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Morales et al.

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(54) **MIXED MATERIAL GOLF CLUB HEAD**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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(22) Filed: **Sep. 8, 2020**

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Related U.S. Application Data

(63) Continuation of application No. 16/380,873, filed on Apr. 10, 2019, now Pat. No. 10,765,922, which is a (Continued)

(51) **Int. Cl.**

A63B 53/04 (2015.01)
A63B 60/02 (2015.01)
A63B 60/00 (2015.01)

(52) **U.S. Cl.**

CPC ...... ***A63B 53/0475*** (2013.01); ***A63B 53/0466*** (2013.01); ***A63B 60/02*** (2015.10); (Continued)

(58) **Field of Classification Search**

CPC . A63B 53/0475; A63B 53/0466; A63B 60/02; A63B 2209/00; A63B 2053/0491; (Continued)

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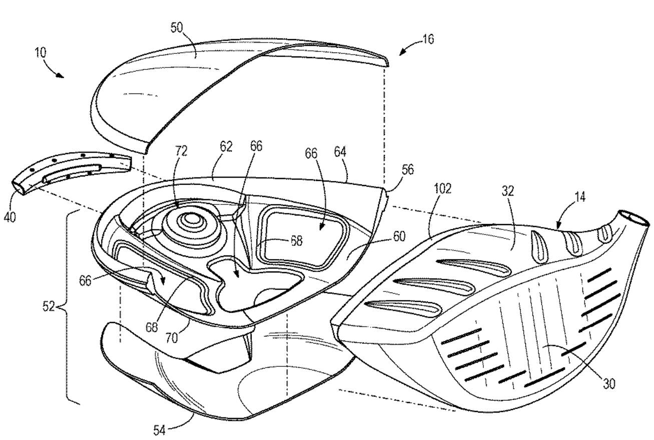
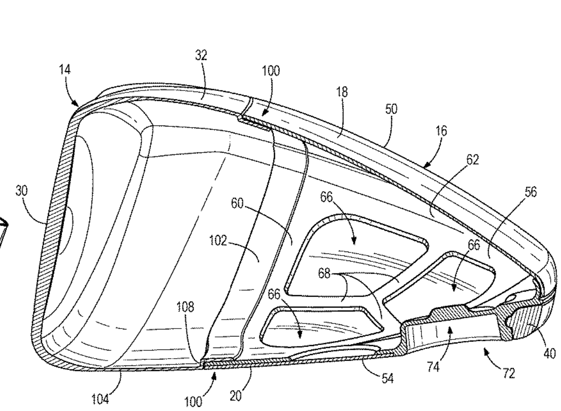
Primary Examiner — Sebastiano Passaniti

(57) **ABSTRACT**

A golf club head includes a metallic front body coupled with a rear body to define a substantially hollow structure. The metallic front body includes a strike face and a surrounding frame that extends rearward from a perimeter of the strike face. The rear body includes a crown member and a sole member coupled to the crown member. The sole member comprises a structural layer formed from a filled thermoplastic material and a fiber reinforced composite resilient layer bonded to an external surface of the structural layer. The structural layer includes a plurality of stiffening members extending from a forward portion to a rear peripheral portion of the sole member. The resilient layer can comprise a uniform thickness. The structural layer and the resilient layer each include a common thermoplastic resin component, and are directly bonded to each other without an intermediate adhesive.

20 Claims, 8 Drawing Sheets





Related U.S. Application Data

continuation of application No. 15/901,081, filed on Feb. 21, 2018, now Pat. No. 10,300,354, which is a continuation of application No. 15/607,166, filed on May 26, 2017, now Pat. No. 9,925,432.

(60) Provisional application No. 62/342,741, filed on May 27, 2016.

(52) **U.S. Cl.**
CPC *A63B 53/04* (2013.01); *A63B 53/042* (2020.08); *A63B 53/045* (2020.08); *A63B 53/047* (2013.01); *A63B 53/0416* (2020.08); *A63B 53/0433* (2020.08); *A63B 53/0437* (2020.08); *A63B 60/002* (2020.08); *A63B 2053/0491* (2013.01); *A63B 2209/00* (2013.01); *A63B 2209/02* (2013.01)

(58) **Field of Classification Search**
CPC . A63B 53/042; A63B 53/045; A63B 53/0416; A63B 53/0433; A63B 53/0437; A63B 53/04; A63B 60/002; A63B 53/047; A63B 2209/02
USPC 473/324–350, 287–292
See application file for complete search history.

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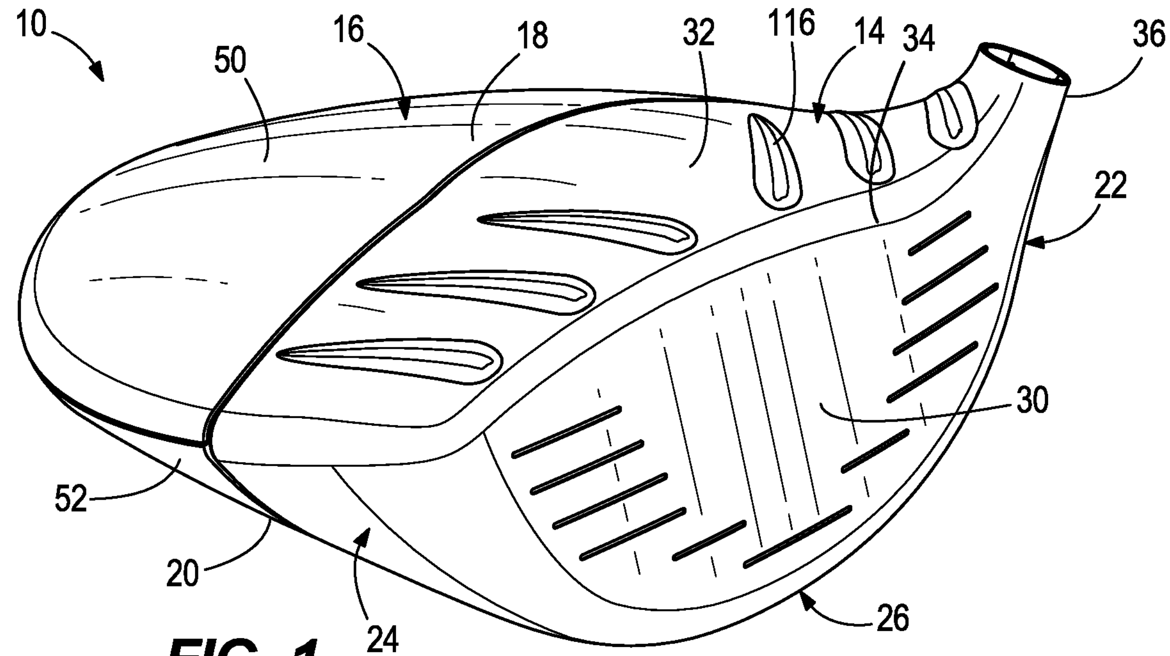
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FIG. 1

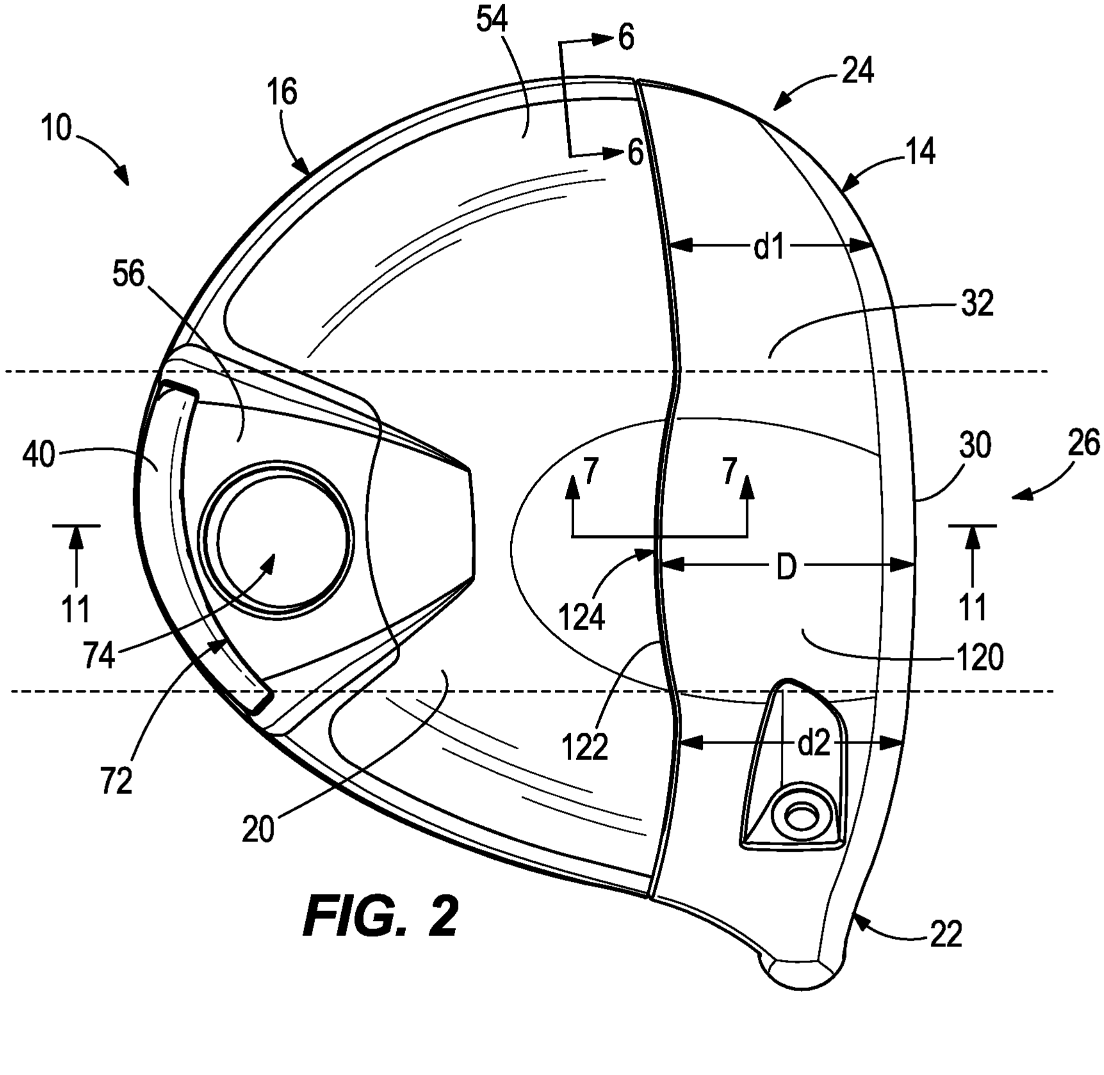
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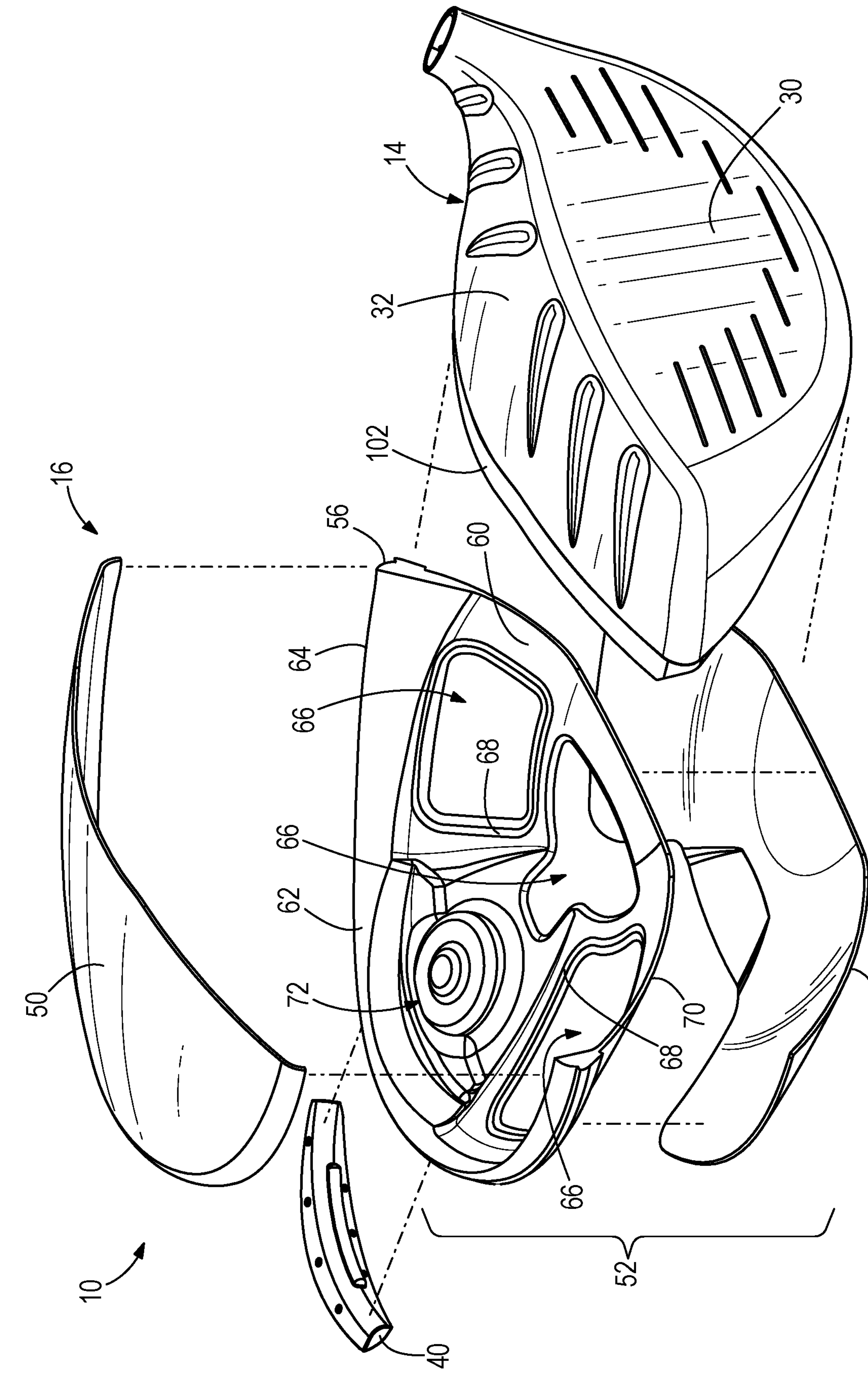
FIG. 2



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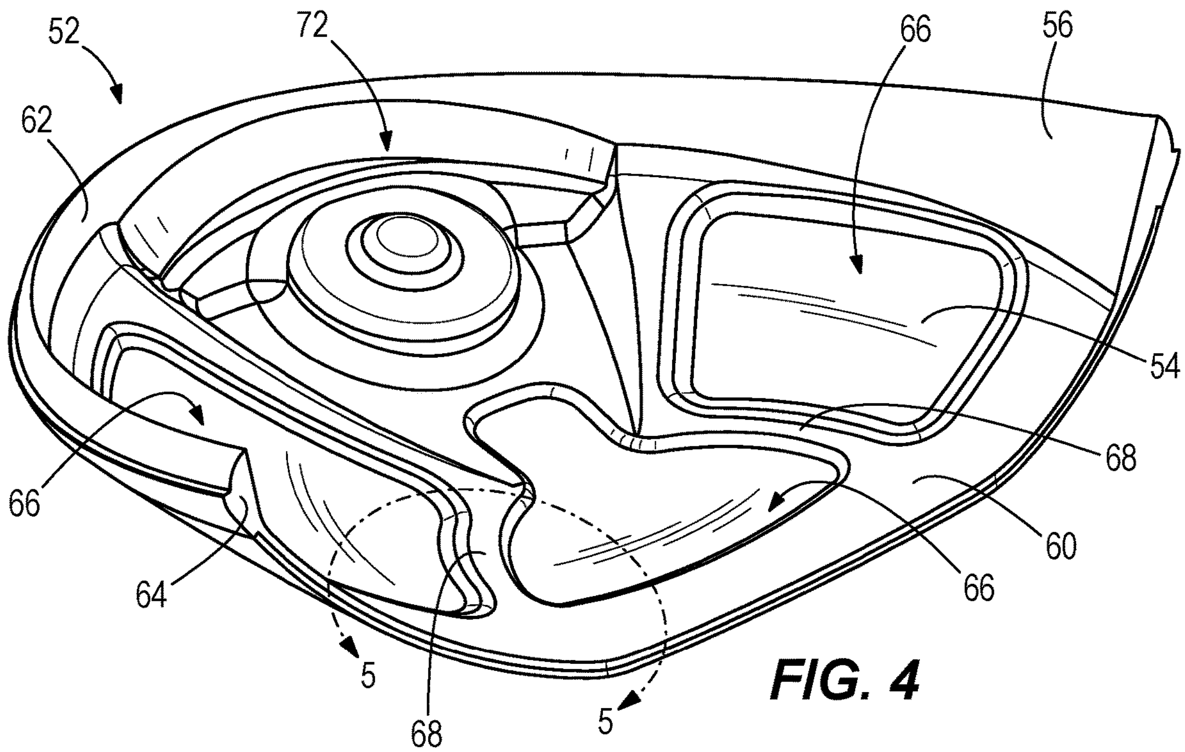

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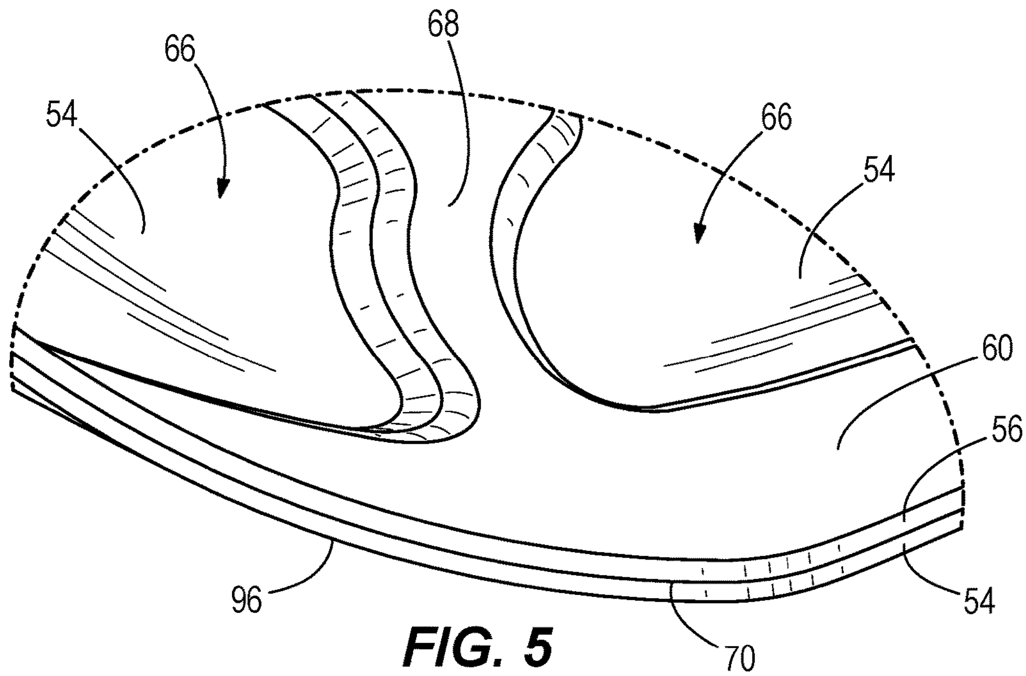

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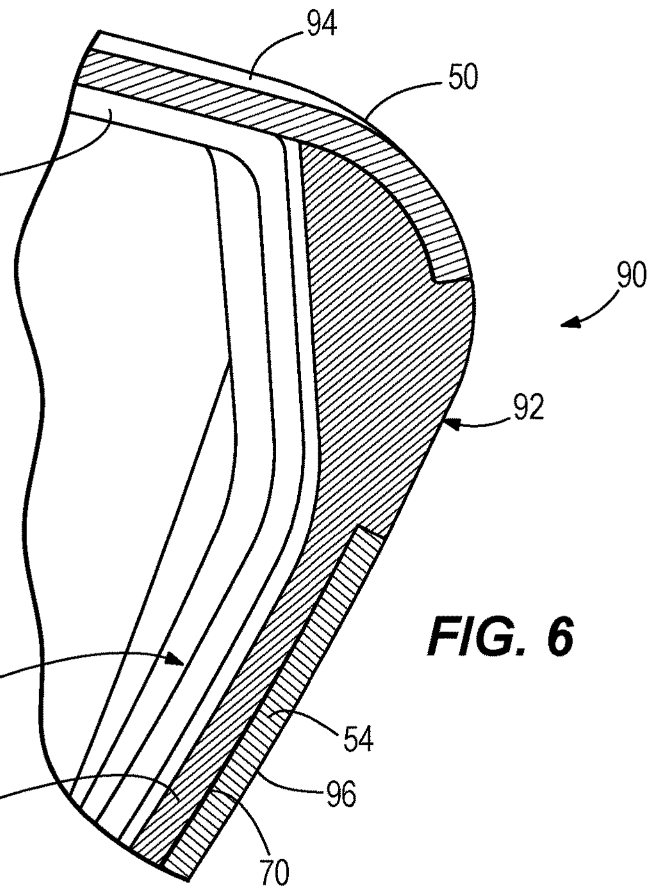
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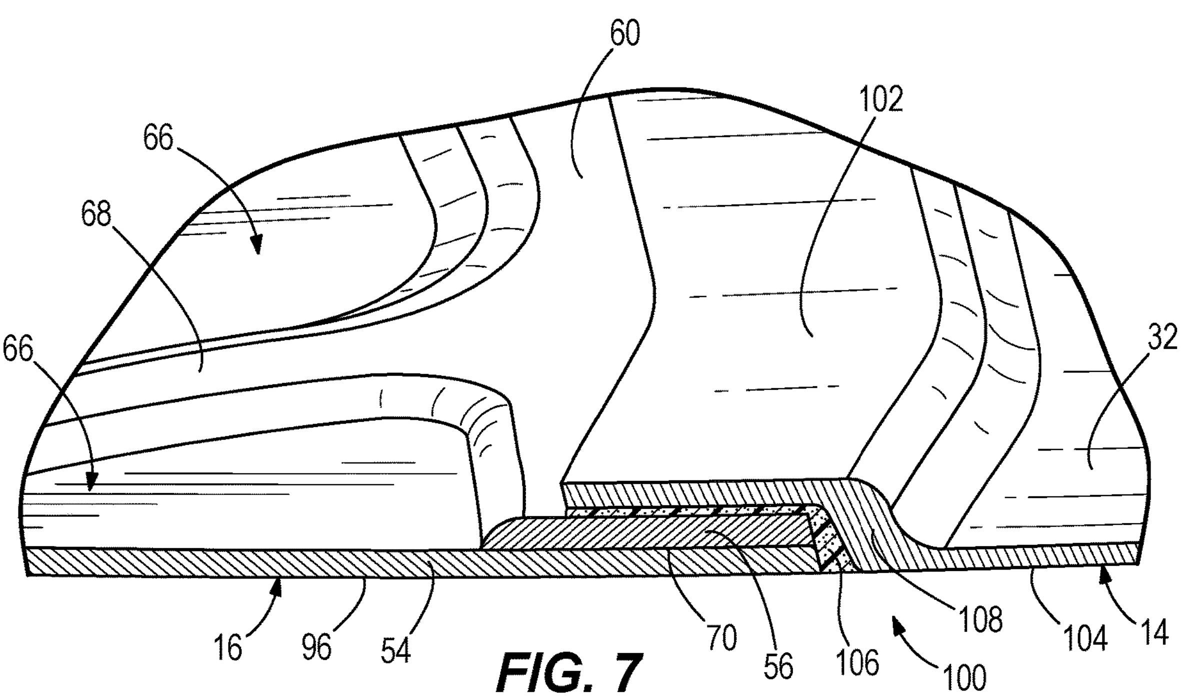
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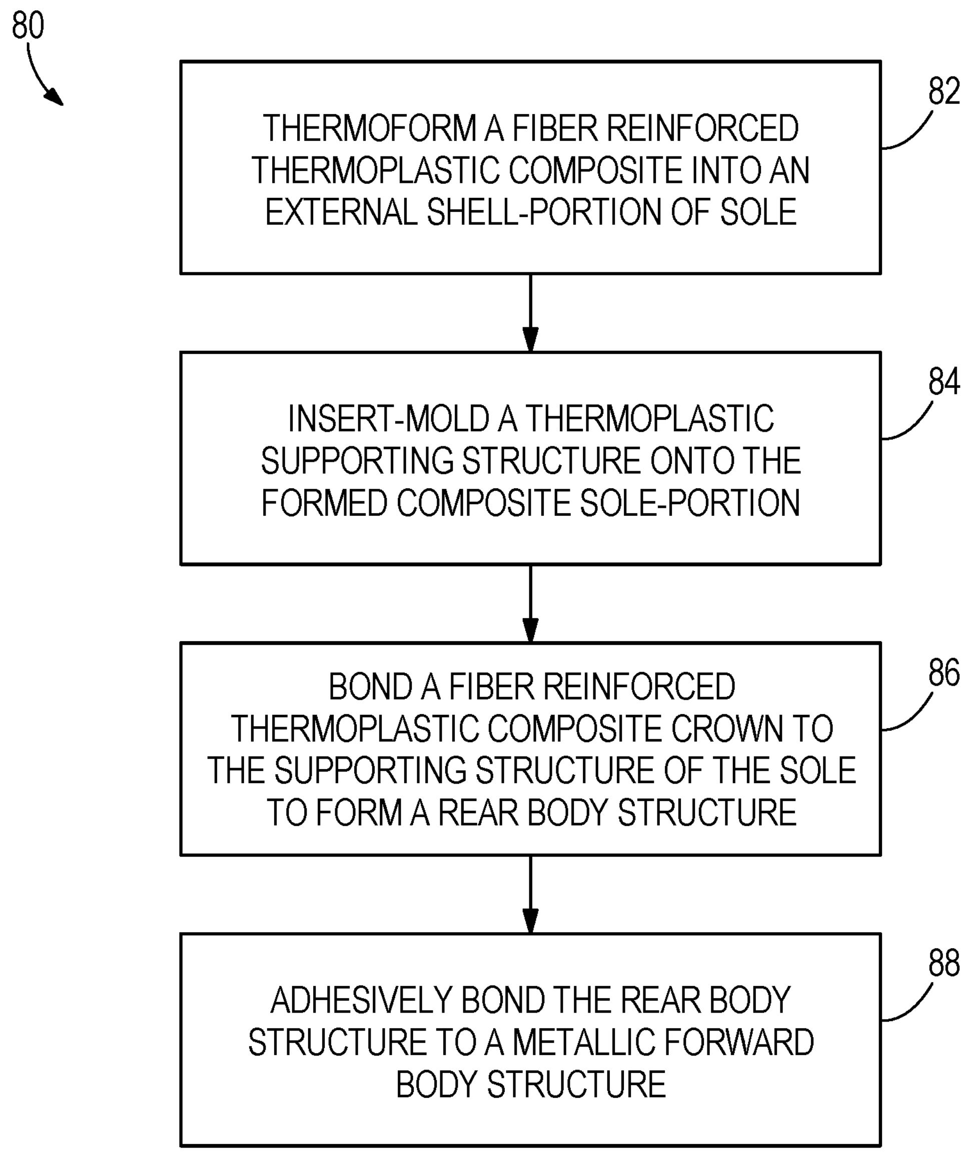
FIG. 7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THERMOFORM A FIBER REINFORCED THERMOPLASTIC COMPOSITE INTO AN EXTERNAL SHELL-PORTION OF SOLE
82
INSERT-MOLD A THERMOPLASTIC SUPPORTING STRUCTURE ONTO THE FORMED COMPOSITE SOLE-PORTION
84
BOND A FIBER REINFORCED THERMOPLASTIC COMPOSITE CROWN TO THE SUPPORTING STRUCTURE OF THE SOLE TO FORM A REAR BODY STRUCTURE
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ADHESIVELY BOND THE REAR BODY STRUCTURE TO A METALLIC FORWARD BODY STRUCTURE
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FIG. 8

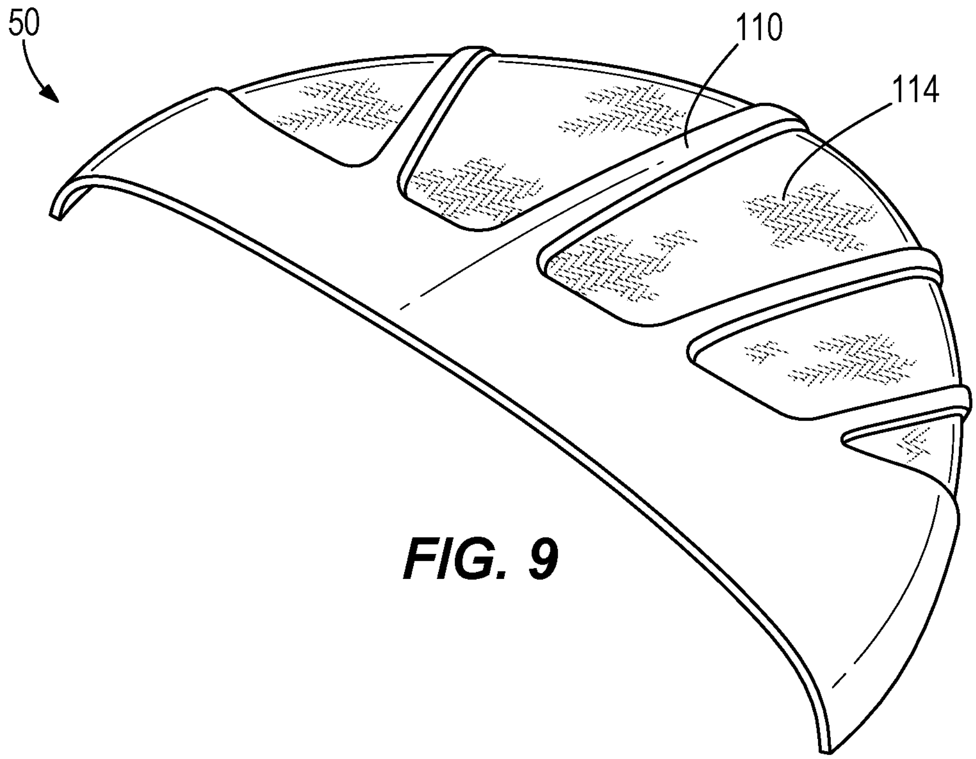

FIG. 9

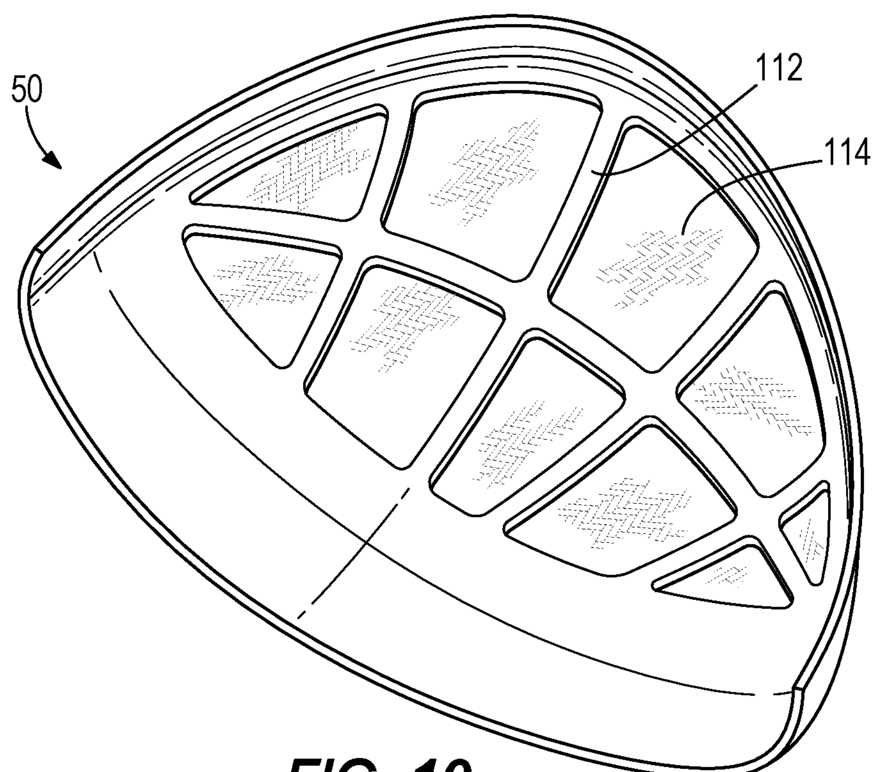

FIG. 10

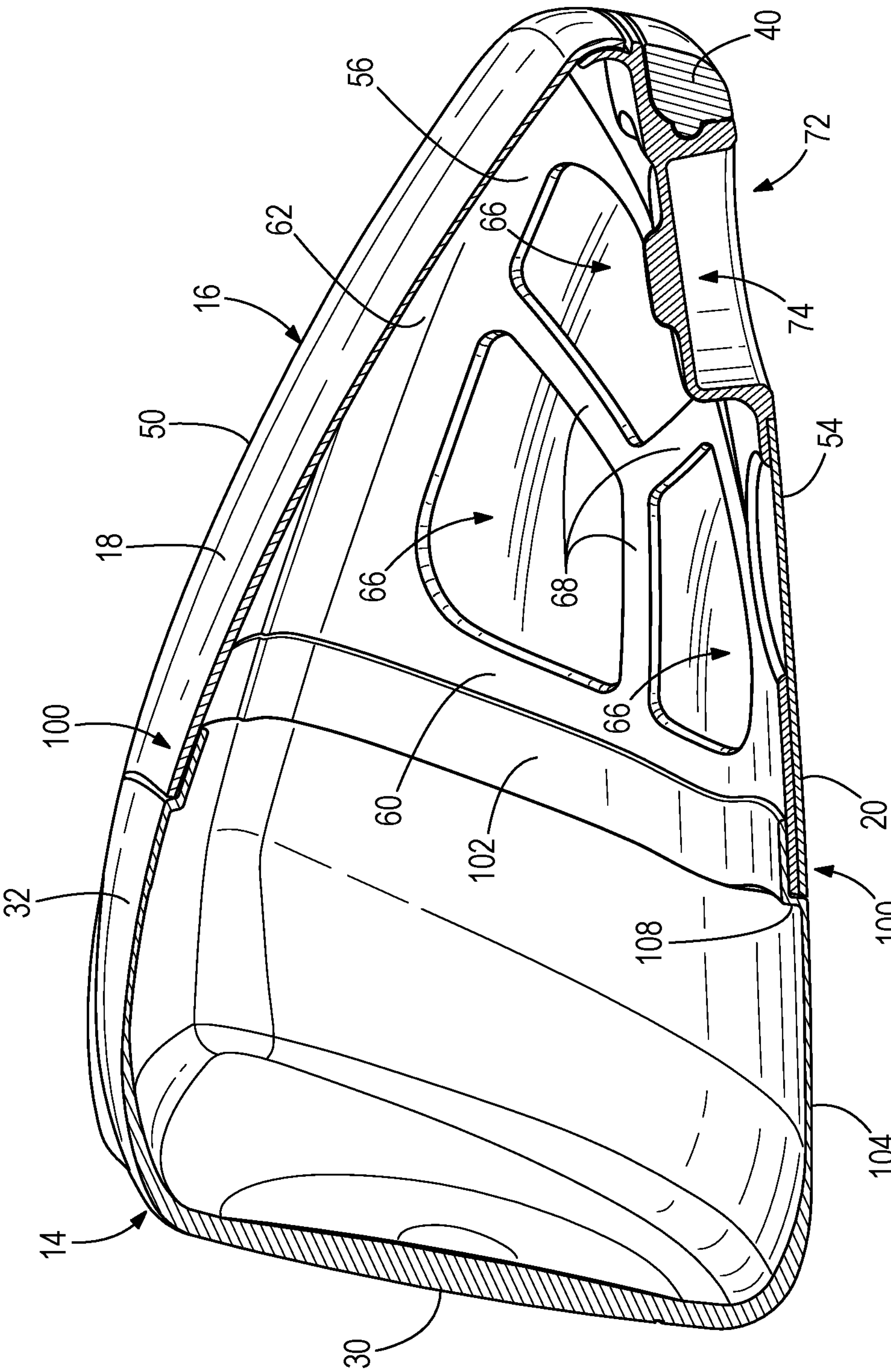
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FIG. 11

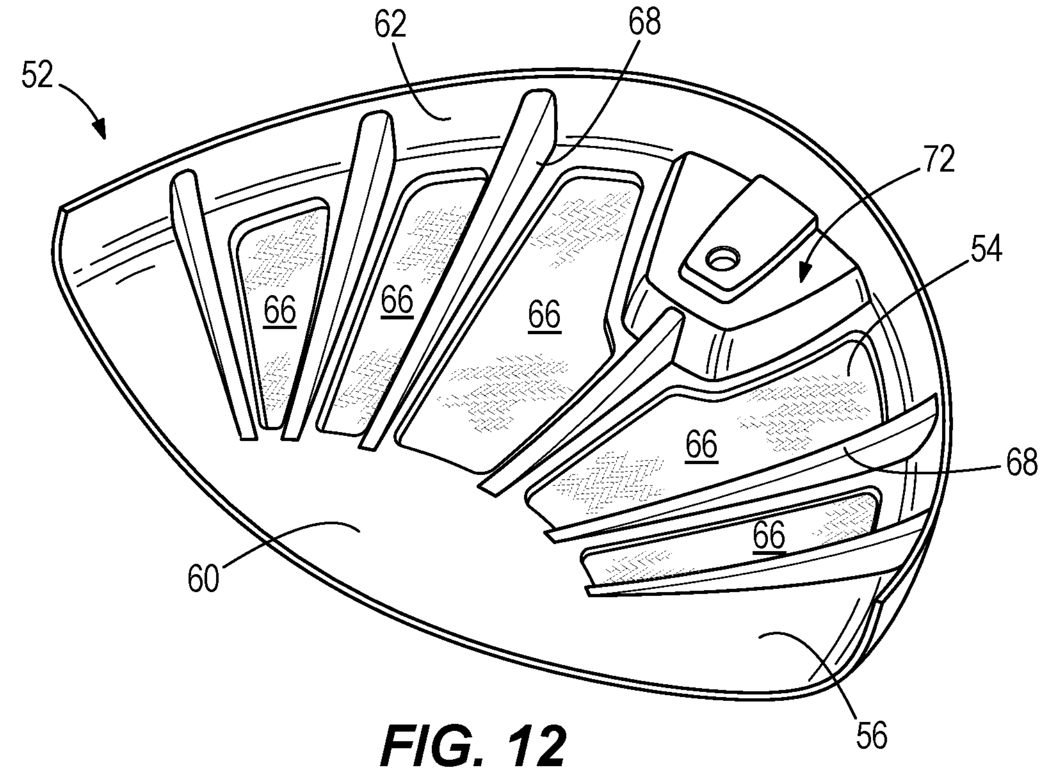
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FIG. 12

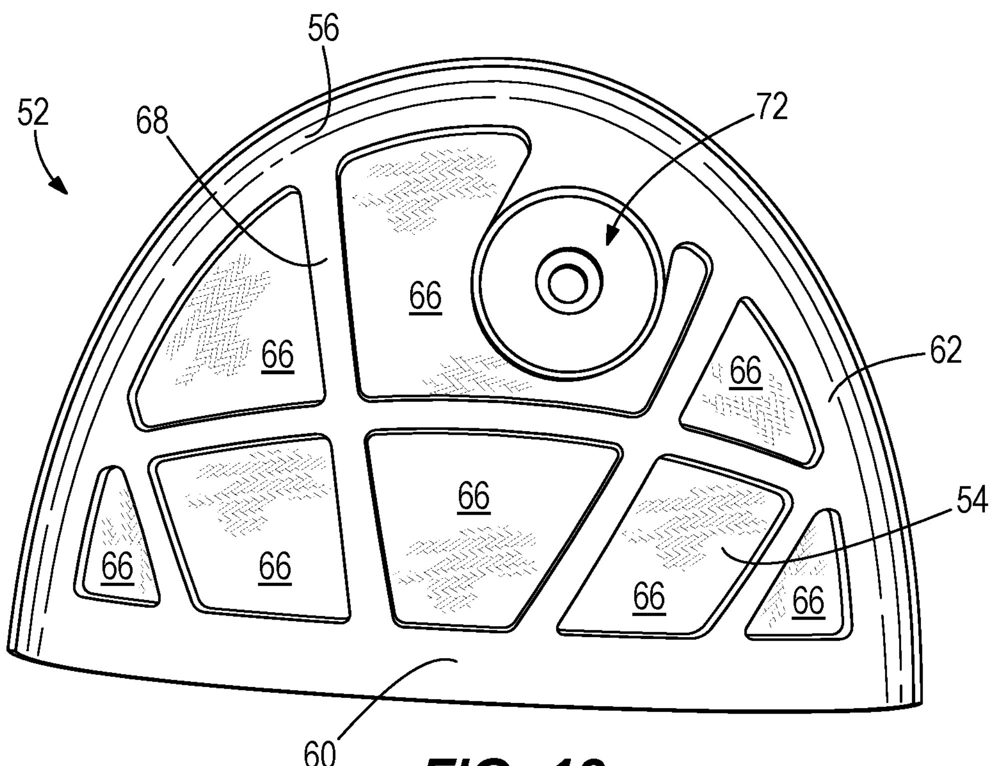
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FIG. 13

MIXED MATERIAL GOLF CLUB HEAD

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation of U.S. patent application Ser. No. 16/380,873, filed Apr. 10, 2019, which is a continuation of U.S. patent application Ser. No. 15/901,081, filed Feb. 21, 2018, now U.S. Pat. No. 10,300,354, issued on May 28, 2019, which is a continuation of U.S. patent application Ser. No. 15/607,166, filed May 26, 2017, now U.S. Pat. No. 9,925,432, issued on Mar. 27, 2018, which claims the benefit of priority from U.S. Provisional Patent Application No. 62/342,741, filed 27 May 2016, all of which are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

The present invention relates generally to a golf club head with a mixed material construction.

BACKGROUND

In an ideal club design, for a constant total swing weight, the amount of structural mass would be minimized (without sacrificing resiliency) to provide a designer with additional discretionary mass to specifically place in an effort to customize club performance. In general, the total of all club head mass is the sum of the total amount of structural mass and the total amount of discretionary mass. Structural mass generally refers to the mass of the materials that are required to provide the club head with the structural resilience needed to withstand repeated impacts. Structural mass is highly design-dependent, and provides a designer with a relatively low amount of control over specific mass distribution. Conversely, discretionary mass is any additional mass (beyond the minimum structural requirements) that may be added to the club head design for the sole purpose of customizing the performance and/or forgiveness of the club. There is a need in the art for alternative designs to all metal golf club heads to provide a means for maximizing discretionary weight to maximize club head moment of inertia (MOI) and lower/back center of gravity (COG).

While this provided background description attempts to clearly explain certain club-related terminology, it is meant to be illustrative and not limiting. Custom within the industry, rules set by golf organizations such as the United States Golf Association (USGA) or The R&A, and naming convention may augment this description of terminology without departing from the scope of the present application.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic perspective view of a mixed-material golf club head.

FIG. **2** is a schematic bottom view of a mixed-material golf club head.

FIG. **3** is a schematic exploded perspective view of an embodiment of a mixed-material golf club head similar to that shown in FIG. **1**.

FIG. **4** is a schematic perspective view of a sole member of a mixed-material golf club head.

FIG. **5** is a schematic enlarged sectional view of a portion of the sole member of FIG. **4**, taken along section **5-5**.

FIG. **6** is a schematic partial cross-sectional view of a joint structure of the golf club head of FIG. **2**, taken along line **6-6**.

FIG. **7** is a schematic partial cross-sectional view of a joint structure of the golf club head of FIG. **2**, taken along line **7-7**.

FIG. **8** is a schematic flow chart illustrating a method of manufacturing a mixed material golf club head.

FIG. **9** is a schematic top perspective view of a mixed material crown member.

FIG. **10** is a schematic bottom perspective view of a mixed material crown member.

FIG. **11** is a schematic cross-sectional side view of an embodiment of a mixed material golf club head such as may be taken along line **11-11** of FIG. **2**.

FIG. **12** is a schematic top perspective view of an embodiment of a mixed material sole member.

FIG. **13** is a schematic top perspective view of an embodiment of a mixed material sole member.

DETAILED DESCRIPTION

The present embodiments discussed below are directed to a club head that utilizes a mixed material rear body construction in combination with metallic strikeface and front frame structure. The mixed material rear body is comprised of a fiber reinforced thermoplastic composite resilient layer and a molded thermoplastic structural layer. Utilizing a mixed material rear body construction provides a significant reduction in structural weight while not sacrificing any design flexibility.

A further advantage of the mixed material rear body embodiments described below is the manufacturer has the ability to provide robust means for reintroducing discretionary mass. While such designs may be formed entirely from a filled thermoplastic, such as polyphenylene sulfide (PPS), the use of a fiber reinforced composite provides a stronger and lighter construction across a continuous outer surface. Further, the molded resilient layer further comprises a filled thermoplastic resin. Having thermoplastic resins in both the fiber reinforced thermoplastic composite resilient layer and the molded thermoplastic structural layer provide an ability to co-mold these materials. This provides a club head design of unique geometries for weight savings via the thermoplastic structural layer, but also manufacturing capability of merging layers of rigid strength via the composite resilient layer. Overall, the merging of these mixed material rear constructions with the metallic strikeface and front frame structure facilitate the transfer of dynamic impact loads from the weight/weighted portion to the metallic front of the club head.

Further, the use of thermoplastic resins may provide certain acoustic advantages that are not possible with other polymers. Use of the thermoplastic polymers of the present construction enable the assembled golf club head to acoustically respond closer to that of an all-metal design.

"A," "an," "the," "at least one," and "one or more" are used interchangeably to indicate that at least one of the item is present; a plurality of such items may be present unless the context clearly indicates otherwise. All numerical values of parameters (e.g., of quantities or conditions) in this specification, including the appended claims, are to be understood as being modified in all instances by the term "about" whether or not "about" actually appears before the numerical value. "About" indicates that the stated numerical value allows some slight imprecision (with some approach to exactness in the value; about or reasonably close to the value; nearly). If the imprecision provided by "about" is not otherwise understood in the art with this ordinary meaning, then "about" as used herein indicates at least variations that may arise from ordinary methods of measuring and using such parameters. In addition, disclosure of ranges includes disclosure of all values and further divided ranges within the entire range. Each value within a range and the endpoints of a range are hereby all disclosed as separate embodiment. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of stated items, but do not preclude the presence of other items. As used in this specification, the term "or" includes any and all combinations of one or more of the listed items. When the terms first, second, third, etc. are used to differentiate various items from each other, these designations are merely for convenience and do not limit the items.

The terms "loft" or "loft angle" of a golf club, as described herein, refers to the angle formed between the club face and the shaft, as measured by any suitable loft and lie machine.

The terms "first," "second," "third," "fourth," and the like in the description and in the claims, if any, are used for distinguishing between similar elements and not necessarily for describing a particular sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances such that the embodiments described herein are, for example, capable of operation in sequences other than those illustrated or otherwise described herein. Furthermore, the terms "include," and "have," and any variations thereof, are intended to cover a non-exclusive inclusion, such that a process, method, system, article, device, or apparatus that comprises a list of elements is not necessarily limited to those elements, but may include other elements not expressly listed or inherent to such process, method, system, article, device, or apparatus.

The terms "left," "right," "front," "back," "top," "bottom," "over," "under," and the like in the description and in the claims, if any, are used for descriptive purposes with general reference to a golf club held at address on a horizontal ground plane and at predefined loft and lie angles, though are not necessarily intended to describe permanent relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances such that the embodiments of the apparatus, methods, and/or articles of manufacture described herein are, for example, capable of operation in other orientations than those illustrated or otherwise described herein.

The terms "couple," "coupled," "couples," "coupling," and the like should be broadly understood and refer to connecting two or more elements, mechanically or otherwise. Coupling (whether mechanical or otherwise) may be for any length of time, e.g., permanent or semi-permanent or only for an instant.

Other features and aspects will become apparent by consideration of the following detailed description and accompanying drawings. Before any embodiments of the disclosure are explained in detail, it should be understood that the disclosure is not limited in its application to the details or construction and the arrangement of components as set forth in the following description or as illustrated in the drawings. The disclosure is capable of supporting other embodiments and of being practiced or of being carried out in various ways. It should be understood that the description of specific embodiments is not intended to limit the disclosure from covering all modifications, equivalents and alternatives falling within the spirit and scope of the disclosure. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

Referring to the drawings, wherein like reference numerals are used to identify like or identical components in the various views, FIG. **1** schematically illustrates a perspective view of a golf club head **10**. In particular, the present technology relates to the design of a wood-style head, such as a driver, fairway wood, or hybrid iron.

The golf club head **10** includes a front body portion **14** ("front body **14**") and a rear body portion **16** ("rear body **16**") that are secured together to define a substantially closed/hollow interior volume. As is conventional with wood-style heads, the golf club head **10** includes a crown **18** and a sole **20**, and may be generally divided into a heel portion **22**, a toe portion **24**, and a central portion **26** that is located between the heel portion **22** and toe portion **24**.

The front body **14** generally includes a strike face **30** intended to impact a golf ball, a frame **32** that surrounds and extends rearward from a perimeter **34** of the strike face **30** to provide the front body **14** with a cup-shaped appearance, and a hosel **36** for receiving a golf club shaft or shaft adapter. To withstand the impact stresses that occur when the club head **10** strikes a golf ball, the front body **14** is formed from a metal or metal alloy, and preferably a light-weight metal alloy, such as, for example, a stainless steel or steel alloy (e.g., C300, C350, Ni (Nickel)-Co(Cobalt)-Cr(Chromium)-Steel Alloy, 565 Steel, AISI type 304 or AISI type 630 stainless steel), a titanium alloy (e.g., a Ti-6-4, Ti-3-8-6-4-4, Ti-10-2-3, Ti 15-3-3-3, Ti 15-5-3, Ti185, Ti 6-6-2, Ti-7s, Ti-92, or Ti-8-1- 1 Titanium alloy), an amorphous metal alloy, or other similar materials.

To reduce the structural mass of the club head beyond what is possible with traditional metal forming techniques, the rear body **16** may be substantially formed from one or more polymeric materials and/or fiber reinforced polymeric composites. The structural weight savings accomplished through this design may be used to either reduce the entire weight of the club head **10** (which may provide faster club head speeds and/or longer hitting distances) or to increase the amount of discretionary mass that is available for placement on the club head **10** (i.e., for a constant club head weight). In a preferred embodiment, the additional discretionary mass is re-included in the final club head design via one or more metallic weights **40** that are coupled with the sole **20** and/or rear-most portion of the club head **10**.

Referring to FIG. **3**, the rear body **16** may generally be formed by bonding a crown member **50** to a sole member **52**. In a preferred embodiment, the crown member **50** forms a portion of the crown **18**, the sole member **52** forms a portion of the sole **20**, and they generally meet at an external seam that is at or slightly below where the tangent of the club head surface exists in a vertical plane (i.e., when the club head **10** is held in a neutral hitting position according to predetermined loft and lie angles).

In the present design, the rear body **16** may include a mix of molded thermoplastic materials (e.g., injection molded thermoplastic materials) and fiber reinforced thermoplastic composite materials. As used herein, a molded thermoplastic material is one that relies on the polymer itself to provide structure and rigidity to the final component. The molded thermoplastic material is one that is readily adapted to molding techniques such as injection molding, whereby the material is freely flowable when in a heated to a temperature above the melting point of the polymer. A molded thermoplastic material with a mixed-in filler material is referred to as a filled thermoplastic (FT) material. Filled thermoplastic materials are freely flowable when in a heated/melted state. To facilitate the flowable characteristic, filler materials generally include discrete particulate having a maximum dimension of less than about 25 mm, or more commonly less than about 12 mm. For example, the filler materials can include discrete particulate having a maximum dimension of 4 mm, 5 mm, 6 mm, 7 mm, 8 mm, 9 mm, or 10 mm. Filler materials useful for the present designs may include, for example, glass beads or discontinuous reinforcing fibers formed from carbon, glass, or an aramid polymer.

In contrast to molded and filled thermoplastic materials, fiber reinforced composite (FRC) materials generally include one or more layers of a uni- or multi-directional fiber fabric that extend across a larger portion of the polymer. Unlike the reinforcing fibers that may be used in FT materials, the maximum dimension of fibers used in FRCs may be substantially larger/longer than those used in FT materials, and may have sufficient size and characteristics such that they may be provided as a continuous fabric separate from the polymer. When formed with a thermoplastic polymer, even if the polymer is freely flowable when melted, the included continuous fibers are generally not.

FRC materials are generally formed by arranging the fiber into a desired arrangement, and then impregnating the fiber material with a sufficient amount of a polymeric material to provide rigidity. In this manner, while FT materials may have a resin content of greater than about 45% by volume or more preferably greater than about 55% by volume, FRC materials desirably have a resin content of less than about 45% by volume, or more preferably less than about 35% by volume. FRC materials traditionally use two-part thermoset epoxies as the polymeric matrix, however, it is possible to also use thermoplastic polymers as the matrix. In many instances, FRC materials are pre-prepared prior to final manufacturing, and such intermediate material is often referred to as a prepreg. When a thermoset polymer is used, the prepreg is partially cured in intermediate form, and final curing occurs once the prepreg is formed into the final shape. When a thermoplastic polymer is used, the prepreg may include a cooled thermoplastic matrix that can subsequently be heated and molded into final shape.

With continued reference to FIG. **3**, in an embodiment, the crown member **50** may be substantially formed from a formed fiber reinforced composite material that comprises a woven glass or carbon fiber reinforcing layer embedded in a polymeric matrix. In such an embodiment, the polymeric matrix is preferably a thermoplastic material such as, for example, polyphenylene sulfide (PPS), polyether ether ketone (PEEK), or a polyamide such as PA6 or PA66. In other embodiments, the crown member **50** may instead be formed from a filled thermoplastic material that comprises a glass bead or discontinuous glass, carbon, or aramid polymer fiber filler embedded throughout a thermoplastic material such as, for example, polyphenylene sulfide (PPS), polyether ether ketone (PEEK), or polyamide. In still other embodiments, such as described below with respect to FIGS. **9** and **10**, the crown member **50** may have a mixed-material construction that includes both a filled thermoplastic material and a formed fiber reinforced composite material.

In the embodiment illustrated in FIG. **3**, the sole member **52** has a mixed-material construction that includes both a fiber reinforced thermoplastic composite resilient layer **54** and a molded thermoplastic structural layer **56**. In a preferred embodiment, the molded thermoplastic structural layer **56** may be formed from a filled thermoplastic material that comprises a glass bead or discontinuous glass, carbon, or aramid polymer fiber filler embedded throughout a thermoplastic material such as, for example, polyphenylene sulfide (PPS), polyether ether ketone (PEEK), or a polyamide such as PA6 or PA66. The resilient layer **54** may then comprise a woven glass, carbon fiber, or aramid polymer fiber reinforcing layer embedded in a thermoplastic polymeric matrix that includes, for example, a polyphenylene sulfide (PPS), a polyether ether ketone (PEEK), or a polyamide such as PA6 or PA66. In one particular embodiment, the crown member **50** and resilient layer may each comprise a woven carbon fiber fabric embedded in a polyphenylene sulfide (PPS), and the structural layer may comprise a filled polyphenylene sulfide (PPS) polymer.

With respect to both the polymeric construction of the crown member **50** and the sole member **52**, any filled thermoplastics or fiber reinforced thermoplastic composites should preferably incorporate one or more engineering polymers that have sufficiently high material strengths and/or strength/weight ratio properties to withstand typical use while providing a weight savings benefit to the design. Specifically, it is important for the design and materials to efficiently withstand the stresses imparted during an impact between the strike face **30** and a golf ball, while not contributing substantially to the total weight of the golf club head **10**. In general, preferred polymers may be characterized by a tensile strength at yield of greater than about 60 MPa (neat), and, when filled, may have a tensile strength at yield of greater than about 110 MPa, or more preferably greater than about 180 MPa, and even more preferably greater than about 220 MPa. In some embodiments, suitable filled thermoplastic polymers may have a tensile strength at yield of from about 60 MPa to about 350 MPa. In some embodiments, these polymers may have a density in the range of from about 1.15 to about 2.02 in either a filled or unfilled state, and may preferably have a melting temperature of greater than about 210° C. or more preferably greater than about 250° C.

PPS and PEEK are two exemplary thermoplastic polymers that meet the strength and weight requirements of the present design. Unlike many other polymers, however, the use of PPS or PEEK is further advantageous due to their unique acoustic properties. Specifically, in many circumstances, PPS and PEEK emit a generally metallic-sounding acoustic response when impacted. As such, by using a PPS or PEEK polymer, the present design can leverage the strength/weight benefits of the polymer, while not compromising the desirable metallic club head sound at impact.

With continued reference to FIG. **3**, the present design utilizes a mixed material sole construction to leverage the strength to weight ratio benefits of FRCs, while also leveraging the design flexibility and dimensional stability/consistency offered by FTs. More specifically, while FRCs are typically stronger and less dense than FTs of the same polymer, their strength is typically contingent upon a smooth and continuous geometry. Conversely, while FTs are marginally more dense than FRCs, they can form significantly more complex geometries and are generally stronger than FRCs in intricate or discontinuous designs. These differences are largely attributable to the FRCs heavy reliance on continuous fibers to provide strength, whereas FTs rely more heavily on the structure of polymer itself.

As such, to maximize the strength of the present design at the lowest possible structural weight, the present design utilizes an FRC material to form large portions of the resilient outer shell of the sole **20**, while using an FT material to locally enhance design flexibility and/or strength. More specifically, the FT material is used to: provide optimized selective structural reinforcement (i.e., where voids/apertures would otherwise compromise the strength of an FRC); affix one or more metallic swing weights **40** (i.e., where the FT more readily facilitates the attachment of discretionary metallic swingweights by molding complex receiving cavities or over-molding aspects of the weight); and/or provide a dimensionally consistent joint structure that facilitates a structural attachment between the crown member **50** and the sole member **52** while providing a continuous club head outer surface.

FIG. **4** more clearly illustrates an embodiment of the sole member **52**, with an FRC resilient layer **54** bonded to a FT structural layer **56**. As shown, the structural layer **56** may generally include a forward portion **60** and a rear peripheral portion **62** that define an outer perimeter **64** of the sole member **52**. In an assembled club head **10**, the forward portion **60** is bonded to the metallic front body **14**, and the rear peripheral portion **62** is bonded to the crown member **50**. The structural layer **52** defines a plurality of apertures **66** located interior to the perimeter **64** that each extend through the thickness of the layer **50**. Finally, the structural layer **52** may include one or more structural members **68** that extend from the forward portion **60** and between at least two of the plurality of apertures **66**.

As shown in FIG. **4**, and more clearly in FIGS. **5-7**, the resilient layer **54** may be bonded to an external surface **70** of the structural layer **56** such that it directly abuts and/or overlaps at least a portion of the forward portion **60**, the rear peripheral portion **62**, and the one or more structural members **68**. In doing so, the resilient layer **54** may entirely cover each of the plurality of apertures **66** when viewed from the exterior of the club head **10**. Likewise, the one or more structural members **68** may serve as selective reinforcement to an interior portion of the resilient layer **54**, akin to a reinforcing rib or gusset.

With reference to FIGS. **2-4**, in some embodiments, the structural layer **56** may include a weighted portion **72** that is adapted to receive the one or more metallic weights **40** (e.g., tungsten-based swing weights) either by directly adhering or embedding the weight into a molded cavity, or by providing a recess **74** that is operative to receive a removable metallic mass. The weighted portion **72** is generally located toward the rear most point on the club head **10**, and therefore may be integral to and/or directly coupled with the rear peripheral portion **62** of the structural layer **56**, and spaced apart from the forward portion **60**. As noted above, the filled thermoplastic construction of the structural layer **56** is particularly suited to receive the one or more weights **40** due to its ability to form complex geometry in a structurally stable manner. More specifically, the filled thermoplastic construction of the structural layer **56** allows the design to include one or more dimensional recesses that would generally not be possible with an all-FRC construction (i.e., as the strength benefits of FRCs are typically only available across continuous surface geometries). For example, as shown in FIG. **3**, and more clearly in the cross-sectional view of FIG. **11**, the weighted portion **72** may be molded to define one or more weight-receiving channels or recesses that have non-uniform thicknesses, that extend around corners, and/or that join with other surfaces at sharp angles; all of which would be difficult or impossible to form strictly with a fiber reinforced composite.

While affixing the one or more weights **40** to the structural layer **56** at a rear portion of the club head **10** desirably shifts the center of gravity of the club head **10** rearward and lower while also increasing the club head's moment of inertia, it also can create a cantilevered point mass spaced apart from the more structural metallic front body **14**. As such, in some embodiments, the one or more structural members **68** may span between the weighted portion **72** and the forward portion **60** to provide a reinforced load path between the one or more weights **40** and the metallic front body **14**. In this manner, the one or more stiffening members **68** may be operative to aid in transferring a dynamic load between the weighted portion **72** and the front body **14** during an impact between the strike face **30** and a golf ball. At the same time, these same rib-like stiffening members **68** may be operative to reinforce the resilient layer **54** and increase the modal frequencies of the club head at impact such that the natural frequency is greater than about 3,500 Hz at impact, and exists without substantial dampening by the polymer. When this surface reinforcement is combined with the desirable metallic-like acoustic impact properties of polymers such as PPS or PEEK, a user may find the club head **10** to be audibly similar from an all-metal club head while the design provides significantly improved mass properties (CG location and/or moments of inertia).

In a preferred embodiment, the resilient layer **54** and the structural layer **56** may be integrally bonded to each other without the use of an intermediate adhesive. Such a construction may simplify manufacturing, reduce concerns about component tolerance, and provide a superior bond between the constituent layers than could be accomplished via an adhesive or other joining methods. To accomplish the integral bond, each of the resilient layer **54** and structural layer **56** may include a compatible thermoplastic polymer that may be thermally bonded to the polymer of the mating layer.

FIG. **8** illustrates an embodiment of a method **80** for manufacturing a golf club head **10** having the integrally bonded resilient layer **54** and structural layer **56** of the sole member **52**. The method **80** involves thermoforming a fiber reinforced thermoplastic composite into an external shell portion of the club head **10** at step **82**. The thermoforming process may involve, for example, pre-heating a thermoplastic prepreg to a molding temperature at least above the glass transition temperature of the thermoplastic polymer, molding the prepreg into the shape of the shell portion, and then trimming the molded part to size.

Once the composite shell portion is in a proper shape, a filled polymeric supporting structure may then be injection molded into direct contact with the shell at step **84**. Such a process is generally referred to as insert-molding. In this process, the shell is directly placed within a heated mold having a gated cavity exposed to a portion of the shell. Molten polymer is forcibly injected into the cavity, and thereafter either directly mixes with molten polymer of the heated composite shell, or locally bonds with the softened shell. As the mold is cooled, the polymer of the composite shell and supporting structure harden together in a fused relationship. The bonding is enhanced if the polymer of the shell portion and the polymer of the supporting structure are compatible, and is even further enhanced if the two components include a common thermoplastic resin component. While insert-molding is a preferred technique for forming the structure, other molding techniques, such as compression molding, may also be used.

With continued reference to FIG. **8**, once the sole member **52** is formed through steps **82** and **84**, an FRC crown member **50** may be bonded to the sole member **52** to substantially complete the structure of the rear body **16** (step **86**). In a preferred embodiment, the crown member **50** may be formed from a thermoplastic FRC material that is formed into shape using a similar thermoforming technique as described with respect to step **82**. Forming the crown member **50** from a thermoplastic composite allows the crown member **50** to be bonded to the sole member **52** using a localized welding technique. Such welding techniques may include, for example, laser welding, ultrasonic welding, or potentially electrical resistance welding if the polymers are electrically conductive. If the crown member **50** is instead formed using a thermoset polymer, then the crown member **50** may be bonded to the sole member **52** using, for example, an adhesive or a mechanical affixment technique (studs, screws, posts, mechanical interference engagement, etc).

FIG. **6** generally illustrates an embodiment of a joint **90** that is operative to couple the crown member **50** and sole member **52**. As shown, the structural layer **56** separately receives the resilient layer **54** and crown member **50** to form a continuous external surface **92** (i.e., the external surface **92** of the rear body **16** comprises an external surface **94** of the crown member **50**, an external surface **70** of the structural layer **56**, and an external surface **96** of the resilient layer **54**).

Referring again to FIG. **8**, the rear body **16**, comprising the affixed crown member **50** and sole member **52** may subsequently be adhesively bonded to the metallic front body structure **14** at step **88**. While adhesives readily bond to most metals, the process of adhering to the polymer may require the use of one or more adhesion promoters or surface treatments to enhance bonding between the adhesive and the polymer of the rear body **16**.

FIG. **7** schematically illustrates an example of a bond interface **100** between the sole member **52** and the frame **32** of the front body **14**. As shown, the bond interface **100** resembles a lap joint where the structural layer **56** and/or resilient layer **54** overlay a bonding flange **102** that is inwardly recessed from an external surface **104** of the frame **32**. In the illustrated embodiment, the structural layer **56** may be adhesively bonded directly to the bonding flange **102** via an intermediately disposed adhesive **106**. Furthermore, the resilient layer **54** may extend over the entire forward portion **60** of the structural layer **56** such that the external surface **96** of the resilient layer **54** is flush with the external surface **104** of the frame **32**. By recessing the bonding flange **102** in the manner shown, the structural layer **56** and/or resilient layer **54** may directly abut an extension wall **108** joining the frame **32** and flange **102** to further facilitate the transfer of dynamic impact loads from the weight **40**/weighted portion **72** to the frame **32**.

In some embodiments, the resilient layer **54** may have a substantially uniform thickness that may be in the range of from about 0.5 mm to about 0.7 mm, from about 0.5 mm to about 1.0 mm, or from about 0.6 mm to about 0.9 mm, or from about 0.7 mm to about 0.8 mm. In some embodiments, the resilient layer **54** may have a substantially uniform thickness of 0.5 mm, 0.55 mm, 0.60 mm, 0.65 mm, or 0.70 mm. In areas of the structural layer **56** that directly abut the resilient layer **54** (i.e., areas where the resilient layer **54** is located exterior to the structural layer **56**), some embodiments of the structural layer **56** may have a substantially uniform thickness of from about 0.5 mm to about 0.7 mm, from about 0.5 mm to about 1.0 mm, or from about 0.6 mm to about 0.9 mm, or from about 0.7 mm to about 0.8 mm. In some embodiments, the structural layer **56** may have a substantially uniform thickness of 0.5 mm, 0.55 mm, 0.60 mm, 0.65 mm, or 0.70 mm. A substantially uniform construction of both the resilient layer **54** and the structural layer **56** is generally illustrated in FIGS. **4-7** and **11**. In these embodiments, the total thickness of the resilient layer **54** and the structural layer **56** may be, for example, in the range of from about 1.0 mm to about 1.5 mm, from about 1.0 mm to about 2.0 mm, or from about 1.25 mm to about 1.75 mm, or from about 1.4 mm to about 1.6 mm. In some embodiments, the total thickness of the resilient layer **54** and the structural layer **56** may be 1.0 mm, 1.1 mm, 1.2 mm, 1.3 mm, 1.4 mm, or 1.5 mm.

Referring again to FIGS. **3** and **6**, in an embodiment, the recessed bonding flange **102** may entirely encircle the strike face **30** and/or extend from the frame **32** across all portions of the crown **18** and sole **20**. In this manner, as shown in FIG. **6**, the rear body **16** may further be adhesively bonded to the front body **14** by adhering the crown member **50** to the bonding flange **102**.

While the method **80** illustrated in FIG. **8** is primarily focused with forming a club head similar to that shown in FIG. **3** (i.e., where step **82** forms the resilient layer **54** of the sole member **52** and step **84** forms the structural layer **56** of the sole member **52**), the processes described with respect to steps **82** and **84** may also (or alternatively) be used to form a crown member **50**. For example, as shown in FIGS. **9** and **10**, the crown member **50** may include one or both of an outer structural layer **110** and an inner structural layer **112** bonded to a thermoplastic FRC resilient crown layer **114**. While the inner structural layer **112** may generally function in a similar manner as the structural layer **56** of the sole member **52**, the outer structural layer **110** may provide further weight saving benefits by concentrating reinforcing structure in areas where it provides the most structural benefit while also enabling thinner component thicknesses at interstitial spaces. In general, the present concept of structural ribbing generally results in the creation of weight reduction zones between the ribbing. These weight reduction zones can be in the sole or the crown, and are further described in U.S. Pat. Nos. 7,361,100 and 7,686,708, which are incorporated by reference in its entirety.

Specific to construction of a mixed-material crown member **50**, and similar to that described above with respect to the sole member **52**, the formation may begin by thermoforming a fiber reinforced thermoplastic composite into an external shell portion of the club head **10**. The thermoforming process may involve, for example, pre-heating a thermoplastic prepreg to a molding temperature at least above the glass transition temperature of the thermoplastic polymer, molding the prepreg into the shape of the shell portion, and then trimming the molded part to size.

Once the composite shell portion is in a proper shape, a filled polymeric supporting structure (i.e., one or both of the inner structural layer **112** and outer structural layer **114**) may then be injection molded into direct contact with the shell (e.g., via insert-molding, as described above).

Additional aerodynamic features **116**, such as turbulators, illustrated in FIG. **1** can be used to reduce club head drag and increase the speed of the club. These aerodynamic features **116** are further described in U.S. Pat. No. 9,555,294 (the '294 patent), which is incorporated by reference in its entirety.

Referring to FIG. **2**, the frame **32** may define a forward sole portion **120** that directly abuts the strike face **30**. The forward sole portion **120** may terminate at a rearward edge **122** that mates with the rear body **16**. In some embodiments, this rearward edge **122** may define a rearwardly protruding section **124** within the central region **26** that has a generally convex shape and extends an average distance D from the strike face **30** that is greater than both a first average distance d**1** between the rearward edge **122** and the strike face **30** in the toe region **24** and a second average distance d**2** between the rearward edge **122** and the strike face **30** in the heel region **22**. In some configurations, the convex shape may be defined by a radius of curvature in the range of from about 25 mm to about 125 mm and an arc length in the range of from about 12 mm to about 50 mm. The rearwardly protruding section **124** generally bounds the region of the sole **20** that is under the highest stress and exhibits the highest deflection in an all-metal club head (not shown) of identical size and shape compared to the illustrative embodiment. The rear edge **122** of protruding section **124** corresponds essentially to a nodal line of the first vibration mode of the club head sole **20** which, therefore, experiences little or no deflection during impact.

Construction of the forward sole portion **120** with the illustrated geometry ensures that the portions of the sole **20** with the highest stress concentration are formed from metal. This has the practical effect of enabling a thinner, lighter rear body **16** sole member **52** due to the need for less structural reinforcement, while also maintaining a desirable dominant natural frequency at impact of at least 3,500 Hz without substantial dampening by the polymer. Similar geometry may be provided on the crown **18** of the club head **10**, as described in U.S. Pat. No. 7,601,078, which is incorporated by reference in its entirety.

Utilizing a mixed material rear body construction can provide a significant reduction in structural weight while not sacrificing any design flexibility, and providing a robust means for reintroducing discretionary mass. While such a design may be formed entirely from a filled thermoplastic, such as polyphenylene sulfide (PPS), as discussed above, the use of a fiber reinforced composite provides a stronger and lighter construction across continuous outer surfaces. Conversely, an all-FRC design would not readily incorporate weight-receiving structures, and thus would not be able to easily capitalize on increased discretionary mass.

Table 1 provides comparative mass estimates for the rear body **16** design shown in FIG. **3** between an all filled PPS construction and the mixed material design described above. As shown, the mixed material design contributes to a significant weight savings over an all filled PPS construction, which can then be reintroduced into the weighted portion **72** to effect an additional translation of the center of mass down and back to increase forgiveness and dynamic loft.

TABLE 1

Mass comparison of rear body all PPS and mixed FRC/FT construction

	Crown Member	Sole Member	Combined
All Filled PPS	11.1 g	33.2 g	44.3 g
Mixed Material	9.8 g	28.0 g	37.8 g

If all the recovered mass is relocated to the rear weighted portion of the sole member **52**, then the Mixed Material design may result in a net translation of the center of gravity (for a club head with a 205 g total mass) by approximately 0.008 mm lower, and 0.058 mm rearward when compared to an all filled PPS construction.

Table 2 illustrates the effect that the present, mixed-material construction may have on the club head moment of inertia for a club head with a 205 g total mass. Specifically, Table 2 compares the club head moments of inertia about a vertical axis (I_{YY}) and about a horizontal axis extending from the heel to the toe (I_{XX}) for a metal reference design having a similar exterior shape, for a club head with an all PPS sole member construction, and for a club head with the above-described mixed-material sole member construction.

TABLE 2

Moment of Inertia comparison of reference metal, all PPS sole member and mixed FRC/FT sole member

	I_{XX} (g-cm^2)	I_{YY} (g-cm^2)
Metal	3252	5407
All Filled PPS	4031	5580
Mixed Material	4286	5767

As shown in Table 2, the present mixed material design may result in about a 6.3% increase in I_{XX} over the all filled PPS sole member club head, and about a 31.8% increase in I_{XX} over the reference metal design. Likewise, the present mixed material design may result in about a 3.3% increase in I_{YY} over the all filled PPS sole member club head, and about a 6.6% increase in I_{YY} over the reference metal design. In this manner, the present mixed-material construction results in a club head that is significantly more stable during off-center impacts than either an all-PPS sole member construction or the reference metal design. Furthermore, the mixed-material design results in an increase in 2.5-3.0× increase in sole strength/resiliency when compared with an all filled-PPS construction, and present about 90%-98% of the strength/resiliency of the all-metal reference design.

Again, as noted above, these stability benefits are generated without sacrificing the sound quality of the impact. Specifically, the use of PPS or PEEK thermoplastic resins may provide certain acoustic advantages that are not possible with other polymers. Specifically, PPS and PEEK have particularly metallic acoustic properties when impacted. As such, use of these polymers in the present construction may enable the assembled golf club head **10** to acoustically respond closer to that of an all-metal design. While polyamides and some thermoplastic polyurethane materials may have sufficient strength to be suitable in the current design, their use may provide a substantially different acoustic response.

FIGS. **11-13** illustrate alternate sole member designs that may similarly be used in the present golf club head construction. For example, FIG. **11** illustrates an embodiment where at least one of the plurality of stiffening members **68** extends to the rear peripheral portion **62** separate from the weighted portion **72**. In this embodiment, the stiffening member **68** may resemble a "Y" that extends between the forward portion **60**, the weighted portion **72**, and the rear peripheral portion **62** separate from the weighted portion **72**. This design may further leverage the stiffened "skirt" (i.e., the reinforced band of material where the crown **18** meets the sole **20**) to operatively stiffen the sole and to provide an additional load path from the weighted portion **72**.

FIG. **12** illustrates an embodiment of the sole member **52** where a plurality of the stiffening members **68** extend directly from the forward portion **60** of the structural layer **56** to the rear peripheral portion **62** separate from the weighted portion **72**. One stiffening member **68**, however remains directly extending between the weighted portion **72** and forward portion. Additionally, FIG. **12** schematically illustrates an embodiment where the structural layer **56** may have a non-uniform/non-sheet-like geometry. Such a configuration for at least the stiffening member **68** may similarly be used with any of the previously illustrated embodiments. In an embodiment with a non-uniform structural layer, such as generally shown in FIG. **12**, some constructions may still provide the resilient layer **54** with a substantially uniform thickness attributable to the nature of the fiber reinforced composite. This thickness may, for example, be in the range of from about 0.5 mm to about 1.0 mm, or from about 0.6 mm to about 0.9 mm, or even from about 0.7 mm to about 0.8 mm. Finally, FIG. **13** illustrates an embodiment where the weighted portion **72** is supported by only the rear peripheral portion **62**, with no structural member **68** being connected thereto.

Replacement of one or more claimed elements constitutes reconstruction and not repair. Additionally, benefits, other advantages, and solutions to problems have been described with regard to specific embodiments. The benefits, advantages, solutions to problems, and any element or elements that may cause any benefit, advantage, or solution to occur or become more pronounced, however, are not to be construed as critical, required, or essential features or elements of any or all of the claims, unless such benefits, advantages, solutions, or elements are expressly stated in such claims.

As the rules to golf may change from time to time (e.g., new regulations may be adopted or old rules may be eliminated or modified by golf standard organizations and/or governing bodies such as the United States Golf Association (USGA), the Royal and Ancient Golf Club of St. Andrews (R&A), etc.), golf equipment related to the apparatus, methods, and articles of manufacture described herein may be conforming or non-conforming to the rules of golf at any particular time. Accordingly, golf equipment related to the apparatus, methods, and articles of manufacture described herein may be advertised, offered for sale, and/or sold as conforming or non-conforming golf equipment. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

While the above examples may be described in connection with an iron-type golf club, the apparatus, methods, and articles of manufacture described herein may be applicable to other types of golf club such as a driver wood-type golf club, a fairway wood-type golf club, a hybrid-type golf club, an iron-type golf club, a wedge-type golf club, or a putter-type golf club. Alternatively, the apparatus, methods, and articles of manufacture described herein may be applicable to other types of sports equipment such as a hockey stick, a tennis racket, a fishing pole, a ski pole, etc.

Moreover, embodiments and limitations disclosed herein are not dedicated to the public under the doctrine of dedication if the embodiments and/or limitations: (1) are not expressly claimed in the claims; and (2) are or are potentially equivalents of express elements and/or limitations in the claims under the doctrine of equivalents.

Various features and advantages of the disclosures are set forth in the following clauses.

Clause 1: A golf club head comprising a metallic front body including a strike face and a surrounding frame that extends rearward from a perimeter of the strike face; a rear body coupled to the metallic front body to define a substantially hollow structure, the rear body including a crown member and a sole member coupled to the crown member, the sole member comprising: a structural layer formed from a filled thermoplastic material and bonded to the crown member, the structural layer including a plurality of apertures extending through a thickness of the structural layer; and a resilient layer bonded to an external surface of the structural layer such that the resilient layer extends across each of the plurality of apertures, wherein the resilient layer is formed from a fiber-reinforced thermoplastic composite material; wherein the structural layer and the resilient layer each comprise a common thermoplastic resin component, and wherein the structural layer is directly bonded to the resilient layer without an intermediate adhesive.

Clause 2: The golf club head of clause 1, wherein the structural layer further includes: a forward portion in contact with, and bonded to the metallic front body; a weighted portion spaced apart from the forward portion; a structural member extending from the forward portion to the weighted portion and between at least two of the plurality of apertures, the structural member integrally molded with both the forward portion and the weighted portion; and the sole member further including a metallic weight at least partially embedded in, or adhesively bonded to the weighted portion of the structural layer.

Clause 3: The golf club head of any of clauses 1-2, wherein an external surface of the rear body comprises an external surface of the crown member, an external surface of the resilient layer, and a portion of the external surface of the structural layer.

Clause 4: The golf club head of any of clauses 1-3, wherein the metallic front body further includes a bonding flange that is inwardly recessed from an external surface of the frame; wherein the structural layer is adhesively bonded to the bonding flange; and wherein an external surface of the resilient layer is flush with the external surface of the frame.

Clause 5: The golf club head of clause 4, wherein the metallic front body further includes an extension wall that couples the frame to the bond flange; wherein the structural layer and resilient layer each abut the extension wall; and wherein the stiffening member is operative to transfer a dynamic load between the weighted portion and the extension wall during an impact between the strike face and a golf ball.

Clause 6: The golf club head of any of clauses 1-5, wherein the common thermoplastic resin component comprises polyphenylene sulfide or polyether ether ketone.

Clause 7: The golf club head of any of clauses 1-6, wherein the frame includes a crown portion and a sole portion, wherein the golf club head includes a heel region, a toe region, and a central region disposed between the heel region and the toe region; wherein the sole portion of the frame defines a rearward edge that extends a first average distance from the strike face within the heel region, a second average distance from the strike face within the toe region, and a third average distance from the strike face within the central region; and wherein the third average distance is greater than both the first average distance and the second average distance.

Clause 8: A golf club head comprising: a metallic front body including a strike face and a surrounding frame that extends rearward from a perimeter of the strike face; a rear body coupled to the metallic front body to define a substantially hollow structure, the rear body including a crown member coupled with a sole member, the sole member comprising: a structural layer having: a forward portion in contact with and bonded to the metallic front body; a weighted portion spaced apart from the forward peripheral portion; a plurality of apertures extending through a thickness of the structural layer, wherein the forward portion and weighted portion are disposed on opposing sides of at least one of the plurality of apertures; and a plurality of stiffening members, each stiffening member extending from the forward portion to the weighted portion and between at least two of the plurality of apertures; a resilient layer bonded to an external surface of the structural layer such that the resilient layer abuts the metallic front body and extends across each of the plurality of apertures; a metallic weight at least partially embedded in, or adhesively bonded to the weighted portion of the structural layer; and wherein the structural layer is formed from a filled thermoplastic material, and the resilient layer is formed from a fiber-reinforced thermoplastic composite material.

Clause 9: The golf club head of clause 8, wherein the resilient layer is directly bonded to the structural layer without an intermediate adhesive.

Clause 10: The golf club head of any of clauses 8-9, wherein the structural layer further includes a rear peripheral portion extending between the weighted portion and the forward portion, wherein the rear peripheral portion is bonded to the crown member.

Clause 11: The golf club head of clause 10, wherein at least one of the plurality of stiffening members extends to the rear peripheral portion separate from the weighted portion.

Clause 12: The golf club head of any of clauses 8-11, wherein an external surface of the rear body comprises an external surface of the crown member, an external surface of the resilient layer, and a portion of the external surface of the structural layer.

Clause 13: The golf club head of any of clauses 8-12, wherein the metallic front body further includes a bonding flange that is inwardly recessed from an external surface of the frame; wherein the structural layer is adhesively bonded to the bonding flange; and wherein an external surface of the resilient layer is flush with the external surface of the frame.

Clause 14: The golf club head of clause 13, wherein the metallic front body further includes an extension wall that couples the frame to the bond flange; wherein the structural layer and resilient layer each abut the extension wall; and wherein the plurality of stiffening members are operative to transfer a dynamic load between the weighted portion and the extension wall during an impact between the strike face an a golf ball.

Clause 15: The golf club head of any of clauses 8-14, wherein the frame includes a crown portion and a sole portion, wherein the golf club head includes a heel region, a toe region, and a central region disposed between the heel region and the toe region; wherein the sole portion of the frame defines a rearward edge that extends a first average distance from the strike face within the heel region, a second average distance from the strike face within the toe region, and a third average distance from the strike face within the central region; and wherein the third average distance is greater than both the first average distance and the second average distance.

Clause 16: The golf club head of clause 15, wherein the weighted portion and a geometric center of the strike face are located within the central region.

Clause 17: The golf club head of any of clauses 8-16, wherein each of the filled thermoplastic material and fiber reinforced thermoplastic composite material includes a common resin component; and wherein the common resin component is present in the filled thermoplastic material in a first amount and is present in the fiber reinforced thermoplastic composite material in a second amount that is less than the first amount.

Clause 18: The golf club head of clause 17, wherein the common resin component comprises polyphenylene sulfide or polyether ether ketone.

Clause 19: The golf club head of any of clauses 17-18, wherein the first amount greater than about 55% by volume, and the second amount less than about 35% by volume.

Clause 20: A method of manufacturing a multi-material golf club head comprising: thermoforming a first sole layer from a fiber-reinforced composite comprising a thermoplastic resin matrix and a woven fiber reinforcement layer; injection molding a second sole layer in direct contact with the thermoformed first sole layer, wherein the second sole layer comprises a filled thermoplastic resin, and wherein the thermoplastic resin matrix and the filled thermoplastic resin each comprise a common thermoplastic polymer; bonding a crown member to the second sole layer; and bonding the first sole layer and the crown member to a metallic forward body to define a substantially hollow structure, and wherein the metallic forward body includes a strike face and a hosel.

Clause 21: The method of clause 21, wherein bonding a crown member to the second sole layer includes welding the crown member to the second sole layer through at least one of laser welding, ultrasonic welding, or electrical resistance welding.

Clause 22: The method of any of clauses 20-21, further comprising forming the crown member by thermoforming a first crown layer from a fiber-reinforced composite comprising a thermoplastic resin matrix and a woven fiber reinforcement layer; injection molding a second crown layer in direct contact with the thermoformed first crown layer, wherein the second crown layer comprises a filled thermoplastic resin, and wherein the thermoplastic resin matrix and the filled thermoplastic resin each comprise a common thermoplastic polymer

Clause 23: A golf club head comprising a metallic front body including a strike face and a surrounding frame that extends rearward from a perimeter of the strike face; a rear body coupled to the metallic front body to define a substantially hollow structure, the rear body including a crown member and a sole member coupled to the crown member, the crown member comprising: a structural layer formed from a filled thermoplastic material and bonded to the sole member, the structural layer including a plurality of apertures extending through a thickness of the structural layer; and a resilient layer bonded to the structural layer such that the resilient layer extends across each of the plurality of apertures, wherein the resilient layer is formed from a fiber-reinforced thermoplastic composite material; wherein the structural layer and the resilient layer each comprise a common thermoplastic resin component, and wherein the structural layer is directly bonded to the resilient layer without an intermediate adhesive.

The invention claimed is:

1. A golf club head comprising:

a metallic front body including a strike face and a surrounding frame that extends rearward from a perimeter of the strike face;

a rear body coupled to the metallic front body to define a substantially hollow structure, the rear body including a crown member coupled with a sole member;

wherein the sole member comprises:

a structural layer formed from a filled thermoplastic material, the structural layer including:

a forward portion in contact with and bonded to the metallic front body;

a rear peripheral portion that defines an outer perimeter of the sole member;

a weighted portion spaced apart from the forward portion;

a plurality of apertures extending through a thickness of the structural layer;

a first stiffening member, extending from the forward portion to the weighted portion and between at least two of the plurality of apertures; and

a plurality of secondary stiffening members, each secondary stiffening member extending from the forward portion to the rear peripheral portion, separate from the weighted portion, and located between at least two of the plurality of apertures; and

a resilient layer bonded to an external surface of the structural layer such that the resilient layer abuts the metallic front body and extends across each of the plurality of apertures, wherein the resilient layer is formed from a fiber-reinforced thermoplastic composite material.

2. The golf club head of claim **1**, wherein each of the filled thermoplastic material and fiber reinforced thermoplastic composite material includes a common resin component.

3. The golf club head of claim **1**, wherein the resilient layer comprises a uniform thickness in a range of about 0.5 mm and about 0.7 mm; and the structural layer comprises at least one thickness in a range of about 0.5 mm to about 0.7 mm.

4. The golf club head of claim **1**, wherein:

each of the filled thermoplastic material and fiber reinforced thermoplastic composite material includes a common thermoplastic resin component; and

the common thermoplastic resin component comprises polyphenylene sulfide or polyether ether ketone.

5. The golf club head of claim **1**, wherein the crown member comprises a crown structural layer formed from a filled thermoplastic material and a crown resilient layer formed from a fiber-reinforced thermoplastic composite material.

6. The golf club head of claim **1**, wherein:

the weighted portion is integral to the rear peripheral portion;

the weighted portion defines one or more weight-receiving channels that comprise non-uniform thicknesses; and

the sole member further includes a metallic weight at least partially embedded in the one or more weight-receiving channels.

7. The golf club head of claim **1**, wherein:

the metallic front body further includes a bonding flange that is inwardly recessed from an external surface of the surrounding frame;

the structural layer is adhesively bonded to the bonding flange;

an external surface of the resilient layer is flush with the external surface of the surrounding frame;

the metallic front body further includes an extension wall that couples the surrounding frame to the bonding flange;

the structural layer and resilient layer each abut the extension wall; and

the first stiffening member and the plurality of secondary stiffening members are operative to transfer a dynamic load between the weighted portion and the extension wall during an impact between the strike face and a golf ball.

8. A golf club head comprising:

a metallic front body including a strike face and a surrounding frame that extends rearward from a perimeter of the strike face;

a rear body coupled to the metallic front body to define a substantially hollow structure, the rear body including a crown member coupled with a sole member;

wherein the sole member comprises:

a structural layer formed from a filled thermoplastic material, the structural layer including:

a forward portion in contact with and bonded to the metallic front body;

a weighted portion spaced apart from the forward portion; and

a plurality of apertures extending through a thickness of the structural layer; and

a resilient layer bonded to an external surface of the structural layer such that the resilient layer abuts the metallic front body and extends across each of the plurality of apertures, wherein the resilient layer is formed from a fiber-reinforced thermoplastic composite material;

wherein:

the structural layer comprises a non-uniform geometry; and

the resilient layer comprises a uniform thickness.

9. The golf club head of claim **8**, wherein:

each of the filled thermoplastic material and fiber reinforced thermoplastic composite material includes a common resin component;

the common resin component is present in the filled thermoplastic material in greater than about 55% by volume and is present in the fiber-reinforced thermoplastic composite material in less than about 35% by volume.

10. The golf club head of claim **8**, wherein the resilient layer comprises a uniform thickness in a range of about 0.5 mm and about 0.7 mm; and a total thickness of the resilient layer and the structural layer together falls between 1.0 mm and 1.5 mm.

11. The golf club head of claim **8**, wherein:

each of the filled thermoplastic material and fiber reinforced thermoplastic composite material includes a common thermoplastic resin component; and

the common thermoplastic resin component comprises polyphenylene sulfide or polyether ether ketone.

12. The golf club head of claim **8**, wherein the crown member comprises a crown structural layer formed from a filled thermoplastic material and a crown resilient layer formed from a fiber-reinforced thermoplastic composite material.

13. The golf club head of claim **8**, wherein:

the weighted portion is integral to a rear peripheral portion of the sole;

the weighted portion defines one or more weight-receiving channels that comprise non-uniform thicknesses; and

the sole member further includes a metallic weight at least partially embedded in the one or more weight-receiving channels.

14. The golf club head of claim **8**, wherein:

the metallic front body further includes a bonding flange that is inwardly recessed from an external surface of the surrounding frame;

the structural layer is adhesively bonded to the bonding flange;

an external surface of the resilient layer is flush with the external surface of the surrounding frame;

the metallic front body further includes an extension wall that couples the surrounding frame to the bonding flange;

the structural layer and resilient layer each abut the extension wall.

15. A golf club head comprising:

a metallic front body including a strike face and a surrounding frame that extends rearward from a perimeter of the strike face;

a rear body coupled to the metallic front body to define a substantially hollow structure, the rear body including a crown member coupled with a sole member;

wherein the sole member comprises:

a structural layer formed from a filled thermoplastic material, the structural layer including:

a forward portion in contact with and bonded to the metallic front body;

a rear peripheral portion that defines an outer perimeter of the sole member;

a weighted portion spaced apart from the forward portion;

a plurality of apertures extending through a thickness of the structural layer;

a first stiffening member, extending from the forward portion to the weighted portion; and

a plurality of secondary stiffening members, each secondary stiffening member extending from the forward portion to the rear peripheral portion and separate from the weighted portion; and

a resilient layer bonded to an external surface of the structural layer such that the resilient layer abuts the metallic front body and extends across each of the plurality of apertures, wherein the resilient layer is formed from a fiber-reinforced thermoplastic composite material;

wherein each of the filled thermoplastic material and fiber reinforced thermoplastic composite material includes a common thermoplasticresin component.

16. The golf club head of claim **15**, wherein:

the resilient layer is directly bonded to the structural layer without an intermediate adhesive; and

the common thermoplastic resin component comprises polyphenylene sulfide or polyether ether ketone.

17. The golf club head of claim **15**, wherein the resilient layer comprises a uniform thickness in a range of about 0.5 mm and about 0.7 mm; and the structural layer comprises at least one thickness in a range of about 0.5 mm to about 0.7 mm.

18. The golf club head of claim **15**, wherein:

the weighted portion is integral to the rear peripheral portion;

the weighted portion defines one or more weight-receiving channels that comprise non-uniform thicknesses; and

the sole member further includes a metallic weight at least partially embedded in the one or more weight-receiving channels.

19. The golf club head of claim **15**, wherein:

the metallic front body further includes a bonding flange that is inwardly recessed from an external surface of the surrounding frame;

the structural layer is adhesively bonded to the bonding flange;

an external surface of the resilient layer is flush with the external surface of the surrounding frame;

the metallic front body further includes an extension wall that couples the surrounding frame to the bonding flange;

the structural layer and resilient layer each abut the extension wall; and

the first stiffening member and the plurality of secondary stiffening members are operative to transfer a dynamic load between the weighted portion and the extension wall during an impact between the strike face and a golf ball.

20. The golf club head of claim **19**, further comprising a skirt formed of a reinforced band of material where the crown member meets the sole member; wherein the skirt operatively stiffens the sole and provides an additional load path from the weighted portion and the extension wall during an impact between the strike face and a golf ball.

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