(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 216 727 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.06.2002 Bulletin 2002/26

(51) Int Cl.[7]: **A63B 53/00**, A63B 53/10, A63B 53/12

(21) Application number: **01870073.2**

(22) Date of filing: **29.03.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **21.12.2000 US 745001**

(71) Applicant: **True Temper Sports, Inc.**
Memphis, TN 38125-8871 (US)

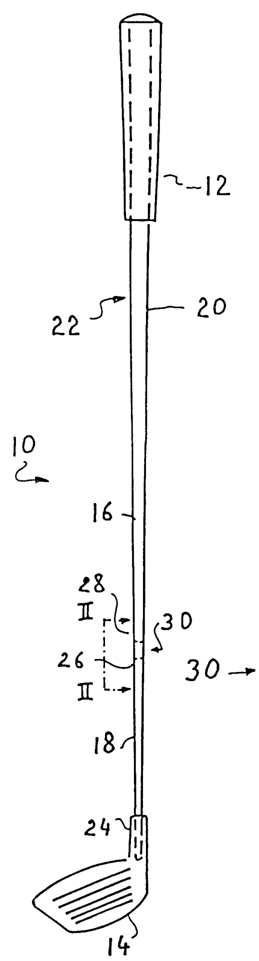
(72) Inventors:
- **Hedwick, Michael W.**
  Vyhalia, MS 38611 (US)
- **Walker, Michael D.**
  Memphis, TN 38117 (US)
- **Cokeing, Scott D.**
  Eads, TN 36028 (US)
- **Thomas, James S.**
  Bartlett, TN 38133 (US)
- **Horwood, Graeme**
  Germantown, TN 38138 (US)

(74) Representative: **Weller, Wolfgang, Dr.**
Witte, Weller & Partner
Patentanwälte
Postfach 105462
70047 Stuttgart (DE)

(54) Metal and composite golf shaft

(57) A golf club (10) shaft is provided including a metal tip section (18) and a composite butt section (20). The butt section (20) includes a reduced diameter portion (32) telescopically received within an axial bore of the tip section (18). An adhesive (31) is disposed between the tip section (18) and the butt section (20) to secure the two together. An insulating layer may be disposed between the tip section (18) and the butt section (20) to prevent galvanic corrosion.

Fig 1



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Description

BACKGROUND OF THE INVENTION

[0001] This invention relates to a golf club shaft having improved performance characteristics and more particularly to a two piece golf club shaft combining a metal portion and a composite portion which retains the advantages of both materials while eliminating their disadvantages.

[0002] Control and accuracy in the game of golf is influenced by the torsional stiffness of the shaft. The torsional stiffness of the shaft resists twisting of the club head during the swing and particularly when there is less than perfect contact between the golf ball and club head. Metal golf club shafts, the most popular metal being steel, are used by many golfers. An advantage of steel shafts is their high torsional stiffness which are known in the relevant art as "low torque" shafts.

[0003] Many golf shaft manufacturers offer composite shafts, often referred to as graphite shafts, which are usually made from a composite of graphite or carbon fiber and epoxy resin. Composite shafts can be significantly lighter than metal shafts, but the torsional stiffness of a conventional graphite shaft is less than that of a steel shaft. Graphite shafts are therefore known in the art as 'higher torque' than steel shafts.

[0004] In an attempt to torsionally stiffen composite shafts, manufacturers have used different fiber types such as high modulus carbon, aramid and boron fibers. They have also varied the construction by wrapping the fibers at different angles in an attempt to improve torsional stiffness. Most of these changes have increased the cost and often had a negative effect on the playability of the shaft.

[0005] Recent studies have shown that only the tip section of the shaft provides the torsional resistance to prevent club head twisting due to poor ball/head contact. Contact between the club head and ball is a very brief dynamic event and only the tip section of the shaft gets loaded during this time period. The event is effectively over before the full length of the shaft is loaded. It is therefore desirable to construct the tip section of the shaft from metal which has a high torsional stiffness, such as steel, whereas the butt section can be constructed from a composite, such as graphite, with a lower torsional stiffness. In such a manner, the effective torque characteristic of the shaft can be enhanced while maintaining a light weight.

[0006] One attempt to combine the advantages of metal and composite shafts is disclosed in U.S. Patent No. 4,836,545 to Pompa. However, Pompa does not describe the affect the physical characteristics of the two shaft sections has on shaft performance. The length and weight of the two sections of the Pompa shaft were arbitrarily selected. Testing also revealed that the weight of the metal tip section was extremely heavy as compared to the weight of the composite butt section. By having a tip section that was too heavy, the center of gravity (CG) of the shaft moved towards the tip end and undesirably increased the swing weight of the club.

[0007] Swing weight is a measure of the static moment of the assembled club about a point usually 35 cm (14") from the grip end. The absolute weight and balance point (CG position) of head, shaft and grip all affect club swing weight. Although it is common for major club manufacturers to specify head weights to achieve desired club swing weights knowing the specifications of the shaft and grip, this approach is not always possible. Component suppliers typically offer club head weights which conform to industry accepted weight ranges. As such, it is highly desirable to provide shafts that may be used with such heads to achieve popular club swing weights.

[0008] Further, it is undesirable for the head to receive secondary weighting to achieve a desired club swing weight. Secondary weighting is usually introduced at the extreme tip end of the shaft where the shaft is inserted in the hosel of the head. This positioning is not optimal being away from the head center of gravity and thus reduces momentum transfer to the ball for a given swing speed. Less momentum transfer to the ball reduces the distance the ball will travel.
Pompa also failed to appreciate the difficulty of joining the metal and composite sections of the shaft. The joint must be cosmetically acceptable and strong enough to prevent failure.

[0009] In view of the foregoing, it would be desirable to provide an improved golf club shaft that exhibits the advantages of both metal and composite shafts while eliminating their respective disadvantages.

SUMMARY OF THE INVENTION

[0010] It is a primary purpose and principal objective of the present invention to provide a golf club shaft combining the separate advantages of metal and composite shafts into a single, hybrid design.

[0011] It is another objective of the present invention to eliminate the separate disadvantages of metal and composite shafts in a single, hybrid design.

[0012] It is yet another objective of the present invention to provide a method for manufacturing a golf club shaft having a tip section of a metallic material and a butt section of a composite material.

[0013] It is still yet another objective of the present invention to provide a method and device for achieving the above objectives while conforming to the rules of golf as defined by the United States Golf Association.

[0014] According to one embodiment of the present invention, a golf club shaft is provided including a metal tip section and a composite butt section. The cylindrical tip section is formed of a metallic material such as steel. The cylindrical butt section is formed of a composite material such as graphite and includes a reduced diameter portion or plug formed at an end thereof. The plug of the butt section is telescopically received in the end of the tip section such that the end of the tip section overlaps the reduced diameter portion of the butt section. An adhesive, such as epoxy, is disposed between the tip and butt sections to secure the two sections together.

[0015] In another embodiment of the present invention, an insulating layer is disposed between the tip and butt sections to prevent metal to composite contact within the metal/composite joint. By preventing metal to composite contact, the insulating layer reduces or eliminates the potential for galvanic corrosion within the joint. The insulating layer may be formed as a plurality of insulating spacers such as glass beads or a glass layer built into the butt section within the joint.

[0016] The invention will be better understood and further objects and advantages thereof will become more apparent from the ensuing detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a schematic side elevation view of a golf club shaft incorporating the teachings of the present invention;
FIG. 2 is a graph showing the relationship of torsional resistance to metal tip length;
FIG. 3 is a graph showing the relationship of torsional resistance to metal (A) and composite (B) tip lengths;
FIG.4 is a graph showing the relationship of shaft weight to tip length and its affect on club swing weight;
FIG. 5 is a detailed schematic cross sectional view of a metal/composite joint of the golf club shaft of FIG. 1;
FIG. 6 is a graph showing the relationship of the tip bending stiffness of the shaft of the present invention (B) to that of a conventional steel shaft (A);
FIG. 7 is a graph showing the relationship of the tip wall thickness of the shaft 10 of the present invention (B) to that of a conventional steel shaft (A) as a function of the length from the tip of the shaft;
FIG. 8 is a graph showing the relationship of the butt wall thickness of the shaft of the present invention (B) to that of a conventional graphite shaft (A) as a function of the distance from the butt end of the shaft;
FIG. 9 is a detailed schematic cross sectional view of a metal/composite joint of the golf club shaft of FIG. 1 according to a second embodiment of the present invention;
FIG. 10 is a detailed schematic cross sectional view of a metal/composite joint of the golf club shaft of FIG. 1 according to a third embodiment of the present invention; and
FIGS. 11a and 11b are detailed schematic cross sectional views of a metal/composite joint of the golf club shaft of FIG. 1 according to a fourth embodiment of the present invention.

DETAILED DESCRIPTION

[0018] Referring to FIG. 1, there is shown a golf club 10 having a grip 12, a head 14 and a tubular shaft 16. Although the club 10 is illustrated as a wood, it may also be an iron or a putter. The shaft 16 includes a tip section 18 and a butt section 20. The tip section 18 is preferably formed of a metallic material such as high strength steel while the butt section 20 is preferably formed of a composite material such as graphite. While the shaft 16 has been illustrated as having a smooth, tapered sidewall 22, it should be appreciated that a parallel or stepped sidewall could substitute therefore.

[0019] The tip section 18 is secured at a lower end 24 to head 14 by sizing it to fit standard club head hosel sockets. The upper end 26 of tip section 18 is telescopically and slidingly fit over the lower end 28 of the butt section 20. The physical characteristics of the tip section 18 from head 14 to the joint 30 where it meets the butt section 20, are designed to provide desired balance of torsional stiffness, bending stiffness (flex), strength, and weight in order to yield the best playability when combined with the composite butt section.

[0020] The relationship between the physical characteristics of the tip 18 and the playability of the shaft 16 is complex and many factors must be taken into consideration.

1) As the metallic tip section 18 is shortened, the torsional stiffness it provides becomes less significant. As the tip section 18 is lengthened, the weight of the tip section 18 becomes more significant.
2) It is desirable to retain an industry standard diameter of either 8,375 mm (335 inch) or 8,75 mm (350 inches) at the lower end 24 of the tip section 18 to allow fitment of industry standard club heads. However, the diameter can be increased towards the upper end 26 of the tip section 18 to increase both torsional and bending stiffness.
3) For the same weight tip section 18, increasing the diameter at the upper end 26 decreases the wall thickness and reduces durability.
4) To minimize the weight of the tip section 18, the wall of the tip section 18 can be made thinner. However, as the wall thickness is reduced, the strength and stiffness of the tip section 18 is reduced.
5) As the diameter and wall thickness of tip section 18 is varied, the bending stiffness (flex) is also changed. If the bending stiffness (flex) is too high or too low the playability and feel of the shaft becomes unacceptable. Extensive playability and durability testing has allowed an acceptable geometry range and a preferred geometry to be defined for the tip section 18 of a 1,15 m (46 inch) wood shaft

weighing between 65g and 90g.

[0021] If the length of tip section 18 is less than 15 cm (6 inches) it does not provide sufficient torsional stiffness to improve shot accuracy. FIG. 2 shows how the torque T of the club, as measured in degrees using a torque test, is reduced as the length L of the tip section is increased. FIG. 3 shows the lower torque characteristics (A) of a steel tip compared to a graphite tip (B).

[0022] If the tip section 18 is greater than 30 cm (12 inches), the shaft weight is undesirably increased and the center of gravity position of the shaft 16 is moved too far towards the tip end 24. FIG. 4 shows how the shaft weight W increases with tip length L. FIG. 4 also shows that with shaft weights for tip lengths L between 15 and 30 cm (6 and 12 inches) it is possible to achieve club swing weights ranging from 01 to 05 using an industry accepted head weight (club length 111 cm, Head weight 195 g).

[0023] If the diameter of the upper end 26 of the tip section 18 is increased above 10,375 mm (.415 inches), the bending stiffness becomes undesirably high adversely affecting tip flexibility and providing a low ball trajectory and a harsh feel to the club. Likewise, if the diameter of the upper end 26 of the tip section 18 is reduced below 9,625 mm (.385 inches), the bending stiffness is undesirably low providing a high ball trajectory and too soft a feel to the club.

[0024] Durability testing carried out with an air cannon has shown that diameters above 1cm (.415 inches) for the upper end 26 of tip section 18 with a length range from 15 to 30 cm (6 to 12 inches) and an overall weight of shaft 16 of less than 65g does not provide a tip section 18 with sufficient durability.

[0025] In the preferred embodiment, a 1,15 m (46 inch) wood shaft weighs 75g and has a tip section 18 with a length of 20 cm (8 inches) and a diameter at the upper end 26 of 10 cm (.4 inches) and a diameter of 8,375 or 8,75 mm (.335 or .350 inches) at the lower end 24. Such a preferred tip section 18 has a torque of less than 0.6 degrees over the 20 cm (8 inch) length when measured using a torque test. This compares with a torque of greater than 1.5 degrees for the tip section of a typical graphite shaft measured using the same test method.

[0026] Turning now to FIG. 5, the joint 30 of FIG. 1 is illustrated in greater detail. An important aspect affecting the durability of the shaft 16 is the strength of the joint 30 between the metal tip section 18 and the composite butt section 20. As can be seen, the tip section 18 is in the form of a hollow metal cylinder and the but! section 20 is formed as a hollow composite cylinder. The butt section 20 includes a reduced diameter cylindrical portion or plug 32 for insertion into the tip section 18. The reduced diameter portion 32 may be formed during the lay-up of the composite butt section 20 or may be formed by grinding away a pre-selected annular amount of the butt material after initial formation. The reduced diameter portion 32 is dimensioned to ensure a sufficient overlap and durable interconnection with the tip section 18.

[0027] The metal tip section 18 and composite butt section 20 are joined together with an adhesive, such as epoxy bond 31. The thickness of the adhesive 31 is carefully controlled and the surface area of the tip section 18 and butt section 20 along the adhesive 31 is sufficient to ensure adequate strength. Bond strength is selected such that the joint 30 does not fail in shear from the torsional loads imposed through generally accepted levels of abuse while playing the game of golf. Limiting the maximum thickness of the adhesive 31 and increasing the surface area of the joint 30 also maintains the highest straightness standard for the assembled shaft 16.

[0028] Static and dynamic durability testing has shown that bond thickness should be controlled to between 0,075 mm and 0,15 mm (.003" and .006"). Testing has also shown that for a metal tip section 18 with a diameter at the upper end 26 of between 9,625 and 10,375 mm (0.385" and 0.415") the composite butt section 20 should be inserted into the metal tip section 18 between about 18,75 mm (0.75") and about 37,5 mm (1.5") to provide an adequate bond area. In the preferred embodiment, a 46 inch shaft driver has a bond thickness of 0,1125 mm (.0045") and the composite butt section 20 is inserted 31,25 mm (1.25") into the metal tip section 18. Such geometry has been proven to provide adequate strength and straightness in the assembled shaft 16.

[0029] The overall bending stiffness of the shaft 16, which defines the shaft flex, is influenced by the design of the tip section 18, the butt section 20 and the geometry of the joint 30. Local stiffness in the joint could be high and the length of the joint 30 must be such to provide sufficient durability while not being excessively stiff.

[0030] Flex ranges for various categories of players with different swing characteristics are generally accepted throughout the industry with those provided by True Temper Dynamic (trademark) shafts often being used as a point of reference. Using the geometry range and overall shaft weights defined above, FIG. 6 shows the bending stiffness (B) of shaft 16 through the joint compares favourably to that of a Dynamic shaft (A) ensuring excellent feel and desirable ball flight. The stiffness of the shaft in FIG. 6 is measured as the tip deflection D in relation with the clamp distance from tip (L) in a simple cantilever load test.

[0031] FIGS. 7 and 8 compare the wall thickness along the length of the metal tip section 18 and composite butt section 20 in the preferred embodiment of shaft 16 with (B) the wall thickness found in a popular True Temper Dynamic (trademark) steel shaft (A) and a popular Grafalloy Prolite (trademark) graphite shaft (A) . It will be apparent that the wall thickness in the shaft 16 is very different to that in the available True Temper steel and Grafalloy graphite shafts. This illustrates that the shaft 16 cannot be made by bonding together tip and butt sections cut from commercially available steel and graphite shafts.

[0032] Referring again to FIG. 5, the formation of the reduced diameter portion 32 also defines an edge in the form of a radial wall 34 in the butt section 20. Although the radial wall 34 is illustrated as extending orthogonally to the reduced diameter portion 32, the radial wall 34 may also be formed at an acute or obtuse angle relative thereto. The radial wall 34 is preferably dimensioned so as to be equal to or slightly greater than the sum of the thickness of the end 38 of the tip section 18 and the thickness of the adhesive 31 so as to yield a smooth-wall, concentric transition between the tip section 18 and the butt section 20 along the perimeter of the shaft 16 adjacent the joint 30.

[0033] Turning now to FIG. 9, a second embodiment of the present invention is illustrated. In this embodiment, the components which are the same as those in the previous embodiment are identified with the same reference numeral but increased by 200. The second embodiment differs from the previous embodiment by the insertion of an insulating layer 252 in the form of a plurality of spacers between the tip section 218 and the butt section 220. The insulating spacers 252 are preferably in the form of beads and are preferably formed of an insulating material such as ceramic or glass. The insulating beads 252 prevent the metal of the tip section 218 from contacting the graphite of the butt section 220 to reduce or eliminate galvanic corrosion within the joint 230.

[0034] The beads 252 also help control the alignment and separation of the tip section 218 relative to the butt section 220. In this regard, the diameter of the beads 252 is selected in accordance with the gap 242 so as to provide sufficient space for the adhesive 231 between the beads while also coaxially aligning the tip section 218 with the butt section 220 so as to ensure a smooth perimeter surface along the shaft 216 adjacent the joint 230. Preferably, the beads 252 are pre-mixed with the adhesive 246 prior to its application within the joint 230.

[0035] Turning now to FIG. 10, a third embodiment of the present invention is illustrated. In this embodiment, the components which are the same as those in the previous embodiments are identified with the same reference numeral but increased by 300. The third embodiment differs from the previous embodiments by the inclusion of an insulating layer 352 in the form of an overlayer between the tip section 318 and the butt section 320. The overlayer 352 is preferably in the form of an insulating layer integrally formed along the outboard surface of the reduced diameter portion 332 and is preferably formed of an insulating material such as ceramic or glass to prevent the metal of the tip section 318 from contacting the graphite of the butt section 320 to reduce or eliminate galvanic corrosion within the joint 330. The layer 352 also helps control the alignment and separation of the tip section 418 relative to the butt section 320.

[0036] The layer 352 is preferably formed by forming the butt section 320 with a relatively thick layer of glass at one end thereof prior to the formation of the reduced diameter portion 332. The reduced diameter portion 332 is then formed by grinding away a pre-selected annular amount of the glass so as to leave the layer 352 as an outboard surface of the reduced diameter portion 332. In this way, the fabric 352 isolates the remaining composite material of the butt section 320 from the metallic material of the tip section 318.

[0037] Referring to FIGS. 11a and 11b, in production shafts, a plastic ferrule 500 is incorporated in the joint 430 between the steel tip 418 and the graphite butt section 420. The ferrule 500, is made from suitable extruded or injection molded plastic and is used to accommodate any slight geometrical misalignment between the graphite section 420 and steel section 418. The outside diameter of the ferrule 500 is sized to be slightly larger than the diameter of either the graphite section 410 or steel section 418. After assembly, excess material can be removed from the plastic ferrule 500 either by buffing on a fine abrasive belt or by wiping with a solvent such as acetone. Removing material from the ferrule 500 in this way can provide a smooth transition on the outside surface between the steel and graphite sections 418 and 420.

[0038] The cross section of the ferrule 500 can be altered from the rectangular form in FIG. 11 a to incorporate inwardly sloping faces as shown in FIG. 11 b. Such ferrule geometry can be used to accommodate a small radius in the corner of the machined graphite butt section 420 that can ease the manufacture of the shaft 416.

[0039] Referring again to FIGS. 1 and 2, the steps for manufacturing the shaft 16 will be described. The hollow cylindrical butt section 20 is formed to a given length by arranging a plurality of layers of a pre-selected composite fibers such as carbon-graphite at different angles relative to one another and bonding them with a resin. The bull section 20 may be formed with parallel, tapered or stepped sidewalls as desired. The reduced diameter portion 32 is formed at one end of the bull section 20 during lay-up or by grinding away a pre-selected annular amount of the material at one end thereof.

[0040] The hollow cylindrical tip section 18 is formed to a given length by drawing a blank of metallic material such as a high strength steel or aluminium through a mandrel. The tip section 18 may be formed with parallel, tapered or stepped sidewalls as desired. The length and weight of the tip section 18 is selected as described above.

[0041] An adhesive is deposited on at least one of the reduced diameter portion 32 and the inside of the tip section 18. The reduced diameter portion 32 is then telescopically inserted within the tip section 18. As illustrated in FIGS. 9 and 10, an insulating layer 52 may be inserted between the tip section 18 and the butt section 20 to prevent galvanic corrosion within the joint 30.

[0042] The foregoing relates to preferred exemplary embodiments of the present invention, it being understood that other embodiments and variants thereof are possible within the scope of the invention, the latter being defined by the appended claims.

Claims

1. A shaft (10) **characterised in that** it comprises a tip section (18, *18) formed of a metal material and having a length between about 15 and about 30 cm and a diameter at an upper end thereof between about 9,625 and about 10,375 mm; and
   a butt section (20, *20) formed of a composite material coupled to said tip section (18, *18).

2. A shaft (10) according to claim 1, **characterized in that** said butt section (20, *20) has a plug (32, *32) telescopically received within said tip section (18, *18).

3. A shaft according to either one of claim 1 and 2, **characterized in that** said tip section overlaps said plug (32, *32) over a length of about 10,75 to about 37,5 mm.

4. A shaft (10) **characterized in that** it comprises a tip section (18, *18) formed of a metal material; and
   a butt section (20, *20) formed of a composite material and having a plug (32) extending from one end thereof telescopically received within said tip section (18, *18), said tip section (18, *18) overlapping said plug (32, *32) by a length between about 18,75 and 37,5 mm.

5. A shaft according to claim 4 **characterized in that** said tip section (18, *18) has a length between about 15 and about 30 cm.

6. A shaft according to any one of claims 4 and 5 **characterized in that** said tip section has an upper end (26, *26) and a lower end (24, *24), a diameter of said upper end (26, *26) being between about 9,625 mm and about 10,375 mm.

7. A shaft according to any one of the preceding claims **characterized in that** said tip section has an upper end (26, *26) and a lower end (24, *24) a diameter of said lower end (24, *24) being about 8,375 mm or about 8,75 mm.

8. A shaft according to every one of the preceding claims **characterized in that** said tip section (18, *18) has a wall thickness between about 0,3 mm and about 0,4 mm.

9. A shaft of according to any one of the preceding claims **characterized in that** said butt section (20, *20) has a wall thickness between about 0,3 mm and about 3,125 mm.

10. A shaft according to any one of the preceding claims **characterized in that** an adhesive (31, *31) is disposed between said tip section (18, *18) and said butt section (20, *20).

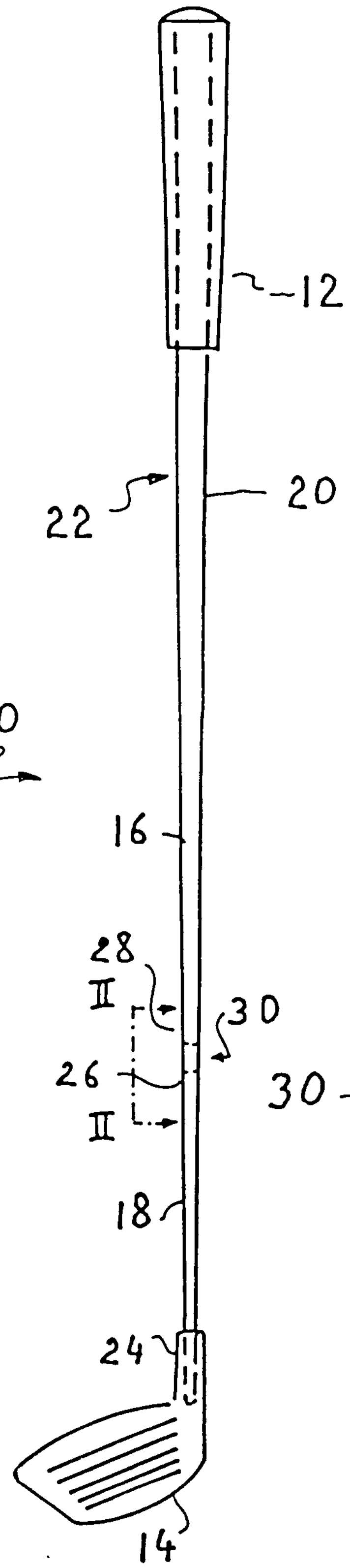
11. A shaft according to claim 10 **characterized in that** said adhesive (31, *31) has a thickness between about 0,075 mm and about 0,15 mm.

12. A shaft according to any one of the preceding claims **characterized in that** a plastic ferrule (500) is disposed between said tip section (18, *18) and said butt section (20, *20).

13. A shaft according to any one of the preceding claims **characterized in that** an insulating layer (352) is disposed between said tip section (18, *18) and said butt section (20, *20).

14. A shaft according to claim 13 **characterized in that** said insulating layer (352) further comprises one or a plurality of insulating spacers disposed between said tip section (18, *18) and said butt section (20, *20) and a glass layer formed as an outboard part of said tip section (18, *18) so as to be located proximate said butt section (20, *20).

Fig 1



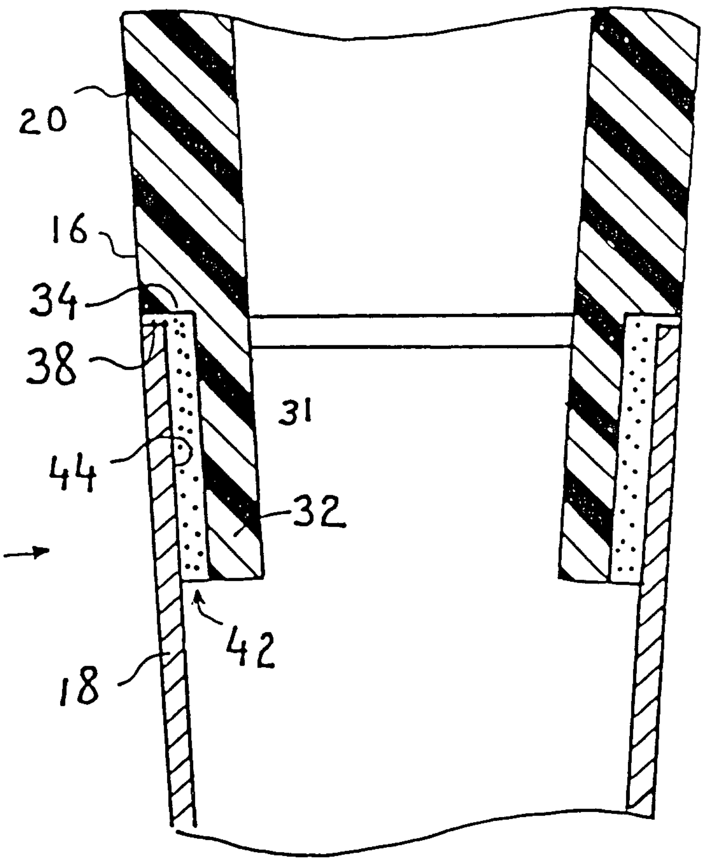


Fig 5

Fig. 2

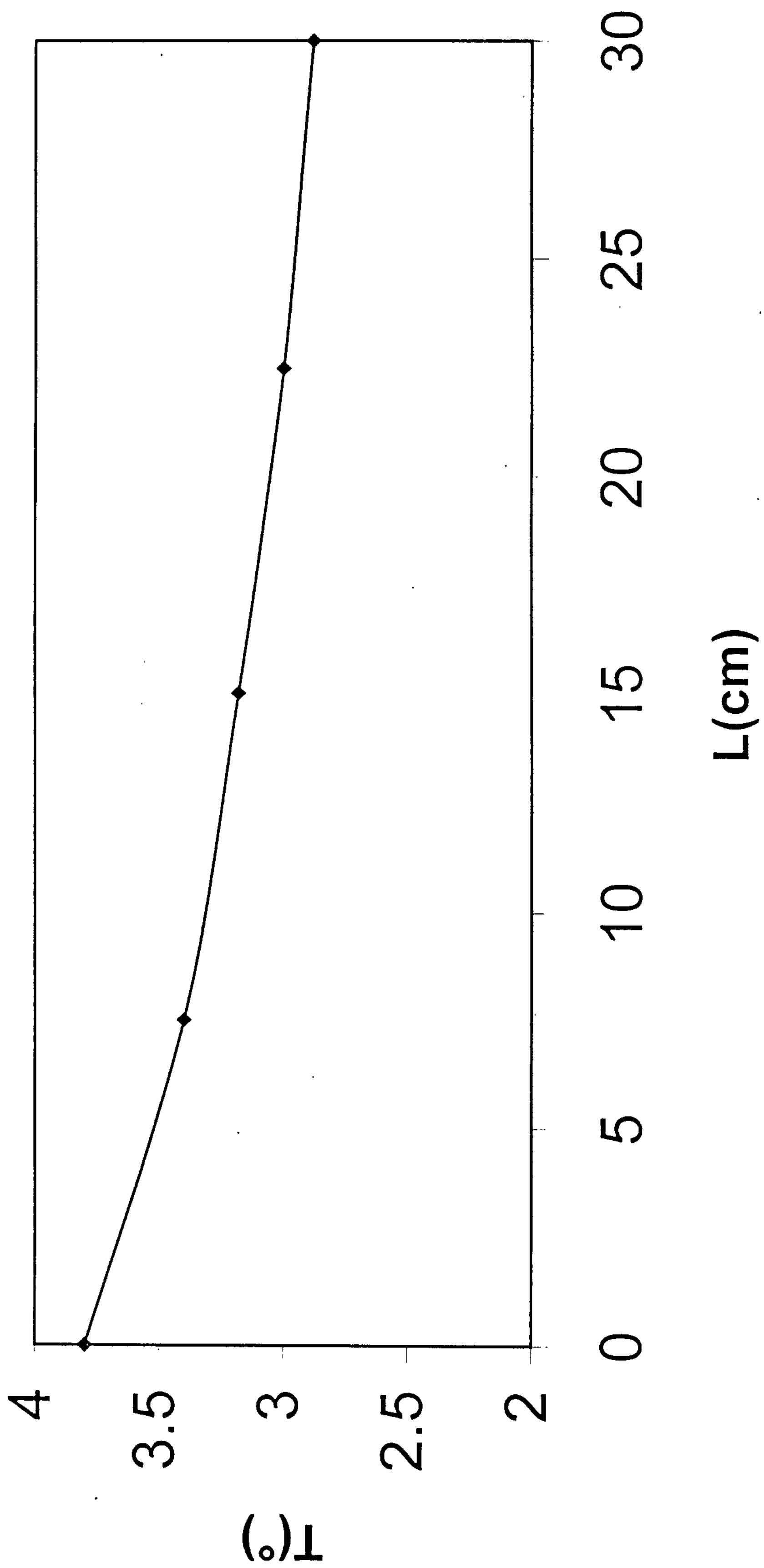


Fig. 3

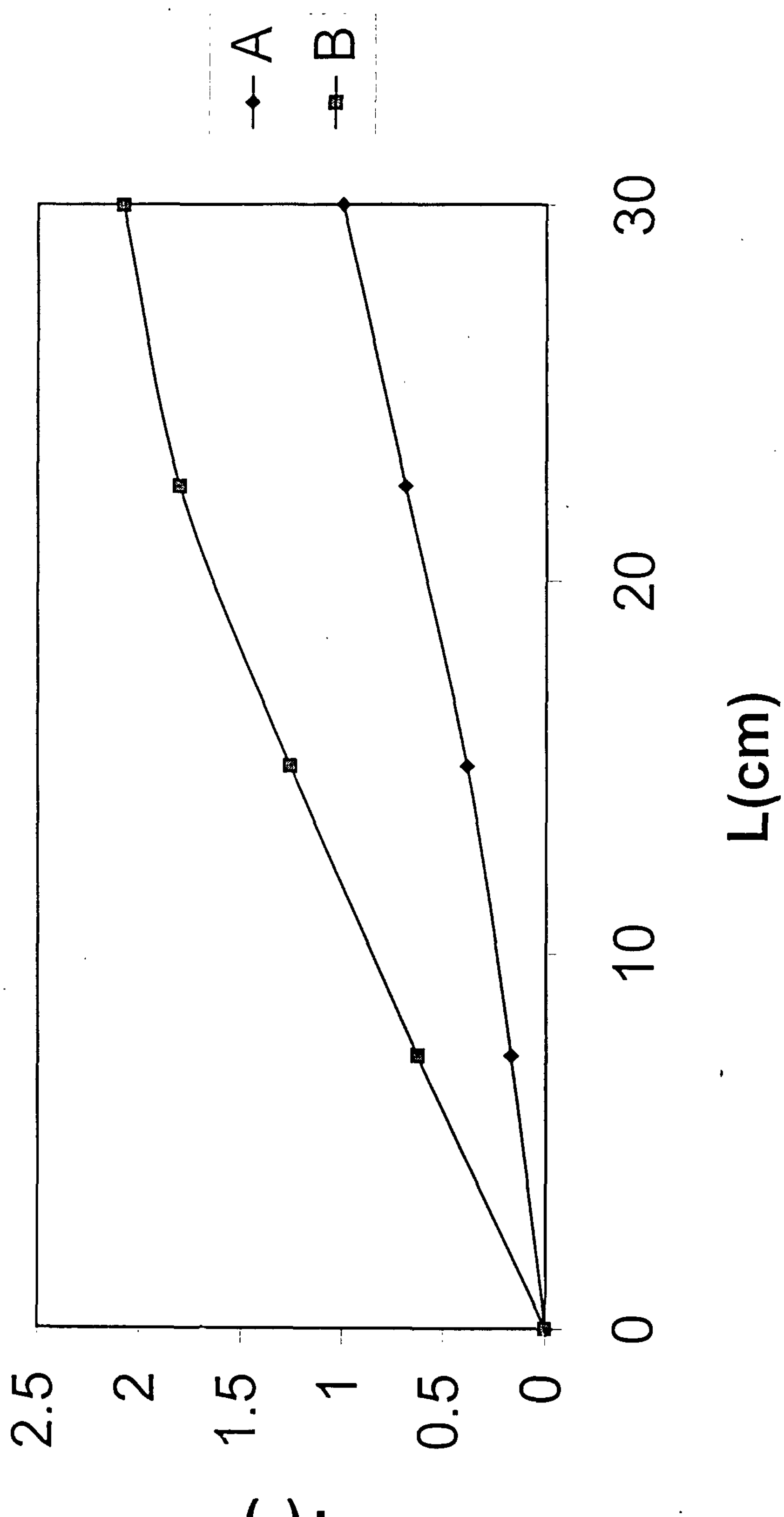


Fig. 4

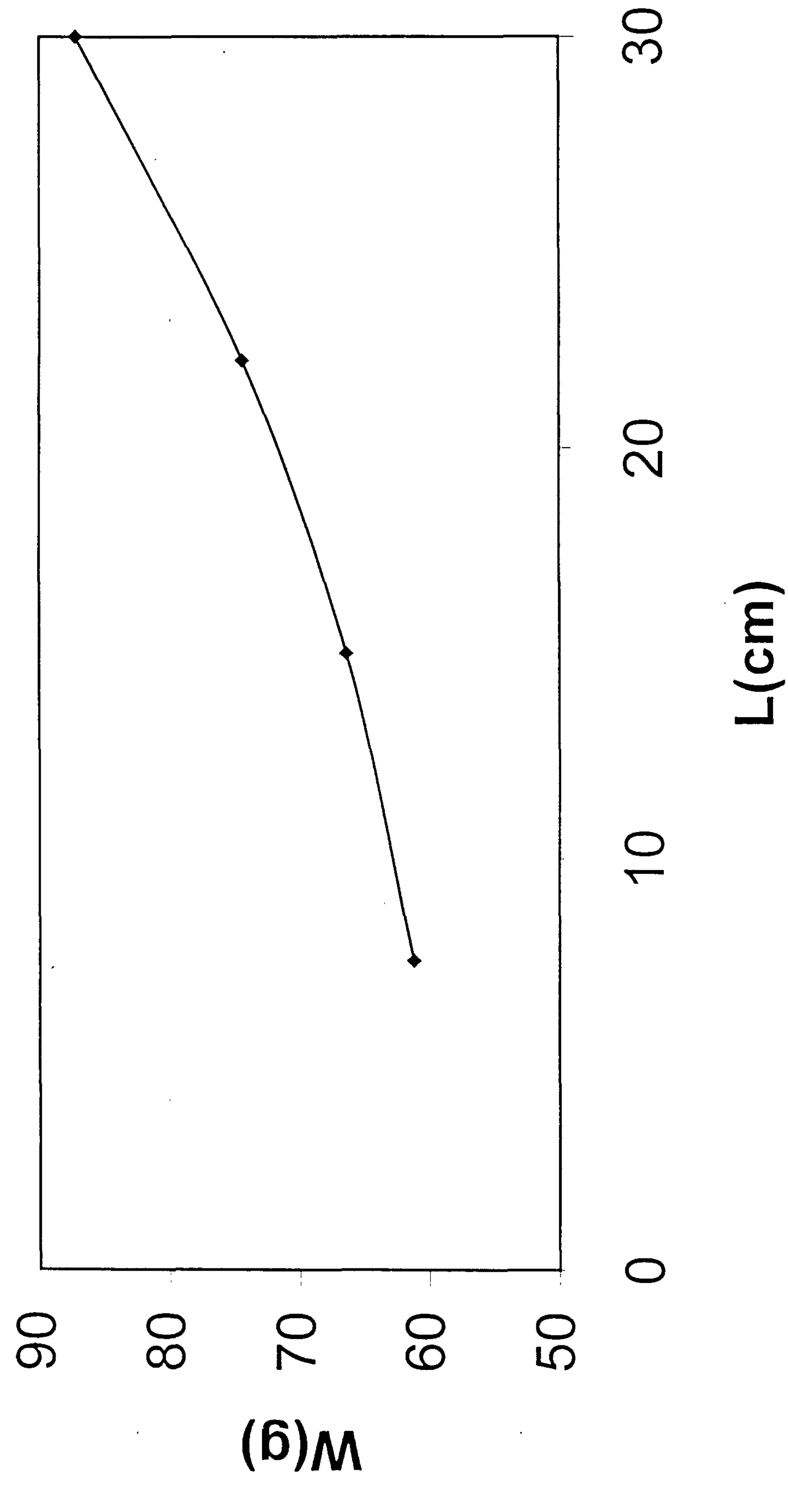


Fig. 6

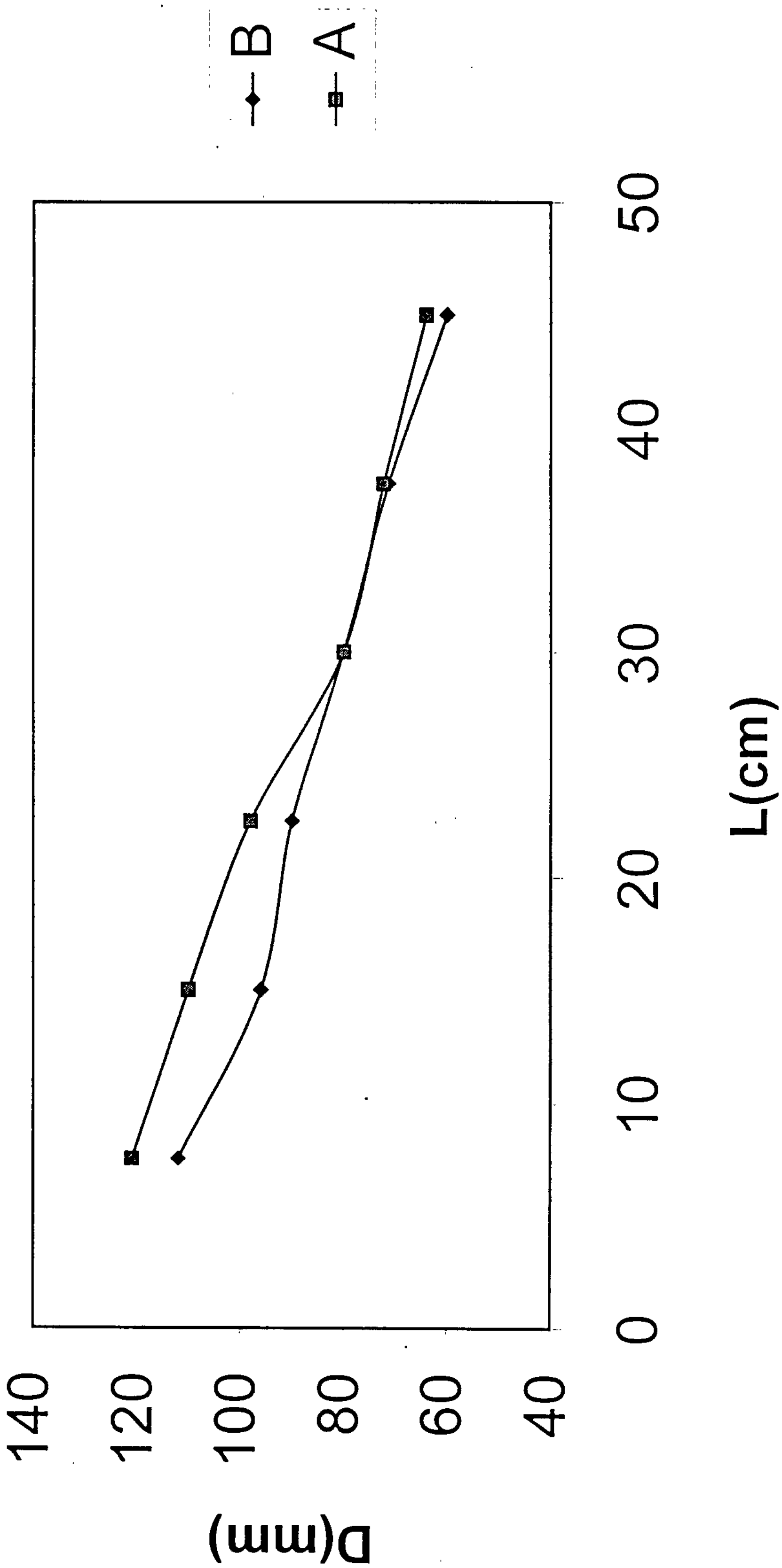


Fig. 7

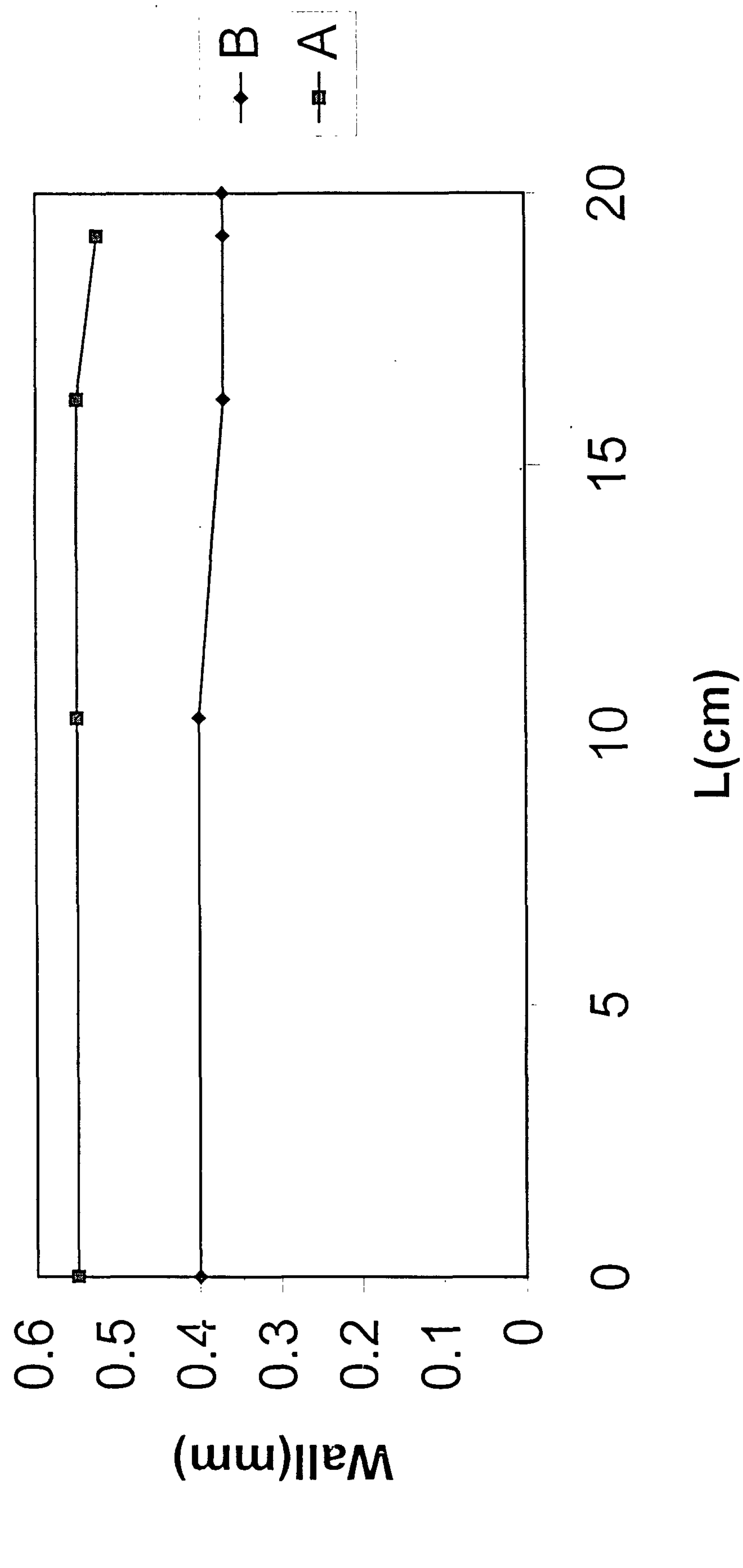
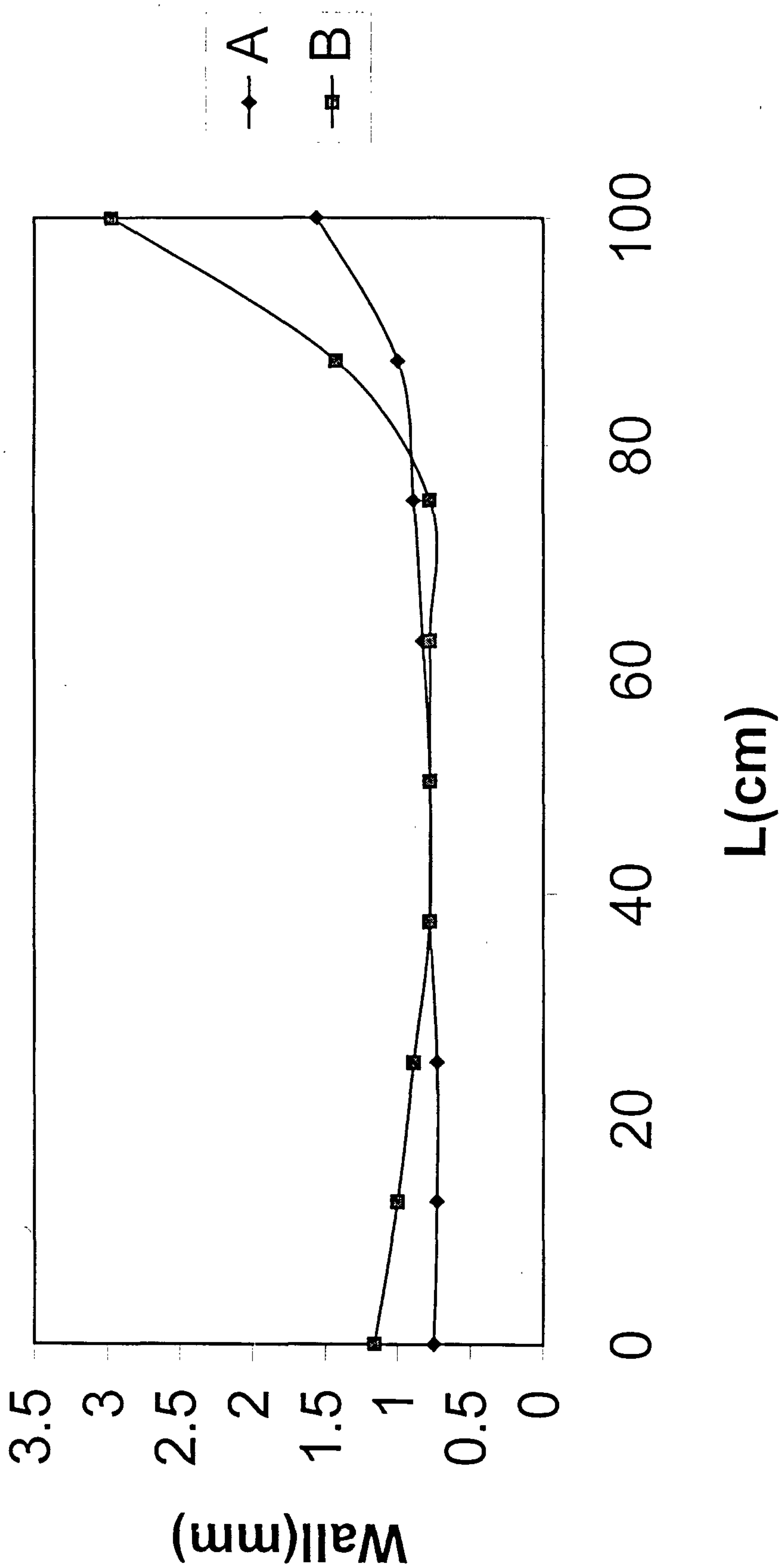


Fig. 8



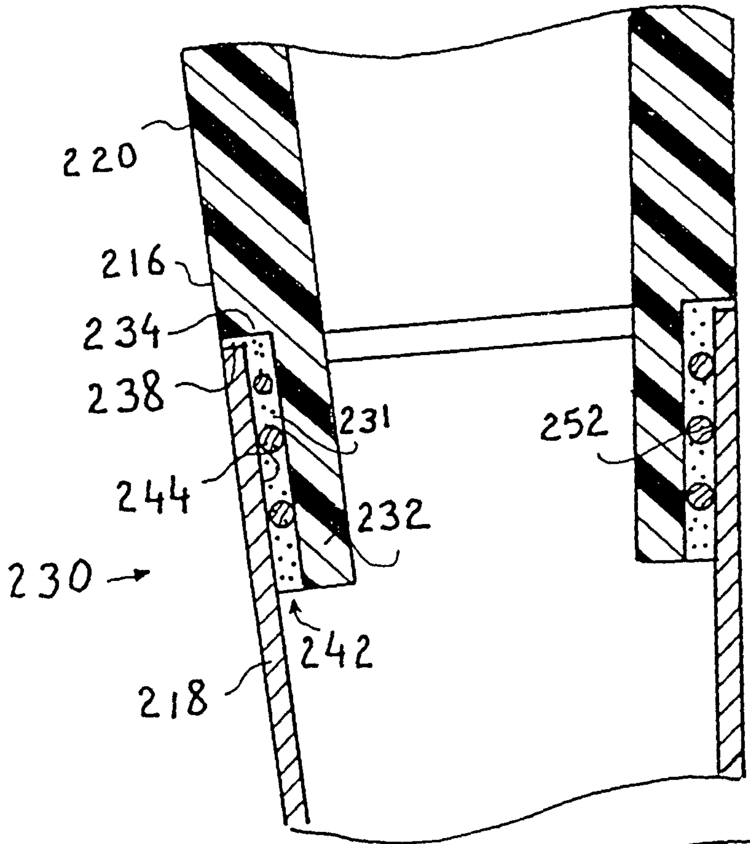

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Fig 9

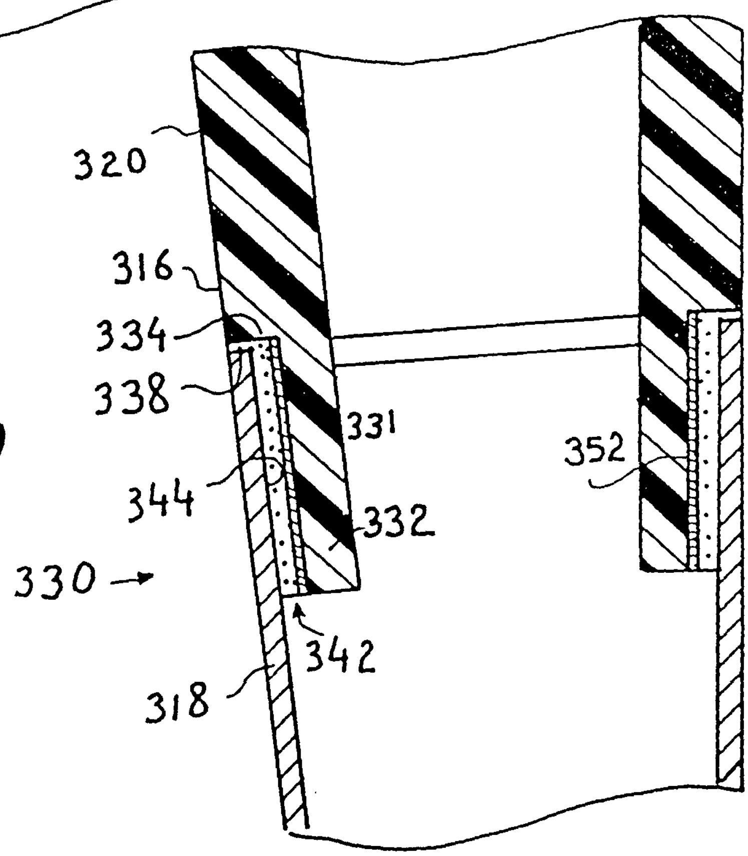
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Fig 10

Fig 11b

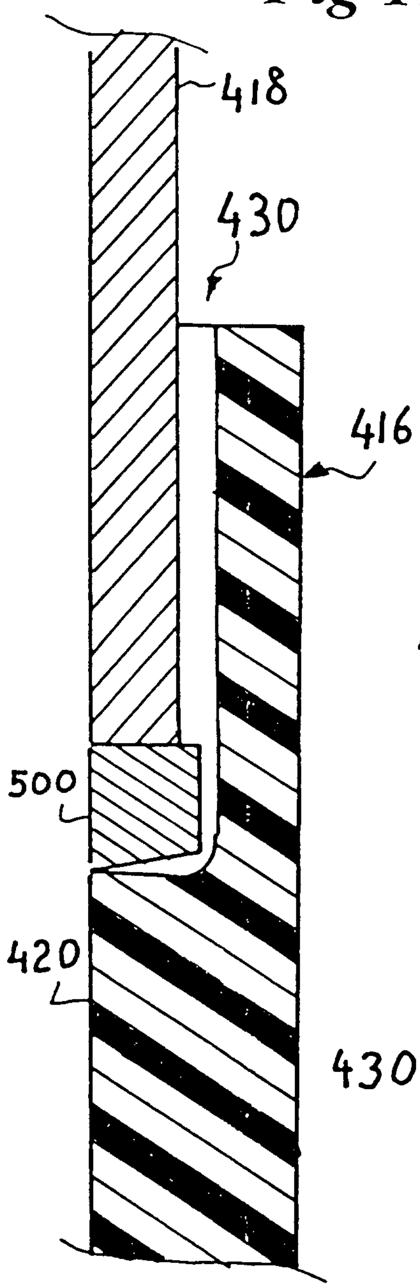
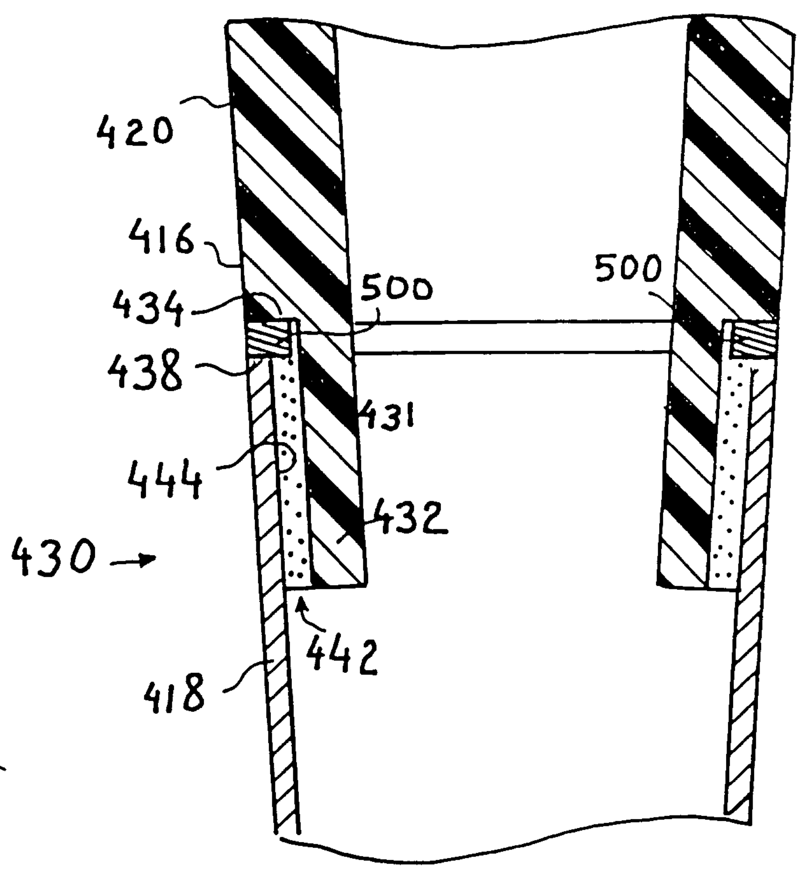


Fig 11a



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 87 0073

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.7)
D,X Y	US 4 836 545 A (POMPA J BENEDICT) 6 June 1989 (1989-06-06) * column 2, line 33 - line 68; figures 1-3 * * column 4, line 33 - line 57 *	4,5,7,10 1-3,6,8,9,11-14	A63B53/00 A63B53/10 A63B53/12
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EUROPEAN SEARCH REPORT

Application Number
EP 01 87 0073

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