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Golf club heads and methods to manufacture golf club heads

Abstract

Embodiments of golf club heads and methods to manufacture golf club heads are generally described herein. In one example, a putter-type golf club head includes a body portion and a retention cavity extending into the body portion and having an opening and one or more interior side walls. The retention cavity defines two or more ball retention areas for frictionally engaging and retaining a golf ball within the retention cavity. The two or more ball retention areas frictionally engage the golf ball along a ball circumference located above an equator of the golf ball at a distance greater than or equal to 0.050 inches (0.127 centimeters) and less than or equal to 0.070 inches (0.178 centimeters). The golf club head has a head mass greater than or equal to 300 grams and less than or equal to 400 grams. Other examples and embodiments may be described and claimed.

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Background/Summary

CROSS REFERENCE (1) This application is a continuation of U.S. application Ser. No. 18/778,133, filed Jul. 19, 2024, which is a continuation of U.S. application Ser. No. 18/621,629, filed Mar. 29, 2024, now U.S. Pat. No. 12,076,625, which claims the benefit of U.S. Provisional Application No. 63/619,405, filed Jan. 10, 2024, and claims the benefit of U.S. Provisional Application No. 63/612,481, filed Dec. 20, 2023. (2) U.S. application Ser. No. 18/621,629, filed Mar. 29, 2024, is a continuation-in-part of U.S. application Ser. No. 18/385,952, filed Nov. 1, 2023, now U.S. Pat. No. 12,011,644, which is a continuation of U.S. application Ser. No. 18/219,215, filed Jul. 7, 2023, now U.S. Pat. No. 11,839,801, which claims the benefit of U.S. Provisional Application No. 63/524,452, filed Jun. 30, 2023, and the benefit of U.S. Provisional Application No. 63/470,711, filed Jun. 2, 2023. (3) U.S. application Ser. No. 18/621,629, filed Mar. 29, 2024, is a continuation-in-part of U.S. application Ser. No. 18/102,534, filed Jan. 27, 2023, now U.S. Pat. No. 12,138,512, which claims the benefit of U.S. Provisional Application No. 63/402,587, filed Aug. 31, 2022, and claims the benefit of U.S. Provisional Application No. 63/390,206, filed Jul. 18, 2022. (4) The disclosures of the above-referenced applications are incorporated by reference herein in their entirety.

FIELD
(2) The present disclosure generally relates to golf equipment, and more particularly, to golf club heads and methods to manufacture golf club heads.
BACKGROUND
(3) Certain putters include a retention feature that enables an individual to pick up a golf ball using a putter a head. Oftentimes, it may be difficult to release the golf ball from retention. Accordingly, there is a need for a putter head equipped with a retention feature that not only sufficiently retains a golf ball, but also does not impede an individual from dislodging the golf ball. This need is addressed by the following disclosure.

Description

DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** depicts a front view of a golf club according to an embodiment of the apparatus, methods, and articles of manufacture described herein.
(2) FIG. **2** depicts a front and top perspective view of a golf club head according to an embodiment of the apparatus, methods, and articles of manufacture described herein.
(3) FIG. **3** depicts a front and bottom perspective view of the golf club head of FIG. **2**.
(4) FIG. **4** depicts a rear and bottom perspective view of the golf club head of FIG. **2**.
(5) FIG. **5** depicts a heel-side and bottom perspective view of the golf club head of FIG. **2**.
(6) FIG. **6** depicts a toe-side and bottom perspective view of the golf club head of FIG. **2**.
(7) FIG. **7** depicts a front view of the golf club head of FIG. **2**.
(8) FIG. **8** depicts a rear view of the golf club head of FIG. **2**.
(9) FIG. **9** depicts a heel-side view of the golf club head of FIG. **2**.
(10) FIG. **10** depicts a toe-side view of the golf club head of FIG. **2**.
(11) FIG. **11** depicts a bottom view of the golf club head of FIG. **2** in which a golf ball is retained within a retention cavity located at a sole portion of the golf club head.
(12) FIG. **12** depicts a cross-sectional view of the golf club head of FIG. **2** taken along line **12-12**

of FIG. **11**.
(13) FIG. **13** depicts a cross-sectional view of the golf club head of FIG. **2** taken along line **13-13** of FIG. **11**.
(14) FIG. **14** depicts a cross-sectional view of the golf club head of FIG. **2** taken along line **14-14** of FIG. **11**.
(15) FIG. **15** depicts a cross-sectional view of the golf club head of FIG. **2** taken along line **15-15** of FIG. **11**.
(16) FIG. **16** depicts a process for manufacturing a golf club head according to an embodiment of the apparatus, methods, and articles of manufacture described herein.
(17) For simplicity and clarity of illustration, the drawing figures illustrate the general manner of construction, and descriptions and details of well-known features and techniques may be omitted to avoid unnecessarily obscuring the present disclosure. Additionally, elements in the drawing figures may not be depicted to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help improve understanding of embodiments of the present disclosure.

DESCRIPTION

(18) The following U.S. Patents and Patent Applications, which are collectively referred to herein as "the incorporated by reference patent documents," are incorporated by reference herein in their entirety: U.S. Pat. Nos. 9,233,283; 9,387,375; 9,440,124; 9,649,540; 9,895,585; 10,478,680; 10,493,331; 10,576,339; 10,737,153; 10,821,341; 10,960,271; 10,981,038; 11,045,698; 11,298,597; 11,369,849; and 11,517,798; 11,839,801; 11,918,869; and U.S. Patent Publication Nos. 20180200589; 20220219054; and 20230338795.
(19) In general, golf club heads and methods to manufacture golf club heads are described herein. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.
(20) In the example of FIG. **1**, a golf club **100** is generally shown as a putter-type golf club. The golf club **100** may include a shaft **120**, a grip **130**, a hosel portion **140**, and a golf club head **200**. The hosel portion **140** may be a separate part of the golf club **100** or be an integral part of the golf club head **200**. The shaft **120** may have a first end portion **121** and a second end portion **122** and may define a shaft axis **123** that may or may not intersect with the golf club head **200**. The second end portion **122** of the shaft **120** may be coupled to the grip **130** and the first end portion **121** of the shaft **120** may be coupled to the hosel portion **140**. The hosel portion **140** may be coupled to the golf club head **200** via a hosel bore or may be integral with the golf club head **200** or otherwise coupled to the golf club head **200**. The golf club head **200** may have a head mass greater than or equal to 300 grams and less than or equal to 400 grams. The shaft **120** may be formed from a metal material, a composite material, or any other suitable material or combination of materials. The grip **130** may be formed from a rubber material, a polymer material, or any other suitable material or combination of materials. Additional examples of golf clubs and golf club components may be found in the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.
(21) In the example of FIGS. **2-15**, the golf club head **200** may include a body portion **210** having a toc portion **220**, a heel portion **230**, a front portion **240**, a rear portion **250**, a top portion **260**, and a sole portion **270**. The body portion **210** may also include a hosel bore **235** located at or proximate the heel portion **230**, a face portion **245** (e.g., a strike face) located at the front portion **240**, and an alignment aid **265** located at the top portion **260**, examples of which may be found in the incorporated by reference patent documents. The body portion **210** may be manufactured via various manufacturing methods and/or processes (e.g., a casting process, a forging process, a milling process, a cutting process, a grinding process, a welding process, a combination thereof, etc.). The body portion **210** may be partially or entirely made of an aluminum-based material (e.g., a high-strength aluminum alloy or a composite aluminum alloy coated with a high-strength alloy), a magnesium-based material, a stainless steel-based material, a titanium-based material, a tungsten-

based material, any combination thereof, and/or other suitable types of materials. Alternatively, the body portion **210** may be partially or entirely made of a non-metal material (e.g., composite, plastic, etc.). In one example, the body portion **210** may be made of an aluminum-based material having a mass greater than or equal to 150 grams and less than or equal to 200 grams. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(22) The golf club head **200** may also include one or more weight portions (e.g., shown as weight portions **301**, **302**, and **303**), each of which may be coupled to a corresponding weight port (e.g., shown as weight ports **311**, **312**, and **313**) that may be variously located in the body portion **210**. In one example, weight ports **311** and **312** and corresponding weight portion **301** and **302** may be located at the sole portion **270** at or proximate the front portion **240**. Additionally, weight ports **311** and **312** may be disposed at or proximate the toc portion **220** and the heel portion **230**, respectively. Weight portions **301** and **302** may be configured as screw weights configured to engage corresponding threads in the weight ports **311** and **312**, respectively. In one example, weight portions **301** and **302** may be interchangeable. Weight port **313** and corresponding weight portion **303** may be located at or proximate the rear portion **250** and may extend between the toe portion **220** and the heel portion **230**. Weight portion **303** may be configured as a complementary insert that is adhered or otherwise coupled to weight port **313**. Weight portions **301**, **302**, and **303** may be configured to be flush or substantially flush with a bottom surface **275** of the sole portion **270**. Weight portions **301**, **302**, and **303** may each be made of any of the materials described herein. In one example, weight portions **301**, **302**, and **303** may each be made of a material having a density that is greater than a material of the body portion **210** to redistribute mass at or proximate a periphery of the golf club head **200** in order to increase a moment of inertia (MOI) of the golf club head **200**. Additionally, weight portion **303** may be significantly larger in size and mass than each of weight portions **301** and **302** to increase a center of gravity (CG) depth of the golf club head **200**, or in other words, shift the CG of the golf club head **200** farther away from a shaft axis (e.g., see shaft axis **123**) in a rearward direction of the golf club head **200** to improve the stability of the golf club head **200** during a golf swing. By locating the CG farther away from the shaft axis, a greater force may be required to twist or rotate the golf club head **200** from its natural path during a putting stroke. Accordingly, the golf club head **200** described herein may benefit from higher MOI and greater forgiveness. In one example, weight portion **303** may be at least ten times larger in size and/or mass than each of weight portions **301** and **302**. In another example, weight portion **303** may be at least 11 times larger in size and/or mass than each of weight portions **301** and **302**. In yet another example, weight portion **303** may be at least 12 times larger in size and/or mass than each of weight portions **301** and **302**. In one example, weight portions **301** and **302** may each have a volume greater than or equal to 0.061 cubic inches (ci) (1.003 cubic centimeters (cc)) and less than or equal to 0.083 ci (1.360 cc). Weight portions **301** and **302** may each be made of a stainless steel-based material having a mass greater than or equal to 8 grams and less than 10 grams. Weight portion **303** may have a volume greater than or equal to 0.844 ci (13.831 cc) and less than or equal to 1.142 ci (18.714 cc) and may be made of a stainless steel-based material having a mass greater than or equal to 108 grams and less than or equal to 146 grams. In another example, weight portions **301**, **302**, and/or **303** may be made of a tungsten-based material of variable size and/or mass. Additional examples of weight portions and weight ports may be found in the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(23) The golf club head **200** may additionally include a filler material **1410** housed within a cavity **320** located at the sole portion **270** and disposed behind at least a portion of the face portion **245**. The cavity **320** may extend toward the top portion **260** and may extend between the toe portion **220** and the heel portion **230**. In one example, the filler material **1410** may be provided to the cavity **320** as an injectable polymer material that undergoes hardening via a curing process. In another example, the filler material **1410** may be provided to the cavity **320** as a polymer insert. The filler

material **1410** may be configured to partially or entirely fill the cavity **320**. In one example, the filler material **1410** may have a volume greater than or equal to 1.547 ci (25.351 cc) and less than or equal to 2.094 ci (34.315 cc) and may be made of a polymer material having a mass greater than or equal to 5.508 grams and less than or equal to 7.452 grams. The filler material **1410** may structurally support the face portion **245** and may dampen sound and/or vibration when the face portion **245** strikes a golf ball. In one example, the face portion **245** may have a uniform or variable face thickness **1420** greater than or equal to 0.035 inch (0.089 cm) and less than or equal to 0.055 inch (0.140 cm). In another example, the face portion **245** may have a uniform or variable face thickness **1420** less than 0.035 inch (0.089 cm) or greater than 0.055 inch (0.140 cm). A sole plate **330** or other cover may be coupled to the sole portion **270** to close the cavity **320**. The sole plate **330** may be configured to be flush or substantially flush with the bottom surface **275** of the sole portion **270**. The sole plate **330** may be coupled to the sole portion **270** via welding, adhesive, mechanical fasteners, or any other suitable means. The sole plate **330** may be made of a material having a density that is similar to or different from a material of the body portion **210**. In one example, the sole plate **330** may be made of an aluminum-based material having a mass greater than or equal to 2.907 grams and less than or equal to 3.933 grams. Additional examples of golf club heads including a filler material may be found in the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(24) The golf club head **200** may further include a retention cavity **340** located at the sole portion **270** and configured to engage and retain at least a portion of a golf ball **1100**, which is shown in broken lines for visualization purposes. Accordingly, an individual using the golf club head **200** described herein may not be required to bend over to pick up the golf ball **1100**. The retention cavity **340** may be concealed by the body portion **210** such that the retention cavity **340** is not visible when the golf club head **200** is viewed from above the top portion **260**. The retention cavity **340** may be located between the filler material **1410** and weight portion **303** and between weight portions **301** and **302**. In one example, the retention cavity **340** may include an opening **345**, one or more interior side walls (e.g., shown as interior walls **351**, **352**, **353**, **354**, **355**, **356**, **357**, and **358**) extending upwardly from the opening **345** toward the top portion **260**, and one or more interior roof structures (e.g., shown interior roof structure **361**) connected to the one or more interior side walls. While the retention cavity **340** is generally shown in a particular orientation at or proximate a central location of the sole portion **270**, in other examples, the retention cavity **340** may be disposed elsewhere at the sole portion **270**. In other words, the location of the retention cavity **340** may be shifted toward the toe portion **220**, the heel portion **230**, the front portion **240**, the rear portion **250**, or a combination thereof. Additionally, the orientation of the retention cavity **340** may differ, or said differently, the retention cavity **340** may be rotated in a clockwise or a counterclockwise direction with respect to the orientation of the retention cavity **340** generally shown in FIG. **11**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(25) In the illustrated example, the opening **345** may have a polygonal or non-polygonal shape. In one example, the opening **345** may have an octagonal shape defined by opposing interior side walls **351** and **352**, opposing interior side walls **353** and **354**, opposing interior side walls **355** and **357**, and opposing interior side walls **356** and **358**. Interior side wall **351** may be disposed at or proximate the front portion **240** and may extend between the toc portion **220** and the heel portion **230**. Interior side wall **352** may be disposed at or proximate the rear portion **250** and may extend between the toe portion **220** and the heel portion **230**. Interior side wall **353** may be disposed at or proximate the toe portion **220** and may extend between the front portion **240** and the rear portion **250**. Interior side wall **354** may be disposed at or proximate the heel portion **230** and may extend between the front portion **240** and the rear portion **250**. Interior side wall **355** may extend from a toc-ward end of interior side wall **351** to a frontward end of interior side wall **353**. Interior side wall

356 may extend from a heel-ward end of interior side wall **351** to a frontward end of interior side wall **354**. Interior side wall **357** may extend from a rearward end of interior side wall **354** to a heel-ward end of interior side wall **352**. Interior side wall **358** may extend from a rearward end of interior side wall **353** to a toc-ward end of interior side wall **352**. Interior roof structure **361** may connect to an upper extent of each of interior side walls **351**, **352**, **353**, **354**, **355**, **356**, **357**, and **358**, respectively. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(26) The retention cavity **340** may define a space extending into the body portion **210** and may include two or more ball retention areas configured to frictionally engage and retain at least a portion of the golf ball **1100** within the retention cavity **340**. In one example, the retention cavity **340** may have four retention areas including a first ball retention area **1111** defined by interior side wall **351**, a second ball retention area **1112** defined by interior side wall **352**, a third ball retention area **1113** defined by interior side wall **353**, and a fourth ball retention area **1114** defined by interior side wall **354**. In this configuration, the golf ball **1100** may be retained and prevented from shifting in a longitudinal direction (i.e., a front-to-rear direction of the golf club head **200**) and a lateral direction (i.e., a heel-to-toc direction of the golf club head **200**). In one example, the first, second, third, and fourth ball retention areas **1111**, **1112**, **1113**, and **1114** may include portions of interior side walls **351**, **352**, **353**, and **354** located at or proximate the opening **345** of the retention cavity **340**, respectively. In operation, the retention cavity **340** may be positioned directly over the golf ball **1100** and the golf club head **200** may be urged downward toward the golf ball **1100** to eventually engage and retain at least a portion of the golf ball **1100** within the retention cavity **340**. In the illustrated example, the first, second, third, and fourth retention areas **1111**, **1112**, **1113**, and **1114** may include portions of interior side walls **351**, **352**, **353**, and **354** that are rounded at the opening **345** to help urge the golf ball **1100** into retention and increase a ball contact area of each of the first, second, third, and fourth ball retention areas **1111**, **1112**, **1113**, and **1114**. Additionally, interior side walls **355**, **352**, **353**, and **358** may also be rounded at the opening **345**. The adoption of rounded edges at the opening **345** may also reduce tear on the golf ball **1100** when compared to sharp edges that tend to cut or dig into the golf ball **1100**. With respect to any of the examples provided herein, any one of interior side walls **351**-**358** may include grip features for enhancing frictional engagement between the golf ball **1100** and the corresponding ball retention area. Such grip features may include grooves, textured surfaces, protrusions, and the like. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(27) To assist a user in dislodging the golf ball **1100** from the retention cavity **340**, the retention cavity **340** may include a ball release feature characterized by one or more relief gaps formed between the golf ball **1100** retained within the retention cavity **340** and one or more of the interior side walls **351**, **352**, **353**, **354**, **355**, **356**, **357**, and **358**. In the illustrated example, the retention cavity **340** may include a first relief gap **1121** formed between the golf ball **1100** and interior side wall **355**, a second relief gap **1122** formed between the golf ball **1100** and interior side wall **356**, a third relief gap **1123** formed between the golf ball **1100** and interior side wall **357**, and a fourth relief gap **1124** formed between the golf ball **1100** and interior side wall **358**. With respect to any of the examples provided herein, the ball release feature may be variously configured to provide sufficient clearance to allow an individual to easily dislodge the golf ball **1100** from the retention cavity **340** using his or her finger(s) or some other object (e.g., a tee, divot repair tool, and the like). In the illustrated example, the retention cavity **340** may alternate between interior side walls (e.g., interior side walls **351**, **352**, **353**, and **354**) that contact the golf ball **1100** and interior side walls (e.g., interior side walls **355**, **356**, **357**, and **358**) that do not contact the golf ball **1100**. In other examples, two or more interior side walls that contact a golf ball may be disposed adjacent to each other. Likewise, two or more interior side walls that do not contact a golf ball may be disposed adjacent to each other. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(28) In the illustrated example, the golf ball **1100** may have a diameter **1130** of 1.680 inches (4.268 cm) to comply with United States Golf Association (USGA) standards. In one example, the retention cavity **340** may have a volume greater than or equal to 1.547 ci (25.351 cc) and less than or equal to 2.094 ci (about 34.315 cc). Opposing interior side walls **351** and **352** and opposing interior side walls **353** and **354** may be separated by a distance (e.g., shown in FIG. **11** as **1141** and **1142**, respectively), measured at or proximate the opening **345**, that is less than or equal to the diameter **1130** of the golf ball **1100** to enable the corresponding first, second, third, and fourth ball retention areas **1111**, **1112**, **1113**, and **1114** to frictionally engage the golf ball **1100** at or proximate an equator **1200** of the golf ball **1100**. In one example, the distance **1141** between opposing interior side walls **351** and **352** and the distance **1142** between opposing interior side walls **353** and **354** may be greater than or equal to 1.620 inches (4.115 centimeters) and less than or equal to 1.670 inches (4.242 centimeters) such that the first, second, third, and fourth ball retention areas **1111**, **1112**, **1113**, and **1114** frictionally engage the golf ball **1100** along a ball circumference **1210** located above the equator **1200** at a height **1230** greater than or equal to 0.050 inch (0.127 centimeters) and less than or equal to 0.070 inch (0.178 centimeters). Accordingly, the retention cavity **340** may be configured to retain less than 50% of a total volume of the golf ball **1100**. In other examples, the retention cavity **340** may be configured to retain greater than or equal to 50% of the total volume of the golf ball **1100**. By fashioning the retention cavity **340** to engage the golf ball **1100** slightly above the equator **1200**, a greater degree of ball retention may be achieved due to an individual being able to exert greater downward force onto the golf ball **1100**, which may cause the golf ball **1100** to become increasingly pinched between the first, second, third, and fourth ball retention areas **1111**, **1112**, **1113**, and **1114**. Additionally, in one example, opposing interior side walls **355** and **357** and opposing interior side walls **356** and **358** may be separated by a distance (e.g., shown in FIG. **11** as **1143** and **1144**, respectively), measured at or proximate the opening **345**, that is greater than the diameter **1130** of the golf ball **1100** to provide sufficient clearance via the corresponding first, second, third, and fourth relief gaps **1121**, **1122**, **1123**, and **1124** to enable an individual to easily dislodge the golf ball **1100** using his or her finger(s) or some other object as described herein. In one example, the distance **1143** between opposing side walls **355** and **357** and/or the distance **1144** between opposing side walls **356** and **358** may be greater than or equal to 1.800 inches (4.572 centimeters) and less than or equal to 2.000 inches (5.080 centimeters). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(29) Interior side walls **351**, **352**, **353**, **354**, **355**, **356**, **357**, and **358** may be configured with a variety of physical properties (e.g., size, shape, dimension, etc.) to accommodate the golf ball **1100** or other golf balls of different diameters. Interior side walls **351**-**358** may be similar or different from each other. Interior side walls **351**, **352**, **353**, **354**, **355**, **356**, **357**, and **358** may be planar, curved, inward bulging, outward bulging, or follow any other suitable contour. In the illustrated example, interior side walls **351** and **352** may each have an arch shape or arch-like shape and interior side walls **353**, **354**, **355**, **356**, **357**, and **358** may each have a trapezoidal shape or trapezoidal-like shape. Interior side walls **351**-**354** may have similar lengths (e.g., shown in FIG. **3** as length **370**) and interior side walls **355**, **356**, **357**, and **358** may have similar lengths (e.g., shown in FIG. **3** as length **380**). In one example, the length **370** of interior side walls **351**, **352**, **353**, and **354** may be about 1.141 inches (2.898 centimeters) and the length **380** of interior side walls **355**, **356**, **357**, and **358** may be about 0.345 inches (0.876 centimeters). Any two adjacent interior side walls may form an interior angle of 135 degrees or about 135 degrees. Interior side walls **351** and **352** may each increase in height toward a center longitudinal plane **1240** of the golf club head **200** from both a heel-side direction and a toc-side direction of the golf club head **200**. In one example, interior side wall **351** may have a variable height **1300** greater than or equal 0.600 inch (1.524 centimeters) and less than or equal to 0.950 inch (2.413 centimeters) and interior side wall **352** may have a height **1250** greater than or equal to 0.500 inch (1.270 centimeters) and less than or equal to 0.800 inch (2.032 centimeters). Interior side walls **353** and **354** may mirror each other about the

center longitudinal plane **1240** of the golf club head **200** and may each decrease in height in a front-to-rear direction of the golf club head **200**. In one example, interior side walls **353** and **354** may have each have a variable height **1430** greater than or equal to 0.300 inch (0.762 centimeters) and less than or equal to 0.500 inch (1.270 centimeters). Interior side walls **355** and **356** may mirror each other about the center longitudinal plane **1240** and may decrease in height in the front-to-rear direction of the golf club head **200**. Additionally, interior side wall **355** may decrease in height in a heel-to-toe direction of the golf club head **200** whereas interior side wall **356** may increase in height in the heel-to-toc direction of the golf club head **200**. In one example, interior side walls **355** and **356** may each have a variable height **1310** greater than or equal to 0.400 inch (1.016 centimeters) and less than or equal to 0.700 inch (1.778 centimeters). Interior side walls **357** and **358** may mirror each other about the center longitudinal plane **1240** and may increase in height in the front-to-rear direction of the golf club head **200**. Additionally, interior side wall **357** may increase in height in the heel-to-toe direction of the golf club head **200** whereas interior side wall **358** may decrease in height in the heel-to-toe direction of the golf club head **200**. In one example, interior side walls **357** and **358** may each have a height **1260** that is greater than or equal to 0.300 inch (0.762 centimeters) and less than or equal to 0.600 inch (1.524 centimeters). In the illustrated example, any two opposing interior side walls (e.g., opposing interior side walls **351** and **352**, opposing interior side walls **353** and **354**, opposing interior side walls **355** and **357**, and opposing interior side walls **356** and **358**) may be slanted such that the corresponding distance (e.g., distances **1141**, **1142**, **1143**, and **1144**) between the any two opposing interior side walls decreases in a sole-to-top direction of the golf club head **200**. In other examples, any two opposing interior side walls may be configured such that a corresponding distance between the any two opposing interior side walls increases, decreases, and/or remains constant in the sole-to-top direction of the golf club head **200**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(30) The interior roof structure **361** may also be configured with a variety of physical properties (e.g., size, shape, dimension, etc.) to accommodate the golf ball **1100** or other golf balls of different diameters. Interior roof structure **361** may be planar, curved, inward bulging, outward bulging, or follow any other suitable contour. Interior roof structure **361** may contact or be spaced apart from the golf ball **1100** in retention. In the illustrated example, the interior roof structure **361** may have a dome shape or dome-like shape and may decrease in height in the front-to-rear direction of the golf club head **200** and may increase in height toward the center longitudinal plane **1240** of the golf club head **200** from both the heel-side direction and the toc-side direction of the golf club head **200**. In one example, interior roof structure **361** may have a height **1270** along the center longitudinal plane **1240** that is greater than or equal to 0.800 inch (2.032 centimeters) and less than or equal to 0.950 inch (2.413 centimeters). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(31) FIG. **16** depicts a process **1600** by which the golf club head **200** described herein may be manufactured and is described below with continued reference to the example golf club head **200** of FIGS. **2**-**15**. In the example of FIG. **16**, the process **1600** may begin with providing a body portion **210** having a toc portion **220**, a heel portion **230**, a front portion **240**, a rear portion **250**, a top portion **260**, and a sole portion **270** (block **1610**). A retention cavity **340** may be provided at the sole portion **270**, the retention cavity **340** including an opening **345**, one or more interior side walls (e.g., interior side walls **351**, **352**, **353**, **354**, **355**, **356**, **357**, and **358**) extending upwardly from the opening **345**, and one or more interior roof structures (e.g., interior roof structure **361**) connected to the one or more interior side walls (block **1620**). The retention cavity **340** may be configured with two or more ball retention areas (e.g., ball retention areas **1111**, **1112**, **1113**, and **1114**) for frictionally engaging and retaining at least a portion of a golf ball (e.g., golf ball **1100**) within the retention cavity **340** (block **1630**). The retention cavity **340** may also be configured with one or more relief gaps (e.g., relief gaps **1121**, **1122**, **1123**, and **1124**) to enable the golf ball **1100** to be

dislodged from the retention cavity **340** (block **1640**). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(32) While the above examples and figures may depict a retention cavity with a particular shape (e.g., one shown as the retention cavity **340** in FIG. **3**), the apparatus, methods, and articles of manufacture described herein may include a retention cavity with a different bowl or cup shape (e.g., symmetrical or asymmetrical). Further, the opening of the retention cavity **340** (e.g., one shown as the opening **345** in FIG. **3**) may have a shape different than the shape described and depicted in the above examples such as a circular shape, an elliptical shape, a triangular shape, a square shape, a rectangular shape, a pentagon shape, a hexagon shape, a heptagon shape, a nonagon shape, a decagon shape, or a shape including any other number of sides with one or more sides to frictionally engage a golf ball. Further, the interior roof structure of the retention cavity (e.g., one shown as the interior roof structure **361** of FIG. **11**) may include one or more openings through the top portion **260** of the golf club head **100** (e.g., one or more holes, slots, or slits) and extending in one or more directions of the interior roof structure **361** (e.g., radially, diagonally, or longitudinally between the toe portion **220** and the heel portion **230**, longitudinally between the front portion **240** and the rear portion **250**). In another example, the interior roof structure **361** may include one or more grooves or channels extending in one or more directions of the interior roof structure **361** (e.g., radially, diagonally, or longitudinally between the toe portion **220** and the heel portion **230**, longitudinally between the front portion **240** and the rear portion **250**). In another example, the interior roof structure **361** may include one or more ribs, projections, protrusions, or ridges extending in one or more directions of the interior roof structure **361** (e.g., radially, diagonally, or longitudinally between the toc portion **220** and the heel portion **230**, longitudinally between the front portion **240** and the rear portion **250**). In another example, the interior roof structure may include a plurality of perforations or holes through which a golf ball that is retained in the retention cavity **340** may be visible. In another example, the interior roof structure may include a mesh structure through which a golf ball that is retained in the retention cavity **340** may be visible. In yet another example, the interior roof structure may be constructed from a transparent or semi-transparent material such as plexiglass through which a golf ball that is retained in the retention cavity **340** may be visible. The interior roof structure **361** may include one or more openings only, one or more grooves only, one or more ribs only, or one or more of any combination of openings, grooves, or ribs. The interior roof structure **361** may include one or more openings, grooves, or ribs forming various configurations (e.g., a U-shape, a V-shape, a web shape, hexagonal shapes to form a honeycomb cell pattern, etc.). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(33) While each of the above examples may describe a certain type of golf club head, the apparatus, methods, and articles of manufacture described herein may be applicable to other types of golf club heads (e.g., a driver-type golf club head, a fairway wood-type golf club head, a hybrid-type golf club head, an iron-type golf club head, a putter-type golf club head, etc.).

(34) Procedures defined by golf standard organizations and/or governing bodies such as the United States Golf Association (USGA) and/or the Royal and Ancient Golf Club of St. Andrews (R&A) may be used for measuring the club head volume of any of the golf club heads described herein. For example, a club head volume may be determined by using the weighted water displacement method (i.e., Archimedes Principle). Although the figures may depict particular types of club heads (e.g., a driver-type club head or iron-type golf club head), the apparatus, methods, and articles of manufacture described herein may be applicable to other types of club head (e.g., a fairway wood-type club head, a hybrid-type club head, a putter-type club head, etc.). Accordingly, any golf club head as described herein may have a volume that is within a volume range corresponding to certain type of golf club head as defined by golf governing bodies. A driver-type golf club head may have a club head volume of greater than or equal to 300 cc. In another example, a driver-type golf club head may have a club head volume of 460 cc. A fairway wood golf club head may have a club head

volume of between 100 cc and 300 cc. In one example, a fairway wood golf club head may have a club head volume of 180 cc. An iron-type golf club head may have a club head volume of between 25 cc and 100 cc. In one example, an iron-type golf club head may have a volume of 50 cc. Any of the golf clubs described herein may have the physical characteristics of a certain type of golf club (i.e., driver, fairway wood, iron, etc.), but have a volume that may fall outside of the above-described ranges. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(35) Any of the golf club heads and/or golf clubs described herein may include one or more sensors (e.g., accelerometers, strain gauges, etc.) for sensing linear motion (e.g., acceleration) and/or forces in all three axes of motion and/or rotational motion (e.g., angular acceleration) and rotational forces about all three axes of motion. In one example, the one or more sensors may be internal sensors that may be located inside the golf club head, the hosel, the shaft, and/or the grip. In another example, the one or more sensors may be external sensors that may be located on the grip, on the shaft, on the hosel, and/or on the golf club head. In yet another example, the one or more sensors may be external sensors that may be attached by an individual to the grip, to the shaft, to the hosel, and/or to the golf club head. In one example, data collected from the sensors may be used to determine any one or more design parameters for any of the golf club heads and/or golf clubs described herein to provide certain performance or optimum performance characteristics. In another example, data from the sensors may be collected during play to assess the performance of an individual. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

(36) Any of the apparatus, methods, or articles of manufacture described herein may include one or more visual identifiers such as alphanumeric characters, colors, images, symbols, logos, and/or geometric shapes. For example, one or more visual identifiers may be manufactured with one or more portions of a golf club such as the golf club head (e.g., casted or molded with the golf club head), painted on the golf club head, etched on the golf club (e.g., laser etching), embossed on the golf club head, machined onto the golf club head, attached as a separate badge or a sticker on the golf club head (e.g., adhesive, welding, brazing, mechanical lock(s), any combination thereof, etc.), or any combination thereof. The visual identifier may be made from the same material as the golf club head or a different material than the golf club head (e.g., a plastic badge attached to the golf club head with an adhesive). Further, the visual identifier may be associated with manufacturing and/or brand information of the golf club head, the type of golf club head, one or more physical characteristics of the golf club head, or any combination thereof. In particular, a visual identifier may include a brand identifier associated with a manufacturer of the golf club (e.g., trademark, trade name, logo, etc.) or other information regarding the manufacturer. In addition, or alternatively, the visual identifier may include a location (e.g., country of origin), a date of manufacture of the golf club or golf club head, or both.

(37) The visual identifier may include a serial number of the golf club or golf club head, which may be used to check the authenticity to determine whether or not the golf club or golf club head is a counterfeit product. The serial number may also include other information about the golf club that may be encoded with alphanumeric characters (e.g., country of origin, date of manufacture of the golf club, or both). In another example, the visual identifier may include the category or type of the golf club head (e.g., 5-iron, 7-iron, pitching wedge, etc.). In yet another example, the visual identifier may indicate one or more physical characteristics of the golf club head, such as one or more materials of manufacture (e.g., visual identifier of “Titanium” indicating the use of titanium in the golf club head), loft angle, face portion characteristics, mass portion characteristics (e.g., visual identifier of “Tungsten” indicating the use of tungsten mass portions in the golf club head), interior cavity and filler material characteristics (e.g., one or more abbreviations, phrases, or words indicating that the interior cavity is filled with a polymer material), any other information that may visually indicate any physical or play characteristic of the golf club head, or any combination

thereof. Further, one or more visual identifiers may provide an ornamental design or contribute to the appearance of the golf club, or the golf club head.

(38) Any of the golf club heads described herein may be manufactured by casting from metal such as steel. However, other techniques for manufacturing a golf club head as described herein may be used such as **3**D printing or molding a golf club head from metal or non-metal materials such as ceramics.

(39) All methods described herein may be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. Although a particular order of actions may be described herein with respect to one or more processes, these actions may be performed in other temporal sequences. Further, two or more actions in any of the processes described herein may be performed sequentially, concurrently, or simultaneously.

(40) The terms “and” and “or” may have both conjunctive and disjunctive meanings. The terms “a” and “an” are defined as one or more unless this disclosure indicates otherwise. The term “coupled.” and any variation thereof, refers to directly or indirectly connecting two or more elements chemically, mechanically, and/or otherwise. The phrase “removably connected” is defined such that two elements that are “removably connected” may be separated from each other without breaking or destroying the utility of either element.

(41) The term “substantially” when used to describe a characteristic, parameter, property, or value of an element may represent deviations or variations that do not diminish the characteristic, parameter, property, or value that the element may be intended to provide. Deviations or variations in a characteristic, parameter, property, or value of an element may be based on, for example, tolerances, measurement errors, measurement accuracy limitations and other factors. The term “proximate” is synonymous with terms such as “adjacent.” “close.” “immediate,” “nearby,” “neighboring.” etc., and such terms may be used interchangeably as appearing in this disclosure.

(42) Recitation of ranges of values herein is merely intended to serve as a shorthand method of referring individually to each separate value falling within the range. Unless otherwise indicated herein, each individual value is incorporated into the specification as if it were individually recited herein. A numerical range defined using the word “between” includes numerical values at both end points of the numerical range. A spatial range defined using the word “between” includes any point within the spatial range and the boundaries of the spatial range. A location expressed relative to two spaced apart or overlapping elements using the word “between” includes (i) any space between the elements, (ii) a portion of each element, and/or (iii) the boundaries of each element.

(43) The use of any and all examples, or exemplary language (e.g., “such as”) provided herein is intended merely for clarification and does not pose a limitation on the scope of the present disclosure. No language in the specification should be construed as indicating any non-claimed element essential to the practice of any embodiments discussed herein.

(44) Groupings of alternative elements or embodiments disclosed herein are not to be construed as limitations. Each group member may be referred to and claimed individually or in any combination with other members of the group or other elements disclosed herein. One or more members of a group may be included in, or deleted from, a group for reasons of convenience and/or patentability. When any such inclusion or deletion occurs, the specification is deemed to contain the group as modified thus fulfilling the written description of all Markush groups used in the appended claims.

(45) While different features or aspects of an embodiment may be described with respect to one or more features, a singular feature may comprise multiple elements, and multiple features may be combined into one element without departing from the scope of the present disclosure. Further, although methods may be disclosed as comprising one or more operations, a single operation may comprise multiple steps, and multiple operations may be combined into one step without departing from the scope of the present disclosure.

(46) The apparatus, methods, and articles of manufacture described herein may be implemented in a variety of embodiments, and the foregoing description of some of these embodiments does not

necessarily represent a complete description of all possible embodiments. Instead, the description of the drawings, and the drawings themselves, disclose at least one embodiment, and may disclosure alternative embodiments.

(47) As the rules of 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 USGA, the 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.

(48) Further, while the above examples may be described with respect to golf clubs, the apparatus, methods, and articles of manufacture described herein may be applicable to other suitable types of sports equipment such as a fishing pole, a hockey stick, a ski pole, a tennis racket, etc.

(49) Although certain example apparatus, methods, and articles of manufacture have been described herein, the scope of coverage of this disclosure is not limited thereto. On the contrary, this disclosure covers all apparatus, methods, and articles of articles of manufacture fairly falling within the scope of the appended claims either literally or under the doctrine of equivalents.

Claims

1. A putter-type golf club head comprising: a body portion comprising a toe portion, a heel portion, a front portion, a rear portion, a top portion, and a sole portion; and a retention cavity extending into the body portion, the retention cavity having an opening, one or more interior side walls, and an interior roof structure connected to the one or more interior side walls, the interior roof structure configured to decrease in height in a front-to-rear direction of the putter-type golf club head and increase in height toward a center longitudinal plane from both a heel-side direction and a toe-side direction of the putter-type golf club head, the center longitudinal plane bisecting the body portion between the heel portion and the toe portion, wherein the retention cavity defines two or more ball retention areas configured to frictionally engage and retain a portion of a golf ball within the retention cavity, wherein the two or more ball retention areas frictionally engage the golf ball along a ball circumference located above an equator of the golf ball at a distance greater than or equal to 0.050 inches (0.127 centimeters) and less than or equal to 0.070 inches (0.178 centimeters), wherein the putter-type golf club head has a head mass greater than or equal to 300 grams and less than or equal to 400 grams, wherein the body portion further comprises an interior cavity located between the retention cavity and a face portion of the body portion, and wherein the interior cavity houses a filler material configured to support the face portion.

2. A putter-type golf club head as defined in claim 1, wherein the body portion is partially or entirely made of an aluminum-based material.

3. A putter-type golf club head as defined in claim 1, wherein the two or more ball retention areas are each located at or proximate to the opening.

4. A putter-type golf club head as defined in claim 1, wherein the two or more ball retention areas include two ball retention areas disposed opposite each other and separated by a distance greater than or equal to 1.620 inches (4.115 centimeters) and less than or equal to 1.670 inches (4.242 centimeters).

5. A putter-type golf club head as defined in claim 1, wherein the retention cavity further defines one or more relief gaps formed between the one or more interior side walls and the golf ball when the golf ball is retained in the retention cavity.

6. A putter-type golf club head as defined in claim 1, wherein the opening has an octagonal shape.

7. A putter-type golf club head as defined in claim 1, wherein the two or more ball retention areas

comprise a rounded portion of the one or more interior side walls, the rounded portion located at the opening and configured to guide the ball into a retained position and increase a ball contact area of the two or more ball retention areas.

8. A putter-type golf club head comprising: a body portion having a toe portion, a heel portion, a front portion, a rear portion, a top portion, and a sole portion; and a retention cavity located at the sole portion and extending into the body portion, the retention cavity having an opening, a first ball retention area, a second ball retention area, and an interior roof structure, the interior roof structure configured to decrease in height in a front-to-rear direction of the putter-type golf club head and increase in height toward a center longitudinal plane from both a heel-side direction and a toe-side direction of the putter-type golf club head, the center longitudinal plane bisecting the body portion between the toe portion and the heel portion, wherein the first ball retention area and the second ball retention area cooperate to frictionally engage and retain a portion of a golf ball within the retention cavity, wherein the portion of the golf ball retained within the retention cavity is less than 50% of a total volume of the golf ball, wherein the putter-type golf club head has a head mass greater than or equal to 300 grams and less than or equal to 400 grams, wherein the body portion further comprises an interior cavity located between the retention cavity and a face portion of the body portion, and wherein the interior cavity is at least partially filled with a filler material.

9. A putter-type golf club head as defined in claim 8, wherein the first ball retention area and the second ball retention area are each located at or proximate to the opening.

10. A putter-type golf club head as defined in claim 8, wherein the first ball retention area and the second ball retention area are disposed opposite each other.

11. A putter-type golf club head as defined in claim 8, wherein the first ball retention area and the second ball retention area are separated by a distance less than or equal to 1.680 inches (4.268 centimeters).

12. A putter-type golf club head as defined in claim 8, wherein the retention cavity is disposed at or proximate to a central location of the sole portion.

13. A putter-type golf club head as defined in claim 8, wherein the first ball retention area and the second ball retention area comprise a rounded portion at the opening, the rounded portion configured to guide the ball into a retained position and increase a ball contact area of the first ball retention area and the second ball retention area.

14. A putter-type golf club head comprising: a body portion having a toe portion, a heel portion, a front portion, a rear portion, a top portion, and a sole portion; and a retention cavity located at the sole portion and extending into the body portion, the retention cavity having an opening, two or more ball retention areas, and an interior roof structure, the interior roof structure configured to decrease in height in a front-to-rear direction of the putter-type golf club head and increase in height toward a center longitudinal plane from both a heel-side direction and a toe-side direction of the putter-type golf club head, the center longitudinal plane bisecting the body portion between the heel portion and the toe portion, wherein the two or more ball retention areas are each located at or proximate to the opening, wherein the two or more ball retention areas are configured to frictionally engage and retain a portion of a golf ball within the retention cavity, wherein the two or more ball retention areas frictionally engage the golf ball above an equator of the golf ball, wherein the putter-type golf club head has a head mass greater than or equal to 300 grams and less than or equal to 400 grams, and wherein the two or more ball retention areas each include a rounded edge located at the opening.

15. A putter-type golf club head as defined in claim 14, wherein the two or more ball retention areas include two ball retention areas disposed opposite each other and separated by a distance less than or equal to 1.680 inches (4.268 centimeters).

16. A putter-type golf club head as defined in claim 14, wherein the opening has a polygonal shape.

17. A putter-type golf club head as defined in claim 14, wherein the retention cavity further defines one or more relief gaps formed between an edge of the opening and the golf ball when the golf ball

is retained in the retention cavity.

18. A putter-type golf club head as defined in claim 14, wherein the body portion further comprises an interior cavity located between the retention cavity and a face portion of the body portion, and wherein the interior cavity is at least partially filled with a filler material.

19. A putter-type golf club head as defined in claim 14, wherein the body portion further comprises one or more weight ports, and wherein the one or more weight ports are each configured to receive a weight portion.

20. A putter-type golf club head as defined in claim 14, wherein the rounded edge is configured to guide the ball into a retained position and increase a ball contact area of the two or more ball retention areas.