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(12) **United States Patent**
Parsons et al.

(10) **Patent No.: US 12,383,804 B2**
(45) **Date of Patent: Aug. 12, 2025**

(54) **GOLF CLUB HEADS AND METHODS TO MANUFACTURE GOLF CLUB HEADS**

(71) Applicant: **PARSONS XTREME GOLF, LLC**, Scottsdale, AZ (US)

(72) Inventors: **Robert R. Parsons**, Scottsdale, AZ (US); **Michael R. Nicolette**, Scottsdale, AZ (US); **Bradley D. Schweigert**, Cave Creek, AZ (US); **Daniel C. Kirtley**, Scottsdale, AZ (US)

(73) Assignee: **PARSONS XTREME GOLF, LLC**, Scottsdale, AZ (US)

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

(21) Appl. No.: **19/014,978**

(22) Filed: **Jan. 9, 2025**

(65) **Prior Publication Data**

US 2025/0144484 A1 May 8, 2025

Related U.S. Application Data

(63) Continuation-in-part of application No. 18/221,568, filed on Jul. 13, 2023, now Pat. No. 12,251,607, which is a continuation of application No. 18/089,683, filed on Dec. 28, 2022, now Pat. No. 11,745,067, which is a continuation-in-part of application No. 17/988,585, filed on Nov. 16, 2022, (Continued)

(51) **Int. Cl.**
A63B 53/04 (2015.01)
A63B 60/54 (2015.01)

(52) **U.S. Cl.**
CPC ***A63B 53/0475*** (2013.01); *A63B 53/0408* (2020.08); *A63B 2053/0479* (2013.01); *A63B 2053/0491* (2013.01); *A63B 60/54* (2015.10); *A63B 2209/00* (2013.01)

(58) **Field of Classification Search**
CPC A63B 53/0475; A63B 2053/0479; A63B 60/54; A63B 2209/00; A63B 2053/0491; A63B 53/0408; A63B 53/0454; A63B 53/0466
USPC 473/324–350, 287–292
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,326,326 A * 4/1982 MacDonald A63B 53/047 164/35
5,586,947 A 12/1996 Hutin
(Continued)

FOREIGN PATENT DOCUMENTS

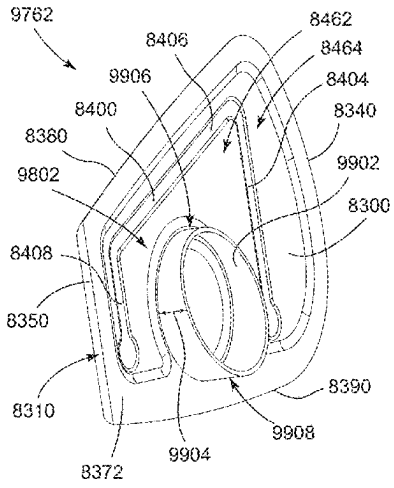
JP 2007044445 A 2/2007

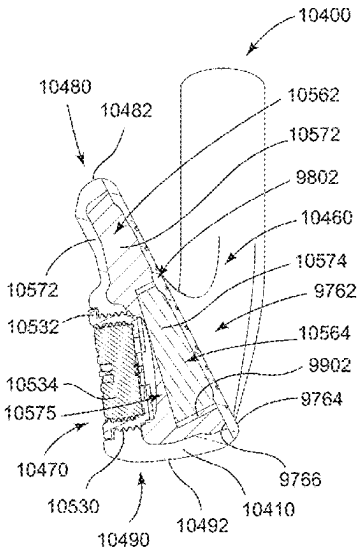
Primary Examiner — Sebastiano Passaniti

(57) **ABSTRACT**

Embodiments of golf club heads, golf clubs, and methods to manufacture golf club heads and golf clubs are generally described herein. In one example, a golf club head includes a body portion, a first interior cavity portion, and a face portion, which includes a back surface with a face perimeter portion, a ridge portion extending from the face perimeter portion, and a wall portion coupled to the ridge portion and extending outward from the ridge portion to define a second interior cavity portion in the body portion. The golf club head further includes a first filler material and a second filler material. The first interior cavity portion is at least partially filled with the first filler material, and the second interior cavity portion is at least partially filled with the second filler material. Other examples and embodiments may be described and claimed.

13 Claims, 36 Drawing Sheets





Related U.S. Application Data

now Pat. No. 11,779,820, which is a continuation of application No. 17/841,893, filed on Jun. 16, 2022, now Pat. No. 11,806,590, which is a continuation of application No. 17/685,546, filed on Mar. 3, 2022, now Pat. No. 11,400,352.

(60) Provisional application No. 63/621,262, filed on Jan. 16, 2024, provisional application No. 63/435,128, filed on Dec. 23, 2022, provisional application No. 63/428,641, filed on Nov. 29, 2022, provisional application No. 63/276,981, filed on Nov. 8, 2021.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,776,011	A *	7/1998	Su	A63B 53/0466 473/345
6,206,790	B1 *	3/2001	Kubica	A63B 53/04 473/335
6,322,459	B1	11/2001	Nishimura et al.	
7,220,190	B2 *	5/2007	Hirano	A63B 53/0466 473/330
7,351,164	B2	4/2008	Schweigert et al.	
7,387,579	B2	6/2008	Lin et al.	
7,396,299	B2	7/2008	Nicolette et al.	
7,597,633	B2	10/2009	Shimazaki et al.	
8,535,177	B1	9/2013	Wahl et al.	
9,119,999	B2	9/2015	Cole et al.	
9,199,143	B1	12/2015	Parsons et al.	
9,403,071	B2 *	8/2016	Sander	A63B 60/00
9,623,292	B2 *	4/2017	Abe	A63B 60/52
9,662,546	B2	5/2017	Cole et al.	
9,993,704	B2	6/2018	Hebreo et al.	
10,086,244	B2	10/2018	Morin et al.	
10,150,018	B2	12/2018	Cole et al.	
10,449,428	B2	10/2019	Parsons et al.	
10,751,587	B2	8/2020	Clarke et al.	
10,758,789	B2 *	9/2020	Bacon	A63B 53/08
10,905,920	B2	2/2021	Parsons et al.	
10,905,926	B2	2/2021	Morales et al.	
10,918,919	B2	2/2021	Morales et al.	
11,406,883	B2	8/2022	Clarke et al.	
11,565,158	B1	1/2023	Parsons et al.	
11,701,558	B2	7/2023	Morales et al.	
11,707,653	B2	7/2023	Parsons et al.	
11,786,789	B2	10/2023	Morin et al.	
11,826,620	B2	11/2023	Ines et al.	
12,145,038	B2	11/2024	Golden et al.	
2001/0014628	A1 *	8/2001	Erickson	A63B 53/0466 473/349
2008/0022502	A1	1/2008	Tseng	
2009/0029790	A1	1/2009	Nicolette et al.	
2009/0163295	A1	6/2009	Tseng	
2014/0228149	A1 *	8/2014	Cole	A63B 53/0466 473/332
2015/0328506	A1 *	11/2015	Morales	A63B 60/00 473/331
2022/0152465	A1	5/2022	Martens et al.	
2022/0305356	A1 *	9/2022	Parsons	A63B 53/0466
2022/0395733	A1	12/2022	Carr et al.	
2023/0014218	A1	1/2023	Martens et al.	
2023/0018341	A1	1/2023	Breier et al.	
2023/0042378	A1	2/2023	Ines et al.	
2023/0097561	A1	3/2023	Martens et al.	
2023/0166167	A1	6/2023	Zimmerman et al.	
2023/0173358	A1	6/2023	Martens et al.	
2023/0211217	A1	7/2023	Zimmerman et al.	
2023/0321507	A1	10/2023	Ferguson et al.	
2023/0347222	A1	11/2023	Gonzalez et al.	
2023/0405427	A1	12/2023	Sanchez et al.	
2024/0001206	A1	1/2024	Ines et al.	

* cited by examiner

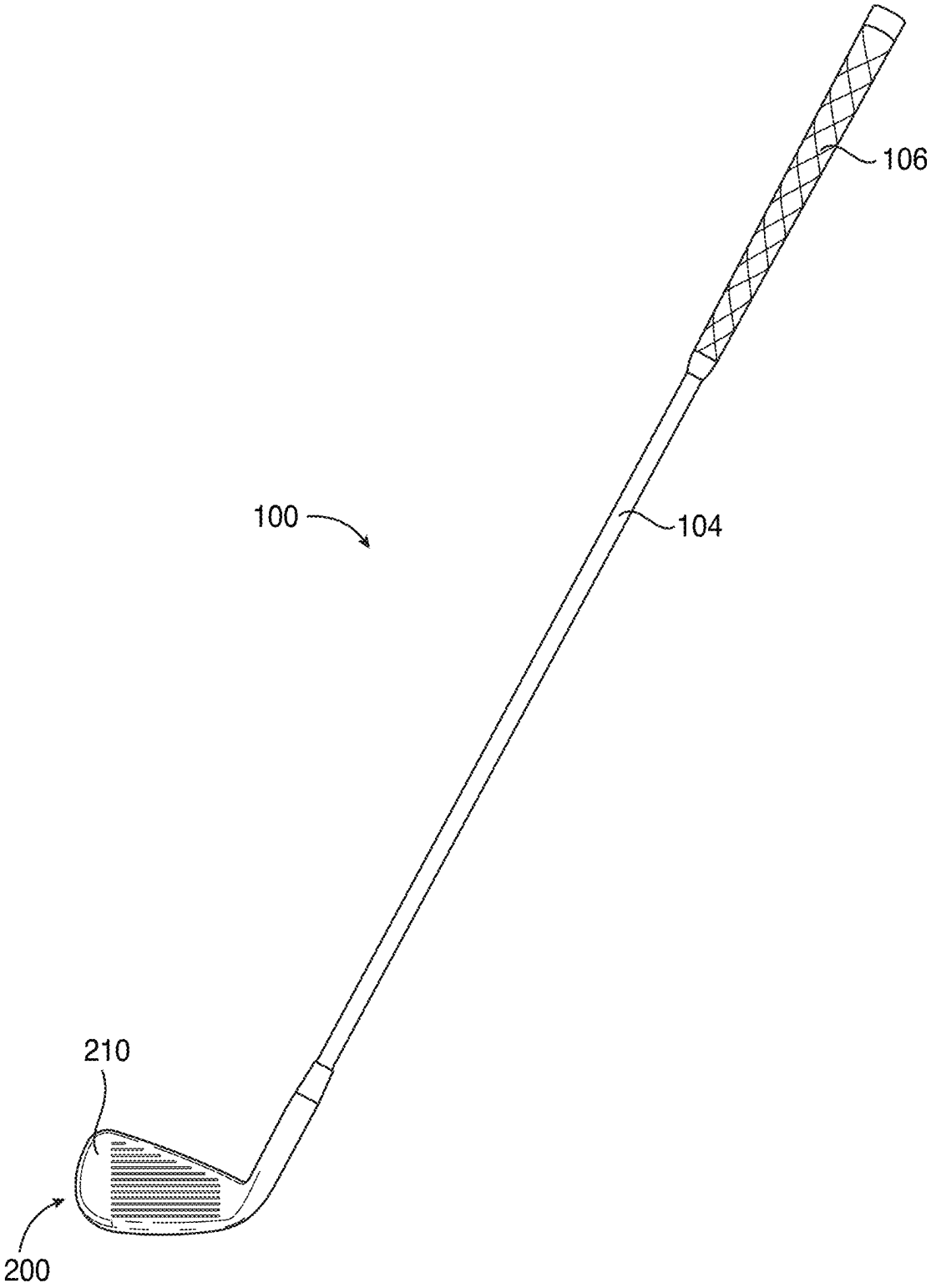


FIG. 1

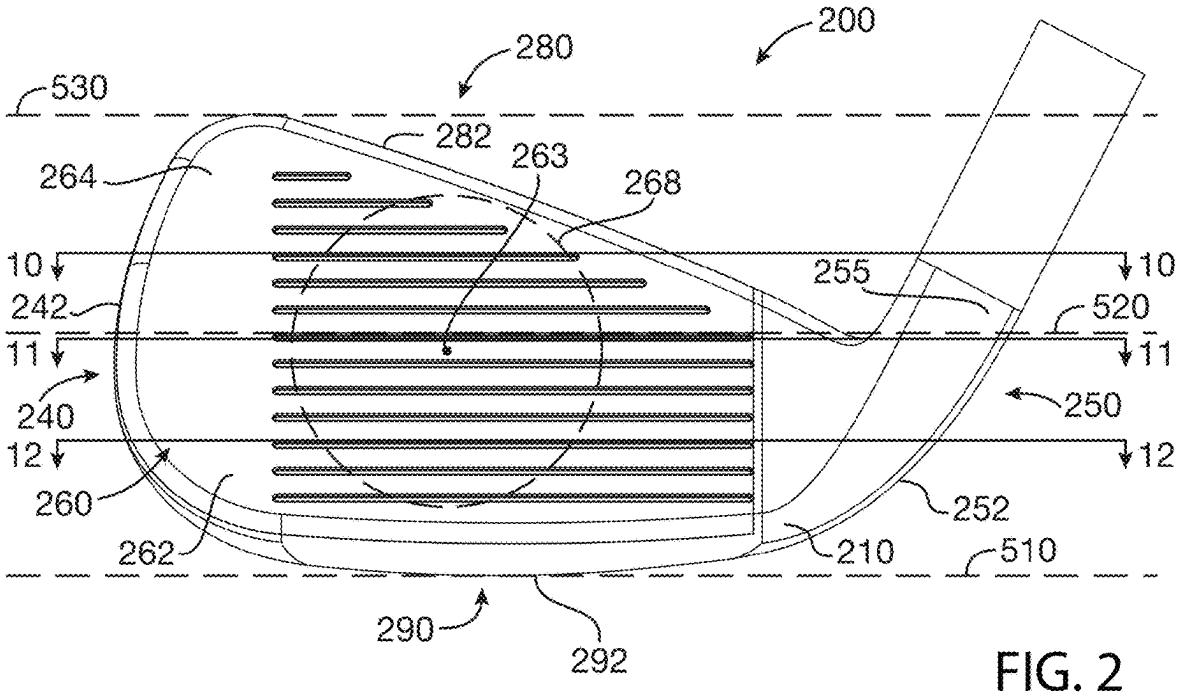

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FIG. 2

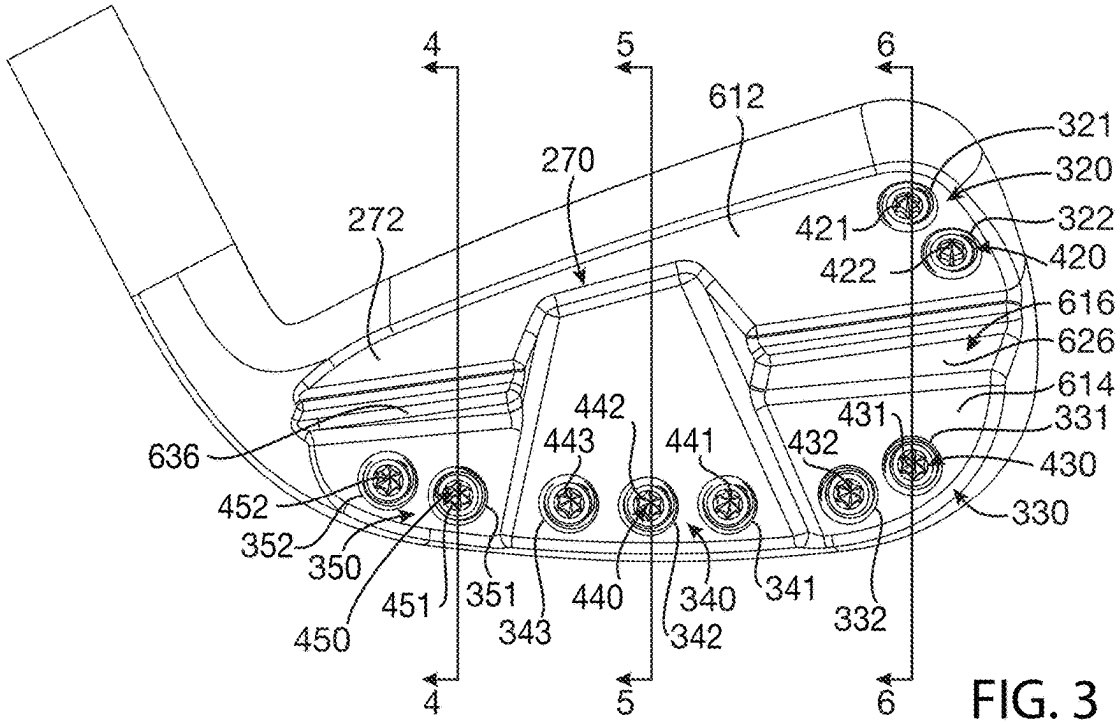
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FIG. 3

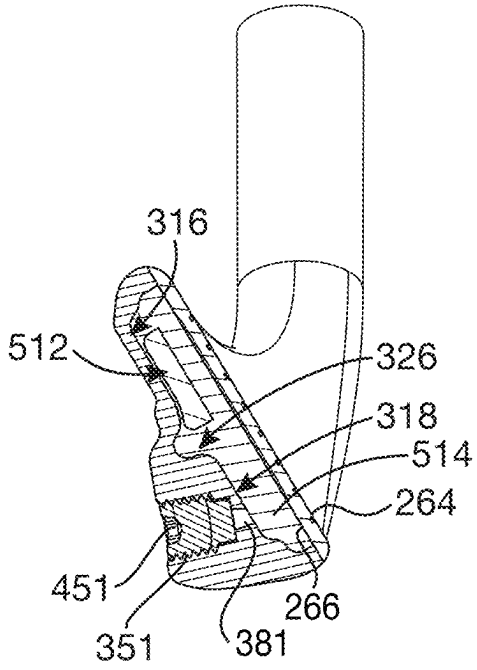
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FIG. 4

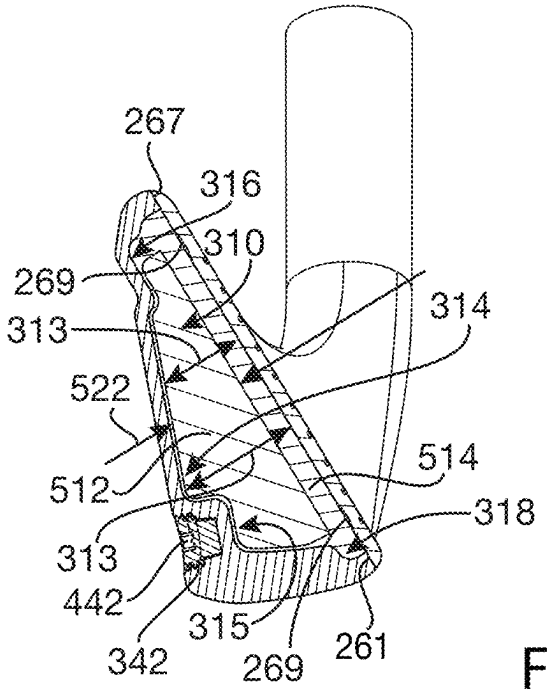
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FIG. 5

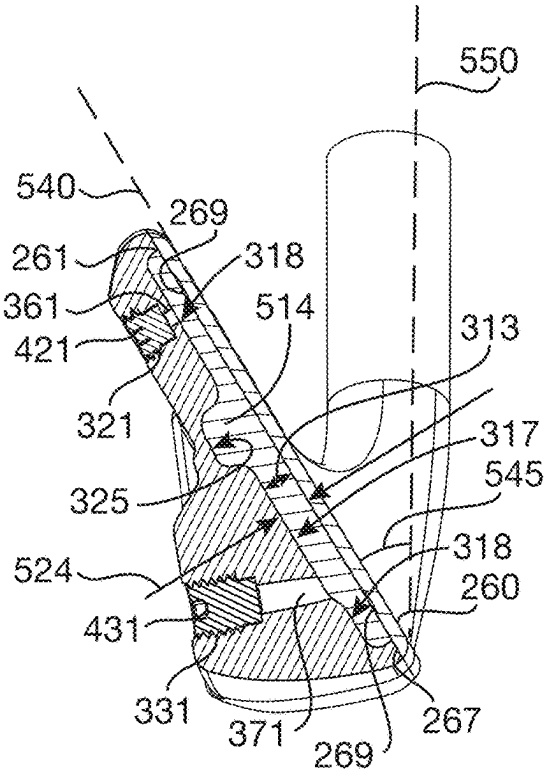
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FIG. 6

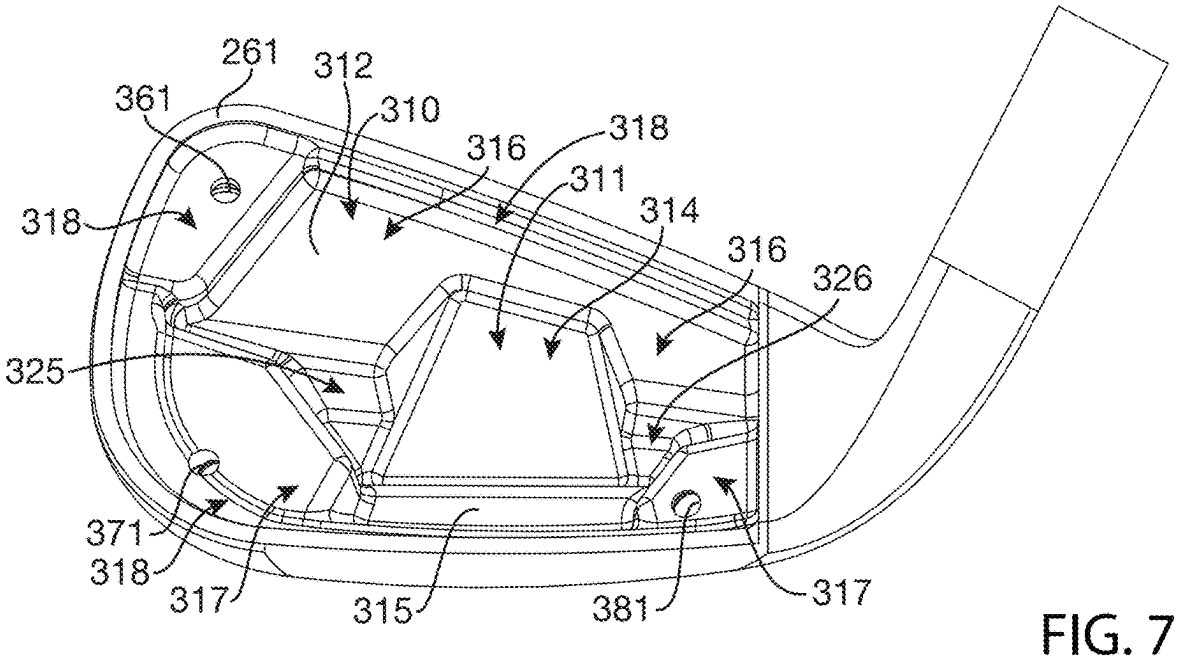
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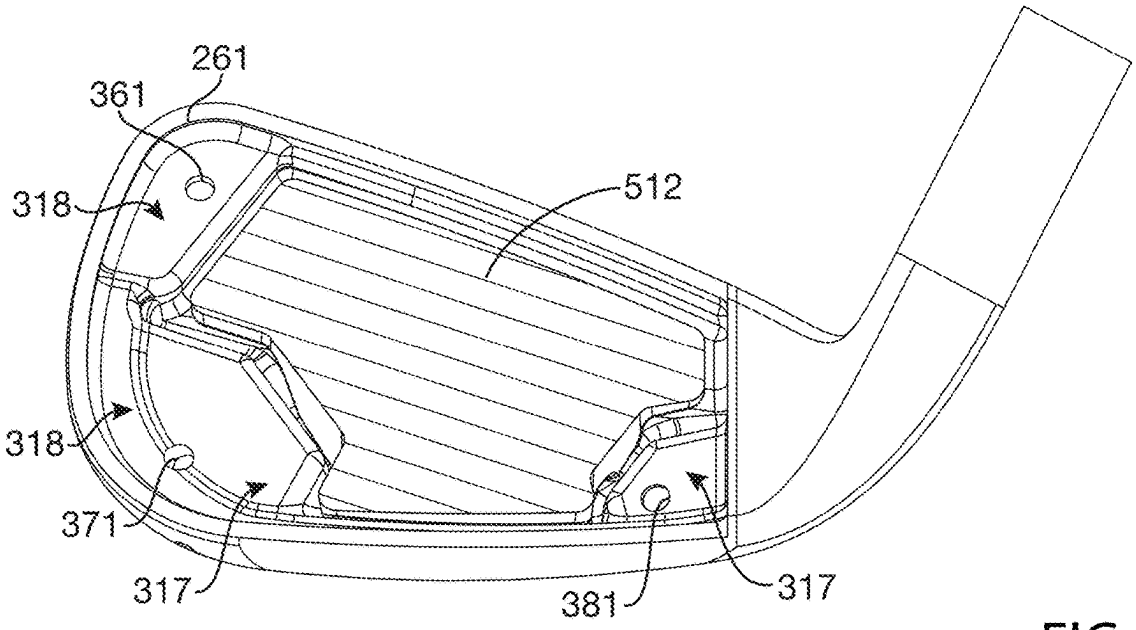
FIG. 7



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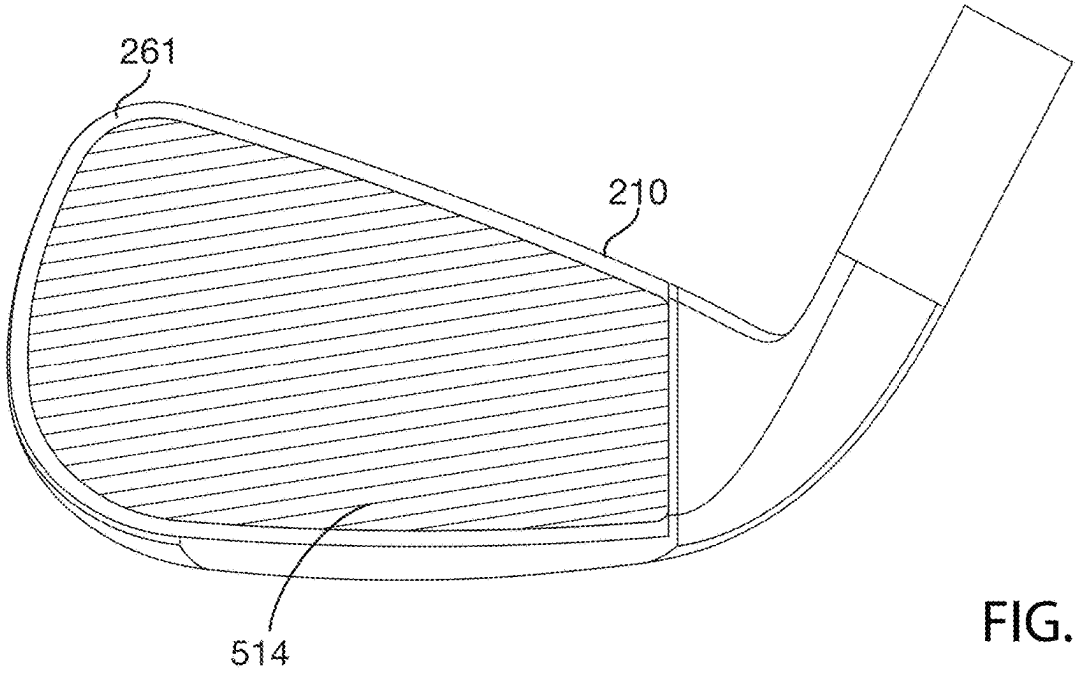

FIG. 9

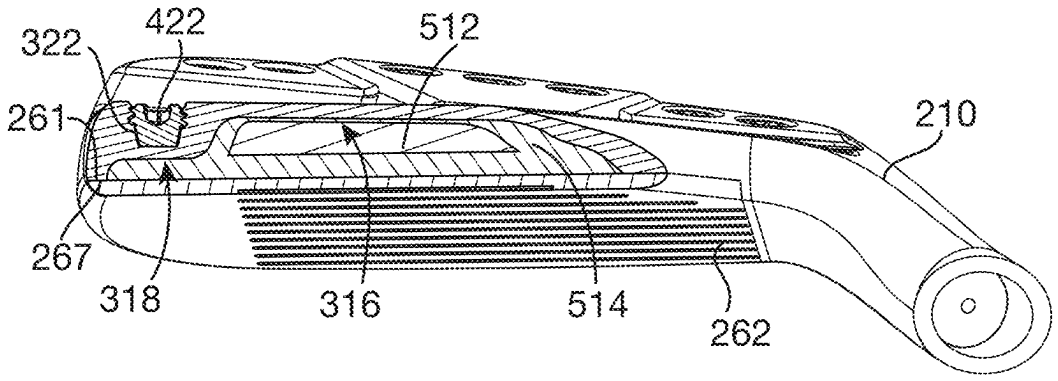

FIG. 10

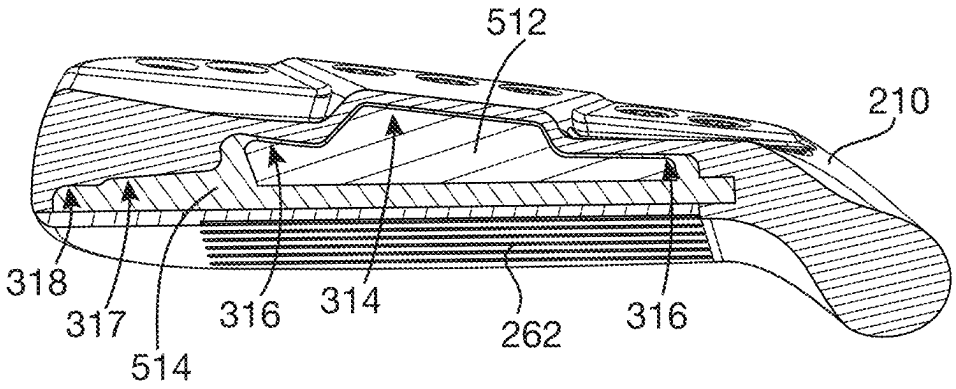

FIG. 11

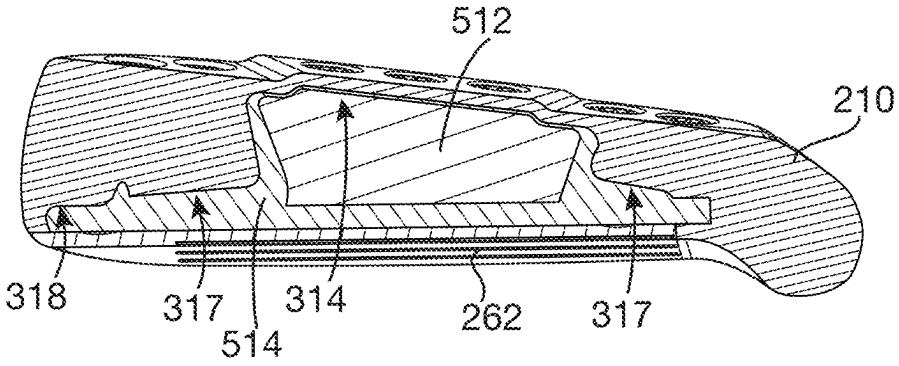

FIG. 12

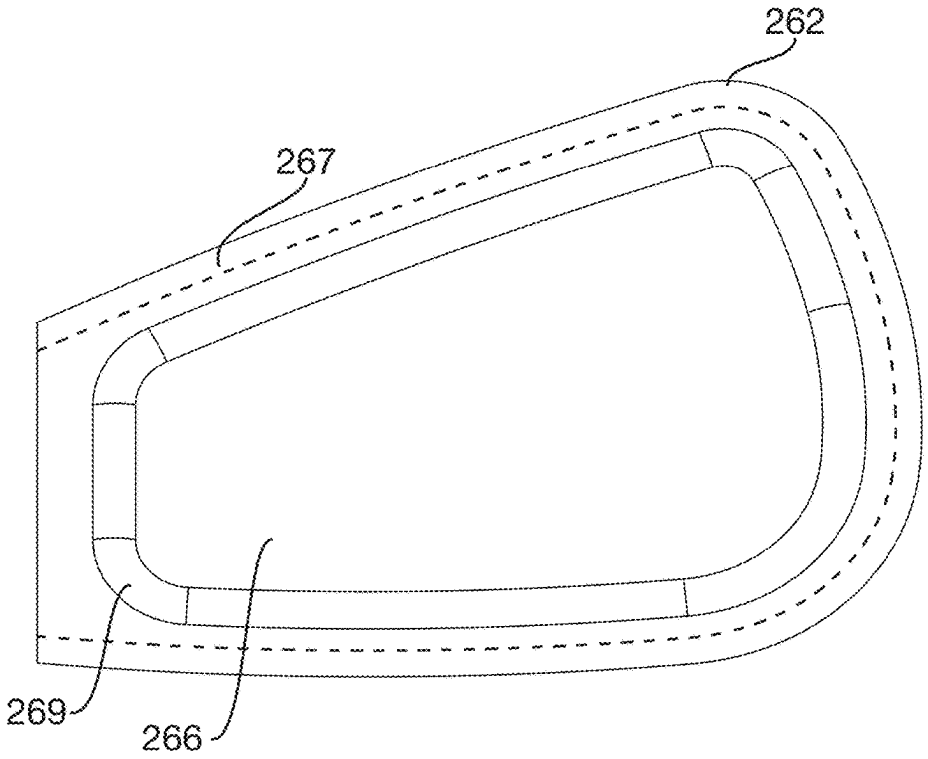
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FIG. 13

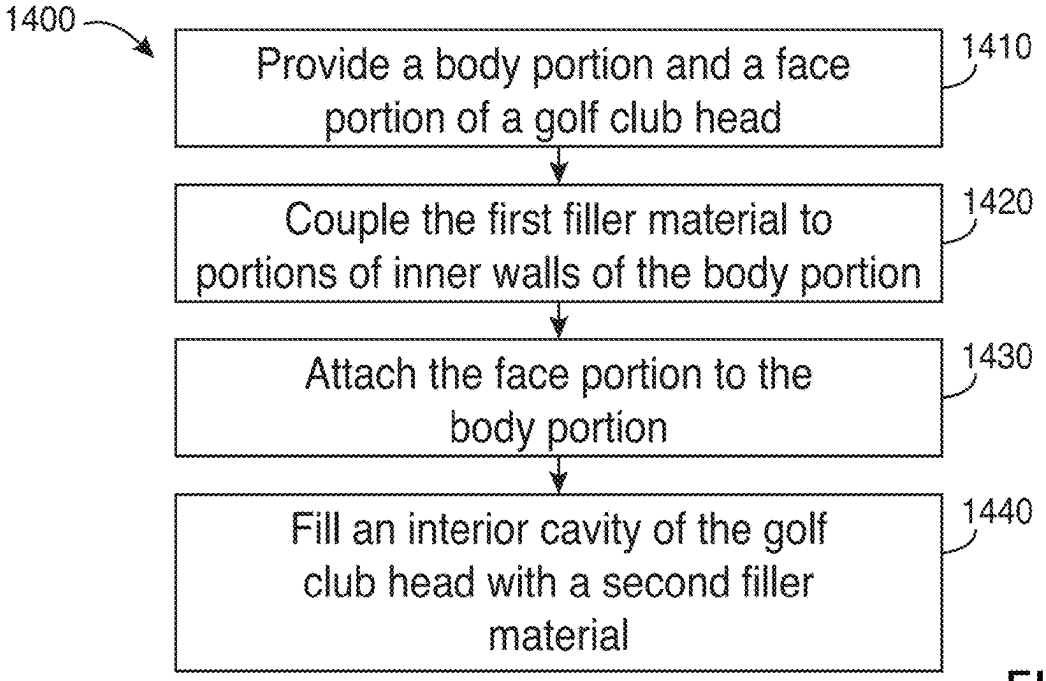

1400
Provide a body portion and a face portion of a golf club head
1410
Couple the first filler material to portions of inner walls of the body portion
1420
Attach the face portion to the body portion
1430
Fill an interior cavity of the golf club head with a second filler material
1440

FIG. 14

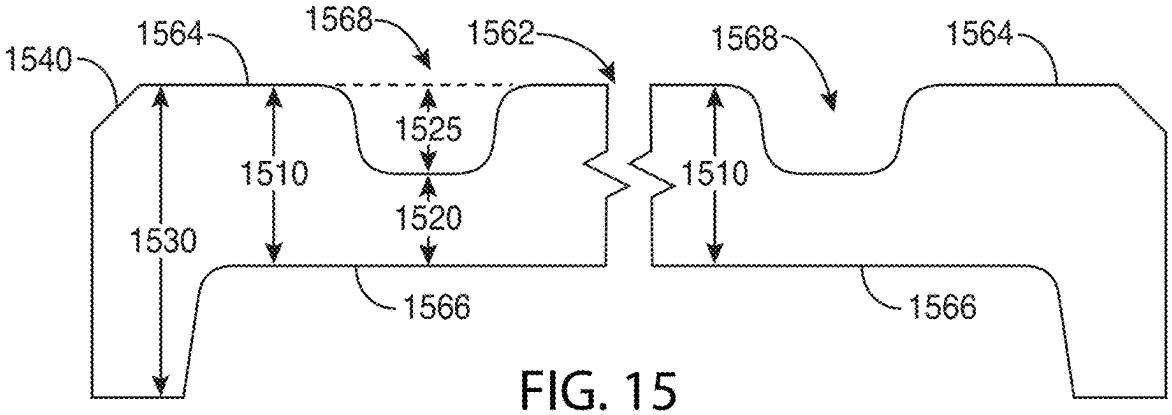


FIG. 15

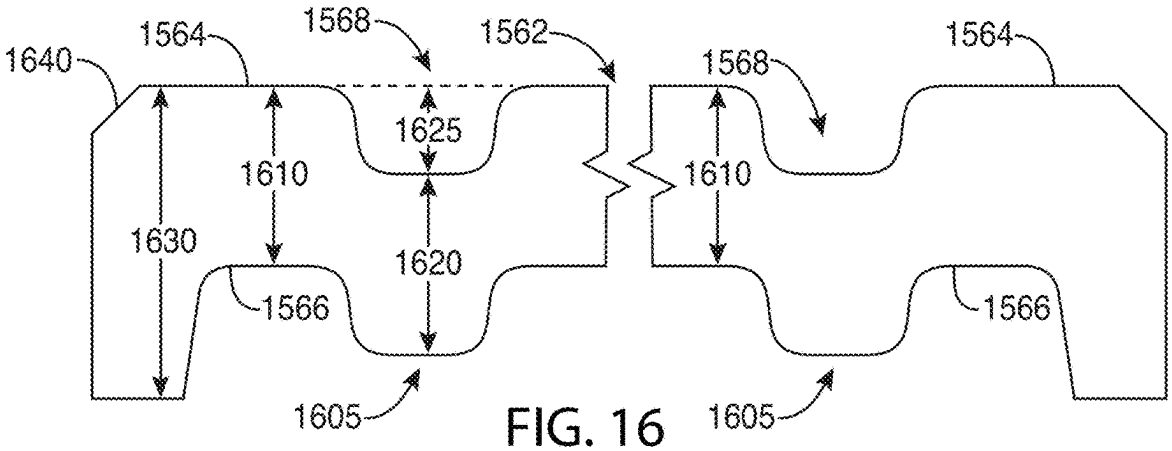


FIG. 16

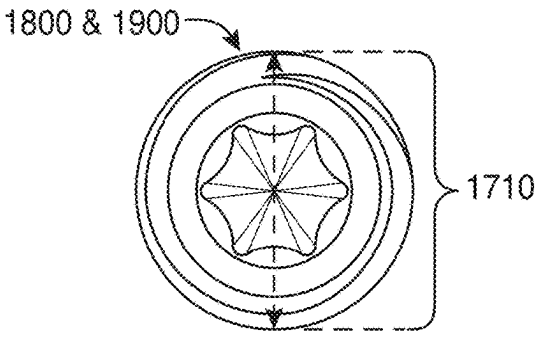


FIG. 17

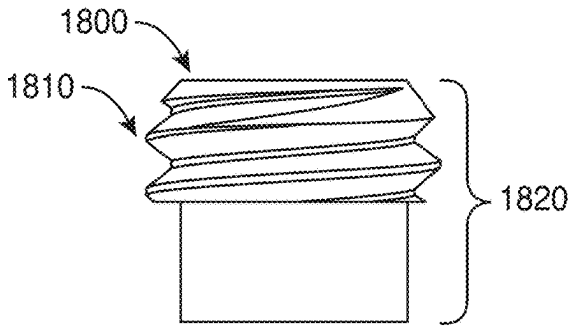


FIG. 18

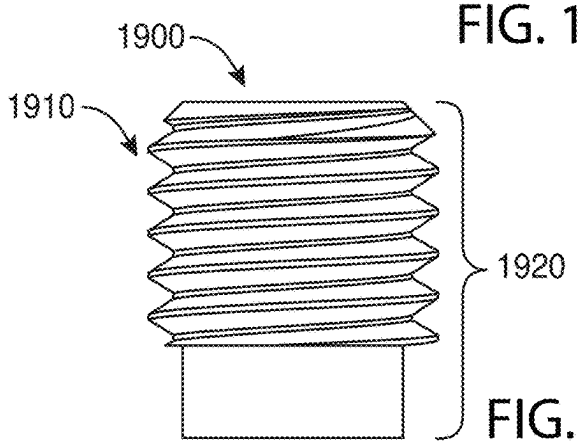


FIG. 19

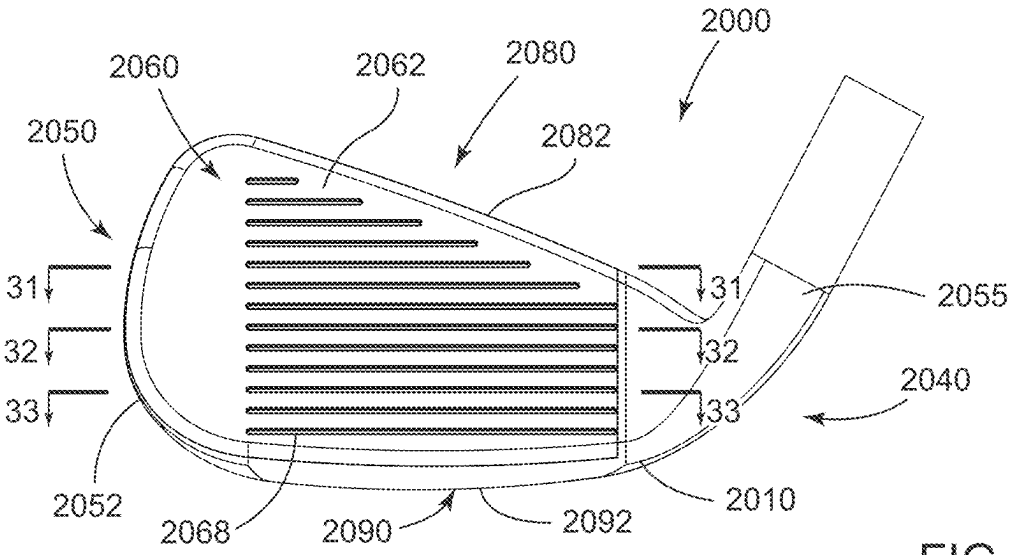


FIG. 20

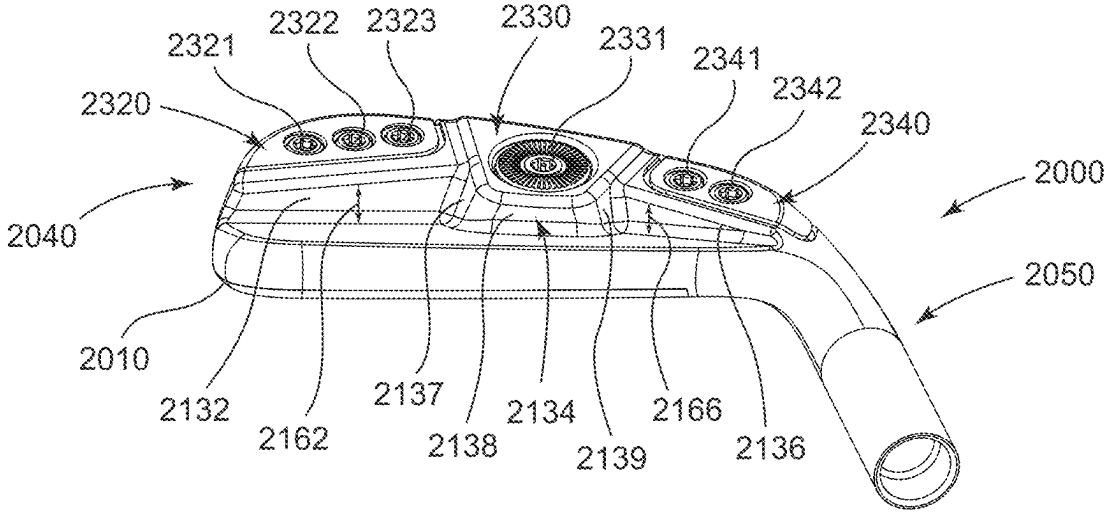


FIG. 21

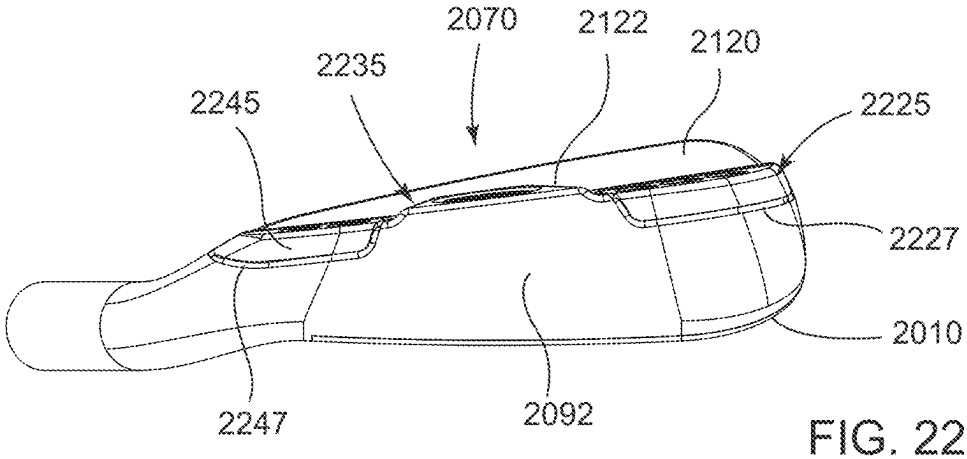
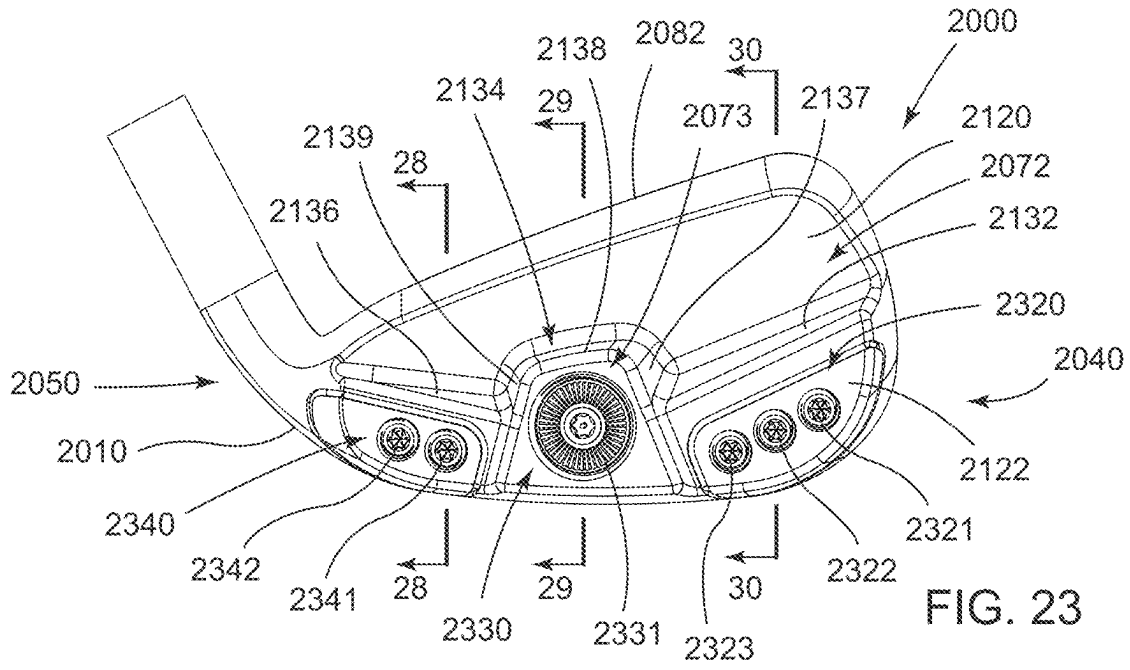


FIG. 22



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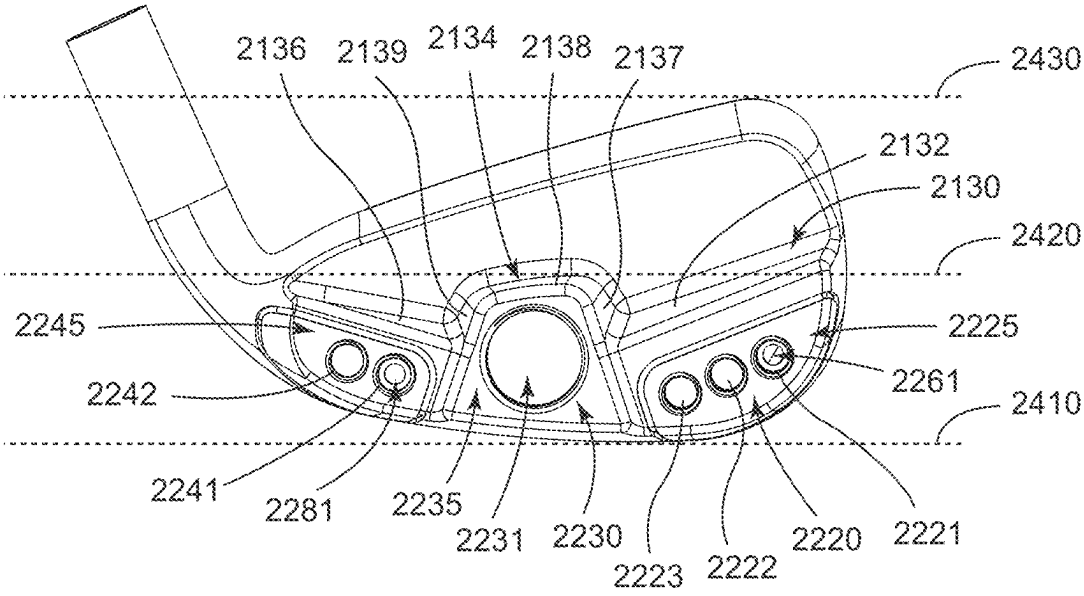
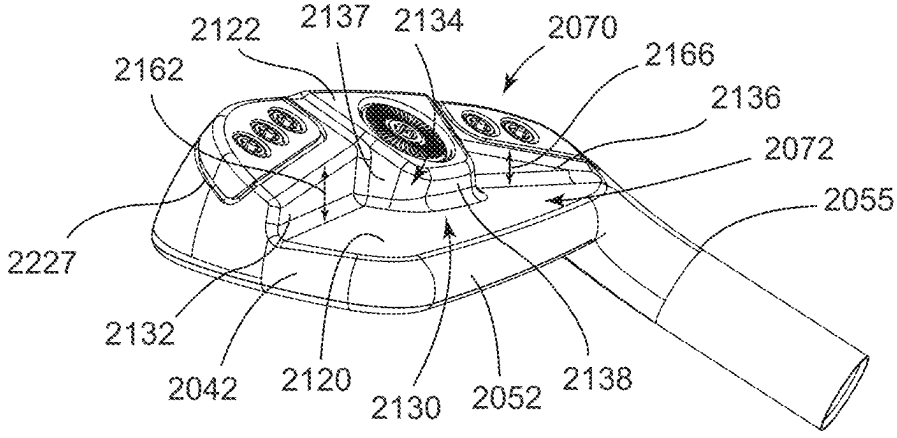


FIG. 24



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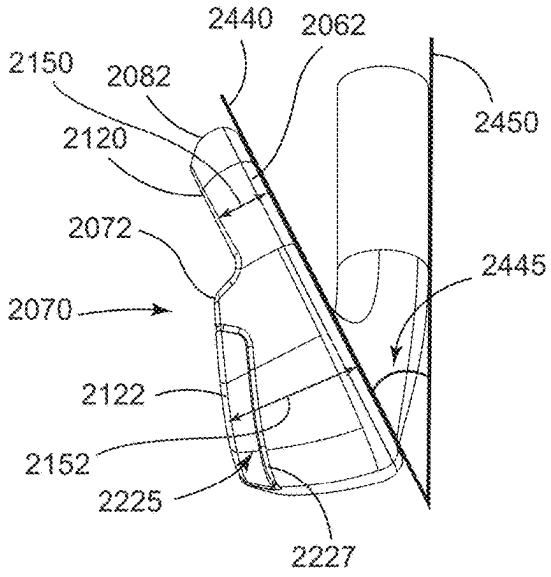

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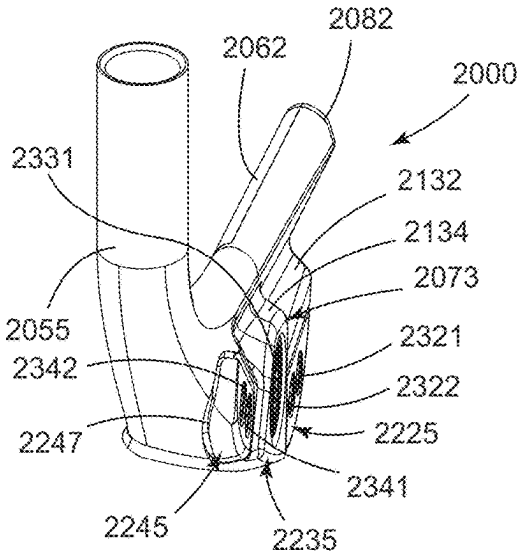

FIG. 27

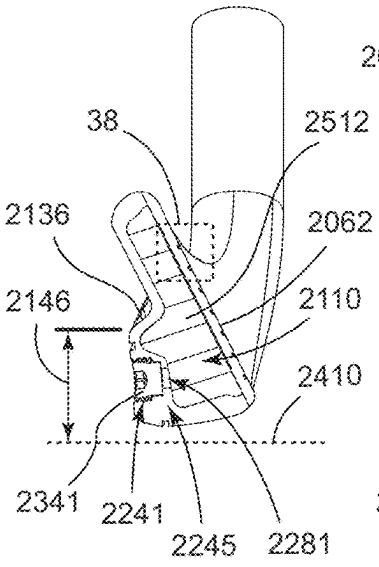

FIG. 28

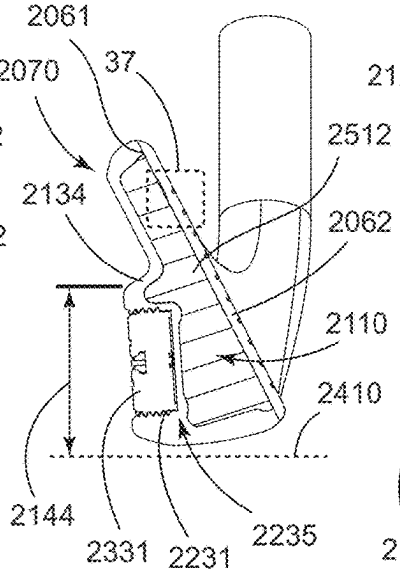

FIG. 29

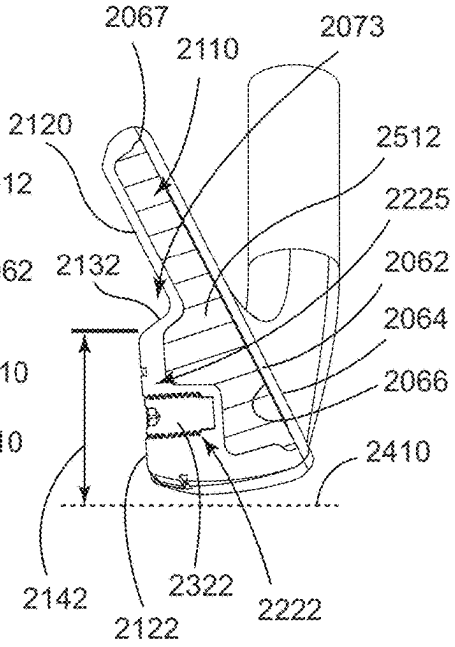

FIG. 30

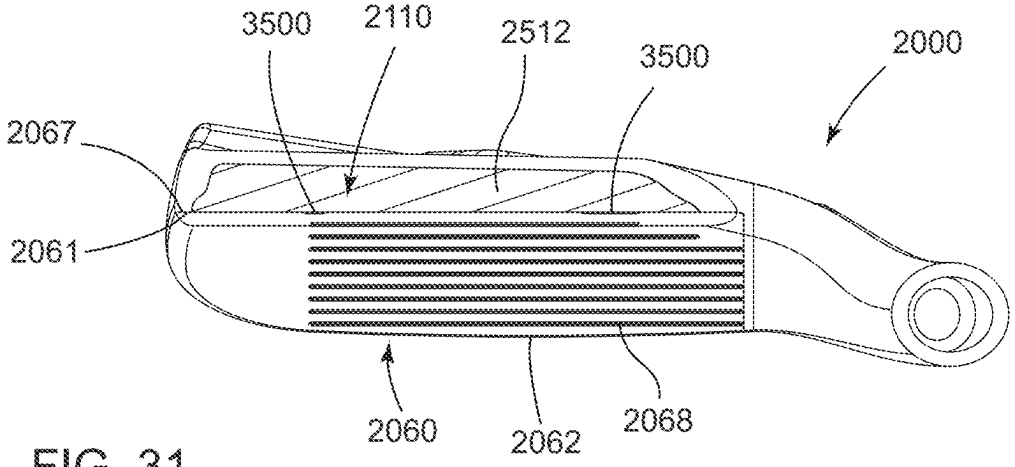

FIG. 31

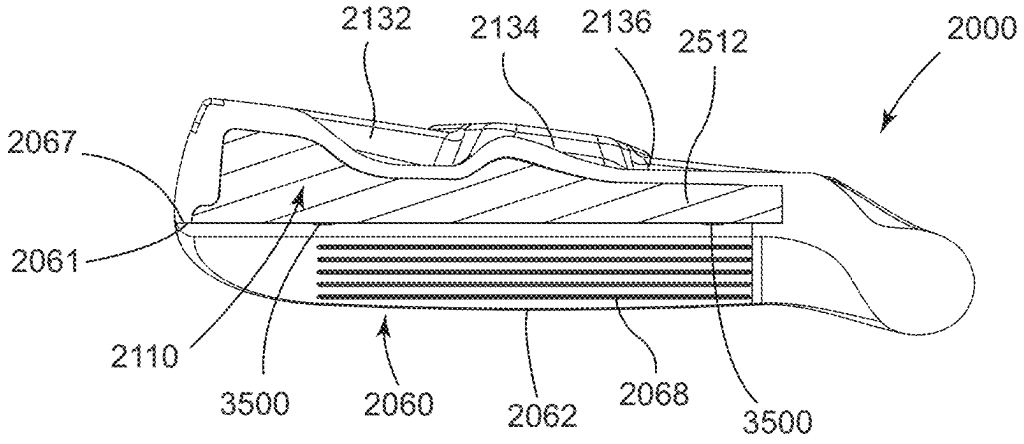

FIG. 32

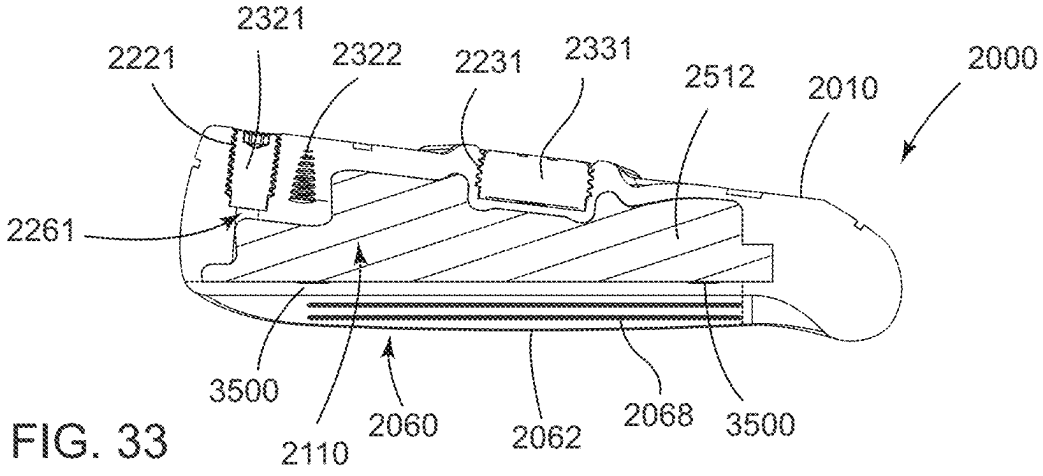

FIG. 33

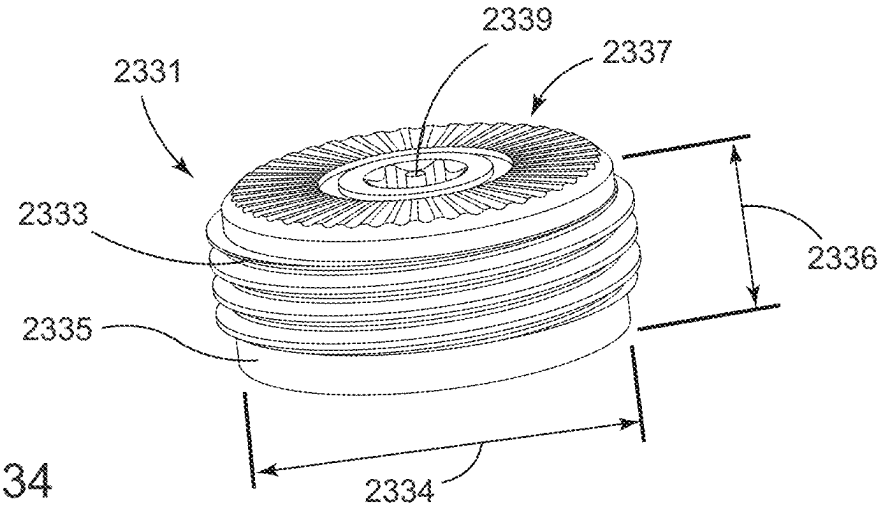

FIG. 34

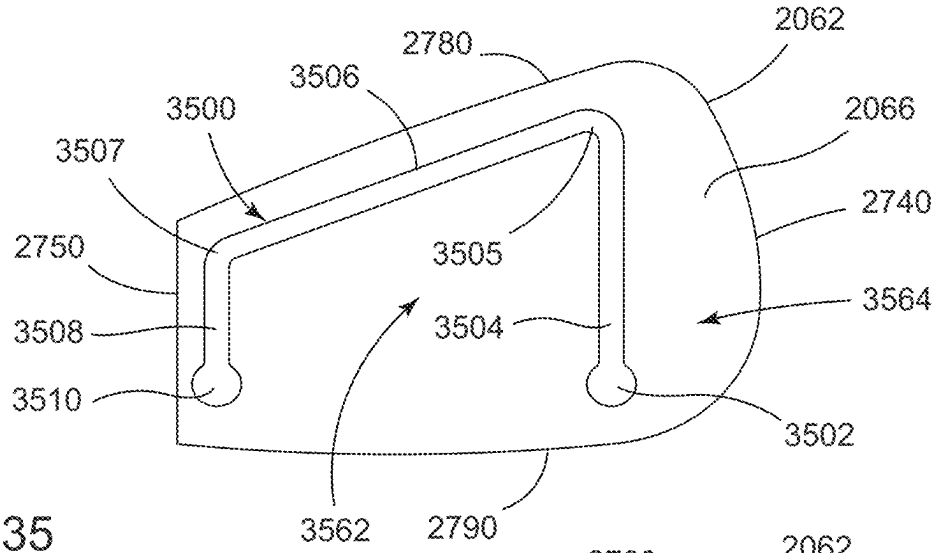

FIG. 35

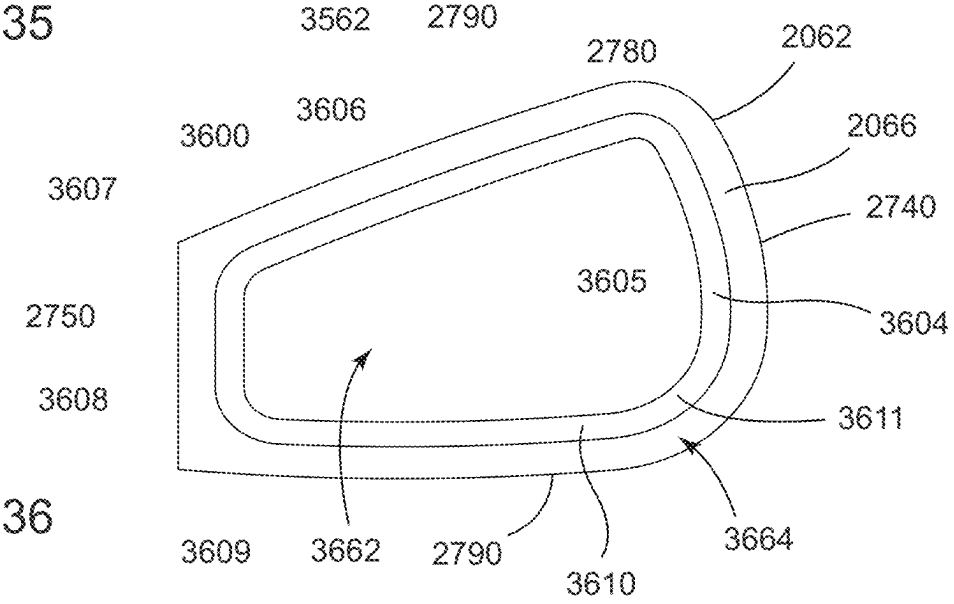

FIG. 36

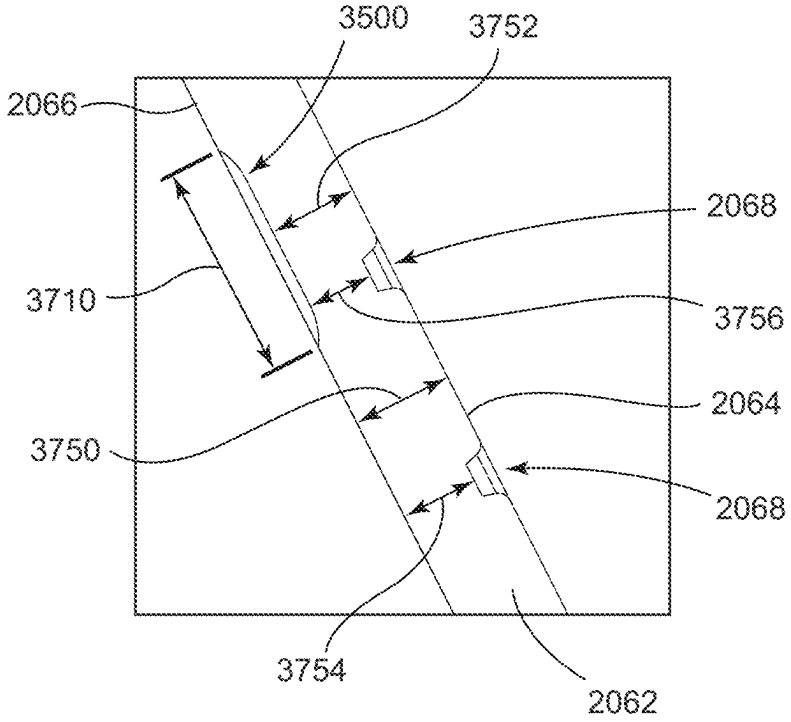
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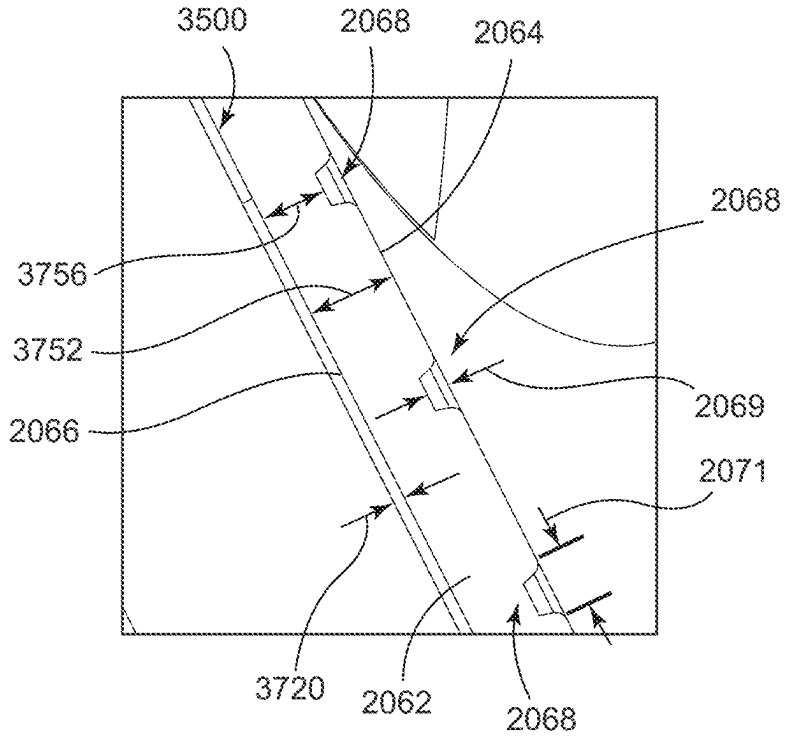
FIG. 37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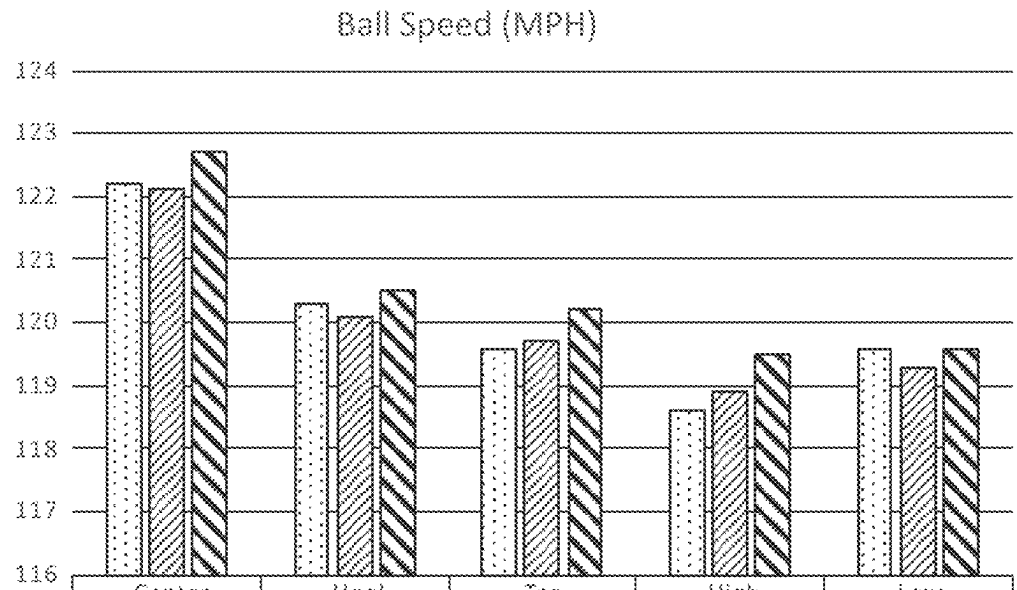
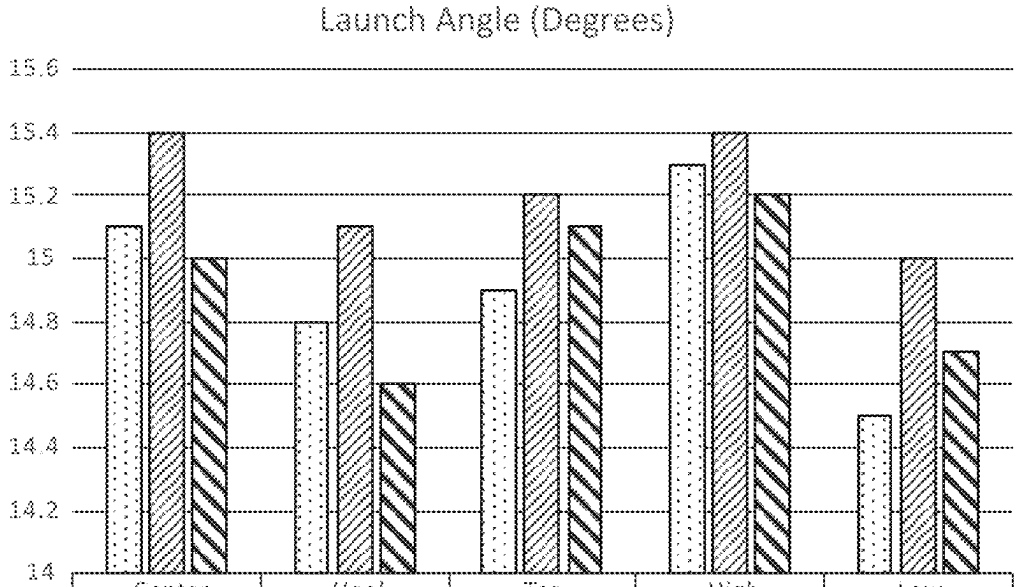
3720
2062
2068

FIG. 38



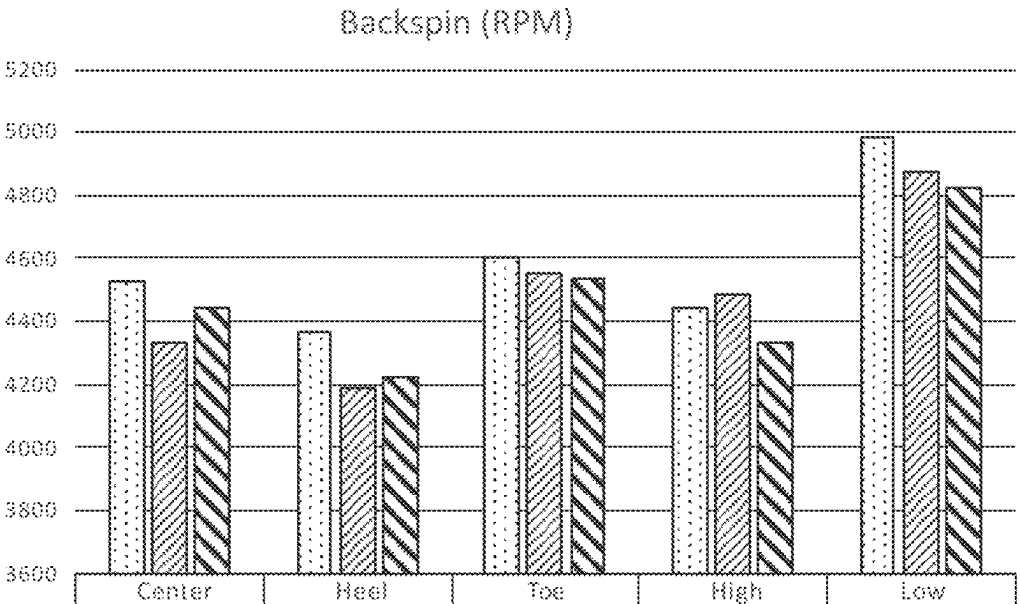
	Center	Heel	Toe	High	Low
Club No. 1	122.2	120.3	119.6	118.6	119.5
Club No. 2	122.1	120.1	119.7	118.9	119.3
Club No. 3	122.7	120.5	120.2	119.5	119.6

FIG. 39



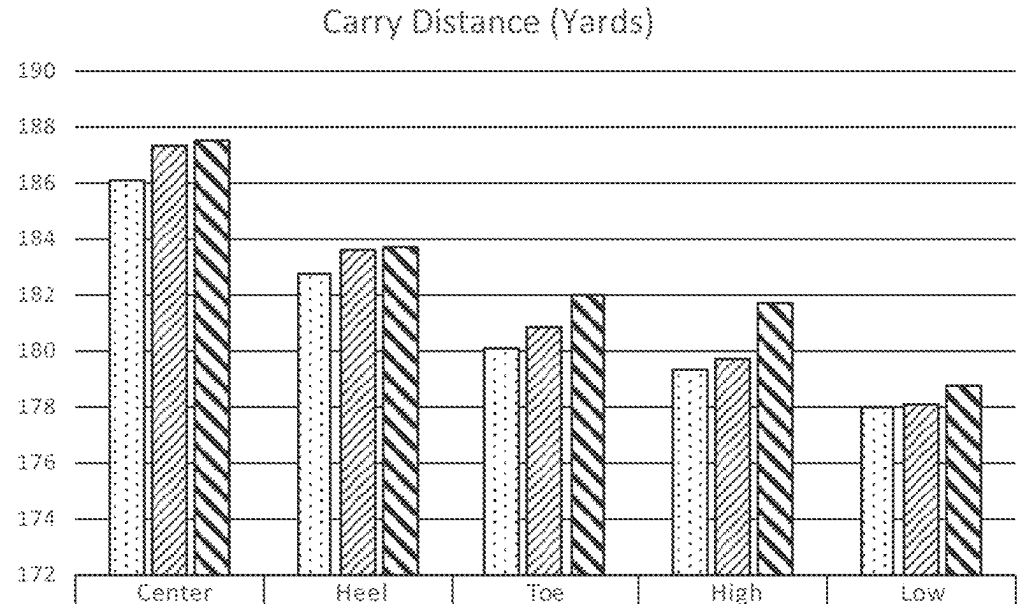
	Center	Heel	Toe	High	Low
Club No. 1	15.1	14.8	14.9	15.3	14.5
Club No. 2	15.4	15.1	15.2	15.4	15
Club No. 3	15	14.6	15.1	15.2	14.7

FIG. 40



	Center	Heel	Toe	High	Low
Club No. 1	4528	4366	4602	4447	4982
Club No. 2	4333	4187	4556	4487	4874
Club No. 3	4443	4222	4536	4336	4820

FIG. 41



	Center	Heel	Toe	High	Low
Club No. 1	186.1	182.8	180.1	179.3	178
Club No. 2	187.3	183.6	180.9	179.7	178.1
Club No. 3	187.5	183.7	182	181.7	178.8

FIG. 42

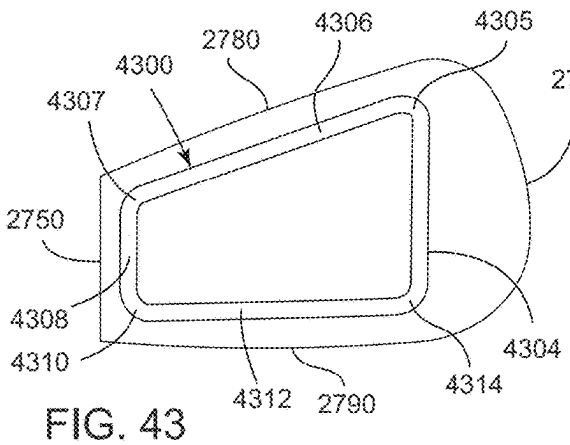


FIG. 43

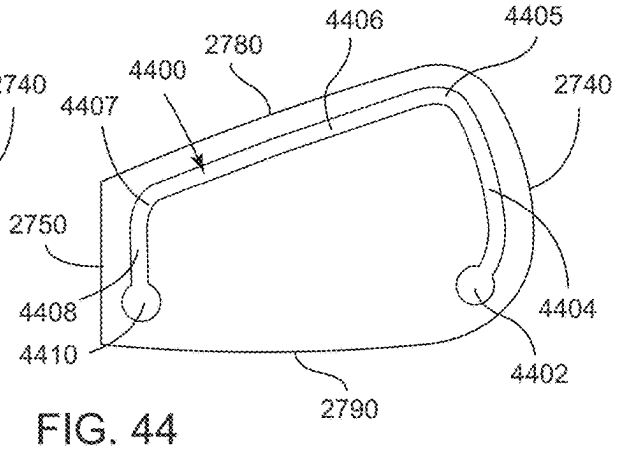


FIG. 44

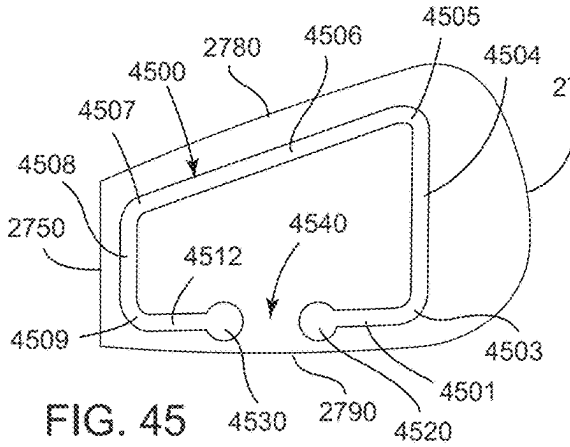


FIG. 45

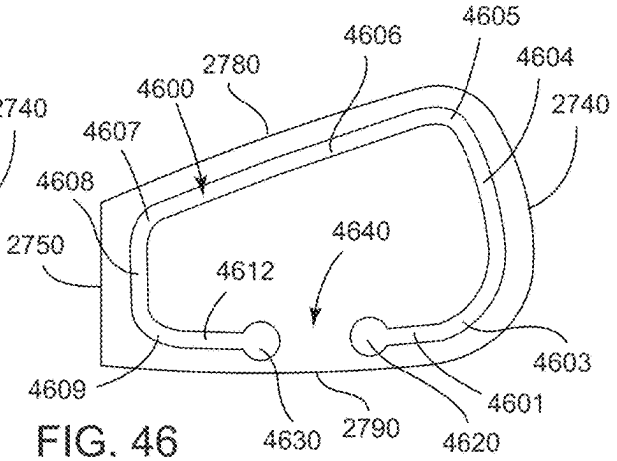


FIG. 46

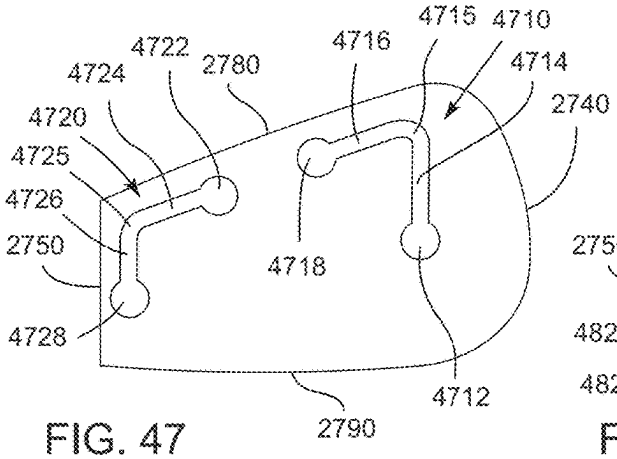


FIG. 47

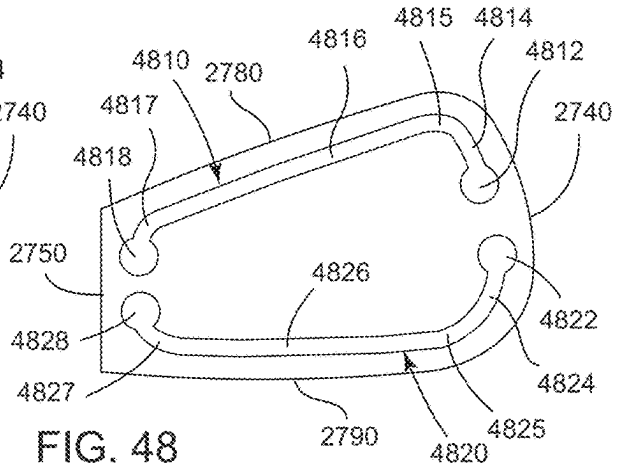


FIG. 48

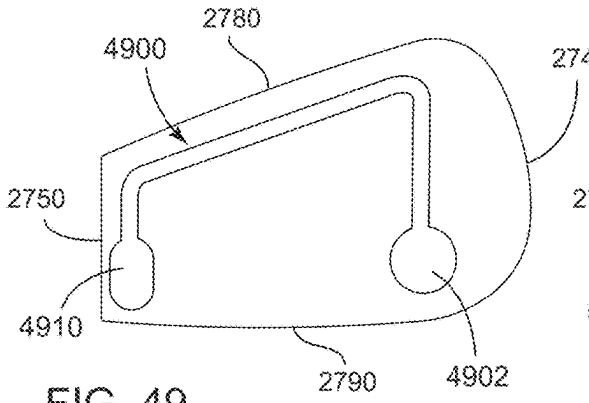


FIG. 49

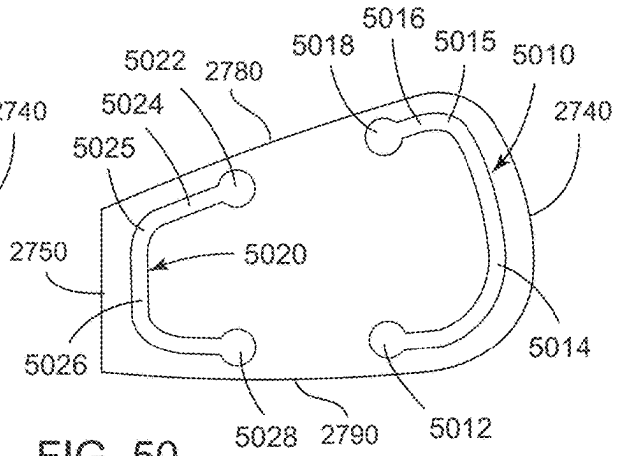


FIG. 50

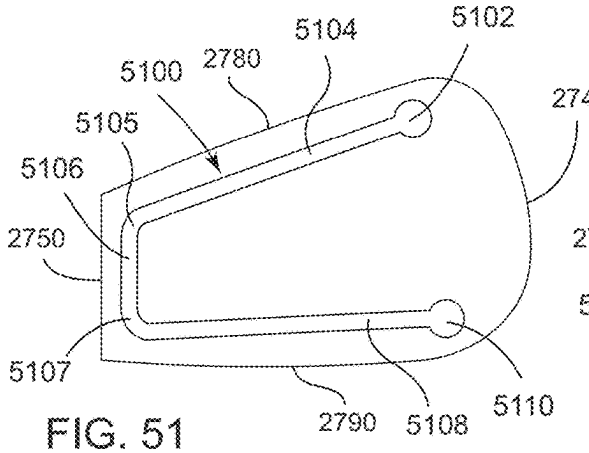


FIG. 51

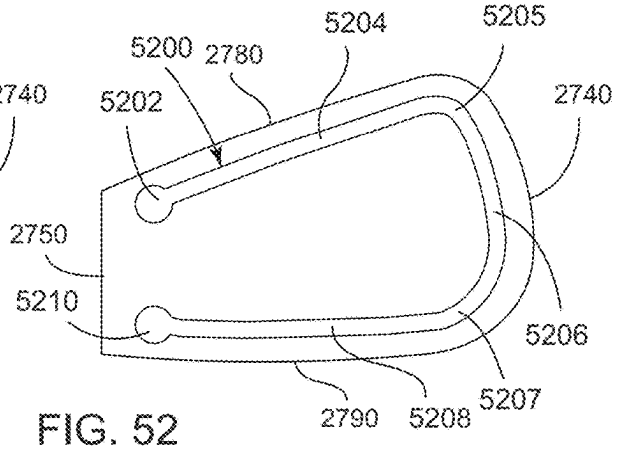


FIG. 52

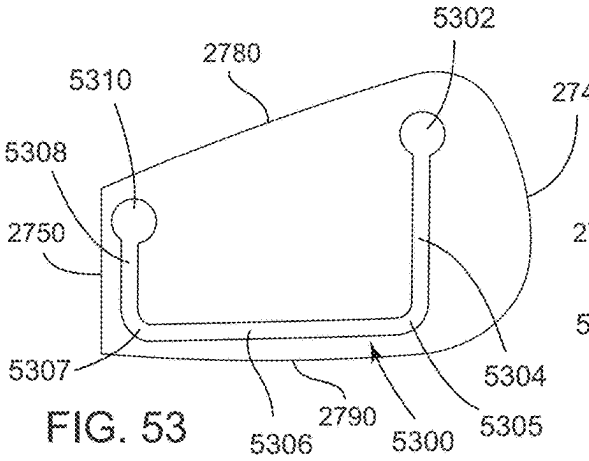


FIG. 53

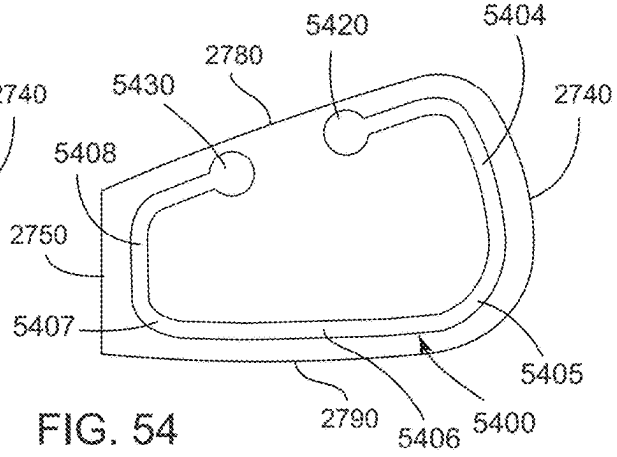


FIG. 54

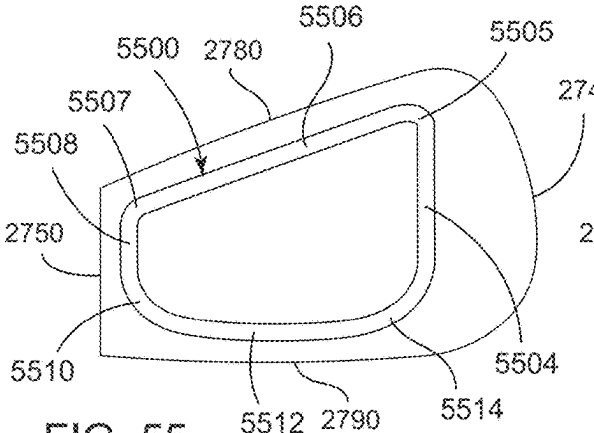


FIG. 55

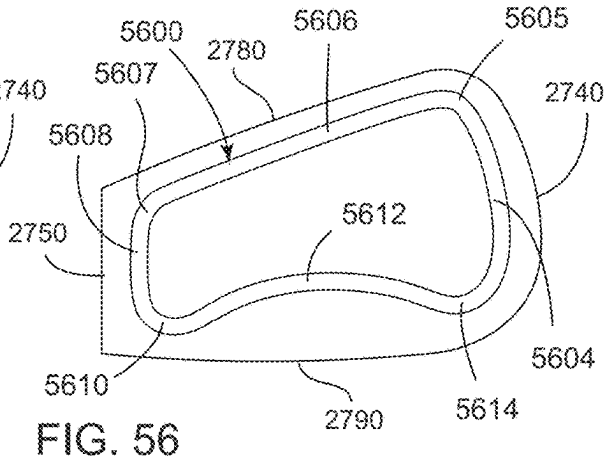


FIG. 56

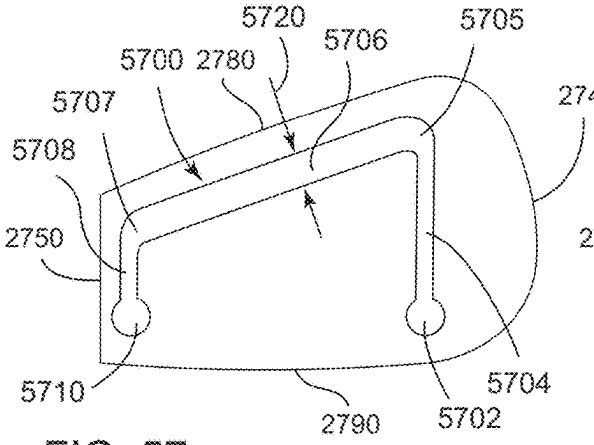


FIG. 57

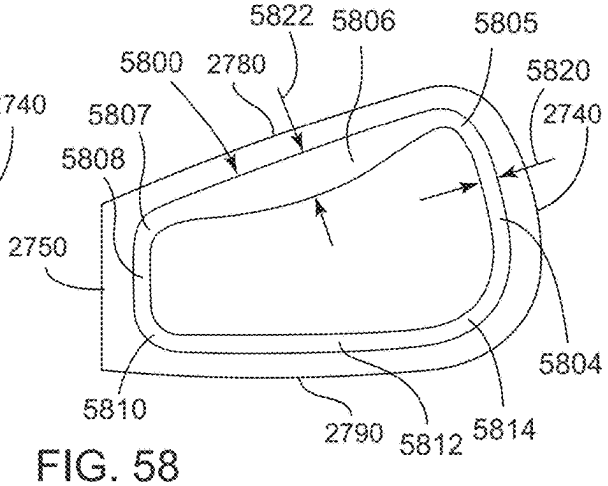


FIG. 58

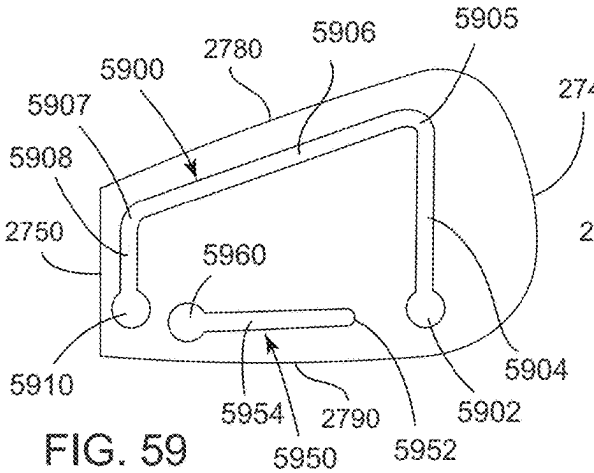


FIG. 59

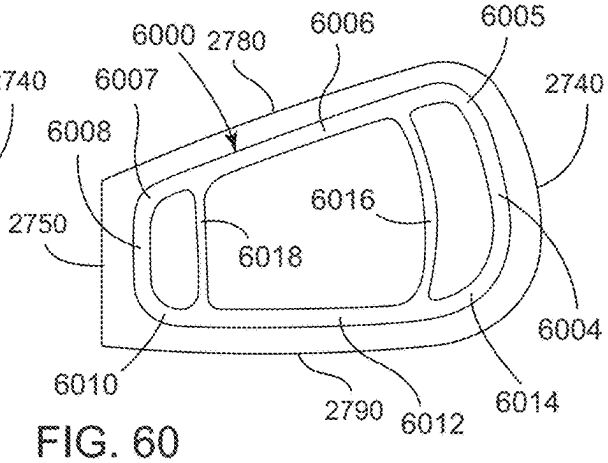


FIG. 60

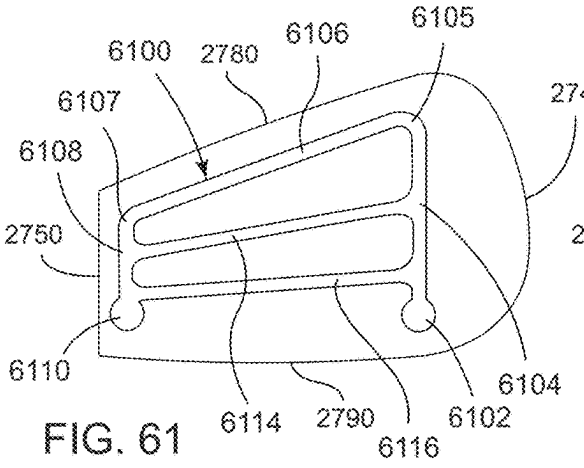


FIG. 61

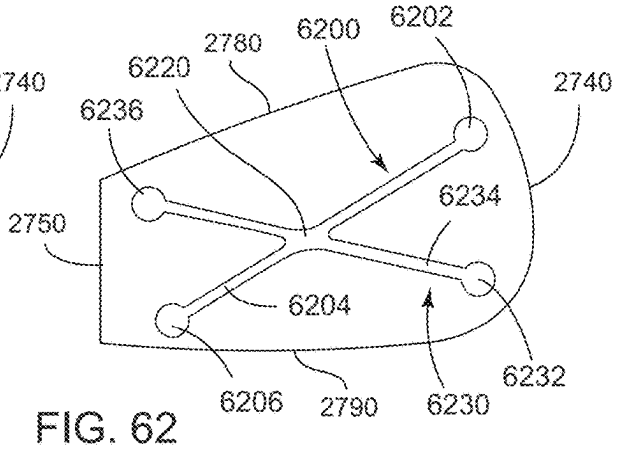


FIG. 62

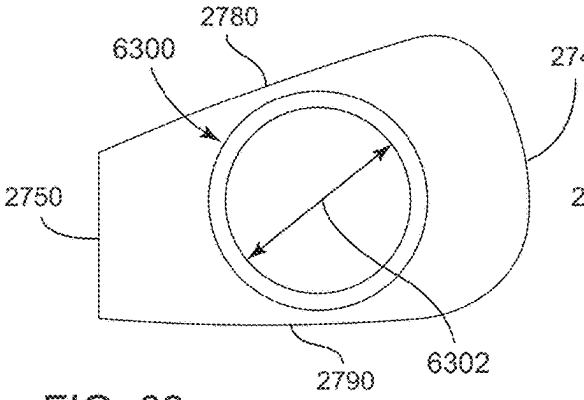


FIG. 63

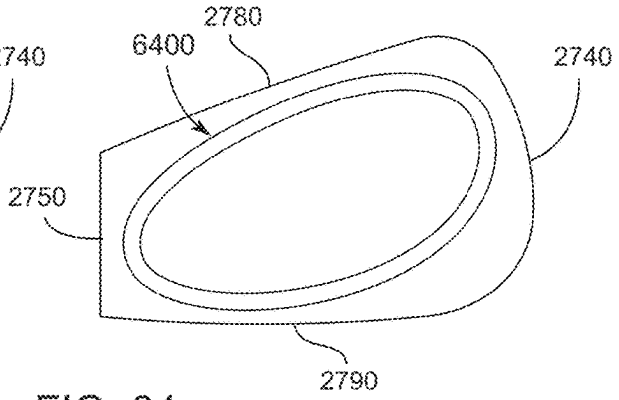


FIG. 64

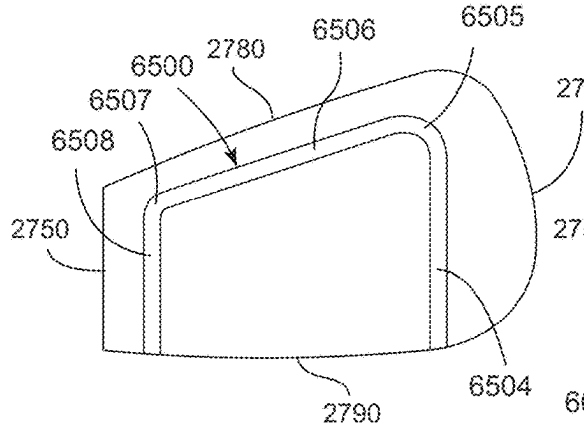


FIG. 65

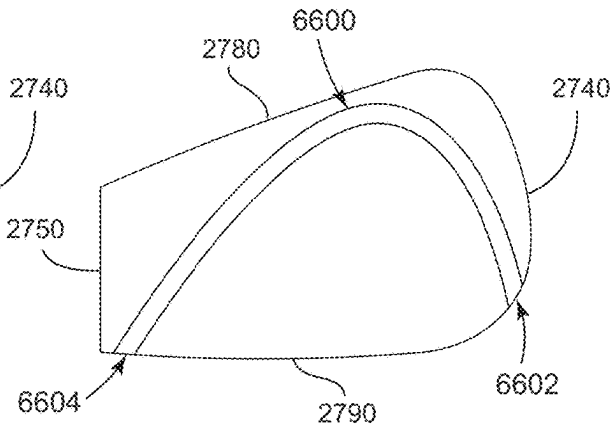


FIG. 66

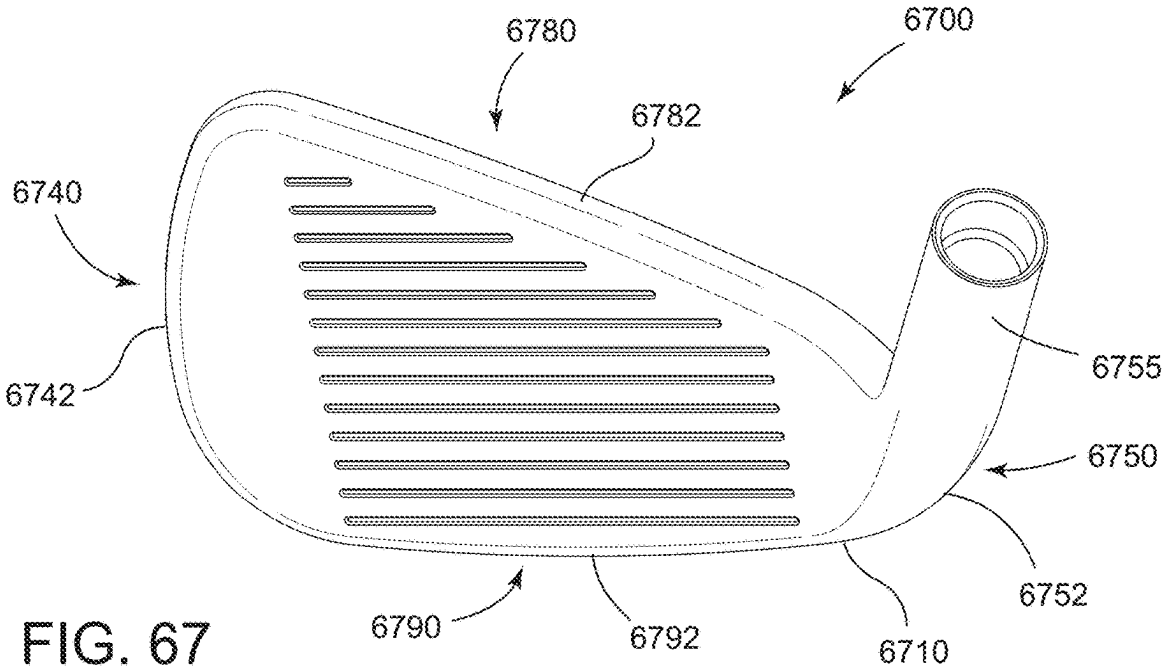

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FIG. 67

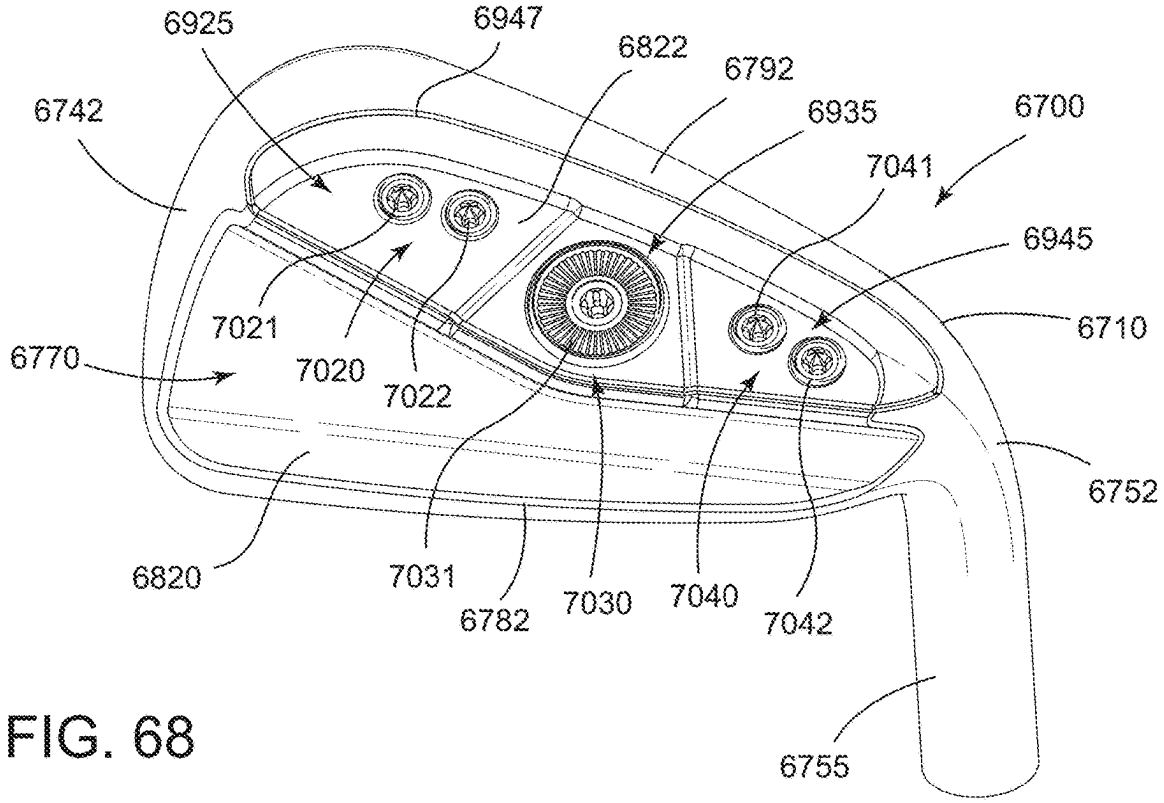
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FIG. 68

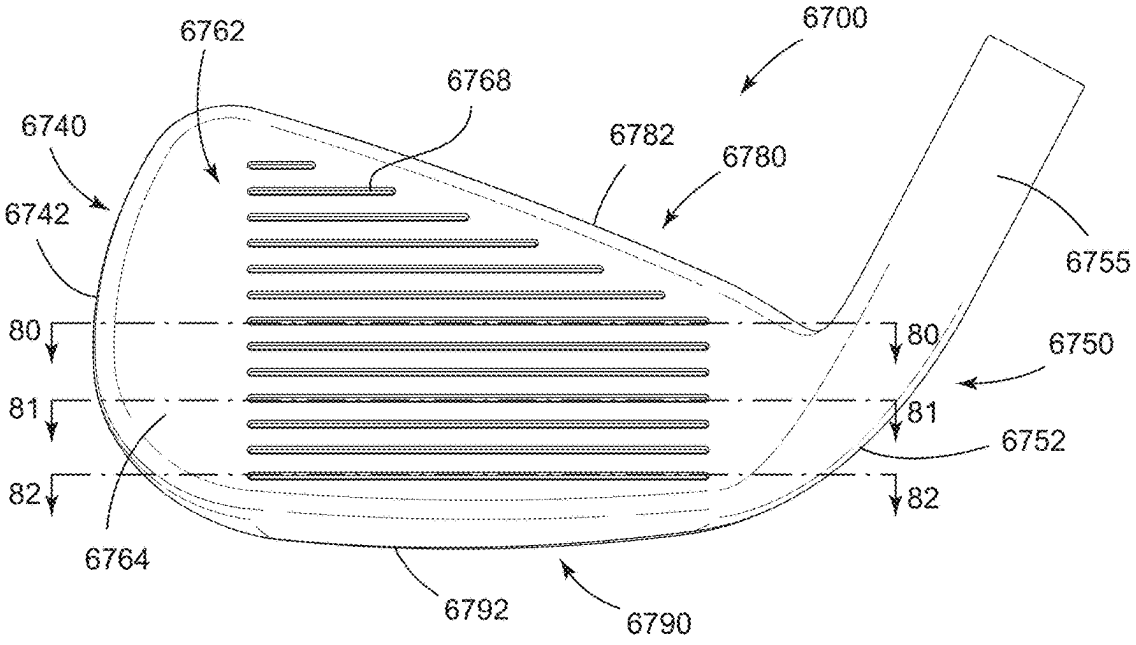
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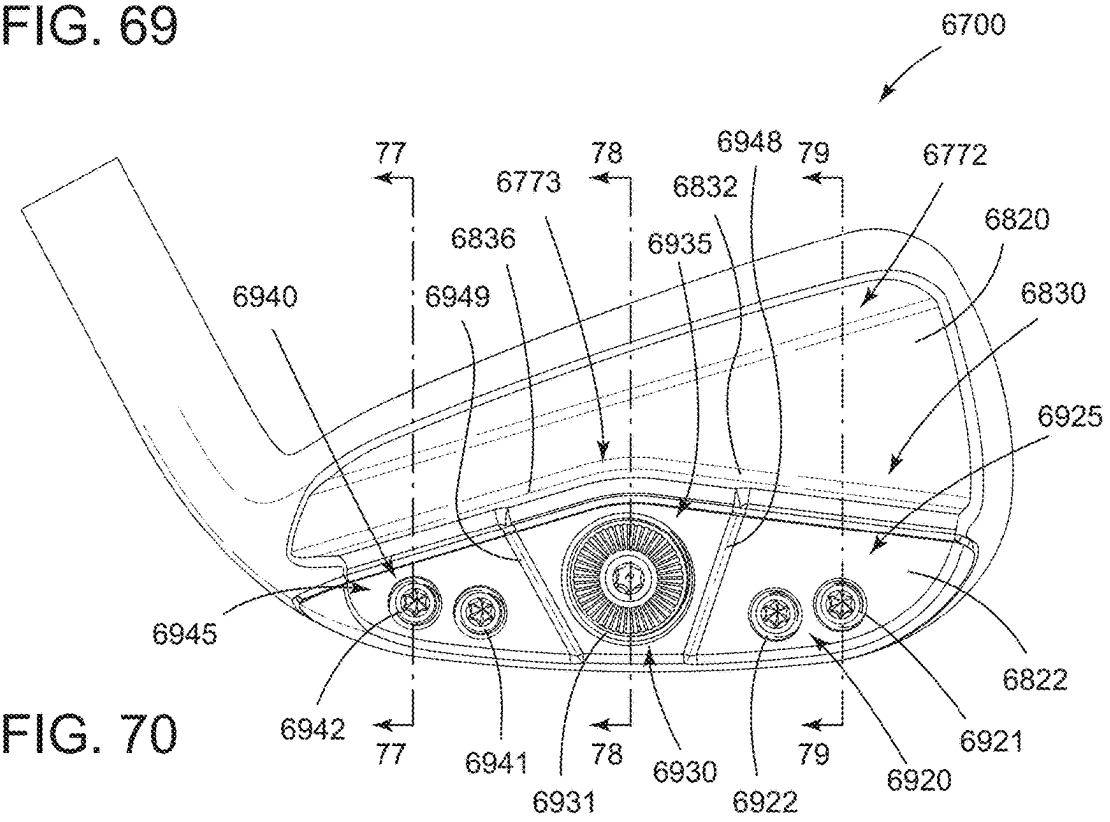
FIG. 69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79

FIG. 70

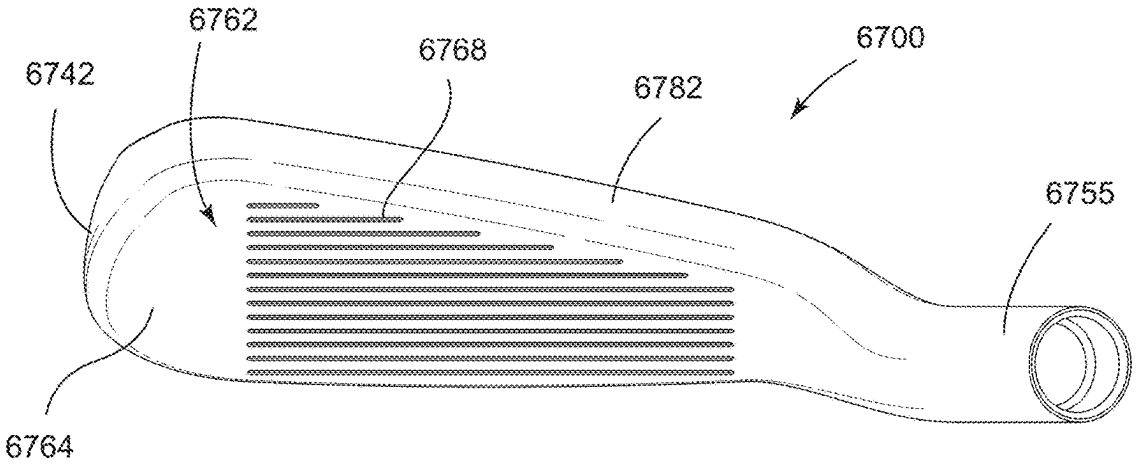
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FIG. 71

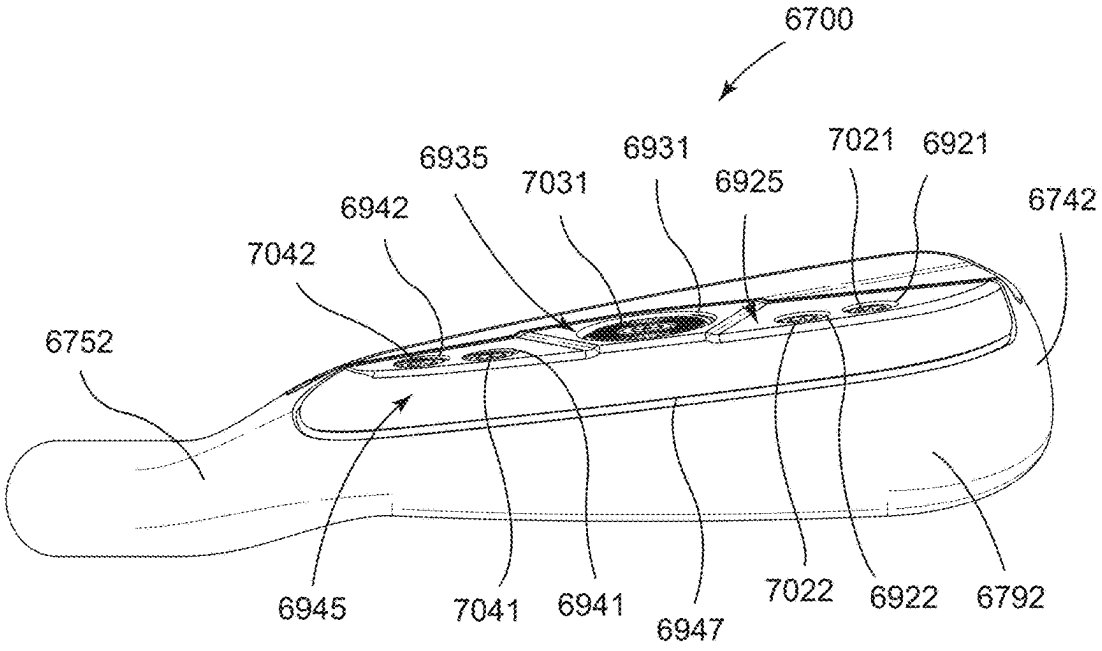
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FIG. 72

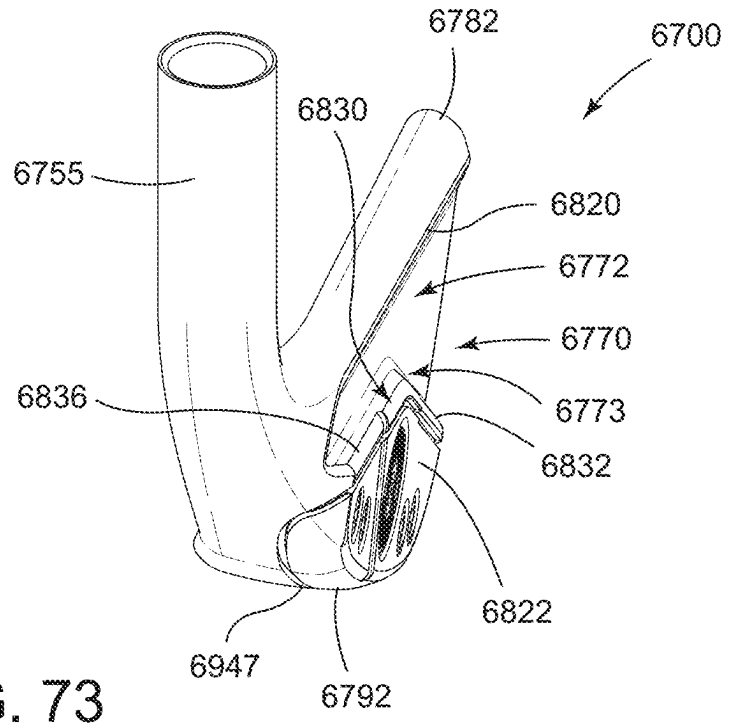
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FIG. 73

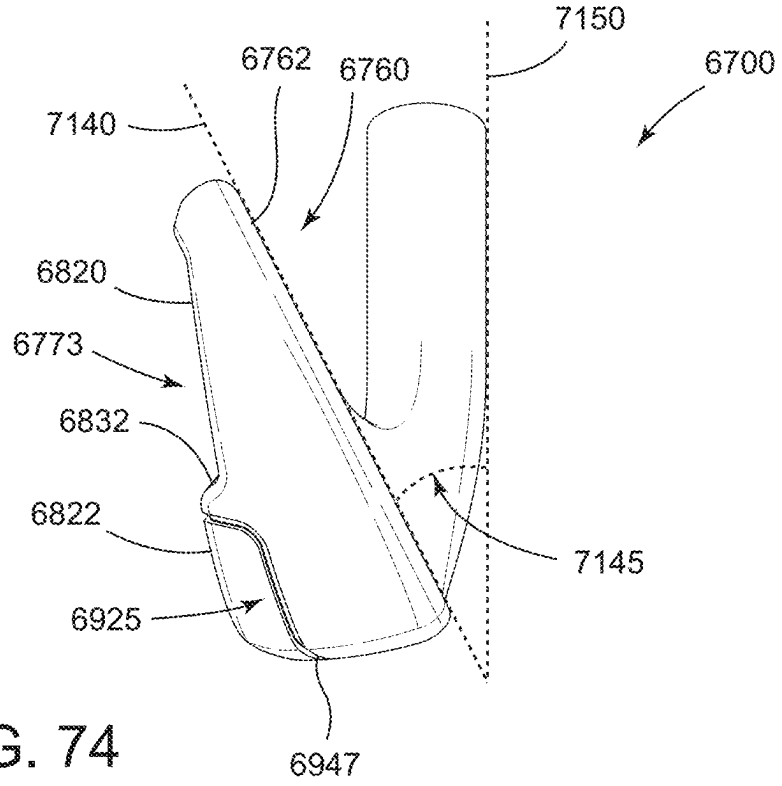
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FIG. 74

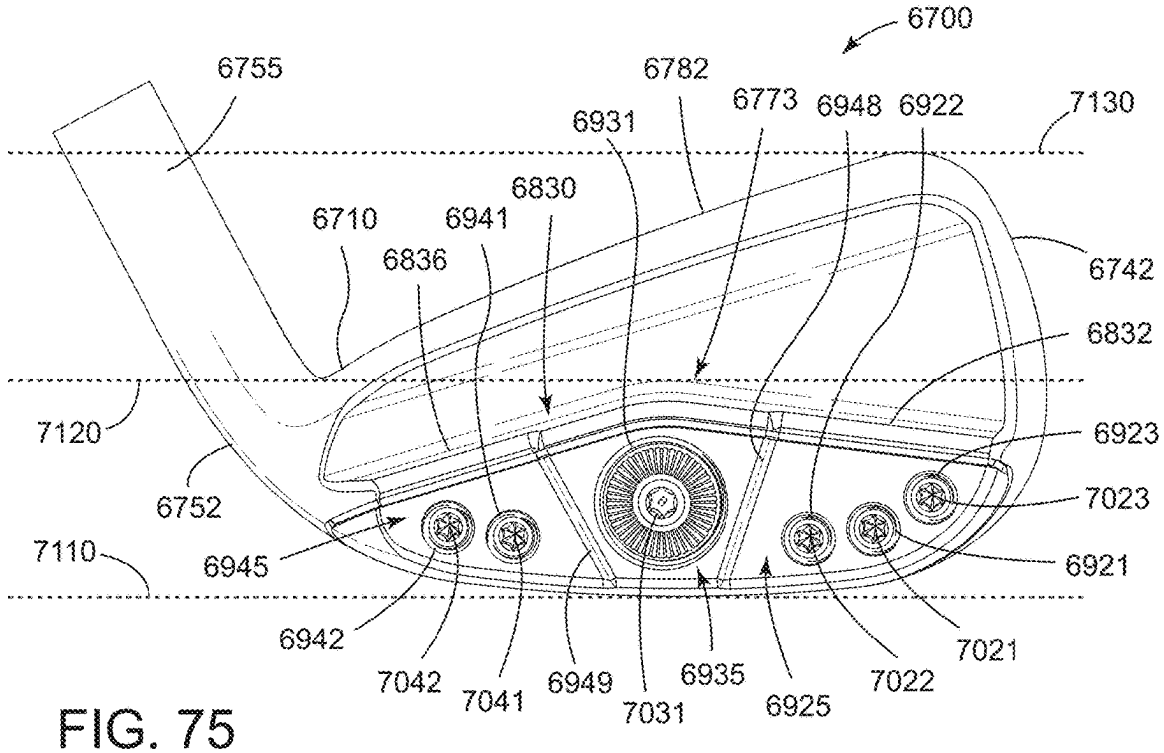
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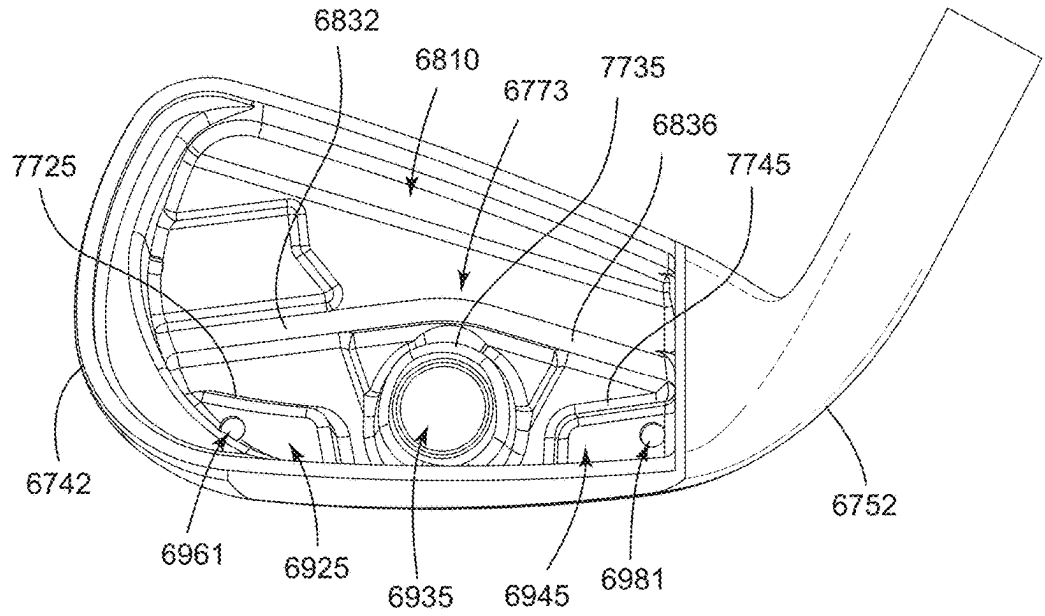
FIG. 75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6945
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FIG. 76

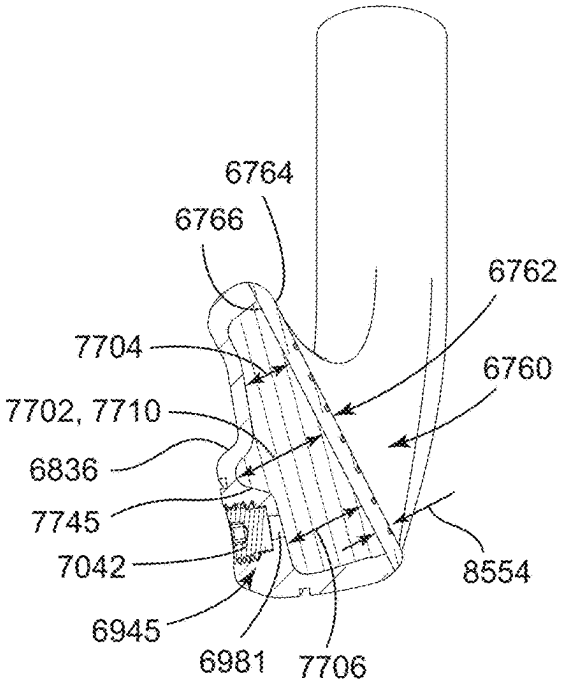

FIG. 77

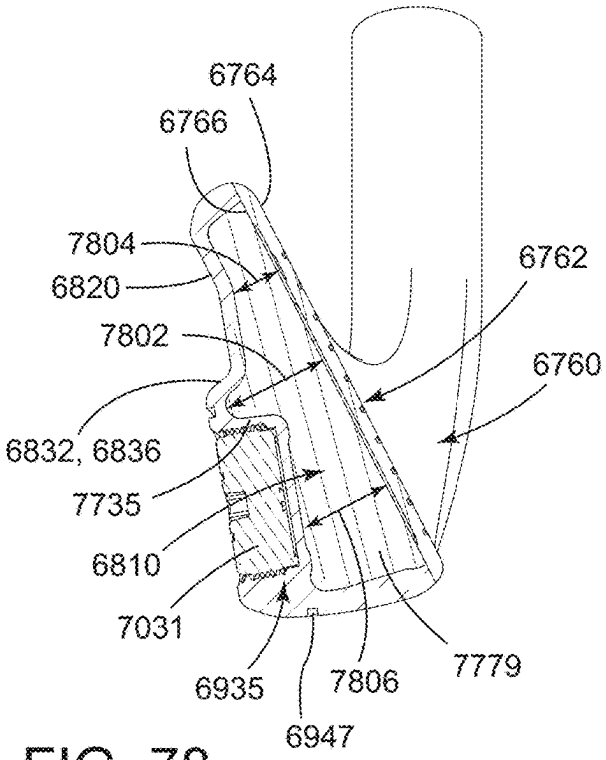

FIG. 78

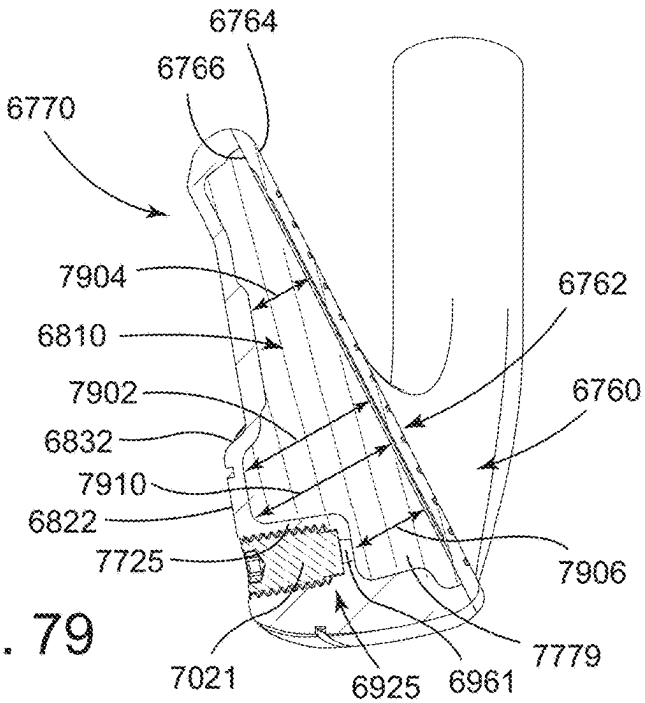

FIG. 79

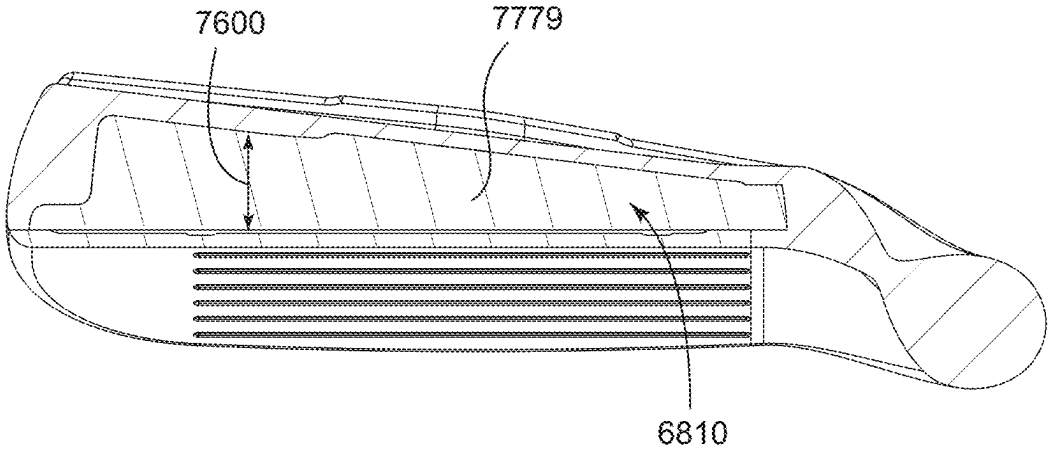

FIG. 80

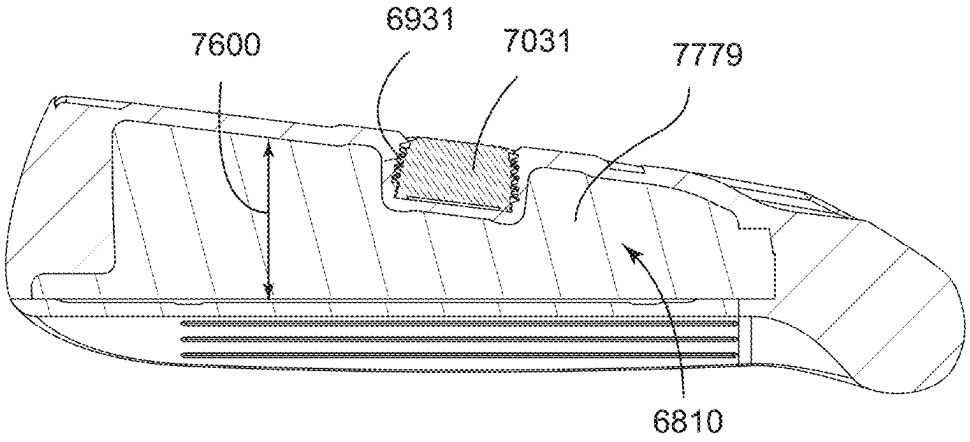

FIG. 81

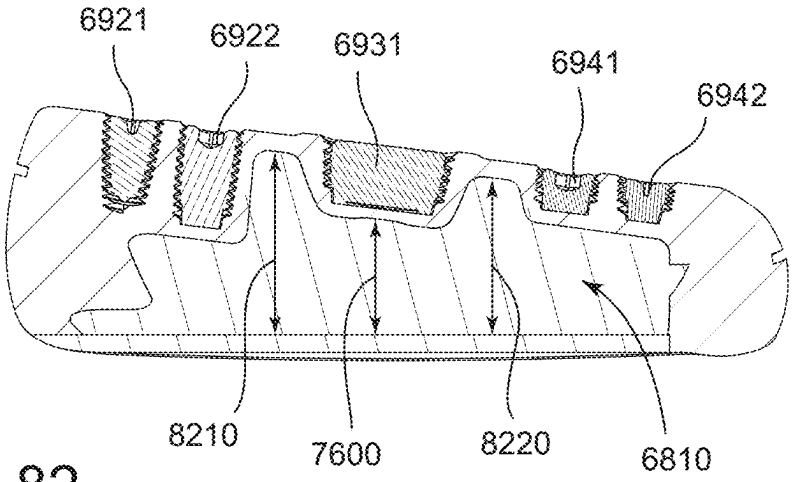

FIG. 82

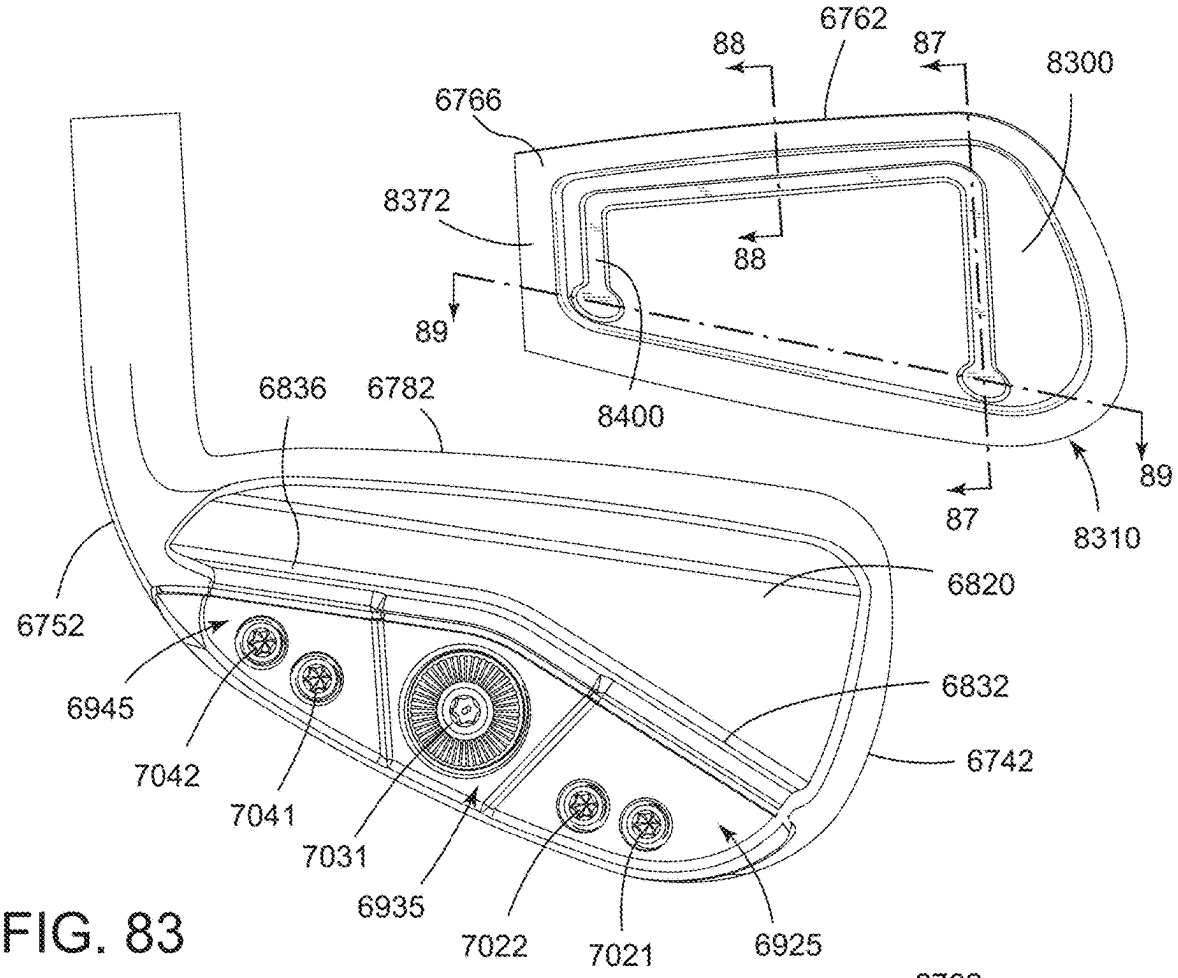
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FIG. 83

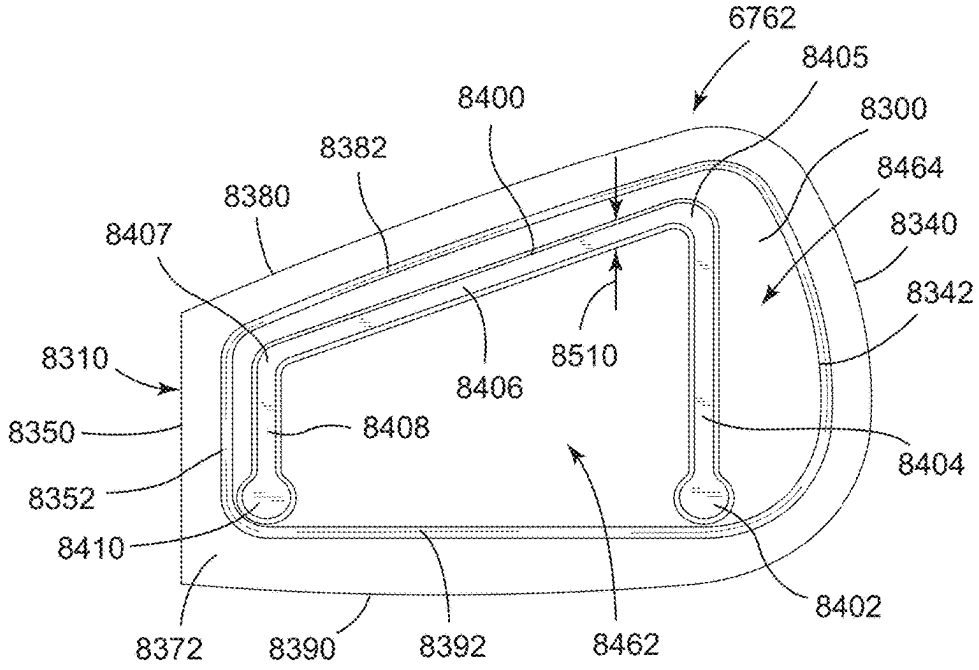
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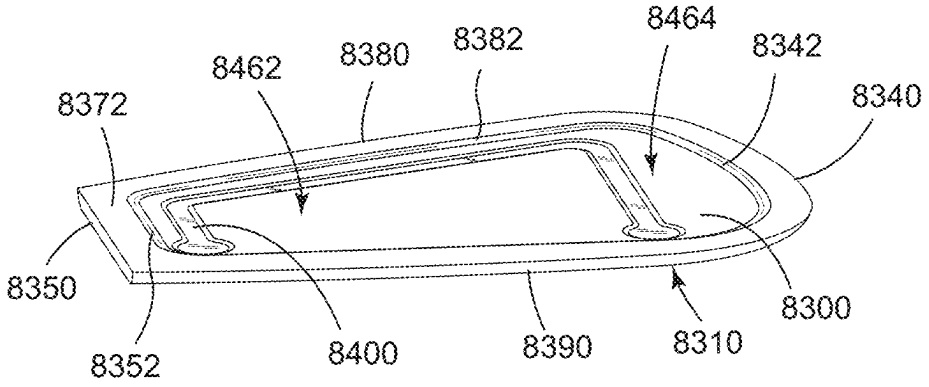
FIG. 84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8390
8310
8300

FIG. 85

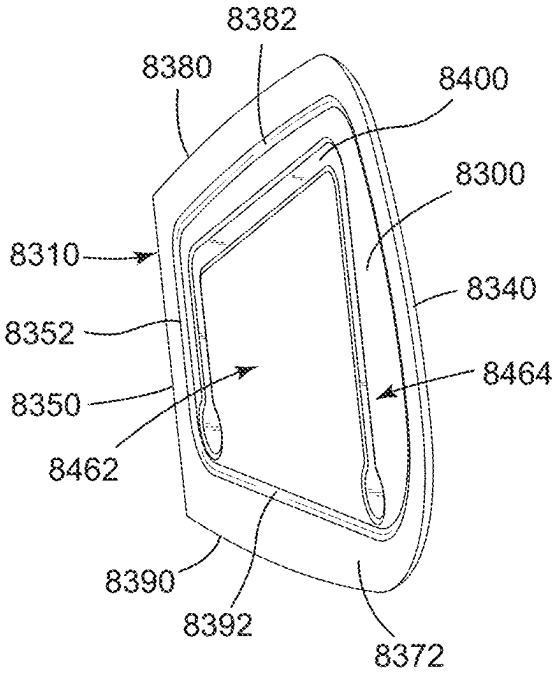
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FIG. 86

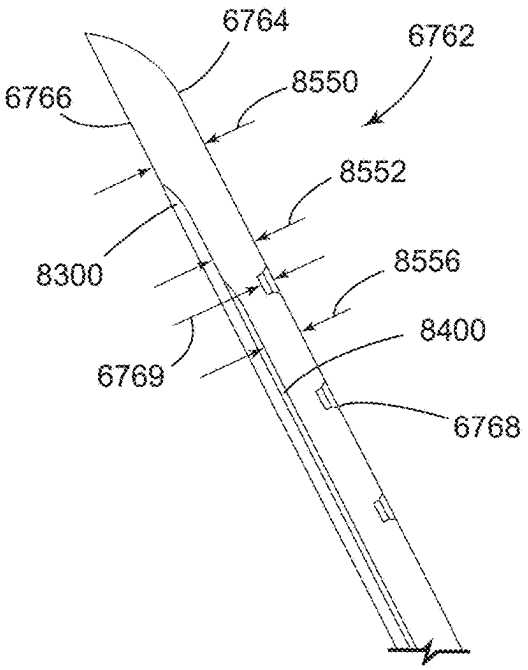

FIG. 87

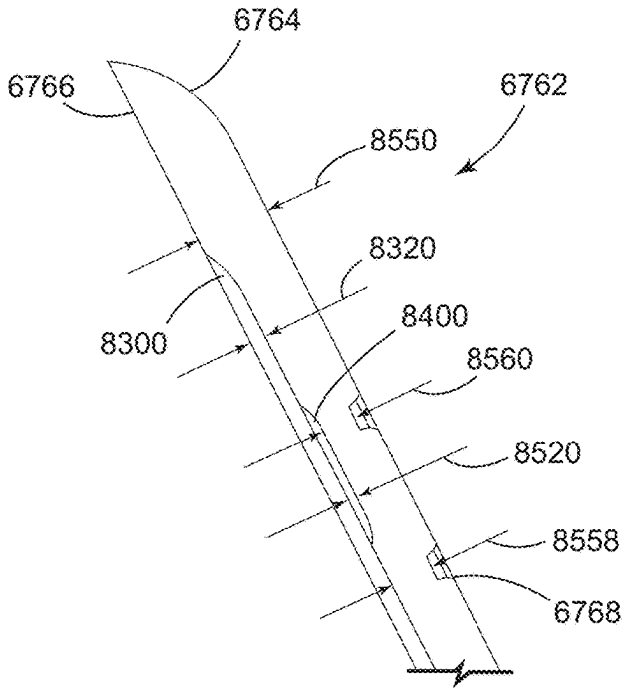

FIG. 88

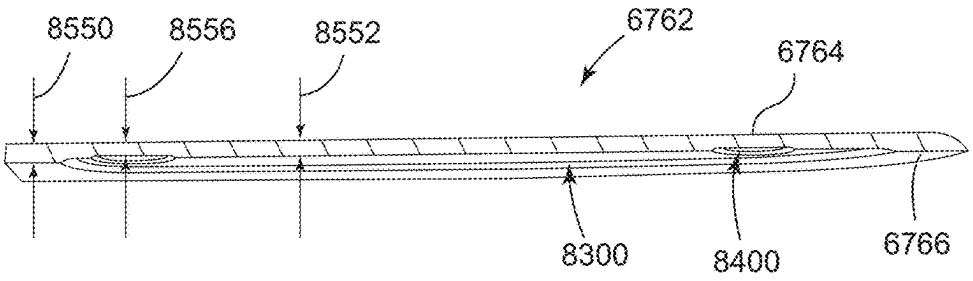

FIG. 89

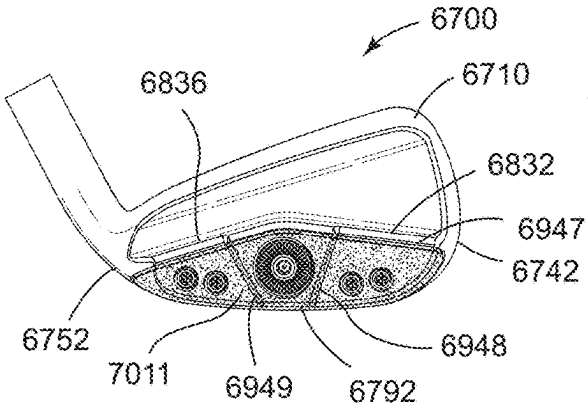

FIG. 90

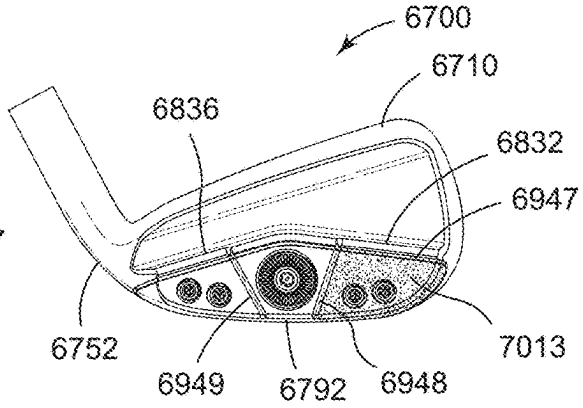

FIG. 91

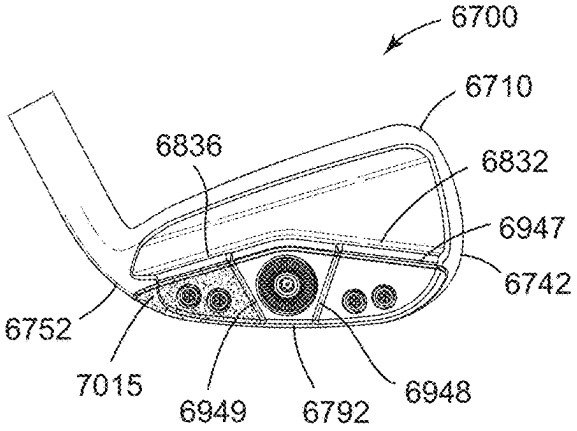

FIG. 92

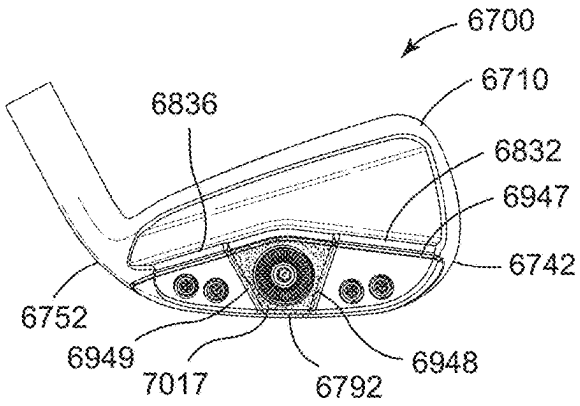

FIG. 93

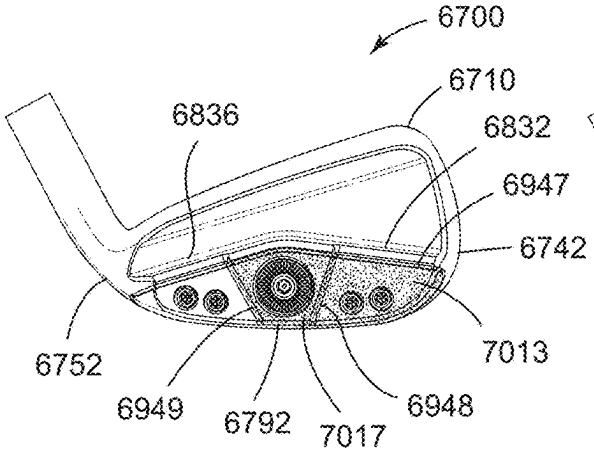

FIG. 94

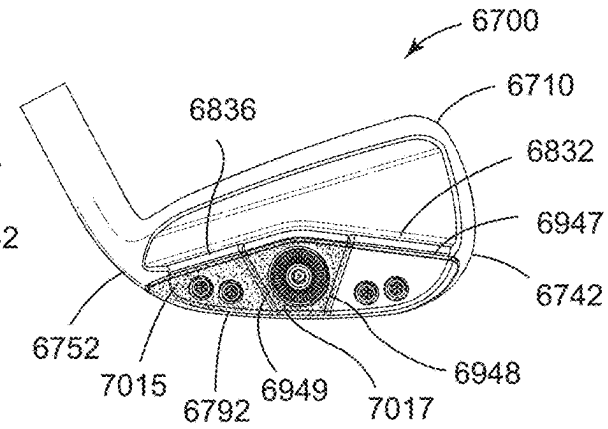

FIG. 95

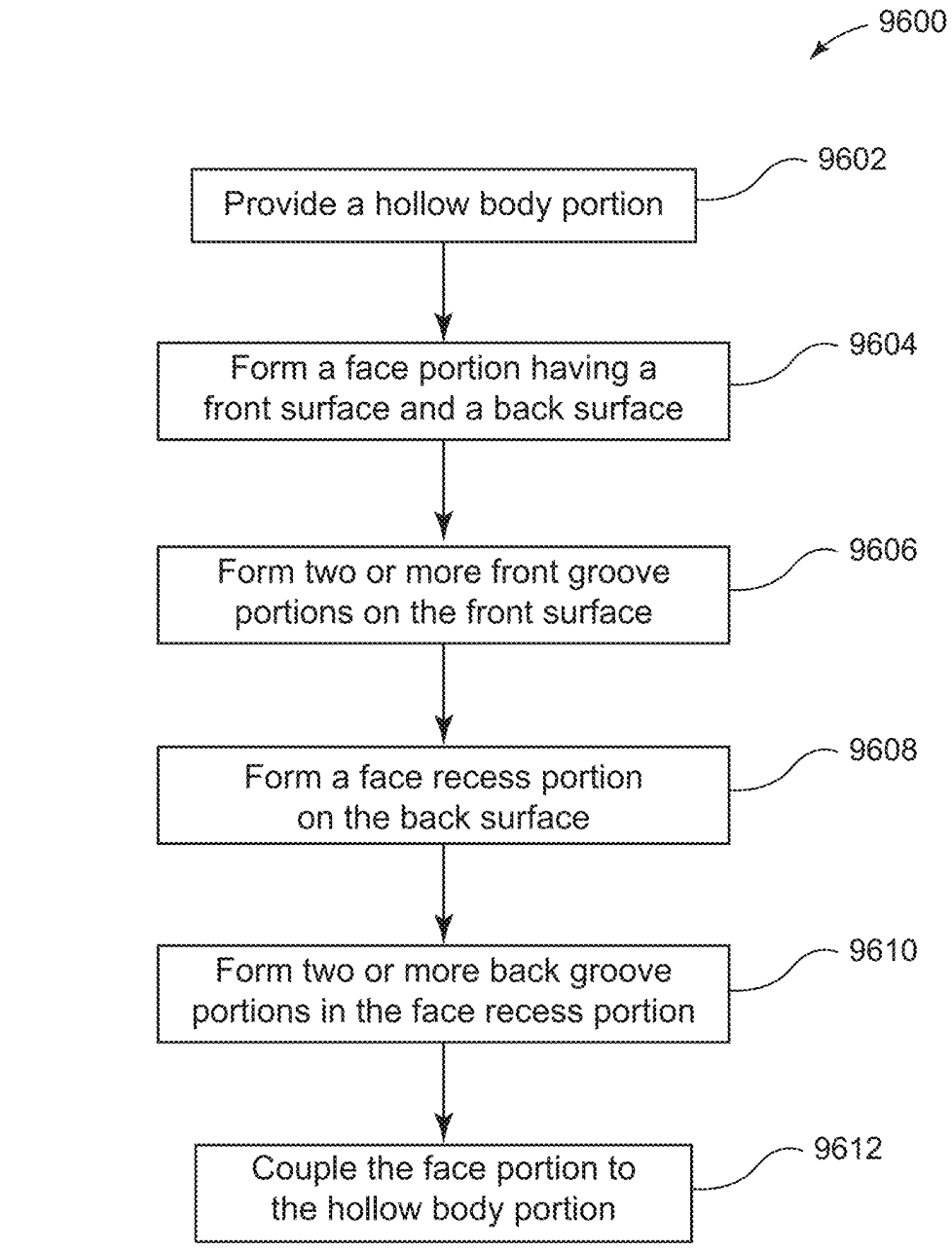
9600
Provide a hollow body portion
9602
Form a face portion having a front surface and a back surface
9604
Form two or more front groove portions on the front surface
9606
Form a face recess portion on the back surface
9608
Form two or more back groove portions in the face recess portion
9610
Couple the face portion to the hollow body portion
9612

FIG. 96

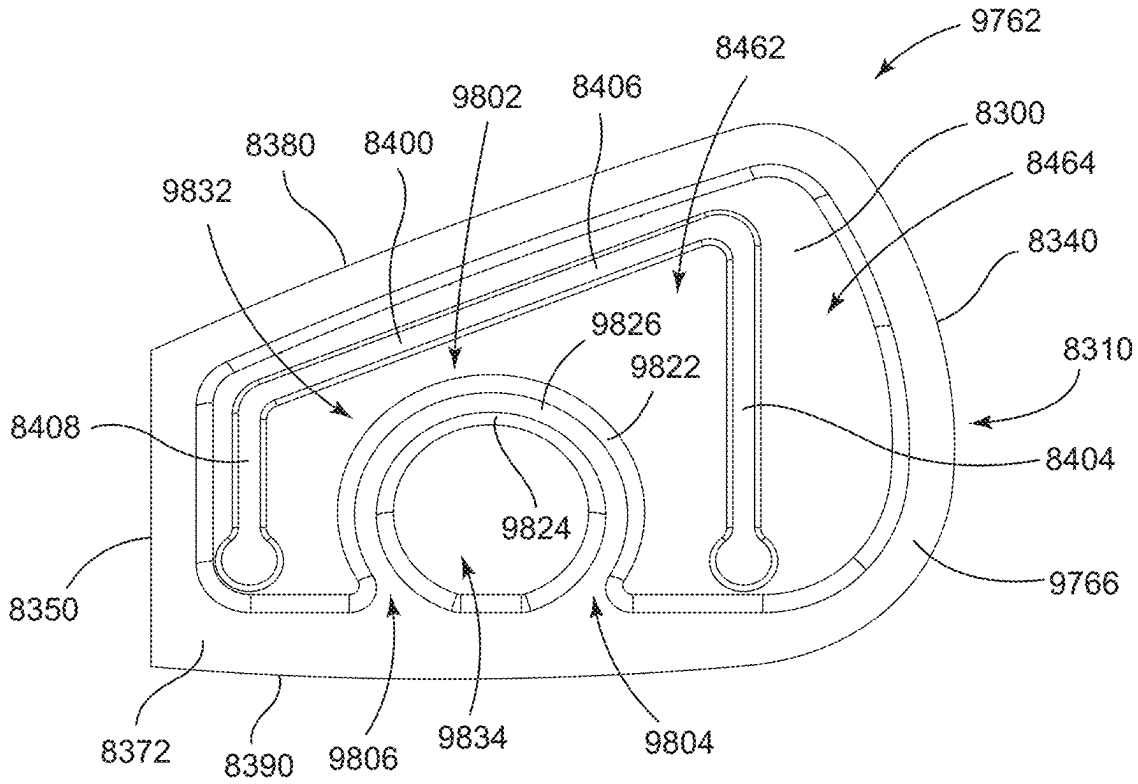
9762
8462
9802
8406
8300
8380
8400
8464
9832
8340
9826
8310
9822
8408
8404
9824
8350
9766
8372
8390
9806
9834
9804

FIG. 97

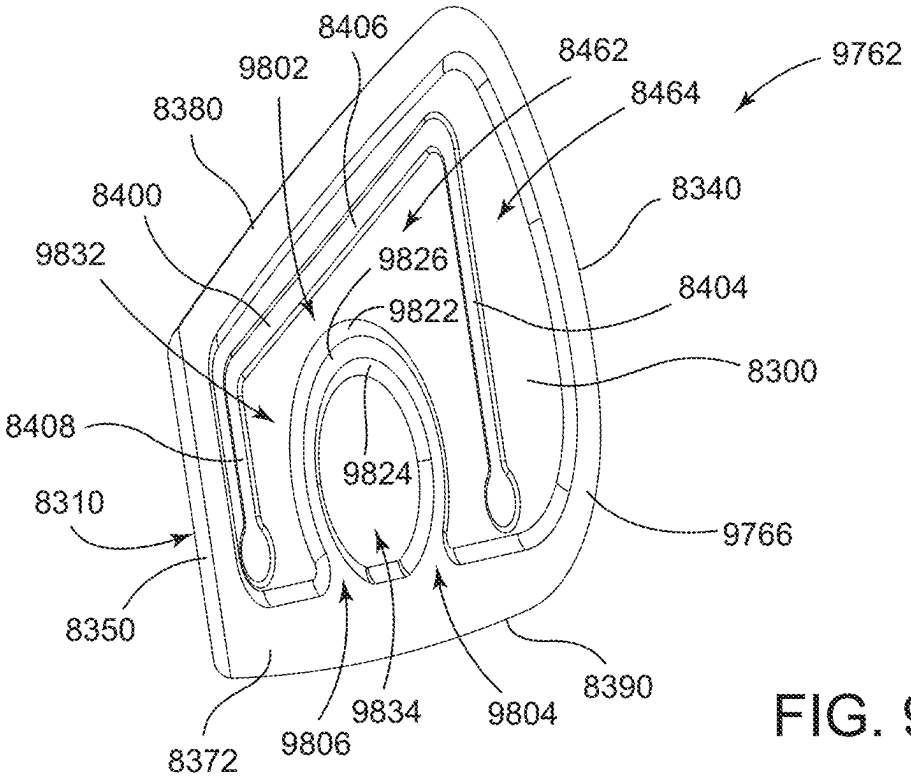
8406
9762
9802
8462
8380
8464
8340
8400
9832
9826
8404
9822
8300
8408
9824
8310
9766
8350
8390
9834
9804
9806
8372

FIG. 98

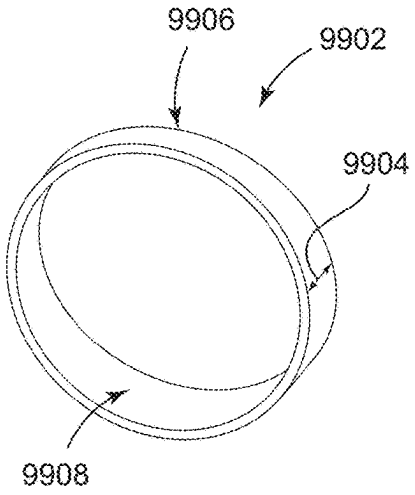

FIG. 99

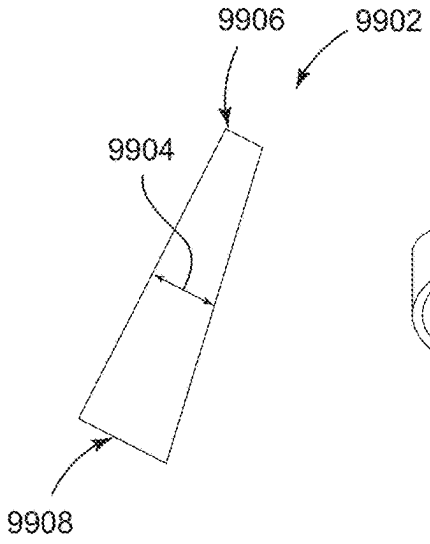

FIG. 100

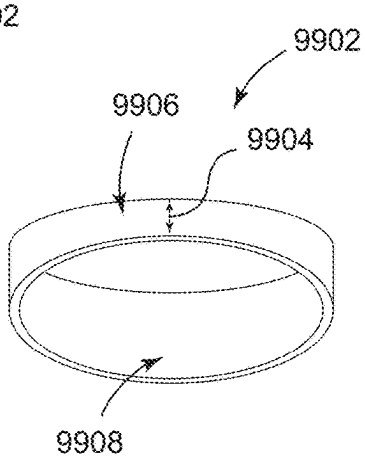

FIG. 101

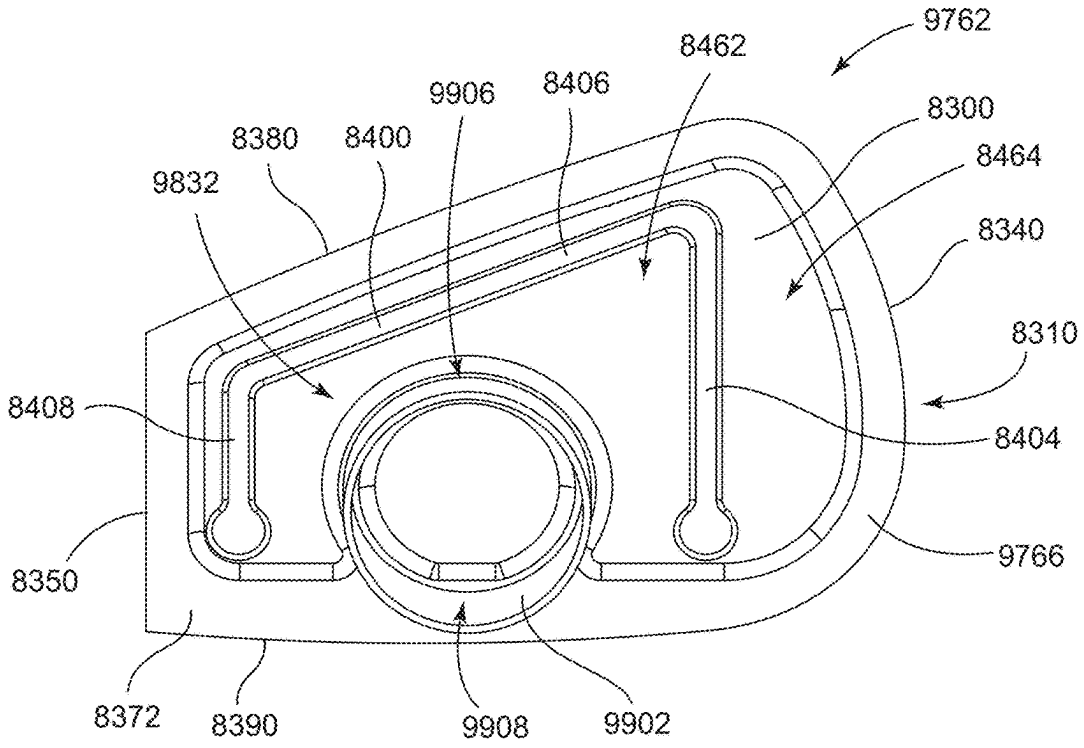

FIG. 102

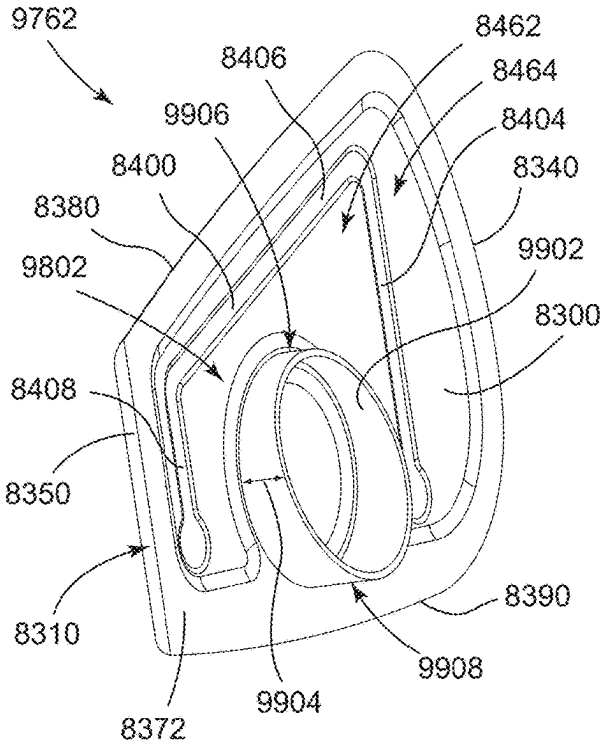

FIG. 103

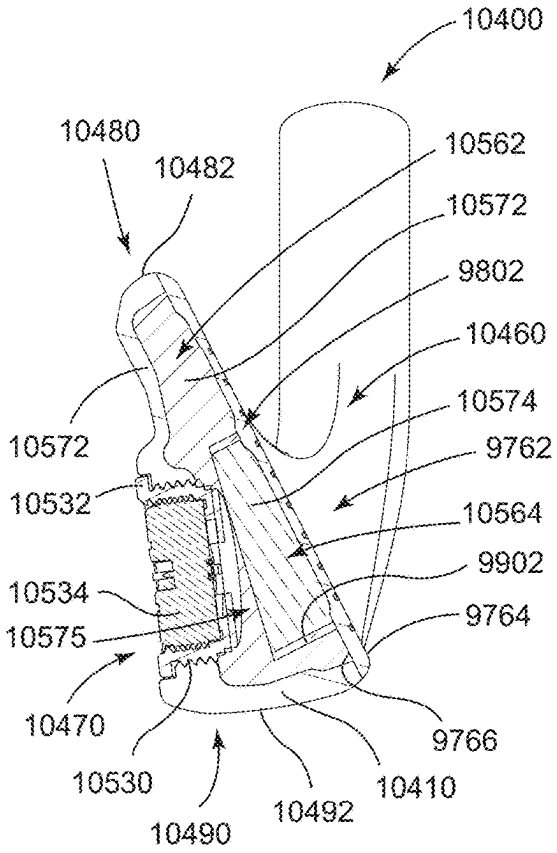

FIG. 104

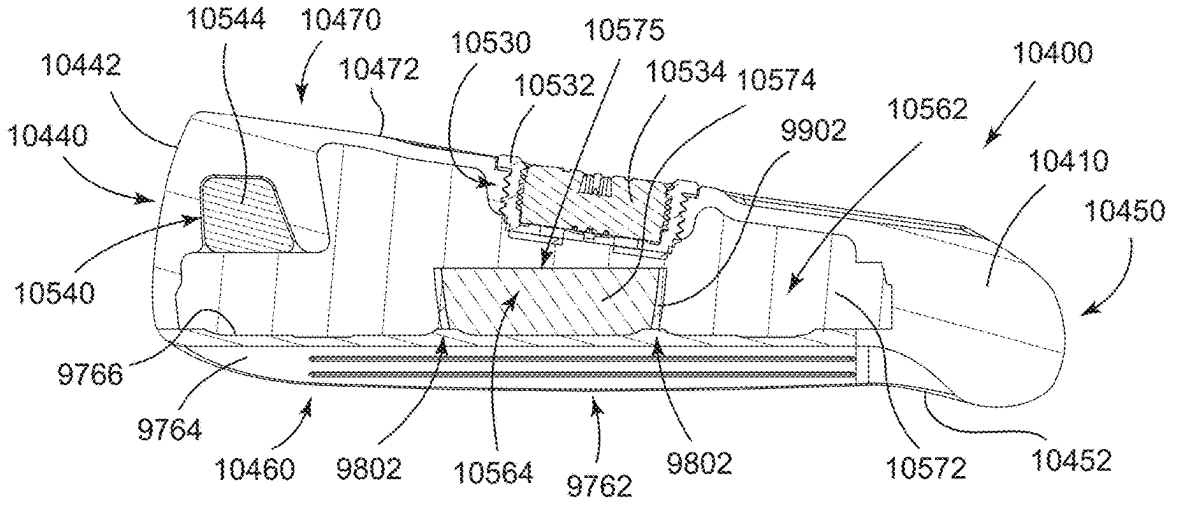

FIG. 105

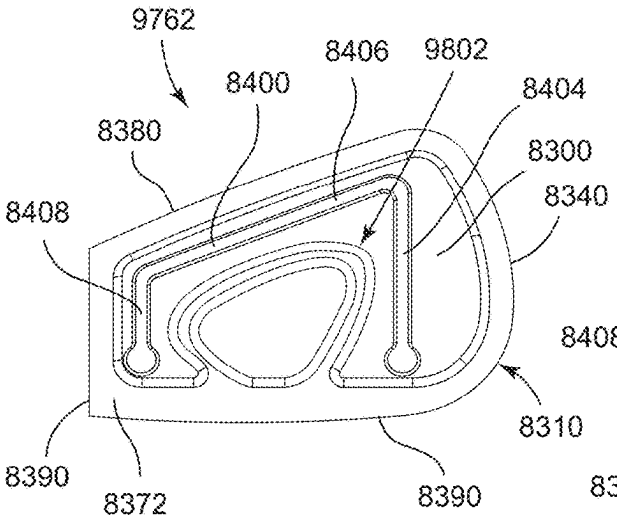

FIG. 106

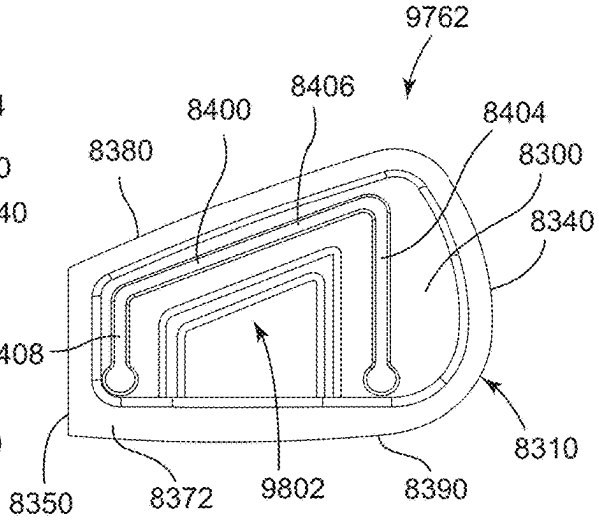

FIG. 107

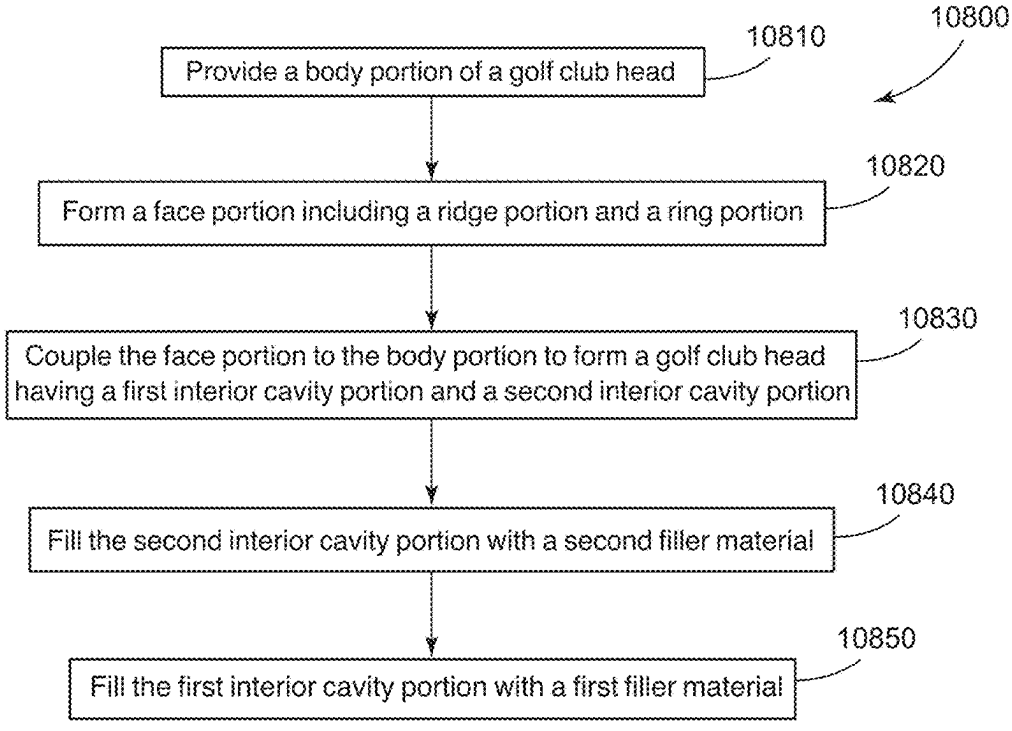

FIG. 108

GOLF CLUB HEADS AND METHODS TO MANUFACTURE GOLF CLUB HEADS

COPYRIGHT AUTHORIZATION

CROSS REFERENCE

This application claims the benefit of U.S. Provisional Application No. 63/621,262, filed Jan. 16, 2024.

This application is a continuation-in-part of application Ser. No. 18/221,568, filed Jul. 13, 2023, which is a continuation of U.S. application Ser. No. 18/089,683, filed Dec. 28, 2022, now U.S. Pat. No. 11,745,067, which claims the benefit of U.S. Provisional Application No. 63/428,641, filed Nov. 29, 2022, and claims the benefit of U.S. Provisional Application No. 63/435,128, filed Dec. 23, 2022.

U.S. application Ser. No. 18/089,683, filed Dec. 28, 2022, is a continuation-in-part of U.S. application Ser. No. 17/988,585, filed Nov. 16, 2022, now U.S. Pat. No. 11,779,820, which is a continuation of application Ser. No. 17/841,893, filed Jun. 16, 2022, now U.S. Pat. No. 11,806,590, which is a continuation of U.S. application Ser. No. 17/685,546, filed Mar. 3, 2022, now U.S. Pat. No. 11,400,352, which claims the benefit of U.S. Provisional Application No. 63/276,981, filed Nov. 8, 2021.

The disclosures of the above-referenced applications are incorporated by reference herein in their entirety.

FIELD

The present disclosure generally relates to golf equipment, and more particularly, to golf club heads and methods to manufacturing golf club heads.

BACKGROUND

Various materials (e.g., steel-based materials, titanium-based materials, tungsten-based materials, etc.) may be used to manufacture golf club heads. By using multiple materials to manufacture golf club heads, the position of the center of gravity (CG) and/or the moment of inertia (MOI) of the golf club heads may be optimized to produce certain trajectory and spin rate of a golf ball.

DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a golf club head having a golf club according to any embodiment of the apparatus, methods, and articles of manufacture described herein.

FIGS. **2**, **3**, **4**, **5**, **6**, **7**, **8**, **9**, **10**, **11**, and **12** depict a perspective front view, a perspective back view, a perspective cross-sectional view (along line **4-4** of FIG. **3**), a perspective cross-sectional view (along line **5-5** of FIG. **3**), a perspective cross-sectional view (along line **6-6** of FIG. **3**), a perspective front view illustrated without a face portion, another perspective front view illustrated without a face portion, another perspective front view illustrated without a face portion, a perspective cross-sectional view (along line **10-10** of FIG. **2**), a perspective cross-sectional view (along line **11-11** of FIG. **2**), and a perspective cross-sectional view (along line **12-12** of FIG. **2**), respectively, of a golf club head according to an embodiment of the apparatus, methods, and articles of manufacture described herein.

FIG. **13** depicts a back view of a face portion of a golf club head according to any embodiment of the apparatus, methods, and articles of manufacture described herein.

FIG. **14** depicts a manner in which an example golf club head described herein may be manufactured.

FIGS. **15** and **16** depict schematic cross-sectional views of two example face portions of a golf club head according to embodiments of the apparatus, methods, and articles of manufacture described herein.

FIG. **17** depicts a top view of a mass portion of a golf club head according to an embodiment of the apparatus, methods, and articles of manufacture described herein.

FIGS. **18** and **19** depict side views of two example mass portions of a golf club head according to embodiments of the apparatus, methods, and articles of manufacture described herein.

FIGS. **20**, **21**, **22**, **23**, **24**, **25**, **26**, **27**, **28**, **29**, **30**, **31**, **32**, and **33** depict a front view, a top view, a bottom view, a back view, another back view, a top and toe side view, a toe side view, a heel side view, a cross-sectional view taken at line **28-28** of FIG. **23**, a cross-sectional view taken at line **29-29** of FIG. **23**, a cross-sectional view taken at line **30-30** of FIG. **23**, a cross-sectional view taken at line **31-31** of FIG. **20**, a cross-sectional view taken at line **32-32** of FIG. **20**, a cross-sectional view taken at line **33-33** of FIG. **20**, respectively, of a golf club head according to an embodiment of the apparatus, methods, and articles of manufacture described herein.

FIG. **34** depicts a mass portion for the golf club head of FIG. **20** according to an embodiment of the apparatus, methods, and articles of manufacture described herein.

FIG. **35** depicts a face portion of the golf club head of FIG. **20** according to an embodiment of the apparatus, methods, and articles of manufacture described herein.

FIG. **36** depicts a face portion of the golf club head of FIG. **20** according to another embodiment of the apparatus, methods, and articles of manufacture described herein.

FIG. **37** depicts an enlarged view of area **37** of FIG. **28**.

FIG. **38** depicts an enlarged view of area **38** of FIG. **29**.

FIGS. **39**, **40**, **41**, and **42** are plots of experimental results for the golf club head of FIG. **20** according to several embodiments of the apparatus, methods, and articles of manufacture described herein.

FIGS. **43**, **44**, **45**, **46**, **47**, **48**, **49**, **50**, **51**, **52**, **53**, **54**, **55**, **56**, **57**, **58**, **59**, **60**, **61**, **62**, **63**, **64**, **65**, and **66** depict face portions according to several embodiments of the apparatus, methods, and articles of manufacture described herein.

FIGS. **67**, **68**, **69**, **70**, **71**, **72**, **73**, **74**, **75**, **76**, **77**, **78**, **79**, **80**, **81**, **82**, **83**, **84**, **85**, **86**, **87**, **88**, and **89** depict a front view, a back view, a top view, a bottom view, a heel-side view, a toe-side view, a back view, a front view without a face portion, a cross-sectional view taken at line **77-77** of FIG. **70**, a cross-sectional view taken at line **78-78** of FIG. **70**, a cross-sectional view taken at line **79-79** of FIG. **70**, a cross-sectional view taken at line **80-80** of FIG. **69**, a cross-sectional view taken at line **81-81** of FIG. **69**, a cross-sectional view taken at line **82-82** of FIG. **69**, a rear perspective exploded view, a back view of a face portion, a bottom perspective view of a face portion, a side perspective view of a face portion, a partial cross-sectional view of taken at line **87-87** of the face portion of FIG. **83**, a partial cross-sectional view of taken at line **88-88** of the face portion of FIG. **83**, a cross-sectional view of taken at line **89-89** of the face portion of FIG. **83**, respectively, of a golf

club head according to an embodiment of the apparatus, methods, and articles of manufacture described herein.

FIGS. **90-95** illustrate back views of golf club heads according to embodiments of the apparatus, methods, and articles of manufacture described herein.

FIG. **96** depicts a manner in which any example golf club head described herein such as the golf club heads of FIGS. **67-95** may be manufactured.

FIGS. **97** and **98** illustrate a back view and a side perspective view of a face portion for a golf club head according to an embodiment of the apparatus, methods, and articles of manufacture described herein.

FIGS. **99**, **100**, and **101** illustrate wall portions for the face portion of FIG. **97** according to an embodiment of the apparatus, methods, and articles of manufacture described herein.

FIGS. **102** and **103** illustrate the wall portion of FIG. **100** coupled to the face portion of FIG. **98**.

FIGS. **104** and **105** illustrate cross sectional views of a golf club head including the face portion of FIG. **101** according to an embodiment of the apparatus, methods, and articles of manufacture described herein.

FIGS. **106** and **107** each illustrates a face portion according to an embodiment of the apparatus, methods, and articles of manufacture described herein.

FIG. **108** depicts a manner in which an example golf club head described herein may be manufactured.

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

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. 8,961,336, 9,199,143, 9,421,437, 9,427,634, 9,468,821, 9,533,201, 9,610,481, 9,649,542, 9,675,853, 9,814,952, 9,878,220, 10,029158, 10,029159, 10,159876, 10,232235, 10,265590, 10,279233, 10,286267, 10,293229, 10,449,428, 10,478,684, 10,512829, 10,596424, 10,596425, 10,632349, 10,716978, 10,729948, 10,729949, 10,814193, 10,821,339, 10,821340, 10,828538, 10,864414, 10,874919, 10,874921, 10,905920, 10,933286, 10,940375, 11,058,932, 11,097,168, 11,117,030, 11,141,633, 11,154,755, 11,167,187, 11,173,359, 11,192, 003, 11,207,575, 11,235,211; and U.S. Patent Publication Nos. 20170282026, 20170282027, 20170368429, 20180050243, 20180050244, 20180133567, 20180140910, 20180169488, 20180221727, 20180236325, 20190232125, 20190232126, 20190247727, 20200171363, 20210023422, 20210069557, 20210086044, 20210162278, 20210197037, 20210205672, 20210308537, 20220032138, and 20220040541.

In the example of FIGS. **1-14**, a golf club **100** may include a golf club head **200**, a shaft **104**, and a grip **106**. The golf club head **200** may be attached to one end of the shaft **104** and the grip **106** may be attached to the opposite end of the shaft **104**. An individual can hold the grip **106** and swing the golf club head **200** with the shaft **104** to strike a golf ball (not illustrated). The golf club head **200** may include a body portion **210** having a toe portion **240** with a toe portion edge **242**, a heel portion **250** with a heel portion edge **252** that may include a hosel portion **255** configured to receive a shaft (an example shaft **104** is illustrated in FIG. **1**) with a grip (an example grip **106** is illustrated in FIG. **1**) on one end and the golf club head **200** on the opposite end of the shaft to form a golf club (an example golf club **100** is illustrated in FIG. **1**), a front portion **260** with a perimeter edge portion **261**, a back portion **270** with a back wall portion **272**, a top portion **280** with a top portion edge **282**, and a sole portion **290** with a sole portion edge **292**. The toe portion edge **242**, the heel portion edge **252**, the top portion edge **282**, and the sole portion edge **292** may define a periphery of the body portion **210**. The toe portion **240**, the heel portion **250**, the front portion **260**, the back portion **270**, the top portion **280**, and/or the sole portion **290** may partially overlap each other. For example, a portion of the toe portion **240** may overlap portion(s) of the front portion **260**, the back portion **270**, the top portion **280**, and/or the sole portion **290**. In a similar manner, a portion of the heel portion **250** may overlap portion(s) of the front portion **260**, the back portion **270**, the top portion **280**, and/or the sole portion **290**. In another example, a portion of the back portion **270** may overlap portion(s) of the toe portion **240**, the heel portion **250**, the top portion **280**, and/or the sole portion **290**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The golf club head **200** may include a face portion **262** (i.e., the strike face), which may be integrally formed with the body portion **210** (e.g., a single unitary piece). In one example, as illustrated in FIGS. **2-13**, the face portion **262** may be a separate piece coupled (e.g., adhesively, mechanically, by welding, and/or by soldering) to the front portion **260**. The face portion **262** may include a front surface **264** and a back surface **266**. In one example (not illustrated), the front portion **260** may include one or a plurality of recessed shoulders configured to receive the face portion **262** for attachment of the face portion **262** to the body portion **210**. In another example, as illustrated in FIGS. **2-13**, the back surface **266** may include a perimeter portion **267** that may be attached to a perimeter edge portion **261** of the body portion **210**. The perimeter portion **267** of the face portion **262** may be attached to the perimeter edge portion **261** of the body portion **210** by one or more fasteners, one or more adhesive or bonding agents, and/or welding or soldering. In one example, as illustrated in FIGS. **2-13**, the perimeter portion **267** of the face portion **262** may be welded to the perimeter edge portion **261** of the body portion **210** at one or more locations. Alternatively, the entire perimeter portion **267** of the face portion **262** may be welded to the entire perimeter edge portion **261** of the body portion **210** (i.e., a continuous weld). The face portion **262** may include a ball strike region **268** to strike a golf ball. In one example, the center of the ball strike region **268** may be a geometric center **263** of the face portion **262**. In another example, the geometric center **263** of the face portion **262** may be offset from a center of the ball strike region **268**. In one example, the geometric center **263** and one or more regions near and/or surrounding the geometric center within the ball strike region **268** may provide a generally optimum location (i.e., optimum ball distance, ball speed, ball spin characteristics, etc.) on the face portion **262** for striking a golf ball. In yet another example, any location at or near the geometric center **263** and within the ball strike region **268** may provide a generally optimum location on the face portion **262** for striking a golf ball. However, a ball may be struck with any portion of the face portion **262** within the ball strike region **268** or outside

the ball strike region **268** for any of the golf club heads described herein resulting in certain ball flight characteristics different from an on-center hit that may be preferred by an individual. The configuration of the face portion **262** and the attachment of the face portion **262** (e.g., welding) to the body portion **210** may be similar in many respects to any of the golf club heads described herein and/or described in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The golf club head **200** may be associated with a ground plane **510**, a horizontal midplane **520**, and a top plane **530**. In particular, the ground plane **510** may be a plane that is parallel or substantially parallel to the ground and is tangent to the lowest portion of the sole portion edge **292** when the golf club head **200** is at an address position (e.g., the golf club head **200** aligned to strike a golf ball). A top plane **530** may be a plane that is tangent to the upper most portion of top portion edge **282** when the golf club head **200** is at the address position. The ground plane **510** and the top plane **530**, respectively, may be parallel or substantially parallel to each other. The horizontal midplane **520** may be vertically halfway between the ground plane **510** and top plane **530**, respectively. Further, the golf club head **200** may be associated with a loft plane **540** defining a loft angle **545** (*a*) of the golf club head **200**. The loft plane **540** may be a plane that is tangent to the face portion **262**. The loft angle **545** may be defined by an angle between the loft plane **540** and a vertical plane **550** normal to the ground plane **510**.

The body portion **210** may be a hollow body including an interior cavity **310** having inner walls **312**. The interior cavity **310** may extend between the front portion **260**, the back portion **270**, the top portion **280**, and the sole portion **290**. In the example of FIGS. **2-13**, the interior cavity **310** of the body portion **210** may be enclosed with and partially defined with the face portion **262**. The configuration of the interior cavity **310** (e.g., height, width, volume, shape, etc.), the configuration of the interior cavity **310** relative to the body portion **210** (e.g., volume of the interior cavity **310** relative to the volume of body portion **210**), the width and height variation of the interior cavity **310**, and access to the interior cavity **310** from one or more ports on the body portion **210** may be similar to any of the golf club heads described herein and/or described in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The back wall portion **272** of the back portion **270** may include an upper back wall portion **612** and a lower back wall portion **614**. The back wall portion **272** may include a ledge portion **616** that may extend between the toe portion edge **242** and the heel portion edge **252** in a continuous or discontinuous manner. The lower back wall portion **614** may be located farther back on the body portion **210** than the upper back wall portion **612**, with the ledge portion **616** defining a transition portion between the upper back wall portion **612** and the lower back wall portion **614**. Accordingly, the ledge portion **616** may extend transverse to the upper back wall portion **612** and the lower back wall portion **614**. In one example, as illustrated in FIG. **2-13**, the ledge portion **616** may include a first ledge portion **626** and a second ledge portion **636**. The first ledge portion **626** may extend on the back wall portion from the toe portion edge **242** to a center portion of the back wall back wall portion **272**. The second ledge portion **636** may extend from the center portion of the back wall portion **272** to the heel portion edge **252**. As illustrated in FIGS. **2-13**, the ledge portion **616** may provide for a relatively greater mass of the body portion **210** below the horizontal midplane **520**, and the mass of the body portion **210** below the horizontal midplane **520** to be moved farther back on the body portion **210**. The width of the ledge portion **616** may be greater than, equal to, or less than the width of the interior cavity at certain locations of the body portion **210**. The configuration of the ledge portion **616** (e.g., width, segments, tapering, shape, etc.) and the properties of the ledge portion **616** relative to the width of the interior cavity may be similar to any ledge portion or similar structure of any of the golf club heads described herein and/or described in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The body portion **210** may include one or more ports, which may be exterior ports and/or interior ports (e.g., located inside the body portion **210**). The inner walls **312** of the interior cavity **310** may include one or more ports (not illustrated). In one example, as illustrated in FIGS. **2-13**, the back portion **270** may include one or more ports along or proximate to the periphery of the body portion **210**. For example, the body portion **210** may include a first set of ports **320** (e.g., illustrated as ports **321** and **322**) above the horizontal midplane **520**, a second set of ports **330** (e.g., illustrated as ports **331** and **332**) below the horizontal midplane **520**, a third set of ports **340** (e.g., illustrated as ports **341**, **342**, and **343**) below the horizontal midplane **520**, and a fourth set of ports **350** (e.g., illustrated as ports **351** and **352**) below the horizontal midplane **520**. The locations, spacing relative to other ports, and any other configuration of each port of the first set of ports **320**, the second set of ports **330**, the third set of ports **340**, and/or the fourth set of ports **350** may be similar in many respects to any of the ports described herein or described in any of the incorporated by reference patent documents. Further, any one or more of the ports of the first set of ports **320**, the second set of ports **330**, the third set of ports **340**, and/or the fourth set of ports **350** may be connected to interior cavity **310** through which one or more filler materials may be injected into the interior cavity **310**. In the example of FIGS. **2-13**, the ports **321**, **331**, and **351** may be connected to the interior cavity **310** via openings **361**, **371**, and **381**, respectively. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The body portion **210** may include one or more mass portions (e.g., weight portion(s)), which may be integral mass portion(s) or separate mass portion(s) that may be coupled to the body portion **210**. In the illustrated example as illustrated in FIGS. **2-13**, the body portion **210** may include a first set of mass portions **420** (e.g., illustrated as mass portions **421** and **422**), a second set of mass portions **430** (e.g., illustrated as mass portions **431** and **432**), a third set of mass portions **440** (e.g., illustrated as mass portions **441**, **442**, and **443**), and a fourth set of mass portions **450** (e.g., illustrated as mass portions **451** and **452**). While the above example may describe a particular number or portions of mass portions, a set of mass portions may include a single mass portion, or a plurality of mass portions as described herein and in any of the incorporated by reference patent documents. For example, any one or a combination of adjacent sets of mass portions of the first set of mass portions **420** may be a single mass portion, the second set of mass portions **430** may be a single mass portion, the third set of mass portions **440** may be a single mass portion, and/or the fourth set of mass portions **450** may be a single mass portion. Further, the first set of mass portions **420**, the second set of

mass portions **430**, the third set of mass portions **440**, and/or the fourth set of mass portions **450** may be a portion of the physical structure of the body portion **210**. The mass portions of the first set of mass portions **420**, the second set of mass portions **430**, the third set of mass portions **440**, and/or the fourth set of mass portions **450** may be similar to any of the mass portions described in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The interior cavity **310** may be partially or entirely filled with one or more filler materials (i.e., a cavity filling material), which may include one or more similar or different types of materials. In one example, as illustrated in FIGS. **2-13**, the interior cavity **310** may be filled with a first filler material **512** and a second filler material **514**. In one example, the first filler material **512** may be a rubber or rubber compound, and the second filler material **514** may be an epoxy-type of material. In another example, the first filler material **512** and/or the second filler material **514** may be different polymer materials. The first filler material **512** and the second filler material **514** may be similar to any of the filler materials described herein or described in any of the incorporated by reference patent documents. The first filler material **512** and/or the second filler material **514** may be coupled to all or portions of the inner walls **312** of the interior cavity **310**. In one example, the first filler material **512** and/or the second filler material **514** may have inherent adhesive or bonding properties to attach to all or portions of the inner walls **312**. In another example, the first filler material **512** and/or the second filler material may be attached to all or portions of the inner walls **312** with one or more bonding agents or adhesives that may be mixed with the first filler material **512** and/or the second filler material **514**, respectively. In another example, the first filler material **512** and/or the second filler material **514** may be attached to all or portions of the inner walls **312** with one or more bonding agents or adhesives that may be separate from the first filler material **512** and/or the second filler material **514**, respectively. The amount (i.e., volume and/or mass) of the first filler material **512** and/or the second filler material **514** may be determined for each golf club head (i.e., having a certain loft angle) to (i) provide vibration dampening or sound dampening (e.g., consistent and/or pleasing sound and feel when the golf club head **200** strikes a golf ball as perceived by an individual using the golf club head **200**), (ii) provide structural support for the face portion **262**, and/or (iii) optimize ball travel distance, ball speed, ball launch angle, ball spin rate, ball peak height, ball landing angle and/or ball dispersion. Details regarding the filler materials **512** and **514**, coupling of the filler materials **512** and **514** to the body portion **210** and each other, material compositions and/or physical properties of the filler materials **512** and **514**, the mass and/or volume of each of the filler materials **512** and **514** in the interior cavity **310** may be provided in detail in any of the incorporated by reference patent documents, and in particular, in U.S. Pat. No. 10,632,349, which is incorporated by reference herein. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the example of FIGS. **2-13**, a portion of the interior cavity **310** including a central portion **311** of the interior cavity **310**, which may be a portion of the interior cavity **310** that may generally correspond to the ball strike region **268**, may be include the first filler material **512** and the second filler material **514**. The width **313** of the interior cavity **310** at the central portion **311** of the interior cavity **310** may be generally greater than the width **313** of the interior cavity **310** at other portions of the interior cavity **310**. Accordingly, the region of the interior cavity **310** behind the ball strike region **268**, i.e., the central portion **311**, may include a relatively large volume of the first filler material **512** and/or the second filler material **514**. Further, the configuration of the central portion **311** (i.e., size, shape, contour, volume, etc.) may depend on the loft angle **545**. For example, a golf club head **200** with a relatively small loft angle may have a larger central portion **311** (i.e., larger volume, depth, height, etc.) than a golf club head **200** with a relatively large loft angle. Accordingly, as described herein, the amount of first filler material **512** and/or the second filler material **514** inside the interior cavity **310**, and more specifically, in the central portion **311** may be determined based on the loft angle **545** to provide (i) provide vibration dampening or sound dampening (e.g., consistent and/or pleasing sound and feel when the golf club head **200** strikes a golf ball as perceived by an individual using the golf club head **200**), (ii) provide structural support for the face portion **262**, and/or (iii) optimize ball travel distance, ball speed, ball launch angle, ball spin rate, ball peak height, ball landing angle and/or ball dispersion. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The contour of the interior cavity **310** or the shape of the inner walls **312** may be defined by a plurality of recessed portions that may be recessed relative to the perimeter edge portion **261**. In the example of FIGS. **2-13**, the interior cavity **310** may include a first recessed portion **314**, a second recessed portion **315** that may have a generally smaller depth (i.e., defined by width **313** on the interior cavity **310** as viewed in cross section in FIGS. **5-40**) relative to the first recessed portion **314**, a third recessed portion **316** that may have a generally smaller depth than the second recessed portion **315**, a fourth recessed portion **317** that may have a generally smaller depth than the third recessed portion **316**, and a fifth recessed portion **318** that may have a generally smaller depth than the fourth recessed portion **317**. The interior cavity **310** may have more or less recessed portions. The interior cavity **310** may include a first internal channel **325** that may extend from a location at the toe portion **240** to the central portion **311**, and a second internal channel **326** that may extend from a location at the heel portion **250** to the central portion **311**. The first recessed portion **314**, the second recessed portion **315**, the third recessed portion **316**, the fourth recessed portion **317**, the fifth recessed portion **318**, the first internal channel **325**, the second internal channel **326**, and/or any transition regions therebetween may be described in detail in one or more of the incorporated by reference patent documents, and in particular, in U.S. Pat. No. 10,632,349, which is incorporated by reference herein. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **2-13**, the first recessed portion **314**, the second recessed portion **315**, the third recessed portion **316**, and the internal channels **325** and **326** may be filled with the first filler material **512**, whereas the remaining portions of the interior cavity **310** may be filled with the second filler material **514**. In another example, the first recessed portion **314**, the second recessed portion **315**, and the internal channels **325** and **326** may be filled with the first filler material **512**, whereas the remaining portions of the interior cavity **310** may be filled with the second filler material **514**. In another example, the first recessed portion **314**, the second recessed portion **315**, the internal channels **325** and **326**, the third recessed portion **316**

and the fifth recessed portion **318** may be filled with the first filler material **512**, whereas the remaining portions of the interior cavity **310** may be filled with the second filler material **514**. In yet another example, the entire interior cavity **310** may be filled with the first filler material **512** or the first filler material. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

A width **522** (W_{F1}) of the first filler material **512** and the width **524** (W_{F2}) of the second filler material **514** may vary from the toe portion **240** to the heel portion **250** and/or from the top portion **280** to the sole portion **290** and/or according to the shapes of the first recessed portion **314**, the second recessed portion **315**, the third recessed portion **316**, the fourth recessed portion **317**, and/or the fifth recessed portion **318** depending on the location inside the interior cavity **310**. The width **522** of the first filler material **512** and the width **524** of the second filler material **514** as related to the physical properties, ball strike and trajectory characteristics, and configuration of the golf club head **200** (e.g., loft angle) may be provided in detail in any of the incorporated by reference patent documents, and in particular, in U.S. Pat. No. 10,632,349, which is incorporated by reference herein. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIG. **13**, the back surface **266** of the face portion **262** may include one or more grooves proximate to the perimeter portion **267** of the face portion **262**. In one example, as illustrated in FIG. **13**, a back groove **269** may be a continuous groove (i.e., defining a loop) extending in a path similar to the path of the perimeter portion **267** proximate to the perimeter portion **267**. The back groove **269** may include a relatively thinner portion of the face portion **262**. Accordingly, the back groove **269** may increase the flexibility of the face portion **262** so that when a golf ball strikes the face portion **262**, the face portion **262** provides a greater rebound (i.e., a greater trampoline effect), and hence may provide a greater velocity for the golf ball. All or portions of the back groove **269** may be filled with the first filler material **512** and/or second filler material **514**. In the example of the golf club head **200**, all of the back groove **269** may be filled with the second filler material **514**. Accordingly, the second filler material **514** may structurally support the relatively thinner portions of the face portion **262** defined by the back groove **269**. In another example, a plurality of separate grooves (not illustrated) may be provided on the back surface **266** of the face portion **262** at certain locations proximate to the perimeter portion **267** to provide a certain rebound effect for the face portion **262**. In yet another example, a continuous groove similar to the back groove **269** and/or a plurality of separate grooves (not illustrated) may be provided at certain locations between the perimeter portion **267** and the geometric center **263** on the back surface **266** of the face portion **262** to provide a certain rebound effect for the face portion **262**. The face portion of any of the golf club heads described herein may include the back groove **269**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

As described herein, the face portion **262** may be relatively thin to provide increased bending and deflection of the face portion **262** during a golf ball strike. Further, the face portion **262** may include one or more grooves such as the back groove **269** on the back surface **266** of the face portion **262** as described herein to further increase the flexibility of the face portion **262**. The second filler material **514** may be a polymer material with a relatively high strength and stiffness to provide structural support and stability for the face portion **262** to prevent failure of the face portion **262** during a golf ball strike or repeated golf ball strikes (i.e., face portion fatigue). As described herein, the second filler material **514** may be an epoxy-type of material. The second filler material **514** may also have a relatively high COR as described herein to provide a rebound effect for the face portion **262** after a golf ball strike. As further described herein, the first filler material **512** may be a rubber-type of compound with a lower strength and stiffness (i.e., softer or less rigid) than the second filler material **514** and a higher COR than the second filler material **514**. Accordingly, the first filler material **512** may provide additional structural support for the face portion **262**. Further, the relatively higher COR of the first filler material **512** may allow the first filler material **512** to store the energy from a golf ball strike and to release a substantial amount of the energy back to the golf ball (i.e., without losing much impact energy) by providing a relatively large rebound effect for the face portion **262**. Additionally, the different material properties of the first filler material **512** and the second filler material **514** as described herein may provide sound and vibration dampening at different frequency ranges to provide a pleasant sound and feel for an individual. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

FIG. **14** depicts one manner by which the golf club head **200** or any of the golf club heads described herein may be manufactured. In the example of FIG. **14**, the process **1400** may begin with providing a body portion **210** and a face portion **262** of a golf club head **200** (block **1410**). The first filler material **512** may be coupled to the interior cavity **310** (block **1420**). In one example, the first filler material **512** may be formed in one or more recessed portions as described herein (i.e., any of the recessed portions described herein) of the interior cavity **310** by injection molding. The first filler material **512** may then cure at ambient temperature or by one or more heating/cooling cycles depending on the material used for the first filler material **512**. In another example, the first filler material **512** may be molded into the shape of one or more recessed portions as described herein and then coupled to the one or more recessed portions with a bonding agent as described herein. The face portion **262** may then be attached to the body portion **210** as described herein to enclose the interior cavity **310** (block **1430**). The second filler material **514** may then be injected into the interior cavity **310** through one or more of the ports of the first set of ports **320**, the second set of ports **330**, the third set of ports **340**, and/or the fourth set of ports **350** that may be connected to the interior cavity **310** as described herein (block **1440**). The second filler material **514** may then cure at ambient temperature or by one or more heating/cooling cycles depending on the material used for the second filler material **514**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIG. **15**, a face portion **1562**, which may be any of the face portions described herein, may have a first thickness **1510** (T1) or a second thickness **1520** (T2). The first thickness **1510** may be a thickness of a section of the face portion **1562** adjacent to a groove **1568** whereas the second thickness **1520** may be a thickness of a section of the face portion **1562** below the groove **1568**. For example, the first thickness **1510** may be a maximum distance between the front surface **1564** and the back surface **1566**. The second thickness **1520** may be based on the groove **1568**. In particular, the groove **1568** may have a groove depth **1525** (Dgroove). The second thickness **1520** may be a maximum distance between the bottom of the

groove **1568** and the back surface **1566**. The sum of the second thickness **1520** and the groove depth **1525** may be substantially equal to the first thickness **1510** (e.g., T**2**+Dgroove=T**1**). Accordingly, the second thickness **1520** may be less than the first thickness **1510** (e.g., T**2**≤T**1**).

To lower and/or move the CG of a golf club head further back, such as the CG of any of the golf club heads described herein, mass from the front portion of a golf club head may be removed by using a relatively thinner face portion **1562**. For example, the first thickness **1510** or the second thickness **1520** may be less than or equal to 0.1 inch (2.54 millimeters). In another example, the first thickness **1510** or the second thickness **1520** may be about 0.075 inch (1.875 millimeters) (e.g., T**1**=0.075 inch). With the support of the back wall portion of a golf club head to form an interior cavity and filling at least a portion of the interior cavity with one or more filler materials as described herein, the face portion **1562** may be relatively thinner (e.g., T**1**≤0.075 inch) without degrading the structural integrity, sound, and/or feel of a golf club head. In one example, the first thickness **1510** may be less than or equal to 0.060 inch (1.524 millimeters) (e.g., T**1**≤0.060 inch). In another example, the first thickness **1510** may be less than or equal to 0.040 inch (1.016 millimeters) (e.g., T**1**≤0.040 inch). Based on the type of material(s) used to form the face portion **1562** and/or the body portion **210**, the face portion **1562** may be even thinner with the first thickness **1510** being less than or equal to 0.030 inch (0.762 millimeters) (e.g., T**1**≤0.030 inch). The groove depth **1525** may be greater than or equal to the second thickness **1520** (e.g., Dgroove≥T**2**). In one example, the groove depth **1525** may be about 0.020 inch (0.508 millimeters) (e.g., Dgroove=0.020 inch). Accordingly, the second thickness **1520** may be about 0.010 inch (0.254 millimeters) (e.g., T**2**=0.010 inch). In another example, the groove depth **1525** may be about 0.015 inch (0.381 millimeters), and the second thickness **1520** may be about 0.015 inch (e.g., Dgroove=T**2**=0.015 inch). Alternatively, the groove depth **1525** may be less than the second thickness **1520** (e.g., Dgroove≤T**2**). Without the support of the back wall portion of a golf club head and one or more filler materials used to fill in the interior cavity, the golf club head may not be able to withstand multiple impacts by a golf ball on a face portion. In contrast, a golf club head with a relatively thin face portion but without the support of the back wall portion and the one or more filler materials as described herein (e.g., a cavity-back golf club head) may produce unpleasant sound (e.g., a tinny sound) and/or feel during impact with a golf ball. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

Based on manufacturing processes and methods used to form a golf club head such as any of the golf club heads described herein, the face portion **1562** may include additional material at or proximate to a periphery of the face portion **1562**. Accordingly, the face portion **1562** may also include a third thickness **1530**, and a chamfer portion **1540**. The third thickness **1530** may be greater than either the first thickness **1510** or the second thickness **1520** (e.g., T**3**>T**1**>T**2**). In particular, the face portion **1562** may be coupled to the body portion of a golf club head by a welding process. For example, the first thickness **1510** may be about 0.030 inch (0.762 millimeters), the second thickness **1520** may be about 0.015 inch (0.381 millimeters), and the third thickness **1530** may be about 0.050 inch (1.27 millimeters). Accordingly, the chamfer portion **1540** may accommodate some of the additional material when the face portion **1562** is welded to the body portion of the golf club head.

As illustrated in FIG. **16**, for example, the face portion **1562** may include a reinforcement section, which is generally illustrated as reinforcement section **1605**, below one or more grooves **1568**. In one example, the face portion **1562** may include a reinforcement section **1605** below each groove. Alternatively, face portion **1562** may include the reinforcement section **1605** below some grooves (e.g., every other groove) or below only one groove. The face portion **1562** may include a first thickness **1610**, a second thickness **1620**, a third thickness **1630**, and a chamfer portion **1640**. The groove **1568** may have a groove depth **1625**. The reinforcement section **1605** may define the second thickness **1620**. The first thickness **1610** and the second thicknesses **1620**, respectively, may be substantially equal to each other (e.g., T**1**=T**2**). In one example, the first thickness **1610** and the second thicknesses **1620**, respectively, may be about 0.030 inch (0.762 millimeters) (e.g., T**1**=T**2**=0.030 inch). The groove depth **1625** may be about 0.015 inch (0.381 millimeters), and the third thickness **1630** may be about 0.050 inch (1.27 millimeters). The groove **1568** may also have a groove width. The width of the reinforcement section **1605** may be greater than or equal to the groove width. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

Alternatively, the face portion **1562** may vary in thickness at and/or between the top portion and the sole portion of a golf club head. In one example, the face portion **1562** may be relatively thicker at or proximate to the top portion than at or proximate to the sole portion (e.g., thickness of the face portion **1562** may taper from the top portion towards the sole portion). In another example, the face portion **1562** may be relatively thicker at or proximate to the sole portion than at or proximate to the top portion (e.g., thickness of the face portion **1562** may taper from the sole portion towards the top portion). In yet another example, the face portion **1562** may be relatively thicker between the top portion and the sole portion than at or proximate to the top portion and the sole portion (e.g., thickness of the face portion **1562** may have a bell-shaped contour). The face portion **1562** may be similar to any of the face portions described in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

One or more mass portions of any of the sets of mass portions described herein may have similar or different physical properties (e.g., color, marking, shape, size, density, mass, volume, external surface texture, materials of construction, etc.). In the illustrated example as illustrated in FIG. **17**, one or more mass portions of any of the sets of mass portions described herein may have a cylindrical shape (e.g., a circular cross section). Alternatively, one or more mass portions of any of the sets of mass portions described herein may have similar or different shapes relative to one or more other mass portions of the set of mass portions. In another example, one or more mass portions of any of the sets of mass portions described herein may have a different color(s), marking(s), shape(s), density or densities, mass(es), volume(s), material(s) of construction, external surface texture(s), and/or any other physical property as compared to one or more mass portions of another one of the sets of mass portions as described herein. The properties of any of the mass portions and sets of mass portions described herein may be similar to any of the mass portions and sets of mass portions described in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

Referring to FIGS. **18** and **19**, for example, a first mass portion **1800** and a second mass portion **1900** may include threads, generally illustrated as threads **1810** and threads **1910**, respectively, to engage with correspondingly configured threads in ports on the to secure in the ports as described herein. Accordingly, one or more mass portions as described herein may be shaped similar to and function as a screw or threaded fastener for engaging threads in a port. For example, one or more mass portions of any of the sets of mass portions described herein may be a screw. One or more mass portions of any of the mass portions described herein may not be readily removable from the body portion of a golf club head with or without a tool. Alternatively, one or more mass portions of any of the sets of mass portions described herein may be readily removable (e.g., with a tool) so that a relatively heavier or lighter mass portion may replace one or more mass portions of any of the sets of mass portions described herein. In another example, one or more mass portions of any of the sets of mass portions described herein may be secured in the ports with epoxy or adhesive so that the mass portions may not be readily removable. In yet another example, one or more mass portions of any of the sets of mass portions described herein may be secured in the ports with both threads and thread sealant (e.g., acrylic adhesive, cyanoacrylate adhesive, epoxy, thermoplastic adhesive, silicone sealant, or urethane adhesive) so that the mass portions may not be readily removable. In yet another example, one or more mass portions of any of the sets of mass portions described herein may be press fit in a port. In yet another example, one or more mass portions of any of the sets of mass portions described herein may be formed inside a port by injection molding. For example, a liquid metallic material (i.e., molten metal) or a plastic material (e.g., rubber, foam, or any polymer material) may be injected or otherwise introduced into a port. After the liquid material is cooled and/or cured inside the port, the resulting solid material (e.g., a metal material, a plastic material, or a combination thereof) may form a mass portion. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

As mentioned above, one or more mass portions of any of the sets of mass portions described herein may be similar in some physical properties but different in other physical properties. For example, a mass portion may be made from an aluminum-based material or an aluminum alloy whereas another mass portion may be made from a tungsten-based material or a tungsten alloy. In another example, a mass portion may be made from a polymer material whereas another mass portion may be made from a steel-based material. In yet another example, as illustrated in FIGS. **17-19**, one or more mass portions of any of the sets of mass portions described herein may have a diameter **1710** of about 0.25 inch (6.35 millimeters) but one or more mass portions of another one or more sets of mass portions described herein may be different in height. In particular, one or more mass portions of any of the sets of mass portions described herein may be associated with a first height **1820**, and one or more mass portions of another one or more sets of mass portions described herein may be associated with a second height **1920**. The first height **1820** may be relatively shorter than the second height **1920**. In one example, the first height **1820** may be about 0.125 inch (3.175 millimeters) whereas the second height **1920** may be about 0.3 inch (7.62 millimeters). In another example, the first height **1820** may be about 0.16 inch (4.064 millimeters) whereas the second height **1920** may be about 0.4 inch (10.16 millimeters). Alternatively, the first height **1820** may be equal to or greater than the second height **1920**. Although the above examples may describe particular dimensions, one or more mass portions described herein may have different dimensions. In one example, any of the mass portions described herein may be interchangeably used in any of the ports described herein. Any property of any of the mass portions described herein may be similar to the corresponding property of any of the mass portions described in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the example of FIGS. **20-38**, a golf club head **2000** may include a body portion **2010** having a toe portion **2040** with a toe portion edge **2042**, a heel portion **2050** with a heel portion edge **2052** that may include a hosel portion **2055**. A golf club shaft (such as the shaft **104** that is illustrated for example in FIG. **1**) may include one end coupled to the hosel portion **2055**, and an opposite end coupled to a golf club grip portion (such as the grip **106** that is illustrated for example in FIG. **1**) to form a golf club (such as the golf club **100** that is illustrated for example in FIG. **1**). The body portion **2010** may further include a front portion **2060** with a perimeter edge portion **2061**, a back portion **2070** with a back wall portion **2072**, a top portion **2080** with a top portion edge **2082**, and a sole portion **2090** with a sole portion edge **2092**. The toe portion **2040**, the heel portion **2050**, the front portion **2060**, the back portion **2070**, the top portion **2080**, and/or the sole portion **2090** may partially overlap each other. The toe portion edge **2042**, the heel portion edge **2052**, the top portion edge **2082**, and the sole portion edge **2092** may define a periphery of the body portion **2010**. The golf club head **2000** may be any type of golf club head described herein, such as, for example, an iron-type golf club head or a wedge-type golf club head. The volume of the golf club head **2000**, the materials of construction of the golf club head **2000**, and/or any components thereof may be similar to any of the golf club heads described herein and/or described in any of the incorporated by reference applications. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The golf club head **2000** may include a face portion **2062** (i.e., the strike face), which may be integrally formed with the body portion **2010** (e.g., a single unitary piece). In one example, as illustrated in FIGS. **20-38**, the face portion **2062** may be a separate piece coupled (e.g., directly or indirectly, adhesively, mechanically, by welding, and/or by soldering) to the front portion **2060** to close a front opening of the front portion **2060**. The face portion **2062** may include a front surface **2064** and a back surface **2066**. The front surface **2064** may include a plurality of front grooves **2068** that may extend between the toe portion **2040** and the heel portion **2050**. Each front groove **2068** may have a front groove depth **2069** (D_{FG}). In one example, the front groove depth **2069** may be greater than or equal to 0.005 inch (0.127 mm) and less than or equal to 0.025 inch (0.635 mm) (0.005 in $\leq D_{FG} \leq$0.025 in). In another example, the front groove depth **2069** may be greater than or equal to 0.011 inch (0.267 mm) and less than or equal to 0.018 inch (0.445 mm) (0.011 in $\leq D_{FG} \leq$0.018 in). In another example, the front groove depth **2069** may be greater than or equal to 0.012 inch (0.311 mm) and less than or equal to 0.016 inch (0.400 mm) (0.012 in $\leq D_{FG} \leq$0.016 in). In yet another example, the front groove depth **2069** may be greater than or equal to 0.013 inch (0.33 mm) and less than or equal to 0.015 inch (0.381 mm) (0.013 in $\leq D_{FG} \leq$0.015 in). The front groove depth **2069** and the configuration of the front grooves **2068** (i.e., cross-sectional shape, curvature, length, width, etc.) may be determined to

provide certain performance characteristics for the golf club head **2000**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

Each front groove **2068** may have a front groove width **2071** (W_{FG}). In one example, the front groove width **2071** may be greater than or equal to 0.011 inch (0.267 mm) and less than or equal to 0.033 inch (0.833 mm) (0.011 in $\leq W_{FG} \leq$0.033 in). In another example, the front groove width **2071** may be greater than or equal to 0.014 inch (0.347 mm) and less than or equal to 0.055 inch (1.406 mm) (0.014 in $\leq W_{FG} \leq$0.055 in). In another example, the front groove width **2071** may be greater than or equal to 0.017 inch (0.427 mm) and less than or equal to 0.062 inch (1.562 mm) (0.017 in $\leq W_{FG} \leq$0.062 in). In another example, the front groove width **2071** may be greater than or equal to 0.021 inch (0.521 mm) and less than or equal to 0.041 inch (1.041 mm) (0.021 in $\leq W_{FG} \leq$0.041 in). In another example, the front groove width **2071** may be greater than or equal to 0.025 inch (0.640 mm) and less than or equal to 0.032 inch (0.800 mm) (0.025 in $\leq W_{FG} \leq$0.032 in). In yet another example, the front groove width **2071** may be greater than or equal to 0.027 inch (0.677 mm) and less than or equal to 0.053 inch (1.354 mm) (0.027 in $\leq W_{FG} \leq$0.053 in). The front groove width **2071** and the configuration of the front grooves **2068** (i.e., cross-sectional shape, curvature, length, width, etc.) may be determined to provide certain performance characteristics for the golf club head **2000**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example (not illustrated), the front portion **2060** may include one or a plurality of recessed shoulders configured to receive the face portion **2062** for attachment of the face portion **2062** to the body portion **2010**. In another example, as illustrated in FIGS. **20-38**, the back surface **2066** may include a perimeter portion **2067** that may be attached to a perimeter edge portion **2061** of the body portion **2010**. The perimeter portion **2067** of the face portion **2062** may be attached to the perimeter edge portion **2061** of the body portion **2010** by one or more fasteners, one or more adhesive or bonding agents, and/or welding or soldering. In one example, the perimeter portion **2067** may be welded to the perimeter edge portion **2061** at one or more locations. In another example, the entire perimeter portion **2067** may be welded to the entire perimeter edge portion **2061** (i.e., a continuous weld). The configuration of the face portion **2062** and the attachment of the face portion **2062** (e.g., welding) to the body portion **2010** may be similar in many respects to any of the golf club heads described herein and/or described in any of the incorporated by reference applications. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The golf club head **2000** may be associated with a ground plane **2410**, a horizontal midplane **2420**, and a top plane **2430**. In particular, the ground plane **2410** may be a plane that is parallel or substantially parallel to the ground and is tangent to the lowest portion of the sole portion edge **2092** when the golf club head **2000** is at an address position (e.g., the golf club head **2000** aligned to strike a golf ball). A top plane **2430** may be a plane that is tangent to the upper most portion of top portion edge **2082** when the golf club head **2000** is at the address position. The ground plane **2410** and the top plane **2430**, respectively, may be parallel or substantially parallel to each other. The horizontal midplane **2420** may be vertically halfway between the ground plane **2410** and the top plane **2430**, respectively, and be parallel or substantially parallel to the ground plane **2410**. Further, the golf club head **2000** may be associated with a loft plane **2440** defining a loft angle **2445** (a) of the golf club head **2000**. The loft plane **2440** may be a plane that is tangent or coplanar to the face portion **2062**. The loft angle **2445** may be defined by an angle between the loft plane **2440** and a vertical plane **2450** that is normal to the ground plane **2410**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The back wall portion **2072** may include an upper back wall portion **2120**, a lower back wall portion **2122**, and a ledge portion **2130** between the upper back wall portion **2120** and the lower back wall portion **2122**. The ledge portion **2130** may extend outward (i.e., away from the face portion **2062**) from the upper back wall portion **2120** to the lower back wall portion **2122** (i.e., the ledge portion **2130** may extend inward or toward the face portion **2062** from the lower back wall portion **2122** to the upper back wall portion **2120**). Accordingly, a body portion upper width **2150** (W_{UB}) may be defined by a distance between the front surface **2064** of the face portion **2062** and the outer surface of the upper back wall portion **2120**, and a body portion lower width **2152** (W_{LB}) may be defined by a distance between the front surface **2064** of the face portion **2062** and the outer surface of the lower back wall portion **2122**. In one example, the maximum value of the body portion lower width **2152** may be greater than or equal to 1.5 the maximum value of the body portion upper width **2150** ($W_{LB(MAX)} \geq 1.5\ W_{UB(MAX)}$). In another example, the maximum value of the body portion lower width **2152** may be greater than or equal to 1.25 the maximum value of the body portion upper width **2150** ($W_{LB(MAX)} \geq 1.25\ W_{UB(MAX)}$). In another example, the maximum value of the body portion lower width **2152** may be greater than or equal to 1.75 the maximum value of the body portion upper width **2150** ($W_{LB(MAX)} \geq 1.75\ W_{UB(MAX)}$). In another example, the maximum value of the body portion lower width **2152** may be greater than or equal to twice the maximum value of the body portion upper width **2150** ($W_{LB(MAX)} \geq 2.0\ W_{UB(MAX)}$). In another example, the maximum value of the body portion lower width **2152** may be greater than the maximum value of the body portion upper width **2150** ($W_{LB(MAX)} \geq W_{UB(MAX)}$). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the example of FIGS. **20-38**, the ledge portion **2130** may include a first ledge portion **2132** that may extend from a location at or proximate to the toe portion edge **2042** toward the heel portion **2050**, a second ledge portion **2134** that may be located at or proximate to a center portion **2073** of the back wall portion **2072**, and a third ledge portion **2136** that may extend from a location at or proximate to the heel portion edge **2052** toward the toe portion **2040**. The second ledge portion **2134** may extend between the first ledge portion **2132** and the third ledge portion **2136**. The first ledge portion **2132** and the third ledge portion **2136** may also extend in a downwardly inclined direction toward the sole portion **2090**. Accordingly, as illustrated in FIGS. **20-38**, a first ledge portion height **2142**, which may be defined by a distance between the first ledge portion **2132** and the ground plane **2410**, may increase from the center portion **2073** toward the toe portion edge **2042**, and a third ledge portion height **2146**, which may be defined by a distance between the third ledge portion **2136** and the ground plane **2410**, may increase from the center portion **2073** toward the heel portion edge **2052**. As illustrated in FIGS. **20-38**, for example, the second ledge portion **2134** may include a first side wall portion **2137** that may extend from the first ledge portion **2132** toward the top portion **2080**, a center ledge portion **2138** that may extend from the first side wall portion **2137** toward the heel portion **2050**, and a second side wall

portion **2139** that may extend from the center ledge portion **2138** toward the sole portion **2090** and to the third ledge portion **2136**. The second ledge portion **2134** may include a second ledge portion height **2144**, which may be defined by a distance between the center ledge portion **2138** and the ground plane **2410**. The second ledge portion height **2144** may be greater than the first ledge portion height **2142** and the third ledge portion height **2146** at or proximate to the center portion **2073**. In another example, the ledge portion **2130** may be similar in some or many respects to the ledge portion **616** of the golf club head **200**. In yet another example, the ledge portion **2130** may be similar in some or many respects to any of the ledge portions of the golf club heads described in any of the incorporated by reference applications. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the example of FIGS. **20-38**, the first ledge portion **2132** may include a first ledge portion width **2162** that may decrease from the center portion **2073** toward the toe portion edge **2042**. Accordingly, the widest part of the first ledge portion **2132** may be at the location where the first ledge portion **2132** and the first side wall portion **2137** meet. In one example, the increase in the first ledge portion height **2142** and the decrease in the first ledge portion width **2162** may be correlated. For example, every increase in the first ledge portion height **2142** may correspond to a decrease in the first ledge portion width **2162** that may be based on a certain factor, similar rate of change, certain non-similar rate of change, or a certain mathematical relationship. In another example, the increase in the first ledge portion height **2142** and decrease in the first ledge portion width **2162** may not have any correlation. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the example of FIGS. **20-38**, the third ledge portion **2136** may include a third ledge portion width **2166** that may decrease from the center portion **2073** toward the heel portion edge **2052**. Accordingly, the widest part of the third ledge portion **2136** may be at the location where the third ledge portion **2136** and the second side wall portion **2139** meet. In one example, the increase in the third ledge portion height **2146** and the decrease in the third ledge portion width **2166** may be correlated. For example, every increase in the third ledge portion height **2146** may correspond to a decrease in the third ledge portion width **2166** that may be based on a certain factor, similar rate of change, certain non-similar rate of change, or a certain mathematical relationship. In another example, the increase in the third ledge portion height **2146** and the decrease in the third ledge portion width **2166** may not have any correlation. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the example of FIGS. **20-38**, the first side wall portion **2137** and the second side wall portion **2139** may increase in width from the center ledge portion **2138** to the first ledge portion **2132** and from the center ledge portion **2138** to the third ledge portion **2136**, respectively. The downwardly inclined configuration and the increasing widths toward the center portion **2073** of the first ledge portion **2132** and the third ledge portion **2136**, and the downwardly increasing widths of the first side wall portion **2137** and the second side wall portion **2139** may allow more mass to be placed at the toe portion **2040** and/or the heel portion **2050** below the first ledge portion **2132** and the third ledge portion **2136**, respectively, for optimizing the moment of inertia (MOI) of the golf club head **2000**, and more mass may be placed at or below the center portion **2073** of the back wall portion to lower and move farther aft the center of gravity (CG) of the golf club head **2000**. In other words, the configuration of the ledge portion **2130** may provide for a relatively large portion of the mass of the golf club head **2000** to be selectively placed (i) below the ledge portion **2130** and closer to the toe portion edge **2042**, (ii) below the ledge portion **2130** and closer to the heel portion edge **2052**, (iii) at or proximate to the center portion **2073**, and/or, (iv) at or proximate to the sole portion edge **2092** to increase the MOI of the golf club head **2000** and move the CG of the golf club head lower and farther aft. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The body portion **2010** may include one or more ports, which may be exterior ports and/or interior ports (e.g., located inside the body portion **2010**). The one or more ports may be at any location on the body portion **2010**. The inner walls of the body portion **2010** that define the interior cavity **2110** may include one or more ports. In the illustrated example of FIGS. **20-38**, the body portion may include a first port region **2225** located below the first ledge portion **2132** and between the toe portion edge **2042** and the center portion **2073**. In one example, as illustrated in FIGS. **20-38**, the first port region **2225** may include a first perimeter groove **2227**, which may visually define a portion or all of the first port region **2225**. The first perimeter groove **2227** may be a slot, channel, depression, or a recess. The mass that may be removed from the body portion **2010** to define the first perimeter groove **2227** may be placed at other locations on or inside the body portion **2010** to provide certain MOI, CG location, and/or golf club performance characteristics without changing or substantially changing the overall mass of the body portion **2010**. In another example, the portion of the body portion **2010** within the first perimeter groove **2227** may have a different color, texture, or other visual distinguishing features relative to outside the first perimeter groove **2227** to visually define the first port region **2225**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the illustrated example of FIGS. **20-38**, the body portion may include a second port region **2235** located below the center ledge portion **2138** of the second ledge portion **2134**, and a third port region **2245** located below the third ledge portion **2136** and between the heel portion edge **2052** and the center portion **2073**. The second port region **2235** may be between the first port region **2225** and the third port region **2245**. In one example, as illustrated in FIGS. **20-38**, the third port region **2245** may include a second perimeter groove **2247**, which may visually define a portion or all of the third port region **2245**. The second perimeter groove **2247** may be a slot, channel, depression, or a recess. The mass that may be removed from the body portion **2010** to define the second perimeter groove **2247** may be placed at other locations on or inside the body portion **2010** to provide certain MOI, CG location, and golf club performance characteristics without changing or substantially changing the overall mass of the body portion **2010**. In another example, the portion of the body portion **2010** within the second perimeter groove **2247** may have a different color, texture, or other visual distinguishing features relative to outside the second perimeter groove **2247** to visually define the third port region **2245**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The first port region **2225** may include any number of ports, and any one or more of the ports of the first port region **2225** may be connected to the interior cavity **2110**. In one example, as illustrated in FIGS. **20-38**, the first port region **2225** may include a first set of ports **2220** (e.g., illustrated as

ports **2221**, **2222**, and **2223**). The ports **2221**, **2222**, and **2223** may be arranged in the first port region **2225** in any manner. In one example, the ports **2221**, **2222**, and **2223** may be arranged so as to be aligned with the contour of the sole portion edge **2092** similar to the ports of the golf club head **200**. In another example, as illustrated in FIGS. **20-38**, the ports **2221**, **2222**, and **2223** may be arranged so as to be aligned with the general direction of the first ledge portion **2132**. The spacing between the ports of the first set of ports **2220** may have any configuration. In the illustrated example of FIGS. **20-38**, each port of the first set of ports **2220** may be spaced apart from an adjacent port of the first set of ports **2220** by a distance of less than or equal to the port diameter of any of the ports of the first set of ports **2220**. The distance from any of the ports of the first set of ports **2220** to the toe portion edge **2042** may be less than the distance from any of the ports of the first set of ports **2220** to the heel portion edge **2052** or to the hosel portion **2055**. The first port region **2225** may be a thicker portion and/or a structurally enhanced portion of the back wall portion **2072** to accommodate the structures and/or functions of the ports of the first set of ports **2220**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The second port region **2235** may include any number of ports, and any one or more of the ports may be connected to the interior cavity **2110**. In one example, as illustrated in FIGS. **20-38**, the second port region **2235** may include a second set of ports **2230** (e.g., illustrated as port **2231**). The second port region **2235** may be at or proximate to the center portion **2073**. The second port region **2235** may be a thicker portion and/or a structurally enhanced portion of the back wall portion **2072** to accommodate the ports of the second set of ports **2230**. In one example, as illustrated in FIG. **29**, the second port region **2235** may include structurally enhanced portions of the back wall portion **2072** to accommodate the structure and/or function of the port **2231**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The third port region **2245** may include any number of ports, and any one or more of the ports of the third port region **2245** may be connected to the interior cavity **2110**. In one example, as illustrated in FIGS. **20-38**, the third port region **2245** may include a third set of ports **2240** (e.g., illustrated as ports **2241** and **2242**). The ports **2241** and **2242** may be arranged in the third port region **2245** in any manner. In one example, the ports **2241** and **2242** may be arranged so as to be aligned with the contour of the sole portion edge **2092** similar to the ports of the golf club head **200**. In another example, as illustrated in FIGS. **20-38**, the ports **2241** and **2242** may be arranged so as to be aligned with the general direction of the third ledge portion **2136**. The spacing between the ports of the third set of ports **2240** may have any configuration. In the illustrated example of FIGS. **20-38**, each port of the third set of ports **2240** may be spaced apart from an adjacent port of the third set of ports **2240** by a distance of less than or equal to the port diameter of any of the ports of the third set of ports **2240**. The distance from any of the ports of the third set of ports **2240** to the toe portion edge **2042** may be greater than the distance from any of the ports of the third set of ports **2240** to the heel portion edge **2052** or to the hosel portion **2055**. The third port region **2245** may be a thicker portion and/or a structurally enhanced portion of the back wall portion **2072** to accommodate the structures and/or functions of the ports of the third set of ports **2240**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The first set of ports **2220**, the second set of ports **2230**, and/or the third set of ports **2240** may include any number of ports. The locations, spacing relative to other ports, and any other configuration of each port of the first set of ports **2220**, the second set of ports **2230**, and/or the third set of ports **2240** may be similar in many respects to any of the ports described herein or described in any of the incorporated by reference applications. Further, any one or more of the ports of the first set of ports **2220**, the second set of ports **2230**, and/or the third set of ports **2240** may be connected to interior cavity **2110** through which one or more filler materials may be injected into the interior cavity **2110**. In the illustrated example of FIGS. **20-38**, the port **2221** and the port **2241** may be connected to the interior cavity **2110** via opening **2261** and opening **2281**, respectively. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **20-38**, the second set of ports **2230** may include a single port **2231** that may be larger in diameter than any of the ports of the first set of ports **2220** and/or the third set of ports **2240**. The port **2231** may be located at or proximate to the center portion **2073** of the back wall portion **2072** and at or proximate to the sole portion edge **2092**. In one example, the diameter of the port **2231** may be greater than or equal to 1.1 times the diameter and less than or equal to 8.0 times the diameter of any of the ports of the first set of ports **2220** and any of the ports of the third set of ports **2240**. In another example, the diameter of the port **2231** may be greater than or equal to twice the diameter of any of the ports of the first set of ports **2220** and the third set of ports **2240**. In another example, the diameter of the port **2231** may be greater than or equal to 2.5 times the diameter of any of the ports of the first set of ports **2220** and the third set of ports **2240**. In another example, the diameter of the port **2231** may be greater than or equal to 3.5 times the diameter of any of the ports of the first set of ports **2220** and the third set of ports **2240**. In yet another example, the diameter of the port **2231** may be greater than or equal to the diameter any of the ports of the first set of ports **2220** and any of the ports of the third set of ports **2240**. In the example of FIGS. **20-38**, the ports of the first set of ports **2220**, the second set of ports **2230** and the third set of ports **2240** are illustrated to be cylindrical. In other examples (not illustrated), the ports may have any shape. Accordingly, the relative sizes of the ports may be expressed by any dimension such as length, width, radius, diameter, distance between two boundaries, or any dimension corresponding to a particular geometric shape (e.g., major and minor axes for an elliptical shaped port). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The body portion **2010** may include any number of ports above and/or below the first ledge portion **2132**, the second ledge portion **2134**, and/or the third ledge portion **2136**. The body portion **2010** may include any number of ports above and/or below the horizontal midplane **2420**. The body portion **2010** may include any number of ports on the toe portion edge **2042**, the heel portion edge **2052**, the top portion edge **2082**, and/or the sole portion edge **2092**. The number of ports on the body portion **2010**, the arrangement and/or the configuration of the ports on the body portion **2010** may be similar in many respects to the golf club head **200** or any of the golf club heads described in any of the incorporated by reference applications. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The body portion **2010** may include one or more mass portions (e.g., weight portion(s)) at any location on the body portion **2010**. The one or more mass portions may be integral mass portion(s) or separate mass portion(s) that may be coupled to the body portion **2010** at any exterior or interior location on the body portion **2010**. In the illustrated example of FIGS. **20-38**, the body portion **2010** may include a first set of mass portions **2320** (e.g., illustrated as mass portions **2321**, **2322**, and **2323**), a second set of mass portions **2330** (e.g., illustrated as mass portion **2331**), and a third set of mass portions **2340** (e.g., illustrated as mass portions **2341** and **2342**). In the example of FIGS. **20-38**, the mass portions of the first set of mass portions **2320** and the third set of mass portions **2320** may be similar to any of the mass portions described herein, such as the mass portions **1800** and **1900** of FIGS. **17-19**, or the mass portions described in any of the incorporated by reference applications. The second set of mass portions **2330** may include a single mass portion **2331**, which may have a greater mass than any of the mass portions of the first set of mass portions **2320** and the third set of mass portions **2340**. In one example, as illustrated in FIG. **33**, the mass portion **2331** may be cylindrical with a head portion **2333**, a shaft portion **2335** and a top portion **2337** including a tool engagement portion **2339**. The diameter **2334** of the mass portion **2331** may be greater than the length **2336** of the mass portion **2331**. Accordingly, the mass portion **2331** may be disc shaped as illustrated in FIG. **34** with the diameter **2334** being greater as described herein than the diameters of the mass portions of the first set of mass portions **2320** and the third set of mass portions **2340** as illustrated for example by mass portions **1800** and **1900** of FIGS. **17-19**. The port **2231** may be configured to receive the mass portion **2331**, which may be inserted and secured into the port **2231** by any of the methods described herein such as being screwed in, press fitted, secured with an adhesive, or welded. In one example, as illustrated in FIG. **33**, the head portion **2333** may be threaded to engage internal threads in the port **2231** to secure the mass portion **2331** in the port **2231**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

Each port of the first set of ports **2220** and the third set of ports **2240** may be configured to receive any of the mass portions of the first set of mass portions **2320** and/or the third set of mass portions **2340** similar to the coupling and/or engagement of any of the mass portions and ports described herein (e.g., mass portions **1800** and **1900** of FIGS. **17-19**) or described in any of the incorporated by reference applications. As illustrated in the example of FIGS. **18** and **19**, the mass portions of the first set of mass portions **2320** and/or the third set of mass portions **2340** may have different lengths or other physical properties (e.g., one or more materials of construction) as described herein. Accordingly, each port of the first set of ports **2220** and/or the third set of ports **2240** may receive a mass portion of the first set of mass portions **2320** or the third set of mass portions **2340** that may correspond or substantially correspond in length to the depth of the port. For example, as illustrated in FIGS. **28** and **30**, the depth of the port **2222** may be greater than the depth of the port **2241**. Accordingly, the mass portion **2322** that is secured in the port **2222** may have a greater length (an example illustrated in FIG. **19**) than the mass portion **2341** (an example illustrated in FIG. **18**) that is secured in the port **2241**. Thus, as illustrated in FIGS. **20-38**, the inner diameter and/or the depth of each port of the first set of ports **2220**, the second set of ports **2230**, and the third set of ports **2240** and/or the diameter and/or length of each mass portion of the first set of mass portions **2320**, the second set of mass portions **2330**, and the third set of mass portions **2340** may determine the selection of a corresponding mass portion for a flush configuration of the mass portion relative to the outer surface of the back wall portion **2072**. Further, as described herein and in any of the incorporated by reference applications, the material of construction of each mass portion, which affects the density of each mass portion, may determine the selection of a mass portion. In other words, each port may receive a correspondingly sized mass portion having a certain total mass as described herein. In another example, the inner diameter and/or the depth of each port of the first set of ports **2220**, the second set of ports **2230**, and the third set of ports **2240** and/or the diameter and/or length of each mass portion of the first set of mass portions **2320**, the second set of mass portions **2330**, and the third set of mass portions **2340** may determine the selection of a corresponding mass portion for a recessed configuration of the mass portion relative to the outer surface of the back wall portion **2072**. In yet another example, the inner diameter and/or the depth of each port of the first set of ports **2220**, the second set of ports **2230**, and the third set of ports **2240** and/or the diameter and/or length of each mass portion of the first set of mass portions **2320**, the second set of mass portions **2330**, and the third set of mass portions **2340** may determine the selection of a corresponding mass for a protruding configuration of the mass portion relative to the outer surface of the back wall portion **2072**. Certain golf club head performance criteria, which may be affected by the MOI and CG location of the golf club head may also dictate the section of a mass portion for a port. In one example, mass portions having greater masses may be placed in the ports that are closer to the toe portion than to the heel portion to increase the moment of inertia (MOI) of the golf club head. In another example, the ports that are closest to the center portion **2073** may receive relatively heavier mass portions to lower the center of gravity of the golf club head. Each mass of the first set of mass portions **2320**, the second set of mass portions **2330**, and/or the third set of mass portions **2340** may be interchangeable with a relatively heavier or lighter mass to provide certain performance characteristics for the golf club head **2000**. Thus, the configuration of each port, the configuration of each mass portion, and/or certain golf club head performance criteria may determine selection and/or placement of a mass portion in a port. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The total mass of the mass portion **2331** may be greater than the total mass of any mass portion of the first set of mass portions **2320** and/or the third set of mass portions **2340**. The total mass of the mass portion **2331** may be greater than or equal to the total mass of the first set of mass portions **2320** and/or the third set of mass portions **2340**. The total mass of the mass portion **2331** may be determined to provide certain performance characteristics for the golf club head **2000**. In one example, the mass portion **2331** may have a total mass that is greater than or equal to 2 grams and less than or equal to 30 grams. In another example, the mass portion **2331** may have a total mass that is greater than or equal to 4 grams and less than or equal to 18 grams. In another example, the mass portion **2331** may have a total mass that is greater than or equal to 6 grams and less than or equal to 12 grams. In another example, the mass portion **2331** may have a total mass that is greater than or equal to 7 grams and less than or equal to 9 grams. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The diameter of the mass portion **2331** may be determined based on one or more properties (e.g., material density) of the materials of construction of the mass portion **2331**. In one example, the mass portion **2331** may have a diameter that is greater than or equal to 0.2 inch (5.08 mm) and less than or equal to 1.0 inch (25.4 mm). In another example, the mass portion **2331** may have a diameter that is greater than or equal to 0.3 inch (7.62 mm) and less than 1.5 inch (38.1 mm). In another example, the mass portion **2331** may have a diameter that is greater than or equal to 0.4 inch (10.16 mm) and less than or equal to 0.8 inch (20.32 mm). In another example, the mass portion **2331** may have a diameter that is greater than or equal to 0.5 inch (12.7 mm) and less than or equal to 0.7 inch (17.78 mm). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

A center region or a geometric center of the port **2231** of the second set of ports **2230** may be located at or proximate to the CG of the golf club head **2000**. Accordingly, a center of gravity of the mass portion **2331** may also be located at or proximate to the CG of the golf club head **2000** when the mass portion **2331** is secured in the port **2231** as described herein. As a result, the mass portion **2331** may be interchangeable with another mass portion **2331** having lower mass or a mass portion **2331** having a higher mass without causing a relatively large or a significant shift in the CG of the golf club head **2000**. In one example, for each gram mass increase of the mass portion **2331**, the CG location of the golf club head may shift by less than 0.5% of the CG_X location (x-axis coordinate of the CG), less than 0.5% of the CG_Y location (y-axis coordinate of the CG), and/or less than 0.2% of the CG_Z location (z-axis coordinate of the CG). In another example, for each gram mass increase of the mass portion **2331**, the CG location of the golf club head may shift by less than 0.35% of the CG_X location, less than 0.35% of the CG_Y location, and/or less than 0.15% of the CG_Z location. In yet another example, for each gram mass increase of the mass portion **2331**, the CG location of the golf club head may shift by less than 0.25% of the CG_X location, less than 0.25% of the CG_Y location, and/or less than 0.10% of the CG_Z location. Thus, the mass portion **2331** may be interchangeable with another mass portion **2331** having a lower or a greater mass to provide certain performance characteristics for an individual (i.e., customize the performance of the golf club head **2000** for a certain individual) without substantially shifting the CG of the golf club head **2000** and/or altering the overall or general performance characteristics of the golf club head **2000**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, each mass portion of the first set of mass portions **2320** and/or the third set of mass portions **2340** may have a mass of greater than or equal to 0.25 grams and less than or equal to 6.0 grams. In another example, each mass portion of the first set of mass portions **2320** and/or the third set of mass portions **2340** may have a mass of greater than or equal to 1.25 grams and less than or equal to 5.25 grams. In another example, each mass portion of the first set of mass portions **2320** and/or the third set of mass portions **2340** may have a mass of greater than or equal to 1.75 grams and less than or equal to 4.1 grams. In another example, each mass portion of the first set of mass portions **2320** and/or the third set of mass portions **2340** may have a mass of greater than or equal to 0.75 grams and less than or equal to 3.5 grams. In yet another example, each mass portion of the first set of mass portions **2320** and/or the third set of mass portions **2340** may have a mass of greater than or equal to 0.5 grams and less than or equal to 4.0 grams. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The interior cavity **2110** may be partially or entirely filled with one or more filler materials (i.e., a cavity filling material), which may include one or more similar or different types of materials. In one example, as illustrated in FIGS. **20-38**, the interior cavity **2110** may be filled with a filler material **2512** that may be similar to any of the filler materials described herein or in any of the incorporated by reference applications. In another example (not illustrated for FIGS. **20-38**), the interior cavity **2110** may be filled with a first filler material and a second filler material that may be similar to the golf club head **200** or similar to any of the golf club heads described in any of the incorporated by reference applications. In one example, as illustrated in FIGS. **20-38**, the filler material **2512** may be injected into the interior cavity **2110** from any of the ports **2221** and **2241**, while the other one of the ports **2221** and **2241** may functions as an air exhaust port through which the air in the interior cavity **2110** that is displaced by the filler material **2512** may exit. Accordingly, as illustrated in FIGS. **20-38**, the filler material **2512** may be molded in the shape of the interior cavity **2110**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, one or more materials of the filler material, the physical properties of the one or more materials (i.e., density and/or elasticity), the amount (i.e., volume and/or mass) of the filler material **2512** may be determined for each golf club head (i.e., having a certain loft angle) to (i) provide vibration dampening or sound dampening (e.g., consistent and/or pleasing sound and feel when the golf club head **2000** strikes a golf ball as perceived by an individual using the golf club head **2000**), (ii) provide structural support for the face portion **2062**, and/or (iii) optimize ball travel distance, ball speed, ball launch angle, ball spin rate, ball peak height, ball landing angle and/or ball dispersion. In one example, the filler material **2512** may be formed from any type of polymer materials such as any of the polymer materials described herein or described in any of the incorporated by reference applications. In one example, the filler material **2512** may be formed from a rubber or a rubber-based compound such as any of the rubber-based compounds described herein. In another example, the filler material **2512** may be formed from a thermoset material, such as an epoxy-based material. In another example, the filler material **2512** may be formed from a thermoplastic material. In yet another example, the filler material may be formed from a metal or metal alloy (e.g., aluminum or aluminum alloy) that may have a different density than the density of the material of the body portion **2010**. The filler material **2512** may be attached to the inner walls of the body portion **2010** and the face portion **2062** with any bonding agent or any adhesive that may be appropriate for bonding or attaching the filler material **2512** to the material of the body portion **2010** and/or the face portion **2062**. In another example (not illustrated), the filler material **2512** may be a polymer material that may include self adhesive properties so as to adhere to the body portion **2010** and/or the face portion **2062** without using a bonding agent or an adhesive. In another example, the injection molding and/or curing the filler material **2512** may provide sufficient holding forces (e.g., the filler material **2512** expanding during the filling or curing process) to maintain the filler material **2512** engaged with the body portion **2010** and/or the face portion **2062** without the use of bonding agents or adhesives. In yet another example, the filler material **2512** may be preformed

and placed inside the interior cavity **2110** and/or attached to the interior walls of the body portion **2010** that define the interior cavity **2110** prior to enclosing the interior cavity **2110**. The injection molding, curing, and/or attachment of the filler material **2512** in the interior cavity **2110** may be similar to the processes described herein or in any of the incorporated by reference application. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the illustrated example of FIG. **35**, the face portion **2062** may include a face perimeter that may include four perimeter sides, which may be a first perimeter side defined by a face portion toe portion edge (referred to herein as the face toe edge **2740**), a second perimeter side defined by a face portion heel portion edge (referred to herein as the face heel edge **2750**), a third perimeter side defined by a face portion top portion edge (referred to herein as face top edge **2780**), and fourth perimeter side defined by a face portion sole portion edge (referred to herein as face sole edge **2790**). The back surface **2066** of the face portion **2062** may include one or more grooves, slots, channels, depressions, or recesses, any of which may be referred to herein as back grooves and may define any structure on the back surface **2066** that may provide a relatively decreased face thickness. In the illustrated example of FIG. **35**, the back surface **2066** may include a back groove **3500** having a first end portion **3502**, a first portion **3504**, a first transition portion **3505**, a second portion **3506**, a second transition portion **3507**, a third portion **3508**, and a second end portion **3510**. In one example, as illustrated in FIG. **35**, the first end portion **3502** may be proximate to the face toe edge **2740** and proximate to the face sole edge **2790**. The first end portion **3502** may be circular as illustrated in FIG. **35** to eliminate or reduce stress concentration regions on the face portion **2062** at or proximate to the first end portion **3502**. The first portion **3504** may extend from the first end portion **3502** toward the face top edge **2780**. In the illustrated example of FIG. **35**, the first portion **3504** may be linear and extend vertically from the first end portion **3502** toward the face top edge **2780**. In another example, the first portion **3504** may extend from the first end portion **3502** toward the face top edge **2780** with a curvature that may be similar or substantially similar to the curvature or contour of the face toe edge **2740**. In yet another example, the first portion **3504** may be inwardly curved. The first portion **3504** may then transition to the second portion **3506** via the first transition portion **3505** located proximate to the face toe edge **2740** and proximate to the face top edge **2780**. The first transition portion **3505** may be curved to eliminate or reduce stress concentration regions on the face portion **2062** at or proximate to the first transition portion **3505**. The second portion **3506** may extend from the first transition portion **3505** toward the face heel edge **2750**. The second portion **3506** may be linear and have the same orientation and contour as the face top edge **2780**. The second portion **3506** may then transition to the third portion **3508** via the second transition portion **3507** located proximate to the face heel edge **2750** and proximate to the face top edge **2780**. The second transition portion **3507** may be curved to prevent or reduce stress concentration regions on the face portion **2062** at or proximate to the second transition portion **3507**. The third portion **3508** may extend from the second transition portion **3507** toward the second end portion **3510** to the second end portion **3510**. The second portion **3506** may be linear and have the same orientation and contour as the face heel edge **2750**. The second end portion **3510** may be located proximate to the face heel edge **2750** and proximate to the face sole edge **2790**. The second end portion **3510** may be circular as illustrated in FIG. **35** to eliminate or reduce stress concentration regions on the face portion **2062** at or proximate to the second end portion **3510**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

As illustrated in FIG. **35**, the back groove **3500** may define an inner area **3562** and an outer area **3564** of the face portion **2062**. The inner area **3562** may correspond to or include a portion of the face portion **2062** that may generally strike a golf ball. As discussed herein, the back groove **3500** may provide a relatively thinner part of the face portion **2062** as compared to the remaining parts of the face portion **2062**. Accordingly, the back groove **3500** may provide enhanced deflection of the inner area **3562** relative to the outer area **3564** as compared a face portion **2062** without the back groove **3500**. In other words, the back groove **3500** may provide a trampoline effect for the inner area **3562** of the face portion **2062**. The enhanced deflection of the inner area **3562** may provide enhanced rebounding of the inner area **3562** after the face portion **2062** strikes a golf ball, which may increase ball launch angle, decrease ball backspin and/or increase ball carry distance compared to a similar golf club head as the golf club head **2000** but without having the back groove **3500**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **35**, **37**, and **38**, any portion of the back groove **3500** may include a back groove width **3710** (W_{BG}). The back groove width **3710** (W_{BG}) may have any value to provide certain performance characteristics for the golf club head **2000**. In one example, the back groove width **3710** may be greater than or equal to 0.050 inch (1.270 mm) and less than or equal to 0.200 inch (5.080 mm) (0.050 in $\leq W_BG \leq$0.200 in). In another example, the back groove width **3710** may be greater than or equal to 0.094 inch (2.381 mm) and less than or equal to 0.156 inch (3.969 mm) (0.094 in $\leq W_{BG} \leq$0.156 in). In another example, the back groove width **3710** may be greater than or equal to 0.109 inch (2.778 mm) and less than or equal to 0.141 inch (3.572 mm) (0.109 in $\leq W_BG \leq$0.141 in). In yet another example, the back groove width **3710** may be greater than or equal to 0.120 inch (3.048 mm) and less than or equal to 0.130 inch (3.302 mm) (0.120 in $\leq W_{BG} \leq$0.130 in). The back groove width **3710** may be constant or substantially constant (considering manufacturing tolerances) along any one or more portions of back groove **3500** or along the entire back groove **3500**. The back groove width **3710** may vary at a certain portion or portions of the back groove **3500**. Any portion of back groove **3500** and/or any portion of the back groove **3600** may have any cross-sectional shape. Accordingly, the back groove width **3710** at any one or more portions may vary according to corresponding variations in the cross-sectional shape of the back groove **3500**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **35**, **37**, and **38**, any portion of the back groove **3500** may include a back groove depth **3720** (D_{BG}). The back groove depth **3720** (D_{BG}) may have any value to provide certain performance characteristics for the golf club head **2000**. In one example, the back groove depth **3720** may be greater than or equal to 0.003 inch (0.076 mm) and less than or equal to 0.015 inch (0.381 mm) (0.003 in $\leq D_{BG} \leq$0.015 in). In another example, the back groove depth **3720** may be greater than or equal to 0.005 inch (0.133 mm) and less than or equal to 0.009 inch (0.222 mm) (0.005 in $\leq D_{BG} \leq$0.009 in). In another example, the back groove depth **3720** may be greater than or equal to

0.006 inch (0.156 mm) and less than or equal to 0.008 inch (0.200 mm) (0.006 in $\leq D_{BG} \leq 0.008$ in). In yet another example, the back groove depth **3720** may be greater than or equal to 0.0065 inch (0.1651 mm) and less than or equal to 0.0075 inch (0.1905 mm) (0.0065 in $\leq D_{BG} \leq 0.0075$ in). The back groove depth **3720** may be constant or substantially constant (considering manufacturing tolerances) along any one or more portions of back groove **3500** or along the entire back groove **3500**. The back groove depth **3720** may vary at a certain portion or portions of the back groove **3500**. Any portion of back groove **3500** and/or any portion of the back groove **3600** may have any cross-sectional shape. Accordingly, the back groove depth **3720** at any one or more portions may vary according to corresponding variations in the cross-sectional shape of the back groove **3500**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **37** and **38**, the face portion **2062** may include a first face thickness **3750** (T_1), a second face thickness **3752** (T_2), a third face thickness **3754** (T_3), and a fourth face thickness **3756** (T_4). The first face thickness **3750** may be defined by a distance between the front surface **2064** and the back surface **2066** of the face portion **2062** at a location on the face portion **2062** that does not include any portion of a front groove **2068** and any portion of the back groove **3500**. The second face thickness **3752** may be defined by a distance between the front surface **2064** of the face portion **2062** and a bottom surface of the back groove **3500** at a location on the face portion **2062** that includes a portion of the back groove **3500** but does not include any portion of a front groove **2068**. Accordingly, the second face thickness **3752** may be determined by subtracting the back groove depth **3720** from the first face thickness **3750**. The third face thickness **3754** may be defined by a distance between a bottom surface of a front groove **2068** and the back surface **2066** of the face portion **2062** at a location on the face portion **2062** that does not include any portion of the back groove **3500**. Accordingly, the third face thickness **3754** may be determined by subtracting a front groove depth **2069** from the first face thickness **3750**. The fourth face thickness **3756** may be defined by a distance between a bottom surface of a front groove **2068** and a bottom surface of the back groove **3500** at a location on the face portion **2062** that includes a portion of a front groove **2068** and an opposing portion of a back groove **3500**. Accordingly, the fourth face thickness **3756** may be determined by subtracting a sum of the back groove depth **3720** and a front groove depth **2069** from the first face thickness **3750**. The first face thickness **3750** may be greater than the second face thickness **3752**, the third face thickness **3754**, and the fourth face thickness **3756** ($T_1 > T_2$, $T_1 > T_3$, $T_1 > T_4$). The second face thickness **3752** may be greater than the fourth face thickness **3756** ($T_2 > T_4$). The third face thickness **3754** may be greater than the fourth face thickness **3756** ($T_3 > T_4$). In one example, as illustrated in FIGS. **37** and **38**, the second face thickness **3752** may be greater than the third face thickness **3754** ($T_2 > T_3$). In another example (not shown), the third face thickness **3754** may be greater than the second face thickness **3752** ($T_3 > T_2$). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The first face thickness **3750** may have any value to provide certain performance characteristics for the golf club head **2000**. In one example, the first face thickness **3750** may be greater than or equal to 0.025 inch (0.635 mm) and less than or equal to 0.125 inch (3.175 mm) (0.025 in $\leq T_1 \leq 0.125$). In another example, the first face thickness **3750** may be greater than or equal to 0.047 inch (1.181 mm) and less than or equal to 0.078 inch (1.969 mm) (0.047 in $\leq T_1 \leq 0.078$). In another example, the first face thickness **3750** may be greater than or equal to 0.054 inch (1.378 mm) and less than or equal to 0.070 inch (1.772 mm) (0.054 in $\leq T_1 \leq 0.070$). In another example, the first face thickness **3750** may be greater than or equal to 0.060 inch (1.524 mm) and less than or equal to 0.065 inch (1.651 mm) (0.060 in $\leq T_1 \leq 0.065$). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The second face thickness **3752** may have any value to provide certain performance characteristics for the golf club head **2000**. The value of the second face thickness **3752** may be determined by subtracting the value of the back groove depth **3720** as described herein from the value of the first face thickness **3750**. The value of the second face thickness **3752** may also be expressed as a percentage of the value of the first face thickness **3750**. In one example, the second face thickness **3752** may be greater than or equal to 75% and less than or equal to 98% of the first face thickness **3750** ($0.75 \leq T_2/T1 \leq 0.98$). Accordingly, the back groove depth **3720** may be less than or equal to 25% and greater than or equal to 2% of first face thickness **3750** ($0.02 \leq D_{BG}/T_1 \leq 0.25$). In another example, the second face thickness **3752** may be greater than or equal to 70% and less than or equal to 85% of the first face thickness **3750** ($0.70 \leq T_2/T_1 \leq 0.85$). Accordingly, the back groove depth **3720** may be less than or equal to 30% and greater than or equal to 15% of first face thickness **3750** ($0.15 \leq D_{BG}/T_1 \leq 0.30$). In another example, the second face thickness **3752** may be greater than or equal to 85% and less than or equal to 95% of the first face thickness **3750** ($0.85 \leq T_2/T_1 \leq 0.95$). Accordingly, the back groove depth **3720** may be less than or equal to 15% and greater than or equal to 5% of first face thickness **3750** ($0.05 \leq D_{BG}/T_1 \leq 0.15$). In yet another example, the second face thickness **3752** may be greater than or equal to 80% and less than or equal to 90% of the first face thickness **3750** ($0.80 \leq T_2/T_1 \leq 0.90$). Accordingly, the back groove depth **3720** may be less than or equal to 20% and greater than or equal to 10% of first face thickness **3750** ($0.10 \leq D_{BG}/T_1 \leq 0.20$). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The third face thickness **3754** may have any value to provide certain performance characteristics for the golf club head **2000**. The value of the third face thickness **3754** may be determined by subtracting value of the front groove depth **2069** as described herein from the value of first face thickness **3750**. The value of the third face thickness **3754** may also be expressed as a percentage of the value of the first face thickness **3750**. In one example, the third face thickness **3754** may be greater than or equal to 60% and less than or equal to 97% of the first face thickness **3750** ($0.60 \leq T_3/T_1 \leq 0.97$). In another example, the third face thickness **3754** may be greater than or equal to 75% and less than or equal to 85% of the first face thickness **3750** ($0.75 \leq T_3/T_1 \leq 0.85$). In another example, the third face thickness **3754** may be greater than or equal to 80% and less than or equal to 95% of the first face thickness **3750** ($0.80 \leq T_3/T_1 \leq 0.95$). In yet another example, the third face thickness **3754** may be greater than or equal to 70% and less than or equal to 90% of the first face thickness **3750** ($0.70 \leq T_3/T_1 \leq 0.90$). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The fourth face thickness **3756** may have any value to provide certain performance characteristics for the golf club head **2000**. The value of the fourth face thickness **3756** may be determined by subtracting the value of the front groove

depth **2069** as described herein and the value of the back groove depth **3720** as described herein from the value of the first face thickness **3750**. The value of the fourth face thickness **3756** may also be expressed as a percentage of the value of the first face thickness **3750**. In one example, the fourth face thickness **3756** may be greater than or equal to 45% and less than or equal to 85% of the first face thickness **3750** ($0.45 \leq T_4/T_1 \leq 0.85$). In another example, the fourth face thickness **3756** may be greater than or equal to 55% and less than or equal to 75% of the first face thickness **3750** ($0.55 \leq T_4/T_1 \leq 0.75$). In another example, the fourth face thickness **3756** may be greater than or equal to 60% and less than or equal to 70% of the first face thickness **3750** ($0.60 \leq T_4/T_1 \leq 0.70$). In yet another example, the fourth face thickness **3756** may be greater than or equal to 62% and less than or equal to 68% of the first face thickness **3750** ($0.62 \leq T_4/T_1 \leq 0.68$). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **37** and **38**, the back groove width **3710** may be greater than the front groove width **2071**, and the back groove depth **3720** may be less than the front groove depth **2069**. In another example (not shown), the back groove width **3710** may be greater than the front groove width **2071**, and the back groove depth **3720** may be greater than the front groove depth **2069**. In another example (not shown), the back groove width **3710** may be less than the front groove width **2071**, and the back groove depth **3720** may be greater than the front groove depth **2069**. In yet another example (not shown), the back groove width **3710** may be less than the front groove width **2071**, and the back groove depth **3720** may be less than the front groove depth **2069**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, the back groove width **3710** and the back groove depth **3720** may be similar. In another example, the back groove width **3710** may be less than the back groove depth **3720**. In yet another example, the back groove width **3710** may be greater than the back groove depth **3720**. In the illustrated example of FIGS. **37** and **38**, the back groove width **3710** may be substantially greater than the back groove depth **3720**. The back groove width **3710** and the back groove depth **3720** may be determined to provide sufficient deflection for the face portion **2062** without compromising the structural integrity of the face portion. In other words, the back groove width **3710** and the back groove depth **3720** may be determined so that the face portion **2062** may sufficiently deflect to provide the rebounding and the trampoline effect described herein when striking a golf ball without failure after one, a few, or repeated and long-term use of the golf club head **2000** for golf ball strikes. Additionally, values of the back groove width **3710** and the back groove depth **3720** may depend on the values of the first face thickness **3750**, the front groove width **2071**, and/or the front groove depth **2069**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

As described herein, the interior cavity **2110** may be filled with one or more filler materials, such as the filler material **2512**. Accordingly, in one example, all or portions of the back groove **3500** may be filled with the filler material **2512**. The filler material **2512** may structurally support the relatively thinner portions of the face portion **2062** at locations in and/or proximate to the back groove **3500**. In another example, all or portions of the back groove **3500** may be filled with a filler material that may have different physical properties than any of the filler materials in the interior cavity **2110**. In yet another example, a portion of the back groove **3500** may be filled with a first filler material, whereas another portion of the back groove **3500** may be filled with a second filler material having one or more different physical properties than the first filler material. The configuration (e.g., depth, width, location on the face portion, cross-sectional shape) of the back groove **3500** may determine the physical properties of the one or more filler materials and the amount of the one or more filler materials that may be used to fill the back groove **3500** and/or the interior cavity **2110**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The first end portion **3502** and/or or the second end portion **3510** may have any shape and/or size without any sharp corners or vertices to eliminate or reduce stress concentration points or regions at or proximate to the back groove **3500**. In one example, the first end portion **3502** and/or the second end portion **3510** may have an elliptical or a semi-elliptical shape. In another example, the first end portion **3502** and/or the second end portion **3510** may have a triangular shape with rounded vertices. In another example, as illustrated in FIG. **49**, the first end portion **3502** and/or the second end portion **3510** may have an obround shape (i.e., a rectangle with semicircles at opposite sides). In another example, as illustrated in FIGS. **65** and **66**, the back groove **3500** may extend to the face perimeter. In other words, any portion of a back groove **3500** may extend to the face perimeter and terminate at the face perimeter. In yet another example, as illustrated in FIG. **59**, the back groove **3500** may terminate at a rounded or curved end portion **5952** having the same width as the back groove width **3710** without having an enlarged end portion. Any end portion of any of the back grooves described herein may have any shape and/or any shape without sharp corners or vertices so as to eliminate or reduce any stress concentration regions on the face portion **2062** at or proximate to the back groove. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The cross-sectional shape of the back groove **3500** may be without any sharp corners to eliminate or reduce stress concentration points or regions at or proximate to the back groove **3500**. In one example, as illustrated in FIG. **37**, the cross-section of the back groove **3500** may have a wide and shallow U-shape. In another example, the cross-section of the back groove **3500** may have a deep and/or narrow U-shape. In another example, the cross-section of the back groove **3500** may have a rectangular shape with rounded corners or vertices. In yet another example, the cross-sectional shape of the back groove **3500** may be semi-circular or semi-elliptical. Accordingly, the back groove **3500** may be manufactured with any cross-sectional shape. The cross-sectional shape of the back groove **3500** may be manufactured without sharp corners or vertices so as to eliminate or reduce any stress concentration regions on the face portion **2062** at or proximate to the back groove **3500**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **36**, the back surface **2066** of the face portion **2062** may include a back groove **3600**, which may be similar in many respects to the back groove **269** of FIG. **13**. The back groove **3600** may have similar back groove width, back groove depth, and/or cross-sectional shape as described and illustrated herein with respect to the back groove **3500**. The back groove **3600** may include a first portion **3604**, a first transition portion **3605**, a second portion **3606**, a second transition portion **3607**, a third portion **3608**, and a third transition portion **3609**, a fourth portion **3610**, and a fourth transition portion **3611**, all of which may define a continuous back groove **3600** that

extends proximate to a perimeter of the back surface **2066** of the face portion **2062** and generally follows the contour of the perimeter of the face portion **2062** without having any sharp corners to prevent stress concentration regions at or near any portion of the back groove **3600**. As illustrated in FIG. **36**, the back groove **3600** may define an inner area **3662** and an outer area **3664** of the face portion **2062**. The inner area **3662** may correspond to or include a portion of the face portion **2062** that generally strikes a golf ball. Further, the back groove **3600** may provide a relatively thinner part of the face portion **2062** as compared to the remaining parts of the face portion **2062**. Accordingly, the back groove **3600** may provide enhanced deflection of the inner area **3662** relative to the outer area **3664** as compared to face portion **2062** without the back groove **3600**. In other words, the back groove **3600** may provide a trampoline effect for the inner area **3662** of the face portion **2062**. The enhanced deflection of the inner area **3662** may provide enhanced rebounding of the inner area **3662** after the face portion **2062** strikes a golf ball, which may increase ball speed and/or carry distance. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, to eliminate or reduce stress concentration regions in or around the back groove **3500**, any portion of the back groove **3500** may have a curved or chamfered shape when changing directions. In one example, as illustrated in FIG. **35**, the first transition portion **3505** and/or the second transition portion **3507** of the back groove **3500** may be curved. In another example, as illustrated in FIG. **36**, the first transition portion **3605**, the second transition portion **3607**, the third transition portion **3609**, and the fourth transition portion **3611** of the back groove **3600** may be curved. In another example as illustrated in FIG. **35**, the first end portion **3502** and the second end portion **3510** of the back groove **3500** may be circular. The size of the circle defining the first end portion **3502** and/or the second end portion **3510** may be determined considering the first face thickness, the second face thickness, the third face thickness, the fourth face thickness, material properties of the face portion, the method by which the face portion is manufactured, and/or a broad range of deflections to which the face portion **2062** may be subjected with repeated golf ball strikes. In one example, the diameter of a circle defining the first end portion **3502** and/or the second end portion **3510** may be greater than or equal to 0.1 inch (2.54 mm) and less than or equal to 0.4 inch (10.16 mm). In another example, the diameter of a circle defining the first end portion **3502** and/or the second end portion **3510** may be greater than or equal to 0.188 inch (4.763 mm) and less than or equal to 0.313 inch (7.938 mm). In yet another example, the diameter of a circle defining the first end portion **3502** and/or the second end portion **3510** may be greater than or equal to 0.219 inch (5.556 mm) and less than or equal to 0.281 inch (7.144 mm). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

To determine the effect of back grooves **3500** and **3600** on the performance of the golf club head **2000**, certain club performance parameters were measured for three sample golf clubs, which are identified in FIGS. **39-42** as golf club number one (Club No. **1**), golf club number two (Club No. **2**), and golf club number **3** (Club No. **3**). All three golf clubs were 7-iron golf clubs with golf club heads that were identical in every respect to the golf club head **2000** as described herein except for the configuration of the back groove on the back surface **2066** of the face portion **2062**. Club No. **1** did not include any back grooves such as the back groove **3500** or the back groove **3600**. Club No. **2** included the back groove **3500** as described herein and illustrated in FIG. **35**. Club No. **3** included the back groove **3600** as described herein and illustrated in FIG. **36**. The back groove **3500** of Club No. **2** and the back groove **3600** of Club No. **3** had a back groove width **3710** of about 0.125 inch (3.175 mm) and a back groove depth **3720** of about 0.007 inch (0.178 mm). The diameter of the circles defining the first end portion **3502** and the second end portion **3510** of the back groove **3500** were about 0.25 inch (6.350 mm).

Each of the sample golf clubs was tested with a swing robot to strike a golf ball at an average golf club head speed of 84 mph to 86 mph for multiple iterations at each of five locations on the face portion of the golf club head to determine average ball speed (mph), average ball launch angle (degrees), average ball backspin (rpm), and average total carry distance (yards). For example, the swing robot may be a model manufactured by Golf Laboratories of San Diego, California. The five locations of the face portion were a center location, a toe location, a heel location, a low location, and a high location, all of which may be referred to herein as the measurement locations. The center location was determined as the location on the face portion by which a golf ball is typically struck by an individual. In other words, the center location statistically (e.g., greater than 75%) receives the highest number of ball strikes. The center location was set at 0.75 inches or approximately 0.75 inches up from the sole portion edge **2092** and at the center of a corresponding front groove **2068** on the face portion **2062** subject to variations and/or approximations according to measurement tolerances and/or the actual ball strike region on the face portion **2062** by the swing robot. The toe location and the heel location were set as 0.5 inches or approximately 0.5 inches from the center location in the toe direction and in the heel direction, respectively, subject to variations and/or approximations according to measurement tolerances and the actual ball strike point on the face portion **2062** by the swing robot. The high location and the low location were set at 0.25 inches or approximately 0.25 inches from the center location in the top direction and the bottom direction, respectively, subject to variations and/or approximations according to measurement tolerances and the actual ball strike point on the face portion **2062** by the swing robot. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

As illustrated in FIG. **39**, ball speed for Club No. **3** was higher at all measurement locations than the ball speeds for Club No. **1** and Club No. **2**. Referring back to FIG. **36**, the back groove **3600** forms a continuous loop on the back surface **2066** of the face portion **2062**. Accordingly, the entire inner area **3662** of the face portion **2062** may deflect inward relative to the outer area **3664** with a golf ball strike to provide an enhanced trampoline or rebounding effect for the golf ball to result in enhanced ball speeds at all measurement locations relative to Club No. **1** and Club No. **3**.

As illustrated in FIG. **40**, the launch angle for Club No. **2** was higher at all measurement locations than the launch angle for Club No. **1** and Club No. **3**. Referring back to FIG. **35**, the back groove **3500** forms a C-shaped groove on the back surface **2066** of the face portion **2062**. Accordingly, the upper portion of the inner area **3562** of the face portion **2062** may have a greater inward deflection when the face portion **2062** strikes a golf ball than the lower portion of the inner area **3562**, hence launching the golf ball with a higher launch angle. In other words, the upper portion of the inner area **3562** may provide a greater trampoline or rebound effect

than the lower portion of the inner area **3562** to produce a relatively higher launch angle than Club No. **1** and Club No. **3**.

As illustrated in FIG. **41**, ball backspin for Club No. **2** was lower at the center location than the backspin for Club No. **1** and Club No. **3**. Referring back to FIG. **35**, the back groove **3500** forms a C-shaped groove on the back surface **2066** of the face portion **2062**. Accordingly, the center portion of the inner area **3562** of the face portion **2062** may have a greater inward deflection when the face portion **2062** strikes a golf ball than the lower portion of the inner area **3562**, hence creating a lower backspin on the golf ball. In other words, the relatively greater inward deflection of the upper portion of the inner area **3562** may impart a lower backspin on the ball than Club No. **1** and Club No. **3**.

As illustrated in FIG. **42**, ball carry distance for Club No. **2** and Club No. **3** were generally similar at the center location and the heel location, but higher than the ball carry distance for Club No. **1** at all five locations. As discussed herein, the greater trampoline or rebound effects provided by the back groove **3500** of Club No. **2** and the back groove **3600** of Club No. **3** may generate a larger carry distance than Club No. **1**.

The configuration of a back groove on the back surface **2066** of the face portion **2062** may affect performance characteristics of a golf club. Accordingly, certain performance characteristic for a golf club may be achieved by different groove configurations. In one example, as illustrated in FIG. **43**, the face portion **2062** may include a back groove **4300** having a first portion **4304**, a first transition portion **4305**, a second portion **4306**, a second transition portion **4307**, a third portion **4308**, a third transition portion **4310**, a fourth portion **4312**, and a fourth transition portion **4314**, all of which define a continuous back groove **4300**. The back groove **4300** may be similar in many respects to the back groove **3600**, except that the first portion **4304** may extend linearly between the face top edge **2780** and the face sole edge **2790** instead of following the contour of the face toe edge **2740** as illustrated in FIG. **36**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **44**, the face portion **2062** may include a back groove **4400** having a first end portion **4402**, a first portion **4404**, a first transition portion **4405**, a second portion **4406**, a second transition portion **4407**, a third portion **4408**, and a second end portion **4410**. The back groove **4400** may be similar in many respects to the back groove **3600**, except that the first portion **4404** terminates at the first end portion **4402** located at or proximate to the face toe edge **2740** and the face sole edge **2790**, and the third portion **4408** terminates at the second end portion **4410** located at or proximate to the face heel edge **2750** and the face sole edge **2790**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **45**, the face portion **2062** may include a back groove **4500** having a first portion **4504**, a first transition portion **4505**, a second portion **4506**, a second transition portion **4507**, and a third portion **4508**. The back groove **4500** may also include a first end portion **4520** that may be at or proximate to the face sole edge **2790** and a second end portion **4530** at or proximate to the face sole edge **2790**. The first end portion **4520** may be closer to the face toe edge **2740** than to the face heel edge **2750**, and the second end portion **4530** may be closer to the face heel edge **2750** than to the face toe edge **2740**. The back groove **4500** may further include a fourth portion **4501** that extends from the first end portion **4520** toward the face toe edge **2740** and to a third transition portion **4503** that connects the fourth portion **4501** to the first portion **4504**, and a fifth portion **4512** that extends from the second end portion **4530** toward the face heel edge **2750** and to a fourth transition portion **4509** that connects the fifth portion **4512** to the third portion **4508**. Accordingly, the back groove **4500** may be partially similar in configuration to the back groove **3500** and extend continuously on the back surface **2066** of the face portion **2062** except for a discontinuity defined by a gap **4540** between the first end portion **4520** and the second end portion **4530**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **46**, the face portion **2062** may include a back groove **4600** having a first portion **4604**, a first transition portion **4605**, a second portion **4606**, a second transition portion **4607**, and a third portion **4608**. The back groove **4600** may also include a first end portion **4620** that may be at or proximate to the face sole edge **2790** and a second end portion **4630** at or proximate to the face sole edge **2790**. The first end portion **4620** may be closer to the face toe edge **2740** than to the face heel edge **2750**, and the second end portion **4630** may be closer to the face heel edge **2750** than to the face toe edge **2740**. The back groove **4600** may further include a fourth portion **4601** that extends from the first end portion **4620** toward the face toe edge **2740** and to a third transition portion **4603** that connects the fourth portion **4601** to the first portion **4604**, and a fifth portion **4612** that extends from the second end portion **4630** toward the face heel edge **2750** and to a fourth transition portion **4609** that connects the fifth portion **4612** to the third portion **4608**. Accordingly, the back groove **4600** may be partially similar in configuration to the back groove **3600** and extend continuously on the back surface **2066** of the face portion **2062** except for a discontinuity defined by a gap **4640** between the first end portion **4620** and the second end portion **4630**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **47**, the face portion **2062** may include a first back groove **4710** and a second back groove **4720**. The first back groove **4710** may include a first end portion **4712**, a first portion **4714**, a transition portion **4715**, a second portion **4716**, and a second end portion **4718**. The first back groove **4710** may be closer to the face toe edge **2740** than to the face heel edge **2750**. The second back groove **4720** may include a first end portion **4722**, a first portion **4724**, a transition portion **4725**, a second portion **4726**, and a second end portion **4728**. The second back groove **4720** may be closer to the face heel edge **2750** than to the face toe edge **2740**. Further, all or significant portions of the first back groove **4710** and the second back groove **4720** may be closer to the face top edge **2780** than to the face sole edge **2790**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **48**, the face portion **2062** may include a first back groove **4810** and a second back groove **4820**. The first back groove **4810** may include a first end portion **4812**, a first portion **4814**, a first transition portion **4815**, a second portion **4816**, a second transition portion **4817**, and a second end portion **4818**. The first back groove **4810** may be closer to the face top edge **2780** than to the face sole edge **2790**. The second back groove **4820** may include a first end portion **4822**, a first portion **4824**, a transition portion **4825**, a second portion **4826**, a second transition portion **4827**, and a second end portion **4828**. The second back groove **4820** may be closer

to the face sole edge **2790** than to the face top edge **2780**. Further, each of the first back groove **4810** and the second back groove **4820** may extend from a location at or proximate to the face toe edge **2740** to a location at or proximate to the face heel edge **2750**. The first back groove **4810** may be proximate to and follow the contours of the face toe edge **2740**, the face top edge **2780**, and the face heel edge **2750**. The second back groove **4820** may be proximate to and follow the contours of the face toe edge **2740**, the face sole edge **2790**, and the face heel edge **2750**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **49**, the face portion **2062** may include a back groove **4900**, which may be similar in many respects to the back groove **3500** except for the first end portion **4902** and the second end portion **4910**. Referring back to the illustrated example of FIG. **35**, the first end portion **3502** and the second end portion **3510** may be circular and can have any diameter as described herein. In another example, as illustrated in FIG. **49**, the first end portion **4902** may be circular with a larger diameter than the first end portion **3502** of FIG. **35**. In another example, as illustrated in FIG. **49**, the second end portion **4910** may have an obround shape (i.e., a rectangle with semicircles at opposite sides). In another example (not shown), the first end portion **4902** and/or the second end portion **4910** may have an elliptical shape. In another example (not shown), the first end portion **4902** and/or the second end portion **4910** may have a triangular shape with rounded vertices. In yet another example (not shown), the first end portion **4902**, the second end portion **4910**, and/or any of the back groove end portions described herein may have any shape and/or any shape without sharp corners or vertices so as to eliminate or reduce any stress concentration regions on the face portion **2062** at or proximate to the back groove. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **50**, the face portion **2062** may include a first back groove **5010** and a second back groove **5020**. The first back groove **5010** may include a first end portion **5012**, a first portion **5014**, a first transition portion **5015**, a second portion **5016**, and a second end portion **5018**. The first back groove **5010** may be closer to the face toe edge **2740** than to the face heel edge **2750**. The second back groove **5020** may include a first end portion **5022**, a first portion **5024**, a transition portion **5025**, a second portion **5026** and a second end portion **5028**. The second back groove **5020** may be closer to the face heel edge **2750** than to the face toe edge **2740**. Further, each of the first back groove **5010** and the second back groove **5020** may extend from a location at or proximate to the face top edge **2780** to a location at or proximate to the face sole edge **2790**. The first back groove **5010** may be proximate to and follow the contours of the face top edge **2780**, the face toe edge **2740**, and the face sole edge **2790**. The second back groove **5020** may be proximate to and follow the contours of the face top edge **2780**, the face heel edge **2750**, and the face sole edge **2790**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **51**, the face portion **2062** may include a back groove **5100** having a first end portion **5102**, a first portion **5104**, a first transition portion **5105**, a second portion **5106**, a second transition portion **5107**, a third portion **5108**, and a second end portion **5110**. The back groove **5100** may extend proximate to and follow the contours of the face top edge **2780**, the face heel edge **2750**, and the face sole edge **2790**. The first end portion **5102** may be at or proximate to the face top edge **2780** and the face toe edge **2740**, and the second end portion **5110** may be at or proximate to the face sole edge **2790** and the face toe edge **2740**. Accordingly, the back groove **5100** may not include an elongated portion between the first end portion **5102** and the second end portion **5110** that extends in a direction from the face top edge **2780** to the face sole edge **2790** at a location at or proximate to the face toe edge **2740**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **52**, the face portion **2062** may include a back groove **5200** having a first end portion **5202**, a first portion **5204**, a first transition portion **5205**, a second portion **5206**, a second transition portion **5207**, a third portion **5208**, and a second end portion **5210**. The back groove **5200** may extend proximate to and follow the contours of the face top edge **2780**, the face toe edge **2740**, and the face sole edge **2790**. The first end portion **5202** may be at or proximate to the face top edge **2780** and the face heel edge **2750**, and the second end portion **5210** may be at or proximate to the face sole edge **2790** and the face heel edge **2750**. Accordingly, the back groove **5200** may not include an elongated portion between the first end portion **5202** and the second end portion **5210** that extends in a direction from the face top edge **2780** to the face sole edge **2790** at a location at or proximate to the face heel edge **2750**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **53**, the face portion **2062** may include a back groove **5300** having a first end portion **5302**, a first portion **5304**, a first transition portion **5305**, a second portion **5306**, a second transition portion **5307**, a third portion **5308**, and a second end portion **5310**. The back groove **5300** may extend proximate to the face toe edge **2740**, the face sole edge **2790**, and the face heel edge **2750**. The first end portion **5302** may be at or proximate to the face top edge **2780** and the face toe edge **2740**, and the second end portion **5310** may be at or proximate to the face top edge **2780** and the face toe edge **2740**. Accordingly, the back groove **5300** may not include an elongated portion between the first end portion **5302** and the second end portion **5310** that extends in a direction from the face toe edge **2740** to the face heel edge **2750** at a location at or proximate to the face top edge **2780**. As illustrated in FIG. **53**, the back groove **5300** may be similar in many respects to the back groove **3500** but may be in an inverted configuration on the back surface **2066** of the face portion **2062** as compared to the back groove **3500**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **54**, the face portion **2062** may include a back groove **5400** having a first portion **5404**, a first transition portion **5405**, a second portion **5406**, a second transition portion **5407**, and a third portion **5408**. The back groove **5400** may also include a first end portion **5420** that may be at or proximate to the face top edge **2780** and a second end portion **5430** at or proximate to the face top edge **2780**. The first end portion **5420** may be closer to the face toe edge **2740** than to the face heel edge **2750**, and the second end portion **5430** may be closer to the face heel edge **2750** than to the face toe edge **2740**. As illustrated in FIG. **54**, the back groove **5400** may be similar in many respects to the back groove **4600** but may be in an inverted configuration on the back surface **2066** of the face portion **2062** as compared to the back groove **4600**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIG. **55**, the face portion **2062** may include a back groove **5500** having a first portion **5504**, a first transition portion **5505**, a second portion **5506**, a second transition portion **5507**, a third portion **5508**, and a third transition portion **5510**, a fourth portion **5512**, and a fourth transition portion **5514**, all of which may define a continuous back groove **5500**. The back groove **5500** may be similar in many respects to the back groove **4300**, except that the fourth portion **5512** may have a convex shape relative to the face sole edge **2790**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIG. **56**, the face portion **2062** may include a back groove **5600** having a first portion **5604**, a first transition portion **5605**, a second portion **5606**, a second transition portion **5607**, a third portion **5608**, and a third transition portion **5610**, a fourth portion **5612**, and a fourth transition portion **5614**, all of which may define a continuous back groove **5600**. The back groove **5600** may be similar in many respects to the back groove **3600**, except that the fourth portion **5612** may have a concave shape relative to the face sole edge **2790**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **57**, the face portion **2062** may include a back groove **5700** having a first end portion **5702**, a first portion **5704**, a first transition portion **5705**, a second portion **5706**, a second transition portion **5707**, a third portion **5708**, and a second end portion **5710**. The back groove **5700** may be similar in many respects to the back groove **3500**, except that the back groove width **5720** of the second portion **5706** may be greater than the back groove width **5720** of the remaining portions of the back groove **5700**. In another example, any one or more of the first portion **5704**, the second portion **5706**, and the third portion **5708** may have similar or different back groove widths and/or back groove depths. Any of the back grooves described herein may have portions with different or similar back groove widths and/or back groove depths. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **58**, the face portion **2062** may include a back groove **5800** having a first portion **5804**, a first transition portion **5805**, a second portion **5806**, a second transition portion **5807**, a third portion **5808**, a third transition portion **5810**, a fourth portion **5812**, and a fourth transition portion **5814**, all of which may define a continuous back groove **5800**. The back groove **5800** may be similar in many respects to the back groove **3600**, except that the back groove width **5820** of the second portion **5806** may vary between the first transition portion **5805** and the second transition portion **5807**. As illustrated in the example of FIG. **58**, the back groove width **5820** may gradually increase from the first transition portion **5805** in a direction toward the second transition portion **5807** to a maximum back groove width **5822** and may gradually decrease from the location of the maximum back groove width **5822** in a direction toward the second transition portion **5807**. Any portion of any of the back grooves described herein may have portions with different or similar back groove widths and/or back groove depths that may increase, decrease in a continuous (i.e., gradual), or discrete manner (i.e., increase or decrease in steps). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **59**, the face portion **2062** may include a first back groove **5900** and a second back groove **5950**. The first back groove **5900** may include a first end portion **5902**, a first portion **5904**, a first transition portion **5905**, a second portion **5906**, a second transition portion **5907**, a third portion **5908**, and a second end portion **5910**. The first back groove **5900** may be similar in many respects to the back groove **3500**. The second back groove **5950** may extend between the first end portion **5902** and the second end portion **5910** and include a second groove first end portion **5952**, a second groove portion **5954**, and a second groove second end portion **5960**. The second groove first end portion **5952** may be proximate to the first end portion **5902**, and the second groove second end portion **5960** may be proximate to the second end portion **5910**. FIG. **59** illustrates an example of multiple back grooves disposed on the back surface **2066** of the face portion **2062** with different configurations. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **60**, the face portion **2062** may include a back groove **6000** having a first portion **6004**, a first transition portion **6005**, a second portion **6006**, a second transition portion **6007**, a third portion **6008**, a third transition portion **6010**, a fourth portion **6012**, and a fourth transition portion **6014**, all of which may define a continuous back groove **6000**. The back groove **6000** may be similar in many respects to the back groove **6000**, and further include a fifth portion **6016** and a sixth portion **6018**, both of which may be located between the first portion **6004** and the third portion **6008** and extend from the second portion **6006** to the fourth portion **6012**. The fifth portion **6016** may be closer to the face toe edge **2740** than to the face heel edge **2750**. The sixth portion **6018** may be closer to the face heel edge **2750** than to the face toe edge **2740**. The back groove **6000** may include any groove portions extending between and/or connecting any two adjacent or opposing pairs of the first portion **6004**, the first transition portion **6005**, the second portion **6006**, the second transition portion **6007**, the third portion **6008**, the third transition portion **6010**, the fourth portion **6012**, and/or the fourth transition portion **6014**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **61**, the face portion **2062** may include a back groove **6100** having a first end portion **6102**, a first portion **6104**, a first transition portion **6105**, a second portion **6106**, a second transition portion **6107**, a third portion **6108**, and a second end portion **6110**. The back groove **5700** may be similar in many respects to the back groove **3500**, and further include a fifth portion **6114** and a sixth portion **6116**, both of which may be located between the second portion **6106** and the face sole edge **2790** and extend from the first portion **6104** and the third portion **6108**. The fifth portion **6114** may be closer to the face top edge **2780** than to the face sole edge **2700**. The sixth portion **6116** may be closer to the face sole edge **2790** than to the face top edge **2780**. The back groove **6100** may include any groove portions extending between and/or connecting any two adjacent or opposing pairs of the first end portion **6102**, the first portion **6104**, the first transition portion **6105**, the second portion **6106**, the second transition portion **6107**, the third portion **6108**, and/or the second end portion **6110**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. **62**, the face portion **2062** may include a first back groove **6200** and the second back groove **6230**. The first back groove **6200** may extend diagonally on the back surface **2066** of the face portion **2062** and include a first end portion **6202** located proximate to the face toe edge **2740** and the face top edge

2780, a second end portion 6206 located proximate to the face heel edge 2750 and the face sole edge 2790, and a groove portion 6204 connecting the first end portion 6202 and the second end portion 6206. The second back groove 6230 may extend diagonally on the back surface 2066 of the face portion 2062 and include a first end portion 6232 located proximate to the face toe edge 2740 and the face sole edge 2790, a second end portion 6236 located proximate to the face heel edge 2750 and the face top edge 2780, and a groove portion 6234 connecting the first end portion 6232 and the second end portion 6236. The groove portion 6204 of the first back groove 6200 and the groove portion 6234 of the second back groove 6230 may intersect at a common groove portion 6220 that may be located at or proximate to a center region of the face portion 2062. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. 63, the face portion 2062 may include a back groove 6300 that may be circular having an inner diameter 6302 that may be within the boundaries of the face portion 2062 as defined by the face toe edge 2740, the face heel edge 2750, the face top edge 2780, and the face sole edge 2790. The back groove 6300 may be located at a center region of the face portion 2062 as illustrated in the example of FIG. 63. In another example the back groove 6300 may be at any location on the back surface 2066 of the face portion 2062. In another example, the back groove 6300 may include a plurality separate or overlapping circular grooves on the back surface 2066 of the face portion. In yet another example, the back groove 6300 may include a plurality separate and concentric circular grooves on the back surface 2066 of the face portion. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. 64, the face portion 2062 may include a back groove 6400 that may be elliptical and located within the boundaries of the face portion 2062 as defined by the face toe edge 2740, the face heel edge 2750, the face top edge 2780, and the face sole edge 2790. A center portion of the back groove 6400 may be located at a center region of the face portion 2062 as illustrated in the example of FIG. 64. In another example the back groove 6400 may be at any location on the back surface 2066 of the face portion 2062. In another example, the back groove 6400 may include a plurality of separate or overlapping elliptical grooves on the back surface 2066 of the face portion. In yet another example, the back groove 6400 may include a plurality of separate or concentric or nested elliptical grooves on the back surface 2066 of the face portion. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, as illustrated in FIG. 65, the face portion 2062 may include a back groove 6500 having a first portion 6504, a first transition portion 6505, a second portion 6506, a second transition portion 6507, and a third portion 6508. The back groove 6500 may be similar in many respects to the back groove 3500, except that the back groove 6500 may not include the first end portion 3502 and the second end portion 3510 of the back groove 3500. The first portion 6504 and the third portion 6508 extend to the face sole edge 2790. Similarly, any portion of any of the back grooves discussed herein may extend to the face toe edge 2740, the face heel edge 2750, the face top edge 2780, or the face sole edge 2790. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In yet another example, as illustrated in FIG. 66, the face portion 2062 may include a back groove 6600 having a curved shape that may be concave relative to the face sole edge 2790. The back groove 6600 may be continuous and extend from a first groove end 6602 at the face sole edge 2790 and proximate to the face toe edge 2740 to a second groove end 6610 at the face sole edge 2790 and proximate to the face heel edge 2750. Similarly, any portion of any of the back grooves discussed herein may have any linear or curved shape and extend to the face toe edge 2740, the face heel edge 2750, the face top edge 2780, or the face sole edge 2790. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

Any one or more of the back grooves illustrated in examples of FIGS. 13, 35, 36, and 43-66, or any one or more portions of the back grooves illustrated in examples of FIGS. 13, 35, 36, and 43-66 may be combined to provide other back groove configurations. In one example, the back surface 2066 of the face portion 2062 may include any one or both of the first back groove 6200 and the second back groove 6230 of FIG. 62 in combination with the back groove 64 of FIG. 64. In another example, the back surface 2066 of the face portion 2062 may include the back groove 3600 of FIG. 36 and the back groove 6300 of FIG. 63. In another example, the back surface 2066 of the face portion 2062 may include the first back groove 4710 and the second back groove 4720 of FIG. 47 and the second back groove 5950 of FIG. 59. In another example, the back surface 2066 of the face portion 2062 may include the back groove 6500 of FIG. 65 and the second back groove 5950 of FIG. 59. In yet another example, the back surface 2066 of the face portion 2062 may include any one or both of the back groove 5010 and the back groove 5020 of FIG. 50, and the back groove 6300 of FIG. 63. Thus, any one or more back grooves or any one or more portions of the back grooves discussed herein and illustrated in FIGS. 13, 35, 36, and 43-66 may be combined to provide any configuration of back groove portions on the back surface 2066 of the face portion 2062. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

As illustrated by the examples of FIGS. 13, 35, 36, and 43-66, the back surface 2066 of the face portion 2062 may have any number of back grooves with any configuration to provide certain performance characteristics for the golf club head 2000. As described herein, an area of the face portion 2062 that may be partially or fully surrounded by one or more back grooves (i.e., partially or fully bound by a back groove portion) may exhibit greater deflection than an area of the face portion 2062 that surrounds the back groove when a golf ball strikes the face portion 2062. Accordingly, certain face portion deflection characteristics may be achieved by providing certain back groove characteristics. In one example and referring back to FIG. 50, the portion of the face portion 2062 that is surrounded by the first back groove 5010 and the portion of the face portion 2062 that is surrounded by the second back groove 5020 may each have a greater deflection that a center region of the face portion 2062. In another example and referring back to FIG. 51, the portion of the face portion 2062 that is surrounded by the back groove 5100 may have a greater deflection at a location that is closer to the face heel edge 2750 than the portion of the back groove 5100 that is closer to the face toe edge 2740. In another example, and referring back to FIG. 54, the portion of the face portion 2062 that is surrounded by the back groove 5400 may have a greater deflection at a location that is closer to the face sole edge 2790 than a portion of the back groove 5400 that is closer to the face top edge 2780. In

yet another example and referring back to FIG. **62**, the greatest deflection of the face portion **2062** may be at or proximate to the common groove portion **6220**. Accordingly, each of the back groove configurations illustrated in the examples of FIGS. **13**, **35**, **36**, and **43-66** may provide a certain performance characteristic for a golf club head. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the example of FIGS. **67-89**, a golf club head **6700** may include a body portion **6710** having a toe portion **6740** with a toe portion edge **6742** and a heel portion **6750** with a heel portion edge **6752** that may include a hosel portion **6755**. A golf club shaft (such as the shaft **104** that is illustrated for example in FIG. **1**) may include one end coupled to the hosel portion **6755** and an opposite end coupled to a golf club grip (such as the grip **106** that is illustrated for example in FIG. **1**) to form a golf club (such as the golf club **100** that is illustrated for example in FIG. **1**). The body portion **6710** may further include a front portion **6760**, a back portion **6770** with a back wall portion **6772**, a top portion **6780** with a top portion edge **6782**, and a sole portion **6790** with a sole portion edge **6792**. The toe portion **6740**, the heel portion **6750**, the front portion **6760**, the back portion **6770**, the top portion **6780**, and/or the sole portion **6790** may partially overlap each other. The toe portion edge **6742**, the heel portion edge **6752**, the top portion edge **6782**, and the sole portion edge **6792** may define a periphery of the body portion **6710**. The golf club head **6700** may be any type of golf club head described herein, such as, for example, an iron-type golf club head or a wedge-type golf club head. The volume of the golf club head **6700**, the materials of construction of the golf club head **6700**, and/or any components thereof may be similar to any of the golf club heads described herein and/or described in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The golf club head **6700** may include a face portion **6762** (i.e., the strike face), which may include a front surface **6764** and a back surface **6766**. The front surface **6764** may include a plurality of front grooves **6768** that may extend between the toe portion **6740** and the heel portion **6750**. The front grooves **6768** may be similar in many respects to any of the front grooves described herein and illustrated in FIGS. **1-38** including depth, width, cross sectional shape, and/or position and any other configuration or property described and illustrated herein. The back surface **6766** of the face portion **6762** may include one or more back grooves that may be similar in many respects to any of the back grooves described herein and illustrated in FIGS. **13**, **35**, **36**, and **43-66**, including depth, width, cross sectional shape, position on the back surface of the face portion **6762** and any other configuration or property described and illustrated herein. Any of the back grooves described herein may be defined by two or more back groove portions. In other words, any of the back grooves described herein may include any number of back groove portions. The configuration and properties of the face portion **6762** and the attachment of the face portion **6762** (e.g., welding) to the body portion **6710** may be similar in many respects to any of the golf club heads described herein and/or described in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The golf club head **6700** may be associated with a ground plane **7110**, a horizontal midplane **7120**, and a top plane **7130**. In particular, the ground plane **7110** may be a plane that is parallel or substantially parallel to the ground and is tangent to the lowest portion of the sole portion edge **6792** when the golf club head **6700** is at an address position (e.g., the golf club head **6700** aligned to strike a golf ball). A top plane **7130** may be a plane that is tangent to the upper most portion of top portion edge **6782** when the golf club head **6700** is at the address position. The ground plane **7110** and the top plane **7130** may be parallel or substantially parallel to each other. The horizontal midplane **7120** may be vertically halfway between the ground plane **7110** and the top plane **7130** and be parallel or substantially parallel to the ground plane **7110**. Further, the golf club head **6700** may be associated with a loft plane **7140** defining a loft angle **7145** (*a*) of the golf club head **6700**. The loft plane **7140** may be a plane that is tangent or coplanar to the face portion **6762**. The loft angle **7145** may be defined by an angle between the loft plane **7140** and a vertical plane **7150** that is normal to the ground plane **7110**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The back wall portion **6772** may include an external ledge portion **6830** defining an upper back wall portion **6820** above the external ledge portion **6830** and a lower back wall portion **6822** below the external ledge portion **6830**. The external ledge portion **6830** may extend outward (i.e., away from the face portion **6762**). The external ledge portion **6830** may include a first external ledge portion **6832** that may extend from a location at or proximate to the toe portion edge **6742** toward the heel portion **6750** and a second external ledge portion **6836** that may extend from a location at or proximate to the heel portion edge **6752** toward the toe portion **6740**. The first external ledge portion **6832** and the second external ledge portion **6836** may meet at a center portion **6773** of the back wall portion **6772**. The first external ledge portion **6832** may extend from the center portion **6773** to a location at or proximate to the toe portion edge **6742** in a downwardly inclined orientation. The second external ledge portion **6836** may extend from the center portion **6773** to a location at or proximate to the heel portion edge **6752** in a downwardly inclined orientation. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The body portion **6710** may include one or more ports, which may be exterior ports and/or interior ports (e.g., located inside the body portion **6710**). The one or more ports may be at any location on the body portion **6710**. For example, any of the inner walls of the body portion **6710** that define the interior cavity **6810** and/or any of the outer walls of the body portion **6710** that define the exterior surfaces of the body portion **6710** may include one or more ports. In the illustrated example of FIGS. **67-89**, the body portion may include a first port region **6925** located below the first external ledge portion **6832** and having a first set of ports **6920** (e.g., illustrated as ports **6921**, **6922**), a second port region **6935** located below the center portion **6773** of the back wall portion **6772** and having a second set of ports **6930** (e.g., illustrated as port **6931**), and third port region **6945** located below the second external ledge portion **6836** and having a third set of ports **6940** (e.g., illustrated as ports **6941** and **6942**). The second port region **6935** may be between the first port region **6925** and the third port region **6945**. Each of the first set of ports **6920**, the second set of ports **6930**, and the third set of ports **6940** may include a single port or a plurality of ports. For example, as illustrated in FIG. **75**, the first set of ports **6920** may include three ports (e.g., e.g., illustrated as ports **6921**, **6922**, and **6923**). The locations, spacing relative to other ports, and any other

property or configuration of each port of the first set of ports **6920**, the second set of ports **6930**, and/or the third set of ports **6940** may be similar in many respects to any of the port regions and/or ports described herein or described in any of the incorporated by reference patent documents. Further, any one or more of the ports of the first set of ports **6920**, the second set of ports **6930**, and/or the third set of ports **6940** may be connected to interior cavity **6810** through which one or more filler materials may be injected into the interior cavity **6810**. In the illustrated example of FIGS. **67-89**, the port **6921** and the port **6941** may be connected to the interior cavity **6810** via opening **6961** and opening **6981**, respectively. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The body portion **6710** may include any number of ports above and/or below the first external ledge portion **6832** and/or the second external ledge portion **6836**. The body portion **6710** may include any number of ports above, below and/or on the horizontal midplane **7120**. The body portion **6710** may include any number of ports on the toe portion edge **6742**, the heel portion edge **6752**, the top portion edge **6782**, and/or the sole portion edge **6792**. The number of ports on the body portion **6710**, the arrangement and/or the configuration of the ports on the body portion **6710** may be similar in many respects to the golf club head **200** or any of the golf club heads described in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The body portion **6710** may include one or more mass portions (e.g., weight portion(s)) at any location on the body portion **6710**. The one or more mass portions may be integral mass portion(s) or separate mass portion(s) that may be coupled to the body portion **6710** at any exterior or interior location on the body portion **6710**. In one example, one or more mass portions may be constructed from a material having a greater density than a density of the material of the body portion. For example, the body portion **6710** may be constructed from steel and one or more mass portions may be constructed from tungsten or tungsten-based materials. In another example, one or more mass portions may be constructed from a material having a lower density than a density of the material of the body portion. For example, the body portion **6710** may be constructed from steel and one or more mass portions may be constructed from a polymer material. In yet another example, one or more mass portions may be constructed from a material having a similar or substantially similar density to a density of the material of the body portion but with different properties. For example, the body portion **6710** may be constructed from steel and one or more mass portions may be constructed from non-steel or other metal or metal alloy. The properties of the mass portions may be determined to provide certain general MOI and CG parameters for the golf club head **6700** or specific MOI and CG parameters that may be optimized for an individual. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the illustrated example of FIGS. **67-89**, the body portion **6710** may include a first set of mass portions **7020** (e.g., illustrated as mass portions **7021** and **7022**), a second set of mass portions **7030** (e.g., illustrated as mass portion **7031**), and a third set of mass portions **7040** (e.g., illustrated as mass portions **7041** and **7042**). The body portion **6710** may include any number of mass portions at any internal or external location on the body portion **6710**. For example, as illustrated in FIG. **75**, the first set of mass portions **7020** may include three mass portions (e.g., illustrated as mass portions **7021**, **7022**, and **7023**). In the example of FIGS. **67-89**, the mass portions of the first set of mass portions **7020** and the third set of mass portions **7020** may be similar to any of the mass portions described herein, such as the mass portions **1800** and **1900** of FIGS. **17-19**, or the mass portions described in any of the incorporated by reference patent documents. The second set of mass portions **7030** may include a single mass portion **7031**, which may be similar to the mass portion **2331** as described herein and illustrated in FIG. **34**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

Each port of the first set of ports **6920** and the third set of ports **6940** may be configured to receive any of the mass portions of the first set of mass portions **7020** and/or the third set of mass portions **7040**, and each port of the second set of ports **6930** may be configured to receive a mass portion of the second set of mass portions **7030**. The configuration and/or physical properties of each port and each mass portion considered individually or collectively (e.g., total mass of two or more mass portions), and the coupling and/or engagement of any of the mass portions and ports may be similar in many respects to any of the ports and mass portions described herein with respect to the golf club head **200**, the golf club head **2000**, or golf club heads of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **67-89**, the first port region **6925**, the second port region **6935** and the third port region **6945** may be partially or fully surrounded by a perimeter groove **6947**, which may visually define a portion or all of the first port region **6925**, the second port region **6935**, and/or the third port region **6945**. The back wall portion **6772** may also include a first backwall groove **6948** that may be located between the toe portion edge **6742** and the second set of ports **6930** and extend from the sole portion edge **6792** to the first external ledge portion **6832**, and a second backwall groove **6949** that may be located between the heel portion edge **6752** and the second set of ports **6930** and extend from the sole portion edge **6792** to the second external ledge portion **6836**. The perimeter groove **6947**, the first backwall groove **6948**, and/or the second backwall groove **6949** may be slots, channels, depressions, or recesses. The mass that may be removed from the body portion **6710** to define the perimeter groove **6947**, the first backwall groove **6948**, and/or the second backwall groove **6949** may be placed at other locations on or inside the body portion **6710** to provide certain MOI, CG location, and golf club performance characteristics without changing or substantially changing the overall mass of the body portion **6710**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, the portion of the body portion **6710** within the perimeter groove **6947** may have a different color, texture, or other visual distinguishing features relative to portions of the body portion **6710** outside of the perimeter groove **6947** to visually define the first port region **6925**, the second port region **6935** and the third port region **6945**. In another example, the portion of the body portion **6710** bound by the perimeter groove **6947**, the first external ledge portion **6832**, and the first backwall groove **6948**; and/or the portion of the body portion **6710** bound by the perimeter groove **6947**, the second external ledge portion **6836**, and the second backwall groove **6949** may have different colors, textures, or other visual distinguishing features relative to portions of the body portion **6710** outside of the perimeter groove **6947** to visually define the first port region **6925**, the

second port region **6935** and/or the third port region **6945**. In another example, the portion of the body portion **6710** within the perimeter groove **6947** may have a dark (e.g., black) color, whereas portions of the body portion **6710** outside of the perimeter groove **6947** may have a light (e.g., silver) color. In another example, the portion of the body portion **6710** within the perimeter groove **6947** may have a light (e.g., silver) color, whereas portions of the body portion **6710** outside of the perimeter groove **6947** may have a dark (e.g., black) color. In another example, the portion of the body portion **6710** bound by the perimeter groove **6947**, the first external ledge portion **6832**, and the first backwall groove **6948**; and/or the portion of the body portion **6710** bound by the perimeter groove **6947**, the second external ledge portion **6836**, and the second backwall groove **6949** may have a dark (e.g., black) color, whereas portions of the body portion **6710** outside of the perimeter groove **6947** may have a light (e.g., silver) color. In yet another example, the portion of the body portion **6710** bound by the perimeter groove **6947**, the first external ledge portion **6832**, and the first backwall groove **6948**; and/or the portion of the body portion **6710** bound by the perimeter groove **6947**, the second external ledge portion **6836**, and the second backwall groove **6949** may have a light (e.g., silver) color, whereas portions of the body portion **6710** outside of the perimeter groove **6947** may have a dark (e.g., black) color. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIG. **90**, a portion of the body portion **6710** below the first external ledge portion **6832** and the second external ledge portion **6836** and/or visually bound by the perimeter groove **6947** may be a mass portion **7011** (e.g., illustrated in FIG. **90** with shading). Accordingly, the mass portion **7011** may extend from the toe portion edge **6742** to the heel portion edge **6752** and from the first external ledge portion **6832** and the second external ledge portion **6836** to the sole portion edge **6792**. The mass portion **7011** may include the first port region **6925**, the second port region **6935**, and the third port region **6945**. Accordingly, the mass portion **7011** may include the first set of ports **6920**, the second set of ports **6930**, and the third set of ports **6940**. The mass portion **7011** may be formed from one or more materials that may have a higher density than the density of the one or more materials of the body portion **6710** (i.e., portions of the body portion **6710** without the mass portion **7011**). In one example, the mass portion **7011** may be formed from a tungsten-based metal or alloy, whereas the body portion **6710** may be formed from steel. The mass portion **7011** may be formed from one or more materials that may have a lower density than the density of the one or more materials of the body portion **6710** (i.e., portions of the body portion **6710** without the mass portion **7011**). In one example, the mass portion **7011** may be formed from an aluminum-based metal or alloy, whereas the body portion **6710** may be formed from steel. In one example, the mass portion **7011** may be integrally formed with the body portion **6710**. In another example, the mass portion **7011** and the body portion **6710** may be separately formed and attached or fastened together. Accordingly, in one example, the body portion **6710** may include a correspondingly formed notch or cutout on the back wall portion **6772** below the first external ledge portion **6832** and the second external ledge portion **6836** to fittingly receive the mass portion **7011**. For example, any one or more of the mass portions **7021**, **7022**, **7031**, **7041**, and **7042** may be used to fasten the mass portion **7011** to the body portion **6710** as described in U.S. Pat. No. 10,512,829, which is incorporated by reference herein. The configuration of the mass portion **7011**, the coupling and/or fastening of the mass portion **7011** to the body portion **6710**, the configuration of the ports **6921**, **6922**, **6931**, **6941**, and **6942** in the mass portion **7011**, and the use of any one or more of the mass portions **7021**, **7022**, **7031**, **7041**, and **7042** to fasten the mass portion **7011** to the body portion **6710** may be similar in many respects to the golf club head described in U.S. Pat. No. 10,512,829, which is incorporated by reference herein. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIG. **91**, a portion of the body portion **6710** between the first external ledge portion **6832** and the sole portion edge **6792**, between the toe portion edge **6742** and the first back wall groove **6948**, and/or visually bound by the perimeter groove **6947** and the first back wall groove **6948** may be a mass portion **7013** (e.g., illustrated in FIG. **91** with shading). Accordingly, the mass portion **7013** may extend from the toe portion edge **6742** to the first back wall groove **6948**, and from the first external ledge portion **6832** to the sole portion edge **6792**. The mass portion **7013** may include the first port region **6925**. Accordingly, the mass portion **7013** may include the first set of ports **6920**. In one example, the mass portion **7013** may be formed from one or more materials that may have a higher density than the density of the one or more materials of the body portion **6710** (i.e., portions of the body portion **6710** without the mass portion **7013**). In another example, the mass portion **7013** may be formed from one or more materials that may have a lower density than the density of the one or more materials of the body portion **6710**. In one example, the mass portion **7013** may be integrally formed with the body portion **6710**. In another example, the mass portion **7013** and the body portion **6710** may be separately formed and fastened together. Accordingly, in one example, the body portion **6710** may include a correspondingly formed notch or cutout on the back wall portion **6772** below the first external ledge portion **6832** to fittingly receive the mass portion **7013**. For example, any one or more of the mass portions **7021** and **7022** may be used to fasten the mass portion **7013** to the body portion **6710**. The configuration of the mass portion **7013**, the coupling and/or fastening of the mass portion **7013** to the body portion **6710**, the configuration of the ports **6921** and **6922** in the mass portion **7013**, and the use of any one or more of the mass portions **7021** and **7022** to fasten the mass portion **7013** to the body portion **6710** may be similar in many respects to the golf club head described in U.S. Pat. No. 10,512,829, which is incorporated by reference herein. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIG. **92**, a portion of the body portion **6710** between the second external ledge portion **6836** and the sole portion edge **6792**, between the heel portion edge **6752** and the second back wall groove **6949**, and/or visually bound by the perimeter groove **6947** and the second back wall groove **6949** may be a mass portion **7015** (e.g., illustrated in FIG. **92** with shading). Accordingly, the mass portion **7015** may extend from the heel portion edge **6752** to the second back wall groove **6949**, and from the second external ledge portion **6836** to the sole portion edge **6792**. The mass portion **7015** may include the third port region **6945**. Accordingly, the mass portion **7015** may include the third set of ports **6940**. In one example, the mass portion **7015** may be formed from one or more materials that may have a higher density than the density of the one or more materials of the body portion **6710** (i.e., portions of the body portion **6710** without the mass portion **7015**). In

another example, the mass portion **7015** may be formed from one or more materials that may have a lower density than the density of the one or more materials of the body portion **6710**. In one example, the mass portion **7015** may be integrally formed with the body portion **6710**. In another example, the mass portion **7015** and the body portion **6710** may be separately formed and fastened together. Accordingly, in one example, the body portion **6710** may include a correspondingly formed notch or cutout on the back wall portion **6772** below the second external ledge portion **6836** to fittingly receive the mass portion **7015**. For example, any one or more of the mass portions **7041** and **7042** may be used to fasten the mass portion **7015** to the body portion **6710**. The configuration of the mass portion **7015**, the coupling and/or fastening of the mass portion **7015** to the body portion **6710**, the configuration of the ports **6941** and **6942** in the mass portion **7015**, and the use of any one or more of the mass portions **7041** and **7042** to fasten the mass portion **7015** to the body portion **6710** may be similar in many respects to the golf club head described in U.S. Pat. No. 10,512,829, which is incorporated by reference herein. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIG. **93**, a portion of the body portion **6710** between the first external ledge portion **6832** and the second external ledge portion **6836** and the sole portion edge **6792** in the top-to-sole direction, and between the first back wall groove **6948** and the second back wall groove **6949** in the toe-to-heel direction, and/or visually bound by the perimeter groove **6947**, the first back wall groove **6948** and the second back wall groove **6949** may be a mass portion **7017** (e.g., illustrated in FIG. **93** with shading). The mass portion **7017** may include the second port region **6935**. Accordingly, the mass portion **7017** may include the second set of ports **6930**. In one example, the mass portion **7017** may be formed from one or more materials that may have a higher density than the density of the one or more materials of the body portion **6710** (i.e., portions of the body portion **6710** without the mass portion **7017**). In another example, the mass portion **7017** may be formed from one or more materials that may have a lower density than the density of the one or more materials of the body portion **6710**. In one example, the mass portion **7017** may be integrally formed with the body portion **6710**. In another example, the mass portion **7017** and the body portion **6710** may be separately formed and fastened together. Accordingly, in one example, the body portion **6710** may include a correspondingly formed notch or cutout on the back wall portion **6772** below the first external ledge portion **6832** and the second external ledge portion **6836** to fittingly receive the mass portion **7017**. For example, the mass portion **7031** may be used to fasten the mass portion **7017** to the body portion **6710**. The configuration of the mass portion **7017**, the coupling and/or fastening of the mass portion **7017** to the body portion **6710**, the configuration of the ports of the second set of ports **6930** in the mass portion **7017**, and the use of the mass portions **7031** to fasten the mass portion **7017** to the body portion **6710** may be similar in many respects to the golf club head described in U.S. Pat. No. 10,512,829, which is incorporated by reference herein. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIG. **94**, the mass portions **7013** and **7017** may be formed as a single mass portion. In another example, as illustrated in FIG. **95**, the mass portions **7015** and **7017** may be formed as a single mass portion. Any two or more of the mass portions of the golf club head **6700** as described herein may be formed as a single mass portion. Any of the mass portions **7013**, **7015**, and **7015** may be formed from the same material as or different material than any of the other mass portions of the golf club head **6700**. The mass portion **7013** may be formed from a material having a greater density or a lower density than the densities of the materials of the mass portions **7015** and **7017**. The mass portion **7015** may be formed from a material having a greater density or a lower density than the densities of the materials of the mass portions **7013** and **7017**. The mass portion **7017** may be formed from a material having a greater density or lower density than the densities of the materials of the mass portions **7013** and **7015**. Any of the mass portions of the first set of mass portions **7020**, the second set of mass portions **7030**, and/or third set of mass portions **7040** may be formed from the same material as or different material than any of the other mass portions of the golf club head **6700**. Accordingly, the material properties such as density and/or location on the body portion **6710** of any of the mass portions of the golf club head **6700** as described herein may be selected to provide certain MOI, CG location, and/or golf club performance characteristics. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The interior cavity **6810** may be partially or entirely filled with one or more filler materials (i.e., a cavity filling material), which may include one or more similar or different types of materials. In one example, as illustrated in FIGS. **67-89**, the interior cavity **6810** may be filled with a filler material **7779** that may be similar to any of the filler materials described herein or described in any of the incorporated by reference patent documents. In another example (not illustrated for FIGS. **67-89**), the interior cavity **6810** may be filled with a first filler material and a second filler material that may be similar to the golf club head **200** or similar to any of the golf club heads described in any of the incorporated by reference patent documents. In one example, as illustrated in FIGS. **67-89**, the filler material **7779** may be injected into the interior cavity **6810** from any of the ports **6921** and **6941**, while the other one of the ports **6921** and **6941** may functions as an air exhaust port through which the air in the interior cavity **6810** that is displaced by the filler material **7779** may exit. Accordingly, as illustrated in FIGS. **67-89**, the filler material **7779** may be molded in the shape of the interior cavity **6810**. In another example, the filler material **7779** may be pre-molded and inserted into the interior cavity **6810** prior to enclosing the interior cavity **6810** with any parts of the body portion **6710** (e.g., welding the face portion **6762** to the front portion **6760**). The interior cavity **6810** may be fully filled or partially filled with one or more filler materials, or fully unfilled. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **76-82**, a width of the interior cavity **6810**, which may be referred to herein as the cavity width **7600**, may vary between the toe portion edge **6742** and the heel portion edge **6752** and may vary between the top portion edge **6782** and the sole portion edge **6792**. The cavity width **7600** may be defined by a distance that is perpendicular to the face portion **6762** and is between the back surface **6766** of the face portion **6762** and an inner surface of the back wall portion **6772**. The body portion **6710** may include a first internal ledge portion **7725**, a second internal ledge portion **7735**, and a third internal ledge portion **7745**. The first internal ledge portion **7725** may be defined by the upper extent of the first port region **6925** as the first port region **6925** may project into the interior cavity

6810. The second internal ledge portion 7735 may be defined by the upper extent of the second port region 6935 as the second port region 6935 may project into the interior cavity 6810. The third internal ledge portion 7745 may be defined by the upper extent of the third port region 6945 as the third port region 6945 may project into the interior cavity 6810. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the illustrated example of FIGS. 67-89, the first internal ledge portion 7725 may be located below and vertically spaced apart from the first external ledge portion 6832. Accordingly, in one example, at any vertical cross section of the body portion 6710 that includes the first port region 6925 (i.e. a cross section of the body portion 6710 defined by a vertical plane that is perpendicular to the face portion 6762 and intersects the first port region 6925), which may be referred to herein as the first cross section and is illustrated in the example cross section of FIG. 79, a first cavity width 7902 located between the first internal ledge portion 7725 and the first external ledge portion 6832 (i.e., the cavity width 7600 at the noted location or region) may be greater than a second cavity width 7904 above the first external ledge portion 6832 and greater than a third cavity width 7906 below the first internal ledge portion 7725. In one example, for at least one of the first vertical cross sections, the largest value of the first cavity width 7902, which may be referred to herein as a maximum cavity width 7910 of the first cross section, may be at a location immediately above the first internal ledge portion 7725 as illustrated in the example cross section of FIG. 79. In another example, for at least one of the first vertical cross sections, the maximum cavity width 7910 may be at a location above the first internal ledge portion 7725 and below the first external ledge portion 6832. Accordingly, the interior cavity 6810 may extend rearward of all or portions of the first port region 6925 and all or portions of any mass portions that may be coupled to the first port region 6925. In other words, portions of the interior cavity 6810 may be farther from the face portion 6762 than all or portions of the first port region 6925 and/or all or portions of any mass portions that may be coupled to the first port region 6925. In one example, as illustrated in FIG. 76, a height of a region of the interior cavity 6810 having the first cavity width 7902 may decrease in a direction toward the toe portion edge 6742. In other words, a distance between the first external ledge portion 6832 and the first internal ledge portion 7725 may decrease in a direction toward the toe portion edge 6742. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the illustrated example of FIGS. 67-89, the second internal ledge portion 7735 may be located below and vertically spaced apart from the first external ledge portion 6832 and the second external ledge portion 6836 at the center portion 6773, which may be referred to herein as the center ledge portion. Accordingly, in one example, at any vertical cross section of the body portion 6710 that includes the second port region 6935 (i.e. a cross section of the body portion 6710 defined by a vertical plane that is perpendicular to the face portion 6762 and intersects the second port region 6935), which may be referred to herein as the second cross section and is illustrated in the example cross section of FIG. 78, a first cavity width 7802 located between the second internal ledge portion 7735 and the center ledge portion (i.e., the cavity width 7600 at the noted location or region) may be greater than a second cavity width 7804 above the center ledge portion and greater than a third cavity width 7806 below the center ledge portion. Accordingly, the interior cavity 6810 may extend rearward of all or portions of the second port region 6935 and all or portions of any mass portions that may be coupled to the second port region 6935. In other words, portions of the interior cavity 6810 may be farther from the face portion 6762 than all or portions of the second port region 6935 and/or all or portions of any mass portions that may be coupled to the second port region 6935. In one example, as illustrated in FIG. 76, a height of a region of the interior cavity 6810 having the first cavity width 7802 may decrease in a direction from the center portion 6773 toward the toe portion edge 6742 and from the center portion 6773 toward the heel portion edge 6752. In other words, a distance between the center ledge portion and the second internal ledge portion 7735 increases in a direction from the center portion 6773 toward the toe portion edge 6742, and a distance between the center ledge portion and the second internal ledge portion 7735 increases in a direction from the center portion 6773 toward the heel portion edge 6752. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In the illustrated example of FIGS. 67-89, the third internal ledge portion 7745 may be located below and vertically spaced apart from the second external ledge portion 6836. Accordingly, in one example, at any vertical cross section of the body portion 6710 that includes the third port region 6945 (i.e. a cross section of the body portion 6710 defined by a vertical plane that is perpendicular to the face portion and intersects the first port region 6945), which may be referred to herein as the third cross section and is illustrated in the example cross section of FIG. 77, the first cavity width 7702 located between the third internal ledge portion 7745 and the second external ledge portion 6836 (i.e., the cavity width 7600 at the noted location or region) may be greater than the second cavity width 7704 above the second external ledge portion 6836 and greater than the third cavity width 7706 below the third internal ledge portion 7745. For at least one of the third cross sections, the largest value of the first cavity width 7702, which may be referred to herein as the maximum cavity width 7710 of the third cross section, may be at a location above the third internal ledge portion 7745 and below the second external ledge portion 6836 as illustrated in the example cross section of FIG. 77. Accordingly, the interior cavity 6810 may extend rearward of all or portions of the third port region 6945 and all or portions of any mass portions that may be coupled to the third port region 6945. In other words, portions of the interior cavity 6810 may be farther from the face portion 6762 than all or portions of the third port region 6945 and/or all or portions of any mass portions that may be coupled to the third port region 6945. In one example, as illustrated in FIG. 76, a height of a region of the interior cavity 6810 having the first cavity width 7702 may decrease in a direction toward the heel portion edge 6752. In other words, a distance between the second external ledge portion 6836 and the third internal ledge portion 7745 may decrease in a direction toward the heel portion edge 6752. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, at a vertical cross section of the body portion 6710 that does not intersect the first port region 6925, the second port region 6935, and the third port region 6945, which may be referred to herein as a non-port region vertical cross section, the maximum cavity width, which is shown for example in FIG. 82 as the cavity width 8210 and the cavity width 8220, may be at or proximate to the sole portion edge 6792 at the non-port region vertical cross section. In another example, as illustrated in FIGS. 80-82,

the cavity width **7600** may increase in a direction extending from the top portion edge **6782** to the sole portion edge **6792** at a non-port region vertical cross section. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The face portion **6762** may be similar in many respects to any of the face portions described herein including the face portions shown in FIGS. **13**, **15**, **16**, **84-38**, and **43-66**. In the illustrated example of FIGS. **67-89**, the face portion **6762** may include a face perimeter **8310** that may include four perimeter sides, which may be a first perimeter side defined by a face portion toe portion edge (referred to herein as the face toe edge **8340**), a second perimeter side defined by a face portion heel portion edge (referred to herein as the face heel edge **8350**), a third perimeter side defined by a face portion top portion edge (referred to herein as face top edge **8380**), and fourth perimeter side defined by a face portion sole portion edge (referred to herein as face sole edge **8390**). The back surface **6766** of the face portion **6762** may include a face recess portion **8300** having a toe-side wall **8342**, a heel-side wall **8352**, a top-side wall **8382**, and a sole-side wall **8392**. In the illustrated example, the toe-side wall **8342** may be proximate to and extend in the same direction as the face toe edge **8340**, the heel-side wall **8352** may be proximate to and extend in the same direction as the face heel edge **8350**, the top-side wall **8382** may be proximate to and extend in the same direction as the face top edge **8380**, and the sole-side wall **8392** may be proximate to and extend in the same direction as the face sole edge **8390**. In one example, the toe-side wall **8342**, the heel-side wall **8352**, the top-side wall **8382**, and the sole-side wall **8392** may extend along at least 25% of the face perimeter **8310**. In another example, the toe-side wall **8342**, the heel-side wall **8352**, the top-side wall **8382**, and the sole-side wall **8392** may extend along at least 50% of the face perimeter **8310**. In another example, the toe-side wall **8342**, the heel-side wall **8352**, the top-side wall **8382**, and the sole-side wall **8392** may extend along at least 75% of the face perimeter **8310**. In yet another example, the toe-side wall **8342**, the heel-side wall **8352**, the top-side wall **8382**, and the sole-side wall **8392** may extend along the entire face perimeter **8310**. In one example, the toe-side wall **8342**, the heel-side wall **8352**, the top-side wall **8382**, and the sole-side wall **8392** may be connected to define a continuous side wall of the face recess portion **8300**. In another example, as illustrated in FIGS. **67-89**, the toe-side wall **8342**, the heel-side wall **8352**, the top-side wall **8382**, and the sole-side wall **8392** may be connected by rounded corners or sidewall transition portions to reduce or eliminate stress concentration regions on the face portion **6762**. Accordingly, as illustrated in FIGS. **83-86**, the face recess portion **8300** may have the same shape as the face portion **6762** and be surrounded by a back surface perimeter portion **8372**, which may be defined by portions of the back surface **6766** of the face portion between the face recess portion **8300** and the face perimeter **8310**. In one example, the area of the face recess portion **8300** may be greater than or equal to 35% of the area of the back surface **6766** of the face portion **6762**. In another example, the area of the face recess portion **8300** may be greater than or equal to 50% of the area of the back surface **6766** of the face portion **6762**. In yet another example, the area of the face recess portion **8300** may be greater than or equal to 75% of the area of the back surface **6766** of the face portion **6762**. The face recess portion **8300** may provide a relatively thinner part of the face portion **6762**. Accordingly, the face recess portion **8300** may provide enhanced deflection of the face portion **6762** as compared to a face portion **6762** without the face recess portion **8300**. In other words, the face recess portion **8300** may provide a trampoline effect for the face portion **6762**. The enhanced deflection of the face recess portion **8300** may provide enhanced rebounding as the face portion **6762** strikes a golf ball, which may increase ball launch angle, decrease ball backspin and/or increase ball carry distance compared to a similar golf club head as the golf club head **2000** but without having the face recess portion **8300**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In another example, the face recess portion **8300** may be rectangular. In another example, the face recess portion **8300** may be circular. In another example, the face recess portion **8300** may be elliptical. In another example, the face recess portion **8300** may have any geometric, symmetrical, asymmetrical, or irregular shape. In another, the face recess portion **8300** may be located closer to the face toe edge **8340** than to the face heel edge **8350**. In another example, the face recess portion **8300** may be located closer to the face heel edge **8350** than to the face toe edge **8340**. In another example, the face recess portion **8300** may be located closer to the face top edge **8380** than to the face sole edge **8390**. In another example, the face recess portion **8300** may be located closer to the face sole edge **8390** than to the face top edge **8380**. In another example, the face recess portion **8300** may include a plurality of separate face recess portions that may include overlapping portions. In yet another example, the face recess portion **8300** may include a plurality of face recess portions that may not include any overlapping portions. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **67-89**, any portion of the face recess portion **8300** may have a face recess portion depth **8320** (D_R). The face recess portion depth **8320** may have any value to provide certain performance characteristics for the golf club head **6700**. The face recess portion depth **8320** may be constant depth, variable depth, or have a combination of constant and variable depths depending on the location on the face portion **6762**. In one example, the face recess portion depth **8320** may be greater than or equal to 0.007 inch (0.183 mm) and less than or equal to 0.024 inch (0.610 mm) (0.007 in $\leq D_R \leq$0.024 in). In another example, the face recess portion depth **8320** may be greater than or equal to 0.008 inch (0.213 mm) and less than or equal to 0.018 inch (0.457 mm) (0.008 in $\leq D_R \leq$0.018 in). In another example, the face recess portion depth **8320** may be greater than or equal to 0.010 inch (0.244 mm) and less than or equal to 0.015 inch (0.381 mm) (0.010 in $\leq D_R \leq$0.015 in). In yet another example, the face recess portion depth **8320** may be greater than or equal to 0.011 inch (0.274 mm) and less than or equal to 0.013 inch (0.335 mm) (0.011 in $\leq D_R \leq$0.013 in). The face recess portion depth **8320** may be constant or substantially constant (considering manufacturing tolerances) along any one or more portions of face recess portion **8300** or along the entire face recess portion **8300**. Any portion of face recess portion **8300** may have any cross-sectional shape. Accordingly, the face recess portion depth **8320** at any one or more portions may vary according to corresponding variations in the cross-sectional shape of the face recess portion depth **8320**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The back surface **6766** of the face portion **6762** may include one or more grooves, slots, channels, depressions, or recesses, any of which may be referred to herein as back grooves and may define any structure on the back surface **6766** that may provide a relatively decreased face thickness.

The back surface **6766** may include a back groove that me be similar to any of the back grooves described herein such as any of the back grooves illustrated in FIGS. **35-38** and **43-66**. In the illustrated example of FIGS. **67-89**, the back surface **6766** may include a back groove **8400** that may be similar in many respects to the back groove **3500** of FIG. **35**. Accordingly, the back groove **8400** may include a first end portion **8402**, a first portion **8404**, a first transition portion **8405**, a second portion **8406**, a second transition portion **8407**, a third portion **8408**, and a second end portion **8410**. In one example, as illustrated in FIG. **84**, the first end portion **8402** may be proximate to the face toe edge **8340** and proximate to the face sole edge **8390**. The first end portion **8402** may be circular as illustrated in FIG. **84** to eliminate or reduce stress concentration regions on the face portion **6762** at or proximate to the first end portion **8402**. The first portion **8404** may extend from the first end portion **8402** toward the face top edge **8380**. In the illustrated example of FIG. **84**, the first portion **8404** may be linear and extend vertically from the first end portion **8402** toward the face top edge **8380**. In another example, the first portion **8404** may extend from the first end portion **8402** toward the face top edge **8380** with a curvature that may be similar or substantially similar to the curvature or contour of the face toe edge **8340**. In yet another example, the first portion **8404** may be inwardly curved. The first portion **8404** may then transition to the second portion **8406** via the first transition portion **8405** located proximate to the face toe edge **8340** and proximate to the face top edge **8380**. The first transition portion **8405** may be curved to eliminate or reduce stress concentration regions on the face portion **6762** at or proximate to the first transition portion **8405**. The second portion **8406** may extend from the first transition portion **8405** toward the face heel edge **8350**. The second portion **8406** may be linear and have the same orientation and contour as the face top edge **8380**. The second portion **8406** may then transition to the third portion **8408** via the second transition portion **8407** located proximate to the face heel edge **8350** and proximate to the face top edge **8380**. The second transition portion **8407** may be curved to prevent or reduce stress concentration regions on the face portion **6762** at or proximate to the second transition portion **8407**. The third portion **8408** may extend from the second transition portion **8407** toward the second end portion **8410** to the second end portion **8410**. The second portion **8406** may be linear and have the same orientation and contour as the face heel edge **8350**. The second end portion **8410** may be located proximate to the face heel edge **8350** and proximate to the face sole edge **8390**. The second end portion **8410** may be circular as illustrated in FIG. **84** to eliminate or reduce stress concentration regions on the face portion **6762** at or proximate to the second end portion **8410**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

As illustrated in FIGS. **67-89**, the back groove **8400** may be in the face recess portion **8300** and define an inner area **8462** and an outer area **8464** of the face portion **6762**. The inner area **8462** may correspond to an area of the face recess portion **8300** that may be partially or fully surrounded by the back groove **8400**. The outer area **8464** may correspond to portions of the back surface **6766** of the face portion **6762** that partially or fully surround the back groove **8400**. The inner area **8462** may correspond to or include a portion of the face portion **6762** that may generally strike a golf ball. As discussed herein, the back groove **8400** may provide a relatively thinner part of the face portion **6762** as compared to the remaining parts of the face portion **6762**. Accordingly, in addition to the enhanced deflection of the face portion **6762** provided by the relatively thinner portions of the face portion **6762** that are provided by the face recess portion **8300** as described herein, the back groove **8400** may provide relatively thinner portions of the face portion **6762** as compared to the face recess portion **8300** to further enhance deflection of the inner area **8462** relative to the outer area **8464** as compared to a face portion **6762** with the face recess portion **8300** but without the back groove **8400**. In other words, the back groove **8400** may provide a trampoline effect for the inner area **8462** of the face portion **6762**. The enhanced deflection of the inner area **8462** may provide enhanced rebounding of the inner area **8462** after the face portion **6762** strikes a golf ball, which may increase ball launch angle, decrease ball backspin and/or increase ball carry distance compared to a similar golf club head as the golf club head **2000** but without having the back groove **8400**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **67-89**, any portion of the back groove **8400** may include a back groove width **8510** (W_{BG}) and a back groove depth **8520** (D_{BG}). The back groove width **8510** (W_{BG}) may have any value to provide certain performance characteristics for the golf club head **2000**. The back groove width **8510** may be similar in many respects to any of the example back groove widths described herein. Accordingly, in one example, the back groove width **8510** may be greater than or equal to 0.050 inch (1.270 mm) and less than or equal to 0.200 inch (5.080 mm) (0.050 in $\leq W_{BG} \leq$0.200 in). In another example, the back groove width **8510** may be greater than or equal to 0.094 inch (2.381 mm) and less than or equal to 0.156 inch (3.969 mm) (0.094 in $\leq W_{BG} \leq$0.156 in). In another example, the back groove width **8510** may be greater than or equal to 0.109 inch (2.778 mm) and less than or equal to 0.141 inch (3.572 mm) (0.109 in $\leq W_{B}G \leq$0.141 in). In yet another example, the back groove width **8510** may be greater than or equal to 0.120 inch (3.048 mm) and less than or equal to 0.130 inch (3.302 mm) (0.120 in $\leq W_{BG} \leq$0.130 in). The back groove width **8510** may be constant or substantially constant (considering manufacturing tolerances) along any one or more portions of back groove **8400** or along the entire back groove **8400**. The back groove width **8510** may vary at a certain portion or portions of the back groove **8400**. Any portion of back groove **8400** may have any cross-sectional shape. Accordingly, the back groove width **8510** at any one or more portions may vary according to corresponding variations in the cross-sectional shape of the back groove **8400**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **67-89**, any portion of the back groove **8400** may include a back groove depth **8520** (D_{BG}). The back groove depth **8520** (D_{BG}) may have any value to provide certain performance characteristics for the golf club head **2000**. The back groove depth **8520** may be similar in many respects to any of the example back groove depths described herein. Accordingly, in one example, the back groove depth **8520** may be greater than or equal to 0.003 inch (0.076 mm) and less than or equal to 0.015 inch (0.381 mm) (0.003 in $\leq D_{BG} \leq$0.015 in). In another example, the back groove depth **8520** may be greater than or equal to 0.005 inch (0.133 mm) and less than or equal to 0.009 inch (0.222 mm) (0.005 in $\leq D_{B}G \leq$0.009 in). In another example, the back groove depth **8520** may be greater than or equal to 0.006 inch (0.156 mm) and less than or equal to 0.008 inch (0.200 mm) (0.006 in $\leq D_{BG} \leq$0.008 in). In yet another example, the back groove depth **8520** may be greater

than or equal to 0.0065 inch (0.1651 mm) and less than or equal to 0.0075 inch (0.1905 mm) (0.0065 in $\leq D_{BG} \leq 0.0075$ in). The back groove depth **8520** may be constant or substantially constant (considering manufacturing tolerances) along any one or more portions of back groove **8400** or along the entire back groove **8400**. The back groove depth **8520** may vary at a certain portion or portions of the back groove **8400**. Any portion of back groove **8400** and/or any portion of the back groove **3600** may have any cross-sectional shape. Accordingly, the back groove depth **8520** at any one or more portions may vary according to corresponding variations in the cross-sectional shape of the back groove **8400**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **87** and **88**, the face portion **6762** may include a first face thickness **8550** (T_1), a second face thickness **8552** (T_2), a third face thickness **8554** (T_3), a fourth face thickness **8556** (T_4), a fifth face thickness **8558** (T_5), and a sixth face thickness **8560** (T_6). The first face thickness **8550** may be defined by a distance between the front surface **6764** and the back surface **6766** of the face portion **6762** at a location on the face portion **6762** that does not include any portion of a front groove **6768**, any portion of the face recess portion **8300**, and any portion of the back groove **8400**. The first face thickness **8550** may have any value to provide certain performance characteristics for the golf club head **6700**. The first face thickness **8550** may be similar in many respects to the first face thickness **3750** described herein. Accordingly, in one example, the first face thickness **8550** may be greater than or equal to 0.025 inch (0.635 mm) and less than or equal to 0.125 inch (3.175 mm) (0.025 in $\leq T_1 \leq 0.125$ in). In another example, the first face thickness **8550** may be greater than or equal to 0.047 inch (1.181 mm) and less than or equal to 0.078 inch (1.969 mm) (0.047 in $\leq T_1 \leq 0.078$ in). In another example, the first face thickness **8550** may be greater than or equal to 0.054 inch (1.858 mm) and less than or equal to 0.070 inch (1.772 mm) (0.054 in $\leq T_1 \leq 0.070$ in). In another example, the first face thickness **8550** may be greater than or equal to 0.060 inch (1.524 mm) and less than or equal to 0.065 inch (1.651 mm) (0.060 in $\leq T_1 \leq 0.065$ in). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The second face thickness **8552** may be defined by a distance between the front surface **6764** of the face portion **6762** and a bottom surface of the face recess portion **8300** at a location on the face portion **6762** that does not include any portion of the back groove **8400** or any portion of a front groove **6768**. Accordingly, the second face thickness **8552** may be determined by subtracting the face recess portion depth **8320** from the first face thickness **8550** ($T_2=T_1-D_R$). The third face thickness **8554** (shown in FIG. **77**) may be defined by a distance between a bottom surface of a front groove **6768** and the back surface **6766** of the face portion **6762** at a location on the face portion **6762** that does not include any portion of the face recess portion **8300** and any portion of the back groove **8400**. Accordingly, the third face thickness **8554** may be determined by subtracting the front groove depth **6769** from the first face thickness **8550** ($T_3=T_1-D_FG$). The front groove depth **6769** may be similar in many respects to any of the front groove depths described herein. Accordingly, in one example, the front groove depth **6769** may be greater than or equal to 0.005 inch (0.127 mm) and less than or equal to 0.025 inch (0.635 mm) (0.005 in $\leq D_FG \leq 0.025$ in). In another example, the front groove depth **6769** may be greater than or equal to 0.011 inch (0.267 mm) and less than or equal to 0.018 inch (0.445 mm) (0.011 in $\leq D_{FG} \leq 0.018$ in). In another example, the front groove depth **6769** may be greater than or equal to 0.012 inch (0.311 mm) and less than or equal to 0.016 inch (0.400 mm) (0.012 in $\leq D_FG \leq 0.016$ in). In yet another example, the front groove depth **6769** may be greater than or equal to 0.013 inch (0.33 mm) and less than or equal to 0.015 inch (0.381 mm) (0.013 in $D_{FG} \leq 0.015$ in). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The fourth face thickness **8556** may be defined by a distance between the front surface **6764** of the face portion **6762** and a bottom surface of the back groove **8400** at a location of the face portion **6762** that does not include any portion of a front groove **6768**. Accordingly, the fourth face thickness **8556** may be determined by subtracting the back groove depth **8520** and the face recess portion depth **8320** from the first face thickness **8550** ($T_4=T_1-D_{BG}-D_R$). The fifth face thickness **8558** may be defined by a distance between a bottom surface of a front groove **6768** and a bottom surface of the face recess portion **8300** at a location on the face portion **6762** that does not include any portion of the back groove **8400**. Accordingly, the fifth face thickness **8558** may be determined by subtracting the front groove depth **2069** and the face recess portion depth **8320** from the first face thickness **8550** ($T_5=T_1-D_{FG}-D_R$). The sixth face thickness **8560** may be defined by a distance between a bottom surface of a front groove **6768** and a bottom surface of the back groove **8400** at a location on the face portion **6762** that includes a portion of a front groove **6768** and an opposing portion of a back groove **8400**. Accordingly, the sixth face thickness **8560** may be determined by subtracting the front groove depth **2069**, the face recess portion depth **8320**, and the back groove depth **8520** from the first face thickness ($T_6=T_1-D_{FG}-D_R-D_{BG}$). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, the first face thickness **8550** may define the largest thickness of the face portion **6762** and the sixth face thickness **8560** may define the smallest thickness of the face portion **6762**. In another example, the first face thickness **8550** may be larger than the second face thickness **8552**, which may be larger than the third face thickness **8554**, which may be larger than the fourth face thickness **8556**, which may be larger than the fifth face thickness **8558**, and which may be larger than the sixth face thickness **8560** ($T_1>T_2>T_3>T_4>T_5>T_6$). In another example, the first face thickness **8550** may be greater than the second face thickness **8552**, the third face thickness **8554**, and the fourth face thickness **8556** ($T_1>T_2$, $T_1>T_3$, $T_1>T_4$). In another example, the second face thickness **8552** may be greater than the fourth face thickness **8556** ($T_2>T_4$). In another example, the third face thickness **8554** may be greater than the fourth face thickness **8556** ($T_3>T_4$). In another example, the second face thickness **8552** may be greater than the third face thickness **8554** ($T_2>T_3$). In another example, the third face thickness **8554** may be greater than the second face thickness **8552** ($T_3>T_2$). In another example, the second face thickness and the third face thickness may be equal ($T_2=T_3$). In yet another example, the fifth face thickness **8558** may be greater than the sixth face thickness **8560**. As described herein, the first face thickness **8550** may define the largest thickness of the face portion **6762** and the sixth face thickness **8560** may define the smallest thickness of the face portion **6762**, whereas the relative values of the second face thickness **8552**, the third face thickness **8554**, the fourth face thickness **8556**, and the fifth face thickness **8558** may depend on the values of the face recess portion depth **8320**, the back groove depth **8520**, and the front groove depth **6769**. Face thick-

nesses, front groove depths and widths, and/or back groove depths and widths and the relationships between these parameters for the golf club head **6700** may be similar in many respects to the any of the face thicknesses, front groove depths and widths, and/or back groove depths and widths described herein and shown in FIGS. **20-66**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, the face recess portion **8300** may cover at least 50% of the back surface **6766** of the face portion **6762**. In another example, the face recess portion **8300** may cover at least 60% of the back surface **6766** of the face portion **6762**. In another example, the face recess portion **8300** may cover at least 75% of the back surface **6766** of the face portion **6762**. In another example, the face recess portion **8300** may cover between 35% and 85% of the back surface **6766** of the face portion **6762**. In another example, the face recess portion **8300** may cover between 50% and 75% of the back surface **6766** of the face portion **6762**. In yet another example, the face recess portion **8300** may cover all or a substantial portion of the face portion **6762** that has a very high probability of striking a golf ball. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The face recess portion **8300** and the back groove **8400** may provide for a face portion **6762** having a lower mass than a similar face portion without the face recess portion **8300** and the back groove **8400**. In other words, the face recess portion **8300** and the back groove **8400** provide a certain amount of mass to be removed from the face portion **6762**. The removed or saved mass may be relocated to other portions of the body portion **6710** to provide certain CG, MOI, and/or performance characteristics for the golf club head **6700**. In one example, the removed mass representing the face recess portion **8300** and the back groove **8400** may be greater than equal to 2.5 grams and less than or equal to 10 grams. In another example, the removed mass representing the face recess portion **8300** and the back groove **8400** may be greater than equal to 4 grams and less than or equal to 8 grams. In another example, the removed mass representing the face recess portion **8300** and the back groove **8400** may be greater than equal to 4.5 grams and less than or equal to 6.5 grams. In yet another example, the removed mass representing the face recess portion **8300** and the back groove **8400** may be greater than equal to 4.5 grams and less than or equal to 6 grams. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The face recess portion **8300** and the back groove **8400**, which enhance rebounding for the face portion **6762** as described herein, and in combination with the one or more filler materials in the interior cavity **6810**, may provide a high coefficient of restitution (COR) for the golf club head **6700**. In one example, the COR may be at least 0.80. In another example, the COR may be at least 0.81. In another example, the COR may be at least 0.82. In another example, the COR may be at least 0.83. In yet another example, the COR may be greater than 0.83. The properties of the face recess portion **8300**, the back groove **8400**, and the one or more filler materials as described herein may be determined to achieve a high COR while still conforming to the rules of golf established by one or more golf governing bodies. In other words, the properties of the face recess portion **8300**, the back groove **8400**, and the one or more filler materials as described herein may be determined to achieve a maximum conforming COR. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

As described herein, the interior cavity **6810** may be filled with one or more filler materials, such as the filler material **7779** or any of the filler materials described herein or described in any of the incorporated by reference patent documents. The filler material may structurally support the relatively thinner portions of the face portion **6762** at locations in and/or proximate to the face recess portion **8300** and/or the back groove **8400**. In one example, as illustrated in FIGS. **67-89**, the entire face recess portion **8300** and the entire back groove **8400** may be filled with a filler material. In another example, portions of the face recess portion **8300** and/or portions of the back groove **8400** may be filled with a filler material. In another example, all or portions of the face recess portion **8300** and all or portions of the back groove **8400** may be filled with a filler material that may have different physical properties than another filler material in the interior cavity **6810**. In another example, a portion of the face recess portion **8300** and/or a portion of the back groove **8400** may be filled with a first filler material, whereas another portion of the face recess portion **8300** and/or another portion of the back groove **8400** may be filled with a second filler material having one or more different physical properties than the first filler material. In yet another example, the face recess portion **8300** and/or the back groove **8400** may be unfilled. The configuration (e.g., depth, width, location on the face portion, cross-sectional shape) of the face recess portion **8300** and/or the back groove **8400** may determine the physical properties of the one or more filler materials and the amount of the one or more filler materials that may be used to fill the back groove **8400** and/or the interior cavity **6810**. The filler material may structurally support the relatively thinner portions of the face portion **6762** to prevent failure of the face portion **6762** or prolong the life of the face portion **6762** (i.e., fatigue life), provide vibration dampening, provide sound dampening, provide a pleasant sound and feel for an individual using the golf club head **6700**, and/or provide any function described herein or in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The golf club head **2000** may be manufactured by any of the methods described herein, such as the method illustrated in FIG. **14**, or the methods described in any of the incorporated by reference applications. The back groove may be manufactured with the face portion or formed on the face portion after manufacturing the face portion by any method of creating grooves, channels, slots, slits, depressions, dimples, recesses, or in general reducing a thickness of a portion of an object. For example, the back groove may be machined on the back surface of the face portion. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

FIG. **96** depicts one manner by which the golf club head **6700** or any of the golf club heads described herein may be manufactured. In the example of FIG. **96**, the process **9600** may begin with providing a hollow body portion (block **9602**). The process may include forming a face portion having a front surface and a back surface (block **9604**), forming two or more front groove portions on the front surface of the face portion (block **9606**), forming a face recess portion on the back surface of the face portion (block **9608**), and forming two or more back groove portions in the face recess portion (block **9610**). The process may further include coupling the face portion to the hollow body portion

(block **9612**). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

FIGS. **97-105** illustrate another example face portion **9762** having a front surface **9764** and a back surface **9766**. The face portion **9762** may be similar in many respects to the face portion **6762**. Accordingly, similar parts of the face portion **6762** and the face portion **9762** are referred to herein with the same reference numbers. In one example, as illustrated in FIGS. **97-105**, the face portion **9762** may include a ridge portion **9802** extending from a first location **9804** on the back surface perimeter portion **8372** proximate to the face sole edge **8390** toward the face toe edge **8340** and face top edge **8380** and then toward the face heel edge **8350** and the face sole edge **8390** to a second location **9806** on the back surface perimeter portion **8372** proximate to the face sole edge **8390**. The first location **9804** and the second location **9806** may be the same location. In one example, as illustrated in FIGS. **97-105**, the second location **9806** may be spaced apart from the first location **9804** and between the first location **9804** and the face heel edge **8350**. In other words, in one example as illustrated in FIGS. **97-105**, the ridge portion **9802** may be defined by a circular closed-loop rib portion projecting outward from the inner area **8462** of the back surface **9766** of face portion **9762**. As illustrated in FIGS. **97-105**, a portion of the closed-loop rib portion may be defined by a portion of the back surface perimeter portion **8372** proximate to the face sole edge **8390**. In the example of FIGS. **97-105**, the ridge portion **9802** may be circular. In another example (not shown), the ridge portion **9802** may have any geometric or non-geometric shape. The ridge portion **9802** may have any thickness. In one example, as illustrated in FIGS. **97-104**, the thickness of the ridge portion, i.e., thickness of the face portion **9762** at the ridge portion **9802** may be same or substantially the same as (e.g., considering manufacturing tolerances) as the thickness of the face portion **9762** at the back surface perimeter portion **8372**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The ridge portion **9802** may include an outer ridge portion **9822**, an inner ridge portion **9824**, and a ridge portion top **9826**. The outer ridge portion **9822** and the inner ridge portion **9824** may extend outward from the inner area **8462** of the back surface **9766** to the ridge portion top **9826**. The outer ridge portion **9822** and the inner ridge portion **9824** may be curved or chamfered to reduce stress concentration at regions located at or around the ridge portion **9802**. The ridge portion **9802** may divide the inner area **8462** into a first inner area **9832** surrounded by the ridge portion **9802** and a second inner area **9834** between the ridge portion **9802** and the back groove **8400** (i.e., the remaining portions of the inner area **8462** that falls outside the ridge portion **9802**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, as illustrated in FIGS. **97-105**, the face portion **9762** may include a wall portion **9902** that may be coupled or attached to the ridge portion top **9826**. The wall portion **9902** may be constructed from the same material or a different material as the face portion **9762** and attached to the ridge portion top **9826** by welding, soldering, mechanical locking, and/or one or more adhesives, which may depend on the materials of the face portion **9762** and/or the materials of the ridge portion **9802**. The wall portion **9902** may have the same shape as the ridge portion top **9826** such that when coupled or attached to the ridge portion top **9826**, the ridge portion **9802** and the wall portion **9902** define a second interior cavity portion **10564** inside the interior cavity **6810**, which may be also referred to herein as the first interior cavity portion **6810**. In other words, the first inner area **9832**, the ridge portion **9802**, and the wall portion **9902** define a volume, which defines the second interior cavity portion **10564** on the back surface **9766** of the face portion **9762**. The wall portion **9902** may have a wall portion height **9904** that may be constant or vary. In one example, as illustrated in FIGS. **97-104**, the wall portion height **9904** may increase from a first wall portion side **9906** to a second wall portion side **9908** opposite side the first wall portion side **9906**. Accordingly, a depth of the second interior cavity portion **10564** may increase from the first wall portion side **9906** to the second wall portion side **9908**. In another example, the wall portion height **9904** may be constant from the first wall portion side **9906** to the second wall portion side **9908**. Accordingly, a depth of the second interior cavity portion **10564** may be constant from the first wall portion side **9906** to the second wall portion side **9908**. The wall portion height **9904** may vary, be constant, partially vary, or change in stepwise or continuous manner according to any shape or profile. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

As illustrated in the example of FIGS. **97-105**, the wall portion **9902** may be coupled or attached to the ridge portion **9802** such that the depth of the second interior cavity portion **10564** increases in a top-to-sole direction. Accordingly, the distance between the first wall portion side **9906** and the face top edge **8380** may be less than a distance between the second wall portion side **9908** and the face top edge **8380**. In another example, the wall portion **9902** may be coupled or attached to the ridge portion **9802** such that the depth of the second interior cavity portion **10564** increases in a sole-to-top direction. In another example, the wall portion **9902** may be coupled or attached to the ridge portion **9802** such that the depth of the second interior cavity portion **10564** increases in a heel-to-toe direction. In yet another example, the wall portion **9902** may be coupled or attached to the ridge portion **9802** such that the depth of the second interior cavity portion **10564** increases in a toe-to-heel direction. The wall portion **9902** may be coupled or attached to the ridge portion **9802** such that the depth of the second interior cavity portion **10564** increase in any direction (e.g., a diagonal direction). The variation in the wall portion height **9904** and the corresponding variation in the depth of the second interior cavity portion **10564** may depend on a loft angle of a golf club head. For example, the rate of increase of wall portion height **9904** from the first wall portion side **9906** to the second wall portion side **9908** may increase with an increase in loft angle. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The face portion **9762** may be used with any of the golf club heads described herein. In one example, as illustrated in FIGS. **104** and **105**, a golf club head **10400** may include a body portion **10410** having a toe portion **10440** with a toe portion edge **10442**, a heel portion **10450** with a heel portion edge **10452**, a front portion **10460**, a back portion **10470** with a back wall portion **10472**, a top portion **10480** with a top portion edge **10482**, and a sole portion **10490** with a sole portion edge **10492**, an external port **10530** configured to receive a port sleeve **10532**, which is configured to receive an external mass portion **10534**, and an internal port **10540** configured to receive an internal mass portion **10544**. The golf club head **10400** may be similar in many respects to the golf club head described in U.S. patent application Ser. No. 18/526,106, filed Dec. 1, 2023, the disclosure of which is

incorporated by reference herein. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The face portion **9762** as described herein may couple to the front portion **10460** to enclose a first interior cavity portion **10562**. As described herein, the ridge portion **9802** and the wall portion **9902** may define a second interior cavity portion **10564**. As described herein, and illustrated in FIG. **104**, the wall portion height **9904** may increase in a top-to-sole direction. Accordingly, as described herein and illustrated in FIG. **104**, the depth of the second interior cavity portion **10564** may increase in a top-to-sole direction. The first interior cavity portion **10562** and the second interior cavity portion **10564** may be filled with any of the filler materials described herein or described in any of the incorporated by reference patent documents. The first interior cavity portion **10562** may be filled with a first filler material **10572** and the second interior cavity portion **10564** may be fille with a second filler material **10574**. The first filler material **10572** and the second filler material **10574** may be the same material. The first filler material **10572** and the second filler material **10574** may be different materials or include at least one different physical property. In one example, the first filler material **10572** may have a higher coefficient of restitution (e.g., COR>0.80) than the second filler material **10574**, and the second filler material **10574** may have better vibration dampening than the first filler material **10572**. Accordingly, the golf club head **10400** may provide relatively greater ball carry distance due to the higher COR of the first filler material **10572** and the flexure of the face portion **9762**, while providing relatively greater consistency and forgiveness for off-center shots. In another example, the second filler material **10574** may have a greater COR than the first filler material **10572** and the first filler material **10572** may provide greater vibration dampening than the second filler material **10574**. The first interior cavity portion **10562** and the second interior cavity portion **10564** may be filled with any filler material having one or more physical properties to provide a certain performance characteristic for the golf club head **10400**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The ridge portion **9802** and/or the wall portion **9902** may provide additional structural support for the face portion **9762**. Accordingly, all or certain portions of the face portion **9762** may have smaller thicknesses than the same portions of the face portion **6762** that does not include the ridge portion **9802** and/or the wall portion **9902**. In one example, the thicknesses of all or certain portions of the face portion **6762** may be reduced by 5% to 10% as compared to the same portions of the face portion **9762** that does not include the ridge portion **9802** and/or the wall portion **9902**. In another example, the thicknesses of all or certain portions of the face portion **6762** may be reduced by 10% to 15% as compared to the same portions of the face portion **9762** that does not include the ridge portion **9802** and/or the wall portion **9902**. In yet another example, the thicknesses of all or certain portions of the face portion **6762** may be reduced by 15% to 25% as compared to the same portions of the face portion **9762** that does not include the ridge portion **9802** and/or the wall portion **9902**. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The ridge portion **9802** may be circular and located on the face portion **9762** as illustrated in the example of FIGS. **97-105** and configured to include all or portions of the sweet spot of the face portion **9762** or all or portions of the face portion **9762** that have a high probability of striking a golf ball. In another example, as illustrated in FIG. **106**, the ridge portion **9802** and the wall portion **9902** (not shown in FIG. **106**) may be partially semi-elliptical with an angled orientation to include a larger area of the back surface **9766** of the face portion **9762**. In yet another example, as illustrated in FIG. **107**, the ridge portion **9802** and the wall portion **9902** (not shown in FIG. **107**) may have a shape or profile similar to the back groove **8400**. The ridge portion **9802** and the wall portion **9902** may have any shape or profile to provide certain performance characteristics for a golf club having the face portion **9762**. The ridge portion **9802** and the wall portion **9902** and any filler materials associated with the ridge portion **9802** and the wall portion **9902** may be applied to any type of golf club head and any type of face portion such as a face portion without any back face grooves, face portions having a uniform thickness throughout, or other face portions having various grooves, dimples, projections and/or certain thickness profiles. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

FIG. **108** depicts one manner by which the golf club head **10400** or any of the golf club heads described herein may be manufactured. In the example of FIG. **108**, the process **10800** may begin with providing a body portion of a golf club head that may be any type of golf club head or a golf club head that is similar to any of the golf club heads described herein (block **10810**) or described in any of the incorporated by reference patent documents. A face portion, such as the face portion **9762** may be manufactured or formed including the ridge portion **9802** and the wall portion **9902** as described herein (block **10820**). The face portion **9762** may be attached to the body portion of the golf club head (block **10830**) to the define the first interior cavity portion **10562** and the second interior cavity portion **10564** as described herein. The second interior cavity portion **10564** may be filled with the second filler material **10574** from one or more ports on the body portion that are connected to the first interior cavity portion **10562** and/or the second interior cavity portion **10564** (block **10840**). To fill the second interior cavity portion **10564** and/or cure the second filler material **10574** in the second interior cavity portion **10564**, the golf club head may be positioned so that the second filler material top portion **10575** (i.e., the top planar portion) is horizontally oriented. The second filler material **10574** may be cured at room temperature and/or pressure or at elevated temperatures and/or pressures depending on the type of filler material used. The first interior cavity portion **10562** may then be filled with the first filler material **10572** from one or more ports on the body portion that are connected to the first interior cavity portion **10562** and the second interior cavity portion **10564** (block **10850**). Any ports on the body portion may then receive corresponding mass portions as described herein or be closed by any type of plug, screw, adhesive, or other closure methods. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

Any of the mass portions described herein may be constructed from a material having a greater density than one or more materials of a body portion of a golf club head. In one example, any of the mass portions described herein may be constructed from tungsten or tungsten-based materials, whereas the body portion may be constructed from one or more materials having a lower density than tungsten or tungsten-based materials such as aluminum, steel, titanium, and/or composite materials. Any of the mass portions described herein may be similar in some physical properties but different in other physical properties. For example, a

mass portion may be made from an aluminum-based material or an aluminum alloy whereas another mass portion may be made from a tungsten-based material or a tungsten alloy. In another example, a mass portion may be made from a polymer material whereas another mass portion may be made from a steel-based material. Any of the mass portions described herein may be constructed from a material having a lower density than one or more materials of a body portion of a golf club head. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

Any of the golf club heads described herein may be an iron-type golf club head (e.g., a 1-iron, a 2-iron, a 3-iron, a 4-iron, a 5-iron, a 6-iron, a 7-iron, an 8-iron, a 9-iron, etc.), or a wedge-type golf club head (e.g., a pitching wedge, a lob wedge, a sand wedge, an n-degree wedge such as 44 degrees (°), 48°, 52°, 56°, 60°, etc.). Although a particular type of club head may be depicted and described, the apparatus, methods, and articles of manufacture described herein may be applicable to other types of club heads (e.g., a driver-type club head, a fairway wood-type club head, a hybrid-type club head, a putter-type club head, etc.). The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

The body portion and/or the face portion of any of the golf club heads described herein may be partially or entirely made of a steel-based material (e.g., 17-4 PH stainless steel, Nitronic® 50 stainless steel, alloy steel 8620, maraging steel, High Strength HT1770 Maraging Grade Stainless Steel Material, or other types of stainless steel), a titanium-based material, an aluminum-based material (e.g., a high-strength aluminum alloy or a composite aluminum alloy coated with a high-strength alloy), any combination thereof, non-metallic materials, composite materials, and/or other suitable types of materials. The body portion and/or the face portion may be constructed with materials that are similar to any of the body portions and/or face portions described herein or in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, the area of the front surface of the face portion of any of the golf club heads described herein may be greater than or equal to 330 mm^2 and less than or equal to 5000 mm^2. In another example, the area of the front surface of the face portion of any of the golf club heads described herein may be greater than or equal to 1000 mm^2 and less than or equal to 5300 mm^2. In yet another example, the area of the front surface of the face portion of any of the golf club heads described herein may be greater than or equal to 1500 mm^2 and less than or equal to 4800 mm^2. While the above examples may describe particular areas, the area of the front surface may greater than or less than those numbers. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

In one example, a filler material as described herein may include an elastic polymer or an elastomer material (e.g., a viscoelastic urethane polymer material such as Sorbothane® material manufactured by Sorbothane, Inc., Kent, Ohio), a thermoplastic elastomer material (TPE), a thermoplastic polyurethane material (TPU), other polymer material(s), bonding material(s) (e.g., adhesive), and/or other suitable types of materials that may absorb shock, isolate vibration, and/or dampen noise. In another example, a filler material may be one or more thermoset polymers having bonding properties (e.g., one or more adhesive or epoxy materials). A material may also absorb shock, isolate vibration, and/or dampen noise when a golf club head as described herein strikes a golf ball. Further, a filler material may be an epoxy material that may be flexible or slightly flexible when cured. In another example, a filler material may include any of the 3M™ Scotch-Weld™ DP100 family of epoxy adhesives (e.g., 3M™ Scotch-Weld™ Epoxy Adhesives DP100, DP100 Plus, DP100NS and DP100FR), which are manufactured by 3M corporation of St. Paul, Minnesota. In another example, a filler material may include 3M™ Scotch-Weld™ DP100 Plus Clear adhesive. In another example, a filler material may include low-viscosity, organic, solvent-based solutions and/or dispersions of polymers and other reactive chemicals such as MEGUM™, ROBOND™, and/or THIXON™ materials manufactured by the Dow Chemical Company, Auburn Hills, Michigan. In yet another example, a filler material may be LOCTITE® materials manufactured by Henkel Corporation, Rocky Hill, Connecticut. In another example, a filler material may be a polymer material such as an ethylene copolymer material that may absorb shock, isolate vibration, and/or dampen noise when a golf club head strikes a golf ball via the face portion. In another example, a filler material may be a high density ethylene copolymer ionomer, a fatty acid modified ethylene copolymer ionomer, a highly amorphous ethylene copolymer ionomer, an ionomer of ethylene acid acrylate terpolymer, an ethylene copolymer comprising a magnesium ionomer, an injection moldable ethylene copolymer that may be used in conventional injection molding equipment to create various shapes, an ethylene copolymer that can be used in conventional extrusion equipment to create various shapes, an ethylene copolymer having high compression and low resilience similar to thermoset polybutadiene rubbers, and/or a blend of highly neutralized polymer compositions, highly neutralized acid polymers or highly neutralized acid polymer compositions, and fillers. For example, the ethylene copolymer may include any of the ethylene copolymers associated with DuPont™ High-Performance Resin (HPF) family of materials (e.g., DuPont™ HPF AD1172, DuPont™ HPF AD1035, DuPont® HPF 1000 and DuPont™ HPF 2000), which are manufactured by E.I. du Pont de Nemours and Company of Wilmington, Delaware. The DuPont™ HPF family of ethylene copolymers are injection moldable and may be used with conventional injection molding equipment and molds, provide low compression, and provide high resilience, i.e., relatively high coefficient of restitution (COR). In another example, any one or more of the filler materials described herein may be formed from one or more metals or metal alloys, such as aluminum, copper, zinc, and/or titanium. A filler material not specifically described in detail herein may include one or more similar or different types of materials described herein and in any of the incorporated by reference patent documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

Any of the filler materials described herein may be subjected to different processes during manufacturing of any of the golf club heads described herein. Such processes may include one or more filler materials being heated and/or cooled by conduction, convection, and/or radiation during one or more injection molding processes or post injection molding curing processes. For example, all of the heating and cooling processes may be performed by using heating or cooling systems that employ conveyor belts that move a golf club head described herein through a heating or cooling environment for a period of time as described herein. The processes of manufacturing a golf club head with one or more filler materials may be similar to any of the processes described in any of the incorporated by reference patent

documents. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

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.).

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 cubic centimeters (cm^3 or 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.

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.

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.

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.

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 3D printing or molding a golf club head from metal or non-metal materials such as ceramics.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

What is claimed is:

1. A golf club head comprising:

a hollow body portion having a first interior cavity portion and a face portion, the face portion comprising:

a front surface;

a back surface opposite the front surface;

a face perimeter portion having a perimeter edge defined by a face toe edge, a face heel edge, a face top edge, and a face sole edge;

a face recess portion on the back surface located within the face perimeter portion, the face recess portion having a first depth on the back surface relative to the face perimeter portion;

a back groove in the face recess portion, the back groove having a second depth on the back surface relative to the face perimeter portion, the second depth being greater than the first depth;

a ridge portion extending rearwardly away from the back surface and extending from a portion of the face perimeter portion proximate to the face sole edge toward the face top edge; and

a wall portion having a first wall portion end coupled to the ridge portion and extending rearwardly away from the ridge portion to a second wall portion end;

a first filler material; and

a second filler material,

wherein a volume bound by the face recess portion, the ridge portion, and the wall portion defines a second interior cavity portion,

wherein the first interior cavity portion is at least partially filled with the first filler material, and

wherein the second interior cavity portion is at least partially filled with the second filler material.

2. A golf club head as defined in claim **1**, wherein the ridge portion has a circular shape.

3. A golf club head as defined in claim **1**, wherein the ridge portion comprises an inner ridge portion, an outer ridge portion, and a ridge portion top between the inner ridge portion and the outer ridge portion, and wherein the wall portion is attached to the ridge portion top.

4. A golf club head as defined in claim **1**, wherein the wall portion includes a wall portion height defined by a distance between the first wall portion end and the second wall portion end, and wherein the wall portion height decreases in a sole-to-top direction.

5. A golf club head as defined in claim **1**, wherein the back groove comprises a first back groove portion between the

ridge portion and the face toe edge, a second back groove portion between the ridge portion and the face top edge, and a third back groove portion between the ridge portion and the face heel edge.

6. A golf club head as defined in claim **1**, wherein the back groove is at least partially filled with the first filler material.

7. A golf club head as defined in claim **1**, wherein a thickness of the face portion at the ridge portion is a same as or substantially a same as a thickness of the face portion at or proximate to the face perimeter portion.

8. A golf club head comprising:

a hollow body portion including a first interior cavity portion at least partially filled with a first filler material, the hollow body portion having a front portion with a front opening;

a second filler material;

a face portion coupled to the front portion to close the front opening, the face portion comprising:

a front surface;

a back surface opposite the front surface;

a face perimeter portion having a perimeter edge defined by a face toe edge, a face heel edge, a face top edge, and a face sole edge;

a face recess portion on the back surface and having a recess perimeter portion at least partially surrounded by the face perimeter portion, the face recess portion having a first depth on the back surface relative to the face perimeter portion; and

a plurality of back groove portions in the face recess portion, the plurality of back groove portions extending proximate to the recess perimeter portion along at least 50% of the recess perimeter portion, each back groove portion of the plurality of back groove portions having a second depth on the back surface relative to the face perimeter portion, the second depth being greater than the first depth,

a ridge portion extending from a portion of the face perimeter portion proximate to the face sole edge toward the face top edge; and

a wall portion having a first wall portion end coupled to the ridge portion and extending rearwardly away from the ridge portion to a second wall portion end to define a second interior cavity portion in the hollow body portion;

wherein the second interior cavity portion is at least partially filled with the second filler material, and

wherein a coefficient of restitution of the first filler material is different from a coefficient of restitution of the second filler material.

9. A golf club head as defined in claim **8**, wherein the plurality of back groove portions at least partially surround the ridge portion.

10. A golf club head as defined in claim **8**, wherein the ridge portion forms a continuous loop on the back surface of the face portion.

11. A golf club head as defined in claim **8**, wherein the wall portion includes a wall portion height defined by a distance between the first wall portion end and the second wall portion end, and wherein the wall portion height decreases in a sole-to-top direction.

12. A golf club head as defined in claim **8**, wherein the plurality of back groove portions comprise a first back groove portion between the ridge portion and the face toe edge, a second back groove portion between the ridge portion and the face top edge, and a third back groove portion between the ridge portion and the face heel edge.

13. A golf club head as defined in claim **8**, wherein the plurality of back groove portions are at least partially filled with the first filler material.

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