US 20050032586A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2005/0032586 A1

Willett et al. (43) Pub. Date: Feb. 10, 2005

(54) METHOD FOR MANUFACTURING A GOLF CLUB FACE

(75) Inventors: **Kraig A. Willett**, Fallbrook, CA (US); **Stephen A. Kraus**, San Diego, CA (US); **Todd P. Beach**, San Diego, CA (US); **Joseph H. Hoffman**, Carlsbad, CA (US)

Correspondence Address:
SHEPPARD, MULLIN, RICHTER & HAMPTON LLP
333 SOUTH HOPE STREET
48TH FLOOR
LOS ANGELES, CA 90071-1448 (US)

(73) Assignee: **Taylor Made Golf Company, Inc.**

(21) Appl. No.: **10/943,391**

(22) Filed: **Sep. 17, 2004**

Related U.S. Application Data

(63) Continuation of application No. 10/288,551, filed on Nov. 4, 2002.

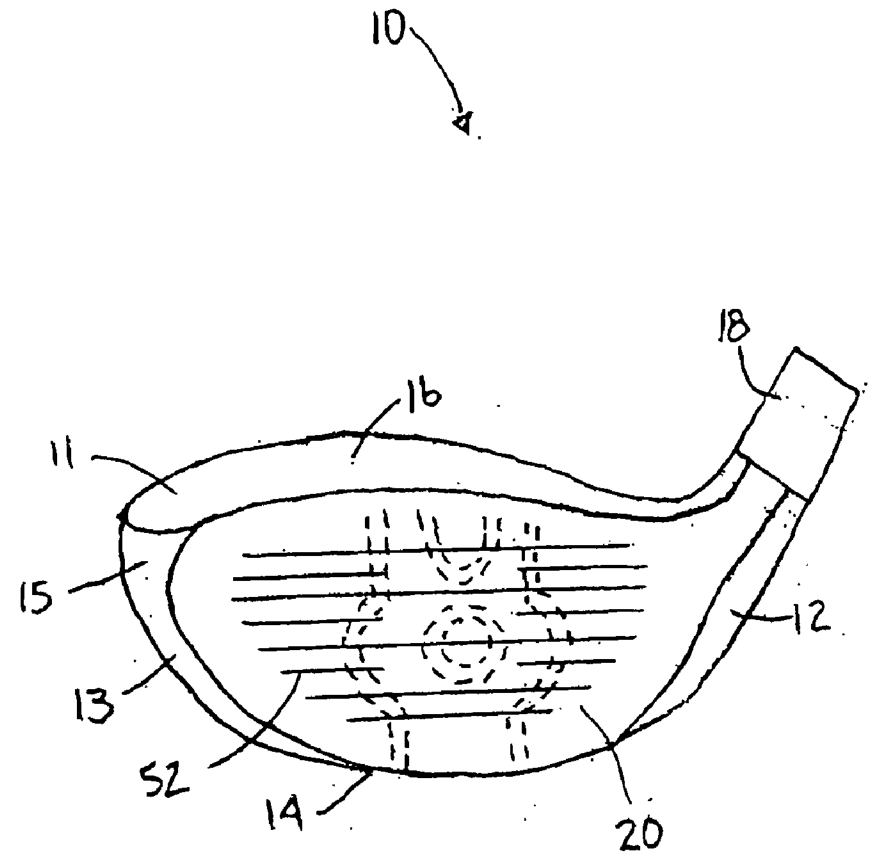
Publication Classification

(51) Int. Cl.[7] A63B 53/04

(52) U.S. Cl. 473/350

(57) ABSTRACT

A method of manufacturing a face plate for a golf club head is presented to provide face having substantial thickness variation for enhanced performance. The method includes the steps of providing a rolled sheet of metal material having an initial thickness and forming a blank having a prescribed outer shape from the material. The method also includes machining a second side of the blank such that the resulting face plate has a variable thickness. The machining is such that the plate has a first thickness less than or equal to the initial thickness, a second thickness less than the first thickness and a third thickness less than the second thickness. The machining is performed over a substantial portion of the surface area of the second side. Either a CNC lathe or milling machine may be used; however, for an axisymmetric face thickness a CNC lathe is preferred and for an asymmetric face thickness a CNC end mill is preferred. The club head may be a wood-type or iron, and titanium or steel alloys may be used.



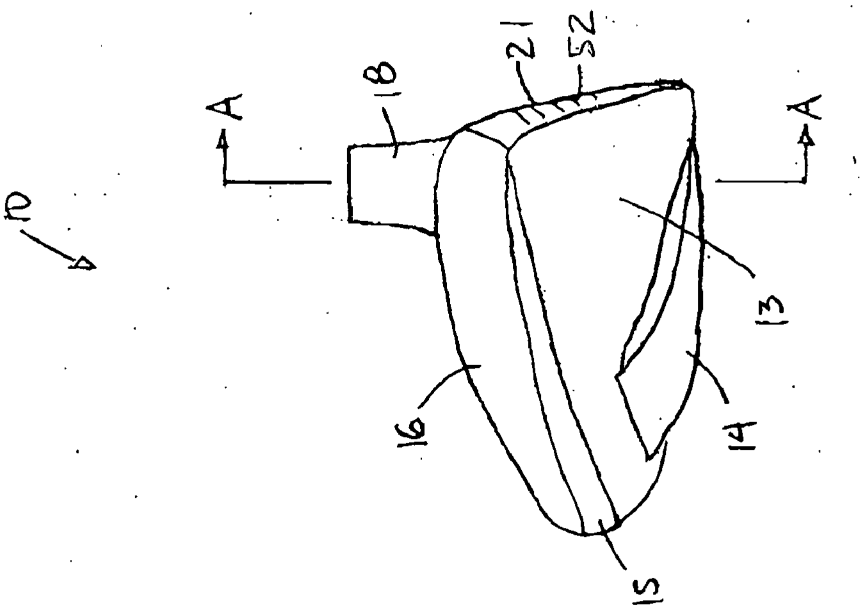


FIG. 2

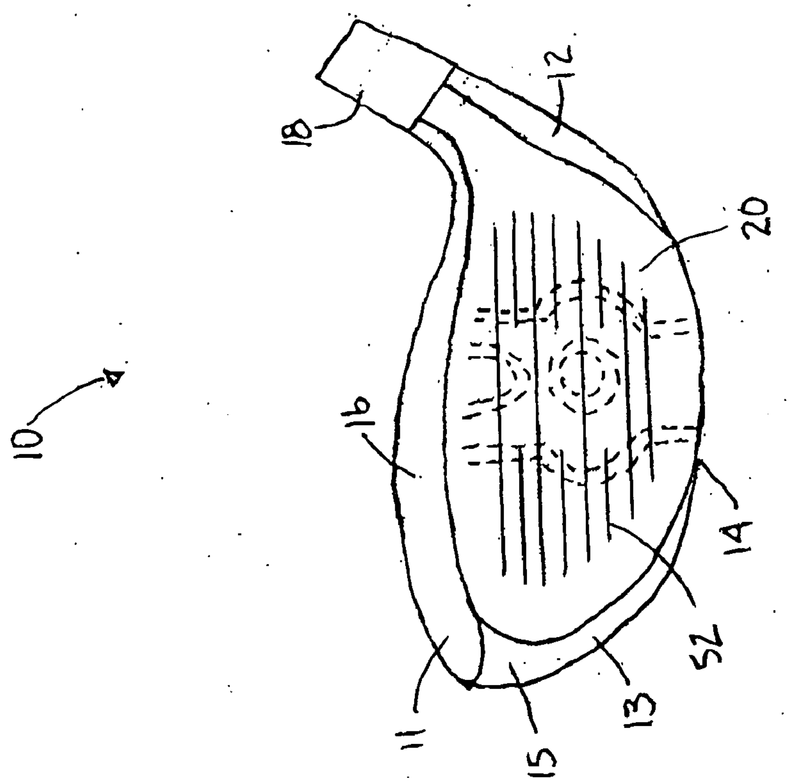


FIG. 1

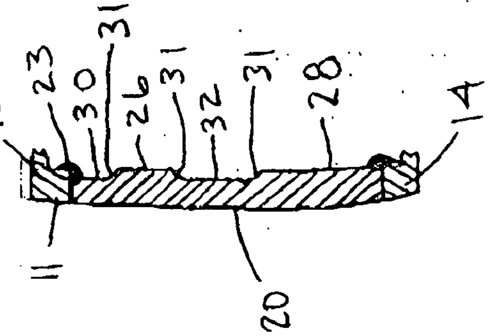


FIG. 3B

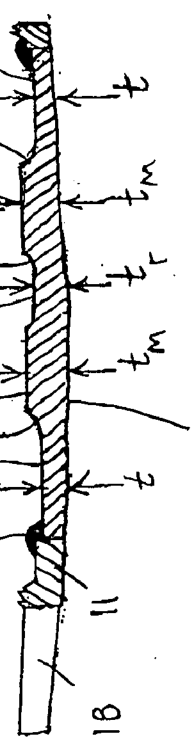


FIG. 3A

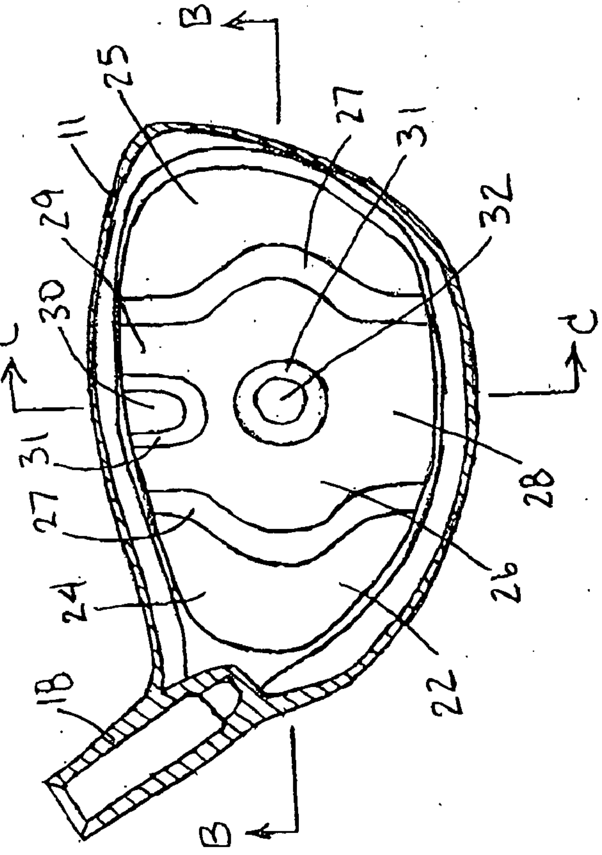


FIG. 3

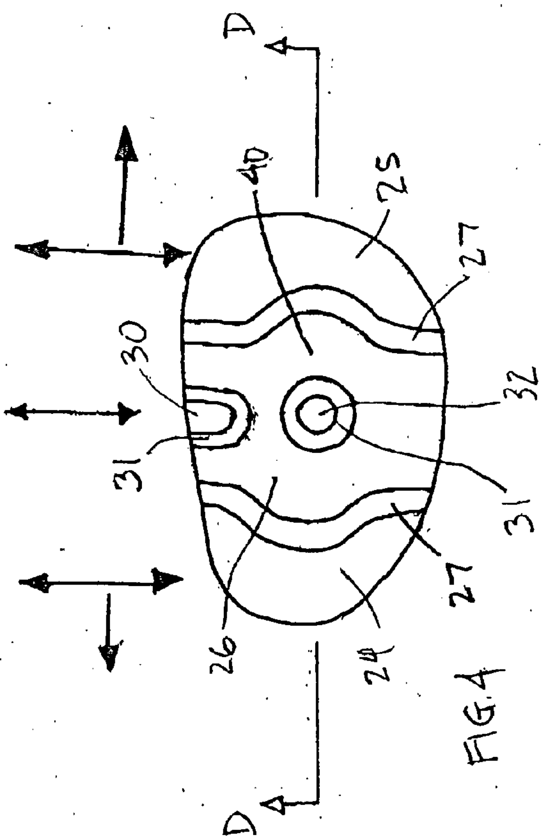


FIG. 4

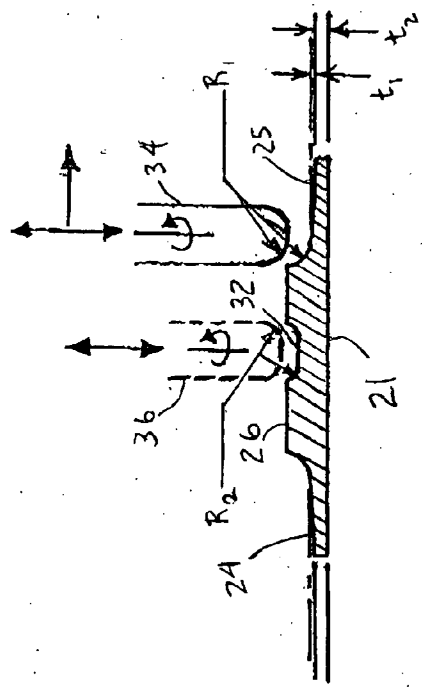


FIG. 5

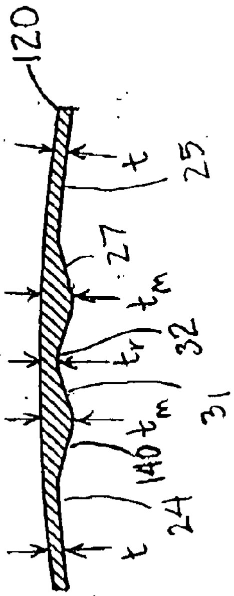


FIG. 6A

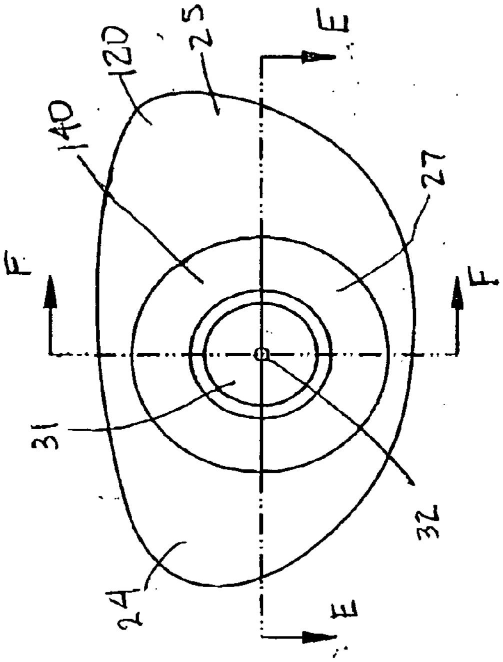


FIG. 6

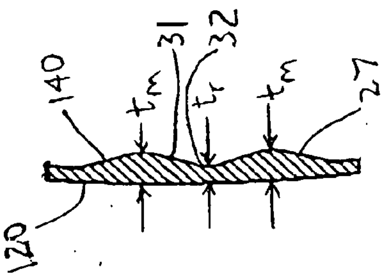


FIG. 6B

FIG. 8

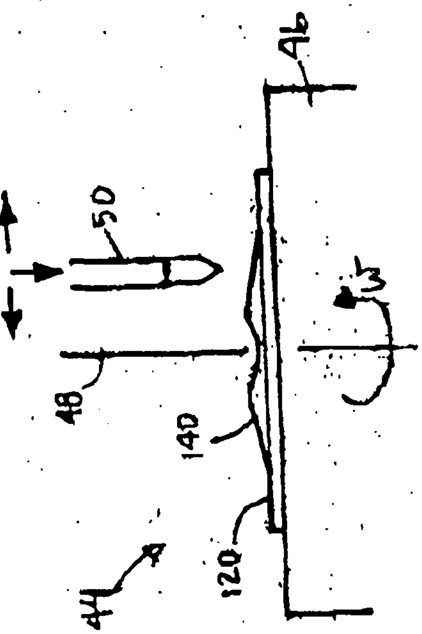


FIG. 9

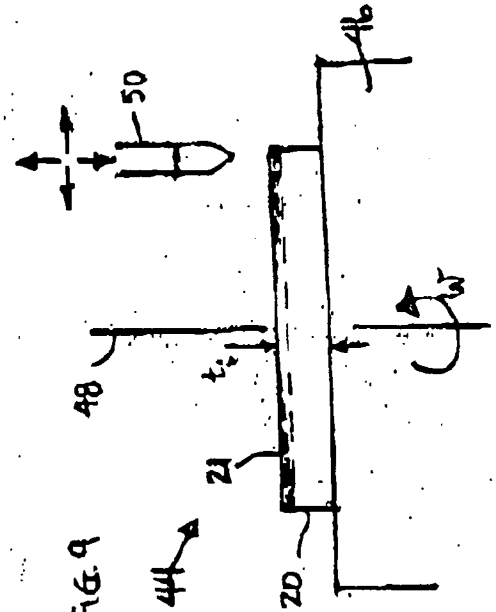
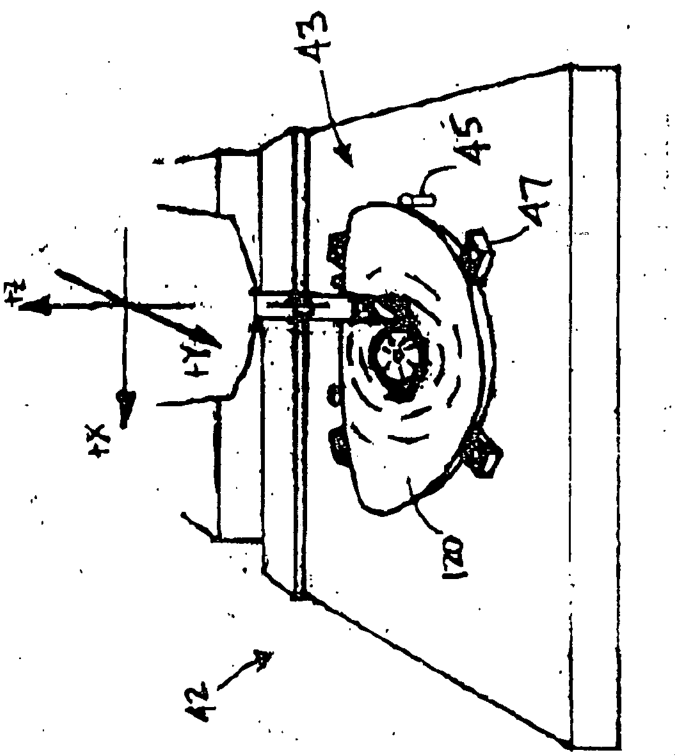


FIG. 7



METHOD FOR MANUFACTURING A GOLF CLUB FACE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of prior application Ser. No. 10/288,551, filed Nov. 4, 2002, which is herein incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] The present invention relates generally to golf club heads and, more particularly, to golf club heads having a face plate of variable thickness.

[0003] Modern golf clubs have typically been classified as either woods, irons or putters. The term "wood" is an historical term that is still commonly used, even for golf clubs that are constructed of steel, titanium, fiberglass and other more exotic materials, to name a few. The woods are now often referred to as "metal woods." The term "iron" is also an historical term that is still commonly used, even though those clubs are not typically constructed of iron, but are rather constructed of many of the same materials used to construct "woods."

[0004] Many advancements have been achieved, particularly over the past couple of decades, to make it easier to hit longer and straighter shots with woods and irons. In general, golf clubs are now designed to be more forgiving, so that shots that are struck less than perfectly will still have fairly consistent distance and directional control. Moreover, club heads now are commonly constructed of combinations of materials, to attempt to optimize the ball flight desired by a particular type of player.

[0005] One particular improvement that relates especially to metal woods is the use of lighter and stronger metals, such as titanium. A significant number of the premium metal woods, especially drivers, are now constructed primarily using titanium. The use of titanium and other lightweight, strong metals has made it possible to create metal woods of ever increasing sizes. The size of metal woods, especially drivers, is often referred to in terms of volume. For instance, current drivers may have a volume of 300 cubic centimeters (cc) or more. Oversized metal woods generally provide a larger sweet spot and a higher inertia, which provides greater forgiveness than a golf club having a conventional head size.

[0006] One advantage derived from the use of lighter and stronger metals is the ability to make thinner walls, including the striking face and all other walls of the metal wood club. This allows designers more leeway in the positioning of weights. For instance, to promote forgiveness, designers may move the weight to the periphery of the metal wood head and backwards from the face. As mentioned above, such weighting generally results in a higher inertia, which results in less twisting due to off-center hits.

[0007] There are limitations on how large a golf club head can be manufactured, which is a function of several parameters, including the material, the weight of the club head and the strength of the club head. Additionally, to avoid increasing weight, as the head becomes larger, the thickness of the walls must be made thinner, including the face plate. As the face plate becomes thinner, it has a tendency to deflect more at impact, and thereby has the potential to impart more energy to the ball. This phenomenon is generally referred to as the "trampoline effect." A properly constructed club with a thin face can therefore impart a higher initial velocity to a golf ball than a club with a rigid face. Because initial velocity is an important component in determining how far a golf ball travels, this is very important to golfers.

[0008] It is appreciated by those of skill in the art that the initial velocity imparted to a golf ball by a thin-faced metal wood varies depending on the location of the point of impact of a golf ball on the striking face. Each face plate has what is referred to as a "sweet spot." Generally, balls struck in the sweet spot will have a higher rebound velocity. Many factors contribute to the location and size of the sweet spot, including the location of the center of gravity (CG) and the shape and thickness of the face plate.

[0009] Manufacturers of metal wood golf club heads have more recently attempted to manipulate the performance of their club heads by designing face plates of variable thicknesses. Because of the use of lightweight materials such as titanium for the face plate, a problem arises in the stresses that are transmitted to the face-crown and face-sole junctions of the club head upon impact with the golf ball. One prior solution has been to provide a reinforced periphery of the face plate in order to withstand the repeated impacts. The manufacture of face plates has typically been accomplished by forging a metal, such as a titanium alloy, to achieve the face thickness variation.

[0010] Another approach to reduce these stresses at impact is to use one or more ribs extending substantially from the crown to the sole vertically across the face, and in some instances extending from the toe to the heel horizontally across the face. Because the largest stresses are located at the impact point, usually at or substantially near the sweet spot, the center of the face is also thickened and is at least as thick as the ribbed portions. However, these club heads fail to ultimately provide much forgiveness to off center hits for all but the most expert golfers. The variable face thickness design and the use of titanium face inserts have also recently been applied to iron golf club heads with similar disadvantages and limitations. Well known casting and forging techniques have typically been employed to achieve the variable face thickness designs for irons.

[0011] It should, therefore, be appreciated that there exists a need for an improved method of manufacturing golf club face plates having a variable thickness that exhibit greater forgiveness across a substantial portion of the face plate while continuing to impart higher initial velocity. The present invention fulfills that need and others.

SUMMARY OF THE INVENTION

[0012] The invention provides a method of manufacturing a golf club face plate having substantial thickness variation for enhanced performance. The method includes the steps of providing a rolled sheet of metal material having an initial thickness and forming a blank having a prescribed outer shape from the material. The method also includes machining a second side of the blank such that the resulting face plate has a variable thickness. The variable thickness includes a first thickness less than or equal to the initial thickness, a second thickness less than the first thickness and a third thickness less than the second thickness. The machining is performed over a substantial portion of the surface area of the second side.

[0013] An advantage of the rolled sheet material is that it can have a very fine, directional grain microstructure that results in improved strength and ductility compared to other materials and manufacturing methods Either a CNC lathe or milling machine may be used; however, for an axisymmetric face thickness a CNC lathe is preferred and for an asymmetric face thickness a CNC end mill is preferred. The club head may be a wood-type or iron, and titanium or steel alloys may be used.

[0014] In a detailed aspect of a preferred embodiment, at least 60% of the surface area of the second side is machined, and the resulting face thickness variation may be axisymmetric or asymmetric.

[0015] In another detailed aspect of a preferred embodiment, a bulge and a roll is formed on a first side of the blank.

[0016] In yet another detailed aspect of a preferred embodiment, at least 15% of the material of the blank is removed. Additional thickness and/or different transition regions may be machined, according to the face thickness design desired.

[0017] For purposes of summarizing the invention and the advantages achieved over the prior art, certain advantages of the invention have been described herein above. Of course, it is to be understood that not necessarily all such advantages may be achieved in accordance with any particular embodiment of the invention. Thus, for example, those skilled in the art will recognize that the invention may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other advantages as may be taught or suggested herein.

[0018] All of these embodiments are intended to be within the scope of the invention herein disclosed. These and other embodiments of the present invention will become readily apparent to those skilled in the art from the following detailed description of the preferred embodiments having reference to the attached figures, the invention not being limited to any particular preferred embodiment(s) disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Embodiments of the present invention will now be described, by way of example only, with reference to the following drawings in which:

[0020] **FIG. 1** is a front view of a wood-type club head having a face thickness (in phantom) provided by a preferred method of the present invention.

[0021] **FIG. 2** is a toe end view of the club head of **FIG. 1**.

[0022] **FIG. 3** is a cross-sectional view taken along line A-A of **FIG. 2** and showing a rear of the face plate.

[0023] **FIG. 3A** is a cross-sectional view taken along line B-B of **FIG. 3**.

[0024] **FIG. 3B** is a cross-sectional view taken along line C-C of **FIG. 3**.

[0025] **FIG. 4** is a rear view of the plate of **FIG. 3** showing the preferred directions (arrows) of the cutters during the machining process.

[0026] **FIG. 5** is a cross-section taken along line D-D of **FIG. 4** showing a first and second (in phantom) formed cutter to achieve the desired radii of the web transitions of the face thickness.

[0027] **FIG. 6** is a rear view of a face plate formed in an alternative method of the present invention.

[0028] **FIG. 6A** is a longitudinal cross-section view taken along line E-E of **FIG. 6**.

[0029] **FIG. 6B** is a lateral cross-section view taken along line F-F of **FIG. 6**.

[0030] **FIG. 7** is a front perspective view of a CNC milling machine in a preferred method of the present invention.

[0031] **FIGS. 8 and 9** are exemplary views of an alternative method of the present invention utilizing a CNC lathe to create face thickness variation and bulge and roll, respectively, for a face plate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] The drawings depict preferred embodiments of face plates achieved by methods of the present invention, the golf club face plates being for different types of golf club heads. With reference to **FIG. 1**, a club head **10** is shown that is similar to many metal wood club heads that are known in the art. Club heads within the scope of the invention are not necessarily limited to the shapes depicted. The club head **10** comprises a hollow metallic body **11** and a face plate **20**. The body comprises a heel portion **12**, a toe portion **13**, a sole portion **14**, skirt or side portion **15** and a crown portion **16** that cooperate to define a periphery **17** for an opening (see **FIG. 3**) for the face plate. The club head is normally connected to a shaft (not shown) by a hosel **18** that is integrally formed with the body.

[0033] Preferably, the body and/or face plate is constructed of steel, titanium or alloys thereof, but alternatively the body may comprise a composite or metal matrix material. The face plate may be constructed of any rolled sheet material that can be machined, and preferably the material has a density of at least 4 g/cc. Prior face plates of rolled sheet material, such as Ti-6AL-4V, have either been constant in thickness or had minimal material removed to achieve relatively small face thickness variation.

[0034] Rolled sheets of high strength titanium alloy, such as SP-700® by NKK Corporation of Japan, have previously been thought to be too expensive to waste material by substantial machining of it to remove material to achieve significant thickness variation, as in the present invention. An advantage of the rolled sheet material is that it can have a very fine, directional grain microstructure that results in improved strength and ductility compared to other materials and manufacturing methods. Applicants have found that the combination of rolled sheet material and machining to be a cost effective and reliable way to produce the quality of the face thickness desired. In addition to the preferred face thickness designs presented herein, those skilled in the art will appreciate that further designs resulting in three or more thickness zones may be achieved using the method of the present invention.

[0035] Referring to **FIGS. 1 and 2**, the club head is preferably manufactured such that the body **11**, including the heel portion **12**, toe portion **13**, sole portion **14**, side portion **15**, crown portion **16** and hosel **18** are integrally formed, and the face plate **20** having a striking face **21** is fixedly attached to the opening periphery **17** by means known in the art. However, the various portions of the preferred body may be separately molded, cast, forged or otherwise manufactured by means known in the art, and fixedly attached to form the body by means known in the art. An initial outer shape for the face plate may be formed by stamping a rolled sheet of metal material.

[**0036**] The machined face plate **20** is welded along its periphery, and at the rear the weld bead **23** is visible. As shown in **FIGS. 3-3B**, heel and toe zones **24**, **25** of the face plate have a similar thickness t that is preferably less than the adjacent thickness of the body **11** at the front opening periphery **17**. A central vertical zone **26** has a maximum thickness tm of the face plate, with transition thickness regions **27** formed between the heel and central zones and the toe and central zones. A lower region **28** of the central vertical zone extends toward the sole portion **14**, and upper segments **29** extend toward the crown portion **16**. The face plate has an asymmetric face thickness about a longitudinal or heel to toe axis.

[**0037**] Between the upper segments is a recess **30** that has a thickness tr less than the maximum thickness tm but preferably greater than the thickness t of the heel and toe zones **24**, **25**. A transition thickness region **31** is formed between the upper segments' thickness tm and the recess thickness tr. In addition for the present invention, at approximately the center of the face plate **20** is a recess **32** that preferably has a thickness tr substantially the same as the upper recess and with a similar transition region **31** between the thickness of the central recess and the thickness of the vertical zone **26**. In alternative embodiments the thickness at the toe zone may be different from the thickness at the heel zone, and the thickness at the upper recess may be different than the thickness at the central recess, as desired.

[**0038**] Preferably, the central recess **32** and transition **31** extend a distance between 20% and 50% of the width of the vertical zone **26** and transitions **27** measured in a toe to heel direction. In the preferred embodiment of **FIG. 3**, the toe and heel zones **25**, **24** of the rear surface **22** each have a thickness t less than 2.5 mm and the thickness of the vertical zone is at least 3.0 mm. The reduced thickness tr of each of the central recess and upper recess **30** is at least about 0.5 mm less than the thickness tm of the vertical zone. Preferably, the thicknesses t, tr, tm are 1.6 mm to 2.4 mm, 2.2 mm to 3.5 mm and 3.2 mm to 4.5 mm, respectively. More preferably, the thickness ranges are 2.2 mm to 2.4 mm, 3.0 mm to 3.2 mm and 3.5 mm to 3.7 mm, respectively. Generally, it is preferred that the heel and toe zones have a minimum thickness at least 1 mm less than the maximum thickness of the vertical zone.

[**0039**] As shown in **FIGS. 3A and 3B**, the transition regions **27**, **31** comprise a web transition having a generally concave cross-section. That is, the cross-section preferably comprises a radiused surface for the web transition between the vertical zone **26** and the recesses **30**, **32** and the heel and toe zones **24**, **25**. In a preferred method, a CNC end mill **42** (**FIG. 7**) is used having a profiled cutter chosen to minimize the number of passes required to provide the desired thickness variation of the face plate. The face plate is placed in a fixture **43**, positioned using locating pins **45** and held in place using adjustable clamps **47**. For a lathe, adjustable jaws are used to hold the piece in place during machining. The rotating cutter moves in X, Y and Z axes according to the programmed face design.

[**0040**] Referring to **FIG. 5**, a single formed cutter **34** having a radius R1 may be used for all the transition regions **27**, **31**, although it is preferred to use a second cutter **36** (shown in phantom) having a radius R2 different than the first cutter for the transition region **31**. The second radius R2 is preferably smaller to accommodate the smaller areas covered by the recesses **30**, **32**. Of course another smaller radius cutter may be used for either the upper recess **30** or central recess **32**; and/or another different radius cutter may be used for the toe zone **25** than the heel zone **24**, as desired. It is most preferable to use only one or two different cutters to simplify and speed up the manufacturing process.

[**0041**] **FIG. 4** shows arrows indicating preferred paths taken by the cutters. At the toe and heel zones, the cutter **34** may be calibrated from the center of the face plate **20** and move first in a top to bottom direction and second in an outward direction to the heel or toe ends of the plate. Preferably, the cutter moves inward from the heel or toe end toward the center of the face plate. The smaller radius cutter **36** may form the upper recess **30** by moving from the top edge toward the center of the face plate, or, alternatively, by moving from adjacent a central region **40** comprising the central recess toward the top edge. As shown in **FIG. 5**, the central recess **32** may be formed by the smaller radius cutter by a vertical or up and down motion to obtain the desired thickness tr.

[**0042**] The CNC end mill **42** using formed cutters advantageously allows production of the desired face thickness in 2 to 3 passes at each of the toe and heel zones (4 to 6 passes), a pass to create each of the upper and central recesses (2 passes); thus, a face plate **20** may be produced in 6 to 8 passes or actions by the machine. The total number of passes or actions required is determined by the selected size/shape of the cutter(s) and the face thickness design.

[**0043**] A face plate **120** shown in **FIGS. 6-6B** comprises a face thickness that varies symmetrically about the longitudinal as well as lateral (top to bottom) axis (lines E-E and F-F, respectively). A central recess **32** is located in a central region **140**. This axisymmetric shape may be achieved using an end mill-type CNC machine **42**, as represented in **FIG. 7**; however, the preferred method utilizes a CNC lathe **44** wherein a spindle **46** rotates and turns the face plate **120** about a central axis **48**, as represented in **FIGS. 8 and 9**. One or more cutting tools **50** move according to the programmed design to provide the desired face thickness.

[**0044**] By computer controlling the relative movement of a cutter in the three axes, using techniques well known to those skilled in the art, a taper may be provided at the toe and heel zones, from a thickness t1 adjacent the transition **27** to a smaller thickness t2 at heel and toe ends of the face plate (see **FIG. 5**). However, the limited incremental or stepwise control of the end mill cutter position typically results in a visible step formed by each pass of the cutting tool across the surface. The CNC lathe method described for **FIGS. 6-6B**, however, provides more continuously variable thickness or surface taper that may be desired on the rear surface of the face plate. Of course, it is understood that the machining methods of the present invention for manufacturing a golf club face may be performed without CNC machining, although CNC machining is preferred for a large production run.

[**0045**] In the method of the present invention, the front striking face **21** may be provided with grooves, dimples or any combination thereof to form a scoreline pattern **52** (see **FIG. 1**) before or after the face thickness variation is provided. Similarly, a bulge radius and a roll radius may be provided on the face plate before or after the face thickness variation. **FIG. 9** illustrates one method wherein the bulge and roll are machined on the striking face **21** prior to the face thickness of the rear surface. The center of the face plate maintains substantially the same initial thickness ti as the original rolled sheet of material. Alternatively, a stamping or forming process may be employed to achieve the desired bulge and roll radii desirable for wood-type golf club heads.

[**0046**] In one preferred method, the bulge and roll are formed on the face plate at a feed rate or cutter advancement of about 0.1 mm per revolution (mm/rev). Preferably, for Ti-6AL-4V material for the face plate the spindle **46** rotates between about 180 to 450 revolutions per minute (RPM), and for SP-700® material the spindle **46** rotates between about 180 to 400 RPM, with the RPM increasing as the cutter **50** advances toward the center of the face plate **20**.

[**0047**] To machine the face thickness variation, a blind hole is first drilled to remove some material at the center of the face. A rough turning is performed to remove a preliminary amount of material using the feed rate and rotations described above for bulge and roll formation. A more precise, fine turning is performed using a preferred feed rate of about 0.14 mm/rev. For Ti-6AL-4V and SP-700® materials the turn or spin rates ω are 180 to 500 RPM and 180 to 450 RPM, respectively. It takes a total of about 6 minutes to provide the face thickness variation on a face plate **120** of SP-700® material.

[**0048**] Alternatively, the center recess **32** and central region **140** of increased thickness may be formed by first drilling at about 0.21 mm/rev with a cutting tool having an outer diameter of 17.0 mm and having a spindle speed ω of about 700 RPM. Rough turning is performed at about 0.4 to 2.5 mm/rev as the spindle **46** rotates from 100 to 600 RPM, with a Z-axis feed depth or vertical displacement of between 0.4 to 1.0 mm. The cutting tool is preferably a 60 deg triangle tip, known to those skilled in the art. The fine turning is performed at about 0.06 to 0.6 mm/rev with a spindle speed ω of about 200 to 2000 RPM (outside to center speed). The Z-axis feed depth is about 0.1 mm and the cutting tool preferably has a 35 deg rhombus tip. For lubrication an oil such as Castrol ® B7 may be used.

[**0049**] One aspect of the method of the present invention is the amount of material removed by the machining. At least 60% of the original surface area is machined to varying depths or thickness. Preferably, machining is performed over at least 70% of the surface area, and more preferably machining is performed over at least 80%. In one embodiment, over 90% of the rear surface of the face plate is machined, and 100%—or the entirety—of the rear surface may be machined. The volume of material removed from the initial shape of the plate that is formed from the rolled sheet is at least 15% and preferably at least 25%. In one preferred embodiment, over 40% of material is removed.

[**0050**] The embodiments described in detail herein are merely illustrative and the present invention may be readily embodied, for example, to provide club heads having hybrid constructions utilizing, e.g., laminations of metal and composite materials. The club heads may be hollow or filled and may comprise unitary or multi-piece bodies. Advantageously, the method of the present invention may be employed for a face plate for a metal wood to achieve COR values greater than about 0.80 across a greater portion of the striking surface than conventional club heads; e.g., increasing a sweet spot for a relatively "hot" metal wood. And, while the preferred methods are described in detail for face plates for metal woods, i.e., drivers and fairway woods, it will be appreciated that the present invention may be utilized to form face plates for irons as well.

[**0051**] Although the invention has been disclosed in detail with reference only to the preferred embodiments, those skilled in the art will appreciate that additional methods for manufacturing face plates for golf club heads can be included without departing from the scope of the invention. Accordingly, the invention is defined only by the claims set forth below.

1-20. (canceled).

21. A method of forming a face plate for a wood-type golf club head, comprising:

forming a face plate blank from a titanium alloy having a density of at least 4 g/cm^3, wherein the face plate blank has a first volume delimited by a first surface, a second surface, and a periphery, and wherein the first surface has a first surface area delimited by the periphery; and

performing a computer numeric controlled milling process on the first surface, thereby forming a toe zone, a heel zone, and a central zone disposed between the toe zone and the heel zone, a transition between the central zone and the heel zone, and a transition between the central zone and the toe zone, wherein the toe zone has a maximum toe zone thickness of less than 2.5 mm, the heel zone has a maximum heel zone thickness of less than 2.5 mm, the central zone has a maximum central zone thickness between 3.2 to 4.5 mm, and the thickness of the central zone varies asymmetrically about a heel to toe axis;

wherein performing the computer numeric controlled milling processes comprises machining at least 80% of the first surface area and removing at least 25% of the first volume.

22. A method as defined in claim 21, wherein machining the face plate blank comprises machining over 90% of the first surface area.

23. A method as defined in claim 22, wherein machining the face plate blank comprises removing more than 40% of the first volume.

* * * * *