UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

PARSONS XTREME GOLF, LLC
Petitioner,

v.

TAYLOR MADE GOLF COMPANY, INC.
Patent Owner.

Inter Partes Review No.: (unassigned)

U.S. Patent No. 7,494,425

DECLARATION OF KEN GALL IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,494,425

PXG
Ex. 1003

TABLE OF CONTENTS

Page

I, Ken Gall, Ph.D., declare as follows:

1. I have been retained by the law firm of Ballard Spahr LLP, who represents Parsons Xtreme Golf, LLC ("PXG") to provide expert testimony in support of PXG's Petition for *Inter Partes* Review of U.S. Patent No. 7,494,425 (the "Petition"), filed concurrently with this Declaration.

2. I understand that this proceeding involves U.S. Patent No. 7,494,425 ("the '425 Patent") titled "GOLF CLUB HEAD." I also understand that the '425 patent issued on February 24, 2009 from U.S. App. No. 11/879,780 filed on July 17, 2007. I also understand that the '425 Patent claims the benefit of U.S. App. No. 10/316,453, filed on December 11, 2002 ("Priority Date").

3. I have been asked to provide my opinion regarding whether one of ordinary skill in the art at the time of the Priority Date would understand that certain prior art references, in combination, disclose or teach each of the elements and limitations recited in claims 1-6, 8-10, and 12-22 of the '425 Patent. I have also been asked to provide my opinion regarding whether one of ordinary skill in the art would have had a rationale to combine certain prior art references.

4. In forming my opinion, I have relied on my own experience and knowledge and my review of the '425 Patent and the prior art references identified in this declaration.

I. QUALIFICATIONS AND COMPENSATION

5. I am currently a professor in the Mechanical Engineering and Materials Science Department at Duke University, where I have been a faculty member since 2015.

6. I received a Ph.D. in Mechanical Engineering in 1998 from the University of Illinois at Urbana Champaign.

7. Since 1998, I have held the following academic appointments:

- Post-Doc at Sandia National Laboratories from 1998-1999;
- Assistant Professor at the University of Colorado at Boulder from 1999-2003;
- Associate Professor at the University of Colorado at Boulder from 2003-2005;
- Associate Professor at the Georgia Institute of Technology from 2005-2007;
- Professor at the Georgia Institute of Technology from 2007-2015.

8. From 2004 to 2017, I mentored 19 Ph.D. students to the completion of the Ph.D. degree.

9. In addition to my academic appointments, I have also founded several start-up companies. The relevant projects are listed below.

10. In 2005, I founded MedShape, an orthopedic device company MedShape's products are based on shape memory polymers for soft tissue reconstruction (Eclipse, ExoShape, Morphix) and shape memory alloys for foot

and ankle joint fusion (DynaNail) and are sold in the orthopedic medical device market. MedShape's annual revenue is nearly $10M and two of its product lines have won industry-level device design excellence awards. MedShape's sports medicine division was acquired by ConMed in 2017.

11. In 2013 I founded Vertera, a developer of a surface porous PEEK spinal fusion cage for both Cervical Fusion (Cohere) and Lumbar Fusion (Coalesce). Vertera was acquired by NuVasive in 2017.

12. I have authored over 225 scientific publications in peer-reviewed journals including, but not limited to, publications in *Nature Materials*, *Advanced Engineering Materials*, *Acta Materialia*, *Engineering Fracture Mechanics*, *International Journal of Fatigue*, and *Physical Review Letters*.

13. I am a co-inventor on 20 patents.

14. I have taught over a thousand students on the deformation, fracture, and fatigue of materials, including welds and many geometrically and microstructurally complex materials. I have spent multiple years consulting on sporting equipment including golf clubs and mountain bikes, including work on engineering alloys and composites.

15. Additional details about my employment history, fields of expertise, and publications are included in my curriculum vitae (attached as Appendix A).

16. For my work related to this *Inter Partes* Review, I am being compensated at the rate of $650.00 per hour.

17. I have no financial interest in this proceeding, and my compensation is not conditioned on or impacted by the content of my testimony or the outcome of this proceeding.

II. MATERIALS CONSIDERED

18. In forming my opinions, I read and considered the ‘425 Patent and its prosecution history, the exhibits listed in the Exhibit List filed with the petition for *inter partes* review of the ’425 Patent, as well as any other material referenced herein.

III. THE’425 PATENT

A. Background

19. The challenged claims of the ’425 Patent are directed to a “wood-type golf club head,” i.e., the part of a golf club that strikes a golf ball. More particularly, the challenged claims are directed to hollow golf club heads manufactured from metals and composite materials (rather than the traditional solid “wood”). By the 1980s, hollow-metal golf club heads were becoming the more prevalent type of wood-type golf club head on the market. Hollow-metal golf club heads are much lighter than an equivalently sized solid wood head. Thus, the hollow-metal club heads could be made larger for a larger “sweet spot.” By the

late 1990s, club heads with volumes from 175 to 400 cc were being developed. *See, e.g.*, PXG1006, 2:27-28; PXG1007, 3:26-30. To achieve these larger sizes, manufacturers began using metal alloys that have a lower density (e.g., titanium alloys) but that are still strong enough to withstand an impact with a golf ball. *See, e.g.*, PXG1008, 2:45-54; PXG1007, 5:51-54.

20. By at least 1992, manufacturers began experimenting with using a combination of materials in a golf club head. *See, e.g.*, PXG1009, 2:29-31; PXG1008, 2:45-51; PXG1010, 3:54-61. There are a number of reasons to use different materials in a golf club head. For example, since titanium is expensive, manufacturers have an incentive to replace some of the titanium with a less expensive metal alloy in areas subject to less stress. *See, e.g.*, PXG1008, 1:26-29; PXG1006, 1:27-30. By using materials with different densities, manufacturers can also adjust the center of gravity ("CG") of the club, which can improve a golf club's properties. *See, e.g.*, PXG1009, 3:10-20; PXG1010, 4:11-16.

21. Another reason to optimize the materials in a golf club head is to maximize the distance a golf ball may be hit. To achieve this goal, among other things, golf manufacturers seek to maximize what is known as the coefficient of restitution ("COR"). *See, e.g.*, PXG1004, 10:8-11; PXG1005, 13:18-21. COR is a measure of the efficiency of the transfer of momentum between two colliding bodies. The value of COR ranges from 0 to 1, where 1 would be a perfect elastic

collision (no loss of incoming energy) and 0 would be a perfect inelastic collision (complete dissipation of incoming energy). *See, e.g.*, PXG1004, 10:26-31; PXG1005, 13:35-40. To increase COR, manufacturers have designed club heads and club head faces (also known as striking plates) that deform and recover during impact, providing a trampoline effect and increasing COR. *See, e.g.*, PXG1005, 12:42-49. In 1998, the United States Golf Association ("USGA") set the COR limit for woods at 0.822 with a test tolerance of 0.007 effectively taking the limit up to 0.83. *See* PXG1019, Appendix B, 1.0, 2.0, Fig. B-1. Thus, at least since 1998, manufacturers have been seeking to make golf clubs that can achieve a COR up to the limit allowed by the USGA. *See, e.g.*, PXG1005, 13:43-47.

22. To achieve these goals, by 1995 if not sooner, manufacturers began using composite material, such as graphite-epoxy, for the crown of a golf club head. *See, e.g.*, PXG1004, 7:54-57, 8:43-48; PXG1009, 3:1-3; PXG1011, 6:45-46. Since this material has a combined higher strength and lower density than metal, it helps keep the weight of the golf club low, allowing for larger club head sizes and faster swing speeds. By having a lighter material on the top of the club head, a composite crown also moves the center of gravity lower, which improves loft and may improve the "forgiveness" of the club. *See, e.g.*, PXG1009, 3:10-20.

23. At least since 1992, golf club manufacturers have also used separately formed "face inserts" or "striking plates" that are attached to a front opening on the

body of a golf club head to improve them. *See, e.g.*, PXG1005 7:33-35; PXG1006, 3:40-45; PXG1012, 2:55-59; PXG1008, 3:52-55, 66-67; PXG1010, 3:36-43. For example, the striking plate (front) could be made from a lower density, higher strength material than the golf club body to shift the CG to the rear. *See, e.g.*, PXG1008, 2:58 – 3:3; PXG1012, 2:22-24. A separately attached striking plate may also reduce vibrations which would be inherent in a club head with an integrally formed striking plate. *See, e.g.*, PXG1012, 2:29-32. Moreover, by using a separately formed striking plate, it can be optimized for strength by using a different metal alloy or different manufacturing process as compared to the club head body, which has a more complex shape that limits practical manufacturing processes and the use of high strength materials. *See, e.g.*, PXG1005, 7:36-45; PXG1006, 3:43-56. For example, a golf head body may be composed of a cast metal material, and the striking plate may be composed of a forged or formed metal material for increased strength. *See, e.g.*, PXG1005, 7:36-38; PXG1006, 2:41-45. Because the striking plate can be made of a stronger material, the striking plate may be made thinner than with an integrally-formed striking plate. *See, e.g.*, PXG1010, 3:64 - 4:4. This may improve the ability of the striking plate to deform and recover during impact, improving COR.

B. Priority Claim

24. I understand that ’425 Patent issued from U.S. App. No. 11/879,780, filed on July 17, 2007, which is a continuation of U.S. App. No. 11/186,022, filed on July 21, 2005, which is a continuation of U.S. Patent App. No. 10/634,023, filed on August 4, 2003, which is a continuation-in-part of U.S. App. No. 10/316,453, filed on December 11, 2002. PXG1001 at 1:6-11. Thus, I have been informed that the earliest possible priority date for the challenged claims is December 11, 2002 (“Priority Date”).

C. Overview of the ‘425 Patent

25. The ’425 Patent is directed to a “golf club head” as generally shown in annotated Figure 1 of the ’425 Patent below.

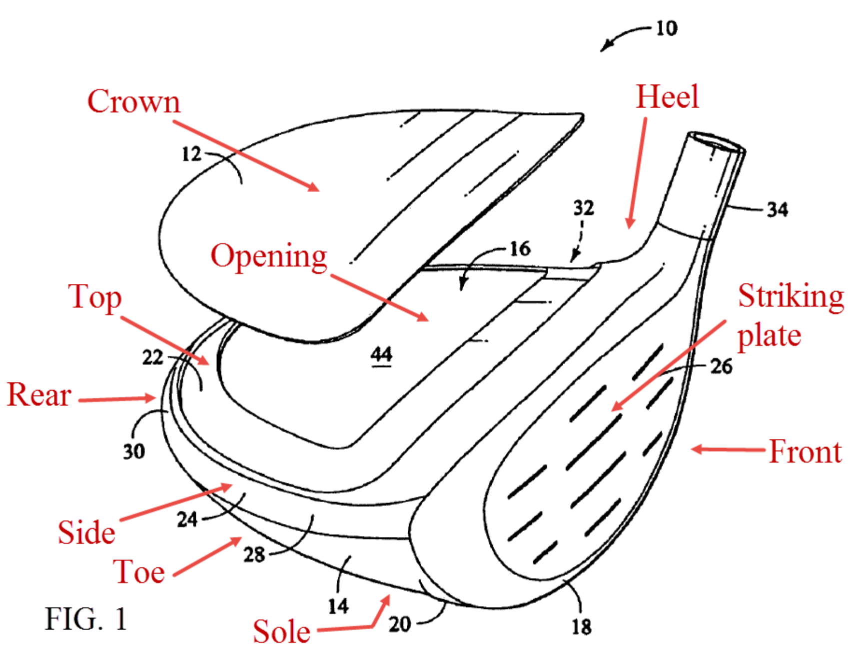


FIG. 1

26. With reference to Figure 1 above, the ’425 Patent discloses the typical structure for a wood-type golf club head having a hollow body 14, which has “a front 18, a sole 20, a top portion 22, and a side portion 24.” PXG1001, 4:35-36. “The side portion 24 extends rearwardly from the front 18 and has a toe region 28, a rear region 30 and a heel region 32.” PXG1001, 4:53-54. “At the front, a striking plate 26 is separately formed and attached to the front of the body in any manner known to those skilled in the art” as shown in annotated Figure 4 of the ’425 Patent below. *Id*., 4:36-39.

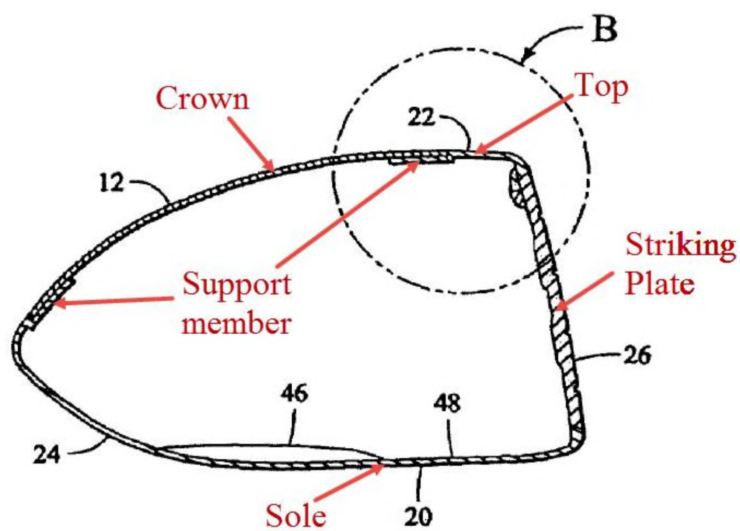


FIG. 4

27. As is also typical in prior art golf club heads, the golf club head 10 includes a separately formed crown 12. *Id*., 4:31-33. In Figure 1 above, the crown 12 has not yet been attached to the body 14 to enclose opening 16. *Id*., Fig. 1. To enable attachment of crown 12 to the body 14, the opening 16 includes a support

member that surrounds the opening, such as a ledge or a plurality of tabs. *Id*., 4:63-67.

28. Once the crown 12 is attached over the opening 16 and the striking plate is attached to the front 18 of the body 14, "the sole 20, top portion 22, front 18 and side portion combine with the crown 12 to form a hollow body having a volume of at least 150 cubic centimeters (cc) and up to 500 cc." *Id*., 4:59-62.

29. The '425 Patent teaches the use of standard materials to manufacture the golf club head. For example, "the body is formed of any metal, such as an aluminum, steel or titanium alloy." *Id*., 4:33-35. "[T]he striking plate may be formed of a different alloy or grade of the same metal as the body, or the striking plate may be a different metal or a composite material, as desired." *Id*., 4:39-42. And finally, the crown 12 is made of a composite material, such as a graphite-epoxy composite material. *Id*., 4:31-32, 6:14-16. The '425 Patent asserts that the use of a composite crown 12 on a metal body 14 increases the coefficient of restitution (COR). *Id*., 6:21-22.

D. The Challenged Claims

30. In this proceeding, PXG is challenging claims 1-6, 8-10, and 12-22 of the '425 Patent. Claims 1 and 22 are the only independent claims. By way of example, claim 1provides:

1. A golf club head, comprising:

> a body having a sole, a front defining a front opening, a top portion defining an upper opening, an upper edge disposed between and separating the front opening and the upper opening, and a side portion, the side portion extending rearward of the front opening and having toe, rear, and heel regions, wherein the body is comprised of a metallic material having a density of at least about 4 g/cc;
>
> a striking plate welded to the body portion, enclosing the front opening;
>
> a weight portion attached to an interior surface of the club head; and
>
> a crown attached to the body enclosing the upper opening, the crown incorporating composite material and having a density between 1 g/cc and 2 g/cc,
>
> wherein the golf club head has a maximum coefficient of restitution of at least 0.80 and a volume of at least 150 cc.

Challenged claims 2-4, 8-10, 12-15, 17, and 20-21 each depend from claim 1 and merely recite slight design variations or claim certain compositions of the materials, all for the same club head of claim 1. Independent claim 22 is very similar to claim 1, except the claim does not recite "a weight portion" or a density limitation for the crown, but does recite "a shoulder disposed around the periphery of the upper opening, and a recessed support extending from the shoulder and positioned adjacent to the upper opening."

IV. LEGAL STANDARDS

31. I have been told the following legal principles apply to analysis of patentability based on 35 U.S.C. § 103. I also have been told that, in an *inter partes* review proceeding, a patent claim may be deemed unpatentable if it is shown by a preponderance of the evidence that the claim is rendered obvious by one or more prior art patents or publications under § 103.

A. Level of Ordinary Skill in the Art

32. I understand that "one of ordinary skill in the art" is not a specific, real individual, but rather a hypothetical individual who is presumed to have known the relevant art at the time of the invention. In defining "one of ordinary skill in the art," I have been advised to consider factors such as (A) the types of problems encountered in the art; (B) prior art solutions to those problems; (C) speed of innovation in the field; (D) sophistication of the technology; and (E) educational level of active workers in the field.

33. Based on these factors and my experience in this area, I have assessed the level of ordinary skill in the art based upon my review of the prior art. A person of ordinary skill in the art would have a person of ordinary skill in the art for the '425 Patent would have (1) a bachelor's degree in mechanical engineering, materials science engineering, physics, or an equivalent degree or coursework, and

(2) at least one year of experience researching or developing golf club heads, and/or methods of their manufacture.

34. I was at least a person of ordinary skill in the art and have rendered my opinions in this Declaration from the view point of one of ordinary skill in the art as of the Priority Date.

B. Claim Construction

35. I understand that in this proceeding the claims of the ‘425 Patent should be understood based on their broadest reasonable construction in light of the ‘425 Patent’s specification. Unless otherwise noted, my opinions in this declaration are consistent with the broadest reasonable construction of the claims to a person of ordinary skill in the art at the Priority Date.

1. “upper opening”

36. I have been informed that the Board has construed the term “upper opening” as used in the challenged claims as requiring that “the upper opening is located entirely within the top portion.” For purposes of my opinions in this declaration, I have adopted this construction.

2. “crown”

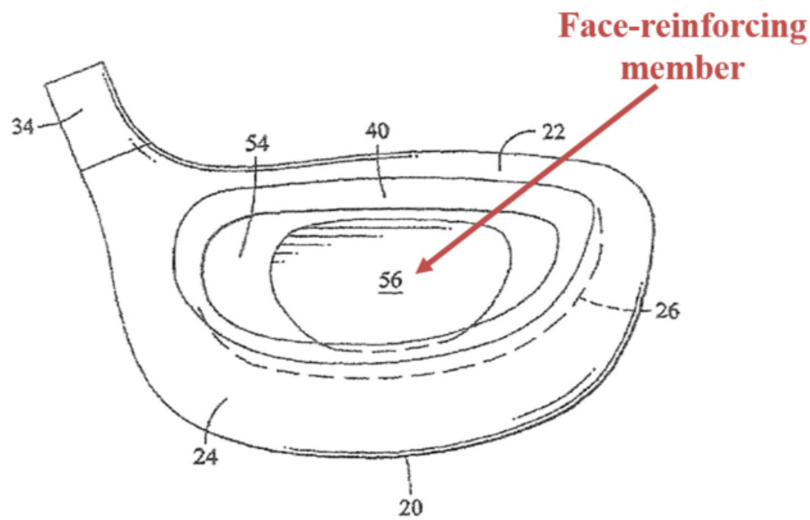
37. I have been informed that in a related proceeding the Board has construed the term “crown” as requiring “that the crown be located entirely within the top portion.” For purposes of my opinions in this declaration, I have adopted this construction.

3. “face-reinforcing member”

38. Claim 5 recites “[a] golf club head as defined in claim 1, further comprising a face reinforcing member coupled to a rear surface of the striking plate.” This claim term should be construed to mean “a separate piece that is attached to the rear of the face plate.” In my opinion, the use of the term “coupled” would indicate to a skilled artisan that the face-reinforcing member is a separate piece that is directly or indirectly attached or connected to the rear surface of the striking plate (i.e., not integrally formed with the striking plate).

39. This definition is consistent with the ’425 patent specification. For example, the ’425 Patent provides that “[b]ecause of the access afforded by the opening in the top 22 of the club head 10, a rear [*sic*] of the striking face 54 is accessible during manufacture for the ***addition*** of a face reinforcing member 56 [formed] of metal or composite material and securely ***attached*** behind the sweet spot, as shown in FIG. 7.” PXG1001, 7:13-18. Figure 7 also shows the face reinforcing member 56 as separate piece. *Id.*, Fig. 7 (annotated).

FIG. 7



Based on the foregoing passage and Figure 7 in the specification, it is my opinion that a skilled artisan would understand that the "face reinforcing member" is a separate piece that is attached to the striking plate after the club head body and striking plate are formed, and prior to enclosing the opening in the top of the body of the club head—not something that is integrally formed with the striking plate.

40. I have been informed that in the Related Litigation, TMG asserts that "face-reinforcing member" should be construed to mean "a component that improves face strength." Even under the BRI standard, TMG's construction is overly broad and would encompass portions that are integrally formed with the striking plate, such as thickened portions of a striking plate. In my opinion, a skilled artisan would not consider such integrally-formed, thickened portions to be a "face-reinforcing member" as that term is used in claim 5. However, in the event the Board adopts TMG's construction of "face-reinforcing member," as discussed

further below, my opinion is that *Helmstetter's* striking plate discloses this limitation.

C. Obviousness

41. I understand that "[a] patent may not be obtained though the invention is not identically disclosed or described . . . , if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." 35 U.S.C. § 103.

42. When considering the issues of obviousness, I have been told that I am to do the following:

a. Determine the scope and content of the prior art;

b. Ascertain the differences between the prior art and the claims at issue;

c. Resolve the level of ordinary skill in the pertinent art; and

d. Consider evidence of secondary indicia of non-obviousness (if available).

43. I have been told that a reference may be modified or combined with other references or with the person of ordinary skill's own knowledge if the person would have found the modification or combination obvious. I have also been told that a person of ordinary skill in the art is presumed to know all the relevant prior

art, and the obviousness analysis may take into account the inferences and creative steps that a person of ordinary skill in the art would employ.

44. In determining whether a prior-art reference could have been combined with another prior-art reference or other information known to a person having ordinary skill in the art, I have been told that the following principles may be considered:

a. A combination of familiar elements according to known methods likely to be obvious if it yields predictable results;

b. The substitution of one known element for another is likely to be obvious if it yields predictable results;

c. The use of a known technique to improve similar items or methods in the same way is likely to be obvious if it yields predictable results;

d. The application of a known technique to a prior art reference that is ready for improvement is likely obvious if it yields predictable results;

e. Any need or problem known in the field and addressed by the reference can provide a reason for combining the elements in the manner claimed;

f. A skilled artisan often will be able to fit the teachings of multiple references together like a puzzle; and

g. The proper analysis of obviousness requires a determination of whether a person of ordinary skill in the art would have a "reasonable expectation of success"—not "absolute predictability" of success—in achieving the claimed invention by combining prior art references.

45. I understand that whether a prior art reference renders a claim unpatentable as obvious is determined from the perspective of a person of ordinary skill in the art. I have also been told that, while there is no requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, a suggestion to combine known elements to achieve the claimed invention may come from the prior art as a whole or individually, as filtered through the knowledge of one skilled in the art. In addition, I have been told that the inferences and creative steps a person of ordinary skill in the art would employ are also relevant to the determination of obviousness.

46. I also understand that, when a work is available in one field, design alternatives and other market forces can prompt variations of it, either in the same field or in another. I have also been told that if a person of ordinary skill in the art can implement a predictable variation and would see the benefit of doing so, that variation is likely to be obvious. I have been told that in many fields, there may be little discussion of obvious combinations, and in these fields market demand—not scientific literature—may drive design trends. I have been told that, when there is a

design need or market pressure and there are a finite number of predictable solutions, a person of ordinary skill in the art has good reason to pursue those known options.

47. I have been told that there is no rigid rule that a reference or combination of references must contain a “teaching, suggestion, or motivation” to combine references. But I also have been told that the “teaching, suggestion, or motivation” test can be a useful guide in establishing a rationale for combining elements of the prior art. I have been told that this test poses the question as to whether there is an express or implied teaching, suggestion, or motivation to combine prior art elements in a way that realizes the claimed invention, and that it seeks to counter impermissible hindsight analysis.

48. I understand that the relevant time for considering whether a claim would have been obvious to a person of ordinary skill in the art is the time of alleged invention, which I have been told to assume is the Priority Date – December 11, 2002.

V. THE CHALLENGED CLAIMS ARE OBVIOUS OVER THE PRIOR ART

49. Based on my education, experience, and my review of the prior art, it is my opinion that a person of ordinary skill in the art as of the Priority Date would conclude that:

a. claims 1-6, 8-10, and 12-22 are obvious over the combination of U.S. Patent No. 6,663,504 (PXG1004, "*Hocknell*"), U.S. Patent No. 6,565,452 (PXG1005, "*Helmstetter*"), and U.S. Patent No. 6,334,817 (PXG1006, "*Ezawa*");

b. claims 1-6, 8-10, and 12-22 are obvious over the combination of *Hocknell*, *Helmstetter*, and U.S. Patent No. 5,624,331 (PXG1009, "*Lo*");

c. claims 1-6, 8-10, and 12-22 are obvious over the combination of *Hocknell*, *Helmstetter*, and Japanese Patent Application No. 2002-165902 (PXG1021, "*Masanori*");

d. claims 1-6, 8-10, and 12-21 are obvious over the combination of *Hocknell Helmstetter*, *Ezawa*, and Geoff Eckold, Design and Manufacture of Composite Structures (Woodhead Publishing Ltd. 1994) (PXG1024, "*Eckold*");

e. claims 1-6, 8-10, and 12-21 are obvious over the combination of *Hocknell*, *Helmstetter*, *Lo*, and *Eckold*; and

f. claims 1-6, 8-10, and 12-21 are obvious over the combination of *Hocknell*, *Helmstetter*, *Masanori*, and *Eckold*.

VI. OVERVIEW OF THE APPLIED REFERENCES

A. *Hocknell*

50. Like the ’425 Patent, *Hocknell* is directed to a golf club head. PXG1004, 5:29-30. *Hocknell* discloses a “club head 40 [that] is generally composed of two components, a major body 50 and minor body 60. The minor body 60 has a crown section 62 and a ribbon section 64. The club head 40 may also be partitioned into a heel end 66 nearest the shaft 48, a toe end 68 opposite the heel section 66, and an aft end 70.” PXG1004, 6:38-43, Figs. 4, 5. “The major body 50 generally includes a striking plate section . . . 72, a sole section 76 extending laterally rearward from the striking plate section 72.” PXG1004, 7:7-12; Fig. 4 (annotated below), and Fig. 5 (annotated below).

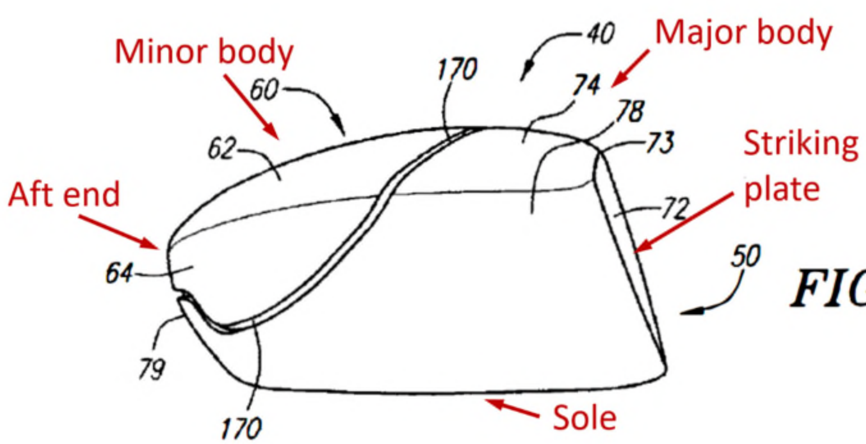


FIG. 4

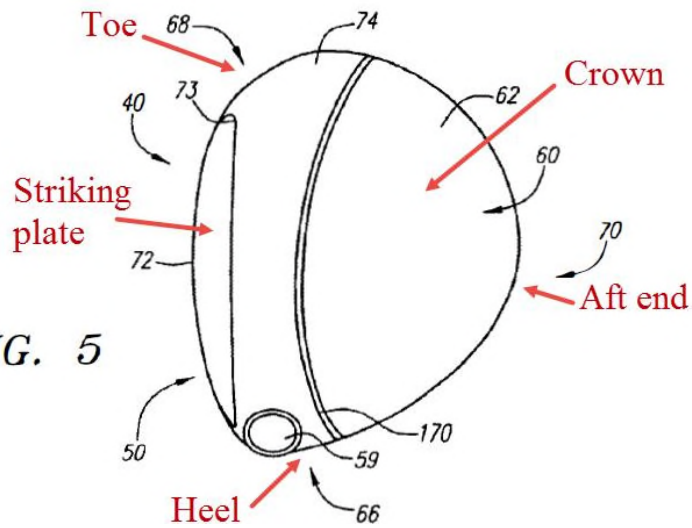


FIG. 5

51. As best seen in annotated Figure 8 below, *Hocknell* teaches that its minor body 60 encloses an upper opening of the club head. PXG1004, Fig. 8. *Hocknell* also discloses a support member (ledge 80) surrounding the upper opening for attaching the minor body 60 to the body. PXG1004, 7:13-14, Fig. 8, Fig. 9. This structure is remarkably similar to the golf club head of the ’425 Patent, which shows a crown 12 enclosing an upper opening supported by a ledge. *Compare* PXG1004, Fig. 8 (annotated below) *to* PXG1001, Fig. 4 (annotated below).

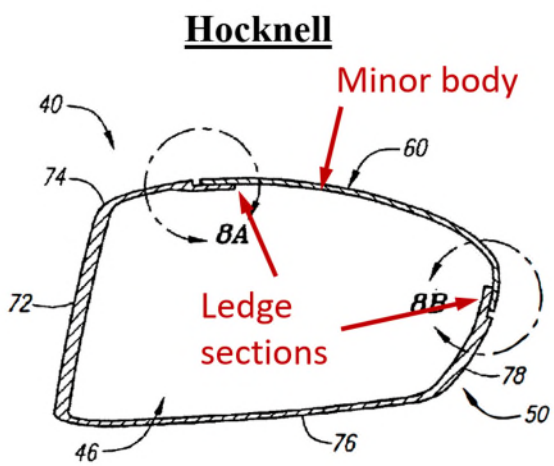
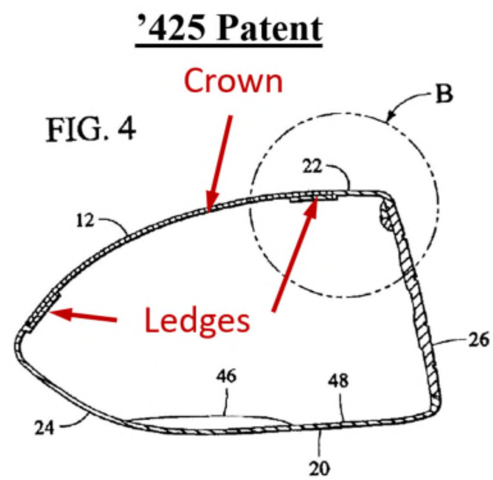


FIG. 8



52. *Hocknell* also teaches golf club heads with crowns that are made of composite material. In particular, *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or thermoplastic resin)." PXG1004, 7:54-57.

B. *Helmstetter*

53. Like the '425 Patent, *Helmstetter* is directed to a wood-type golf club head. PXG1005, 13:54-57. *Helmstetter* discloses "a golf club head 42 with a hollow interior." PXG1005, 7:21-22. "The club head 42 is generally composed of two components, a face component 60, and an aft-body 61." PXG1005, 7:25-26, Fig. 7. "The club head 42 may also be partitioned into a heel section 66 nearest the shaft 48, a toe section 68 opposite the heel section 66, and a rear section 70

opposite the face component 60." PXG1005, 7:29-32, Fig. 5 (annotated below), Fig. 7 (annotated below).

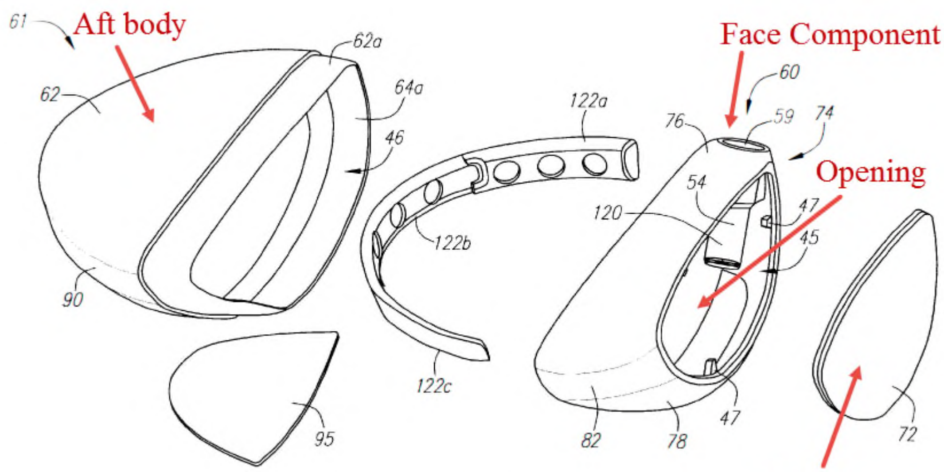


FIG. 7

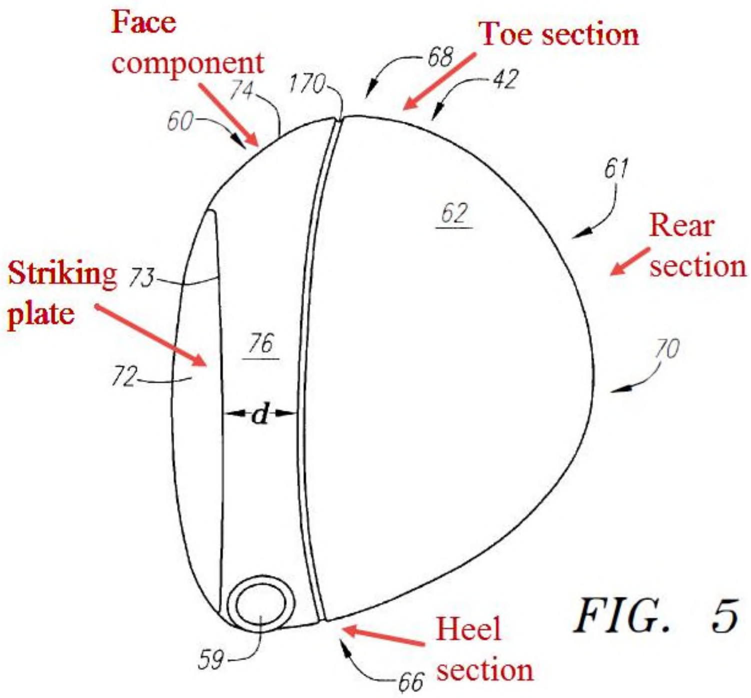


FIG. 5

54. *Helmstetter* teaches golf club heads wherein the striking plate is attached to the body, enclosing a front opening. In particular, *Helmstetter* discloses that "[t]he face component 60 is generally composed of two pieces of metal, the

return portion 74 and the striking plate insert 72. The opening 45 is configured for placement of the striking plate insert 72 therein." PXG1005, 7:33-36, Fig. 7 (annotated below, showing front portion of club head), Fig. 8A (annotated below, showing striking plate insert 72 enclosing the front opening).

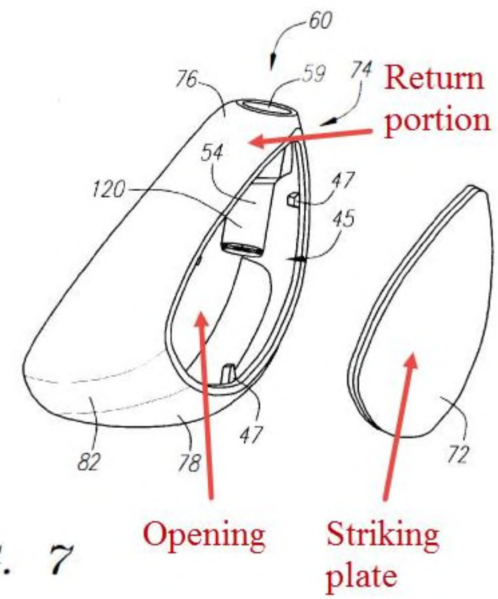


FIG. 7

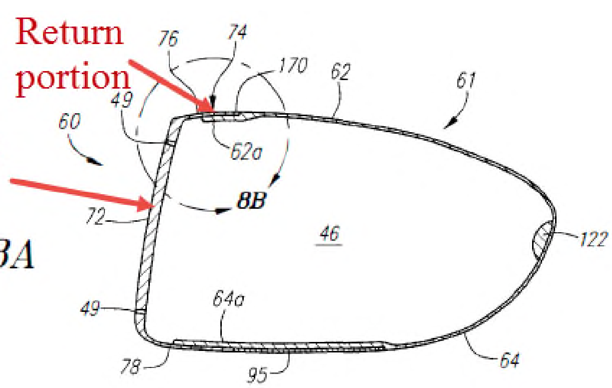


FIG. 8A

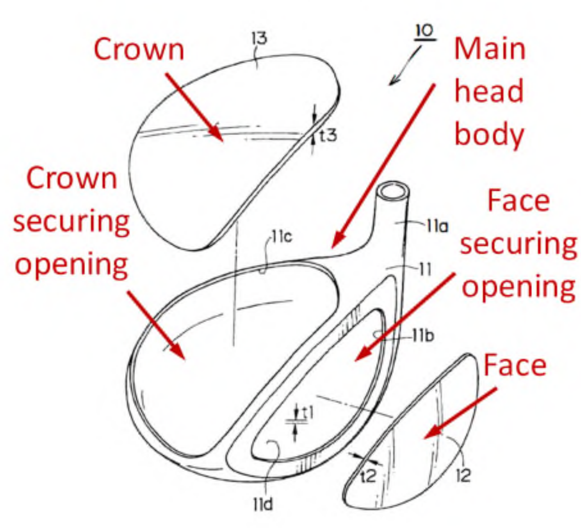
55. *Helmstetter* discloses that "the striking plate insert 72 is composed of a forged or formed metal material, [such as] a forged titanium or stainless steel

material. Such titanium material may include pure titanium and titanium alloys." PXG1005, 7:37-41.

C. *Ezawa*

56. Like the '425 Patent, *Ezawa* is directed to a wood-style golf club head. PXG1006, 1:5-6. *Ezawa* discloses that "present invention relates to a hollow golf club head called a metal wood which is made of a metallic material." *Id*. *Ezawa* also discloses that "[a] first example has a three piece structure comprising a main head body, a face, and a sole or crown." *Id*., 2:41-42. In particular, *Ezawa* discloses that "[t]he main head body 11 has a neck 11a and a sole 11d which are integrally formed therewith, and also has a face securing opening 11b and a crown securing opening 11c." *Id*., 3:43-45. As best seen in Figure 1, *Ezawa's* "crown securing opening" is an upper opening that is located entirely within the top portion of the club head body. *Id*., Fig. 1 (annotated below).

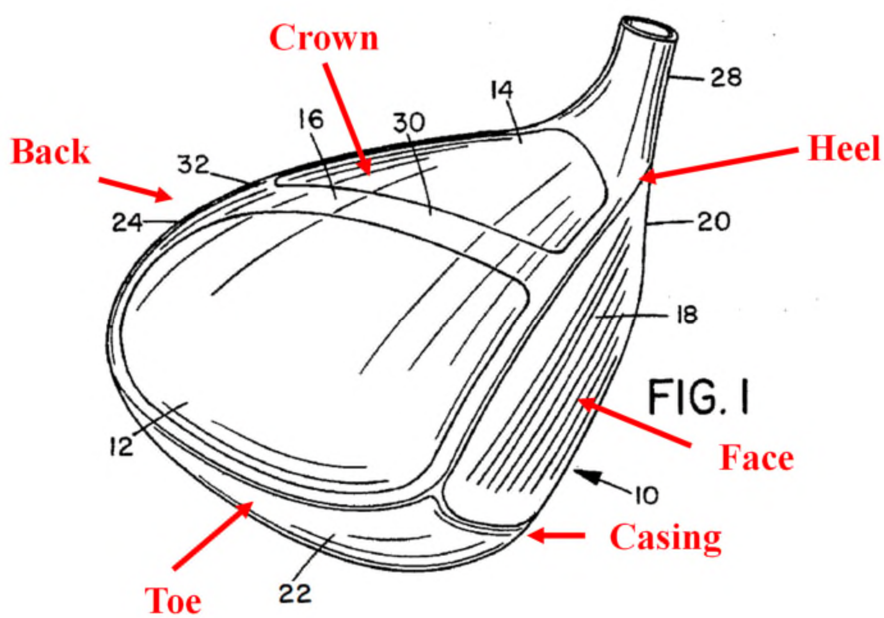
FIG. 1



57. *Ezawa* further teaches that a face 12 is secured to the face securing opening 11b, and a crown 13 is secured to the crown securing opening 11c. *Id.*, 3:63-65. As seen in Figure 1, after attachment, the crown 13 is located entirely within the top portion of the club head body. *Id.*, Fig. 1 (annotated above).

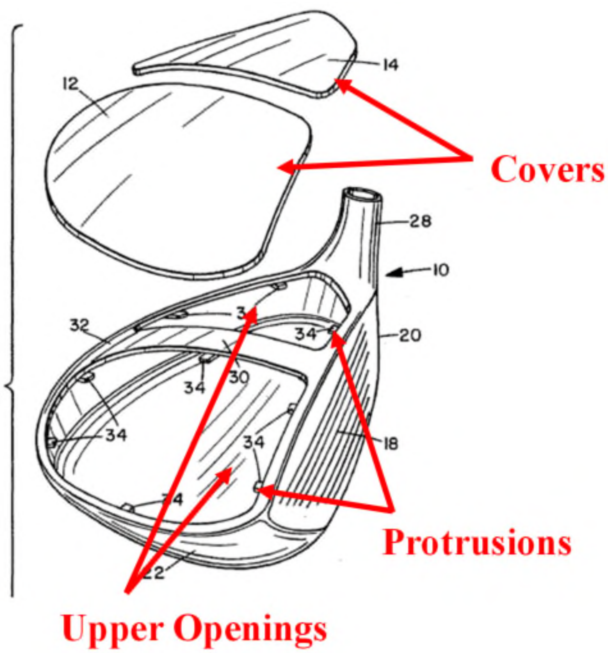
D. *Lo*

58. Like the ’425 Patent, *Lo* is directed to a wood-style golf club head. Ex. 1009, 2:14-15. *Lo* discloses a golf club head comprising “a generally hollow metal head casing.” PXG1009, 4:32. “[A] wood-style golf club head includes a metal casing 10 and two composite covers 12 and 14 that, when assembled, together define the surfaces of the head. These surfaces include a crown 16, a face 18, a heel 20, a toe 22, a back 24 and a sole 26.” *Id.*, 2:14-19, Fig. 1 (annotated).



59. As shown in Figure 5 below, *Lo* teaches golf club heads with upper openings located entirely within the top portion of a metal casing. *Lo* further teaches that that "composite covers 12 and 14 are inserted into the corresponding openings in casing 10." PXG1009, 4:3-5, Figure 5. *Lo* discloses "[m]etal casing 10 may have one or more ridges or protrusions 34 within these openings for supporting covers 12 and 14." *Id.*, 2:55-57, Fig. 5 (annotated below, showing opening surrounded by protrusions 34 for supporting covers 12 and 14).

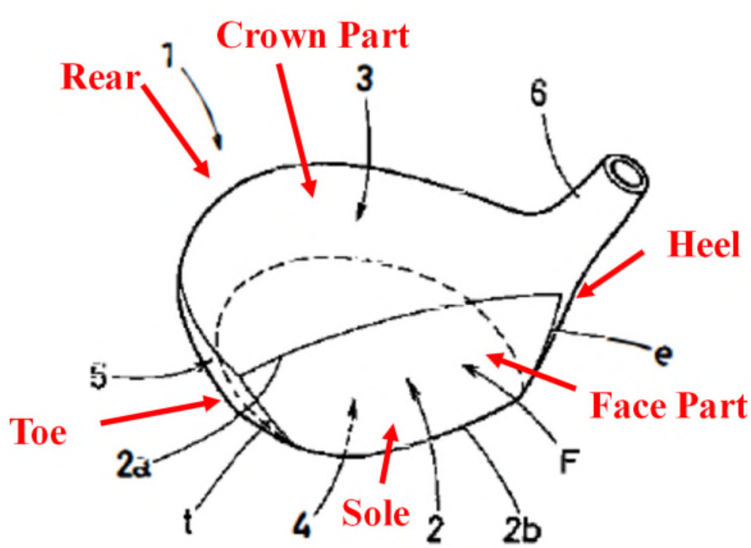
FIG. 5



60. Regarding materials, *Lo* teaches that"[c]overs 12 and 14 are preferably made of graphite-epoxy composite, although any other suitable fiber composite may be used" and that the "[m]etal casing 10 is formed from stainless steel or other durable metal." PXG1009, 2:52-53, 3:1-3.

E. Masanori

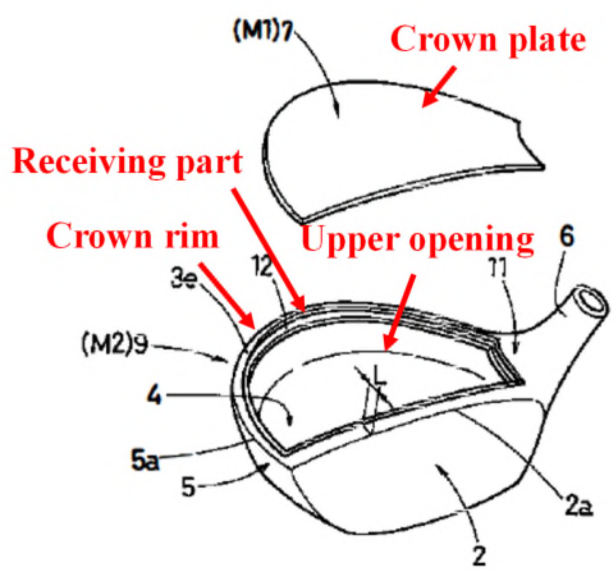
61. Like the ’425 Patent, *Masanori* is directed to a wood-style golf club head. PXG1021, ¶0001. *Masanori* discloses a golf club head “composed of a metal material” and “being a wood-type head provided with a hollow part i in an inner part.” *Id*., ¶0010. *Masanori* also teaches that its golf club head has “a face part 2 provided on a surface with a face surface F for striking a ball, a crown part 3 continuous to an upper edge 2a of the face part 2 and forming a head upper surface, a sole part 4 continuous to a lower edge 2b of the face part 2 and forming a head sole surface, a side part 5 rising up from the circumference of the sole part 4 and extending from a toe t side of the face part 2 through a back face to a heel e side of the face part 2.” *Id*., Fig. 1 (annotated below).



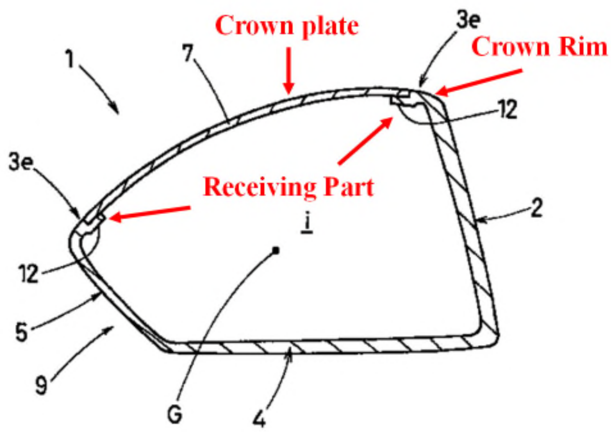
62. As shown in Figure 2 below, *Masanori* discloses a golf club head wherein an upper opening is located entirely within the top portion of the body of a

golf club head. PXG1021, Fig. 2. To support the crown part to enclose the upper opening, *Masanori* teaches a "crown rim part 3e . . . formed with a receiving part 12 for retaining the face [*sic*, crown] plate 7 substantially flush with the crown rim part and supporting it from below" and "formed around the entire rim of the crown plate 7." *Id*., ¶0014, Fig. 2 (annotated below, showing opening prior to crown plate attachment), Fig. 6 (annotated below, showing crown plate enclosing opening).

[FIG. 2]



[FIG. 6]



63. Regarding materials, *Masanori* teaches that the crown plate may be "a composite material with a low specific gravity such as fiber reinforced resin" and the body "is formed using a high specific gravity metal." PXG1021, ¶¶0015, 0020.

F. *Eckold*

64. *Eckold* is directed to composite materials, particularly, as relevant here, to "the fibres[1] and matrices in current use and the mechanics of how they can be combined to form a structural material of the required stiffness and strength." PXG1024, viii. *Eckold* further describes that many parameters effect the properties of composites, such as fiber volume fraction. *Id*., 49. *Eckold* discloses that "[f]or high performance applications, the reinforcement consists of continuous aligned or woven fibres in discrete layers, with typical fibre volume fractions being in the range of 50-70%." *Id*. *Eckold* also provides an example of a typical unidirectional

[1] *Eckold* uses the term "fibre," which is the British spelling of the term "fiber."

carbon/epoxy composite having a fiber volume percentage of 57% and a density of 1.57 g/cm^3. *Id.*, 34 (Table 2.8);

VII. THE COMBINATION OF *HOCKNELL, HELMSTETTER,* AND *EZAWA, LO,* OR *MASANORI* RENDERS THE CHALLENGED CLAIMS OBVIOUS

65. Based on my education and experience, and my review of the prior art, it is my opinion that a person of ordinary skill in the art as of the Priority Date would conclude that claims 1-6, 8-10, and 12-22 are obvious over the combination of *Hocknell, Helmsetter,* and *Ezawa, Lo,* or *Masanori*.

A. The Combination of *Hocknell, Helmstetter,* and *Ezawa, Lo* or *Masanori* Teach All the Elements and Limitations of the Challenged Claims

66. In my opinion, as shown in more detail below, *Hocknell* discloses all the limitations of the challenged claims except a front opening that is enclosed by a striking plate, and an upper opening and a crown enclosing the upper opening that are located entirely within the top portion of a club head. However, *Helmstetter* clearly discloses separately forming a striking plate and attaching the striking plate to the front face of a golf club head to enclose a front opening. Moreover, as was well-known in the art, *Ezawa, Lo*, and *Masanori* teach upper openings and crowns that are located entirely within the top portion of a club head. Thus, the combination of *Hocknell* and *Helmstetter,* and *Ezawa, Lo*, or *Masanori* teach all

the limitations of the claims. To the extent that a limitation is not expressly taught in these references, it would have been an obvious variation to a skilled artisan.

1. Independent Claims 1 and 22

a. "A golf club head" [1, 22][2]

67. *Hocknell* teaches that "[t]he golf club heads are preferably fairway woods . . . ." PXG1004, 5:29-30. *Helmstetter* teaches that the golf club head of the present invention may be different types of "fairway woods." PXG1005, 13:54-57. *Ezawa, Lo,* and *Masanori* are also directed to wood-type golf club heads. PXG1006, 1:5-6; PXG1009, 2:14-15; PXG1021, ¶10. Thus, in my opinion, a skilled artisan would understand that *Hocknell*, *Helmstetter*, *Ezawa, Lo,* and *Masanori* are directed to a "wood type golf club head."

b. "a body having a sole" [1, 22]

68. *Hocknell* describes "a sole section 76 extending laterally rearward from the striking plate section 72," which is part of *Hocknell's* major body 50. PXG1004, 7:7-12, Fig. 2 (annotated below), Fig. 4 (annotated below).

[2] The number in the square brackets indicates the claim in which the element or limitation appears.

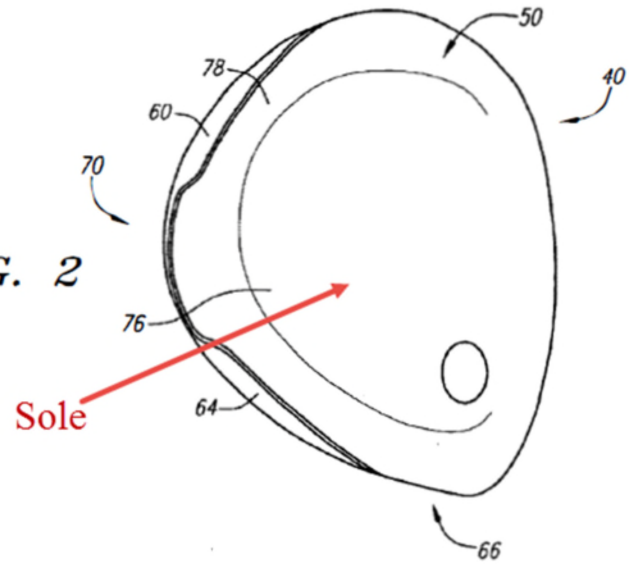


FIG. 2

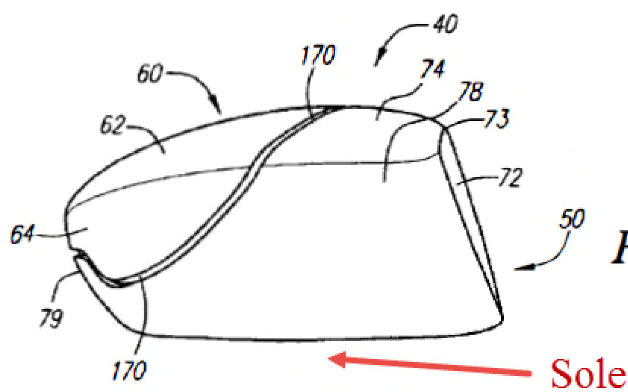


FIG. 4

Thus, in my opinion, a skilled artisan would understand that *Hocknell* discloses a golf club head with "a body having a sole."

c. "a front defining a front opening" [1, 22]

69. *Hocknell* discloses a front section that "includes a striking plate section (also referred to herein as a face plate) 72." PXG1004 at 7:7-8, Fig. 1 (annotated below).

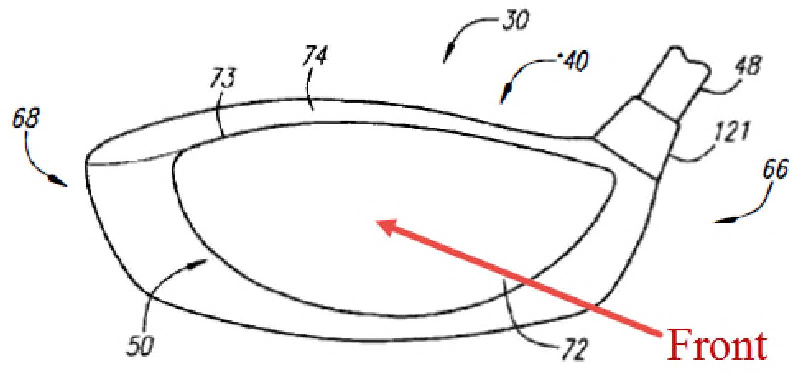


FIG. 1

70. *Helmstetter* discloses a front section that has a front opening. PXG1005, 7:34-36 (referencing "opening 45"), Fig. 7 (annotated below, only front portion of club head shown), Fig. 8A (annotated below).

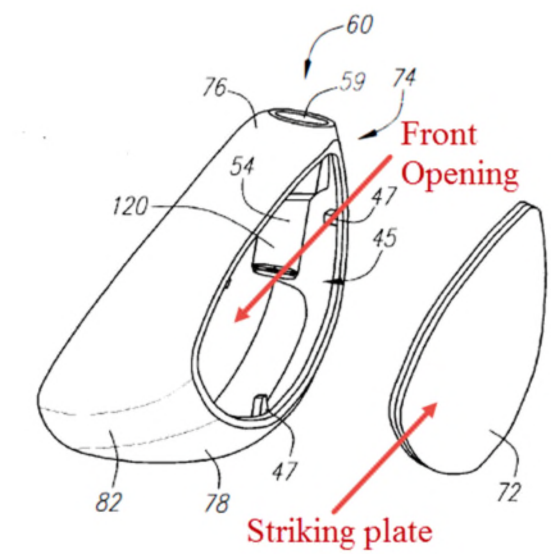


FIG. 7

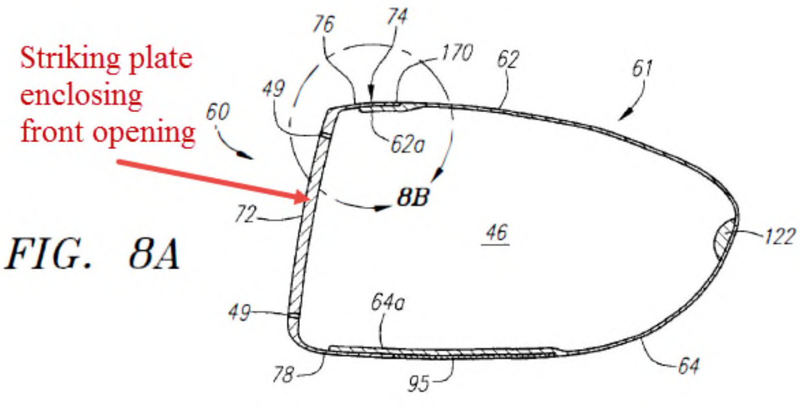


FIG. 8A

71. In my opinion, as discuss further below, it would have been obvious to a skilled artisan to use the front opening and separately formed striking plate of *Helmstetter* with the club body of *Hocknell*.

d. "a top portion defining an upper opening" [1, 22]

72. *Hocknell* discloses an upper opening in the so-called major body of *Hocknell*'s club head. This opening is in the upper portion of the club head. PXG1004, Fig. 8 (annotated below, showing minor body 60 enclosing opening), Fig. 9 (annotated below, showing opening prior to attaching minor body 60).

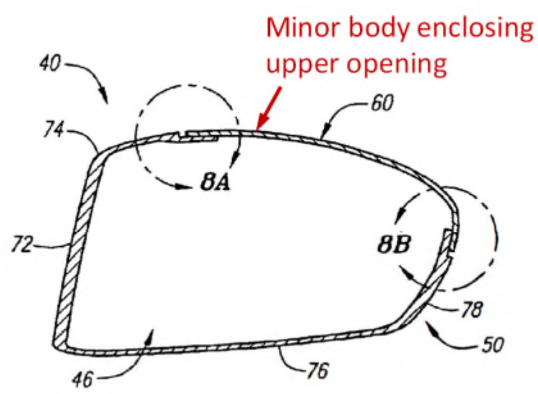


FIG. 8

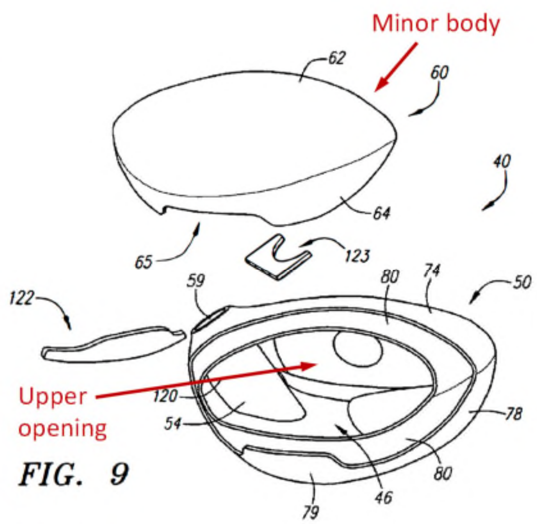
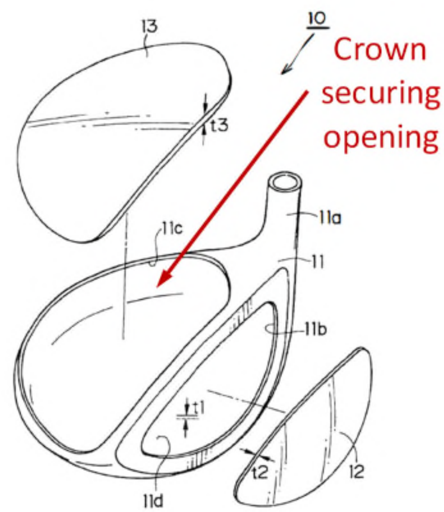


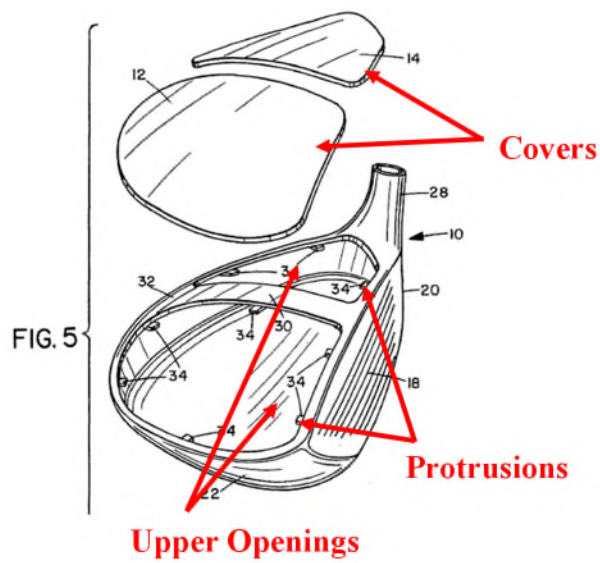
FIG. 9

73. *Ezawa*, *Lo*, and *Masanori* disclose "upper openings" located entirely with the top portion of a club head. *Ezawa* discloses a so-called "crown securing opening" that is an upper opening located entirely within the top portion of the club head. PXG1006, Fig. 1 (annotated below).

FIG. 1

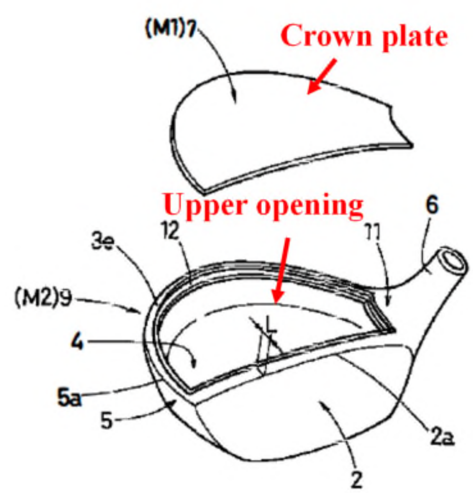


74. *Lo* discloses upper openings in the casing of *Lo's* club head. These upper openings are located entirely within the top portion of the club head. PXG1009, Fig. 5 (annotated below).



75. *Masanori* discloses an upper opening in the head body part of *Masanori's* club head. This upper opening is located entirely within the top portion of the club head. PXG1021, Fig. 2 (annotated below).

[FIG. 2]



76. Thus, in my opinion, as discussed further below, it would have been obvious to a skilled artisan to modify the club head of *Hocknell* such that

Hocknell's upper opening is located entirely within the top portion of a golf club head as taught by *Ezawa*, *Lo* or *Masanori*.

e. "an upper edge disposed between and separating the front opening and the upper opening" [1, 22]

77. *Hocknell* teaches an upper edge (so-called "return section 74") between its striking plate and its crown. PXG1004, Fig. 8 (annotated below, showing return section 74 between striking plate 72 and crown 62).

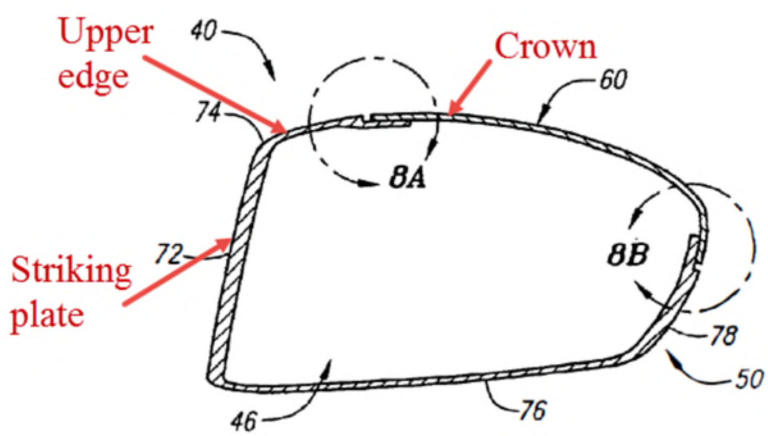


FIG. 8

78. *Helmstetter* also teaches an upper edge (so-called "return section 74") between its striking plate and its crown. *Helmstetter*'s striking plate encloses a front opening. PXG1005, Fig. 8B (annotated below, showing return section 74 between striking plate 72 and crown 62 and striking pate 72 enclosing a front opening).

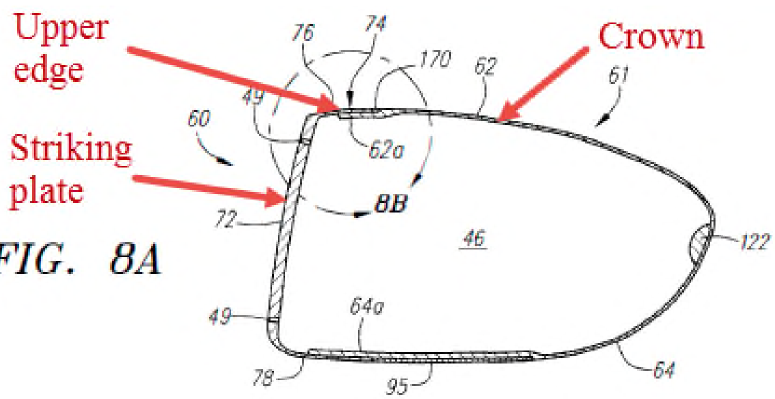
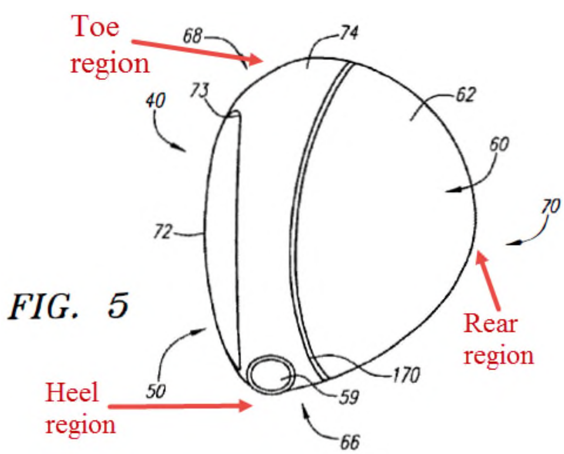


FIG. 8A

79. In my opinion, as discussed further below, it would have been obvious to a skilled artisan to use the front opening and separately formed striking plate of *Helmstetter* with the club body of *Hocknell*, and to modify the club head of *Hocknell* such that *Hocknell's* upper opening is located entirely within the top portion of a golf club head as in *Ezawa*, *Lo*, and *Masanori*. Thus, a skilled artisan would understand that combining a front opening with an upper opening entirely within the top portion of a golf club head would result in a golf club head with "an upper edge disposed between and separating a front opening and an upper opening." In fact, the claimed "edge" is merely the inherent result from having both a front and an upper opening in a golf club body. *See* PXG1006, Fig. 1; PXG1016, Fig. 4.

f. "a side portion, the side portion extending rearward of the front opening and having toe, rear, and heel regions" [1, 22]

80. *Hocknell* explains that once formed, "[t]he club head 40 may also be partitioned into a heel end 66 nearest the shaft 48, a toe end 68 opposite the heel section 66, and an aft end 70 [rear]." PXG1004, 6:38-43, Fig. 5 (annotated below).



In my opinion, a skilled artisan would understand that combining *Helmsetter's* front opening with *Hocknell*'s golf club head would result in a golf club head that has "a side portion extending rearward of the front opening and having toe, rear, and heel regions."

g. "the body is comprised of a metallic material having a density of at least about 4 g/cc" [1, 22]

81. *Hocknell* discloses that "[t]he major body 50 is generally composed of a single piece of metal, and is preferably composed of an amorphous metal material. . . . Such amorphous metals include Fe, Ni, Co and Cr based on amorphous metals, which have a density ranging from 8 grams per cubic

centimeter (g/cc) to 10 g/cc." PXG1004, 6:44-51. In my opinion, a skilled artisan would understand that *Hocknell* and teaches a golf club head that has a body made "of a metallic material having a density of at least about 4 g/cc."

h. "a striking plate welded to the body, enclosing the front opening" [1]

"a striking plate attached to the body, enclosing the front opening" [22]

82. *Helmstetter* teaches that "[t]he face component 60 is generally composed of two pieces of metal, the return portion 74 and the striking plate insert 72. The opening 45 is configured for placement of the striking plate insert 72 therein." PXG1005 at 7:33-36, Fig. 7 (annotated below, only front portion of club head shown), Fig. 8A (annotated below, showing striking plate insert 72 enclosing the front opening).

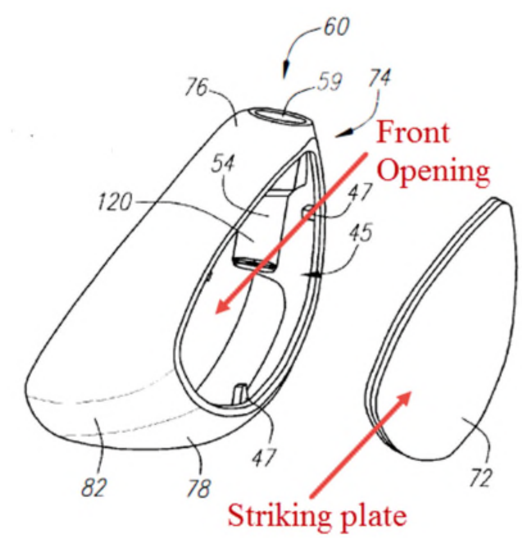


FIG. 7

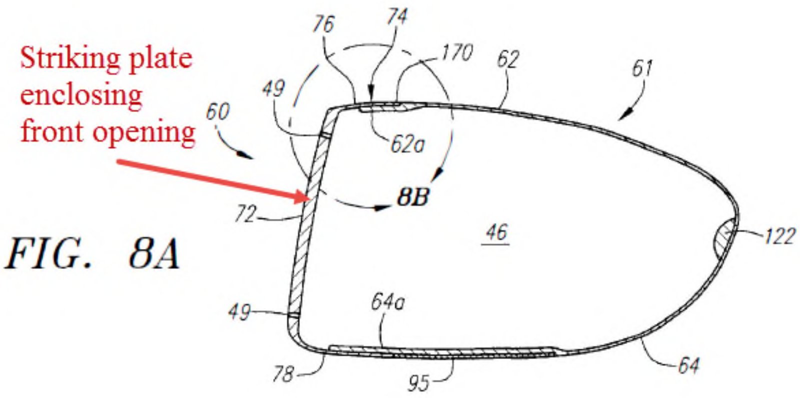


FIG. 8A

83. *Helmstetter* further teaches that the "striking plate insert 72 composed of an amorphous metal is attached through electron beam welding, brazing or press-fitted for attachment to the return portion." PXG1005, 7:64-67.

84. In my opinion, as discussed further below, it would have been obvious to a skilled artisan to use the front opening and separately formed striking plate of *Helmstetter* with the club body of *Hocknell*.

i. "a weight portion attached to an interior surface of the club head" [1]

85. *Hocknell* teaches "a rear weighting member 122 is preferably positioned within the hollow interior 46 of the club head 40. In a preferred embodiment, the rear weighting member 122 is disposed on the interior surface of the ribbon section 78 in order to increase the moment of inertia and control the center of gravity of the golf club head 40. A heel weighting member 123 is placed adjacent the hosel 54 on the interior surface of the sole section 76. However, those skilled in the pertinent art will recognize that additional weighting members may

be placed in other locations of the club head 40 in order to influence the center of gravity, moment of inertia, or other inherent properties of the golf club head 40. The weighting members 122 and 123 are preferably . . . weight chips welded to the interior surface of the major body 50." PXG1004, 9:7-22.

j. "a shoulder disposed around the periphery of the upper opening, and a recessed support extending from the shoulder and positioned adjacent to the upper opening" [22]

86. *Hocknell* discloses a shoulder, which it terms the edge 195 of the major body, disposed around the periphery of an upper opening. PXG1004, 8:14-17; Fig. 8A (annotated below).

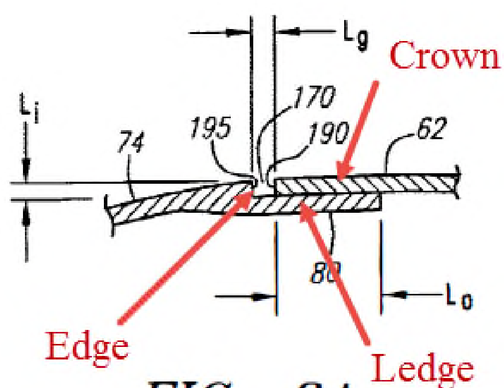


FIG. 8A

87. *Hocknell* further discloses a recessed support extending from a shoulder and adjacent to an upper opening by teaching "a ledge section 80 stepped inward for attachment of the minor body 60." PXG1004, 7:13-14, Fig. 8 (annotated below, showing minor body 60 enclosing an upper opening by engaging with ledge

80 that surrounds the upper opening), Fig. 9 (annotated below, showing ledge 80 surrounding upper opening).

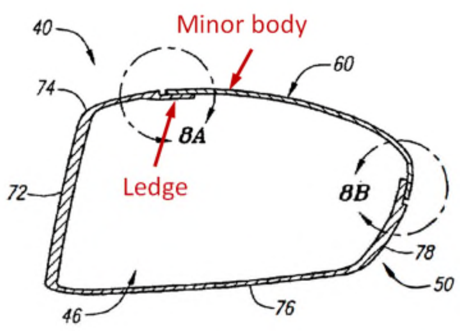


FIG. 8

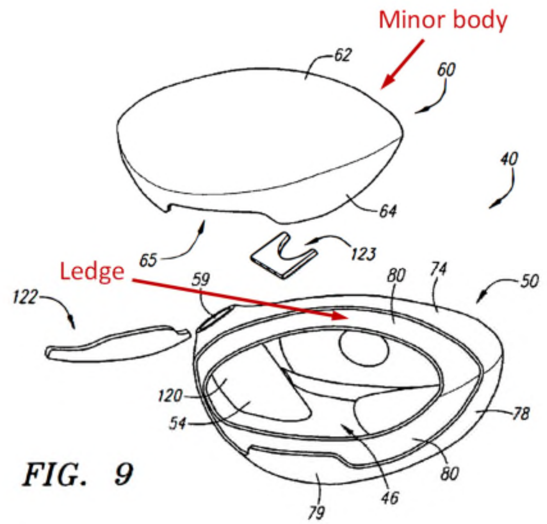


FIG. 9

88. Moreover, using a support surrounding an upper opening for attaching a crown to a golf club body was well known in the art. PXG1009, 2:54-57, Fig. 5; PXG1021, ¶0014, Fig. 2.

k. "a crown attached to the body enclosing the upper opening" [1, 22]

89. *Hocknell* discloses a minor body attached to the major body and supported by the recessed support (ledge 80), thereby enclosing the upper opening. In particular, *Hocknell* discloses "a ledge section 80 stepped inward for attachment of the minor body 60." PXG1004, 7:13-14, Fig. 8 (annotated below, showing minor body 60 enclosing an upper opening via attachment to ledge 80), Fig. 8A (annotated below, showing an isolated view of crown 62 (top part of minor body) attached to ledge 80), Fig. 9 (annotated below, showing how minor body 60

encloses the upper opening by engaging with ledge 80). Although *Hocknell* defines only a portion of its minor body 60 as the crown 62, as would be evident to a skilled artisan, *Hocknell's* minor body 60 functions as the claimed crown by enclosing the upper opening.

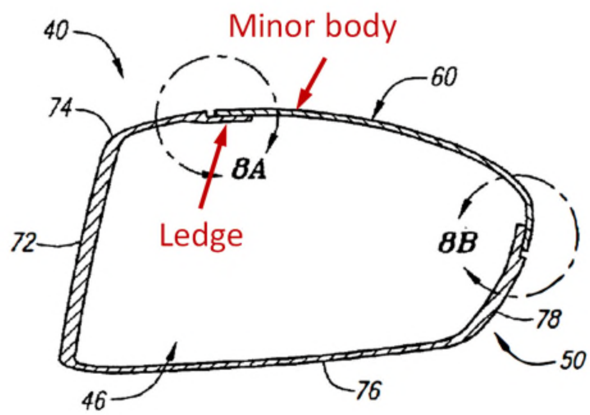


FIG. 8

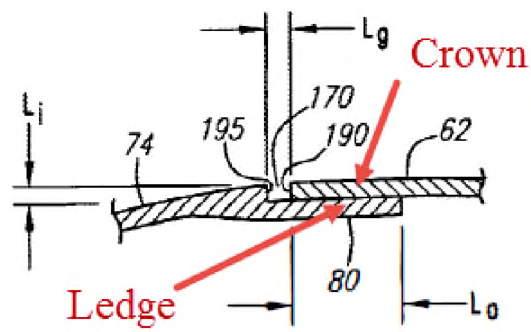


FIG. 8A

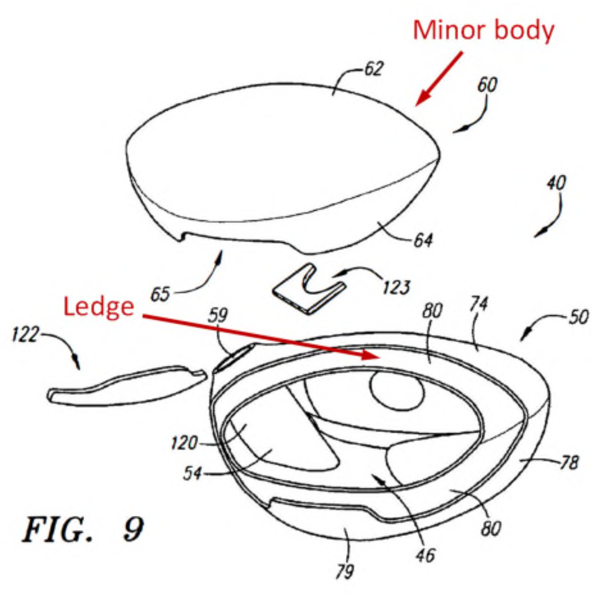
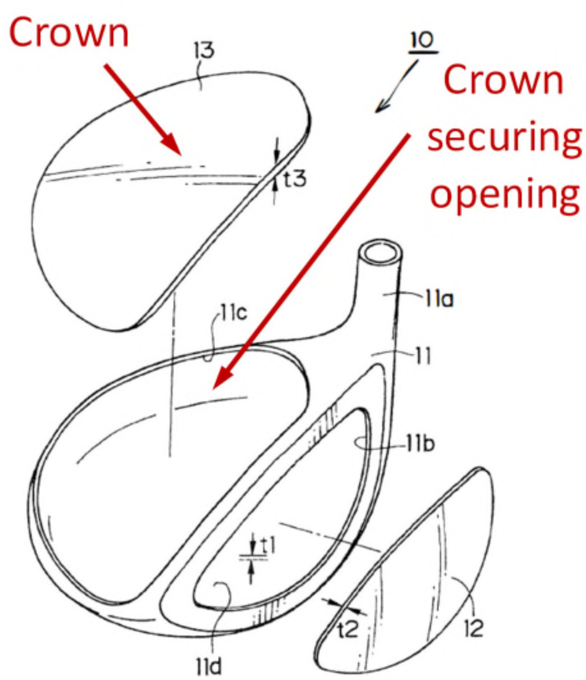


FIG. 9

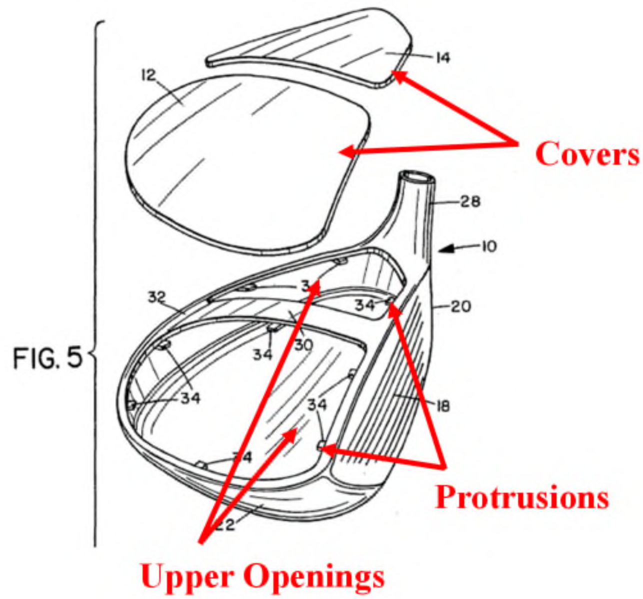
90. *Ezawa*, *Lo,* and *Masanori* each disclose a "crown" that is located entirely within the top portion of a club head. *Ezawa* discloses a crown located

entirely within the top portion of the golf club head. PXG1006, Fig. 1 (annotated below).

F I G. 1

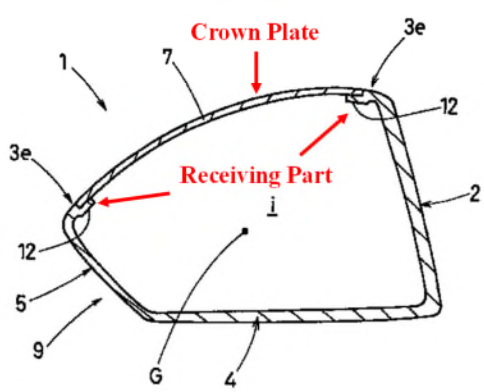


91. *Lo* also discloses a crown, *Lo's* covers, that are located entirely within the top portion of the golf club head. PXG1009, Fig. 5 (annotated below).

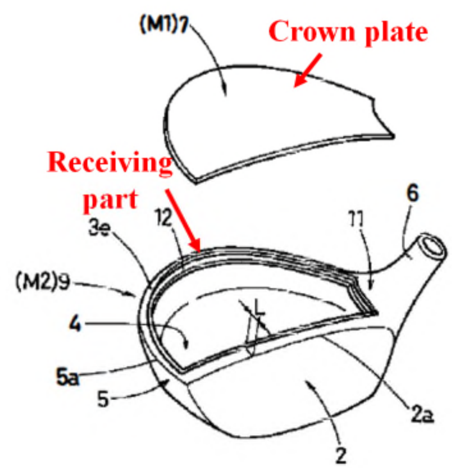


92. *Masanori* also discloses a crown ("crown plate 7") entirely within the top portion of a golf club head. PXG1021, Fig. 2 (annotated below), Fig. 6 (annotated below).

[FIG. 6]



[FIG. 2]



93. In my opinion, as discussed further below, it would have been obvious to a skilled artisan to modify the club head of *Hocknell* such that *Hocknell's* upper

opening and thus *Hocknell's* minor body enclosing the upper opening (which would now include only the crown portion) are located entirely within the top portion of a golf club head as taught by *Ezawa*, *Lo* or *Masanori*.

l. "the crown incorporating composite material and having a density between 1 g/cc and 2 g/cc" [1]

94. *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably composed of a non-metal material, preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or thermosplastic resin). PXG1004, 7:54-57. *Hocknell* further discloses that "[i]n a preferred embodiment, the minor body 60 [which includes the crown 62] is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Pat. No. 6,248,025 ["*Murphy*"], entitled Composite Golf Head Method of Manufacturing, which is hereby incorporated by reference in its entirety." *Id*., 8:43-48. *Murphy* discloses that "the preferred composite material is plies of carbon pre-peg [sic, preg] composite sheets." PXG1011, 6:45-46. *Murphy* further discloses that "[e]xemplary carbon pre-pre fiber sheets may be obtained" from a number of different commercial suppliers. *Id*., 6:55-58. *Hocknell* suggests using a thermosetting resin, and a skilled artisan would understand that the most common thermosetting resin used in carbon fiber composites is epoxy. Thus, in my opinion, to a skilled artisan, it would be obvious to use a carbon-epoxy for the crown.

95. In my opinion, a skilled artisan would understand that typical carbon-epoxy composites have a fiber volume fraction of about 60% and thus based on the densities of the fibers and resin would generally have densities of 1.49 g/cc to 1.73 g/cc which falls within the claimed range. For example, the carbon (graphite) fibers used in such composite materials generally have a density of between 1.75 g/cc to 1.95 g/cc, and the epoxy resins used in such composite materials generally have a density of between 1.1 g/cc to 1.4 g/cc. Ex. 1018 at 3, 4. Thus, for a typical 60% by volume carbon fiber composite material, the resulting density would range from 1.49 g/cc ((1.75 x 0.6) + (1.1 x 0.4)) to 1.73 g/cc ((1.95 x 0.6) + (1.4 x 0.4)). This is consistent with what is taught in the art concerning carbon fiber composites. PXG1023, 2:64; PXG1024, 34, 49. In any event, given that the claimed density encompasses the density of typical carbon-epoxy composites, it would have been an obvious design choice to choose a carbon-epoxy composite within the claimed range.

m. "the crown is comprised of a non-metallic material" [22]

96. *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or thermoplastic resin)." PXG1004, 7:54-57. In my opinion, a skilled artisan would understand that *Hocknell* teaches a golf club head "wherein the crown is comprised of a non-metallic material."

97. Moreover, using a non-metallic material, such as a composite material, for the crown of a golf club head was well known in the art. PXG1009, 3:1-3; PXG1021, ¶20.

n. "the golf club head has a maximum coefficient of restitution of at least 0.80" [1, 22]

98. Both *Hocknell* and *Helmstetter* teach that their inventions provide "a club head having a coefficient of restitution ranging from 0.81 to 0.94, as measured under conventional test conditions." PXG1004, 10:31-33; PXG1005, 13:43-47. In my opinion, as discussed further below, a skilled artisan would have expected the combination of *Helmstetter's* front opening and striking plate with *Hocknell's* major body to at least achieve a COR as recited in both *Hocknell* and *Helmstetter*.

o. "a volume of at least 150 cc" [1, 22]

99. In Tables 1, 2, and 3, *Hocknell* provides various examples of golf club heads using the disclosed design. The tables provide that the volume of the golf club heads (i.e., the major body volume) varies from 21.44 to 23.195 cubic inches. PXG1004, 11:40 – 12:25, Tables 1, 2, and 3. A volume of 21.44 to 23.195 cubic inches equates to a volume of approximately 351 to 380 cc. In my opinion, a skilled artisan would understand that *Hocknell* and teaches a golf club head with "a volume of at least 150 cc."

2. Dependent Claims 2-4, 8-10, 12-21

a. "the striking plate is comprised of a metallic material" [2]

"the striking plate is comprised of titanium" [3]

100. *Helmstetter* discloses that "the striking plate insert 72 is composed of a forged or formed metal material, [such as] a forged titanium or stainless steel material. Such titanium material include pure titanium and titanium alloys." PXG1005, 7:37-41. In my opinion, a skilled artisan would understand that *Helmstetter* teaches a golf club striking plate that is comprised of a metallic material such as titanium.

b. "the body is integrally formed" [4]

101. *Hocknell* discloses that "[t]he major body 50 is generally composed of a single piece of metal." PXG1004, 6:44-45. In my opinion, a skilled artisan would understand that *Hocknell* teaches a golf club head body, "wherein the body is integrally formed."

c. "a face-reinforcing member coupled to a rear surface of the striking plate" [5]

"the face-reinforcing member comprises metallic material" [6]

102. To the extent "face-reinforcing member" is construed as encompassing integrally-formed portions of the striking plate, such as thickened portions, *Helmstetter* disclose this limitation. *Helmstetter* discloses a variable

thickness striking plate with "a central elliptical region" that "preferably has the greatest thickness." PXG1005, 12:27-31. *Helmstetter* further discloses that "the striking plate insert 72 is composed of a forged or formed metal material, [such as] a forged titanium or stainless steel material. Such titanium material include pure titanium and titanium alloys." PXG1005, 7:37-41. Thus, the central elliptical region of the *Helmstetter's* striking plate would also comprise metallic material. Thus, in my opinion, a skilled artisan would understand that *Helmstetter* teaches these limitations.

d. "the body further comprises a support surrounding the upper opening for attaching the crown to the body" [8]

103. *Hocknell* discloses a recessed support extending from a shoulder and adjacent to an upper opening by teaching "a ledge section 80 stepped inward for attachment of the minor body 60." PXG1004, 7:13-14, Fig. 8 (annotated below, showing minor body 60 enclosing an upper opening by engaging with ledge 80 that surrounds the upper opening), Fig. 9 (annotated below, showing ledge 80 surrounding upper opening).

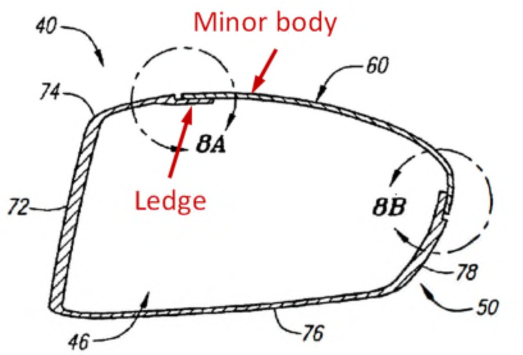


FIG. 8

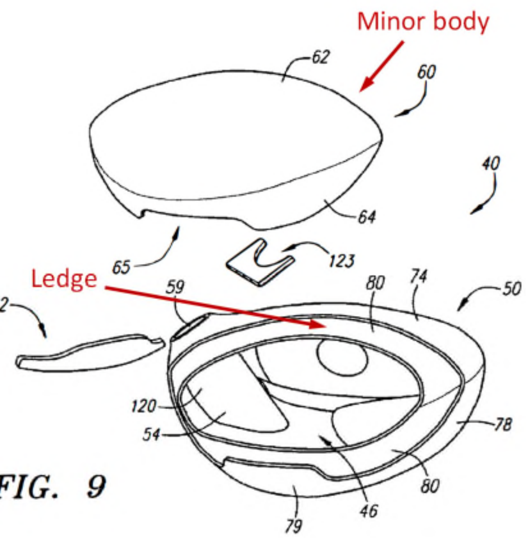


FIG. 9

Thus, in my opinion, a skilled artisan would understand that *Hocknell* teaches this limitation.

104. Moreover, using a support surrounding an upper opening for attaching a crown to a golf club body was well known in the art. PXG1009, 2:54-57, Fig. 5; PXG1021, ¶0014, Fig. 2.

e. "the crown is comprised of a graphite-epoxy composite having a density ranging between 1.4 and 1.65 g/cc" [9]

105. *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably composed of a non-metal material, preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or thermosplastic resin). PXG1004, 7:54-57. *Hocknell* further discloses that "[i]n a preferred embodiment, the minor body 60 [which includes the crown 62] is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Pat. No. 6,248,025 ["*Murphy*"], entitled Composite Golf Head

Method of Manufacturing, which is hereby incorporated by reference in its entirety." *Id*., 8:43-48. *Murphy* discloses that "the preferred composite material is plies of carbon pre-peg [sic, preg] composite sheets." PXG1011, 6:45-46. *Murphy* further discloses that "[e]xemplary carbon pre-pre fiber sheets may be obtained" from a number of different commercial suppliers. *Id*., 6:55-58. A skilled artisan would understand that carbon and graphite are generally used interchangeably to describe carbon-based fibers for composite materials. Moreover, *Hocknell* suggests using a thermosetting resin, and a skilled artisan would understand that the most common thermosetting resin used in carbon fiber composites is epoxy. Thus, in my opinion, to a skilled artisan, it would be obvious to use a graphite-epoxy for the crown.

106. In my opinion, a skilled artisan would understand that typical graphite-epoxy composites have a fiber volume fraction of about 60% and thus based on the densities of the fibers and resin would generally have densities of 1.49 g/cc to 1.73 g/cc which substantially overlaps the claimed range. For example, the carbon (graphite) fibers used in such composite materials generally have a density of between 1.75 g/cc to 1.95 g/cc, and the epoxy resins used in such composite materials generally have a density of between 1.1 g/cc to 1.4 g/cc. Ex. 1018 at 3, 4. Thus, for a typical 60% by volume carbon fiber composite material, the resulting density would range from 1.49 g/cc ((1.75 x 0.6) + (1.1 x 0.4)) to 1.73

g/cc ((1.95 x 0.6) + (1.4 x 0.4)). This is consistent with what is taught in the art concerning carbon fiber composites. PXG1023, 2:64; PXG1024, 34, 49. In any event, given that the claimed density overlaps the density of typical graphite-epoxy composites, it would have been an obvious design choice to choose a graphite-epoxy composite within the claimed range.

f. "the volume is at least 350 cc" [10]

107. In Tables 1, 2, and 3, *Hocknell* provides various examples of golf club heads using the disclosed design. The tables provide that the volume of the golf club heads (i.e., the major body volume) varies from 21.44 to 23.195 cubic inches. *See* PXG1004 at 11:40 – 12:25, Tables 1, 2, and 3. A volume of 21.44 to 23.195 cubic inches equates to a volume of approximately 351 to 380 cc. Thus, in my opinion, a skilled artisan would understand that *Hocknell* teaches this limitation.

g. "the crown is comprised of an uppermost ply of uni-tape standard modulus composite oriented at 0° or 90° and wherein the top section of the body and the uppermost ply of uni-tape are painted" [12]

108. *Hocknell* discloses that "[i]n a preferred embodiment, the minor body 60 [which includes the crown 62] is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Pat. No. 6,248,025 ["*Murphy*"], entitled Composite Golf Head Method Of Manufacturing, which is hereby incorporated by reference in its entirety." PXG1004, 8:43-48. *Murphy* discloses a composite material made up of plies in a quasi-isotropic orientation,

which is "defined as beginning at a zero degree orientation and rotating angles in at least fifteen degree intervals. Preferably, the orientations are zero degrees, plus forty-five degrees, minus forty-five degrees, and ninety degrees." PXG1011, 7:63 – 8:1. Thus, in my opinion, a skilled artisan could arrange the six or seven plies taught by *Hocknell* so that the uppermost ply is oriented at 0° or 90°. Moreover, for aesthetic reasons, it would have been a trivial modification for a skilled artisan to paint the uppermost ply and top section of the body. A skilled artisan would understand that these are trivial design choices.

h. "the crown has a maximum thickness of about 2 mm" [13]

"the crown has a maximum thickness of about 1.5 mm" [14]

"the crown has a thickness of about 1 mm" [15]

109. *Hocknell* discloses that the "crown section 62 preferably has a thickness range of 0.010 to 0.100 inch [approximately 0.25 to 2.5 mm]." PXG1004, 8:32-33. Thus, in my opinion, a skilled artisan would understand that *Hocknell* teaches the use of crowns that meet these limitations.

i. "the crown is comprised of a graphite-epoxy composite having a 50% to 70% fiber volume ratio" [16]

110. *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably composed of a non-metal material, preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or

thermosplastic resin). PXG1004, 7:54-57. *Hocknell* further discloses that "[i]n a preferred embodiment, the minor body 60 [which includes the crown 62] is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Pat. No. 6,248,025 ["*Murphy*"], entitled Composite Golf Head Method of Manufacturing, which is hereby incorporated by reference in its entirety." *Id*., 8:43-48. *Murphy* discloses that "the preferred composite material is plies of carbon pre-peg [sic, preg] composite sheets." PXG1011, 6:45-46. *Murphy* further discloses that "[e]xemplary carbon pre-preg fiber sheets may be obtained" from a number of different commercial suppliers. *Id*., 6:55-58. A skilled artisan would understand that carbon and graphite are generally used interchangeably to describe carbon-based fibers for composite materials. Moreover, *Hocknell* suggests using a thermosetting resin, and a skilled artisan would understand that the most common thermosetting resin used in carbon fiber composites is epoxy. Thus, in my opinion, to a skilled artisan, it would be obvious to use a graphite-epoxy for the crown.

111. In my opinion, a skilled artisan would also understand that typical graphite-epoxy composites have a typical fiber volume fraction of about 60% and certainly within the claimed range of 50% to 70%. PXG1023, 2:64; PXG1024, 34, 49. In any event, given that the claimed fiber volume ratio encompasses the fiber

volume ratio of typical graphite-epoxy composites, it would have been an obvious design choice to choose a graphite-epoxy composite within the claimed range.

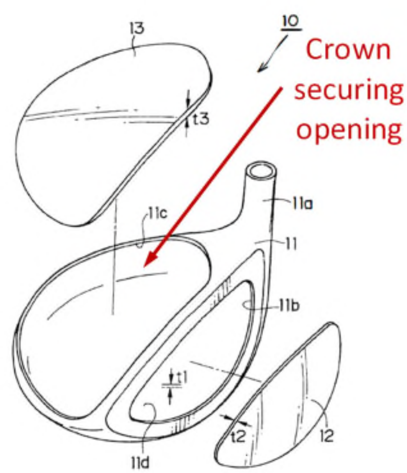
j. "the upper opening comprises at least 25% of a total area of the top portion" [17]

"the upper opening comprises at least 60% of a total area of the top portion" [18]

"the upper opening comprises at least 75% of a total area of the top portion" [19]

112. *Ezawa* discloses a "crown securing opening" that is an upper opening located entirely within the top portion of a club head and as shown in the figure below, comprises at least 25%, at least 60%, and at least 75% of the top portion of *Ezawa's* club head. PXG1006, Fig. 1 (annotated below).

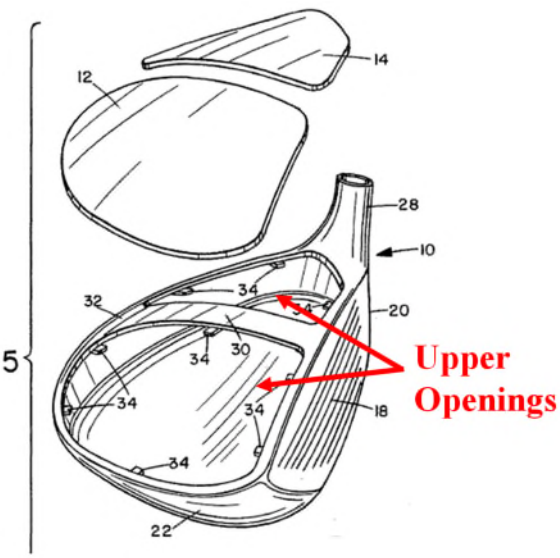
F I G. 1



113. *Lo* discloses upper openings located entirely within the top portion of a club head and as shown in the figure below, comprise at least 25%, at least 60%,

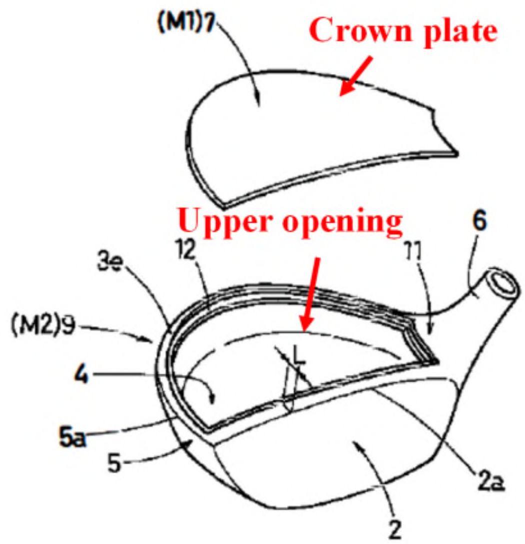
and at least 75% of the top portion of *Lo's* club head. PXG1009, Fig. 5 (annotated below).

FIG. 5



114. *Masanori* discloses an upper opening located entirely within the top portion of a club head and as shown in the figure below, comprises at least 25%, at least 60%, and at least 75% of the top portion of *Ezawa's* club head. PXG1021, Fig. 4 (annotated below)

[FIG. 2]



115. In my opinion, as discussed further below, it would have been obvious to a skilled artisan to modify the club head of *Hocknell* such that *Hocknell's* upper opening is located entirely within the top portion of a golf club head as taught by *Ezawa*, *Lo* or *Masanori*. As discussed above, the upper openings of *Ezawa*, *Lo*, and *Masanori* meet these claimed limitations.

k. "the weight portions attached to an interior surface of the sole of the club head" [20]

116. *Hocknell* teaches "[a] heel weighting member 123 is placed adjacent the hosel 54 on the interior surface of the sole section 76." PXG1004, 9:12-14. Thus, in my opinion, a skilled artisan would understand that *Hocknell* teaches this limitation.

l. "the weight portion comprises a metallic material" [21]

117. *Hocknell* teaches that "[t]he weighting members 122 and 123 are preferably . . . weight chips welded to the interior surface of the major body 50." PXG1004, 9:19-22. Thus, in my opinion, a skilled artisan would understand that since the weighting members are being welded to the major body, the weight members are made of a metallic material.

B. Motivation to Combine *Hocknell*, *Helmstetter*, and *Ezawa*, *Lo*, or *Masanori*

118. In my opinion, a skilled artisan would have had a reason, as of the Priority Date, to modify the golf club head of *Hocknell* by including a separately attached striking plate as disclosed in *Helmstetter* with a reasonable expectation of success. Moreover, a skilled artisan would have had a reason to modify the club head of *Hocknell*/*Helmstetter* to have an upper opening and crown located entirely within the top portion of a club head as taught by *Ezawa*, *Lo*, or *Masanori* with a reasonable expectation of success.

1. Motivation to Combine *Hocknell* and *Helmstetter*

119. In my opinion, a skilled artisan would have had a reason to modify the golf club head of *Hocknell* by including a separately attached striking plate as disclosed in *Helmstetter* with a reasonable expectation of success. First, a skilled artisan could have combined *Helmstetter's* striking plate with the golf club head body of *Hocknell* using known methods with no change in their respective

functions to predictably yield a golf club head with desirable properties. Both *Hocknell* and *Helmstetter* disclose golf club heads with identical performance goals – the creation of golf club heads with coefficients of restitution (CORs) of 0.81 to 0.94. PXG1004, 10:31-33; PXG1005, 13:39-42. Both *Hocknell* and *Helmstetter* are also directed to generally the same size club heads as shown by their largely overlapping volume and mass ranges. PXG1004, 11:40 – 12:25, Tables 1, 2, and 3 (volume), 10:34-39 (mass); PXG1005, 13:48-53 (volume), 13:58-61 (mass).

120. In addition to similarities in performance, size, and mass, both *Hocknell* and *Helmstetter* aim to achieve club performance through the same technical approaches, a "flexible" face plate and a "higher moment of inertia." For example, *Hocknell* discloses a varying thickness striking plate that drops from 0.120 inches to 0.050 inches. PXG1004, 9:25-64. The variation in thickness is aimed at "enhancing the flexibility of the striking plate section." PXG1004, 9:64–10:3. Likewise, *Helmstetter* discloses a varying thickness striking plate, which has a thickness that drops from 0.120 inches to 0.072 inches. PXG1005, 12:19-42. The variation in thickness is aimed at "thereby maintaining flexibility of the striking plate insert." PXG1005, 12:42-48. Both patents also describe distribution of mass within the club and working towards a larger moment of inertia. *Hocknell* describes a club with a "high moment of inertia" (PXG1004, 5:26-29) while

Helmstetter describes a way to "increase the moment of inertia" of the club (PXG1005, 10:60-64).

121. Moreover, in both *Hocknell* and *Helmstetter*, the increased COR is driven by stronger materials on the face, which allows for thinner face sections. *Hocknell* achieves greater strength by proposing an amorphous metal (which are naturally high strength), while *Helmstetter* considers amorphous metals, but also high strength (crystalline) alloys. For example, *Helmstetter* states that the "return portion is composed of a cast metal material and the striking plate insert is composed of a forged or formed material." PXG1005, 7:36-38. As would be readily apparent to one of ordinary skill in the art prior to the '646 Patent, forged or formed metal material has greater strength than cast metal material of the same composition. Thus, *Helmstetter* discloses the use of a higher strength material on the strike plate to facilitate the thinning of the face of the club head toward the lower limits described in both *Hocknell* and *Helmstetter* to achieve a high COR. This supports combining *Hocknell* with *Helmstetter*.

122. Specifically, although *Hocknell* forms its major body from an amorphous metal, there is a technical reason to replace the striking plate in *Hocknell* with an even higher strength material on the face of the club as described in *Helmstetter* and maintain the amorphous material in the main body and composite material in the minor body. As a threshold point, one of ordinary skill

would have understood that stronger materials are typically preferred to weaker materials as long as the material does not become brittle and the stronger materials can be processed into appropriate shapes. Stronger materials allow a designer to make thinner sections, which, in a golf club head, allows one to distribute weight to adjust to the preferred moment of inertia while simultaneously increasing COR on a thinner club face. In "theory," one could make the entire club out of a very high strength material and make all sections very thin. However, in practice, this is not practical due to inherent manufacturing limitations and cost. Instead, it is better to tailor materials to the location in the club head based on stress distribution and place the strongest materials on the club face and the relatively weaker and lighter materials on the back of the club.

123. *Hocknell* teaches the use of a lightweight composite on the top and back of the club where stresses are lower than at the striking plate. *Helmstetter* teaches to replace the striking plate of a club head with higher strength material that is forged or formed. Amorphous metals proposed in *Hocknell* were known to be castable (PXG1004, 5:3-4) like conventional metals that allow a large portion of the club head with moderate stress levels to be fabricated from amorphous metals for proper energy return. However, amorphous metals were also known to be brittle and may not survive the high impact stresses at the club face resulting in failure. *Id*. A desirable solution to this problem to one of ordinary skill in the art

would be to make the front face out of a high strength forged or formed material (as in *Helmstetter*), join this to the amorphous metal of the club head of *Hocknell*, and maintain the composite crown of *Hocknell* to shift the center of gravity towards the bottom of the club. This would facilitate a thin face, high face flexibility, and allow less face and crown weight to increase moment of inertia.

124. Neither *Hocknell* nor *Helmstetter* teach away from this combination. To a skilled artisan, it would not present a structural challenge to add a front opening to *Hocknell*'s major body, nor would it be expected to weaken the club head body of *Hocknell* by substituting a stronger material in this opening. At the time, it was well known how to weld amorphous metals to conventional metals, and the stronger striking plate of *Helmstetter* would structurally reinforce the overall cast amorphous metal club head of *Hocknell*. A skilled artisan would have expected the new striking plate of *Helmstetter* in combination with the amorphous metal body and composite crown of *Hocknell* to achieve a high COR (at least in the range of 0.81 to 0.94 as recited in both *Hocknell* and *Helmstetter*) because the combined club head would maintain the variable thickness striking plate and thus its flexibility.

2. Motivation to Combine *Hocknell* and *Ezawa, Lo* or *Masanori*

125. A skilled artisan would have had a reason to modify *Hocknell's* club head design such that the upper opening and crown would be located entirely

within the top portion of the club head body as is shown in *Ezawa*, *Lo*, or *Masanori* with a reasonable expectation of success.

126. To achieve an upper opening entirely within the top portion, a skilled artisan would only need to make a slight design variation to *Hocknell's* upper opening. As seen below, *Hocknell's* upper opening bends slightly down the rear and sides (not shown) of the club head, but is not much different than the club head depicted in the '425 Patent. *Compare* PXG1004, Fig. 8 (annotated) *to* PXG1001, Fig. 4 (annotated). Thus, a skilled artisan would have only needed to modify *Hocknell's* major body *Hockenell's* opening and support members are located entirely within the top portion of the club head as shown is *Ezawa*, *Lo* and *Masanori*.

Hocknell

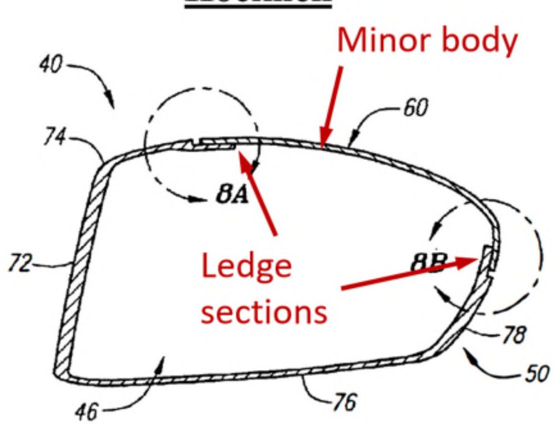
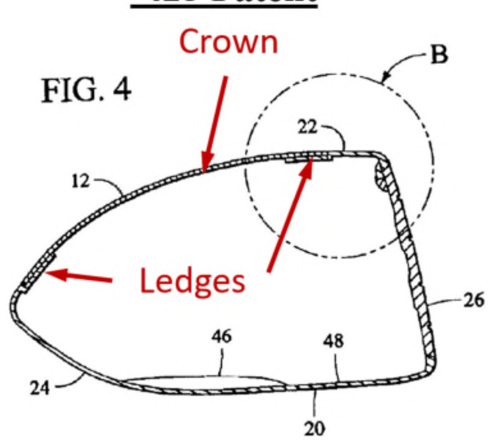


FIG. 8

'425 Patent

FIG. 4



127. A skilled artisan would have been motivated to use an upper opening solely in the top surface of *Hocknell's* design to make *Hocknell's* club less

challenging to manufacture and to improve the reliability of the club head. Composites are notoriously challenging materials to fabricate into curved surfaces and to join to other materials (particularly across paths that go out of plane). A skilled artisan would have understood that when joining two materials, it is preferable to minimize the length of the interface and have the interface exist in a single plane without complex geometrical deviations. Thus, if the crown of *Hocknell* was only on the top portion of the club like *Ezawa*, *Lo*, or *Masanori*, it would be easier to manufacture and have a more reliable interface, which is essential to club function.

128. Moreover, a skilled artisan would not have been dissuaded from modifying *Hocknell's* design to include an upper opening solely in the top portion (and thus limiting the composite crown solely to the top portion). A skilled artisan would have understood that one key purpose of the composite crown in *Hocknell* is to provide the capacity to control the center of gravity of the club head. Because the composite crown is less dense than the metal body, replacing the metal at the top of the club head with composite material shifts the center of gravity of the club downwards. Replacing the metal with composite at the top surface of the club head has a large impact on shifting the center of gravity of the club downwards, while replacing the metal around the sides and the rear has less of an impact. Thus, for ease of manufacture and to achieve a more reliable club head, a skilled artisan

would not have been dissuaded from modifying *Hocknell's* club design to have a crown solely in the top portion as in *Ezawa, Lo* or *Masanori*.

129. Finally, given the minor design change and the fact that the combination of *Helmstetter's* striking plate with *Hocknell's* body will be unchanged, a skilled artisan would still have expected to achieve a COR in the range of 0.81 to 0.94 disclosed by *Hocknell* and *Helmstetter*. Since the mechanical properties of the striking pate and surrounding portions of the body of the club head will be unchanged, a skilled artisan would not expect there to be a substantial difference in the transfer of energy from the club head to a ball contacting the striking plate. Consequently, a skilled artisan would not have been dissuaded from modifying *Hocknell's* crown as discussed above.

VIII. THE COMBINATION OF *ECKOLD* WITH *HOCKNELL, HELMSTETTER*, AND *EZAWA, LO*, OR *MASANORI* RENDERS CLAIMS 1-6, 8-10, AND 12-21 OBVIOUS

A. *Eckold* Teaches Typical Densities and Fiber Volume Fractions for Carbon-Epoxy Composites

130. To the extent that the Board finds that the "density" (claims 1, 9) and "fiber volume ratio" (claim 16) limitations are not taught or rendered obvious by the combination of *Hocknell*, *Helmstetter*, and *Ezawa* or *Lo* or *Masanori* in view of the general skill in the art, *Eckold* clearly teaches these limitations.

1. "the crown incorporating composite material and having a density ranging between 1 g/cc and 2 g/cc" [1]

"the crown is comprised of a graphite-epoxy composite having a density ranging between 1.4 and 1.65 g/cc" [9]

131. *Eckold* discloses an example of a typical unidirectional carbon/epoxy composite having a density of 1.57 g/cm^3. PXG1024, 34 (Table 2.8). Thus, a skilled artisan would understand that *Eckold* teaches these limitations.

2. "the crown is comprised of a graphite-epoxy composite having a 50% to 70% fiber volume ratio" [16]

132. *Eckold* discloses that "[f]or high performance applications, the reinforcement consists of continuous aligned or woven fibres in discrete layers, with typical fibre volume fractions being in the range of 50-70%." PXG1024, 49. *Eckold* also provides an example of a typical unidirectional carbon/epoxy composite having a fiber volume percentage of 57%. *Id*., 34 (Table 2.8). A skilled artisan would understand that "fiber volume ratio," "fiber volume fraction" and "fiber volume percentage" all mean the same thing. Thus, a skilled artisan would understand that *Eckold* teaches this limitation.

B. Motivation to Combine *Eckold* with *Hocknell*

133. As discussed below, a skilled artisan would have had a reason to use a carbon (or graphite) epoxy composite within the claimed ranges for "fiber volume ratio" and "density" for the crown of *Hocknell's* club head with a reasonable expectation of success.

134. *Hocknell* specifically teaches the use of a carbon pre-preg composite for its crown. *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably composed of a non-metal material, preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or thermosplastic resin). PXG1004, 7:54-57. *Hocknell* further discloses that "[i]n a preferred embodiment, the minor body 60 [which includes the crown 62] is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Pat. No. 6,248,025 ["*Murphy*"], entitled Composite Golf Head Method of Manufacturing, which is hereby incorporated by reference in its entirety." *Id*., 8:43-48. *Murphy* discloses that "the preferred composite material is plies of carbon pre-peg [sic, preg] composite sheets." PXG1011, 6:45-46. *Murphy* further discloses that "[e]xemplary carbon pre-preg fiber sheets may be obtained" from a number of different commercial suppliers. *Id*., 6:55-58. A skilled artisan would understand that carbon and graphite are generally used interchangeably to describe carbon-based fibers for composite materials and that the most common thermosetting resin (as suggested by *Hocknell*) used in carbon fiber composites is epoxy. Thus, in my opinion, a skilled artisan, based on the teachings of *Hocknell*, would have had a reason to use a carbon pre-preg, such as graphite-epoxy for the crown.

135. Moreover, in my opinion, a skilled artisan would have had a reason to use a graphite-epoxy within the claimed "fiber volume ratio" and "density" ranges. A skilled artisan would consider the use of a graphite-epoxy composite for the crown of a golf club head to be a typical use of such composite material, and not an extreme application. Thus, a skilled artisan would be motivated to use a graphite-epoxy composite with typical properties. *Eckold* teaches that composites typically have fiber volume fractions/percentages in the range of 50% to 70% with a typical carbon-epoxy composite having a 57% fiber volume percentage and a density of 1.57 g/cm^3. PXG1024, 34 (Table 2.8), 49. Thus, a skilled artisan would be motivated to use a graphite-epoxy composite having a typical fiber volume ratio of 50% to 70% and a density of about 1.57 g/ cm^3.

IX. DECLARATION

I declare all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with knowledge that willful false statements so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code.

Dated: September 14, 2018

Kenneth Gall, Ph.D.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

PARSONS XTREME GOLF, LLC
Petitioner,

v.

TAYLOR MADE GOLF COMPANY, INC.
Patent Owner.

Inter Partes Review No.: (unassigned)

U.S. Patent No. 7,494,425

DECLARATION OF KEN GALL IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,494,425

PXG
Ex. 1003

TABLE OF CONTENTS

Page

I, Ken Gall, Ph.D., declare as follows:

1. I have been retained by the law firm of Ballard Spahr LLP, who represents Parsons Xtreme Golf, LLC ("PXG") to provide expert testimony in support of PXG's Petition for *Inter Partes* Review of U.S. Patent No. 7,494,425 (the "Petition"), filed concurrently with this Declaration.

2. I understand that this proceeding involves U.S. Patent No. 7,494,425 ("the '425 Patent") titled "GOLF CLUB HEAD." I also understand that the '425 patent issued on February 24, 2009 from U.S. App. No. 11/879,780 filed on July 17, 2007. I also understand that the '425 Patent claims the benefit of U.S. App. No. 10/316,453, filed on December 11, 2002 ("Priority Date").

3. I have been asked to provide my opinion regarding whether one of ordinary skill in the art at the time of the Priority Date would understand that certain prior art references, in combination, disclose or teach each of the elements and limitations recited in claims 1-6, 8-10, and 12-22 of the '425 Patent. I have also been asked to provide my opinion regarding whether one of ordinary skill in the art would have had a rationale to combine certain prior art references.

4. In forming my opinion, I have relied on my own experience and knowledge and my review of the '425 Patent and the prior art references identified in this declaration.

I. QUALIFICATIONS AND COMPENSATION

5. I am currently a professor in the Mechanical Engineering and Materials Science Department at Duke University, where I have been a faculty member since 2015.

6. I received a Ph.D. in Mechanical Engineering in 1998 from the University of Illinois at Urbana Champaign.

7. Since 1998, I have held the following academic appointments:

- Post-Doc at Sandia National Laboratories from 1998-1999;
- Assistant Professor at the University of Colorado at Boulder from 1999-2003;
- Associate Professor at the University of Colorado at Boulder from 2003-2005;
- Associate Professor at the Georgia Institute of Technology from 2005-2007;
- Professor at the Georgia Institute of Technology from 2007-2015.

8. From 2004 to 2017, I mentored 19 Ph.D. students to the completion of the Ph.D. degree.

9. In addition to my academic appointments, I have also founded several start-up companies. The relevant projects are listed below.

10. In 2005, I founded MedShape, an orthopedic device company MedShape's products are based on shape memory polymers for soft tissue reconstruction (Eclipse, ExoShape, Morphix) and shape memory alloys for foot

and ankle joint fusion (DynaNail) and are sold in the orthopedic medical device market. MedShape's annual revenue is nearly $10M and two of its product lines have won industry-level device design excellence awards. MedShape's sports medicine division was acquired by ConMed in 2017.

11. In 2013 I founded Vertera, a developer of a surface porous PEEK spinal fusion cage for both Cervical Fusion (Cohere) and Lumbar Fusion (Coalesce). Vertera was acquired by NuVasive in 2017.

12. I have authored over 225 scientific publications in peer-reviewed journals including, but not limited to, publications in *Nature Materials*, *Advanced Engineering Materials*, *Acta Materialia*, *Engineering Fracture Mechanics*, *International Journal of Fatigue*, and *Physical Review Letters*.

13. I am a co-inventor on 20 patents.

14. I have taught over a thousand students on the deformation, fracture, and fatigue of materials, including welds and many geometrically and microstructurally complex materials. I have spent multiple years consulting on sporting equipment including golf clubs and mountain bikes, including work on engineering alloys and composites.

15. Additional details about my employment history, fields of expertise, and publications are included in my curriculum vitae (attached as Appendix A).

16. For my work related to this *Inter Partes* Review, I am being compensated at the rate of $650.00 per hour.

17. I have no financial interest in this proceeding, and my compensation is not conditioned on or impacted by the content of my testimony or the outcome of this proceeding.

II. MATERIALS CONSIDERED

18. In forming my opinions, I read and considered the ‘425 Patent and its prosecution history, the exhibits listed in the Exhibit List filed with the petition for *inter partes* review of the ’425 Patent, as well as any other material referenced herein.

III. THE’425 PATENT

A. Background

19. The challenged claims of the ’425 Patent are directed to a “wood-type golf club head,” i.e., the part of a golf club that strikes a golf ball. More particularly, the challenged claims are directed to hollow golf club heads manufactured from metals and composite materials (rather than the traditional solid “wood”). By the 1980s, hollow-metal golf club heads were becoming the more prevalent type of wood-type golf club head on the market. Hollow-metal golf club heads are much lighter than an equivalently sized solid wood head. Thus, the hollow-metal club heads could be made larger for a larger “sweet spot.” By the

late 1990s, club heads with volumes from 175 to 400 cc were being developed. *See, e.g.*, PXG1006, 2:27-28; PXG1007, 3:26-30. To achieve these larger sizes, manufacturers began using metal alloys that have a lower density (e.g., titanium alloys) but that are still strong enough to withstand an impact with a golf ball. *See, e.g.*, PXG1008, 2:45-54; PXG1007, 5:51-54.

20. By at least 1992, manufacturers began experimenting with using a combination of materials in a golf club head. *See, e.g.*, PXG1009, 2:29-31; PXG1008, 2:45-51; PXG1010, 3:54-61. There are a number of reasons to use different materials in a golf club head. For example, since titanium is expensive, manufacturers have an incentive to replace some of the titanium with a less expensive metal alloy in areas subject to less stress. *See, e.g.*, PXG1008, 1:26-29; PXG1006, 1:27-30. By using materials with different densities, manufacturers can also adjust the center of gravity ("CG") of the club, which can improve a golf club's properties. *See, e.g.*, PXG1009, 3:10-20; PXG1010, 4:11-16.

21. Another reason to optimize the materials in a golf club head is to maximize the distance a golf ball may be hit. To achieve this goal, among other things, golf manufacturers seek to maximize what is known as the coefficient of restitution ("COR"). *See, e.g.*, PXG1004, 10:8-11; PXG1005, 13:18-21. COR is a measure of the efficiency of the transfer of momentum between two colliding bodies. The value of COR ranges from 0 to 1, where 1 would be a perfect elastic

collision (no loss of incoming energy) and 0 would be a perfect inelastic collision (complete dissipation of incoming energy). *See, e.g.*, PXG1004, 10:26-31; PXG1005, 13:35-40. To increase COR, manufacturers have designed club heads and club head faces (also known as striking plates) that deform and recover during impact, providing a trampoline effect and increasing COR. *See, e.g.*, PXG1005, 12:42-49. In 1998, the United States Golf Association ("USGA") set the COR limit for woods at 0.822 with a test tolerance of 0.007 effectively taking the limit up to 0.83. *See* PXG1019, Appendix B, 1.0, 2.0, Fig. B-1. Thus, at least since 1998, manufacturers have been seeking to make golf clubs that can achieve a COR up to the limit allowed by the USGA. *See, e.g.*, PXG1005, 13:43-47.

22. To achieve these goals, by 1995 if not sooner, manufacturers began using composite material, such as graphite-epoxy, for the crown of a golf club head. *See, e.g.*, PXG1004, 7:54-57, 8:43-48; PXG1009, 3:1-3; PXG1011, 6:45-46. Since this material has a combined higher strength and lower density than metal, it helps keep the weight of the golf club low, allowing for larger club head sizes and faster swing speeds. By having a lighter material on the top of the club head, a composite crown also moves the center of gravity lower, which improves loft and may improve the "forgiveness" of the club. *See, e.g.*, PXG1009, 3:10-20.

23. At least since 1992, golf club manufacturers have also used separately formed "face inserts" or "striking plates" that are attached to a front opening on the

body of a golf club head to improve them. *See, e.g.*, PXG1005 7:33-35; PXG1006, 3:40-45; PXG1012, 2:55-59; PXG1008, 3:52-55, 66-67; PXG1010, 3:36-43. For example, the striking plate (front) could be made from a lower density, higher strength material than the golf club body to shift the CG to the rear. *See, e.g.*, PXG1008, 2:58 – 3:3; PXG1012, 2:22-24. A separately attached striking plate may also reduce vibrations which would be inherent in a club head with an integrally formed striking plate. *See, e.g.*, PXG1012, 2:29-32. Moreover, by using a separately formed striking plate, it can be optimized for strength by using a different metal alloy or different manufacturing process as compared to the club head body, which has a more complex shape that limits practical manufacturing processes and the use of high strength materials. *See, e.g.*, PXG1005, 7:36-45; PXG1006, 3:43-56. For example, a golf head body may be composed of a cast metal material, and the striking plate may be composed of a forged or formed metal material for increased strength. *See, e.g.*, PXG1005, 7:36-38; PXG1006, 2:41-45. Because the striking plate can be made of a stronger material, the striking plate may be made thinner than with an integrally-formed striking plate. *See, e.g.*, PXG1010, 3:64 - 4:4. This may improve the ability of the striking plate to deform and recover during impact, improving COR.

B. Priority Claim

24. I understand that ’425 Patent issued from U.S. App. No. 11/879,780, filed on July 17, 2007, which is a continuation of U.S. App. No. 11/186,022, filed on July 21, 2005, which is a continuation of U.S. Patent App. No. 10/634,023, filed on August 4, 2003, which is a continuation-in-part of U.S. App. No. 10/316,453, filed on December 11, 2002. PXG1001 at 1:6-11. Thus, I have been informed that the earliest possible priority date for the challenged claims is December 11, 2002 (“Priority Date”).

C. Overview of the ‘425 Patent

25. The ’425 Patent is directed to a “golf club head” as generally shown in annotated Figure 1 of the ’425 Patent below.

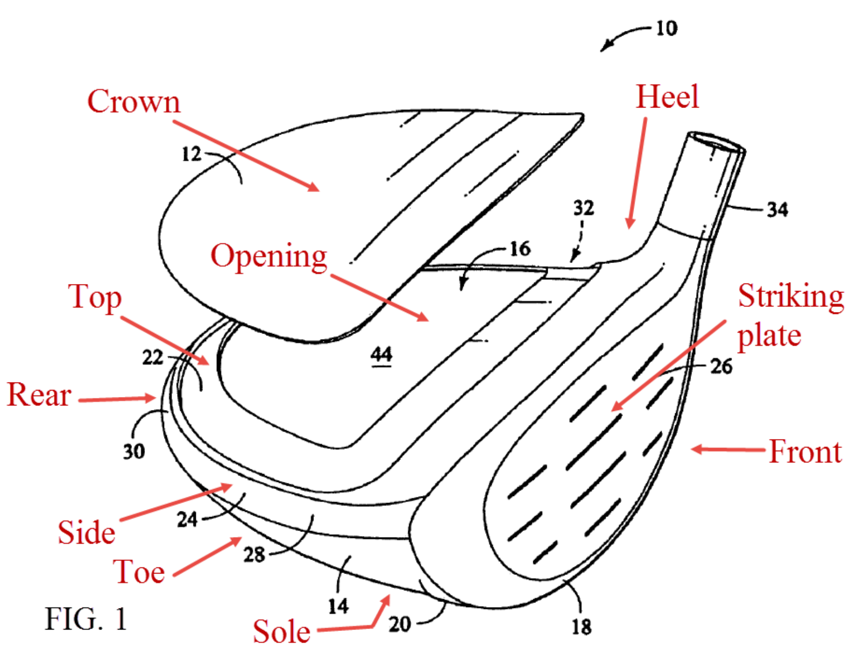


FIG. 1

26. With reference to Figure 1 above, the ’425 Patent discloses the typical structure for a wood-type golf club head having a hollow body 14, which has “a front 18, a sole 20, a top portion 22, and a side portion 24.” PXG1001, 4:35-36. “The side portion 24 extends rearwardly from the front 18 and has a toe region 28, a rear region 30 and a heel region 32.” PXG1001, 4:53-54. “At the front, a striking plate 26 is separately formed and attached to the front of the body in any manner known to those skilled in the art” as shown in annotated Figure 4 of the ’425 Patent below. *Id*., 4:36-39.

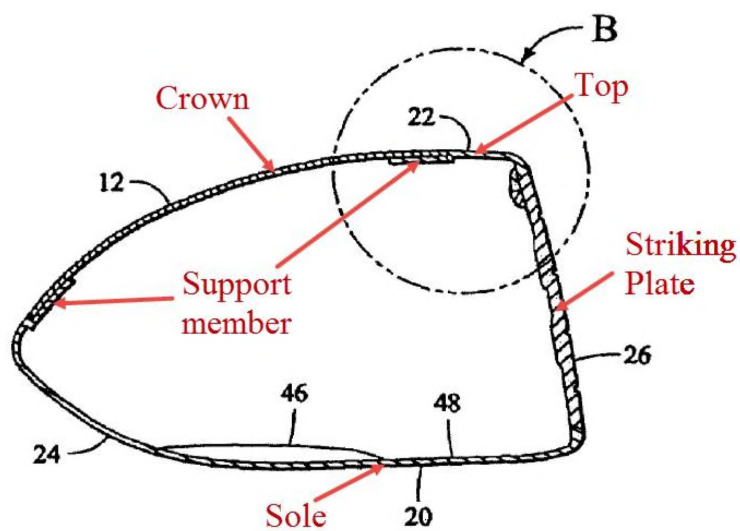


FIG. 4

27. As is also typical in prior art golf club heads, the golf club head 10 includes a separately formed crown 12. *Id*., 4:31-33. In Figure 1 above, the crown 12 has not yet been attached to the body 14 to enclose opening 16. *Id*., Fig. 1. To enable attachment of crown 12 to the body 14, the opening 16 includes a support

member that surrounds the opening, such as a ledge or a plurality of tabs. *Id*., 4:63-67.

28. Once the crown 12 is attached over the opening 16 and the striking plate is attached to the front 18 of the body 14, "the sole 20, top portion 22, front 18 and side portion combine with the crown 12 to form a hollow body having a volume of at least 150 cubic centimeters (cc) and up to 500 cc." *Id*., 4:59-62.

29. The '425 Patent teaches the use of standard materials to manufacture the golf club head. For example, "the body is formed of any metal, such as an aluminum, steel or titanium alloy." *Id*., 4:33-35. "[T]he striking plate may be formed of a different alloy or grade of the same metal as the body, or the striking plate may be a different metal or a composite material, as desired." *Id*., 4:39-42. And finally, the crown 12 is made of a composite material, such as a graphite-epoxy composite material. *Id*., 4:31-32, 6:14-16. The '425 Patent asserts that the use of a composite crown 12 on a metal body 14 increases the coefficient of restitution (COR). *Id*., 6:21-22.

D. The Challenged Claims

30. In this proceeding, PXG is challenging claims 1-6, 8-10, and 12-22 of the '425 Patent. Claims 1 and 22 are the only independent claims. By way of example, claim 1provides:

> 1. A golf club head, comprising:

> a body having a sole, a front defining a front opening, a top portion defining an upper opening, an upper edge disposed between and separating the front opening and the upper opening, and a side portion, the side portion extending rearward of the front opening and having toe, rear, and heel regions, wherein the body is comprised of a metallic material having a density of at least about 4 g/cc;
>
> a striking plate welded to the body portion, enclosing the front opening;
>
> a weight portion attached to an interior surface of the club head; and
>
> a crown attached to the body enclosing the upper opening, the crown incorporating composite material and having a density between 1 g/cc and 2 g/cc,
>
> wherein the golf club head has a maximum coefficient of restitution of at least 0.80 and a volume of at least 150 cc.

Challenged claims 2-4, 8-10, 12-15, 17, and 20-21 each depend from claim 1 and merely recite slight design variations or claim certain compositions of the materials, all for the same club head of claim 1. Independent claim 22 is very similar to claim 1, except the claim does not recite "a weight portion" or a density limitation for the crown, but does recite "a shoulder disposed around the periphery of the upper opening, and a recessed support extending from the shoulder and positioned adjacent to the upper opening."

IV. LEGAL STANDARDS

31. I have been told the following legal principles apply to analysis of patentability based on 35 U.S.C. § 103. I also have been told that, in an *inter partes* review proceeding, a patent claim may be deemed unpatentable if it is shown by a preponderance of the evidence that the claim is rendered obvious by one or more prior art patents or publications under § 103.

A. Level of Ordinary Skill in the Art

32. I understand that "one of ordinary skill in the art" is not a specific, real individual, but rather a hypothetical individual who is presumed to have known the relevant art at the time of the invention. In defining "one of ordinary skill in the art," I have been advised to consider factors such as (A) the types of problems encountered in the art; (B) prior art solutions to those problems; (C) speed of innovation in the field; (D) sophistication of the technology; and (E) educational level of active workers in the field.

33. Based on these factors and my experience in this area, I have assessed the level of ordinary skill in the art based upon my review of the prior art. A person of ordinary skill in the art would have a person of ordinary skill in the art for the '425 Patent would have (1) a bachelor's degree in mechanical engineering, materials science engineering, physics, or an equivalent degree or coursework, and

(2) at least one year of experience researching or developing golf club heads, and/or methods of their manufacture.

34. I was at least a person of ordinary skill in the art and have rendered my opinions in this Declaration from the view point of one of ordinary skill in the art as of the Priority Date.

B. Claim Construction

35. I understand that in this proceeding the claims of the ‘425 Patent should be understood based on their broadest reasonable construction in light of the ‘425 Patent’s specification. Unless otherwise noted, my opinions in this declaration are consistent with the broadest reasonable construction of the claims to a person of ordinary skill in the art at the Priority Date.

1. “upper opening”

36. I have been informed that the Board has construed the term “upper opening” as used in the challenged claims as requiring that “the upper opening is located entirely within the top portion.” For purposes of my opinions in this declaration, I have adopted this construction.

2. “crown”

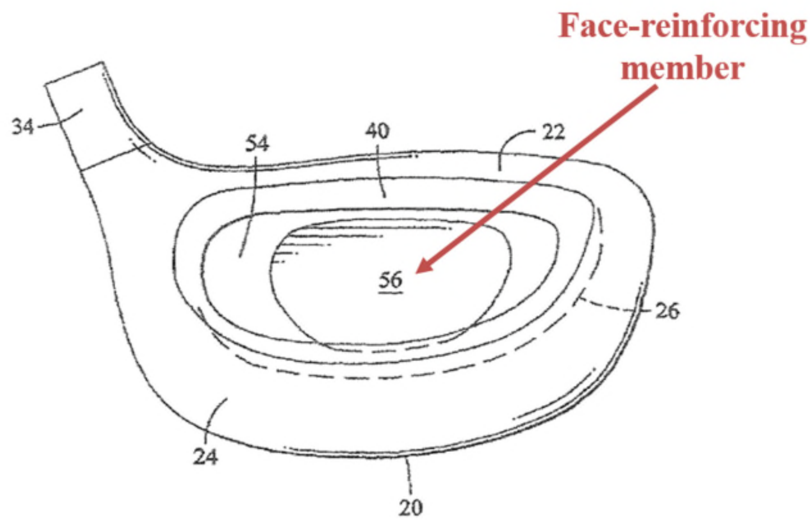
37. I have been informed that in a related proceeding the Board has construed the term “crown” as requiring “that the crown be located entirely within the top portion.” For purposes of my opinions in this declaration, I have adopted this construction.

3. “face-reinforcing member”

38. Claim 5 recites “[a] golf club head as defined in claim 1, further comprising a face reinforcing member coupled to a rear surface of the striking plate.” This claim term should be construed to mean “a separate piece that is attached to the rear of the face plate.” In my opinion, the use of the term “coupled” would indicate to a skilled artisan that the face-reinforcing member is a separate piece that is directly or indirectly attached or connected to the rear surface of the striking plate (i.e., not integrally formed with the striking plate).

39. This definition is consistent with the ’425 patent specification. For example, the ’425 Patent provides that “[b]ecause of the access afforded by the opening in the top 22 of the club head 10, a rear [*sic*] of the striking face 54 is accessible during manufacture for the ***addition*** of a face reinforcing member 56 [formed] of metal or composite material and securely ***attached*** behind the sweet spot, as shown in FIG. 7.” PXG1001, 7:13-18. Figure 7 also shows the face reinforcing member 56 as separate piece. *Id*., Fig. 7 (annotated).

FIG. 7



Based on the foregoing passage and Figure 7 in the specification, it is my opinion that a skilled artisan would understand that the "face reinforcing member" is a separate piece that is attached to the striking plate after the club head body and striking plate are formed, and prior to enclosing the opening in the top of the body of the club head—not something that is integrally formed with the striking plate.

40. I have been informed that in the Related Litigation, TMG asserts that "face-reinforcing member" should be construed to mean "a component that improves face strength." Even under the BRI standard, TMG's construction is overly broad and would encompass portions that are integrally formed with the striking plate, such as thickened portions of a striking plate. In my opinion, a skilled artisan would not consider such integrally-formed, thickened portions to be a "face-reinforcing member" as that term is used in claim 5. However, in the event the Board adopts TMG's construction of "face-reinforcing member," as discussed

further below, my opinion is that *Helmstetter's* striking plate discloses this limitation.

C. Obviousness

41. I understand that "[a] patent may not be obtained though the invention is not identically disclosed or described . . . , if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." 35 U.S.C. § 103.

42. When considering the issues of obviousness, I have been told that I am to do the following:

a. Determine the scope and content of the prior art;

b. Ascertain the differences between the prior art and the claims at issue;

c. Resolve the level of ordinary skill in the pertinent art; and

d. Consider evidence of secondary indicia of non-obviousness (if available).

43. I have been told that a reference may be modified or combined with other references or with the person of ordinary skill's own knowledge if the person would have found the modification or combination obvious. I have also been told that a person of ordinary skill in the art is presumed to know all the relevant prior

art, and the obviousness analysis may take into account the inferences and creative steps that a person of ordinary skill in the art would employ.

44. In determining whether a prior-art reference could have been combined with another prior-art reference or other information known to a person having ordinary skill in the art, I have been told that the following principles may be considered:

a. A combination of familiar elements according to known methods likely to be obvious if it yields predictable results;

b. The substitution of one known element for another is likely to be obvious if it yields predictable results;

c. The use of a known technique to improve similar items or methods in the same way is likely to be obvious if it yields predictable results;

d. The application of a known technique to a prior art reference that is ready for improvement is likely obvious if it yields predictable results;

e. Any need or problem known in the field and addressed by the reference can provide a reason for combining the elements in the manner claimed;

f. A skilled artisan often will be able to fit the teachings of multiple references together like a puzzle; and

g. The proper analysis of obviousness requires a determination of whether a person of ordinary skill in the art would have a "reasonable expectation of success"—not "absolute predictability" of success—in achieving the claimed invention by combining prior art references.

45. I understand that whether a prior art reference renders a claim unpatentable as obvious is determined from the perspective of a person of ordinary skill in the art. I have also been told that, while there is no requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, a suggestion to combine known elements to achieve the claimed invention may come from the prior art as a whole or individually, as filtered through the knowledge of one skilled in the art. In addition, I have been told that the inferences and creative steps a person of ordinary skill in the art would employ are also relevant to the determination of obviousness.

46. I also understand that, when a work is available in one field, design alternatives and other market forces can prompt variations of it, either in the same field or in another. I have also been told that if a person of ordinary skill in the art can implement a predictable variation and would see the benefit of doing so, that variation is likely to be obvious. I have been told that in many fields, there may be little discussion of obvious combinations, and in these fields market demand—not scientific literature—may drive design trends. I have been told that, when there is a

design need or market pressure and there are a finite number of predictable solutions, a person of ordinary skill in the art has good reason to pursue those known options.

47. I have been told that there is no rigid rule that a reference or combination of references must contain a "teaching, suggestion, or motivation" to combine references. But I also have been told that the "teaching, suggestion, or motivation" test can be a useful guide in establishing a rationale for combining elements of the prior art. I have been told that this test poses the question as to whether there is an express or implied teaching, suggestion, or motivation to combine prior art elements in a way that realizes the claimed invention, and that it seeks to counter impermissible hindsight analysis.

48. I understand that the relevant time for considering whether a claim would have been obvious to a person of ordinary skill in the art is the time of alleged invention, which I have been told to assume is the Priority Date – December 11, 2002.

V. THE CHALLENGED CLAIMS ARE OBVIOUS OVER THE PRIOR ART

49. Based on my education, experience, and my review of the prior art, it is my opinion that a person of ordinary skill in the art as of the Priority Date would conclude that:

a. claims 1-6, 8-10, and 12-22 are obvious over the combination of U.S. Patent No. 6,663,504 (PXG1004, "*Hocknell*"), U.S. Patent No. 6,565,452 (PXG1005, "*Helmstetter*"), and U.S. Patent No. 6,334,817 (PXG1006, "*Ezawa*");

b. claims 1-6, 8-10, and 12-22 are obvious over the combination of *Hocknell*, *Helmstetter*, and U.S. Patent No. 5,624,331 (PXG1009, "*Lo*");

c. claims 1-6, 8-10, and 12-22 are obvious over the combination of *Hocknell*, *Helmstetter*, and Japanese Patent Application No. 2002-165902 (PXG1021, "*Masanori*");

d. claims 1-6, 8-10, and 12-21 are obvious over the combination of *Hocknell Helmstetter*, *Ezawa*, and Geoff Eckold, Design and Manufacture of Composite Structures (Woodhead Publishing Ltd. 1994) (PXG1024, "*Eckold*");

e. claims 1-6, 8-10, and 12-21 are obvious over the combination of *Hocknell*, *Helmstetter*, *Lo*, and *Eckold*; and

f. claims 1-6, 8-10, and 12-21 are obvious over the combination of *Hocknell*, *Helmstetter*, *Masanori*, and *Eckold*.

VI. OVERVIEW OF THE APPLIED REFERENCES

A. *Hocknell*

50. Like the ’425 Patent, *Hocknell* is directed to a golf club head. PXG1004, 5:29-30. *Hocknell* discloses a “club head 40 [that] is generally composed of two components, a major body 50 and minor body 60. The minor body 60 has a crown section 62 and a ribbon section 64. The club head 40 may also be partitioned into a heel end 66 nearest the shaft 48, a toe end 68 opposite the heel section 66, and an aft end 70.” PXG1004, 6:38-43, Figs. 4, 5. “The major body 50 generally includes a striking plate section . . . 72, a sole section 76 extending laterally rearward from the striking plate section 72.” PXG1004, 7:7-12; Fig. 4 (annotated below), and Fig. 5 (annotated below).

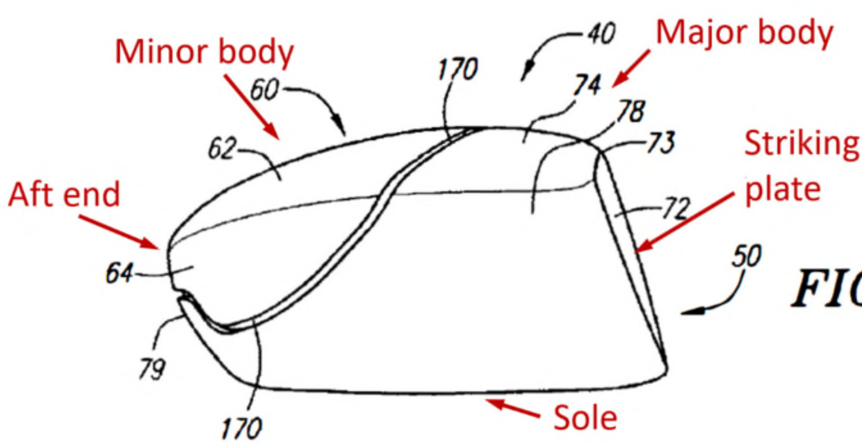


FIG. 4

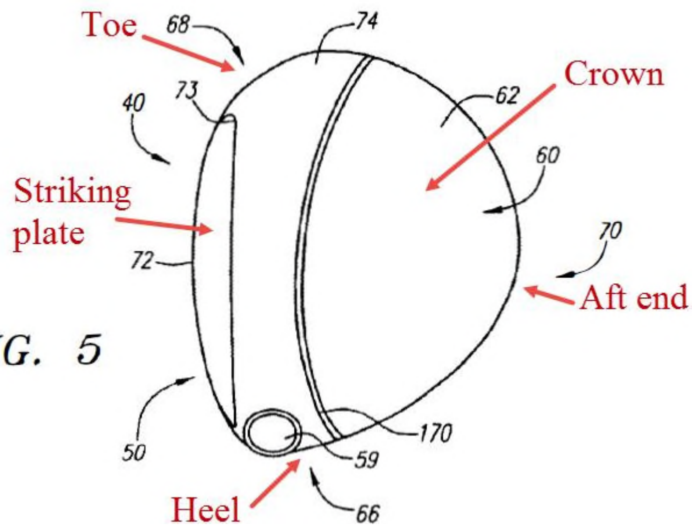


FIG. 5

51. As best seen in annotated Figure 8 below, *Hocknell* teaches that its minor body 60 encloses an upper opening of the club head. PXG1004, Fig. 8. *Hocknell* also discloses a support member (ledge 80) surrounding the upper opening for attaching the minor body 60 to the body. PXG1004, 7:13-14, Fig. 8, Fig. 9. This structure is remarkably similar to the golf club head of the ’425 Patent, which shows a crown 12 enclosing an upper opening supported by a ledge. *Compare* PXG1004, Fig. 8 (annotated below) *to* PXG1001, Fig. 4 (annotated below).

Hocknell

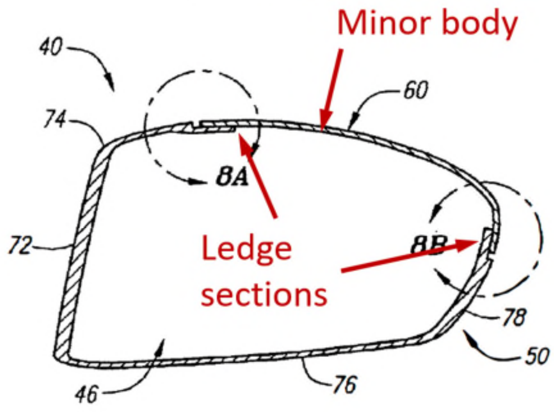
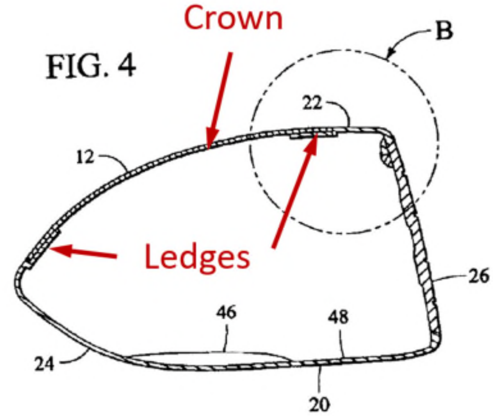


FIG. 8

'425 Patent



52. *Hocknell* also teaches golf club heads with crowns that are made of composite material. In particular, *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or thermoplastic resin)." PXG1004, 7:54-57.

B. *Helmstetter*

53. Like the '425 Patent, *Helmstetter* is directed to a wood-type golf club head. PXG1005, 13:54-57. *Helmstetter* discloses "a golf club head 42 with a hollow interior." PXG1005, 7:21-22. "The club head 42 is generally composed of two components, a face component 60, and an aft-body 61." PXG1005, 7:25-26, Fig. 7. "The club head 42 may also be partitioned into a heel section 66 nearest the shaft 48, a toe section 68 opposite the heel section 66, and a rear section 70

opposite the face component 60." PXG1005, 7:29-32, Fig. 5 (annotated below), Fig. 7 (annotated below).

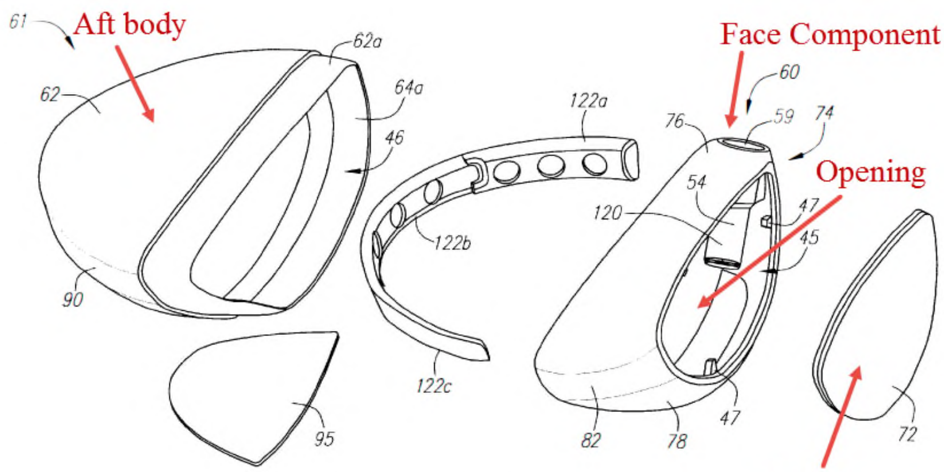


FIG. 7

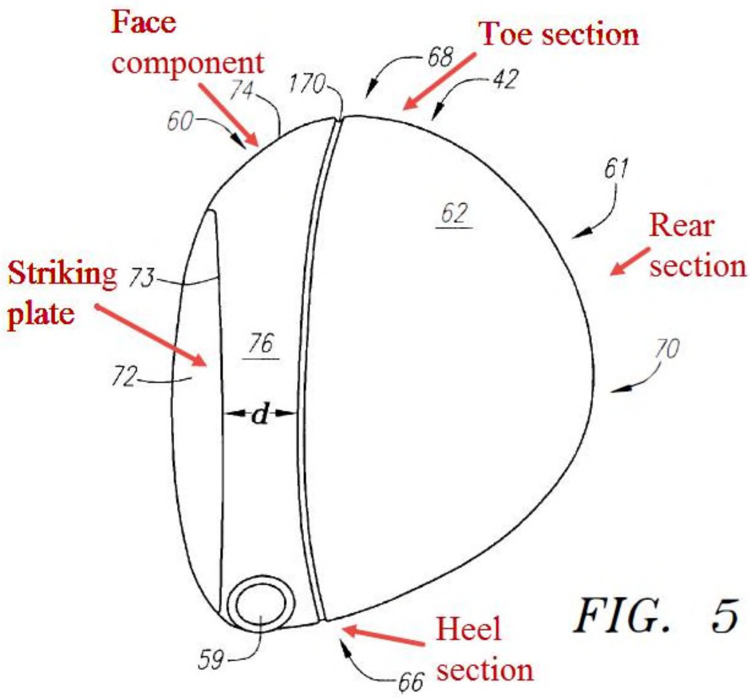


FIG. 5

54. *Helmstetter* teaches golf club heads wherein the striking plate is attached to the body, enclosing a front opening. In particular, *Helmstetter* discloses that "[t]he face component 60 is generally composed of two pieces of metal, the

return portion 74 and the striking plate insert 72. The opening 45 is configured for placement of the striking plate insert 72 therein.” PXG1005, 7:33-36, Fig. 7 (annotated below, showing front portion of club head), Fig. 8A (annotated below, showing striking plate insert 72 enclosing the front opening).

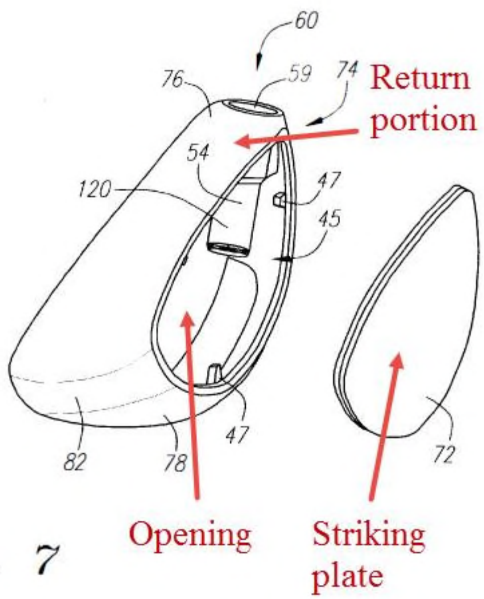


FIG. 7

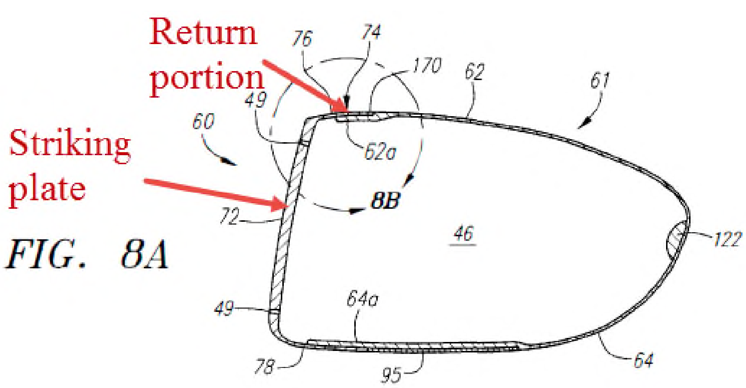


FIG. 8A

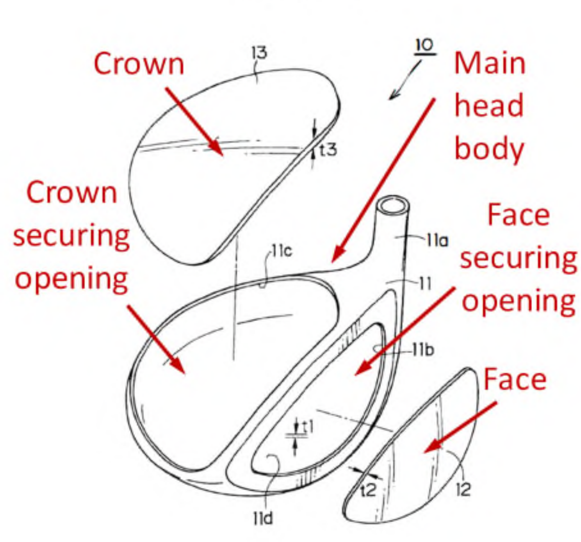
55. *Helmstetter* discloses that “the striking plate insert 72 is composed of a forged or formed metal material, [such as] a forged titanium or stainless steel

material. Such titanium material may include pure titanium and titanium alloys." PXG1005, 7:37-41.

C. *Ezawa*

56. Like the '425 Patent, *Ezawa* is directed to a wood-style golf club head. PXG1006, 1:5-6. *Ezawa* discloses that "present invention relates to a hollow golf club head called a metal wood which is made of a metallic material." *Id*. *Ezawa* also discloses that "[a] first example has a three piece structure comprising a main head body, a face, and a sole or crown." *Id*., 2:41-42. In particular, *Ezawa* discloses that "[t]he main head body 11 has a neck 11a and a sole 11d which are integrally formed therewith, and also has a face securing opening 11b and a crown securing opening 11c." *Id*., 3:43-45. As best seen in Figure 1, *Ezawa's* "crown securing opening" is an upper opening that is located entirely within the top portion of the club head body. *Id*., Fig. 1 (annotated below).

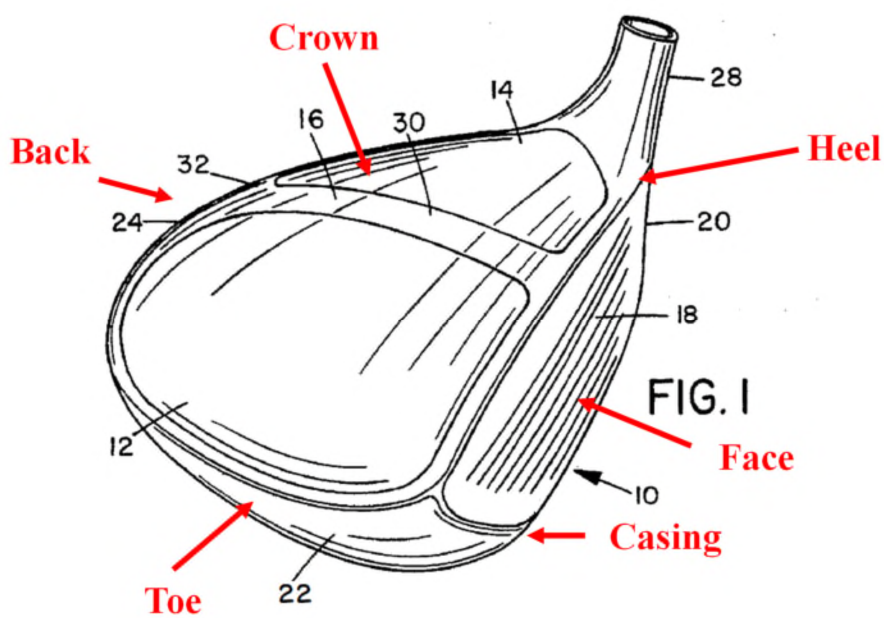
FIG. 1



57. *Ezawa* further teaches that a face 12 is secured to the face securing opening 11b, and a crown 13 is secured to the crown securing opening 11c. *Id.*, 3:63-65. As seen in Figure 1, after attachment, the crown 13 is located entirely within the top portion of the club head body. *Id.*, Fig. 1 (annotated above).

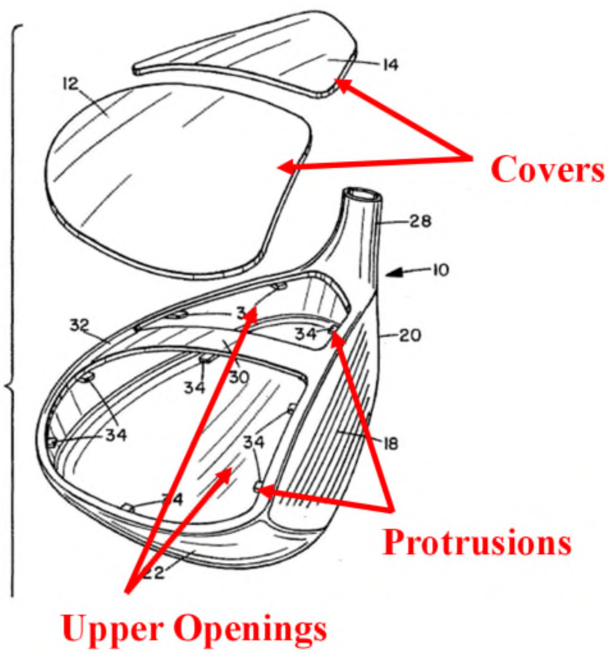
D. *Lo*

58. Like the ’425 Patent, *Lo* is directed to a wood-style golf club head. Ex. 1009, 2:14-15. *Lo* discloses a golf club head comprising “a generally hollow metal head casing.” PXG1009, 4:32. “[A] wood-style golf club head includes a metal casing 10 and two composite covers 12 and 14 that, when assembled, together define the surfaces of the head. These surfaces include a crown 16, a face 18, a heel 20, a toe 22, a back 24 and a sole 26.” *Id.*, 2:14-19, Fig. 1 (annotated).



59. As shown in Figure 5 below, *Lo* teaches golf club heads with upper openings located entirely within the top portion of a metal casing. *Lo* further teaches that that "composite covers 12 and 14 are inserted into the corresponding openings in casing 10." PXG1009, 4:3-5, Figure 5. *Lo* discloses "[m]etal casing 10 may have one or more ridges or protrusions 34 within these openings for supporting covers 12 and 14." *Id.*, 2:55-57, Fig. 5 (annotated below, showing opening surrounded by protrusions 34 for supporting covers 12 and 14).

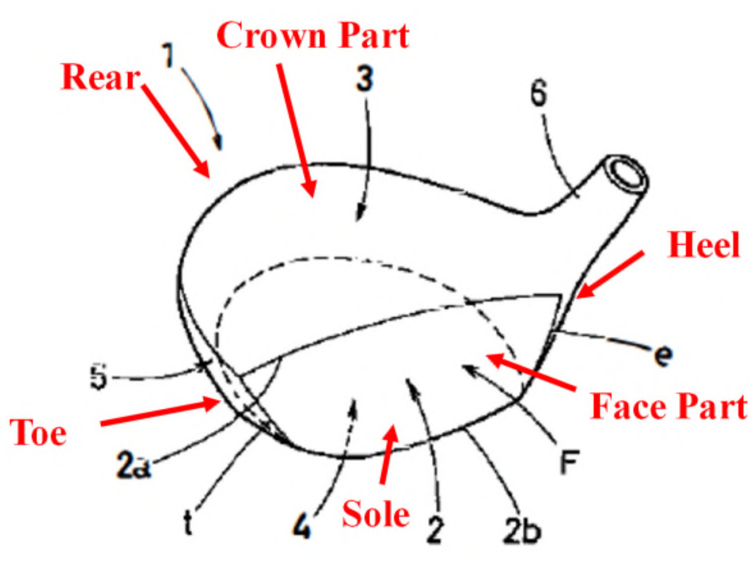
FIG. 5



60. Regarding materials, *Lo* teaches that"[c]overs 12 and 14 are preferably made of graphite-epoxy composite, although any other suitable fiber composite may be used" and that the "[m]etal casing 10 is formed from stainless steel or other durable metal." PXG1009, 2:52-53, 3:1-3.

E. Masanori

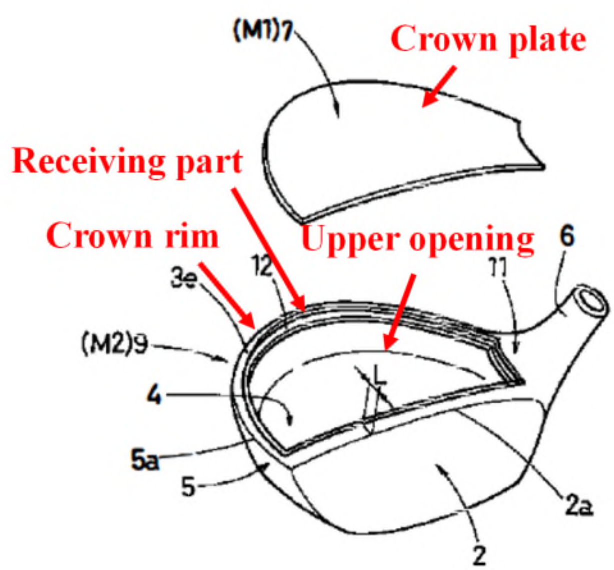
61. Like the '425 Patent, *Masanori* is directed to a wood-style golf club head. PXG1021, ¶0001. *Masanori* discloses a golf club head "composed of a metal material" and "being a wood-type head provided with a hollow part i in an inner part." *Id*., ¶0010. *Masanori* also teaches that its golf club head has "a face part 2 provided on a surface with a face surface F for striking a ball, a crown part 3 continuous to an upper edge 2a of the face part 2 and forming a head upper surface, a sole part 4 continuous to a lower edge 2b of the face part 2 and forming a head sole surface, a side part 5 rising up from the circumference of the sole part 4 and extending from a toe t side of the face part 2 through a back face to a heel e side of the face part 2." *Id*., Fig. 1 (annotated below).



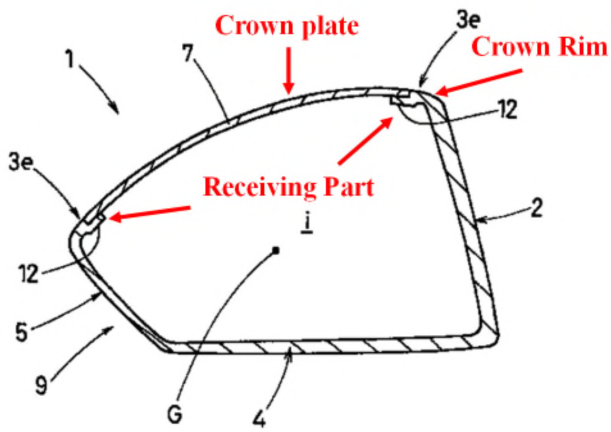
62. As shown in Figure 2 below, *Masanori* discloses a golf club head wherein an upper opening is located entirely within the top portion of the body of a

golf club head. PXG1021, Fig. 2. To support the crown part to enclose the upper opening, *Masanori* teaches a "crown rim part 3e . . . formed with a receiving part 12 for retaining the face [*sic*, crown] plate 7 substantially flush with the crown rim part and supporting it from below" and "formed around the entire rim of the crown plate 7." *Id*., ¶0014, Fig. 2 (annotated below, showing opening prior to crown plate attachment), Fig. 6 (annotated below, showing crown plate enclosing opening).

[FIG. 2]



[FIG. 6]



63. Regarding materials, *Masanori* teaches that the crown plate may be "a composite material with a low specific gravity such as fiber reinforced resin" and the body "is formed using a high specific gravity metal." PXG1021, ¶¶0015, 0020.

F. *Eckold*

64. *Eckold* is directed to composite materials, particularly, as relevant here, to "the fibres[1] and matrices in current use and the mechanics of how they can be combined to form a structural material of the required stiffness and strength." PXG1024, viii. *Eckold* further describes that many parameters effect the properties of composites, such as fiber volume fraction. *Id*., 49. *Eckold* discloses that "[f]or high performance applications, the reinforcement consists of continuous aligned or woven fibres in discrete layers, with typical fibre volume fractions being in the range of 50-70%." *Id*. *Eckold* also provides an example of a typical unidirectional

[1] *Eckold* uses the term "fibre," which is the British spelling of the term "fiber."

carbon/epoxy composite having a fiber volume percentage of 57% and a density of 1.57 g/cm^3. *Id*., 34 (Table 2.8);

VII. THE COMBINATION OF *HOCKNELL, HELMSTETTER,* AND *EZAWA, LO,* OR *MASANORI* RENDERS THE CHALLENGED CLAIMS OBVIOUS

65. Based on my education and experience, and my review of the prior art, it is my opinion that a person of ordinary skill in the art as of the Priority Date would conclude that claims 1-6, 8-10, and 12-22 are obvious over the combination of *Hocknell, Helmsetter,* and *Ezawa, Lo,* or *Masanori*.

A. The Combination of *Hocknell, Helmstetter,* and *Ezawa, Lo* or *Masanori* Teach All the Elements and Limitations of the Challenged Claims

66. In my opinion, as shown in more detail below, *Hocknell* discloses all the limitations of the challenged claims except a front opening that is enclosed by a striking plate, and an upper opening and a crown enclosing the upper opening that are located entirely within the top portion of a club head. However, *Helmstetter* clearly discloses separately forming a striking plate and attaching the striking plate to the front face of a golf club head to enclose a front opening. Moreover, as was well-known in the art, *Ezawa, Lo*, and *Masanori* teach upper openings and crowns that are located entirely within the top portion of a club head. Thus, the combination of *Hocknell* and *Helmstetter,* and *Ezawa, Lo*, or *Masanori* teach all

the limitations of the claims. To the extent that a limitation is not expressly taught in these references, it would have been an obvious variation to a skilled artisan.

1. Independent Claims 1 and 22

a. "A golf club head" [1, 22][2]

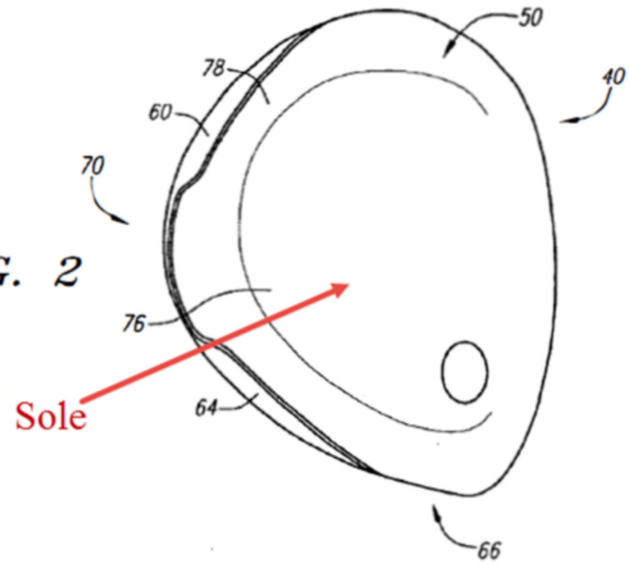
67. *Hocknell* teaches that "[t]he golf club heads are preferably fairway woods . . . ." PXG1004, 5:29-30. *Helmstetter* teaches that the golf club head of the present invention may be different types of "fairway woods." PXG1005, 13:54-57. *Ezawa, Lo,* and *Masanori* are also directed to wood-type golf club heads. PXG1006, 1:5-6; PXG1009, 2:14-15; PXG1021, ¶10. Thus, in my opinion, a skilled artisan would understand that *Hocknell*, *Helmstetter*, *Ezawa, Lo,* and *Masanori* are directed to a "wood type golf club head."

b. "a body having a sole" [1, 22]

68. *Hocknell* describes "a sole section 76 extending laterally rearward from the striking plate section 72," which is part of *Hocknell's* major body 50. PXG1004, 7:7-12, Fig. 2 (annotated below), Fig. 4 (annotated below).

[2] The number in the square brackets indicates the claim in which the element or limitation appears.

FIG. 2



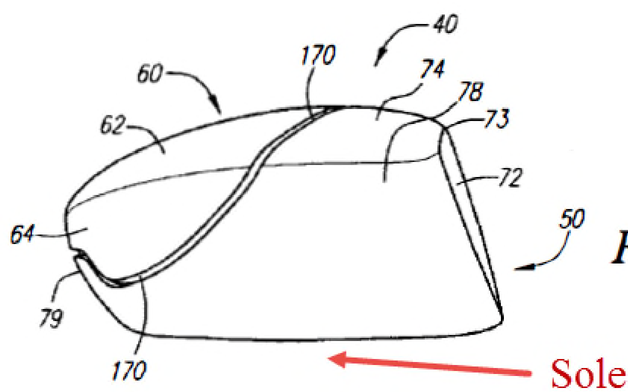


FIG. 4

Thus, in my opinion, a skilled artisan would understand that *Hocknell* discloses a golf club head with "a body having a sole."

c. "a front defining a front opening" [1, 22]

69. *Hocknell* discloses a front section that "includes a striking plate section (also referred to herein as a face plate) 72." PXG1004 at 7:7-8, Fig. 1 (annotated below).

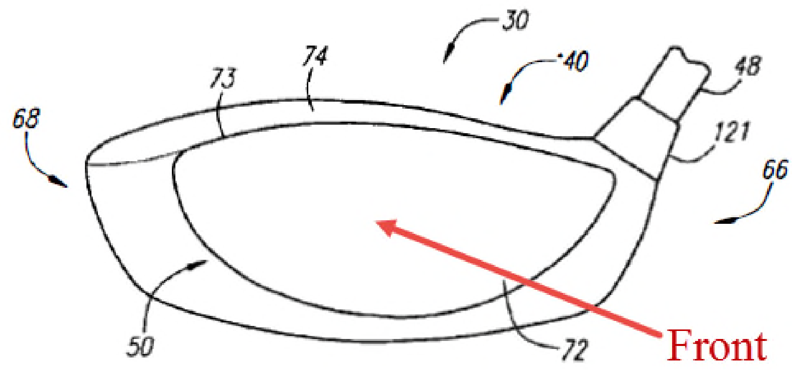


FIG. 1

70. *Helmstetter* discloses a front section that has a front opening. PXG1005, 7:34-36 (referencing "opening 45"), Fig. 7 (annotated below, only front portion of club head shown), Fig. 8A (annotated below).

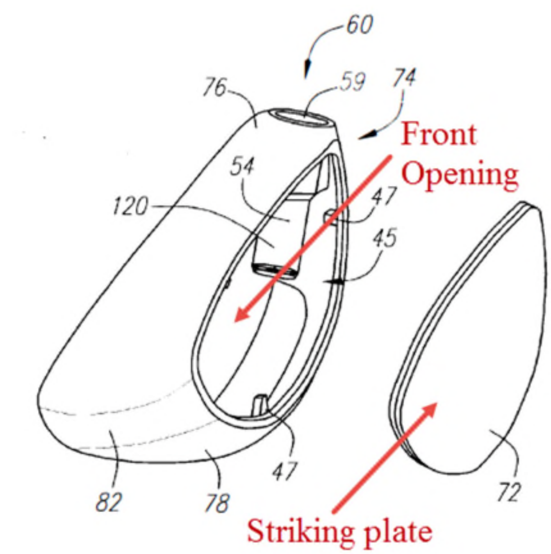


FIG. 7

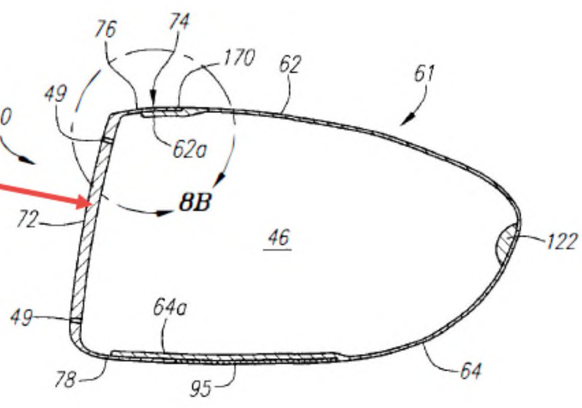


FIG. 8A

71. In my opinion, as discuss further below, it would have been obvious to a skilled artisan to use the front opening and separately formed striking plate of *Helmstetter* with the club body of *Hocknell*.

d. "a top portion defining an upper opening" [1, 22]

72. *Hocknell* discloses an upper opening in the so-called major body of *Hocknell*'s club head. This opening is in the upper portion of the club head. PXG1004, Fig. 8 (annotated below, showing minor body 60 enclosing opening), Fig. 9 (annotated below, showing opening prior to attaching minor body 60).

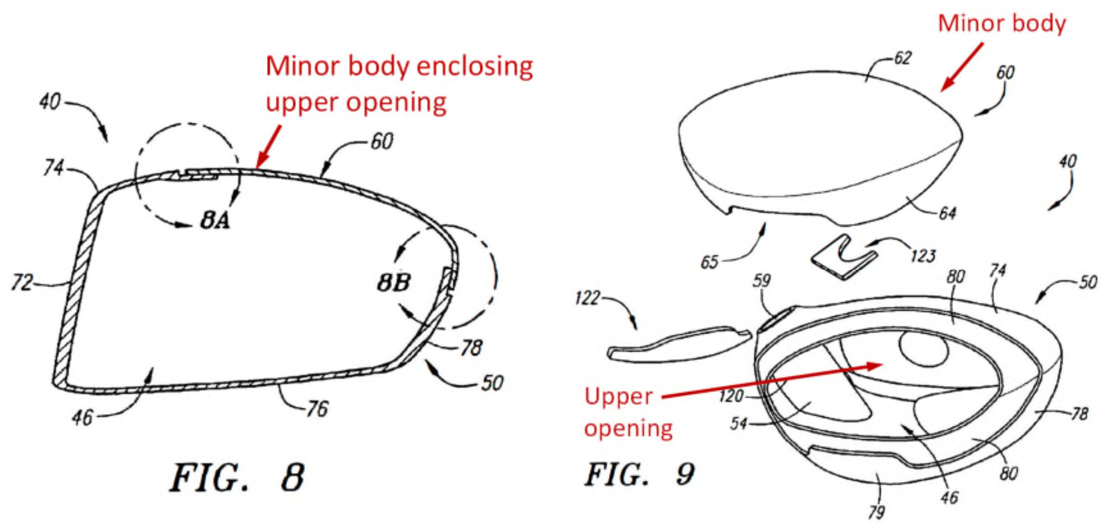
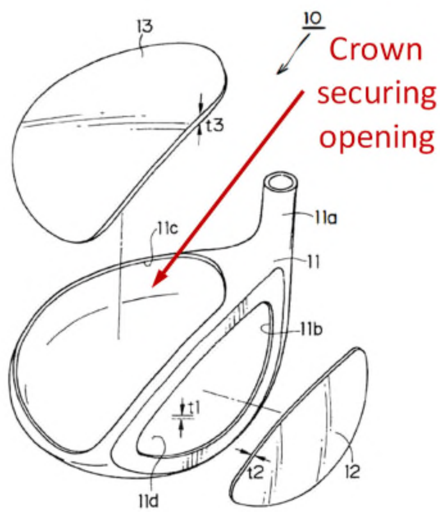


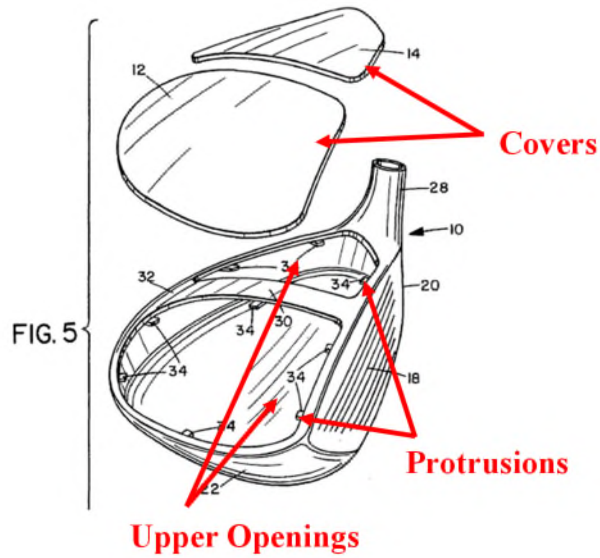
FIG. 8 FIG. 9

73. *Ezawa*, *Lo*, and *Masanori* disclose "upper openings" located entirely with the top portion of a club head. *Ezawa* discloses a so-called "crown securing opening" that is an upper opening located entirely within the top portion of the club head. PXG1006, Fig. 1 (annotated below).

FIG. 1

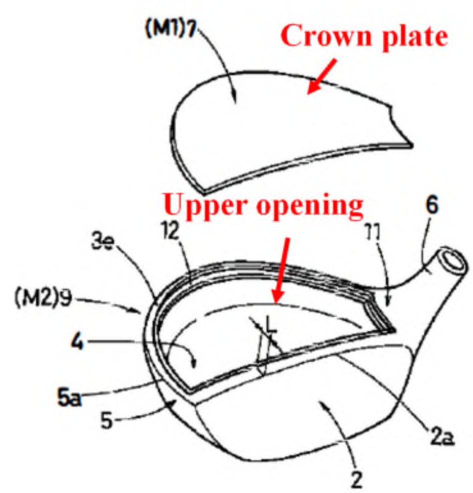


74. *Lo* discloses upper openings in the casing of *Lo's* club head. These upper openings are located entirely within the top portion of the club head. PXG1009, Fig. 5 (annotated below).



75. *Masanori* discloses an upper opening in the head body part of *Masanori's* club head. This upper opening is located entirely within the top portion of the club head. PXG1021, Fig. 2 (annotated below).

[FIG. 2]



76. Thus, in my opinion, as discussed further below, it would have been obvious to a skilled artisan to modify the club head of *Hocknell* such that

Hocknell's upper opening is located entirely within the top portion of a golf club head as taught by *Ezawa*, *Lo* or *Masanori*.

e. "an upper edge disposed between and separating the front opening and the upper opening" [1, 22]

77. *Hocknell* teaches an upper edge (so-called "return section 74") between its striking plate and its crown. PXG1004, Fig. 8 (annotated below, showing return section 74 between striking plate 72 and crown 62).

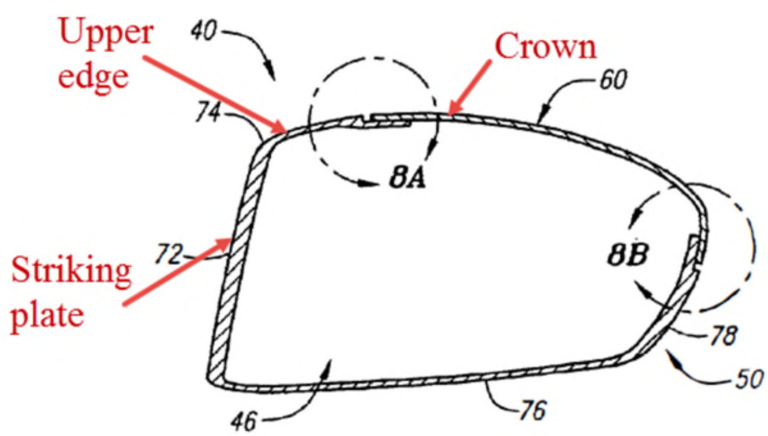


FIG. 8

78. *Helmstetter* also teaches an upper edge (so-called "return section 74") between its striking plate and its crown. *Helmstetter*'s striking plate encloses a front opening. PXG1005, Fig. 8B (annotated below, showing return section 74 between striking plate 72 and crown 62 and striking pate 72 enclosing a front opening).

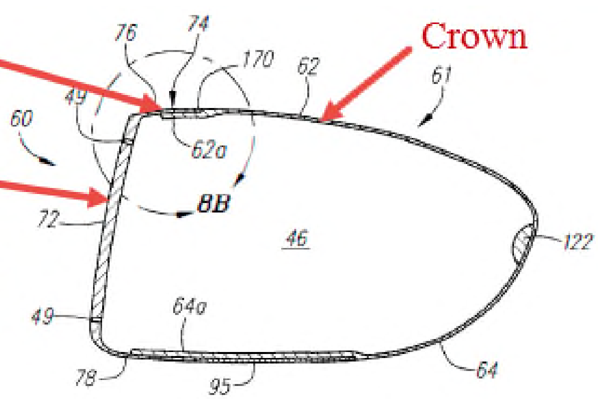
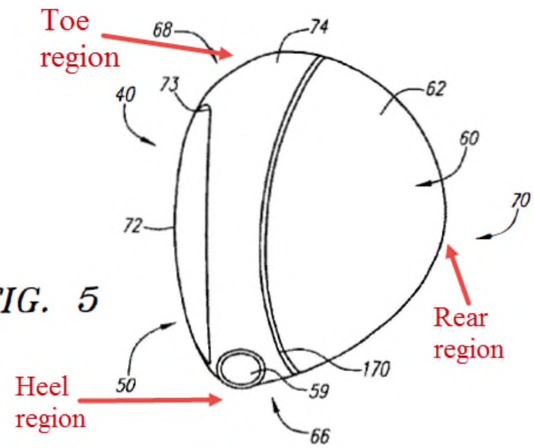


FIG. 8A

79. In my opinion, as discussed further below, it would have been obvious to a skilled artisan would understand using the front opening and separately formed striking plate of *Helmstetter* with the club body of *Hocknell*. Moreover, a skilled artisan would understand that combining *Helmsetter's* front opening with *Hocknell*'s golf club head would result in a golf club head with "an upper edge disposed between and separating a front opening and an upper opening." In fact, the claimed "edge" is merely the inherent result from having both a front and an upper opening in a golf club body. *See* PXG1006, Fig. 1; PXG1016, Fig. 4.

f. "a side portion, the side portion extending rearward of the front opening and having toe, rear, and heel regions" [1, 22]

80. *Hocknell* explains that once formed, "[t]he club head 40 may also be partitioned into a heel end 66 nearest the shaft 48, a toe end 68 opposite the heel section 66, and an aft end 70 [rear]." PXG1004, 6:38-43, Fig. 5 (annotated below).



In my opinion, a skilled artisan would understand that combining *Helmsetter's* front opening with *Hocknell*'s golf club head would result in a golf club head that has "a side portion extending rearward of the front opening and having toe, rear, and heel regions."

g. "the body is comprised of a metallic material having a density of at least about 4 g/cc" [1, 22]

81. *Hocknell* discloses that "[t]he major body 50 is generally composed of a single piece of metal, and is preferably composed of an amorphous metal material. . . . Such amorphous metals include Fe, Ni, Co and Cr based on amorphous metals, which have a density ranging from 8 grams per cubic centimeter (g/cc) to 10 g/cc." PXG1004, 6:44-51. In my opinion, a skilled artisan would understand that *Hocknell* and teaches a golf club head that has a body made "of a metallic material having a density of at least about 4 g/cc."

h. "a striking plate welded to the body, enclosing the front opening" [1]

"a striking plate attached to the body, enclosing the front opening" [22]

82. *Helmstetter* teaches that "[t]he face component 60 is generally composed of two pieces of metal, the return portion 74 and the striking plate insert 72. The opening 45 is configured for placement of the striking plate insert 72 therein." PXG1005 at 7:33-36, Fig. 7 (annotated below, only front portion of club head shown), Fig. 8A (annotated below, showing striking plate insert 72 enclosing the front opening).

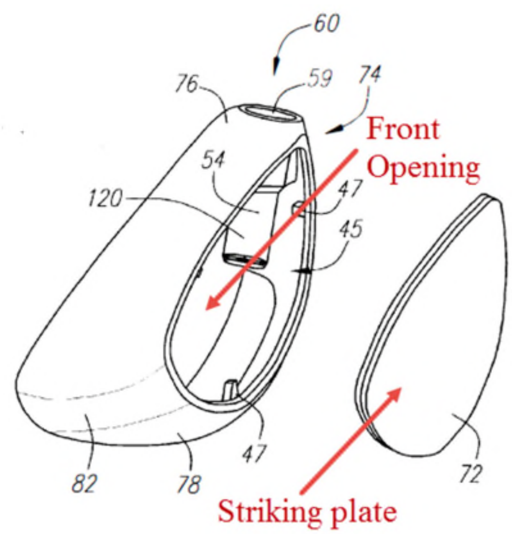


FIG. 7

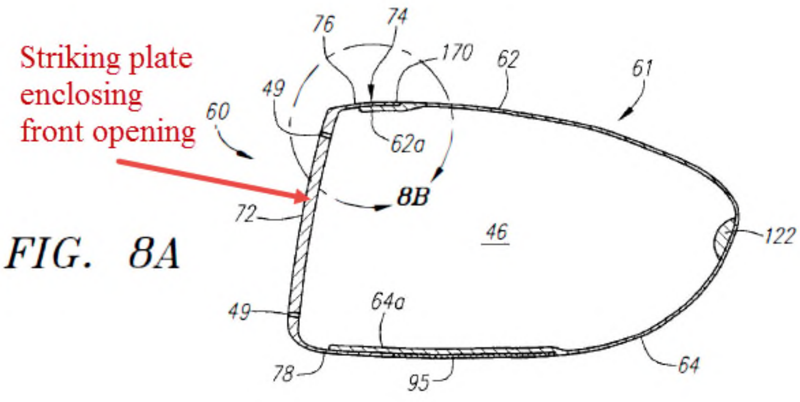


FIG. 8A

83. *Helmstetter* further teaches that the "striking plate insert 72 composed of an amorphous metal is attached through electron beam welding, brazing or press-fitted for attachment to the return portion." PXG1005, 7:64-67.

84. In my opinion, as discussed further below, it would have been obvious to a skilled artisan to use the front opening and separately formed striking plate of *Helmstetter* with the club body of *Hocknell*.

i. "a weight portion attached to an interior surface of the club head" [1]

85. *Hocknell* teaches "a rear weighting member 122 is preferably positioned within the hollow interior 46 of the club head 40. In a preferred embodiment, the rear weighting member 122 is disposed on the interior surface of the ribbon section 78 in order to increase the moment of inertia and control the center of gravity of the golf club head 40. A heel weighting member 123 is placed adjacent the hosel 54 on the interior surface of the sole section 76. However, those skilled in the pertinent art will recognize that additional weighting members may

be placed in other locations of the club head 40 in order to influence the center of gravity, moment of inertia, or other inherent properties of the golf club head 40. The weighting members 122 and 123 are preferably . . . weight chips welded to the interior surface of the major body 50." PXG1004, 9:7-22.

j. "a shoulder disposed around the periphery of the upper opening, and a recessed support extending from the shoulder and positioned adjacent to the upper opening" [22]

86. *Hocknell* discloses a shoulder, which it terms the edge 195 of the major body, disposed around the periphery of an upper opening. PXG1004, 8:14-17; Fig. 8A (annotated below).

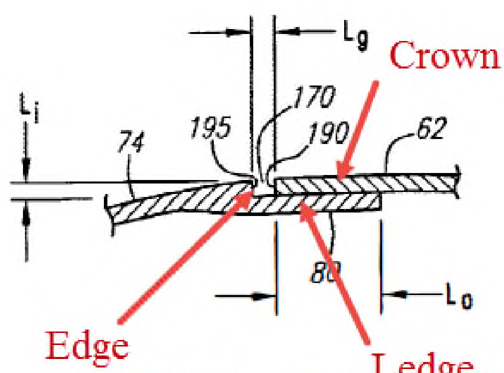


FIG. 8A

87. *Hocknell* further discloses a recessed support extending from a shoulder and adjacent to an upper opening by teaching "a ledge section 80 stepped inward for attachment of the minor body 60." PXG1004, 7:13-14, Fig. 8 (annotated below, showing minor body 60 enclosing an upper opening by engaging with ledge

80 that surrounds the upper opening), Fig. 9 (annotated below, showing ledge 80 surrounding upper opening).

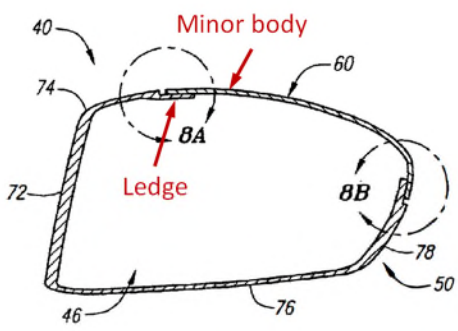


FIG. 8

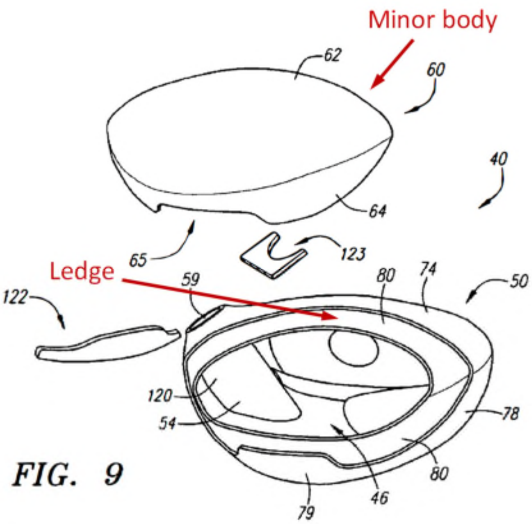


FIG. 9

88. Moreover, using a support surrounding an upper opening for attaching a crown to a golf club body was well known in the art. PXG1009, 2:54-57, Fig. 5; PXG1021, ¶0014, Fig. 2.

k. "a crown attached to the body enclosing the upper opening" [1, 22]

89. *Hocknell* discloses a minor body attached to the major body and supported by the recessed support (ledge 80), thereby enclosing the upper opening. In particular, *Hocknell* discloses "a ledge section 80 stepped inward for attachment of the minor body 60." PXG1004, 7:13-14, Fig. 8 (annotated below, showing minor body 60 enclosing an upper opening via attachment to ledge 80), Fig. 8A (annotated below, showing an isolated view of crown 62 (top part of minor body) attached to ledge 80), Fig. 9 (annotated below, showing how minor body 60

encloses the upper opening by engaging with ledge 80). Although *Hocknell* defines only a portion of its minor body 60 as the crown 62, as would be evident to a skilled artisan, *Hocknell's* minor body 60 functions as the claimed crown by enclosing the upper opening.

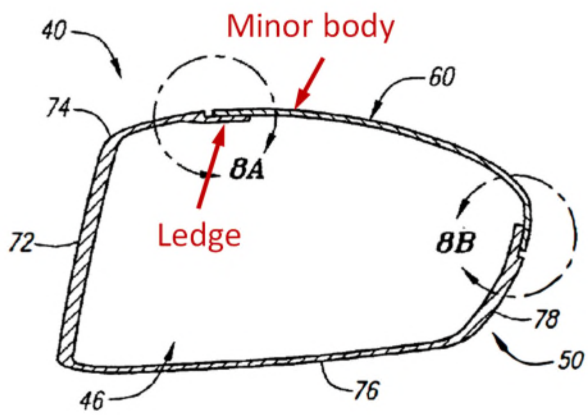


FIG. 8

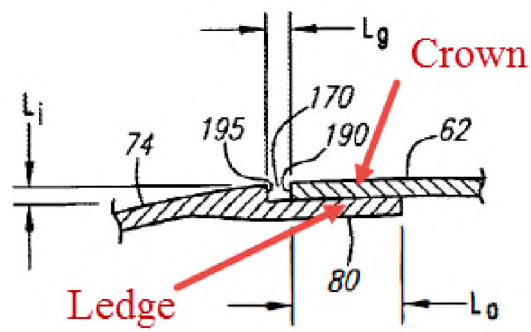


FIG. 8A

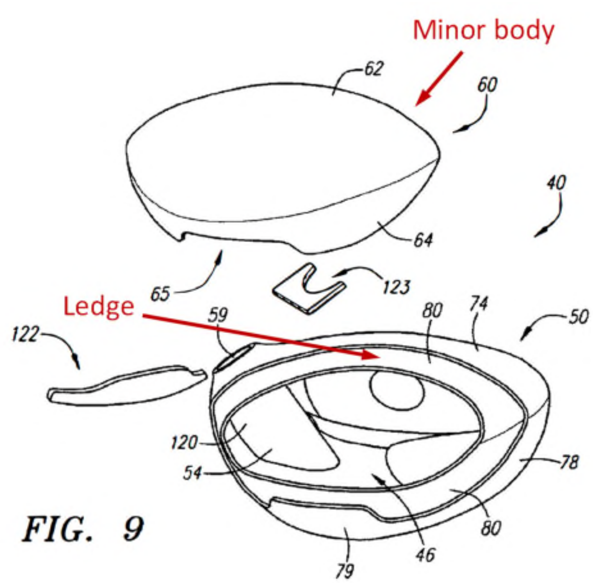
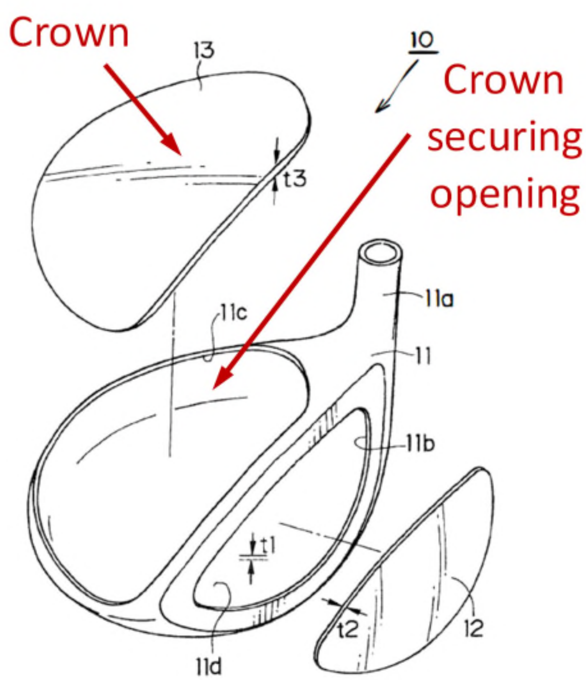


FIG. 9

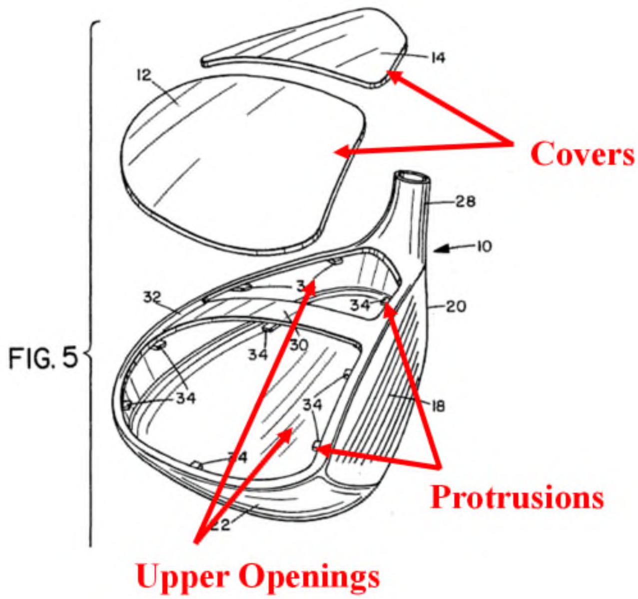
90. *Ezawa*, *Lo*, and *Masanori* each disclose a "crown" that is located entirely within the top portion of a club head. *Ezawa* discloses a crown located

entirely within the top portion of the golf club head. PXG1006, Fig. 1 (annotated below).

F I G. 1



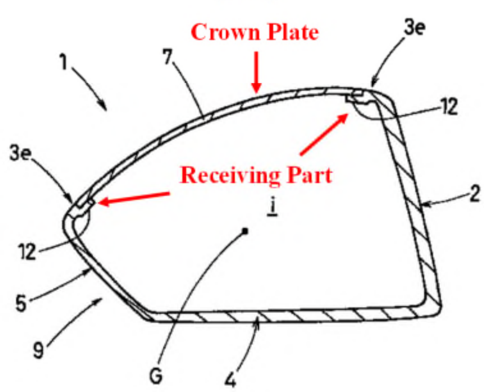
91. *Lo* also discloses a crown, *Lo's* covers, that are located entirely within the top portion of the golf club head. PXG1009, Fig. 5 (annotated below).

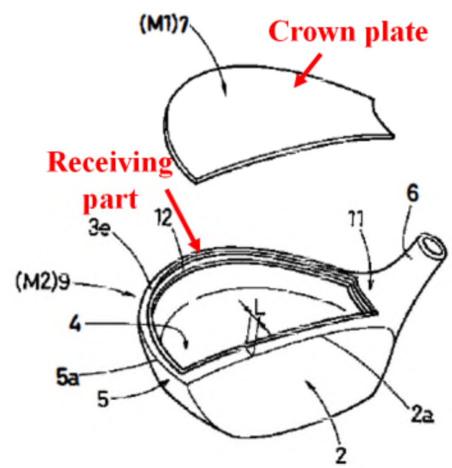


92. *Masanori* also discloses a crown ("crown plate 7") entirely within the top portion of a golf club head. PXG1021, Fig. 2 (annotated below), Fig. 6 (annotated below).

[FIG. 2]

[FIG. 6]





93. In my opinion, as discussed further below, it would have been obvious to a skilled artisan to modify the club head of *Hocknell* such that *Hocknell's* upper

opening and thus *Hocknell's* minor body enclosing the upper opening (which would now include only the crown portion) are located entirely within the top portion of a golf club head as taught by *Ezawa*, *Lo* or *Masanori*.

l. "the crown incorporating composite material and having a density between 1 g/cc and 2 g/cc" [1]

94. *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably composed of a non-metal material, preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or thermosplastic resin). PXG1004, 7:54-57. *Hocknell* further discloses that "[i]n a preferred embodiment, the minor body 60 [which includes the crown 62] is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Pat. No. 6,248,025 ["*Murphy*"], entitled Composite Golf Head Method of Manufacturing, which is hereby incorporated by reference in its entirety." *Id*., 8:43-48. *Murphy* discloses that "the preferred composite material is plies of carbon pre-peg [sic, preg] composite sheets." PXG1011, 6:45-46. *Murphy* further discloses that "[e]xemplary carbon pre-pre fiber sheets may be obtained" from a number of different commercial suppliers. *Id*., 6:55-58. *Hocknell* suggests using a thermosetting resin, and a skilled artisan would understand that the most common thermosetting resin used in carbon fiber composites is epoxy. Thus, in my opinion, to a skilled artisan, it would be obvious to use a carbon-epoxy for the crown.

95. In my opinion, a skilled artisan would understand that typical carbon-epoxy composites have a fiber volume fraction of about 60% and thus based on the densities of the fibers and resin would generally have densities of 1.49 g/cc to 1.73 g/cc which falls within the claimed range. For example, the carbon (graphite) fibers used in such composite materials generally have a density of between 1.75 g/cc to 1.95 g/cc, and the epoxy resins used in such composite materials generally have a density of between 1.1 g/cc to 1.4 g/cc. Ex. 1018 at 3, 4. Thus, for a typical 60% by volume carbon fiber composite material, the resulting density would range from 1.49 g/cc ((1.75 x 0.6) + (1.1 x 0.4)) to 1.73 g/cc ((1.95 x 0.6) + (1.4 x 0.4)). This is consistent with what is taught in the art concerning carbon fiber composites. PXG1023, 2:64; PXG1024, 34, 49. In any event, given that the claimed density encompasses the density of typical carbon-epoxy composites, it would have been an obvious design choice to choose a carbon-epoxy composite within the claimed range.

m. "the crown is comprised of a non-metallic material" [22]

96. *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or thermoplastic resin)." PXG1004, 7:54-57. In my opinion, a skilled artisan would understand that *Hocknell* teaches a golf club head "wherein the crown is comprised of a non-metallic material."

97. Moreover, using a non-metallic material, such as a composite material, for the crown of a golf club head was well known in the art. PXG1009, 3:1-3; PXG1021, ¶20.

n. "the golf club head has a maximum coefficient of restitution of at least 0.80" [1, 22]

98. Both *Hocknell* and *Helmstetter* teach that their inventions provide "a club head having a coefficient of restitution ranging from 0.81 to 0.94, as measured under conventional test conditions." PXG1004, 10:31-33; PXG1005, 13:43-47. In my opinion, as discussed further below, a skilled artisan would have expected the combination of *Helmstetter's* front opening and striking plate with *Hocknell's* major body to at least achieve a COR as recited in both *Hocknell* and *Helmstetter*.

o. "a volume of at least 150 cc" [1, 22]

99. In Tables 1, 2, and 3, *Hocknell* provides various examples of golf club heads using the disclosed design. The tables provide that the volume of the golf club heads (i.e., the major body volume) varies from 21.44 to 23.195 cubic inches. PXG1004, 11:40 – 12:25, Tables 1, 2, and 3. A volume of 21.44 to 23.195 cubic inches equates to a volume of approximately 351 to 380 cc. In my opinion, a skilled artisan would understand that *Hocknell* and teaches a golf club head with "a volume of at least 150 cc."

2. Dependent Claims 2-4, 8-10, 12-21

a. "the striking plate is comprised of a metallic material" [2]

"the striking plate is comprised of titanium" [3]

100. *Helmstetter* discloses that "the striking plate insert 72 is composed of a forged or formed metal material, [such as] a forged titanium or stainless steel material. Such titanium material include pure titanium and titanium alloys." PXG1005, 7:37-41. In my opinion, a skilled artisan would understand that *Helmstetter* teaches a golf club striking plate that is comprised of a metallic material such as titanium.

b. "the body is integrally formed" [4]

101. *Hocknell* discloses that "[t]he major body 50 is generally composed of a single piece of metal." PXG1004, 6:44-45. In my opinion, a skilled artisan would understand that *Hocknell* teaches a golf club head body, "wherein the body is integrally formed."

c. "a face-reinforcing member coupled to a rear surface of the striking plate" [5]

"the face-reinforcing member comprises metallic material" [6]

102. To the extent "face-reinforcing member" is construed as encompassing integrally-formed portions of the striking plate, such as thickened portions, *Helmstetter* disclose this limitation. *Helmstetter* discloses a variable

thickness striking plate with "a central elliptical region" that "preferably has the greatest thickness." PXG1005, 12:27-31. *Helmstetter* further discloses that "the striking plate insert 72 is composed of a forged or formed metal material, [such as] a forged titanium or stainless steel material. Such titanium material include pure titanium and titanium alloys." PXG1005, 7:37-41. Thus, the central elliptical region of the *Helmstetter's* striking plate would also comprise metallic material. Thus, in my opinion, a skilled artisan would understand that *Helmstetter* teaches these limitations.

d. "the body further comprises a support surrounding the upper opening for attaching the crown to the body" [8]

103. *Hocknell* discloses a recessed support extending from a shoulder and adjacent to an upper opening by teaching "a ledge section 80 stepped inward for attachment of the minor body 60." PXG1004, 7:13-14, Fig. 8 (annotated below, showing minor body 60 enclosing an upper opening by engaging with ledge 80 that surrounds the upper opening), Fig. 9 (annotated below, showing ledge 80 surrounding upper opening).

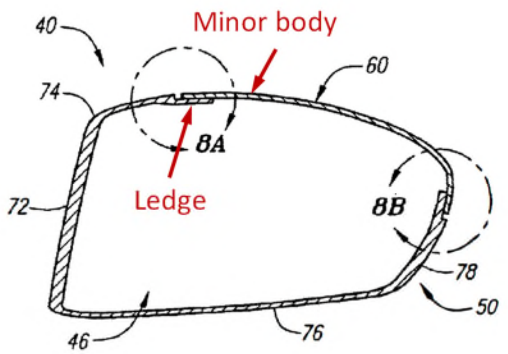


FIG. 8

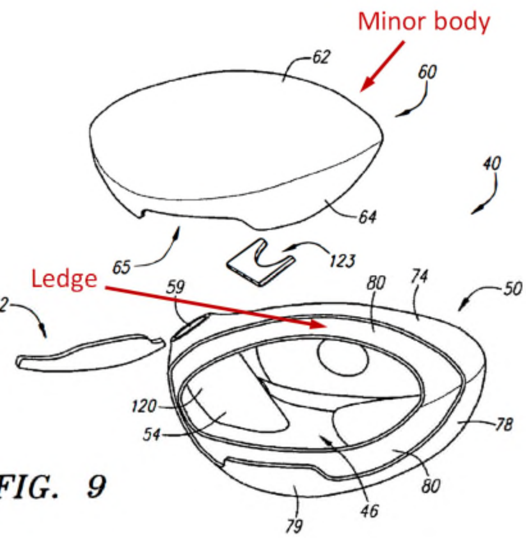


FIG. 9

Thus, in my opinion, a skilled artisan would understand that *Hocknell* teaches this limitation.

104. Moreover, using a support surrounding an upper opening for attaching a crown to a golf club body was well known in the art. PXG1009, 2:54-57, Fig. 5; PXG1021, ¶0014, Fig. 2.

e. "the crown is comprised of a graphite-epoxy composite having a density ranging between 1.4 and 1.65 g/cc" [9]

105. *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably composed of a non-metal material, preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or thermosplastic resin). PXG1004, 7:54-57. *Hocknell* further discloses that "[i]n a preferred embodiment, the minor body 60 [which includes the crown 62] is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Pat. No. 6,248,025 ["*Murphy*"], entitled Composite Golf Head

Method of Manufacturing, which is hereby incorporated by reference in its entirety." *Id*., 8:43-48. *Murphy* discloses that "the preferred composite material is plies of carbon pre-peg [sic, preg] composite sheets." PXG1011, 6:45-46. *Murphy* further discloses that "[e]xemplary carbon pre-pre fiber sheets may be obtained" from a number of different commercial suppliers. *Id*., 6:55-58. A skilled artisan would understand that carbon and graphite are generally used interchangeably to describe carbon-based fibers for composite materials. Moreover, *Hocknell* suggests using a thermosetting resin, and a skilled artisan would understand that the most common thermosetting resin used in carbon fiber composites is epoxy. Thus, in my opinion, to a skilled artisan, it would be obvious to use a graphite-epoxy for the crown.

106. In my opinion, a skilled artisan would understand that typical graphite-epoxy composites have a fiber volume fraction of about 60% and thus based on the densities of the fibers and resin would generally have densities of 1.49 g/cc to 1.73 g/cc which substantially overlaps the claimed range. For example, the carbon (graphite) fibers used in such composite materials generally have a density of between 1.75 g/cc to 1.95 g/cc, and the epoxy resins used in such composite materials generally have a density of between 1.1 g/cc to 1.4 g/cc. Ex. 1018 at 3, 4. Thus, for a typical 60% by volume carbon fiber composite material, the resulting density would range from 1.49 g/cc ((1.75 x 0.6) + (1.1 x 0.4)) to 1.73

g/cc ((1.95 x 0.6) + (1.4 x 0.4)). This is consistent with what is taught in the art concerning carbon fiber composites. PXG1023, 2:64; PXG1024, 34, 49. In any event, given that the claimed density overlaps the density of typical graphite-epoxy composites, it would have been an obvious design choice to choose a graphite-epoxy composite within the claimed range.

f. "the volume is at least 350 cc" [10]

107. In Tables 1, 2, and 3, *Hocknell* provides various examples of golf club heads using the disclosed design. The tables provide that the volume of the golf club heads (i.e., the major body volume) varies from 21.44 to 23.195 cubic inches. *See* PXG1004 at 11:40 – 12:25, Tables 1, 2, and 3. A volume of 21.44 to 23.195 cubic inches equates to a volume of approximately 351 to 380 cc. Thus, in my opinion, a skilled artisan would understand that *Hocknell* teaches this limitation.

g. "the crown is comprised of an uppermost ply of uni-tape standard modulus composite oriented at 0° or 90° and wherein the top section of the body and the uppermost ply of uni-tape are painted" [12]

108. *Hocknell* discloses that "[i]n a preferred embodiment, the minor body 60 [which includes the crown 62] is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Pat. No. 6,248,025 ["*Murphy*"], entitled Composite Golf Head Method Of Manufacturing, which is hereby incorporated by reference in its entirety." PXG1004, 8:43-48. *Murphy* discloses a composite material made up of plies in a quasi-isotropic orientation,

which is “defined as beginning at a zero degree orientation and rotating angles in at least fifteen degree intervals. Preferably, the orientations are zero degrees, plus forty-five degrees, minus forty-five degrees, and ninety degrees.” PXG1011, 7:63 – 8:1. Thus, in my opinion, a skilled artisan could arrange the six or seven plies taught by *Hocknell* so that the uppermost ply is oriented at 0° or 90°. Moreover, for aesthetic reasons, it would have been a trivial modification for a skilled artisan to paint the uppermost ply and top section of the body. A skilled artisan would understand that these are trivial design choices.

h. “the crown has a maximum thickness of about 2 mm” [13]

“the crown has a maximum thickness of about 1.5 mm” [14]

“the crown has a thickness of about 1 mm” [15]

109. *Hocknell* discloses that the “crown section 62 preferably has a thickness range of 0.010 to 0.100 inch [approximately 0.25 to 2.5 mm].” PXG1004, 8:32-33. Thus, in my opinion, a skilled artisan would understand that *Hocknell* teaches the use of crowns that meet these limitations.

i. “the crown is comprised of a graphite-epoxy composite having a 50% to 70% fiber volume ratio” [16]

110. *Hocknell* discloses that “[t]he minor body 60 [which includes the crown 62] is preferably composed of a non-metal material, preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or

thermosplastic resin). PXG1004, 7:54-57. *Hocknell* further discloses that "[i]n a preferred embodiment, the minor body 60 [which includes the crown 62] is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Pat. No. 6,248,025 ["*Murphy*"], entitled Composite Golf Head Method of Manufacturing, which is hereby incorporated by reference in its entirety." *Id*., 8:43-48. *Murphy* discloses that "the preferred composite material is plies of carbon pre-peg [sic, preg] composite sheets." PXG1011, 6:45-46. *Murphy* further discloses that "[e]xemplary carbon pre-preg fiber sheets may be obtained" from a number of different commercial suppliers. *Id*., 6:55-58. A skilled artisan would understand that carbon and graphite are generally used interchangeably to describe carbon-based fibers for composite materials. Moreover, *Hocknell* suggests using a thermosetting resin, and a skilled artisan would understand that the most common thermosetting resin used in carbon fiber composites is epoxy. Thus, in my opinion, to a skilled artisan, it would be obvious to use a graphite-epoxy for the crown.

111. In my opinion, a skilled artisan would also understand that typical graphite-epoxy composites have a typical fiber volume fraction of about 60% and certainly within the claimed range of 50% to 70%. PXG1023, 2:64; PXG1024, 34, 49. In any event, given that the claimed fiber volume ratio encompasses the fiber

volume ratio of typical graphite-epoxy composites, it would have been an obvious design choice to choose a graphite-epoxy composite within the claimed range.

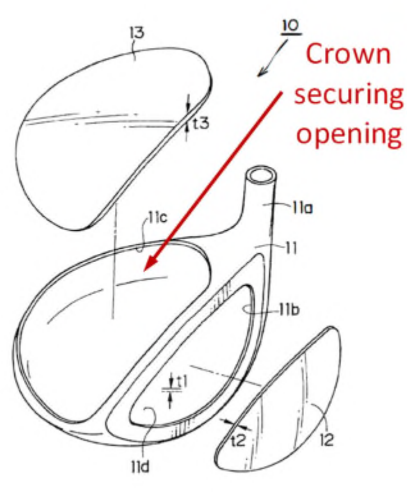
j. "the upper opening comprises at least 25% of a total area of the top portion" [17]

"the upper opening comprises at least 60% of a total area of the top portion" [18]

"the upper opening comprises at least 75% of a total area of the top portion" [19]

112. *Ezawa* discloses a "crown securing opening" that is an upper opening located entirely within the top portion of a club head and as shown in the figure below, comprises at least 25%, at least 60%, and at least 75% of the top portion of *Ezawa's* club head. PXG1006, Fig. 1 (annotated below).

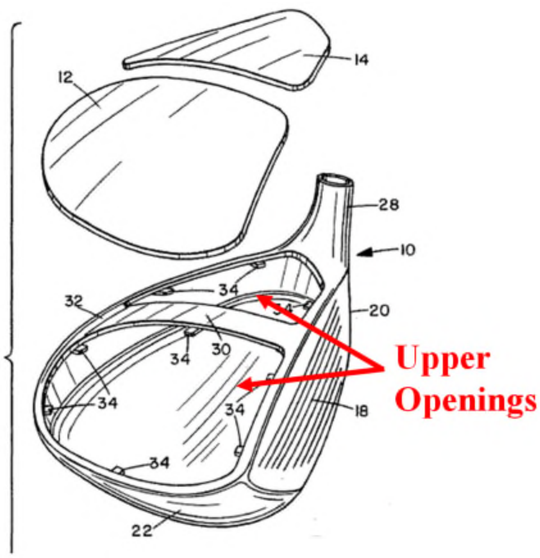
FIG. 1



113. *Lo* discloses upper openings located entirely within the top portion of a club head and as shown in the figure below, comprise at least 25%, at least 60%,

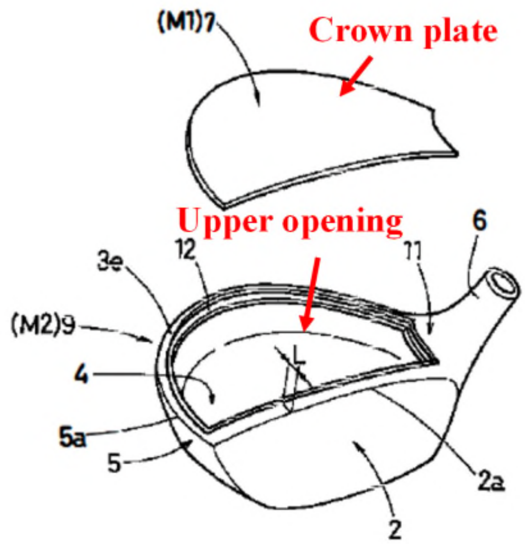
and at least 75% of the top portion of *Lo's* club head. PXG1009, Fig. 5 (annotated below).

FIG. 5



114. *Masanori* discloses an upper opening located entirely within the top portion of a club head and as shown in the figure below, comprises at least 25%, at least 60%, and at least 75% of the top portion of *Ezawa's* club head. PXG1021, Fig. 4 (annotated below)

[FIG. 2]



115. In my opinion, as discussed further below, it would have been obvious to a skilled artisan to modify the club head of *Hocknell* such that *Hocknell's* upper opening is located entirely within the top portion of a golf club head as taught by *Ezawa*, *Lo* or *Masanori*. As discussed above, the upper openings of *Ezawa*, *Lo*, and *Masanori* meet these claimed limitations.

k. "the weight portions attached to an interior surface of the sole of the club head" [20]

116. *Hocknell* teaches "[a] heel weighting member 123 is placed adjacent the hosel 54 on the interior surface of the sole section 76." PXG1004, 9:12-14. Thus, in my opinion, a skilled artisan would understand that *Hocknell* teaches this limitation.

l. "the weight portion comprises a metallic material" [21]

117. *Hocknell* teaches that "[t]he weighting members 122 and 123 are preferably . . . weight chips welded to the interior surface of the major body 50." PXG1004, 9:19-22. Thus, in my opinion, a skilled artisan would understand that since the weighting members are being welded to the major body, the weight members are made of a metallic material.

B. Motivation to Combine *Hocknell*, *Helmstetter*, and *Ezawa*, *Lo*, or *Masanori*

118. In my opinion, a skilled artisan would have had a reason, as of the Priority Date, to modify the golf club head of *Hocknell* by including a separately attached striking plate as disclosed in *Helmstetter* with a reasonable expectation of success. Moreover, a skilled artisan would have had a reason to modify the club head of *Hocknell*/*Helmstetter* to have an upper opening and crown located entirely within the top portion of a club head as taught by *Ezawa*, *Lo*, or *Masanori* with a reasonable expectation of success.

1. Motivation to Combine *Hocknell* and *Helmstetter*

119. In my opinion, a skilled artisan would have had a reason to modify the golf club head of *Hocknell* by including a separately attached striking plate as disclosed in *Helmstetter* with a reasonable expectation of success. First, a skilled artisan could have combined *Helmstetter's* striking plate with the golf club head body of *Hocknell* using known methods with no change in their respective

functions to predictably yield a golf club head with desirable properties. Both *Hocknell* and *Helmstetter* disclose golf club heads with identical performance goals – the creation of golf club heads with coefficients of restitution (CORs) of 0.81 to 0.94. PXG1004, 10:31-33; PXG1005, 13:39-42. Both *Hocknell* and *Helmstetter* are also directed to generally the same size club heads as shown by their largely overlapping volume and mass ranges. PXG1004, 11:40 – 12:25, Tables 1, 2, and 3 (volume), 10:34-39 (mass); PXG1005, 13:48-53 (volume), 13:58-61 (mass).

120. In addition to similarities in performance, size, and mass, both *Hocknell* and *Helmstetter* aim to achieve club performance through the same technical approaches, a "flexible" face plate and a "higher moment of inertia." For example, *Hocknell* discloses a varying thickness striking plate that drops from 0.120 inches to 0.050 inches. PXG1004, 9:25-64. The variation in thickness is aimed at "enhancing the flexibility of the striking plate section." PXG1004, 9:64–10:3. Likewise, *Helmstetter* discloses a varying thickness striking plate, which has a thickness that drops from 0.120 inches to 0.072 inches. PXG1005, 12:19-42. The variation in thickness is aimed at "thereby maintaining flexibility of the striking plate insert." PXG1005, 12:42-48. Both patents also describe distribution of mass within the club and working towards a larger moment of inertia. *Hocknell* describes a club with a "high moment of inertia" (PXG1004, 5:26-29) while

Helmstetter describes a way to "increase the moment of inertia" of the club (PXG1005, 10:60-64).

121. Moreover, in both *Hocknell* and *Helmstetter*, the increased COR is driven by stronger materials on the face, which allows for thinner face sections. *Hocknell* achieves greater strength by proposing an amorphous metal (which are naturally high strength), while *Helmstetter* considers amorphous metals, but also high strength (crystalline) alloys. For example, *Helmstetter* states that the "return portion is composed of a cast metal material and the striking plate insert is composed of a forged or formed material." PXG1005, 7:36-38. As would be readily apparent to one of ordinary skill in the art prior to the '646 Patent, forged or formed metal material has greater strength than cast metal material of the same composition. Thus, *Helmstetter* discloses the use of a higher strength material on the strike plate to facilitate the thinning of the face of the club head toward the lower limits described in both *Hocknell* and *Helmstetter* to achieve a high COR. This supports combining *Hocknell* with *Helmstetter*.

122. Specifically, although *Hocknell* forms its major body from an amorphous metal, there is a technical reason to replace the striking plate in *Hocknell* with an even higher strength material on the face of the club as described in *Helmstetter* and maintain the amorphous material in the main body and composite material in the minor body. As a threshold point, one of ordinary skill

would have understood that stronger materials are typically preferred to weaker materials as long as the material does not become brittle and the stronger materials can be processed into appropriate shapes. Stronger materials allow a designer to make thinner sections, which, in a golf club head, allows one to distribute weight to adjust to the preferred moment of inertia while simultaneously increasing COR on a thinner club face. In "theory," one could make the entire club out of a very high strength material and make all sections very thin. However, in practice, this is not practical due to inherent manufacturing limitations and cost. Instead, it is better to tailor materials to the location in the club head based on stress distribution and place the strongest materials on the club face and the relatively weaker and lighter materials on the back of the club.

123. *Hocknell* teaches the use of a lightweight composite on the top and back of the club where stresses are lower than at the striking plate. *Helmstetter* teaches to replace the striking plate of a club head with higher strength material that is forged or formed. Amorphous metals proposed in *Hocknell* were known to be castable (PXG1004, 5:3-4) like conventional metals that allow a large portion of the club head with moderate stress levels to be fabricated from amorphous metals for proper energy return. However, amorphous metals were also known to be brittle and may not survive the high impact stresses at the club face resulting in failure. *Id*. A desirable solution to this problem to one of ordinary skill in the art

would be to make the front face out of a high strength forged or formed material (as in *Helmstetter*), join this to the amorphous metal of the club head of *Hocknell*, and maintain the composite crown of *Hocknell* to shift the center of gravity towards the bottom of the club. This would facilitate a thin face, high face flexibility, and allow less face and crown weight to increase moment of inertia.

124. Neither *Hocknell* nor *Helmstetter* teach away from this combination. To a skilled artisan, it would not present a structural challenge to add a front opening to *Hocknell*'s major body, nor would it be expected to weaken the club head body of *Hocknell* by substituting a stronger material in this opening. At the time, it was well known how to weld amorphous metals to conventional metals, and the stronger striking plate of *Helmstetter* would structurally reinforce the overall cast amorphous metal club head of *Hocknell*. A skilled artisan would have expected the new striking plate of *Helmstetter* in combination with the amorphous metal body and composite crown of *Hocknell* to achieve a high COR (at least in the range of 0.81 to 0.94 as recited in both *Hocknell* and *Helmstetter*) because the combined club head would maintain the variable thickness striking plate and thus its flexibility.

2. Motivation to Combine *Hocknell* and *Ezawa, Lo* or *Masanori*

125. A skilled artisan would have had a reason to modify *Hocknell's* club head design such that the upper opening and crown would be located entirely

within the top portion of the club head body as is shown in *Ezawa*, *Lo*, or *Masanori* with a reasonable expectation of success.

126. To achieve an upper opening entirely within the top portion, a skilled artisan would only need to make a slight design variation to *Hocknell's* upper opening. As seen below, *Hocknell's* upper opening bends slightly down the rear and sides (not shown) of the club head, but is not much different than the club head depicted in the '425 Patent. *Compare* PXG1004, Fig. 8 (annotated) *to* PXG1001, Fig. 4 (annotated). Thus, a skilled artisan would have only needed to modify *Hocknell's* major body *Hockenell's* opening and support members are located entirely within the top portion of the club head as shown is *Ezawa*, *Lo* and *Masanori*.

Hocknell

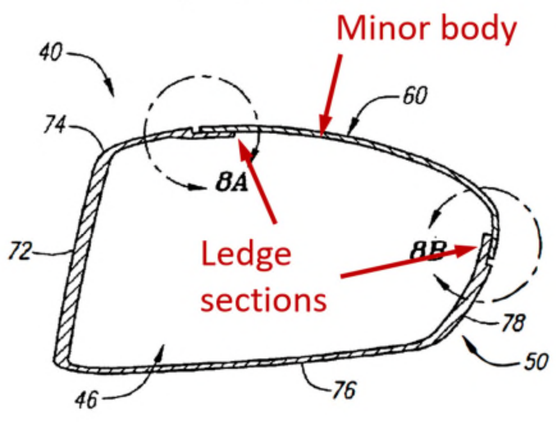
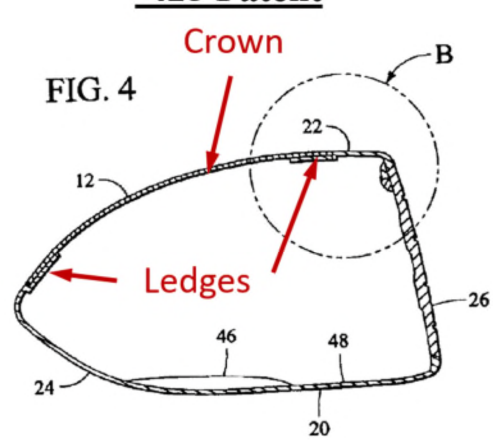


FIG. 8

'425 Patent



127. A skilled artisan would have been motivated to use an upper opening solely in the top surface of *Hocknell's* design to make *Hocknell's* club less

challenging to manufacture and to improve the reliability of the club head. Composites are notoriously challenging materials to fabricate into curved surfaces and to join to other materials (particularly across paths that go out of plane). A skilled artisan would have understood that when joining two materials, it is preferable to minimize the length of the interface and have the interface exist in a single plane without complex geometrical deviations. Thus, if the crown of *Hocknell* was only on the top portion of the club like *Ezawa*, *Lo*, or *Masanori*, it would be easier to manufacture and have a more reliable interface, which is essential to club function.

128. Moreover, a skilled artisan would not have been dissuaded from modifying *Hocknell's* design to include an upper opening solely in the top portion (and thus limiting the composite crown solely to the top portion). A skilled artisan would have understood that one key purpose of the composite crown in *Hocknell* is to provide the capacity to control the center of gravity of the club head. Because the composite crown is less dense than the metal body, replacing the metal at the top of the club head with composite material shifts the center of gravity of the club downwards. Replacing the metal with composite at the top surface of the club head has a large impact on shifting the center of gravity of the club downwards, while replacing the metal around the sides and the rear has less of an impact. Thus, for ease of manufacture and to achieve a more reliable club head, a skilled artisan

would not have been dissuaded from modifying *Hocknell's* club design to have a crown solely in the top portion as in *Ezawa, Lo* or *Masanori*.

129. Finally, given the minor design change and the fact that the combination of *Helmstetter's* striking plate with *Hocknell's* body will be unchanged, a skilled artisan would still have expected to achieve a COR in the range of 0.81 to 0.94 disclosed by *Hocknell* and *Helmstetter*. Since the mechanical properties of the striking pate and surrounding portions of the body of the club head will be unchanged, a skilled artisan would not expect there to be a substantial difference in the transfer of energy from the club head to a ball contacting the striking plate. Consequently, a skilled artisan would not have been dissuaded from modifying *Hocknell's* crown as discussed above.

VIII. THE COMBINATION OF *ECKOLD* WITH *HOCKNELL, HELMSTETTER*, AND *EZAWA, LO,* OR *MASANORI* RENDERS CLAIMS 1-6, 8-10, AND 12-21 OBVIOUS

A. *Eckold* Teaches Typical Densities and Fiber Volume Fractions for Carbon-Epoxy Composites

130. To the extent that the Board finds that the "density" (claims 1, 9) and "fiber volume ratio" (claim 16) limitations are not taught or rendered obvious by the combination of *Hocknell*, *Helmstetter*, and *Ezawa* or *Lo* or *Masanori* in view of the general skill in the art, *Eckold* clearly teaches these limitations.

1. "the crown incorporating composite material and having a density ranging between 1 g/cc and 2 g/cc" [1]

"the crown is comprised of a graphite-epoxy composite having a density ranging between 1.4 and 1.65 g/cc" [9]

131. *Eckold* discloses an example of a typical unidirectional carbon/epoxy composite having a density of 1.57 g/cm^3. PXG1024, 34 (Table 2.8). Thus, a skilled artisan would understand that *Eckold* teaches these limitations.

2. "the crown is comprised of a graphite-epoxy composite having a 50% to 70% fiber volume ratio" [16]

132. *Eckold* discloses that "[f]or high performance applications, the reinforcement consists of continuous aligned or woven fibres in discrete layers, with typical fibre volume fractions being in the range of 50-70%." PXG1024, 49. *Eckold* also provides an example of a typical unidirectional carbon/epoxy composite having a fiber volume percentage of 57%. *Id.*, 34 (Table 2.8). A skilled artisan would understand that "fiber volume ratio," "fiber volume fraction" and "fiber volume percentage" all mean the same thing. Thus, a skilled artisan would understand that *Eckold* teaches this limitation.

B. Motivation to Combine *Eckold* with *Hocknell*

133. As discussed below, a skilled artisan would have had a reason to use a carbon (or graphite) epoxy composite within the claimed ranges for "fiber volume ratio" and "density" for the crown of *Hocknell's* club head with a reasonable expectation of success.

134. *Hocknell* specifically teaches the use of a carbon pre-preg composite for its crown. *Hocknell* discloses that "[t]he minor body 60 [which includes the crown 62] is preferably composed of a non-metal material, preferably a composite material such as continuous fiber pre-preg material (either thermosetting resin or thermosplastic resin). PXG1004, 7:54-57. *Hocknell* further discloses that "[i]n a preferred embodiment, the minor body 60 [which includes the crown 62] is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Pat. No. 6,248,025 ["*Murphy*"], entitled Composite Golf Head Method of Manufacturing, which is hereby incorporated by reference in its entirety." *Id*., 8:43-48. *Murphy* discloses that "the preferred composite material is plies of carbon pre-peg [sic, preg] composite sheets." PXG1011, 6:45-46. *Murphy* further discloses that "[e]xemplary carbon pre-preg fiber sheets may be obtained" from a number of different commercial suppliers. *Id*., 6:55-58. A skilled artisan would understand that carbon and graphite are generally used interchangeably to describe carbon-based fibers for composite materials and that the most common thermosetting resin (as suggested by *Hocknell*) used in carbon fiber composites is epoxy. Thus, in my opinion, a skilled artisan, based on the teachings of *Hocknell*, would have had a reason to use a carbon pre-preg, such as graphite-epoxy for the crown.

135. Moreover, in my opinion, a skilled artisan would have had a reason to use a graphite-epoxy within the claimed "fiber volume ratio" and "density" ranges. A skilled artisan would consider the use of a graphite-epoxy composite for the crown of a golf club head to be a typical use of such composite material, and not an extreme application. Thus, a skilled artisan would be motivated to use a graphite-epoxy composite with typical properties. *Eckold* teaches that composites typically have fiber volume fractions/percentages in the range of 50% to 70% with a typical carbon-epoxy composite having a 57% fiber volume percentage and a density of 1.57 g/cm^3. PXG1024, 34 (Table 2.8), 49. Thus, a skilled artisan would be motivated to use a graphite-epoxy composite having a typical fiber volume ratio of 50% to 70% and a density of about 1.57 g/ cm^3.

IX. DECLARATION

I declare all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with knowledge that willful false statements so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code.

Dated: September 7, 2018

Kenneth Gall, Ph.D.

APPENDIX A

Ken Gall

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Summary

Professor Gall's technical expertise is in the structure and properties of materials, biomaterials, and the 3D printing of metals and polymers. His contributions to the scientific community range from the discovery of a new phase transformation in gold nanowires to the creation and understanding of multiple new functional biomaterials. He has over 230 publications that have been cited over 14,000 times, his publication H-index is 66. Over the past 20 years he has given over 300 presentations at conferences, companies, and universities. In addition to his research and teaching, he has consulted for various companies, the US Military and the US Intelligence Community. He has also served as an expert witness in multiple patent and product litigations involving materials across several industries. Finally, he is a passionate entrepreneur who has approximately 20 patents and has founded five medical device start-up companies. He is involved in all of his companies who are commercializing new university-based technologies in the medical device space.

Education

PhD	1998	Mechanical Engineering	University of Illinois at Urbana Champaign
MS	1996	Mechanical Engineering	University of Illinois at Urbana Champaign
BS	1995	Mechanical Engineering	University of Illinois at Urbana Champaign

Academic Appointments

2016-Current	Professor	Orthopaedic Surgery, Duke University
2015-Current	Associate Director	MEDx, Duke University
2015-Current	Professor and Chair	MEMS Department, Duke University
2007-2015	Professor	Georgia Institute of Technology
2005-2007	Associate Professor	Georgia Institute of Technology
2003-2005	Associate Professor	University of Colorado at Boulder
1999-2003	Assistant Professor	University of Colorado at Boulder
1998-1999	Post-Doc	Sandia National Laboratories
1995-1998	Research Assistant	University of Illinois at Urbana-Champaign

Federal and Industry Grants

Dr. Gall has extensive fundraising experience through government agencies, in particular the National Science Foundation (NSF) and the National Institute of Health (NIH), and the commercial sector including numerous industrial grants. His grants include both basic research awards aimed at new fundamental science and Small Business Innovation in Research awards (SBIR) aimed at hastening technology commercialization. He has been a PI, Co-PI or consultant on 60 grants over the past fifteen years that have totaled $17M.

Awards

Dr. Gall has received several dozen national and international research and teaching awards including the Presidential Early Career Award for Scientists and Engineers (PECASE), the TMS Robert Lansing Hardy Award, and the ASME Gold Medal, all given to top young scientists in their field. He also recently received the Curtis McGraw Award from ASEE given for excellence in publication for a scientist under 40 years of age. His teaching awards include the ASM Bradley Stoughton Award and numerous campus wide awards at both Georgia Tech and the University of Colorado.

Start-Up Companies

MedShape *Founder, BOD Member*

Founded in 2005, Professor Gall has maintained an active leadership role in the company across both business and technology fronts. He co-led a multi-year capital raise of approximately $32M in private, non-institutional equity investment. This investment allowed MedShape to successfully clear five orthopedic implant systems containing advanced materials through the FDA. MedShapes products are based on shape memory polymers for soft tissue reconstruction (Eclipse, ExoShape, Morphix) and shape memory alloys for foot and ankle joint fusion (DynaNail) and are sold in the orthopedic medical device market. MedShapes annual revenue is nearly $10M and two of its product lines have won industry-level device design excellence awards.

ExoShape was acquired by ConMed in Q3 2017

Vertera *Founder, BOD Member*

Founded in 2013, Vertera raised approximately $6.0M in private non-institutional capital and used this money to develop, clear, and launch a surface porous PEEK spinal fusion cage for both Cervical Fusion (Cohere) and Lumbar Fusion (Coalesce). The porous PEEK technology was supported financially by Duke Angel Network (DAN).

Vertera was acquired by NuVasive in Q3 2017.

DeepBlue *Founder, BOD member*

Founded in 2015, DeepBlue is commercializing a novel hernia mesh that distributes stresses evenly across hernia repair sites for improved clinical outcomes.

InnAVasc *BOD member*

Founded in 2015, InnAVasc is commercializing a soft arteriovenous graft (AVG) modification that incorporates two multilayer cannulation chambers, with low bleed technology, that are resistant to posterior and sidewall needle penetration and injury.

restor3d *Founder, BOD Member*

Founded in 2017, restor3d is commercializing 3D printed implants across a broad range of markets.

Lacuna *Founder, BOD Member*

Founded in 2017 Lacuna is developing a shape memory catheter that deploys itself into restricted spaces and prevents mechanical occlusion of the drainage ports.

Graduate Students Advised

Brian Allen	PhD, In proc, Duke	Antibiotic release from 3D printed scaffolds
Will Koshut	PhD, In proc, Duke	The chemo-mechanics of self-healing polymers
Natalia Von Windheim	PhD, In proc, Duke	3D printed PEEK tissue scaffolds
Cambre Kelly	PhD, In proc., Duke	3D printed metal tissue scaffolds
Dalton Sycks	PhD, 2017, Duke	Tough, 3-D printed synthetic polymers

Andy Miller	PhD, 2017, GaTech	Fatigue and degradation in soft-wet polymers for biomedical applications
Brennan Torstrick	PhD, 2017, GaTech	Osteo-integration of bare and biologically treated surface porous PEEK
Nathan Evans	PhD, 2016, GaTech	Effect of Structure on the Mechanical Properties of Surface porous polymers
Reza Mirzaeifar	PhD, 2013, GaTech	A multiscale study of NiTi Shape Memory Alloys
Yuan Zhong	PhD, 2012, Gatech	Nanomechanics of plasticity in ultra-strength metals and shape memory alloys
Mary Pitz	MS, 2011, Gatech	Compression-Aided stability of Orthopedic Devices
David Safranski	PhD, 2010, Gatech	Poly(beta-amino esters) for cardiovascular applications
Kathryn Smith	PhD, 2010, Gatech	Tailoring the toughness and Biological Response of Photopolymerizable Networks for Orthopedic Applications
Bhaskar Pant	MS, 2010, Gatech	Experimental nanomechanics of 1D nanostructures
Alicia Ortega	PhD, 2010, Gatech	Structure-property relationships in photopolymerizable polymer networks.
Walter Voit	PhD, 2009, Gatech	Optimization of Mechanical Properties and Manufacturing Techniques to Enable Shape Memory Polymer Processing
Scott Kasprzak	PhD, 2009, Gatech	Small-Scale Polymer Structures Enabled by Thiol-Ene Copolymer Systems.
Matthew DiPrima	PhD, 2009, Gatech	Thermo-Mechanical and Micro-Structural Characterization of Shape memory Polymer Foams.
Heidi F. Khalil	MS, 2009, Gatech	Changes in the mechanical behavior of Nitinol following variations of heat treatment duration and temperature
Greg Vialle	MS, 2009, Gatech	Inductive Activation of Magnetite Filled Shape Memory Polymers
Brian Lin	MS, 2009, Gatech	Structure and Thermomechanical Behavior of NiTiPt Shape Memory Alloy Wires.
Edem Wornyo	PhD, 2008, Gatech	Nanomechanics of Shape Memory Polymers.

David Safranski	MS, 2008, Gatech	Effect of Chemical Structure and Crosslinking Density on the Thermo-Mechanical Properties and Toughness of (Meth)Acrylate Shape Memory Polymer Networks.
Terra Keim	MS, 2007, Gatech	Synthesis, Characterization, and Cyclic Stress-Influenced Degradation of a Poly(ethylene)glycol based Poly(beta-amino ester)
Austin Leach	PhD, 2007, Gatech	Atomistic Modeling of the Mechanical Behavior of Nanometer Scale Metals.
Chris Yakacki	PhD, 2007, Colorado	Shape-Memory Polymers for Biomedical Applications: An Investigation into Thermomechanics, Recovery Characteristics, and Cytocompatibility.
David Miller	PhD, 2007, Colorado	Galvanic Corrosion-Induced Damage of Miniaturized Silicon Structures.
Jeff Tyber	MS, 2005, Colorado	Mechanical Behavior of Materials for Reconstructive Bioengineering Applications.
Carl Frick	PhD, 2005, Colorado	Processing, Structure, and Property Relationships in NiTi Shape Memory Alloys at Multiple Length Scales.
Yiping Liu	PhD, 2004, Colorado	Thermomechancis of Shape Memory Polymers.
Jiankuai Diao	PhD, 2004, Colorado	Atomistic and Continuum Modeling of the Structure and Mechanical Properties of Metal Nanowires.
Alicia Ortega	MS, 2004, Colorado	Cast NiTi Shape Memory Alloys.
Neil West	MS, 2003, Colorado	Factors Affecting Creep in Gold on Polysilicon Bi-layer Cantilevered MEMS Beams.
Kevin Juntunen	MS, 2001, Colorado	Effects of Precipitate Size and Surface Normal Orientation on Micro-Indentation and Compressive Fatigue of NiTi Shape Memory Alloys.
Brian Corff	MS, 2000, Colorado	High Strain Rate Damage in Ductile Metals.

University Course Instruction

Duke University, 2015-Current

Students provide individual course evaluations online at the end of a course. The maximum score on a question is 5.0 (Strongly Agree) and the minimum is 1.0 (Strongly Disagree), and interpolated medial values are presented. The overall measure for teaching effectiveness is captured in the "Instructor Effectiveness" score.

Year	*Term*	*Course Title*	*Enrollment*	*Quality of Instructor*

2016	Spring	Structure and Properties of Solids	33	4.83

Georgia Institute of Technology, 2005-2015

Students provide individual Course Instructor Opinion Surveys (CIOS) online at the end of a course. The maximum score on a question is 5.0 (Strongly Agree) and the minimum is 1.0 (Strongly Disagree), and interpolated medial values are presented. The overall measure for teaching effectiveness is captured in the "Instructor Effectiveness" score. The symbols U and G designate Undergraduate and Graduate courses, respectively.

Year	*Term*	*Course Title*	*Enrollment*	*Instructor Effectiveness*
2015	Spring	Mech Behavior of Materials (U/G)	59	5.0
2015	Spring	Materials Entrepreneurship (U/G)	17	4.8
2014	Fall	Engineering Materials (U)	99	4.8
2014	Spring	Materials Entrepreneurship (U/G)	42	4.8
2014	Spring	Engineering Materials (U)	106	4.9
2013	Fall	Engineering Materials (U)	106	4.8
2013	Spring	Engineering Materials (U)	100	4.8
2012	Fall	Engineering Materials (U)	97	4.8
2012	Spring	Engineering Materials (U)	97	4.9
2011	Fall	Engineering Materials (U)	95	4.9
2011	Spring	Engineering Materials (U)	85	4.9
2010	Fall	Engineering Materials (U)	96	4.9
2010	Spring	Mech Behavior of Materials (U/G)	57	4.9
2009	Fall	Engineering Materials (U)	99	5.0
2008	Spring	Engineering Materials (U)	100	4.8
2008	Spring	Engineering Materials (U)	101	4.9
2007	Spring	Engineering Materials (U)	112	4.8
2007	Spring	Engineering Materials (U)	117	4.9
2006	Spring	Engineering Materials (U)	88	4.9
2006	Spring	Nanomaterials (U)	14	4.5 (team taught)
2006	Spring	Nanomaterials (G)	12	4.3 (team taught)

University of Colorado, 1999-2005

Students provide individual course and instructor Faculty Course Questionnaire (FCQ) ratings anonymously. The cited "Course" and "Instructor" *overall* ratings are computed from the average of individual student rankings from a range of 0.0 (very poor) to 4.0 (very good). The symbols U and G designates Undergraduate and Graduate courses, respectively, and # is the number of students enrolled in the course.

Year	*Term*	*Course Title*	*#*	*Instructor*	*Course*
2004	Fall	Failure of Materials (U/G)	120	3.96 (A+)	3.85 (A)
2004	Spring	Material Science (U)	174	3.96(A+)	3.89 (A+)
2003	Fall	Failure of Materials (U/G)	93	3.95 (A+)	3.84 (A)
2003	Spring	Freshman Projects (U)	32	3.85 (A)	3.85 (A)
2002	Fall	Failure of Materials (U/G)	77	3.97 (A+)	3.87 (A)
2002	Spring	Freshman Projects (U)	33	3.88 (A+)	3.85 (A)
2001	Fall	Failure of Materials (U/G)	60	3.90 (A+)	3.83 (A)
2001	Fall	Materials Science I (G)	19	3.78 (A)	3.67 (A)
2001	Spring	Freshman Projects (U)	19	3.93 (A+)	4.00 (A+)
2000	Fall	Failure of Materials (U/G)	33	4.00 (A+)	3.96 (A+)

2000	Spring	Freshman Projects (U)	30	3.96 (A+)	3.75 (A)
1999	Fall	Materials Science I (G)	19	3.89 (A+)	3.67 (A)

Publications

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3. Gall, K., Sehitoglu, H., & Kadioglu, Y. (1996). Plastic zones and fatigue-crack closure under plane-strain double slip. *Metallurgical and Materials Transactions A, 27*(11), 3491-3502.

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Patents

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