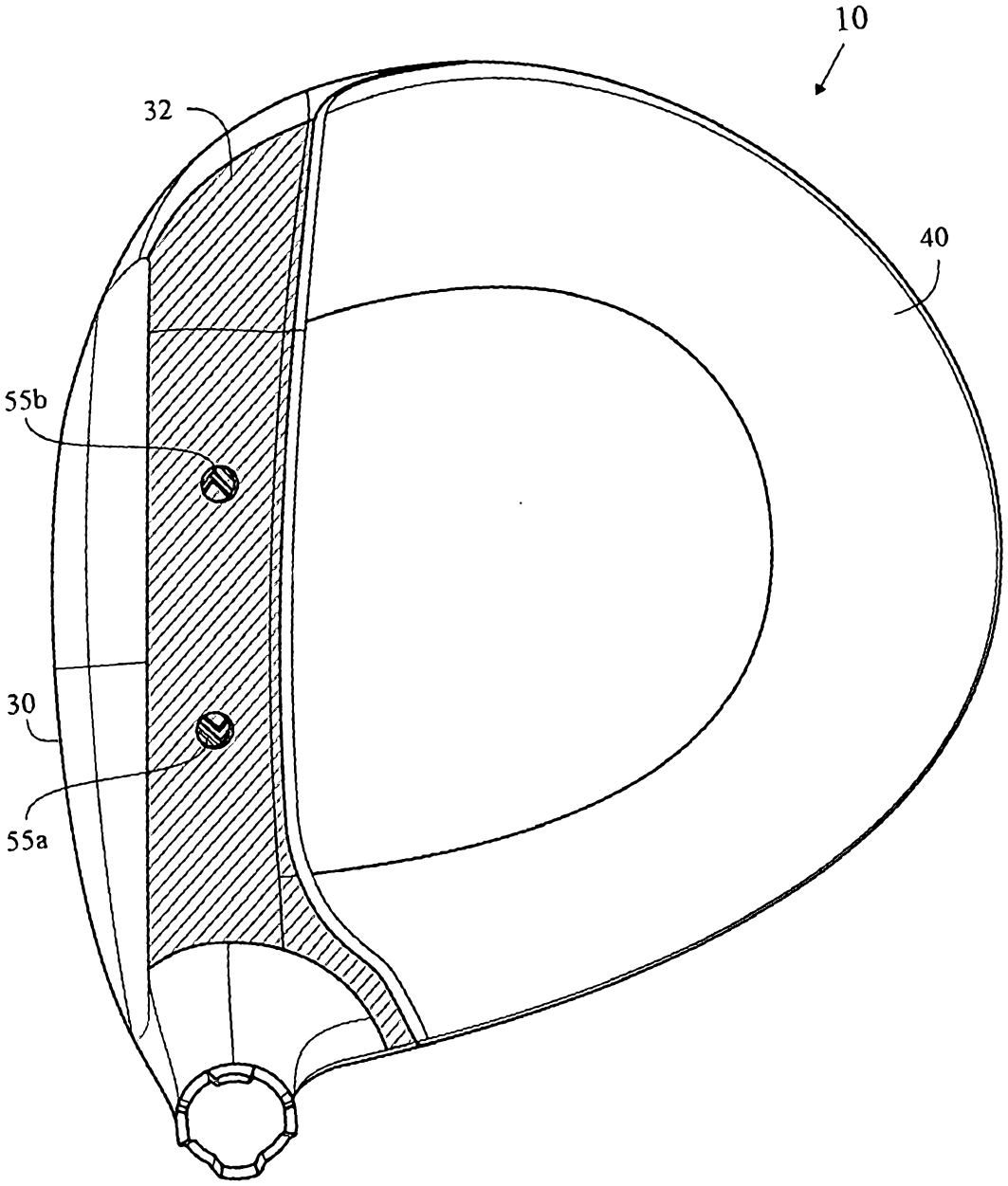


FIG. 14

2017276185 12 Dec 2017

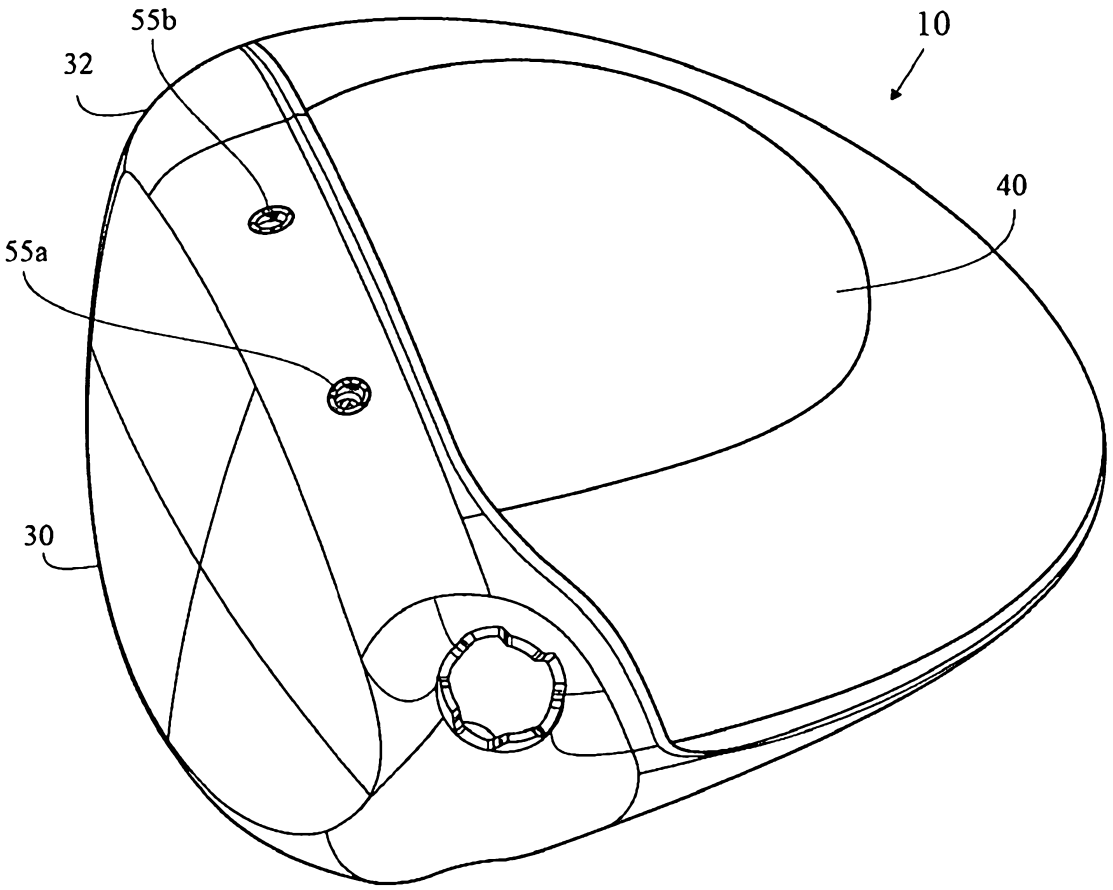


FIG. 15

2017276185 12 Dec 2017

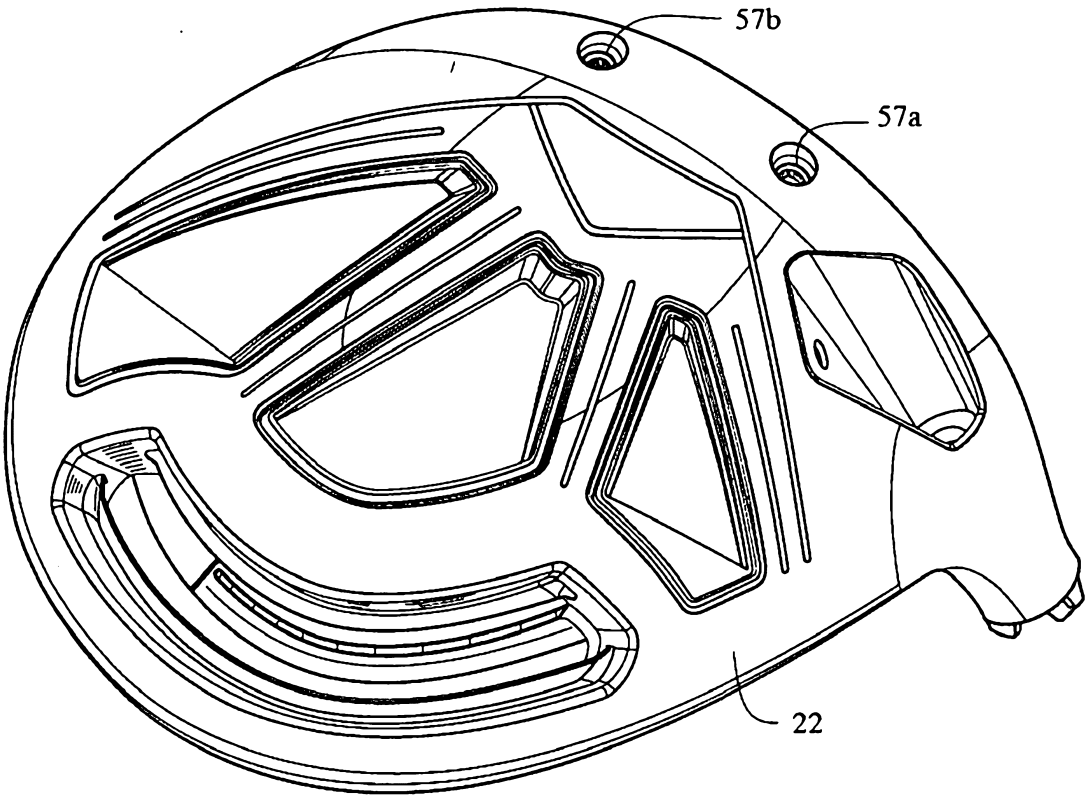


FIG. 16

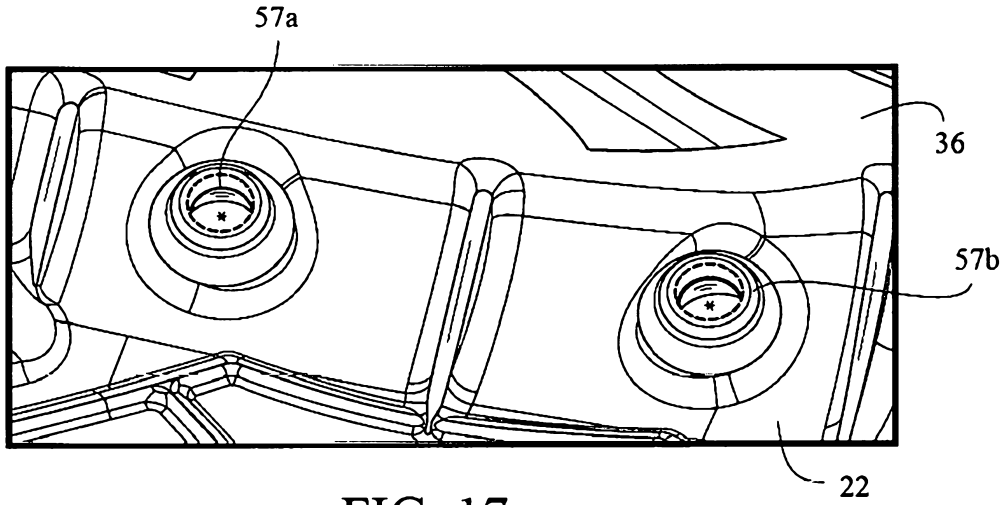


FIG. 17

2017276185 12 Dec 2017

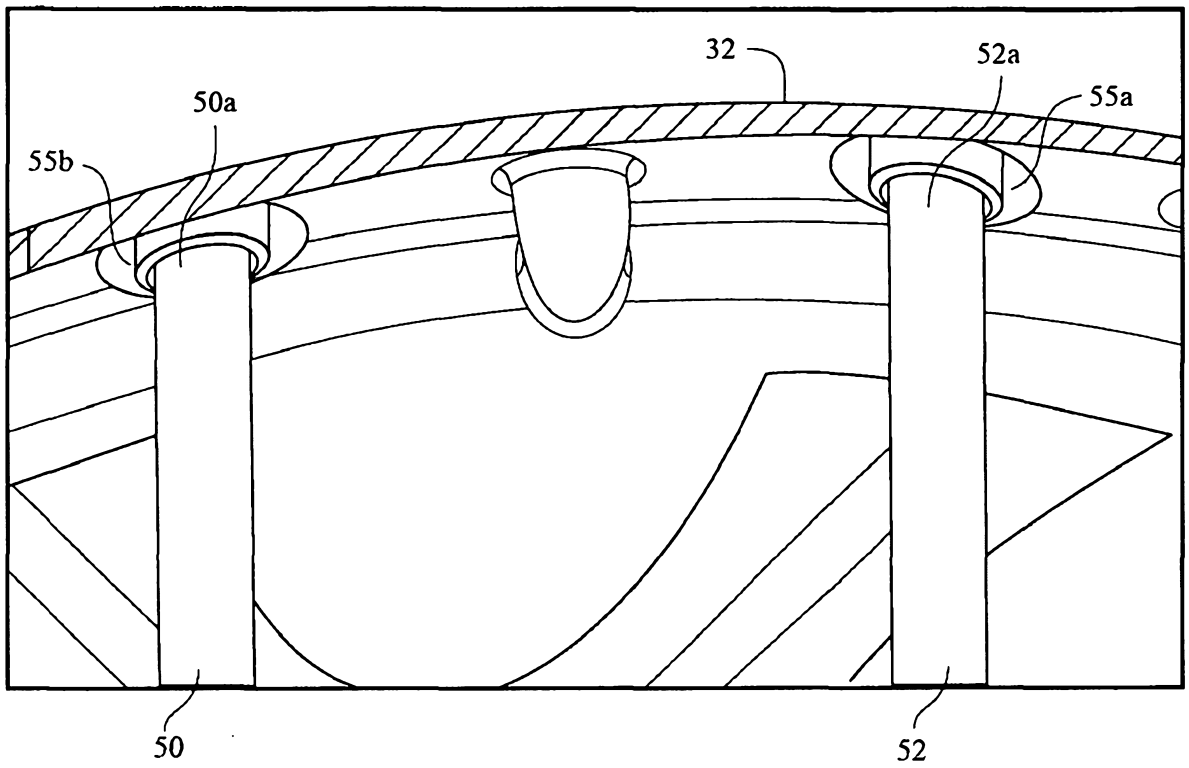


FIG. 18

2017276185 12 Dec 2017

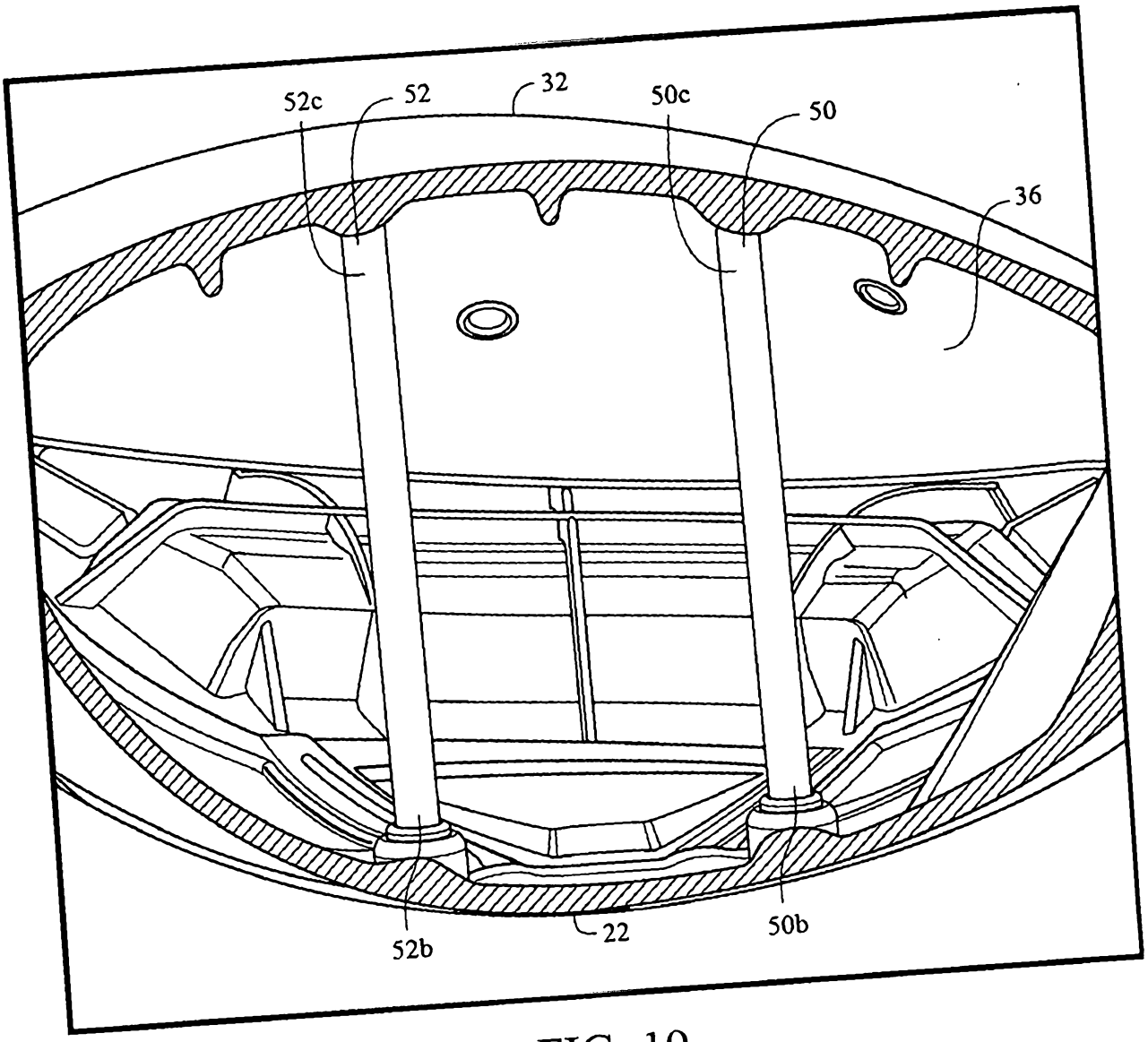


FIG. 19