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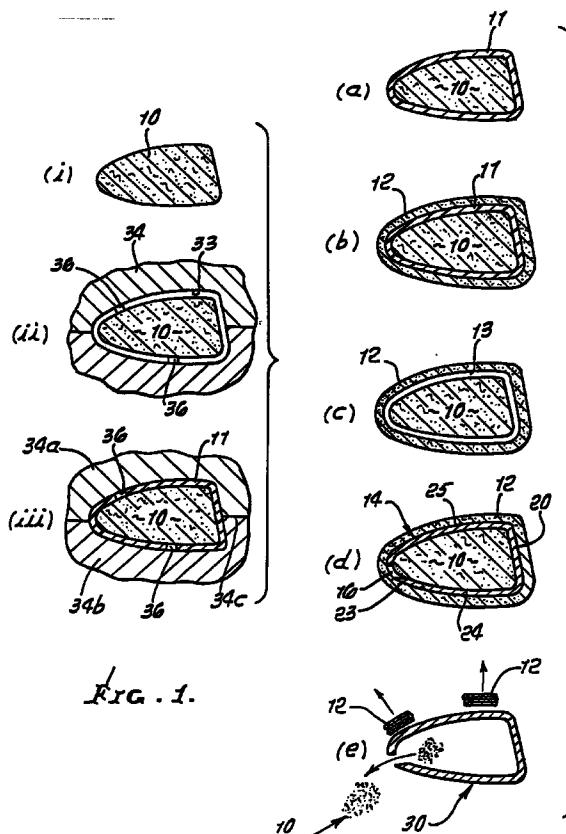
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### (54) Method of forming a hollow metallic golf club head and golf club head so formed

(57) In the method of forming a hollow metallic golf club head having wall structure defining a front wall, a heel, a toe, a rear wall, a sole, and a top wall, the steps that include providing a wax shell covered pre-formed core body, the thickness of the wax shell corresponding to the desired thickness of the wall structure, forming a ceramic shell about the wax shell; removing the wax shell by melting the wax, thereby to form an opened gap between the ceramic shell and the core body, and casting molten metal into the opened gap, thereby to form the wall structure extending about the core body and at the sole, while forming and maintaining port structure through the wall structure and spaced from the sole, and allowing the wall structure to solidify to form the head; removing the ceramic shell from the wall structure, and removing the core body from the interior of the solidified head, and via the port structure.



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## Description

This invention relates generally to forming of hollow, metallic golf club heads.

At the present time, golf club metal heads are typically formed by casting metal about a core body, and in such manner that a large opening is formed at the head sole region. A separate sole plate is subsequently welded to the head to cover that opening. The weld extends in a large loop, and is the source of problems that include undesirable weight differentiations as between heads during their manufacture; weld variations around the loop; possible weld cracking during shock loading upon head high speed impact with a golf ball; and difficulties encountered during the welding process due to very thin walls being weld connected. There is need for method and means to overcome such problems.

The present invention is as claimed in the claims. The method of one embodiment includes the steps:

- a) providing a wax shell covered pre-formed, club head shaped core body, the wax shell covering the shaped body sole area, the thickness of the wax shell corresponding to the desired thickness of the head wall structure,
- b) forming a ceramic shell about the wax shell,
- c) removing the wax shell by melting the wax, thereby to form an opened gap between the ceramic shell and the core body,
- d) and casting molten metal into the opened gap, thereby to form the wall structure extending about the core body including the core body sole area, while forming and maintaining port structure through the wall structure and spaced from the sole, and allowing the wall structure to solidify to form the head,
- e) removing the ceramic shell from the wall structure, and removing the core body from the interior of the solidified head, and via the port structure.

As will appear, the core body is pre-formed and may typically consist of molded ceramic material.

The port structure may extend through the head rear wall; and that port structure is typically formed to have an overall size substantially less than the overall size of the sole. Multiple small access ports may be formed through the head rear wall, where stresses arising during head impact with a golf ball are substantially less than at other regions of the head wall structure. Such small ports may be closed by welding small closures to the head.

Casting formations of a metallic sole may define a medial ridge and two dished recesses at opposite sides of said ridge, the multiple access ports formed rearwardly of said dished recesses.

The core body may define an elongated recess sunk in the surface of the core body and corresponding

to an elongated stiffener rib to be formed by the head wall structure at the interior side thereof. The multiple access ports formed through the head rear wall are typically located at opposite sides of a plane defined by the stiffener rib.

Multiple core body positioning stand-offs may be provided to extend in the gap between the core body and the ceramic shell. Such stand-offs are typically provided during the formation of the ceramic shell about the wax shell.

A wax shell covered core body may be provided, in one embodiment, by:

- i) providing a preformed core body as referred to and having the general shape of the head,
- ii) positioning that body within a cavity formed by mold structure, thereby to provide an initial gap about the core body,
- iii) and filling wax into the initial gap to cover the core body and to form the wax shell.

These and other objects and advantages of the invention as well as the details of an illustrative embodiment and method, will be more fully understood from the following specification and drawings of exemplary embodiments of the invention, in which:

- Fig. 1 is a flow diagram;
- Fig. 2 is a perspective view of a golf club head;
- Fig. 3 is a section taken on lines 3-3 of Fig. 2;
- Figs. 4, 5 and 6 are enlarged sections taken on lines 4-4, 5-5 and 6-6 of Fig. 3;
- Fig. 7 is a rear view elevation taken on lines 7-7 of Fig. 3;
- Fig. 8 is a vertical section taken through a mold showing formation of a wax shell about a pre-formed mold body;
- Fig. 8a is a section taken on lines 8a-8a of Fig. 8;
- Fig. 9 is a view like Fig. 8, showing the wax shell covered core body after removal from the mold;
- Fig. 10 is a view like Fig. 8, but showing formation of a ceramic shell about the wax shell covered core body;
- Fig. 11 is a view like Fig. 10, showing the ceramic shell extending about the pre-formed core, after wax has been removed to form a gap for receiving molten metal forming the golf club head; and
- Fig. 12 is a bottom plan view of a hollow metallic head, with ports in the rear wall.

Referring first to Fig. 1, the illustrated flow diagram basically includes steps (a)-(e), where step (a) may for example be accomplished by performing preliminary steps i)-(iii).

Step a) designates the providing of a wax shell covered, pre-formed core body. See pre-formed body 10 and wax coating 11. Body 10 is schematically shown in the form a golf club head. Body 10 is typically formed of

ceramic material, as for example ceramic particles bonded together as by synthetic resin, in a known manner, to form a solid mass, which is frangible.

Step b) consists of forming a ceramic shell 12 about the wax shell, as by multiple dippings into ceramic slurry and allowing the latter to harden, about the wax, in successive layers.

Step c) consists of removing the wax shell by melting the wax, thereby to form an opened gap 13 between the ceramic shell 12 and the core body.

Step d) consists of casting molten metal 14 into the opened gap 13 thereby to form product wall structure, allowed to solidify in situ. In the case of a hollow metallic golf club head as seen in Figs. 2 and 3, such wall structure includes a front wall 20, a heel 21, a toe 22, a curved rear wall 23, a sole 24, and a top wall 25. Note that the integral sole wall 24, continuous with 20 and 23, is formed by this step, i.e. no large opening is left open at the sole location, whereby an additional step of welding a large sole plate to a large looping rim provided by the wall structure about the sole is eliminated, and problems associated with such welding are eliminated.

A relatively small port structure (a single port, dual ports, or other multiple ports) is formed and maintained at a location spaced from the sole 24. See for example port 16 formed through the downwardly curved rear wall 23 of the head structure, such rear wall curvature providing wall strength at the location of the relatively small port 16, whereby detrimental weakening of the wall structure is avoided. In the case of a golf club head, the port 16 is typically less than 1/2 square inch in cross sectional area. Also, its vertical height "h" is made substantially less than its horizontal length "l", to minimize any weakening of the wall structure. See Fig. 7. Rear wall 23, in which ports 16 are formed, is bi-directionally curved, i.e. in both a vertical plane, (the plane of Fig. 3) and a horizontal plane 17, in ball address position of the head.

Step e) consists of removing the frangible ceramic shell 12, as by cracking, from the solidified metallic wall structure, in the form of a metallic shell shown at 30, and also removing the core body 10 from within the metallic shell, as via the port 16 or ports, formed in the rear wall 23. In this regard, a tool may be passed through the port 16 and into the interior of the metal shell 30, to break-up the ceramic (or other material) core body 10 into small pieces, removed via port 16.

Preliminary steps to achieve the provided wax shell curved core body are shown in Fig. 1 at i), ii) and iii). Step i) consists of providing the pre-formed core body 10 itself. Such techniques are well known, and may include sintering a mass of ceramic particles held in shaped form by a resin binder. Step ii) consists of positioning the body 10 within a cavity 33 formed by mold structure 34, to provide an initial gap 35 between the body 10 and the cavity wall. Gap 35 corresponds to gap 13, referenced above. Small stand-offs or spacers 36 are typically located between the surface of body 10

and the mold cavity wall, to fix the gap 35 thickness. Step iii) consists of filling molten wax 11 into gap 35 to fill same, and about the stand-offs 36. After wax hardening, the mold structure 34 is removed. Note mold structure sections 34a and 34b, and parting line 34c therebetween.

Figs. 8 and 8a, related to step ii) above, show closed mold sections 40 and 41 with a parting line 42 therebetween. A mold cavity 33 is formed, and the pre-formed core body 10 is located in that cavity as by stand-offs or spacers 36, which may be glued to the mold body, as at locations 36a. A precision gap is thereby formed about the body 10. A peripheral recess 46 sunk in the mold body extends about the body in a plane 44 and intersects body surfaces corresponding to the ultimate head front wall, medially of the sweet spot, head rear wall, head top wall, and the sole. See Fig. 5. The plane 44 approximately bisects the head. A stiffening rib 144 is thereby to be formed integrally with the head, at its inner side, as seen in Fig. 3.

Fig. 9 corresponds to step iii) above, and shows wax shell 11 formed by molten wax reception into gap 35, as via a port 45 in mold section 40, in Fig. 8. Recess 46 is also filled with wax. Stand-offs or spacers 36 are removed, to produce openings 36a in the wax shell.

Fig. 10 corresponds to step b) above, and shows formation of the layered ceramic shell 12 about the wax shell, as by successive dippings in a hydrated ceramic mix, such mixes being known. The liquid mix fills the openings 36a, as at 12a. The ceramic shell 12 is then allowed to harden, and solid ceramic stand-offs 12aa are thereby formed, to position the core 10 when the wax is removed.

Fig. 11 corresponds to steps c) and d) above and shows the ceramic shell 12 and core 10 positioned therein, after the wax is removed, to form a gap 13 therebetween. Ceramic stand-offs 12a are formed during dip formation of 12. Molten metal such as steel is then cast into the gap, as via a port 47 formed in shell 12, to form the metal head. Finally, the outer shell 12 is fractured and removed, along with stand-offs 12a.

An opening or openings 16 as described above are formed in the head rear wall to provide access to the head interior for fracturing and removing the core body 10. The small openings formed in the metal wall as by stand-offs 36 and corresponding ceramic stand-offs 12a, can be welded shut. If desired, stand-off 36 can be formed integrally with the ceramic body 10.

In Fig. 7, two rear wall ports 16 are formed, at opposite sides of vertical plane 44. Those ports are located generally rearwardly of two dished recesses 50 and 51 formed in the sole wall, at opposite sides of a downwardly convex central ridge 52 that extends from front to rear, at generally the same level. Plane 44 bisects that ridge. Ports 16 also lie just above the level of rear wall bevel 53. The recesses 50 and 51, ridge 52 and bevel 53 may advantageously take the form as disclosed in U.S. Patent application Serial No. 08/263,970, filed

June 29, 1994, incorporated herein by reference. See also Fig. 12 herein, showing the bottom (sole area) of the latter, and with ports 16 formed in the lower rear wall. See also shaft 150 connected to the head. Ports 16 cannot be seen when the head is viewed from its top side. Ports 16 can be welded shut, if desired.

The metallic golf club head described has wall structure defining a front wall, a heel, a toe, a rear wall, a sole and a top wall, said head having at least one through opening formed in said rear wall at a level above the sole and so as to underlie a rear portion of the top wall.

## Claims

1. In the method of forming a hollow metallic golf club head having wall structure defining a front wall, a heel, a toe, a rear wall, a sole, and a top wall, the steps that include:

- a) providing a wax shell covered pre-formed core body, the thickness of the wax shell corresponding to the desired thickness of said wall structure,
- b) forming a ceramic shell about the wax shell,
- c) removing the wax shell by melting the wax, thereby to form an opened gap between the ceramic shell and the core body,
- d) and casting molten metal into the opened gap, thereby to form said wall structure extending about the core body and at the sole, while forming and maintaining port structure through said wall structure and spaced from the sole, and allowing said wall structure to solidify to form the head,
- e) removing said ceramic shell from said wall structure, and removing said core body from the interior of said solidified head, and via said port structure.

2. The method of claim 1 wherein said core body is ceramic.

3. The method of claim 1 or 2 wherein said port is formed through said head rear wall.

4. The method of any preceding claim wherein said port structure is formed to have an overall size substantially less than the overall size of said sole.

5. The method of any preceding claim wherein said port structure is formed as multiple ports through said head rear wall.

6. The method of any preceding claim including closing said port structure by providing and attaching metallic closure structure over said port structure.

7. The method of claim 5 including closing said multiple ports by providing and attaching metallic closures over said multiple ports.

5 8. The method of any preceding claim including providing spacer means to extend in said cavity between said ceramic shell and said core body.

10 9. The method of any preceding claim wherein said sole is formed to define a medial ridge and two dished recesses at opposite sides of said ridge, said multiple ports formed rearwardly of said dished recesses.

15 10. The method of any preceding claim wherein said core body is provided to define an elongated recess sunk in the surface of the core body and corresponding to an elongated stiffener rib to be formed by said head wall structure at the interior side thereof.

20 11. The method of claim 10 including forming said multiple ports to extend through said head rear wall at opposite sides of a plane defined by said stiffener rib.

25 12. The method of any preceding claim including providing multiple core body positioning ceramic stand-offs to extend in said gap between said core body and said ceramic shell, and optionally, said stand-offs are provided during the formation of said ceramic shell about the wax shell.

30 13. The method of any preceding claim wherein said wax shell covered core body is provided by:

- i) providing a preformed core body having the general shape of the head,
- ii) positioning said body within a cavity formed by mold structure thereby to provide an initial gap about the core body,
- iii) and filling wax into said initial gap to cover the core body and to form said wax shell, and, optionally, either
  - including forming an elongated recess sunk in the surface of the core body and corresponding to an elongated stiffener rib to be formed by said head wall structure at the interior side thereof, or
  - including forming said rib to extend substantially in a loop that extends forwardly and rearwardly with respect to the head wall structure to be formed.

35 55 14. A golf club head produced by the method of any preceding claim.

40 15. A hollow metallic golf club head having wall struc-

ture defining a front wall, a heel, a toe, a rear wall, a sole and a top wall, said head having at least one through opening formed in said rear wall at a level above the sole, for example so as to underlie a rear portion of the top wall, and, optionally,

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having two of said through openings in said rear wall, and/or

wherein said through opening has cross sectional area less than 0.5 square inches, and/or

including a looping rib integral with the head top front and rear walls and at the inner sides thereof, and/or

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including a looping rib integral with the head top front and rear walls and at the inner sides thereof, said rib defining an upright plane that passes between said two through openings.

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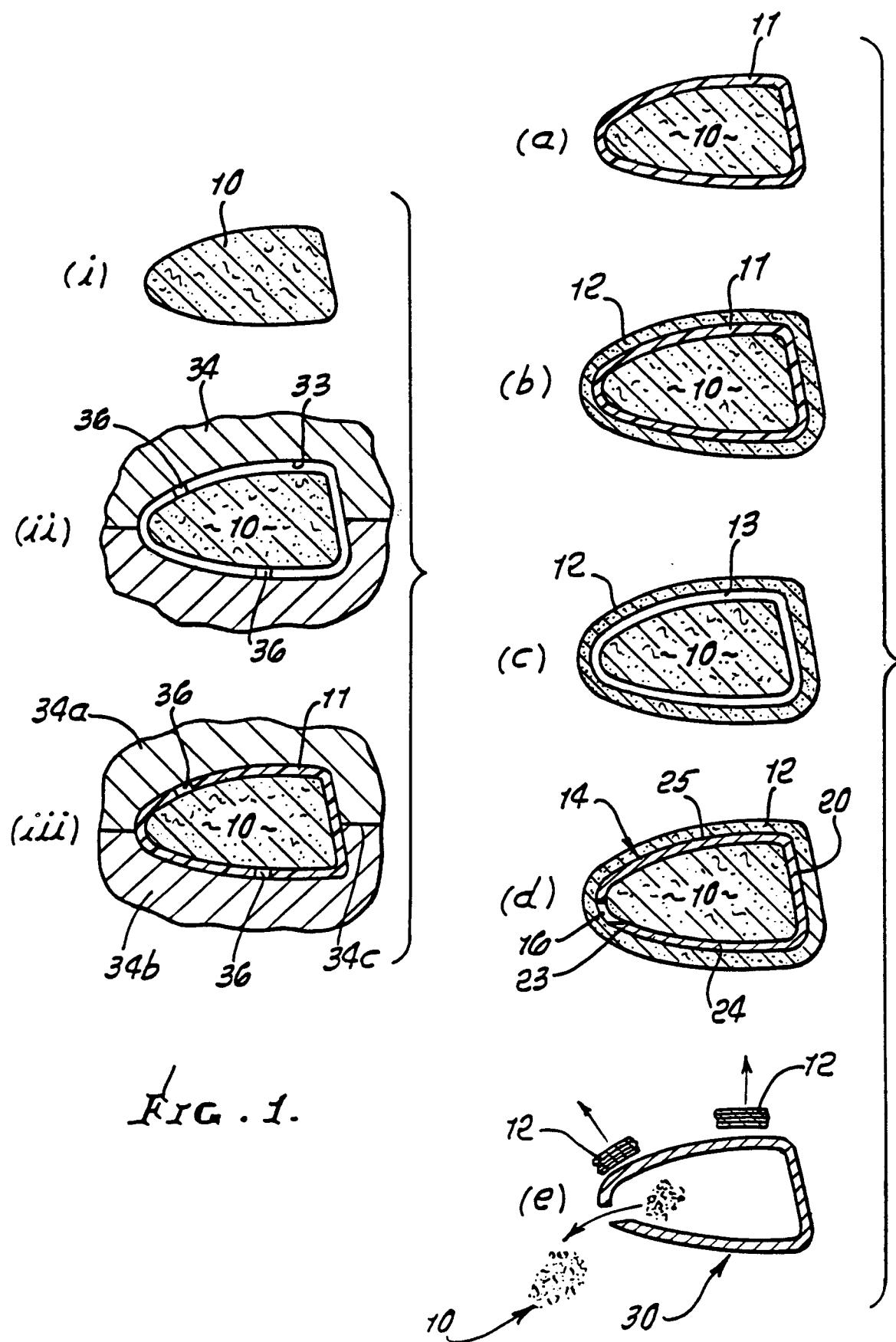


FIG. 1.

FIG. 2.

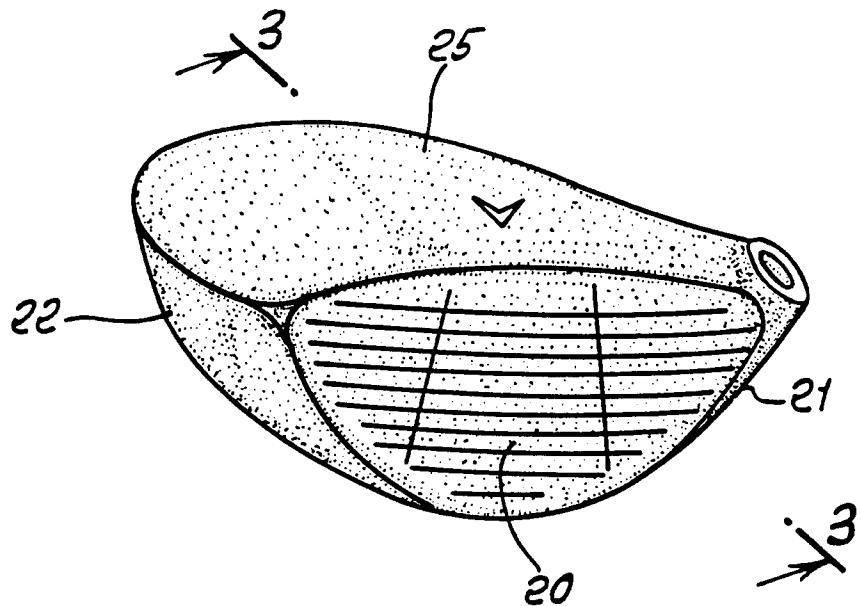


FIG. 3.

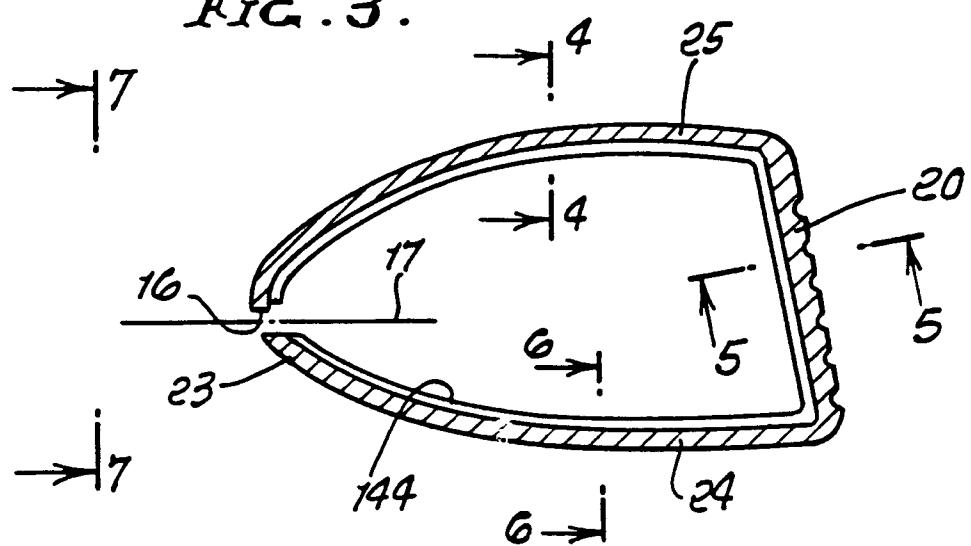


FIG. 4.

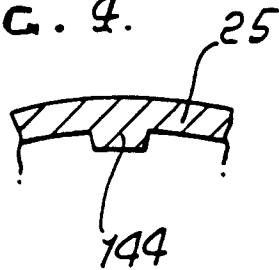


FIG. 5.

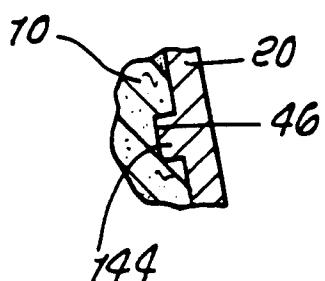


FIG. 6.

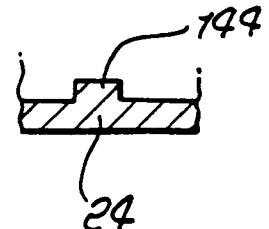


FIG. 7.

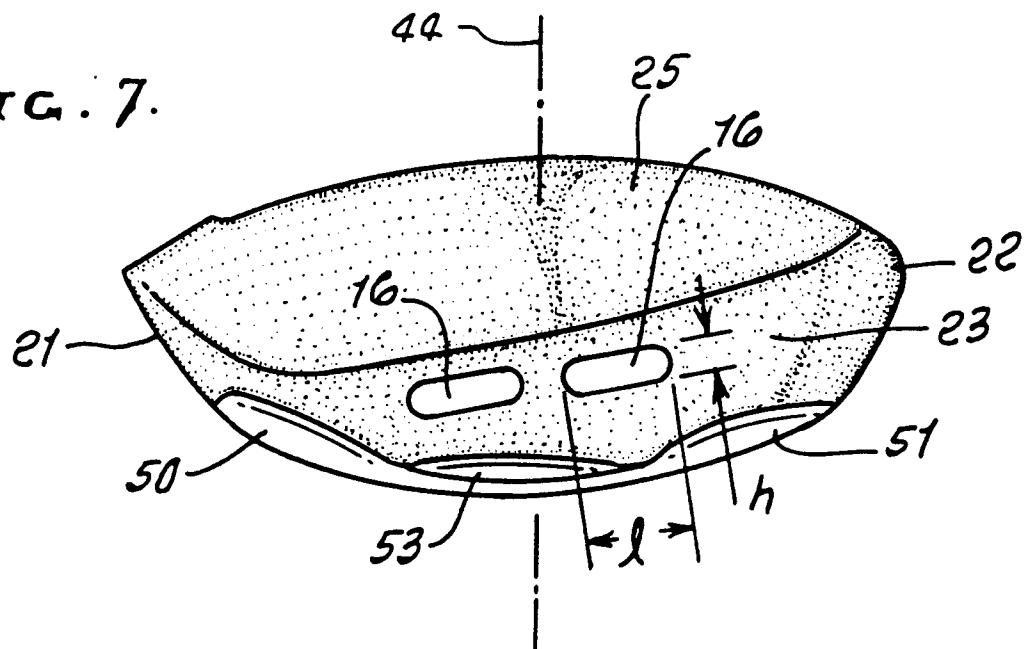


FIG. 8a.

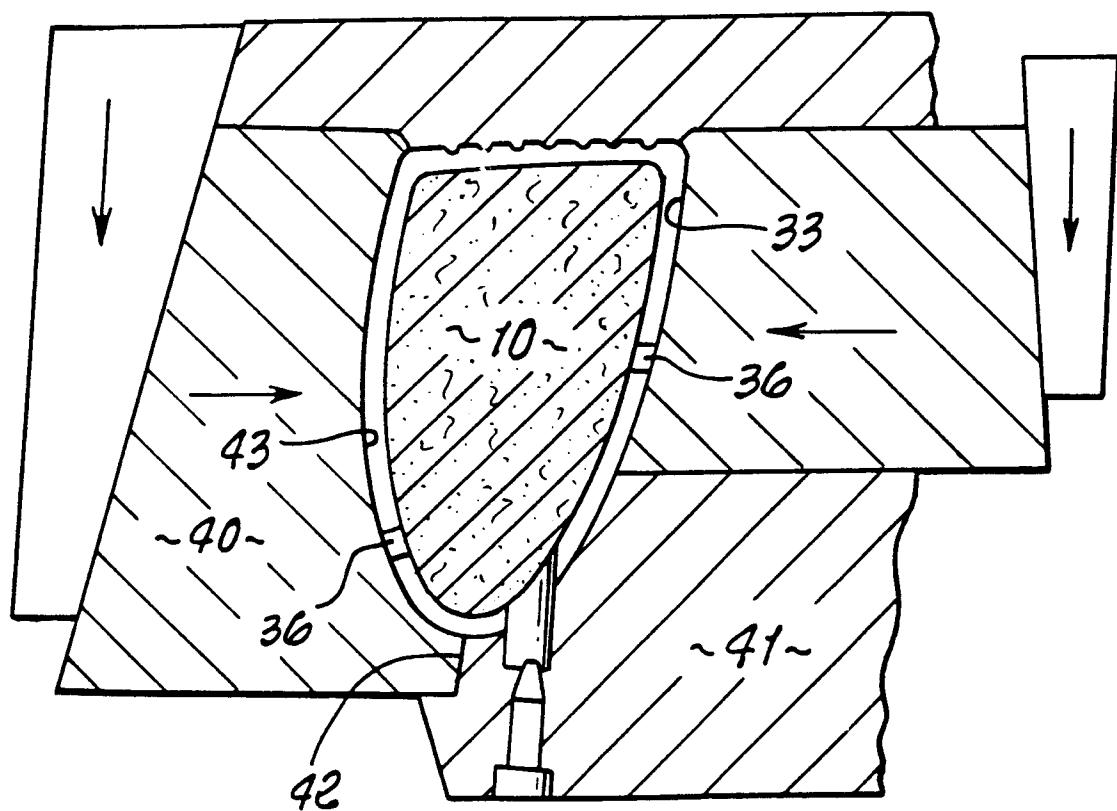


FIG. 8.

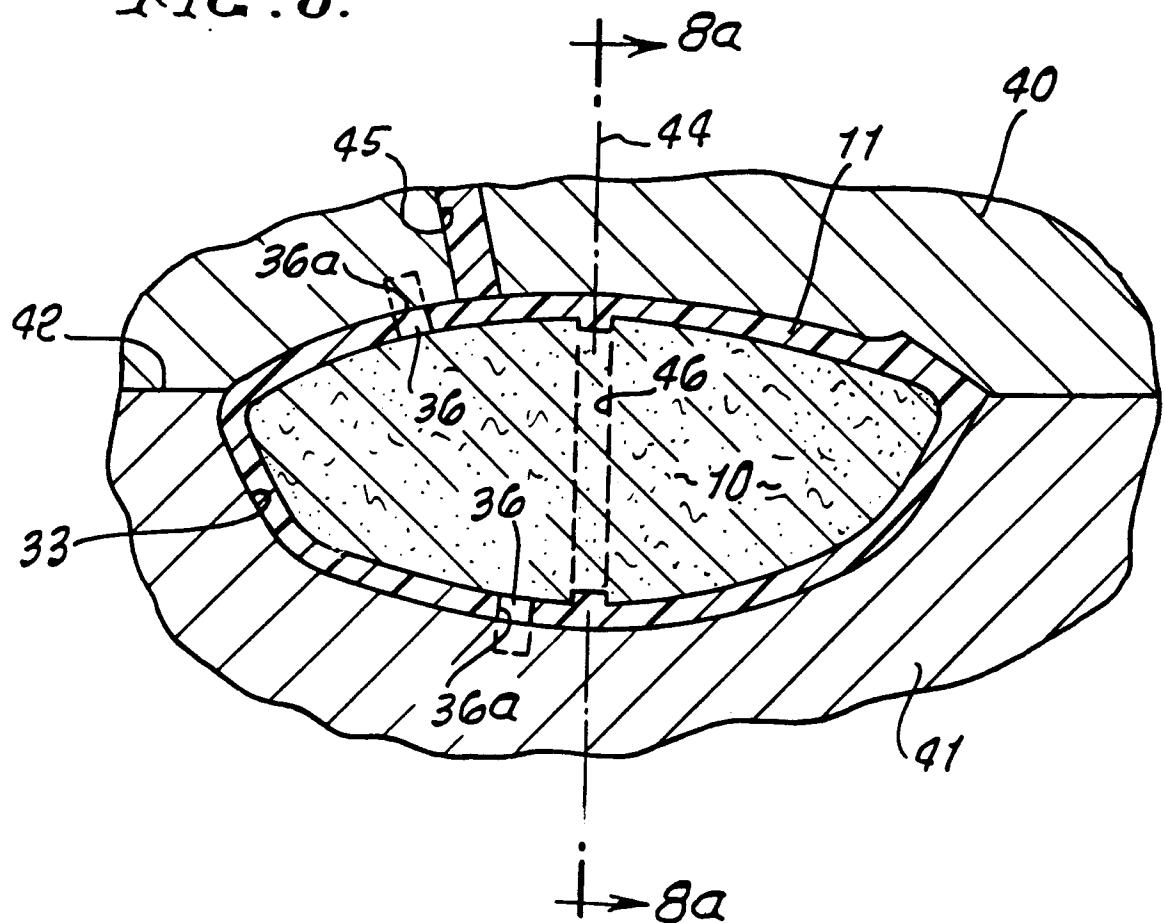
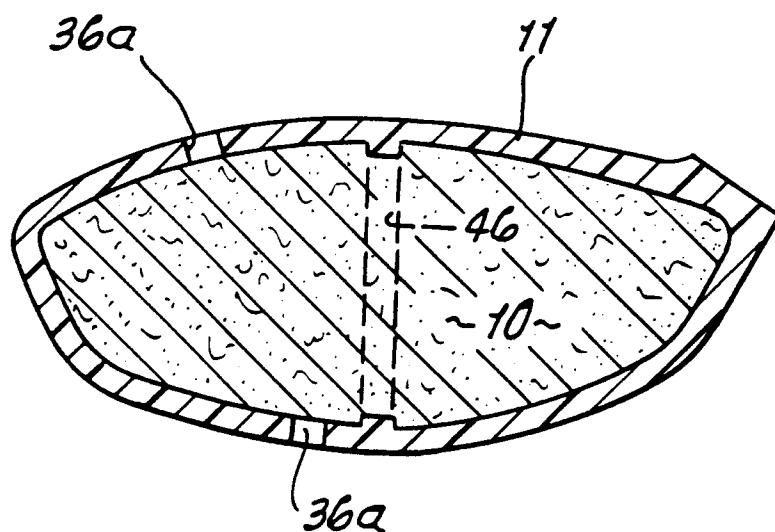
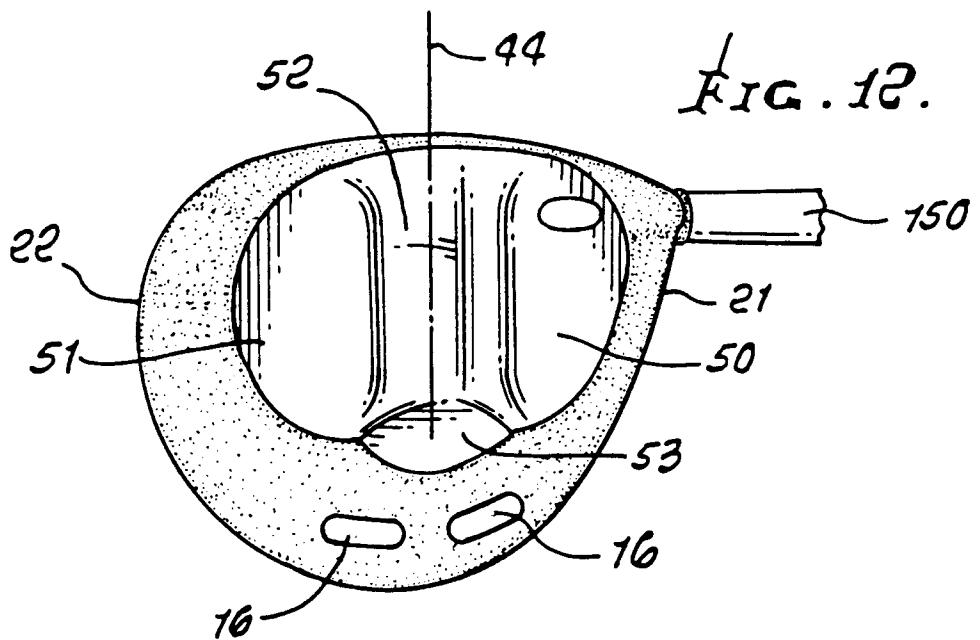
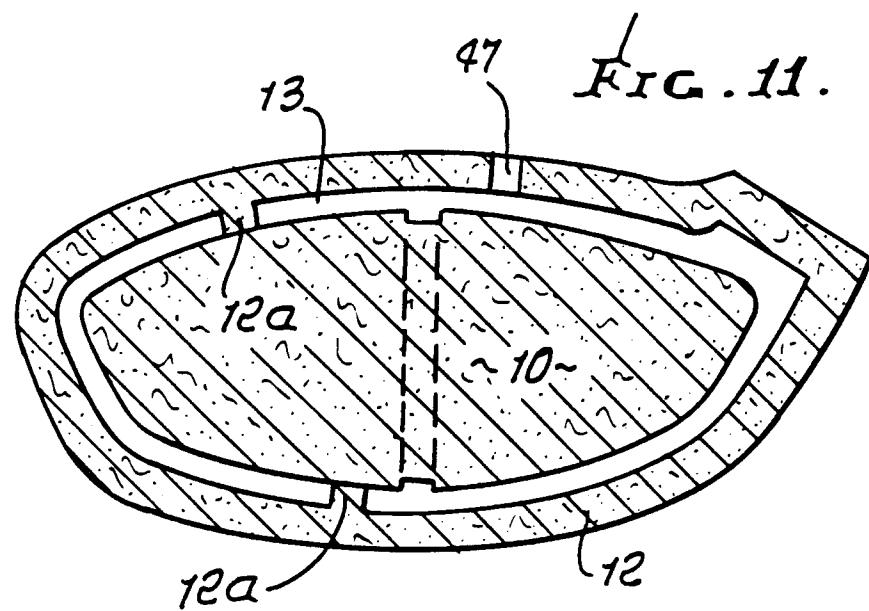
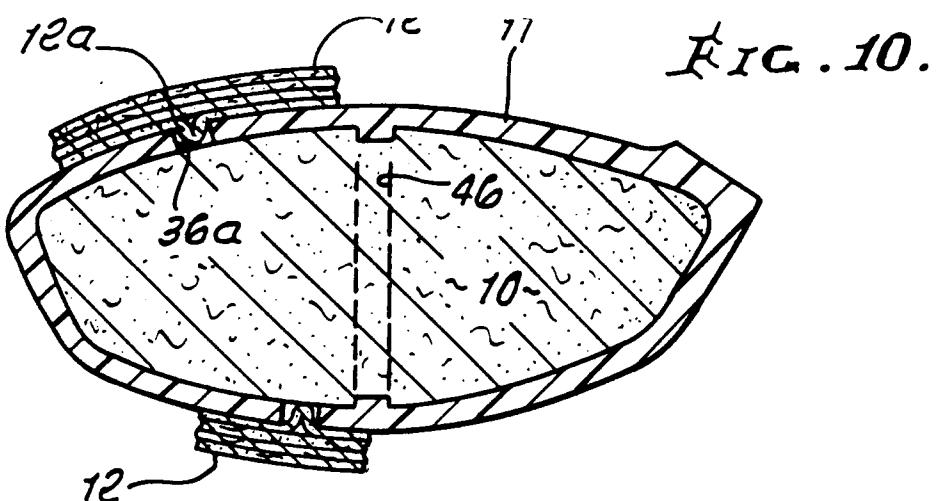


FIG. 9.







## EUROPEAN SEARCH REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT									
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)						
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 254 (C-0724), 31 May 1990 & JP 02 071770 A (MARUMAN GOLF CORP), 12 March 1990, * abstract *	1,15	B22D25/00 B22C7/02						
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 007 (M-1198), 9 January 1992 & JP 03 230845 A (MITSUI ENG & SHIPBUILD CO LTD), 14 October 1991, * abstract *	1,2,15							
A	US 5 538 798 A (SHEEHAN JOHN P) 23 July 1996	1-15							
A	EP 0 662 328 A (CALLAWAY GOLF CO) 12 July 1995	1,15							
D	* abstract; figure 2 * & US 5 460 376 A (SCHMIDT GLENN ET AL) 24 October 1995								
	-----		TECHNICAL FIELDS SEARCHED (Int.Cl.6)						
			B22C B22D A63B						
<p>The present search report has been drawn up for all claims</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Place of search</td> <td style="width: 33%;">Date of completion of the search</td> <td style="width: 34%;">Examiner</td> </tr> <tr> <td>THE HAGUE</td> <td>15 January 1997</td> <td>WOUDENBERG, S</td> </tr> </table>				Place of search	Date of completion of the search	Examiner	THE HAGUE	15 January 1997	WOUDENBERG, S
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THE HAGUE	15 January 1997	WOUDENBERG, S							
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document							
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