

April 5, 1960

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2,931,098

METHOD OF MAKING A GOLF CLUB HEAD

Filed Jan. 26, 1956

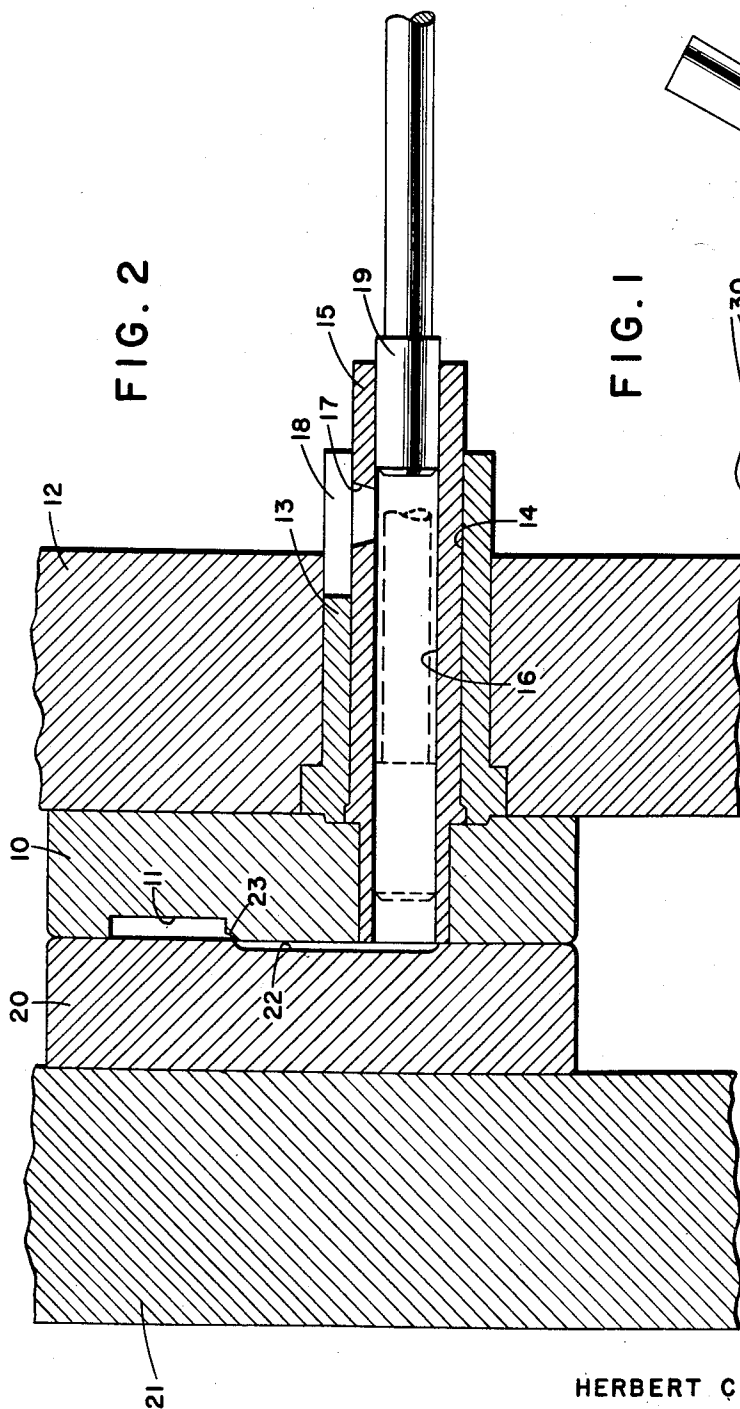
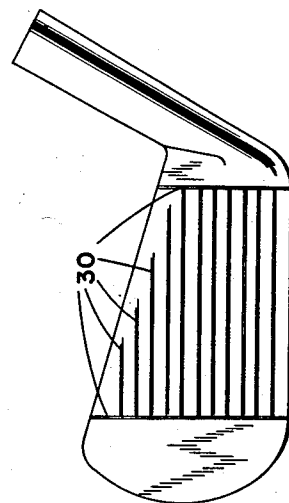


FIG. 1



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ATTORNEYS

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2,931,098

## METHOD OF MAKING A GOLF CLUB HEAD

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Application January 26, 1956, Serial No. 561,544

3 Claims. (Cl. 29—528)

This invention relates to golf clubs and has to do more particularly with a head for an "iron" club and to a method of making the same.

In making a golf shot the experienced player relies upon his senses of sight, feeling and hearing. When making a good shot he notes the flight of the ball and the accompanying feel and sound. The player associates with a good shot the feel and sound experienced when making the shot. When a subsequent shot under generally similar conditions of lie and distance is to be attained, he instinctively employs a muscular effort similar to that employed in making previous good shots. If the feel and sound are similar to those experienced in connection with the previous good shots the player senses that the proper muscular effort has been employed. These effects on his senses aid him in learning to reproduce the conditions necessary to make a good shot. Thus, it is important that a golf club have such properties that when a shot is made, the vibrations transmitted to the hands of the player and the sound transmitted to his ears will be such as to aid him in reproducing similar shots under similar conditions or modifying the shots to suit varying conditions within the scope of the individual clubs. Accordingly, it is important that the feel and sound be such as to make the player recognize and identify a good shot therefrom and to impress themselves upon his mind. Moreover, the feel and sound should be such as to indicate to the player the distance and direction that the ball travels. This is best attained when the vibrations, both those transmitted by the club shaft and through the air, are of suitable amplitude and frequency to produce the necessary impression upon the senses of the player. Moreover, it is important that the feel and sound or "tone" be pleasing to the senses of the player to create the feeling of successful accomplishment which aids in inducing the player to reproduce the conditions of the good shot. My invention, as hereinafter explained permits the construction of a golf club head having the aforementioned desirable properties of feel and "tone."

In golf clubs known as "irons" the head portion is made from metal. Customarily such head has been formed by drop forging steel to approximately the desired size and shape, whereafter the head is subjected to a machining operation, such as grinding, to remove fins and burrs and to smooth the surfaces. Golf club heads so formed are subject to variation in size, shape, weight and balance owing to the wear which takes place in the forging dies and to the impossibility of removing just the right amount of material from each head by grinding.

It is customary to provide a series of grooves or score lines in the striking face of the head. This is accomplished by a cold rolling or knurling operation, with the result that the steel flows during such operation and burrs are thrown up along the sides of the grooves, which burrs must be removed by grinding so as to provide smooth, level face portions between the grooves. This operation also contributes to the non-uniformity of the several clubs of a series of clubs.

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An object of the invention is to provide a new and improved golf club head formed from metal.

Another object is to provide a golf club head formed from metal which is strong, tough and resilient and when used in stroking a golf ball provides a tactile and audible indication distinctively characteristic of the accuracy and force of the stroke.

Another object is to provide a golf club head formed by die casting.

Another object is to provide a method of forming metal golf club heads whereby each club head of a series is of uniform size, shape, weight and balance.

Another object is to provide a golf club head having new and improved surface characteristics.

A further object is to provide a golf club head formed from a metal which has not substantially less density than the steel commonly used in forming golf club heads and which is stronger than such steel and has a lower deflection under stress and more nearly complete return to the initial condition and provides a better "tone."

Another object is to provide a metal golf club head which may be formed quickly and easily substantially to its final shape in a single forming operation and a single scoring operation and with a minimum of machining.

Another object is to provide a metal golf club head formed with the usual number and arrangement of score lines on its face but which has a surface of such nature that the ball when struck does not slip on the face but remains substantially fixed relatively to the face from the time the face contacts the ball until the ball leaves the face.

Still a further object is to provide a method of forming a golf club head whereby uniformity of size, shape, weight and balance can be maintained in the production of a large number of similar heads.

Still another object is to provide a metal golf club head which in the preferred embodiment of the invention is formed of denser metal than a conventional metal head but whereby the hosel may be made shorter with an improved distribution of weight in the club head.

Other objects and advantages will appear from the following description taken in connection with the appended drawing wherein:

Fig. 1 is a front elevational view of a golf club head formed in accordance with my invention; and

Fig. 2 is a diagrammatic view of apparatus for die casting a club head in accordance with my invention.

In accordance with my invention I form the club head, either by die casting, drop forging or sand casting from a material having desirable properties, including especially, desirable tensile strength, yield point, impact strength, elongation, hardness, specific gravity and melting point. These properties provide a golf club head which is stronger, tougher and more shock absorbing than the steel heretofore used in making irons and it provides a better "tone." In addition, the material is acceptable to all methods of electroplating with highly corrosion resistant materials.

The metal has a higher strength than steel and does not deflect to the same extent as steel and after deflection returns substantially to its initial shape to a greater extent than steel. In other words, the "recovery" is substantially 100%.

In forming the golf club in accordance with my invention, I prefer to employ an alloy consisting predominantly of copper and either zinc or aluminum, having the aforementioned and other properties which render it highly suitable for use in forming a golf club head.

By way of illustration of a material suitable for forming a golf club head I have set forth below several specific examples of alloys but it will be understood that other alloys having the properties recited and com-

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positions falling within the ranges set forth also may be employed.

## EXAMPLE I

In accordance with the preferred embodiment of my invention I form the golf club head from an alloy having the following composition and physical properties. (In the following and all succeeding examples the percentage composition is by weight.)

## Chemical analysis

|                  |           |
|------------------|-----------|
| Copper           | 63.0-64.0 |
| Tin              | .25 max.  |
| Lead             | .25 max.  |
| Zinc             | Rem.      |
| Nickel           | ----      |
| Iron             | .15 max.  |
| Aluminum         | .15 max.  |
| Silicon          | 1.25 max. |
| Manganese        | .23 max.  |
| Magnesium        | ----      |
| Other impurities | .50 max.  |

## Physical properties

|                                   |        |
|-----------------------------------|--------|
| Ultimate tensile strength, p.s.i. | 65,000 |
| Yield point, p.s.i.               | 35,000 |
| Impact strength, ft. lb.          | 36     |
| Elongation, percent in 2 in.      | 25.0   |
| Brinell hardness                  | 120    |
| Specific gravity                  | 8.6    |
| Melting point deg. F.             | 1,575  |

This alloy has all of the properties which I have explained above to provide the desirable results of this invention. Among these should be noted particularly the low melting point, relatively high tensile strength and good yield resistance. In addition, the material flows readily and therefore is readily cast, and it has properties of machinability and good workability.

## EXAMPLE II

Another alloy suitable for forming a golf club head in accordance with my invention is one having the following composition and physical properties:

## Chemical analysis

|            | Min.  | Nominal | Max.  |
|------------|-------|---------|-------|
| Copper     | 56.00 | ----    | 59.00 |
| Tin        | ----  | ----    | 1.00  |
| Lead       | ----  | ----    | 0.30  |
| Zinc       | Rem.  | ----    | Rem.  |
| Nickel     | ----  | ----    | 0.50  |
| Iron       | .01   | ----    | 0.10  |
| Antimony   | ----  | ----    | 0.01  |
| Sulphur    | ----  | ----    | 0.05  |
| Aluminum   | 0.75  | ----    | 1.50  |
| Silicon    | ----  | ----    | 0.03  |
| Phosphorus | ----  | ----    | 0.005 |
| Manganese  | 0.10  | ----    | 1.00  |

## Physical properties

|                           |               |
|---------------------------|---------------|
| Tensile strength, p.s.i.  | 70,000-88,000 |
| Yield strength, p.s.i.    | 28,000-40,000 |
| Elongation, percent in 2" | 20-35         |
| Brinell hardness          | 115-150       |
| Impact strength, ft. lbs. | 20-40         |
| Specific gravity          | 8.-8.5        |
| Weight per cu. in. (lbs.) | .289-.307     |
| Melting point, ° F.       | 1690          |

It is to be noted that this alloy has all of the desirable properties, and has a higher tensile strength and hardness than the alloy of Example I. It is somewhat less expensive because of the lower copper content.

## EXAMPLE III

Still another desirable alloy suitable for forming a golf club head in accordance with my invention is one having the following composition and physical properties:

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## Chemical analysis

|            | Min.  | Nominal | Max.  |
|------------|-------|---------|-------|
| 5 Copper   | 60.00 | ----    | 68.00 |
| Tin        | ----  | ----    | 0.05  |
| Lead       | ----  | ----    | 0.10  |
| Zinc       | Rem.  | ----    | Rem.  |
| Nickel     | ----  | ----    | 1.00  |
| Iron       | 2.00  | ----    | 4.00  |
| Antimony   | ----  | ----    | 0.01  |
| 10 Sulphur | ----  | ----    | 0.03  |
| Aluminum   | 4.00  | ----    | 7.50  |
| Silicon    | ----  | ----    | 0.10  |
| Phosphorus | ----  | ----    | 0.005 |
| Manganese  | 3.00  | ----    | 4.50  |

## Physical properties

|                             |                 |
|-----------------------------|-----------------|
| 15 Tensile strength, p.s.i. | 110,000-120,000 |
| Yield strength, p.s.i.      | 65,000-90,000   |
| Elongation, percent in 2"   | 12-18           |
| Brinell hardness            | 190-235         |
| Impact strength, ft. lbs.   | 7-12            |
| 20 Specific gravity         | 7.7-8.0         |
| Melting point, ° F.         | 1700            |

This alloy has the desired properties in accordance with my invention including particularly a very high tensile strength, a very high yield strength, excellent long life and wear resistance; it has particularly good tone qualities when the club formed therefrom is used in striking a ball.

## EXAMPLE IV

A further alloy suitable for forming a golf club head in accordance with my invention is one having a composition and physical characteristics as follows:

## Chemical analysis

|              | Min.  | Nominal | Max.  |
|--------------|-------|---------|-------|
| 35 Copper    | 86.00 | 187.50  | 88.00 |
| Tin          | ----  | ----    | 0.10  |
| Lead         | ----  | ----    | 0.05  |
| 40 Zinc      | ----  | ----    | 0.10  |
| Nickel       | ----  | ----    | 0.25  |
| Iron         | 3.00  | 3.50    | 4.00  |
| Antimony     | ----  | ----    | 0.01  |
| Sulphur      | ----  | ----    | 0.05  |
| Aluminum     | 8.50  | 9.00    | 9.50  |
| Silicon      | ----  | ----    | 0.15  |
| Phosphorus   | ----  | ----    | 0.005 |
| 45 Manganese | ----  | ----    | 0.25  |

<sup>1</sup> (Copper, iron, aluminum, nickel and manganese must total 99.5%.)

## Physical properties

|                             |               |
|-----------------------------|---------------|
| 50 Tensile strength, p.s.i. | 70,000-87,000 |
| Yield strength, p.s.i.      | 25,000-30,000 |
| Elongation, percent in 2"   | 22-38         |
| Brinell hardness            | 110-140       |
| Impact strength, ft. lbs.   | 35-50         |
| 55 Specific gravity         | 7.3-7.50      |
| Melting point, ° F.         | 1820          |

This alloy in addition to the principal desirable properties has high corrosion resistance, good color that becomes decorative as the club head is machined and buffed, and good plating qualities.

## EXAMPLE V

Still a further alloy having a composition and physical properties which render it suitable for forming a golf club head in accordance with my invention is the following:

## Chemical analysis

|           | Min.  | Nominal | Max.  |
|-----------|-------|---------|-------|
| 70 Copper | 83.00 | ----    | ----  |
| Iron      | 3.00  | ----    | 5.00  |
| Aluminum  | 10.00 | ----    | 11.50 |
| Nickel    | ----  | ----    | 2.50  |
| Manganese | ----  | ----    | .50   |
| Others    | ----  | ----    | .50   |

<sup>1</sup> (Copper, iron, aluminum, nickel and manganese must equal 99.50%.)

*Physical properties*

|                                   | As Cast       | As Heat Treated |
|-----------------------------------|---------------|-----------------|
| Tensile Strength, p.s.i.....      | 75,000-95,000 | 90,000-11,000   |
| Yield Strength, p.s.i.....        | 30,000-41,000 | 45,000-52,000   |
| Elongation, percent in 2".....    | 12-20         | 6-15            |
| Brinell Hardness—10 mm. ball..... | 150-185       | 190-235         |
| Impact Strength, ft. lbs.....     | 7-22          | -----           |
| Specific Gravity.....             | 7.52          | -----           |
| Melting Point, ° F.....           | 1,880-1,900   | -----           |

This alloy has not only the desirable properties above explained but in addition has extremely good corrosion resistance and may be heat treated to obtain a very high tensile strength.

While I prefer to form the golf club head by die casting, for reasons hereinafter appearing, and the material herein disclosed is excellently suited for such operation, it also is suited to the forming of a golf club head by sand casting or drop forging, with many advantages resulting from the use of such material which are not found in prior golf club heads. The properties of the material are such as to permit it to be die cast and also permit more accurate drop forging than is possible with steel.

In accordance with the preferred embodiment of my invention I form a golf club head of the so-called "iron" type by die casting the material of my invention to form the club substantially to the desired size and shape, except for the scoring operation hereinafter described and the removal of any fins formed by the die casting operation.

The club head preferably is formed by a known die casting process commonly referred to as the "cold chamber, high pressure process." In this process the head is die cast by forcing molten metal under pressure into a cavity provided in dies. The cavity has a size and shape such that the casting has the size and shape desired in the finished club head except for the grooves or score lines in the striking face. At this point it should be noted that the die casting process is such that the hosel of the club is formed without any bore or opening therein for the receipt of the club shaft and it is of course necessary to drill or otherwise form a suitable bore or opening in the die cast club head for the receipt of the club shaft in the hosel.

In the die casting operation known apparatus is employed and for the purpose of fully disclosing the invention I have indicated somewhat diagrammatically in Fig. 2 of the drawings apparatus commonly employed in the cold chamber, high pressure die casting process.

The apparatus includes dies including two elements or halves. One of the halves is a cavity half 10 having a cavity 11 formed therein of a shape suitable for forming a club head such as shown in Fig. 1 of the drawings herein. The cavity half 10 of the die is supported by a stationary platen 12 which also carries the means for introducing the metal into the die cavity. Accordingly, the platen 12 carries an outer sleeve 13 which is formed with a bore 14 in which is supported an inner or shot sleeve 15 having a bore 16 extending therethrough. The shot sleeve 15 is formed with a metal inlet 17 leading into the bore 16. The supporting sleeve 13 is formed with an opening 18 through which the metal is introduced into the passage or opening 17. A shot plunger 19 is slidable in the bore 16 from a position rearwardly or outwardly of the opening 17 to a position forwardly thereof (as indicated somewhat diagrammatically in broken lines in Fig. 2) for the purpose of forcing the die casting metal into the cavity 11 as hereinafter explained.

An ejector die half 20 is carried by a movable platen 21 for movement into and out of engagement with the cavity half of the die. The ejector half 20 is formed with a runner 22, which when the ejector half 20 is in abutment with the cavity half 10 of the die provides communication between the bore 16 of the shot sleeve and the

cavity 11 through a gate 23 formed in the cavity half of the die and communicating with the cavity 11.

The molding apparatus is employed in the usual manner for forming the golf club head by die casting. The die is closed by moving the ejector half 20 of the die into abutment with the cavity half 10 of the die to thereby close the cavity 11. Prior to introduction of the metal the die is lubricated in the usual manner to prevent the metal from adhering to the cavity walls and to permit removal of the casting. Molten metal of the composition hereinabove referred to is introduced into the shot sleeve 15 through the metal inlet 17 whereafter the shot plunger 19 is rapidly moved inwardly to force the molten metal through the runner 22 and gate 23 and into the cavity 11 to fill the same, whereafter molten metal solidifies and takes the form of the die. The die halves are then separated and the die cast club head is removed from the cavity in the usual manner.

While I have shown a die having but one cavity, it will be understood that it preferably is provided with a plurality of similar cavities all connected to the shot sleeve.

In die casting the golf club head in accordance with my invention certain precautions are necessary in order to provide the most desirable results. In the first place it is desirable to guard against oxidation of the metal and therefore the molten metal is maintained in a closed container during heating and is so introduced into the shot sleeve that there is a minimum of exposure to the atmosphere.

It is also important that the die be so formed as to guard against localized heating. To this end the dies and particularly the cavity and passages leading thereto are made as simple as possible. There are no thin sections of metal in the die, there are no cored openings in the castings and accordingly the hosel is cast integral and solid and is thereafter drilled in order to provide the opening for the shaft. Moreover, the striking face of the club is formed flat and without any grooves or score lines, the latter being formed in the striking face after the club has been die cast and not during the die casting operation. Finally, it is important to employ an adequate and high grade die lubricant in order to insure that the metal from which the casting is formed does not erode the die and cause non-uniformity of the castings.

After the die cast club head is removed from the die any fins or burrs formed thereon by the die casting operation, such as along the parting line, are removed by machining, preferably grinding. However, it will be noted that there will be a minimum of such fins or burrs and therefore only a very small amount of material will be required to be removed from the die cast club head. Except for such burrs or fins the surfaces of the head are sufficiently smooth so that no smoothing operation is required. By way of example I wish to point out that in the case of a club head of conventional size and shape formed by the present process it ordinarily is necessary to remove not more than approximately  $\frac{1}{32}$  of an ounce of material after the die casting operation. On the other hand in the case of a club head formed from steel by a drop forging operation, it is necessary to remove not only any burrs or fins formed by the forging operation but also to smooth the faces and also to remove the burrs thrown up along the sides of the grooves during the grooving or knurling operation. I have found that in such case as much as two ounces of material must be removed in order to bring the club head to the desired smoothness and finish.

In forming the golf club head by drop forging or sand casting from the material above disclosed I carry out such processes in manners similar to those heretofore used in connection with forming golf club heads from steel, the processes being modified in respects necessitated by reason of the use of the different material.

Either before or after the removal of the burrs or fins

resulting from the forming operation I score or knurl the striking face of the club in order to form therein the usual grooves 30 (see Fig. 1) which serve the usual purpose of providing a grip or "bite" on the ball when the club head is caused to strike the ball.

The grooves or score lines 30 are formed in the usual manner as by a roller or knurling tool which is rolled across the face of the club, while the club is in cold condition, and under sufficient pressure to form grooves of the desired depth in the face of the club.

As will be understood by those skilled in the art, when the grooves or score lines are rolled in a club head formed from steel the rolling operation displaces metal which was formerly in the grooves in such a manner that there is thrown up along the sides of the grooves ridges or burrs which project upwardly above the surface or face of the club between the grooves. Such ridges or burrs must necessarily be removed, as by grinding, before the club head is ready for use.

On the other hand in the club head of my invention the scoring or grooving operation which is carried out in a manner similar to that in which it is carried out in connection with a club formed from steel does not throw up fins or burrs along the sides of the grooves or score lines. The scoring or grooving operation upon the material which I employ causes displacement of material of the club face which results in a "wrinkling" or corrugating of the face of the club. This action produces a number of alternate ridges and grooves which are distributed substantially uniformly in the respective portions of the club face intermediate each pair of adjacent grooves or score lines and perpendicular thereto. Thus the club face does not have the high, sharp ridges or burrs such as are produced in the grooving or scoring of a club formed from steel, but the face is of substantially uniform nature and character throughout all of the portions thereof between the grooves or score lines. The alternate ridges and grooves are relatively small and do not detract from the generally planar nature of the face but they do provide a slightly roughened surface. Thus, the surface of the face between the score line or grooves is substantially different both in nature and in function from the face of a club head formed from steel in the conventional manner. I have found that a club face formed in accordance with my invention has a very definite advantage over a club face formed in a conventional manner. In my club head the face is sufficiently roughened so that the ball when in contact with the face does not tend to slide but is held against relative rotation against the face during the entire period from the time that the club head first contacts the ball until the time that the ball separates from its contact with the striking face of the club.

It will be seen from the foregoing that I have provided a golf club head formed from metal and a method of forming the same, whereby in the preferred forming method an almost unlimited number of similar heads may be formed consecutively in a series of operations, with each club head of the series being substantially identical in size, shape, weight and balance to every one of the other club heads. Owing to the fact that the metal is introduced into the dies in molten condition and is die cast there is no appreciable wear or change in size or shape of the die cavities and therefore the club heads produced by the die casting operation are substantially identical. The die casting operation may be carried out rapidly and continuously at relatively small expense with the result that the club heads formed by this operation are not only uniform but may be formed at comparatively little expense.

The material of the preferred example, as well as several of the other examples, in accordance with my invention is slightly denser than the steel conventionally used in forming club heads. Thus, in using such alloys I can form a club head having substantially the same general

size and shape as a conventional club head but owing to the slightly greater density of the material I am able to provide a club head of the same total weight but having a shorter hosel. Therefore the distribution of weight in the club head in accordance with my invention is better than the distribution of weight in a conventional steel club head. That is to say in my club head the center of mass of the club head is slightly lower than in a conventional club head which, as will be recognized by those skilled in the art, provides a definite advantage in the balance of the club.

Owing to the fact that when the club head in accordance with my invention is formed by die casting it can be formed substantially to its final dimensions, the only metal removing operation is that of the removing of slight fins or burrs resulting from the die casting operation which removal can be effected by machining and preferably by grinding. Thus the operation not only is quicker and less expensive than the operation of finishing the surfaces of a drop forged steel club but also there is substantially less material removed from the club head. This results in a more uniform finished product than is possible in the case of a drop forged steel club head wherein a substantial amount of material is removed as by grinding in which case it is difficult if not impossible to remove the same amount of material from each club head of a series.

The material from which I form the club head in accordance with my invention is of such nature that it is extremely well adapted for plating with the usual plating materials and particularly plating with either nickel or chromium. In fact there is a very definite advantage in using the material of my invention inasmuch as either nickel or chromium can be plated directly onto the material of the club head without any preliminary plating with another metal and intermediate metal prior to the final plating operation with nickel or chromium.

I claim:

1. The method of forming a golf club head including a body and a hosel projecting therefrom which comprises die casting the head from an alloy consisting predominantly of copper and a metal of the group consisting of zinc and aluminum and not more than minor percentages of other metals substantially to the final shape and size and thereafter cold rolling in the striking face of the head in a direction parallel to the sole of the head a series of spaced, parallel grooves extending in a direction substantially parallel to the sole of the head to thereby plastically displace the material intermediate said grooves to form wrinkles in said face.

2. The method of forming a golf club head including a body and a hosel projecting therefrom which comprises die casting the head from an alloy consisting of at least 56% copper, at least 8.5% of a metal of the group consisting of zinc and aluminum and not more than minor percentages of other metals and having a melting point of between approximately 1575° F. and approximately 1900° F. to the desired shape and size and thereafter cold rolling in the striking face of the head in a direction parallel to the sole of the head a series of spaced, parallel grooves extending in a direction substantially parallel to the sole of the head thereby plastically displacing the material intermediate said grooves to form wrinkles in said face intermediate and generally transverse to said grooves and of less breadth and depth than said grooves.

3. The method of forming a golf club head having a body, and a hosel projecting therefrom, which comprises injecting under pressure into a die cavity defined by smooth walls and having substantially the size and shape of the finished club head to be formed of a molten alloy of at least 56% copper, a metal of the group consisting of zinc and aluminum, and not more than minor percentages of other metals and having a tensile strength of at least 65,000 pounds per square inch, a yield strength of at least 25,000 pounds per square inch, an elongation of

not more than 38% in 2 inches, a Brinell hardness number of at least 110, an impact strength of at least 7 foot pounds and a melting point of between approximately 1575° F. and approximately 1900° F., allowing the alloy to solidify in the die cavity, removing the cast club head from the die cavity, and thereafter cold rolling in the striking face of the club a series of spaced score lines parallel to the sole of the club head by passing a roller along the face of the club head in a direction parallel to the sole of the club head and in indenting relation to the face to thereby plastically displace the material intermediate the grooves to form a series of alternate ridges and grooves in said face which are of less breadth and depth than said score lines.

1,337,958  
1,438,933  
1,869,554  
1,922,598  
2,005,401  
2,015,462  
2,378,261  
2,422,703  
2,430,419  
2,494,736  
2,503,377  
2,778,733

Reach ----- Apr. 20, 1920  
Bungay ----- Dec. 12, 1922  
Ellis ----- Aug. 2, 1932  
Morin ----- Aug. 15, 1933  
Storz ----- June 18, 1935  
Sachs ----- Sept. 24, 1935  
Turney ----- June 12, 1945  
Rodda ----- June 24, 1947  
Ebens ----- Nov. 4, 1947  
Berwick ----- Jan. 17, 1950  
Cooper ----- Apr. 11, 1950  
Frejacques ----- Jan. 22, 1957

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

723,534 Knight ----- Mar. 24, 1903  
1,186,055 White ----- June 6, 1916

15 762,235

##### FOREIGN PATENTS

Great Britain ----- Nov. 28, 1956

##### OTHER REFERENCES

Butts: Copper the Metal, Its Alloy and Compounds, 1954, pages 654-671; Reinhold Publishing Corporation, Monograph Series No. 122.