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(54) METHOD AND APPARATUS FOR INCREASING HITTING EFFICACY IN A SPORTING IMPLEMENT

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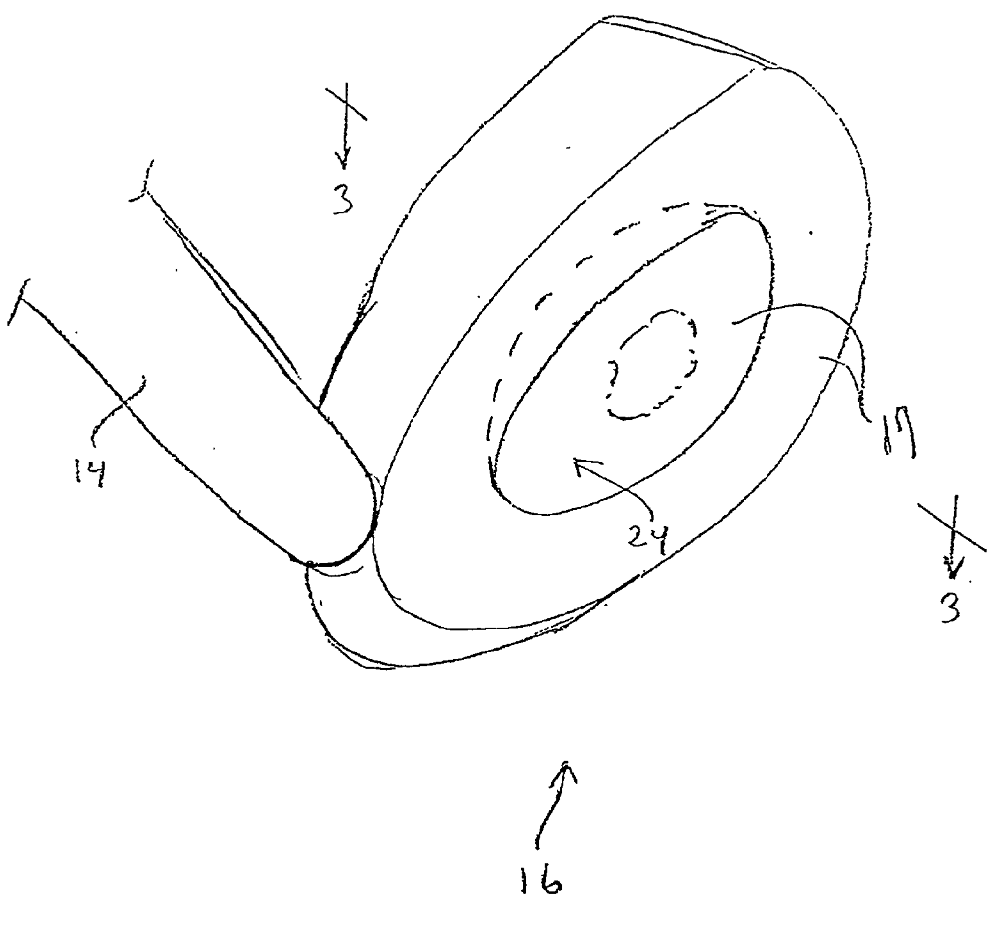
(57) **ABSTRACT**

A method and apparatus for increased hitting efficacy in a sporting implement. Energy absorption characteristics are adjusted so as to vary over the hitting surface of the sporting implement. This may be employed to equalize the hitting performance of the sporting implement with respect to different locations of impact thereon.



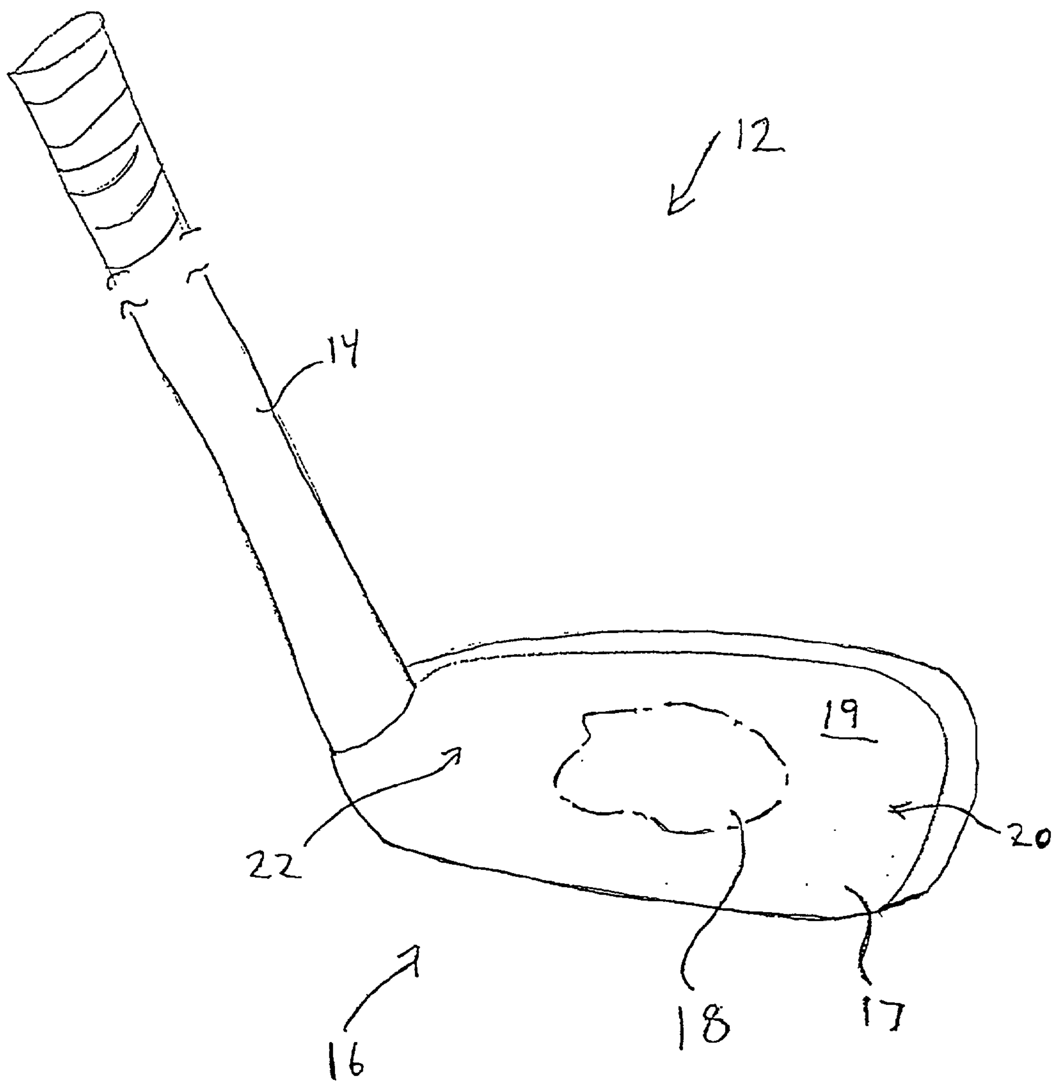


FIG 1

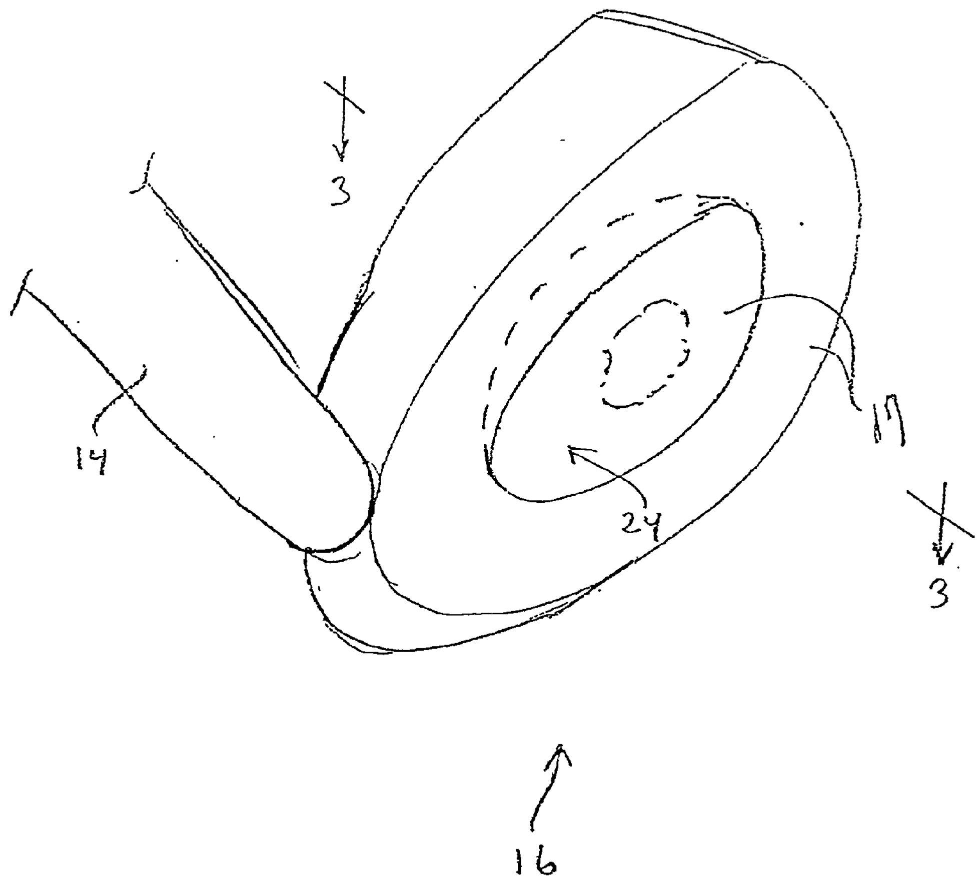


FIG 2

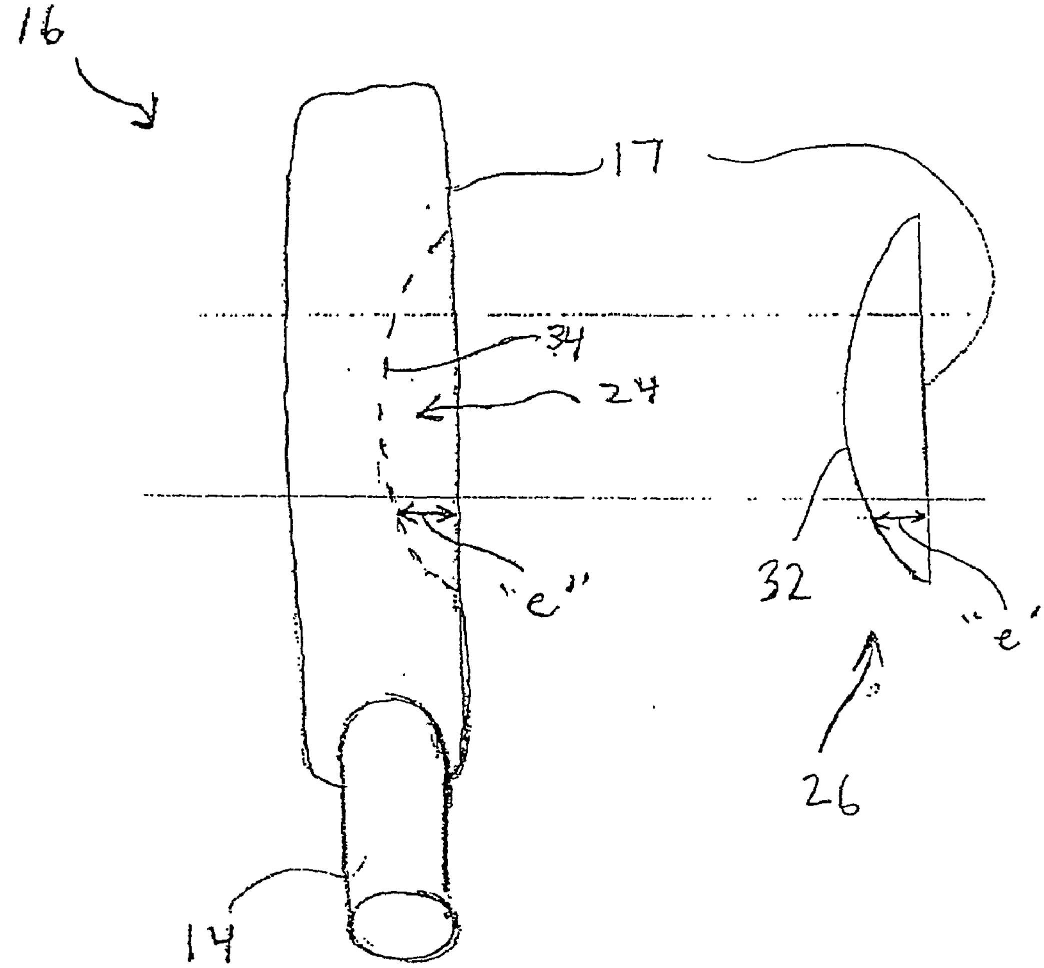


FIG 3

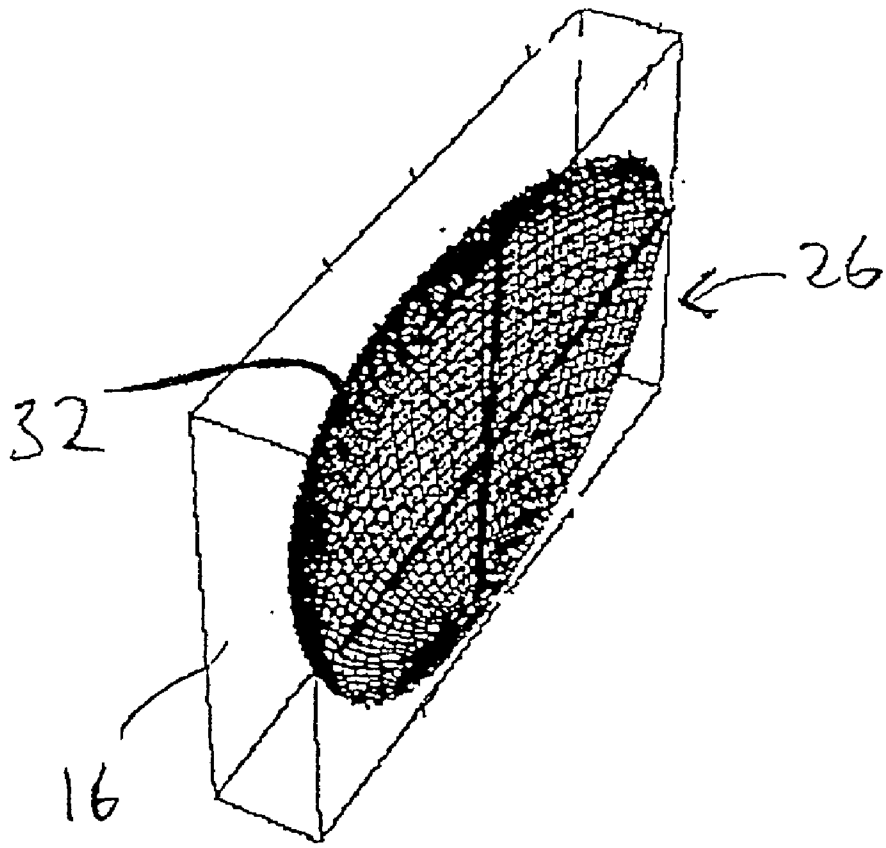


FIG 4

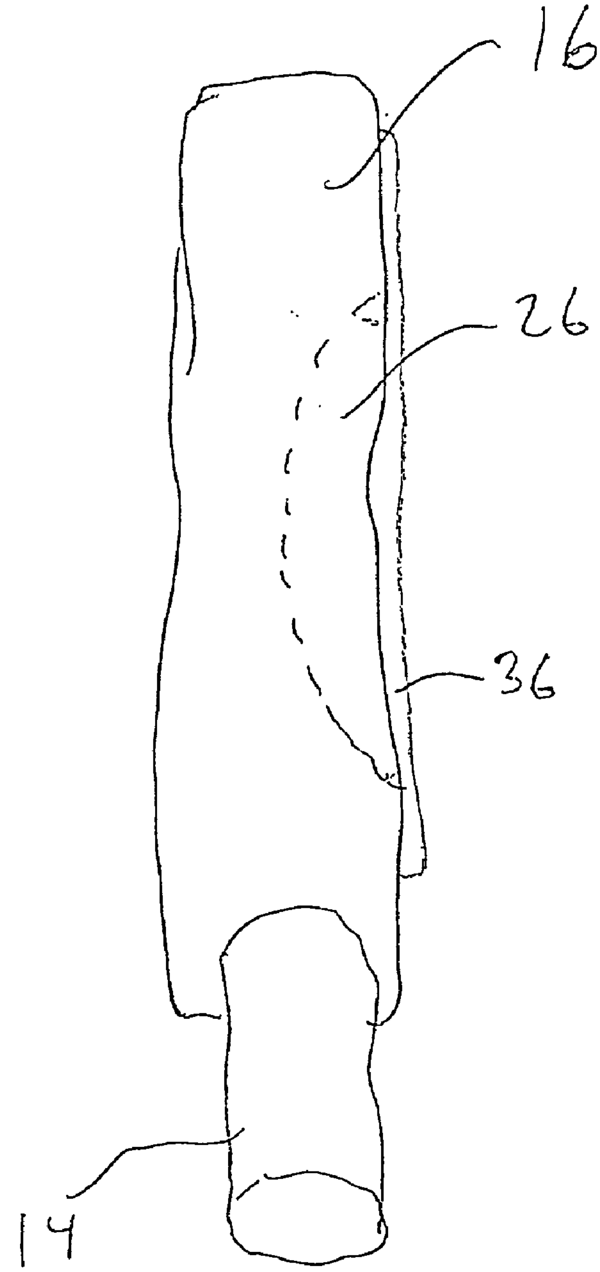


FIG 5

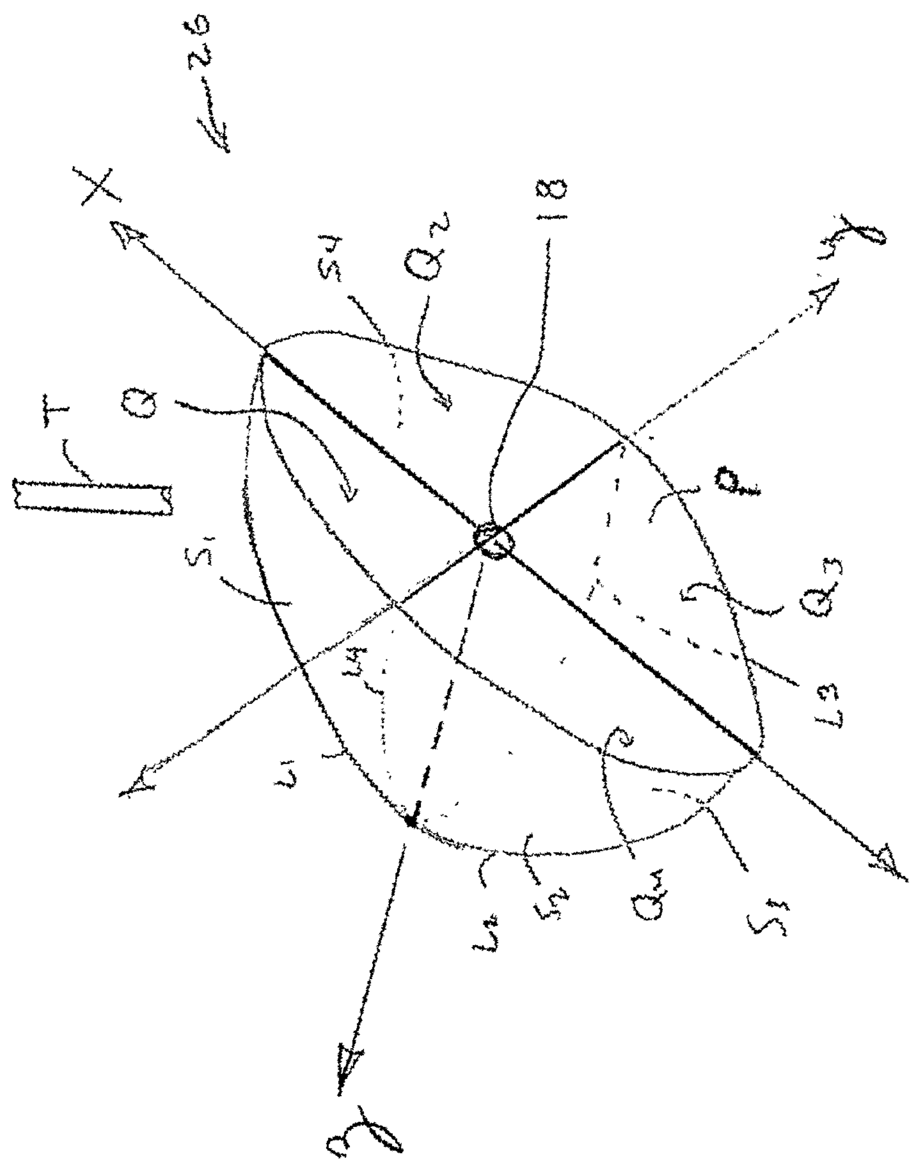


FIG 6

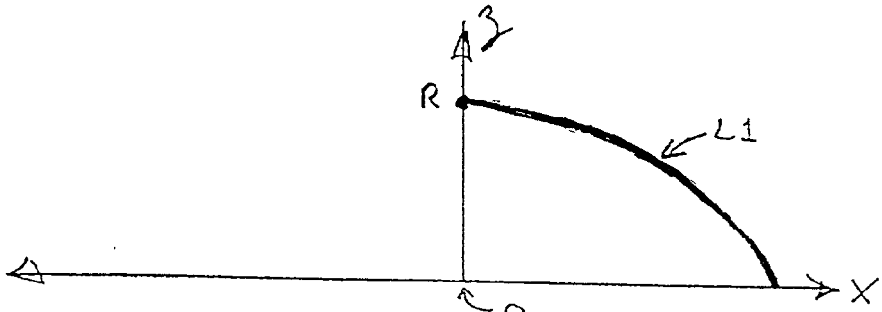


FIG 7A

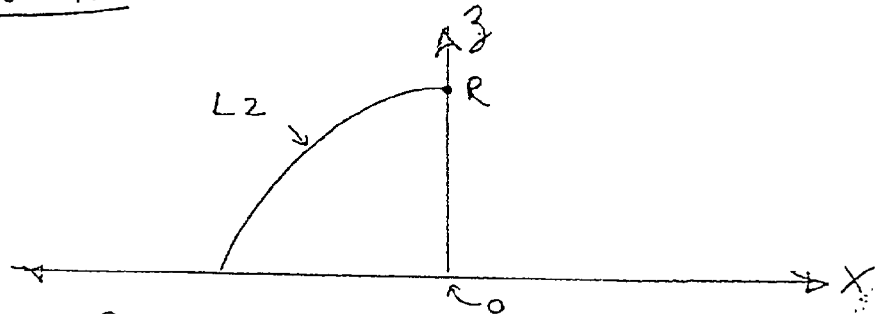


FIG 7B

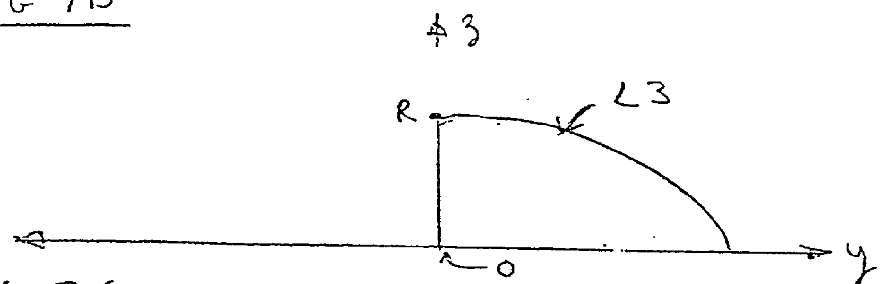


FIG 7C

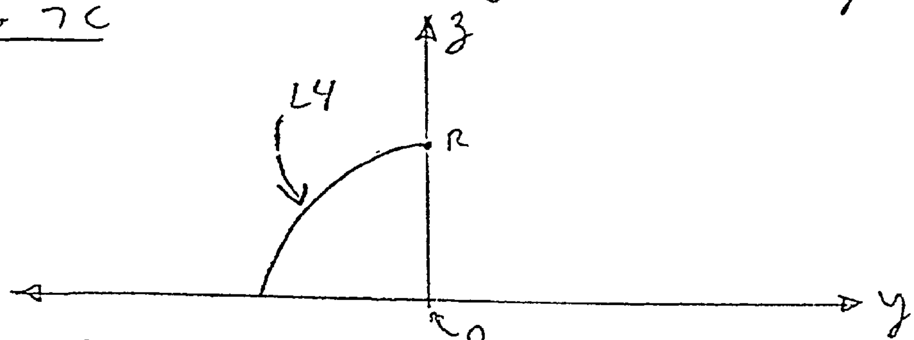


FIG 7D

METHOD AND APPARATUS FOR INCREASING HITTING EFFICACY IN A SPORTING IMPLEMENT

[0001] This is a continuation-in-part of Ser. No. 09/545,561, now pending.

FIELD OF THE INVENTION

[0002] The present invention relates to a method and apparatus for increasing hitting efficacy in a sporting implement, particularly a golf club.

BACKGROUND OF THE INVENTION

[0003] Many sports involve a contest regarding how far or accurately a player can hit a ball with a suitably adapted sporting implement. Most sporting implements designed for hitting, e.g., baseball bats and golf clubs, have a "sweet spot" that is the best or most desirable location for making contact with the ball. For many sports, including golf, hitting the ball at the sweet spot results generally in the ball traveling farther and straighter than when the ball is hit at locations on the implement that are distanced from the sweet spot. As part of the rationale for and fun of the sport, it takes considerable skill to confine the point of impact with the ball to the sweet spot. Nevertheless, there has been a desire on the part of many competitors to improve their performance by employing sporting gear that reduces the difficulty of achieving high performance.

[0004] Aside from a potential loss of distance and control, another disadvantage of the sensitivity of the performance of the hitting implement to the location on the hitting implement that makes contact with the ball is that the reaction is often non-linear and counterintuitive. This may make it difficult for persons practicing the sport to interpret the reaction in such a way that allows efficient learning.

[0005] The prior art has known golf club heads which are weighted more heavily around their perimeters, i.e., so-called "weighted perimeter" or "cavity back" heads. These typically provide that the material of which the head is formed has one distinct thickness around the perimeter or periphery of the head and another distinct thickness interior thereto, including the neighborhood of the sweet spot. Some advantage has been claimed in reducing the sensitivity of the head to the proximity of the location of a hit to the sweet spot; however, an undesirable amount of such sensitivity remains.

[0006] Accordingly, there is a need for a method and apparatus for increasing hitting efficacy in a sporting implement that minimizes or eliminates the loss of control that typically occurs when hitting at locations thereon that are distanced from the sweet spot, and that provides improved feedback to the player.

SUMMARY OF THE INVENTION

[0007] The method and apparatus for increasing hitting efficacy in a sporting implement of the present invention solves the aforementioned problems and meets the aforementioned needs by providing energy absorption characteristics that vary over the hitting surface of the sporting implement. Preferably, the characteristics are adapted so that the implement absorbs energy a greater amount at the sweet spot and a decreasingly lesser amount at locations that are increasingly far from the sweet spot. Preferably, the characteristics are adapted by providing an insert for the implement that is formed of one or more materials providing for a substantially uniform energy absorption property, and varying the thickness of the insert.

[0008] Therefore, it is a principal object of the present invention to provide a novel and improved method and apparatus for increasing hitting efficacy in a sporting implement.

[0009] It is another object of the present invention to provide a method and apparatus for increasing hitting efficacy in a sporting implement that minimizes or eliminates loss of control when hitting at a location thereon that is distanced from the sweet spot of the implement.

[0010] It is yet another object of the present invention to provide a method and apparatus for improving the feedback available to a player using the sporting implement.

[0011] The foregoing and other objects, features and advantages of the present invention will be more readily understood upon consideration of the following detailed description of the invention, taken in conjunction with the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] **FIG. 1** is a pictorial view of a sporting implement for use with the present invention.

[0013] **FIG. 2** is a pictorial view of the head of the sporting implement of **FIG. 1**, showing a cavity according to the present invention.

[0014] **FIG. 3** is an exploded, plan view of the head of **FIG. 2** taken along a line **3-3** thereof, showing an insert for the cavity according to the present invention.

[0015] **FIG. 4** is a pictorial view of the insert of **FIG. 3**.

[0016] **FIG. 5** is a pictorial view of the insert of **FIG. 3** covered by a selected material.

[0017] **FIG. 6** is a pictorial view of an insert according to the present invention.

[0018] **FIG. 7A** is a plot of the thickness of the insert of **FIG. 6** versus distance from the sweet spot in the "+x" direction noted therein.

[0019] **FIG. 7B** is a plot of the thickness of the insert of **FIG. 6** versus distance from the sweet spot in the "−x" direction noted therein.

[0020] **FIG. 7C** is a plot of the thickness of the insert of **FIG. 6** versus distance from the sweet spot in the "+y" direction noted therein.

[0021] **FIG. 7D** is a plot of the thickness of the insert of **FIG. 6** versus distance from the sweet spot in the "−y" direction noted therein.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0022] This invention pertains to a method and apparatus for increasing hitting efficacy in a sporting implement. A preferred, golf club implement for use with the invention is described below and shown in **FIG. 1**. However, the principles described herein apply as well to other sporting implements for use in hitting a ball or other similar object aside from golf clubs, such as but not limited to baseball bats and hockey sticks for example.

[0023] The golf club **12** has an elongate shaft **14** and a head **16** adapted for hitting a golf ball (not shown). Golf clubs are provided as being particularly suited for specific tasks. Drivers are adapted for hitting the ball over long distances through the air, while putters are adapted for hitting the ball over relatively short distances over the grass. For each of these purposes, the head **16** may be formed of different materials and have different shapes. Moreover, different golf clubs having the same purpose may be formed of different materials or have differences in shape. However, regardless of the material of which the implement generally or the head specifically is formed, the configuration of the implement as a whole provides that a predetermined, relatively small area thereon that is the best or most desired location for hitting the ball. This area is termed herein the "sweet spot," as it is commonly referred to by the players engaged in sports.

[**0024**] The sweet spot for a golf club is somewhere on the head **16**, while the sweet spot for a baseball bat, by comparison, is somewhere on its barrel. The sweet spot may have any shape or size. Referring to **FIG. 1, a** generalized sweet spot area **18** is indicated on a larger hitting surface area **17** of the head **16**. An area **19** of the hitting surface area **17** lying outside the sweet spot **18** is a less desired location for hitting the ball than the sweet spot; however, the entire hitting surface area **17** is adapted and intended for hitting the ball according to normal practice of the sport.

[**0025**] A problem for the player who hits the ball with the implement outside of the sweet spot **18** yet within the hitting surface **17** is that the ball will typically not be as accurately or controllably directed. Moreover, the feeling that the player receives from the interaction may not be easily interpreted to lead to appropriate corrections, making learning difficult. For other sports, other deleterious ramifications of hitting the ball "off" the sweet spot may ensue.

[**0026**] Different heads **16** provide for unique hitting characteristics that vary as a function of location on the hitting surface. To illustrate, for a given head **16** a given swing might drive the ball 10 feet if the ball is hit within the sweet spot **18** for the head, while the same swing might drive the ball only 6 feet if the ball is hit at the toe end **20** of the head, and 8 feet if the ball is hit at the heel end **22** of the head. Another head might provide for 9 feet, 6.5 feet and 8.5 feet respectively at corresponding locations under the same circumstances. These varying distances are symptomatic of the aforedescribed problems.

[**0027**] Turning to **FIG. 2**, according to the invention, a method and apparatus for increasing hitting efficacy in the golf club **12** is shown. The method and apparatus provide for equalizing the hitting distances that may be obtained for hitting the ball at various locations on the head.

[**0028**] This equalization is performed by providing for variable energy absorption characteristics over selected portions of the hitting surface **17**. This is preferably accomplished by providing a cavity **24** in the head **16** that removes the surface area **17** that would otherwise be normally used for hitting. An existing head may be machined or otherwise modified to include the cavity, or the head may be formed with the cavity initially. The cavity is shown confined inside the hitting surface **17**; however, it may be extended to cover the entire surface **17** and beyond (where practical) if desired.

[**0029**] Referring to **FIG. 3**, which for convenience only shows two dimensions, the cavity has a depth "e" that is a function of location on the head. An insert **26** is installed in the cavity to restore, by providing at least part of, the hitting surface **17** so that the hitting surface is flat or alternatively has the shape that is normally employed for the sport.

[**0030**] The insert is preferably substantially homogeneous, providing for substantially uniform energy absorption material properties that differ, however, from corresponding material properties of the head **16**. Further, according to the invention, the insert **26** provides energy absorption characteristics that vary over the hitting surface **17**. These varying characteristics are preferably provided by varying the thickness of the insert at different locations on the surface **17**. The thickness of the insert is that dimension of the insert that extends normal to the hitting surface **17** as shown in **FIG. 3**.

[**0031**] Preferably, a back surface **32** of the insert **26** is complementary to a back surface **34** of the cavity **24**, i.e., the back surface **32** makes intimate contact with and follows the shape of the back surface **34**. This provides that the thickness of the insert is equal to the depth "e" of the cavity.

[**0032**] Employing different material properties in the insert and head permit altering the mechanical properties of the head while retaining its original shape. The insert may be any single material or compound; however, a metal or metal matrix, or a polymer or polymer matrix are preferred.

[**0033**] Providing the insert **26** with a thickness "e" that varies as a function of location on the hitting surface **17** provides means for controlling the amount of energy transmitted by the head to the ball as a function of location on the hitting surface. In particular, the amount of energy transferred is controlled so as to equalize, as much as is desired or practical in a given application (hereinafter "equalize" or "equalization"), the energy absorption characteristics of the head across the surface **17**.

[**0034**] To illustrate this equalization feature, a particular head **16** may normally be used to hit the ball 10 feet at the sweet spot **18**, 6 feet at the toe end **20**, and 8 feet at the heel end **22**, indicating that the head is 40% less effective at hitting the ball at the toe end as compared with the sweet spot, and 20% less effective at the heel end than at the sweet spot. For such a head, the insert **26** may be tailored so that the resulting head/insert combination absorbs a selected maximum amount of energy at the sweet spot, 40% less energy at the toe end, and 20% less energy at the heel end. If the 40% loss at the toe end and 20% loss at the heel cannot be achieved due to, for example, a limited depth of the cavity **24**, the insert may simply be tailored to maximize energy losses at the toe and heel, respectively.

[**0035**] The above analysis oversimplifies by assuming that energy loss translates directly to distance loss, which ignores the curvature of the ball's flight path and neglects the effect of air resistance. However, the principles illustrated may be used, without more, to provide for a useful improvement in hitting efficacy.

[**0036**] An optimized value of "e" as a function of location on the hitting surface **17** may be obtained by experiment. Alternatively, the dynamics of the interaction between the head **16** and the ball may be considered analytically. In that regard, it has been determined that the kinetic energy difference (ΔE) for the ball-club system before and after impact is expressed as:

$$\Delta E = \frac{\alpha}{\sqrt{m}}\left(\frac{2k}{n+1}\right)_{x_m}^{3/2\frac{3(n+1)}{2}} \tag{1}$$

[0037] where m is the mass of the ball, x_m is the maximum penetration distance of the ball on the insert **26**, and n is the exponent in the expression $F=kx^n$, which relates the force (F) exchanged between the ball and the putter and the relative displacement (x) (the displacement of the insert at the point of contact). This energy difference represents the energy lost as a result of the impact.

[0038] The maximum penetration distance depends on the impact location, the thickness of the insert at the impact location and the shape of the insert. Given the elastic properties of the insert material, the elastic properties of the ball, and the change in kinetic energy with respect to the time of initiation of impact and the time of maximum penetration, x_m can be calculated either semi-analytically or numerically. In general, x_m is inversely proportional to the thickness of the insert at the impact location. In equation (1) the constant α is such that the coefficient of restitution for the impact e, is expressed as $e=1-\alpha u_i$ where u_i is the impact velocity. The coefficient of restitution increases with decreasing thickness of the insert at the impact location. The amount of increase depends on the shape of the insert and on its mechanical properties, i.e., elastic modulus and frictional characteristics (energy loss from hysterisis). The mechanical properties of the insert influence the value of the exponent n and this together with its geometrical shape dictate the coefficient of restitution as a function of the impact location.

[0039] Based on the above, the aforementioned energy loss (ΔE) is proportional to the insert thickness raised to a power of $-3(n+1)/2$. For an average value of n of 1.25, the insert thickness is therefore approximately proportional to ΔE^3.

[0040] In the above analysis, the main body of the head **16** was considered "rigid" compared to the insert. A more detailed analysis can incorporate the mass of the putter as a whole, yielding the following expression for the coefficient of restitution e,

$$e^2 = 1 - \frac{2(m_1 + m_2)}{m_1 m_2 u_i^2} \int F(x_i^{*} x, t) dx \tag{2}$$

[0041] where m_1, m_2 denote the mass of the ball and the club respectively, F denotes force during the impact, x is the penetration distance as a function of time t and an overdot denotes the time derivative. The integral in (2) can be calculated numerically. The results from this analysis are similar to that resulting from (1).

[0042] The aforementioned energy loss (ΔE) is preferably determined experimentally. In David Pelz, "Putt Like the Pros," Harper Collins Publishers, 1989, pp. 168, it is reported that "Energy Transfer Results Vary with Different Designs. Impact points along center-shafted putterfaces and heel-shafted putterfaces show differences in roll distance for off-sweet spot strikes with each type of putter." Pelz plots differences in roll distance for both center-shafted and heel-shafted putters for strikes at different distances away from the sweet spot along a horizontal line on the putterface. The data show that roll distance is maximum for hits on the sweet spot, that this parameter decreases roughly parabolically and asymmetrically about the sweet spot, much more so for a heel-shafted putter than for a center-shafted putter, and that the rate of variation is also quite different for the two types of putters. However, since there are many factors that can influence roll distance besides energy loss at the point of contact with the ball, it is believed the aforementioned Pelz data cannot be used to arrive at an optimum insert geometry.

[0043] The present inventors have recognized that energy loss for hits that vary in location along a vertical line on the putter face should also vary asymmetrically and non-linearly about the sweet spot as a function of putter geometry. The asymmetry is particularly desirable to produce a spin on the ball.

[0044] Moreover, the insert **26** is preferably formed so that it has a relatively high energy absorption material property as compared to that of the material of which the head **16** is otherwise formed. Accordingly, to equalize performance across the head, the thickness "e" of the insert **26** should be greatest in the area of the sweet spot, where energy transfer to the ball is otherwise greatest, and should decrease as a function of distance from the sweet spot.

[0045] Referring to **FIG. 6**, in accord with the principles of the invention, an optimum insert geometry may be defined by four "quadrants" Q**1**, Q**2**, Q**3** and Q**4**. The aforementioned hitting surface **17** lies in or is parallel to the plane "P" shown in **FIG. 5** having "x" and "y" axes, the axes representing positive and negative excursions from the sweet spot **18** in orthogonal directions.

[0046] Each quadrant of the insert **26** has a thickness in the direction of a "z" axis which is orthogonal to the "x" and "y" axes. The thickness varies as a function of location (x, y) on the plane "P" as defined by outer surfaces S**1**-S**4** of the respective quadrants Q**1**-Q**4**. The intersections of various planes with the outer surfaces S**1**-S**4** define curvilinear lines, that are approximately ellipsoidal. In the "x-z" plane, two lines L**1** and L**2** are defined.

[0047] The "z" coordinate of these lines as a function of "x" represents the thickness of the insert on the "x" axis. Similarly, in the "y-z" plane, two lines L**3** and L**4** are defined, where the "z" coordinate of these lines as a function of "y" represents the thickness of the insert on the "y" axis. Representations of the lines L**1**-L**3** are shown in FIGS. **7**A-**7**D, respectively, illustrating some of the characteristics of these lines.

[0048] The "z" coordinate for each of these lines at the sweet spot ("x"=0 and "y"=0) is the same maximum value "R." The lines preferably continuously vary curvilinearly with increasing absolute values of "x" and "y."**FIGS. 3 and 4** show an insert configuration having this characteristic. More particularly, the thickness of the insert as represented by the lines L decreases curvilinearly with increasing absolute values of "x" and "y" at an increasing rate. For example, the slope of the line L**1** at the sweet spot is zero, while the slope of the line is greatest where it intersects the "x" axis.

[0049] Generally, the lines L vary asymmetrically about the sweet spot. Particularly, where the putter shaft "T" is disposed toward the quadrant defined by the positive "x" axis and the negative "y" axis, the line L**1** is longer than the line L**2**. The inventors have also recognized that, to reduce or eliminate backspin on the ball, the line L**3**, representing the lower half of the insert, is longer than the line L**4**, representing the upper half of the insert.

[0050] The thickness of the insert can also vary stepwise, to approximate the lines L.

[0051] Referring to **FIG. 4**, an insert **26** according to the present invention has a back surface **32** that is in general curved in three dimensions, i.e., forms a three-dimensional surface that intersects each of three orthogonal planes at a curved line. Moreover, as mentioned, the surface is generally asymmetric about the sweet spot. However, the surface **32** may take simpler forms and this may be advantageous even if giving up some of the compensation characteristics, to reduce manufacturing costs. For example, an insert having a simpler surface that retains a desirable asymmetric characteristic may have a thickness that varies linearly with distance from the sweet spot with a slope that varies according to direction. In particular, such an insert that varies asymmetrically, preferably with respect to both the horizontal and vertical axes, is believed to provide a desirable "feel" that may be particularly useful in training use by the novice golfer.

[**0052**] The cavity **24** may be formed in an existing head **16**, or the head and cavity may be formed together. To join the insert **26** to the head, the cavity may be filled with molten material that hardens as it cools to form the insert. The hitting surface **17** may be finished by a machining operation. The head could also be formed along with the insert, such as by dual material injection molding. As shown in **FIG. 5**, the insert may be covered by any selected material **36** so that the insert is not visible. For example, the insert may be coated with an opaque coating, or it may be covered by a thin layer of material which may be the same material of which the insert is formed or a different material. Where a material is provided to cover the insert, this material rather than the insert provides at least part of the hitting surface **17**.

[**0053**] It is further believed that golf clubs in particular, as distinguished from most other hitting implements used in sports, are best used in the manner of pendulums, meaning that the weight of the head and not any manipulation of the shaft by the player's fingers or hands, is of primary importance to properly hitting the ball. Accordingly, it is desirable where changing the weight of the head **17** by use of the insert **22**, to add or subtract mass from the head to adjust the weight to a desired or original amount. This is often achievable without changing substantially the exterior dimensions of the head.

[**0054**] It is to be recognized that, while a particular method and apparatus for increasing hitting efficacy in a sporting implement has been shown and described as preferred, other configurations and methods could be utilized, in addition to those already mentioned, without departing from the principles of the invention. For example, the insert could be provided so that it does not maintain intimate contact with the cavity. This would impact many of the considerations discussed above in connection with the preferred embodiment but would not depart from the principles of the invention.

[**0055**] The terms and expressions which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention of the use of such terms and expressions of excluding equivalents of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

1. A golf club head for hitting a golf ball comprising a body portion and an insert portion contained in said body portion that is relatively energy absorbing as compared to said body portion, said insert having a thickness which is defined by a maximum value and which decreases therefrom at an increasing rate with increasing distance in at least the two opposite directions defined by a first axis.

2. The golf club head of claim 1, wherein said thickness decreases from said maximum value at an increasing rate with increasing distance in at least the two additional opposite directions defined by a second axis that is perpendicular to said first axis.

3. The golf club head of claim 2, wherein said thickness decreases from said maximum value at an increasing rate with increasing distance in all directions.

4. The golf club head of claim 1, wherein said thickness decreases asymmetrically with respect to said two opposite directions.

5. The golf club head of claim 2, wherein said thickness decreases asymmetrically with respect to the two opposite directions defined by said first axis.

6. The golf club head of claim 2, wherein said thickness decreases asymmetrically with respect to the two opposite directions defined by said second axis.

7. The golf club head of claim 3, wherein said thickness decreases asymmetrically with respect to any two opposite directions.

8. The golf club head of claim 1, wherein said insert has a front surface that forms at least part of a hitting surface adapted for making intimate physical contact with the golf ball.

9. The golf club head of claim 1, wherein said insert has a front surface that is spaced from a hitting surface that is adapted for making intimate physical contact with the golf ball.

10. A golf club head for hitting a golf ball comprising a body portion and an insert portion contained in said body portion that is relatively energy absorbing as compared to said body portion, said insert portion having a thickness which is defined by a maximum value and which decreases linearly from said maximum value with increasing distance asymmetrically with respect to at least the two opposite directions defined by a first axis.

11. The golf club head of claim 10, wherein said thickness decreases linearly from said maximum value with increasing distance in at least the two additional opposite directions defined by a second axis that is perpendicular to said first axis.

12. The golf club head of claim 11, wherein said thickness decreases linearly from said maximum value with increasing distance asymmetrically with respect to the two opposite directions defined by said second axis.

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