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

(11) EP 1 329 271 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
23.07.2003 Bulletin 2003/30

(51) Int Cl.[7]: **B22D 41/58**, B22D 41/42, B22D 1/00

(21) Application number: **02250302.3**

(22) Date of filing: **16.01.2002**

(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

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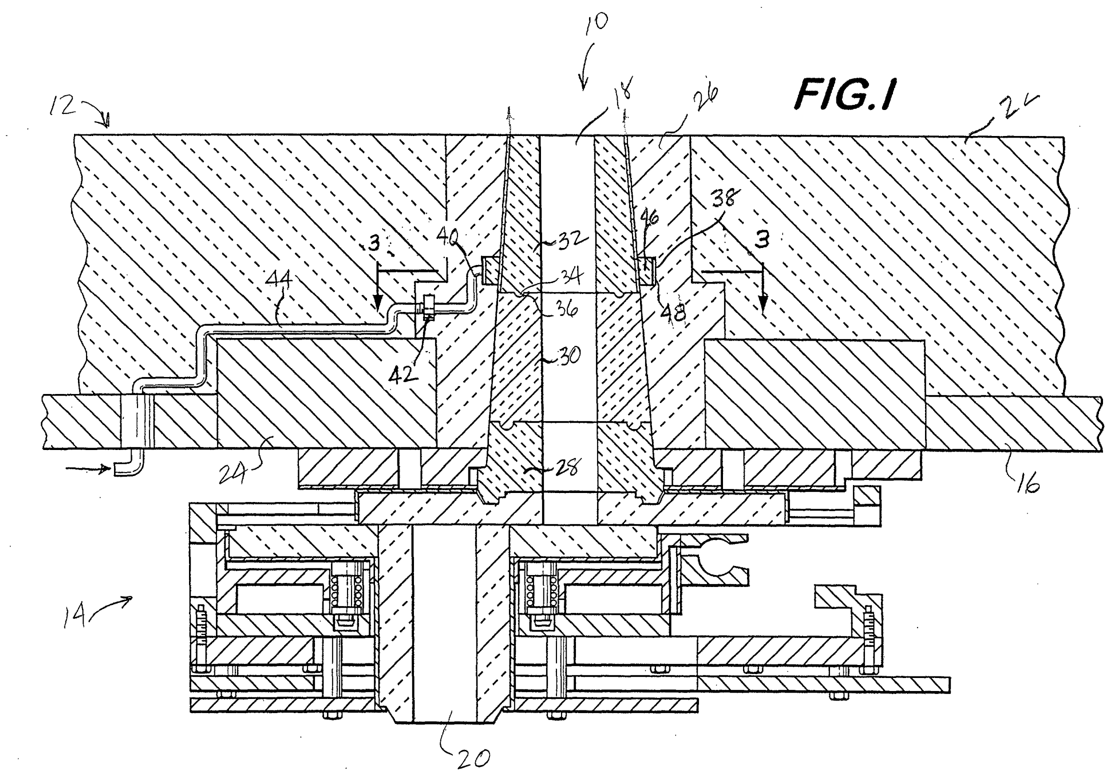
(54) Apparatus to facilitate opening of molten metal casting vessel

(57) An apparatus to facilitate opening of molten metal casting vessels (12) includes a well block (26) within a discharge port of a casting vessel. The well block has a central opening through it along a longitudinal axis. At least one nozzle insert (28,30,32) is located within the central opening, and has a central opening through it that is substantially coaxial with the central opening of the well block. The insert has an outer surface complementary to and matingly engaging the central opening of the well block and at least one channel (50) extending along the outer surface of the insert. The well block includes a plenum (48) substantially surrounding the central opening of the well block and in fluid flow communication with the channel. A fluid supply line (40) communicates with the plenum and supplies a fluid under pressure to the plenum and the channel. Fluid supplied to the plenum flows through the channel and the discharge port and into the interior of the vessel.

FIG.1



EP 1 329 271 A1

Printed by Jouve, 75001 PARIS (FR)

Description

Field of the Invention

[0001] The present invention relates to molten metal casting operations, and in particular to a system to facilitate self opening of a vessel discharge port in molten metal casting vessels.

Background of the Invention

[0002] Molten metal is often dispensed from a bottom discharge pouring and holding reservoir, referred to as a tundish, into casting molds. The tundish is usually kept supplied with molten metal from a ladle. At the bottom, the ladle usually has one or more discharge ports, or nozzles, each having a pouring channel through which molten metal flows to the tundish and then to the casting molds. The flow of molten metal through the pouring channel is often controlled by a slide gate valve.

[0003] Before tapping a heat from a furnace into the ladle, it is a common practice to close the slide gate valves and fill the pouring channel in the nozzles and the well area with a granular material, such as sand, so that the molten metal is not permitted to enter the pouring channel when the heat is tapped and the ladle filled with molten metal from the furnace. If molten metal were allowed to enter the pouring channel when the slide gate valve is in the closed position, the molten metal would freeze in the nozzle and obstruct the channel every time.

[0004] To begin pouring from the ladle, the slide gate valve is moved to the open position, and the granular material flows out of the pouring channel, followed by the molten metal. When this occurs without intervention, it is referred to as a free open or self open. However, ladles sometimes fail to self open because of chilling and/or crusting of a combination of the sand, metal, and possibly slag that may have remained in and around the well area prior to tapping the furnace into the ladle. In a high production facility, a very good free open rate might be 98-99% of the time, a fair free open rate would be about 95-97% of the time, and a poor rate would be 95% or less. It is extremely rare for the success rate to be 100% for periods longer than several months.

[0005] When a ladle does not self open, there are two important considerations. The ladle must be opened in a timely manner, usually within ten minutes or less, to continue the casting operation. In addition, the ladle should be opened with the ladle shroud in place to avoid exposing the molten metal to the atmosphere and/or pouring through the slag layer for a prolonged period.

[0006] When a ladle fails to self open, a number of procedures may be employed to open it. One technique is simply to manually strike the side of the ladle with a hand-held hammer. A sophisticated mechanical vibrating hammer is even more effective in opening stubborn ladles. Stroking the slide gate open and closed several times occasionally is enough to open the ladle.

[0007] If these expedients do not open the ladle, the most common approach to opening the ladle is to first remove the ladle shroud, and then insert an oxygen pipe into the metal pouring channel and lance through the obstruction. Initially, when the molten metal flow begins, it cannot be stopped for longer than a few seconds or it will freeze in the molten metal channel. It is common to pour for five to ten minutes before the ladle is completely shut off and the ladle shroud reattached. The event is commonly called "open pouring" because the metal is exposed to the atmosphere and the system is not closed. In addition, because the ladle shroud is not being used, the molten metal is being poured through the slag layer in the tundish, which introduces additional impurities into the finished product.

[0008] Another solution is to insert a telescoping lance into the ladle shroud and blow oxygen through the lance. When oxygen is injected, the telescoping lance will telescope into the metal pouring channel and automatically burn through whatever material is preventing the ladle from free opening. However, there are several problems associated with using a telescoping lance. Telescoping lances are costly, and they can take more time than desired. The reliability of telescoping lances is only 90 to 95%. Finally, by definition, telescoping lances introduce some oxygen into the metal, which is undesirable.

[0009] The present invention remedies the above problems through an improved system for injecting gas into the ladle near the nozzle inlet to aid in opening the vessel and facilitating the free flow of molten metal.

Summary of the Invention

[0010] In its broad aspect, the present invention is an apparatus to facilitate the opening of molten metal casting vessels, and comprises a well block within a discharge port of a casting vessel, the well block having a central opening therethrough along a longitudinal axis thereof; at least one nozzle insert within the central opening, the nozzle insert having a central opening therethrough substantially coaxial with the central opening of the well block through which molten metal may flow, an outer surface complementary to and matingly engaging the central opening of the well block, and at least one channel extending along the outer surface; a plenum within the well block and substantially surrounding the central opening of the well block and being in fluid flow communication with said channel; and a fluid supply line in communication with the plenum for supplying a fluid under pressure to the plenum and said channel. Fluid supplied to the plenum flows through the channel and upward into the interior of the vessel.

[0011] In another aspect, the invention is a discharge port for a molten metal pouring and holding vessel, and comprises an opening in a wall of the vessel and a well block located within the opening. The well block has a central opening therethrough lined with a refractory insert, the insert having a metal flow channel therethrough. The insert can be made of a material different from the material of the well block for improving the resistance of the insert to wear due to passage of molten metal therethrough, the insert being removable and replaceable after being subjected to a preselected amount of wear.

Brief Description of the Drawings

[0012] For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

> Figure 1 illustrates, in cross-section, the elements of the present invention, shown in context as installed in a pouring ladle having a pouring nozzle controlled by a slide gate valve.
> Figure 2 is an exploded view of a lower nozzle, upper nozzle, and ladle nozzle according to the present invention, shown apart from an associated well block.
> Figure 3 is a cross-sectional view of a modified nozzle well block according to the present invention, taken along the lines 3-3 in Figure 1.
> Figures 3A and 3B are partial sectional views of a portion of the modified nozzle well block of Figure 3, shown at different stages of fabrication.
> Figures 4 and 5 illustrate other styles of well blocks which can be used with the present invention.
> Figure 6 illustrates an alternative embodiment of the present invention.

Description of the Invention

[0013] The description contained herein is intended to be illustrative only and not limiting as to the scope of the present invention.

[0014] Referring now to the drawings, wherein like numerals indicate like elements, there is shown in Figure 1 an apparatus 10 for facilitating the opening of a molten metal casting ladle, in accordance with the present invention. While the present invention described herein is described in connection with a molten metal casting ladle, the invention is applicable generally to other types of bottom pour vessels for use in molten metal casting and smelting operations.

[0015] As shown in Figure 1, the nozzle arrangement 10 is shown in the context of a molten metal holding and pouring box in the form of pouring ladle 12 equipped with a vessel discharge port controlled by a conventional slide gate valve 14 mounted to the exterior of the bottom wall16 of ladle 12. Slide gate valve 14 controls the flow of molten metal through a pouring channel 18 therein and into a casting mold (not shown), as will be understood by those skilled in the art. Slide gate valve 14 is shown in the closed position in Figure 1. Slide gate valve 14 also has an open position (not shown in the figures) in which the opening 20 in the slide gate is aligned with the pouring channel 18.

[0016] The bottom of ladle 12 is lined with a refractory material 22 and includes a ladle level plate 24, preferably made of high temperature steel. Ladle level plate 24 supports a well block 26, which has a central opening through it. The central opening is tapered and increases in diameter from top to bottom. Located within the central opening are, from bottom to top, a bottom nozzle insert 28, a center nozzle insert 30, and a top nozzle insert 32. Each of the bottom nozzle insert 28, center nozzle insert 30, and top nozzle insert 32 has a central opening of constant diameter which together define pouring channel 18. The outer surfaces of each of the bottom nozzle insert 28, center nozzle insert 30, and top nozzle insert 32 is tapered to match the taper of the central opening through the well block 26. If desired, mating surfaces of the bottom nozzle insert 28, center nozzle insert 30, and top nozzle insert 32 may be provided with complementary tongues 34 and grooves 36 to facilitate their alignment and fit.

[0017] Of course, although three separate nozzle inserts are illustrated, the invention is not limited to a specific number of inserts. A single insert, or any other number of inserts, can be used without departing from the scope of the invention.

[0018] Well block 26 is provided with an annular groove 38 around its inner surface, located adjacent the bottom of top nozzle insert 32. Groove 38 is in fluid flow communication with a gas distribution line 40 which has a fitting 42 at one end. Gas distribution line 40 communicates, in turn, to a gas feed line 44 which is connected to a source (not shown) of gas under pressure. Preferably, fitting 42 includes a porous ceramic safety disk between gas distribution line 40 and gas feed line 44, to reduce the risk of runout of molten metal through gas distribution line 40 in the event of damage to top nozzle insert 32 or well block 26.

[0019] Preferably, although not necessarily, groove 38 has a porous ceramic ring 46 fitted therein. Porous ceramic ring 46 has an inner diameter approximately equal to the outer diameter of top nozzle insert 32 at the location where top nozzle insert 32 is adjacent groove 38. The inner diameter of porous ceramic ring 46 may have a taper which is complementary to and matches the taper of top nozzle insert 32. Porous ceramic ring 46 has an outer diameter which is slightly less than the depth of groove 38, so that it does not completely fill groove 38 but leaves a narrow annular plenum 48 between the vertical wall of groove 38 and porous ceramic ring 46.

[0020] Pressurized gas from the source flows in the direction of the arrow in Figure 1 through gas feed line 44 and gas distribution line 40 to annular groove 38. The gas flows through annular plenum 48, and quickly fills plenum 48. Once plenum 48 is filled with gas, the pressure of the gas forces the gas to flow through the ceramic ring 46 (if present) to the outer surface of top nozzle insert 32.

[0021] As best seen in Figure 2, the outer surface of top nozzle insert 32 has a grooved, or serrated, outer surface which defines a plurality of channels 50 which extend axially from top to bottom. Channels 50 permit gas forced through the ceramic ring 46 to flow axially along the outer surface of top nozzle insert 32 and upward into the interior of the ladle 12. The flow of gas serves to dislodge any solid debris or slag that can collect around the inlet to pouring channel 18, such as, for example, residual sand left over from packing the slide gate valve prior to opening the nozzle. To avoid undesired chemical and metallurgical reactions with the molten metal in the ladle, the gas is preferably an inert gas such as argon. However, any other gas can be used as appropriate for the desired effect. For purposes of the present invention, it is the mechanical, rather than chemical or metallurgical, interaction of the gas with the molten metal that agitates any accumulated material located near the inlet to pouring channel 18. The interaction of the gas with the material tends to break up slag, sand, solidified metal, or the like, which may accumulate and prevent pouring channel 18 from opening.

[0022] A preferred fabrication method is to hold the nozzle inserts, including top nozzle insert 32, in place in well block 26 using a refractory mortar 52. As illustrated in Figures 3, 3A, and 3B, a layer of mortar 52 is applied to the outer surface of each nozzle insert, including top nozzle insert 32, which joins each insert to the inner surface of the central opening in well block 26. Mortar alone is usually sufficiently porous to permit gas to flow through it, so that gas from plenum 48 can flow through ceramic ring 46 and along channels 50 through mortar 52.

[0023] Alternatively, a layer of burnout material 54 may first be placed over the outer surface of top nozzle insert 26, before the mortar 52 is applied. As those skilled in the art will understand, burnout material 54 is a non-refractory material which will burn at a temperature much lower than the operating temperature of the ladle 12. Thus, as ladle 12 is heated, burnout material 54 will burn and be consumed, leaving behind a space 56 between the top nozzle insert 32 and the layer of mortar 52. The space permits higher gas flow rates than can be realized with porous mortar alone.

[0024] Although the invention has been illustrated and described with reference to a well block having a continuously tapered central opening, the invention is equally applicable to other styles of well block, as well. For example, the invention can be used with a so-called canopy style well block 58, illustrated in Figure 4, and with a so-called stovepipe style well block 60, illustrated in Figure 5. In each case, the well block is modified to include groove 38, gas distribution line 40, and fitting 42. Also in each case, a top nozzle insert with a serrated outer surface similar to top nozzle insert 32 illustrated in Figures 1 and 2, can be inserted into the central opening in the well block adjacent groove 38, to permit gas to be introduced as already described in connection with the embodiment illustrated in Figure 1. Likewise, a porous ceramic ring may be placed within groove 38, in the same manner as illustrated in Figure 1.

[0025] The invention offers additional benefits. For example, top nozzle insert 32 may be used even without a source of gas as a sacrificial insert to protect the associated well block. As those skilled in the art will understand, as a result of use the inserts and the well block will wear away and will have to be replaced. It is widely known that well block performance, measured by the number of heats that can be poured before the well block must be replaced, can be increased significantly (10% to 20%) by using a canopy style well block such as illustrated in Figure 4, compared to a stove pipe style well block such as illustrated in Figure 5.

[0026] The major reason some casting operations do not use the canopy design is that in those operations, the nozzle inserts are removed by pushing a metal rod that is slightly smaller than the opening at the top of the well block but larger than the bore of the top nozzle insert into the well block throat 62, forcing the inserts down and out of the well block. A few casting operations use a canopy style well block where the opening at the top is larger than necessary to accommodate this method of removal. In many cases, the well block is damaged by the metal rod used to remove the nozzle inserts when the steel rod is not inserted exactly into the center of the opening.

[0027] The configuration shown in Figure 6, without the gas feed feature of the invention, lends itself to a unique well block design that incorporates a removable and replaceable canopy. In Figure 6, top nozzle insert 64, referred to in this instance as a canopy nozzle insert, does not have a serrated outer surface but has a smooth one. The outer diameter of canopy nozzle insert 64 is slightly smaller than the inner diameter of the central opening in well block 60. Canopy nozzle insert 64 is joined to well block 60 by mortar, in conventional fashion.

[0028] Canopy nozzle insert 64 is fabricated from a refractory material, and can be the same material as, or a material different from, the material of well block 60. For example, canopy nozzle insert 64 can be fabricated from a better-wearing material, thus extending its service life. After pouring enough heats to deplete the service life of the well block by 30% to 50%, canopy nozzle insert 64 can be replaced to restore the well block to 80% to 90% of its original service life. Removal and replacement of canopy nozzle insert 64 can be done many times, greatly extending the service life of the well block 60. As a result, the service life of the well block can be eliminated as a limiting factor in the service life of the ladle refractory system.

[0029] The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification, as indicating the scope of the invention.

Claims

1. An apparatus to facilitate opening of molten metal casting vessels, comprising

a. a well block within a discharge port of a casting vessel, the well block having a central opening therethrough along a longitudinal axis thereof,
b. at least one nozzle insert within the central opening, the nozzle insert having a central opening therethrough substantially coaxial with the central opening of the well block through which molten metal may flow, an outer surface complementary to and matingly engaging the central opening of the well block, and at least one channel extending along the outer surface,
c. a plenum within the well block and substantially surrounding the central opening of the well block and being in fluid flow communication with said channel, and
d. a fluid supply line in communication with the plenum for supplying a fluid under pressure to the plenum and said channel,

whereby fluid supplied to the plenum flows through the channel and upwardly into the interior of the vessel.

2. An apparatus to facilitate opening of molten metal casting vessels as in claim 1, further comprising a porous ceramic ring located within the plenum and substantially surrounding the outer surface of the nozzle insert.

3. An apparatus to facilitate opening of molten metal casting vessels as in claim 1, wherein the at least one channel is defined by serrations on the outer surface of the nozzle insert.

4. An apparatus to facilitate opening of molten metal casting vessels as in claim 1, wherein the nozzle insert is made of a refractory material.

5. A nozzle insert for a discharge port of a molten metal casting vessel, the insert having a central opening centered about a longitudinal axis of the insert and defining a passage for the flow of molten metal therethrough and having an outer surface shaped to fit an interior surface of the discharge port, the outer surface including at least one fluid flow channel which extends between respective opposite ends of the insert.

6. A nozzle insert for a discharge port of a molten metal casting vessel as in claim 5, wherein the outer surface includes a plurality of fluid flow channels extending substantially longitudinally between said respective opposite ends.

7. A nozzle insert for a discharge port of a molten metal casting vessel as in claim 6, wherein the fluid flow channels are defined by serrations on the outer surface of the nozzle insert.

8. In a molten metal casting vessel having a discharge port, a system for opening the discharge pork, comprising

a. a well block within the discharge port and having a central opening therethrough along a longitudinal axis thereof,
b. a nozzle insert within the central opening, the nozzle insert having a central opening therethrough substantially coaxial with the central opening of the well block through which molten metal may flow, an outer surface complementary to and matingly engaging the central opening of the well block, and at least one channel extending along the outer surface,
c. an annular groove within the inner wall of the well block and substantially surrounding the central opening of the well block, the groove being open to said channel, and
d. a conduit extending between an outer surface of the well block and the groove for conveying a pressurized gas to the groove,

whereby pressurized gas supplied to the groove flows through the channel and upwardly into the interior of the vessel.

9. The system of claim 8, further composing a porous ceramic ring located within the groove and substantially surrounding the outer surface of the nozzle insert.

10. The system of claim 8, wherein the at least one channel is defined by serrations on the outer surface of the nozzle insert.

11. The system of claim 8, wherein the nozzle insert is made of a refractory material.

12. A molten metal pouring system, comprising

a. a molten metal holding and pouring vessel having a discharge port,
b. a slide gate valve at the outlet of the discharge port for controlling the flow of molten metal from the discharge port,
c. a well block within the discharge port and up-

stream of the slide gate valve, the well block having a central opening therethrough,

d. a nozzle insert within the central opening, the nozzle insert having a molten metal flow channel therethrough substantially coaxial with the central opening of the well block, an outer surface complementary to and matingly engaging the central opening of the well block, and at least one channel extending along the outer surface,

e. a plenum within the well block and substantially surrounding the central opening of the well block and being in fluid flow communication with said channel, and

f. a fluid supply line in communication with the plenum for supplying a fluid under pressure to the plenum and said channel,

whereby fluid supplied to the plenum flows through the channel and upwardly into the interior of the vessel.

13. The system of claim 12, further comprising a porous ceramic ring located within the plenum and substantially surrounding the outer surface of the nozzle insert.

14. The system of claim 1, wherein the nozzle insert is made of a refractory material, and wherein the at least one channel is defined by serrations on the outer surface of the nozzle insert.

15. A modified well block for a molten metal pouring an holding vessel, the well block having a central opening therethrough, a refractory insert located within the central opening and having an outer surface substantially conforming to the central opening, the refractory insert defining a molten metal flow channel therethrough, the refractory insert being selectively removable from the well block after a preselected time and replaceable by a new refractory insert.

16. A discharge port for a molten metal pouring and holding vessel, comprising an opening in a wall of the vessel and a well block located within the opening, the well block having a central opening therethrough lined with a refractory insert, the insert having a metal flow channel therethrough, the insert being made of a material different from the material of the well block for improving the resistance of the insert to wear due to passage of molten metal therethrough, the insert being removable and replaceable after being subjected to a preselected amount of wear.

17. An apparatus to facilitate opening of molten metal casting vessels, comprising

a. a well block within a discharge port of a casting vessel, the well block having a central opening therethrough along a longitudinal axis thereof,

b. at least one nozzle insert within the central opening, the nozzle insert having a central opening therethrough substantially coaxial with the central opening of the well block through which molten metal may flow, an outer surface complementary to and matingly engaging the central opening of the well block, and at least one channel extending along the outer surface,

c. a plenum within the well block and substantially surrounding the central opening of the well block and being in fluid flow communication with said channel, and

d. a gas supply line in communication with the plenum for supplying a gas under pressure to the plenum and said channel,

whereby gas supplied to the plenum flows through the channel and upwardly into the interior of the vessel.

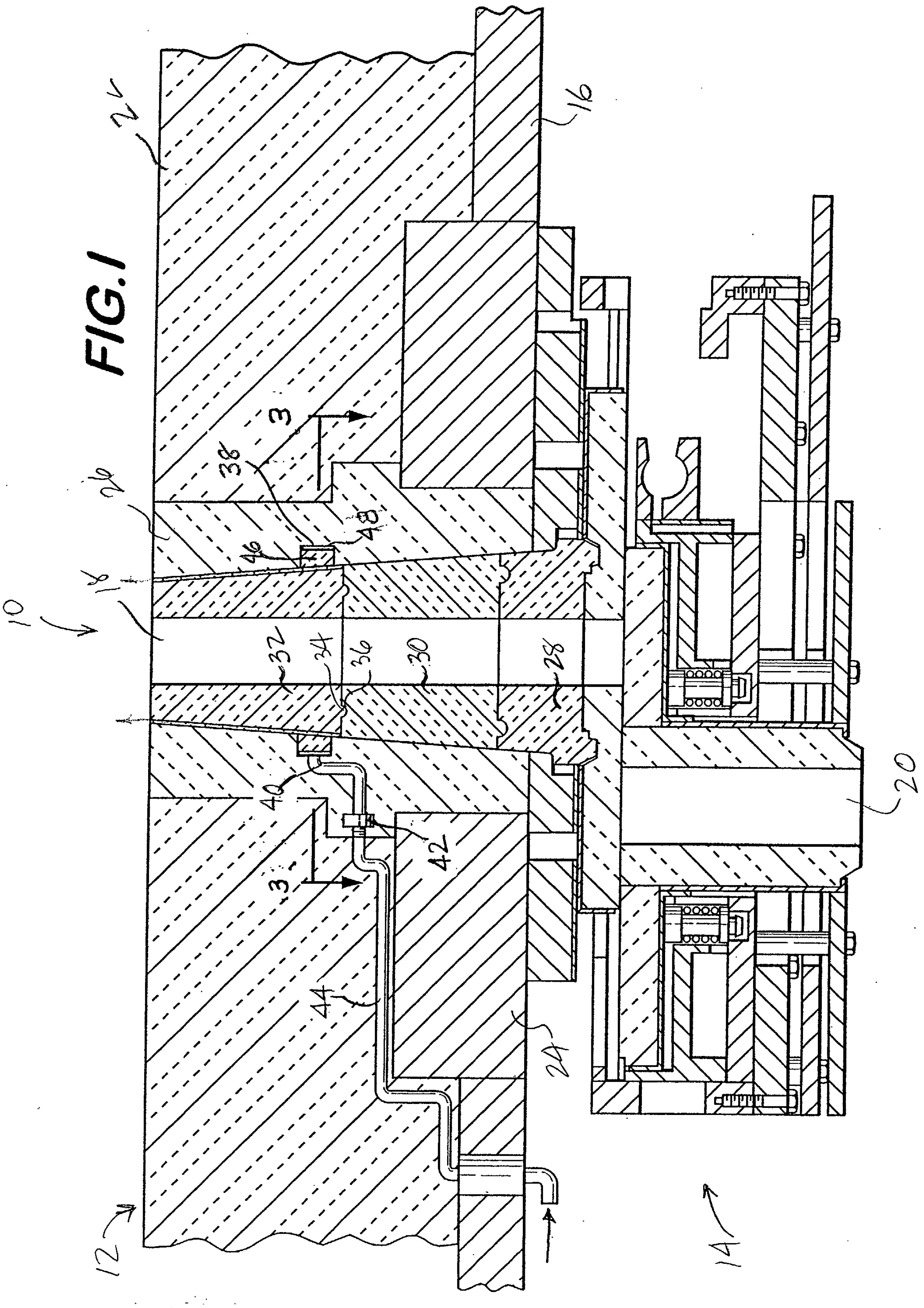


FIG.1

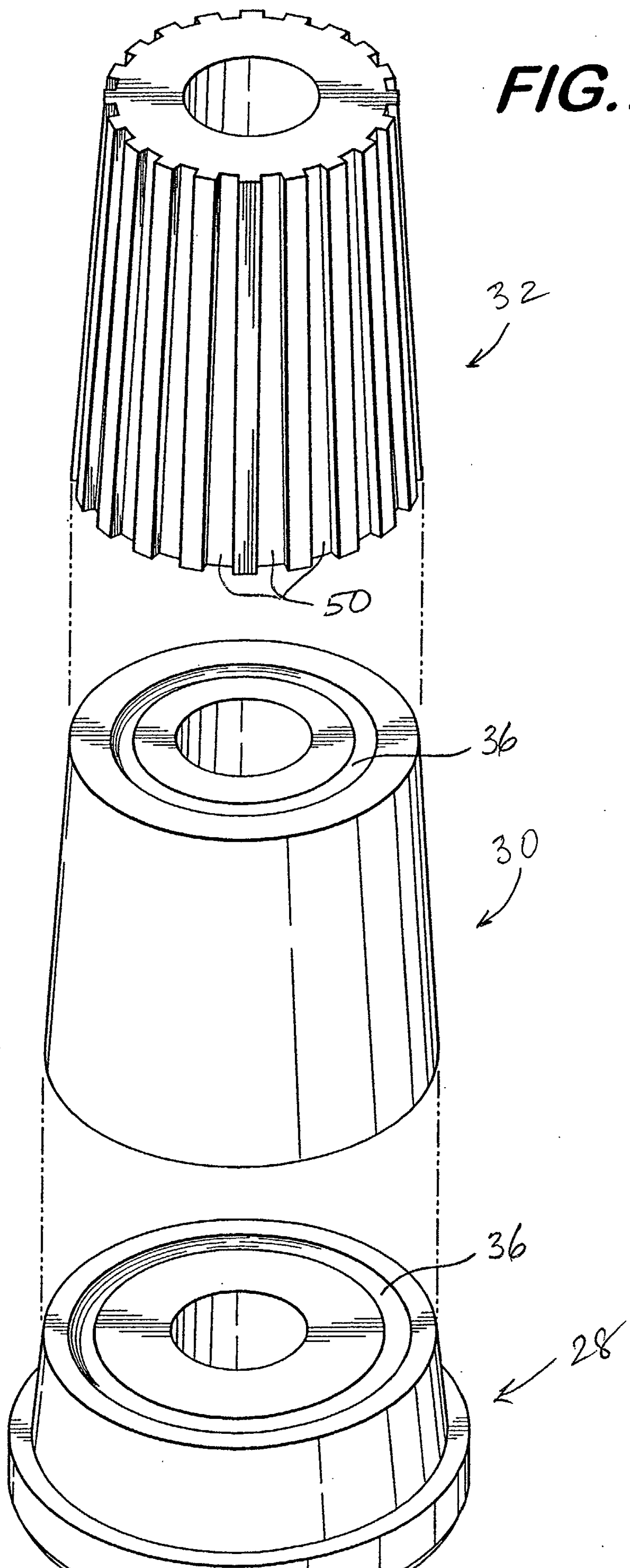
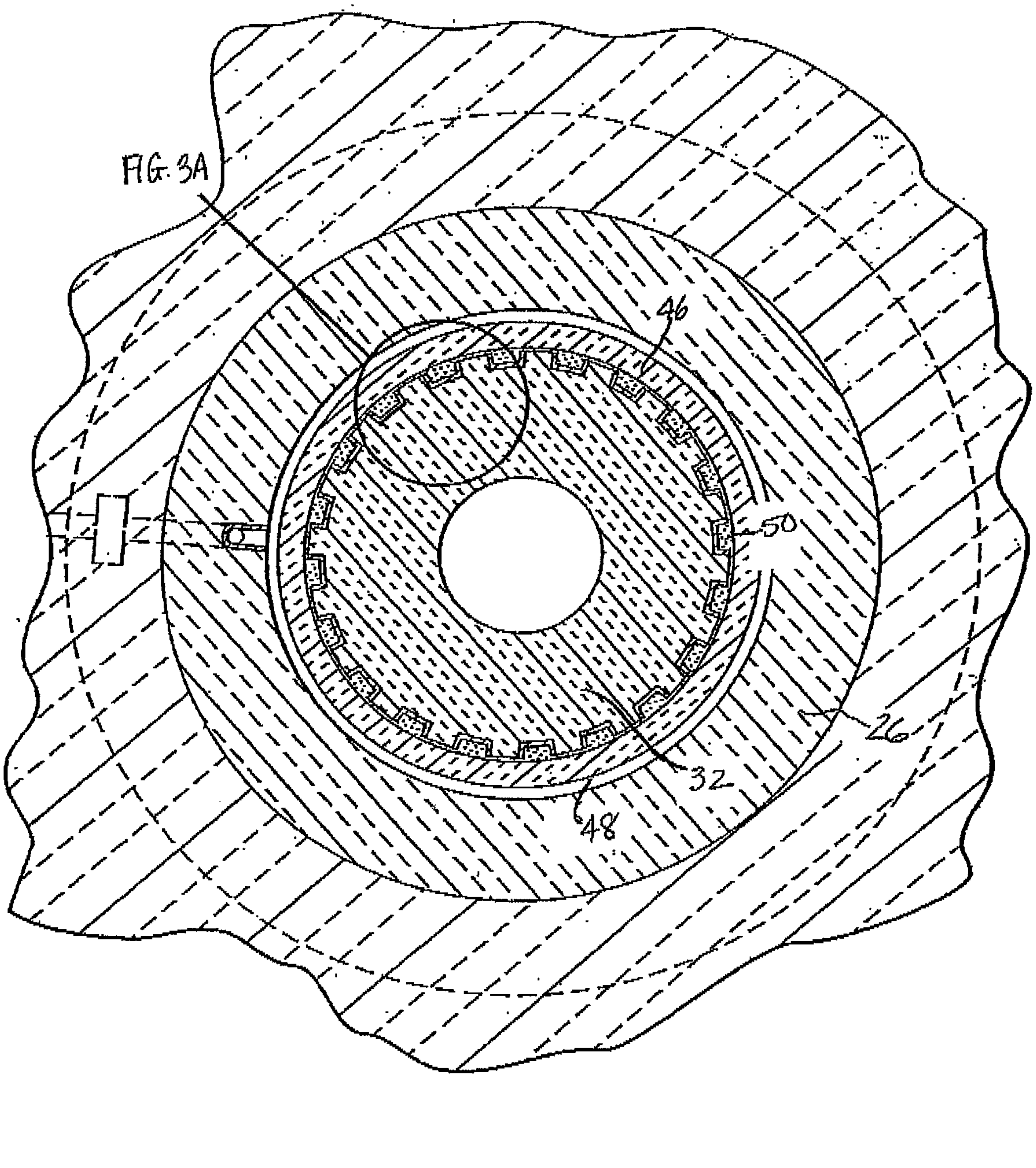


FIG. 2

FIG. 3



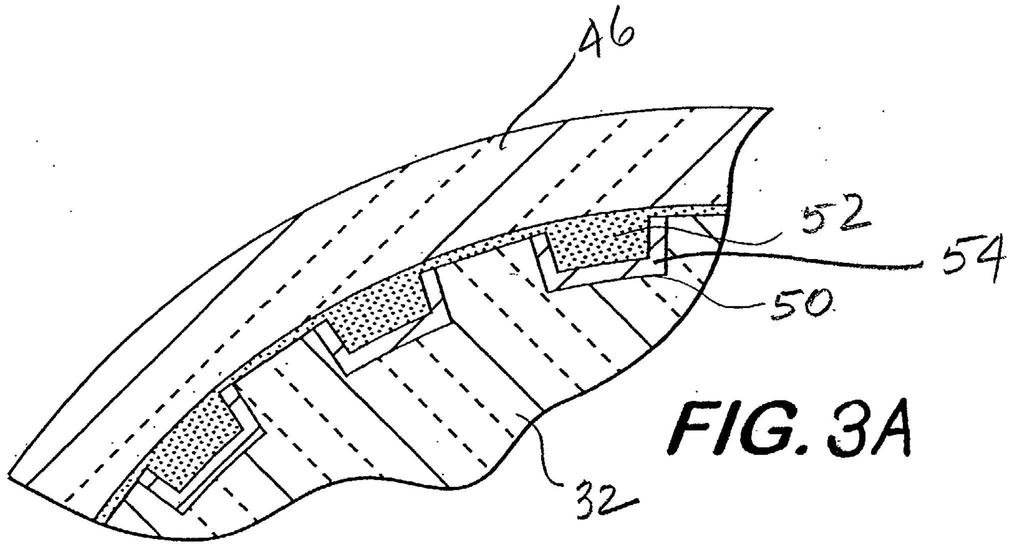


FIG. 3A

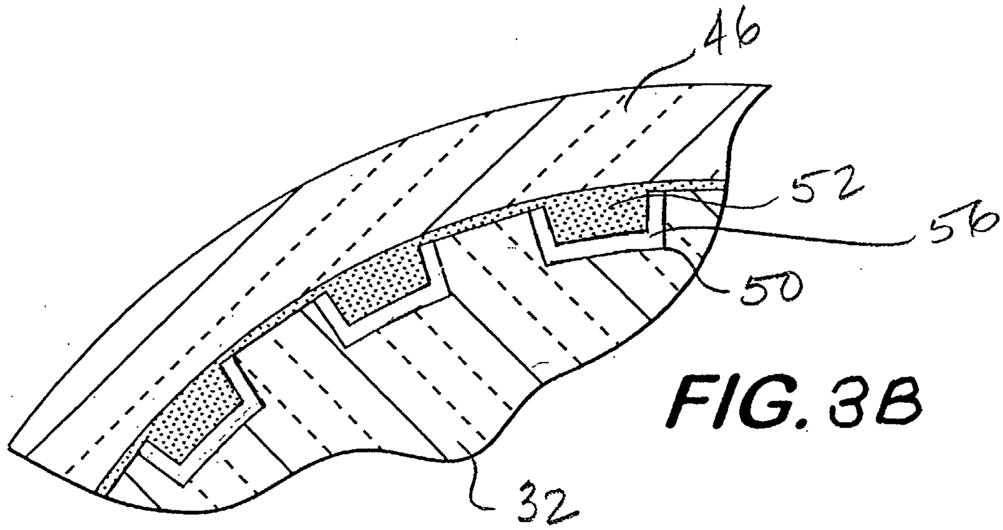
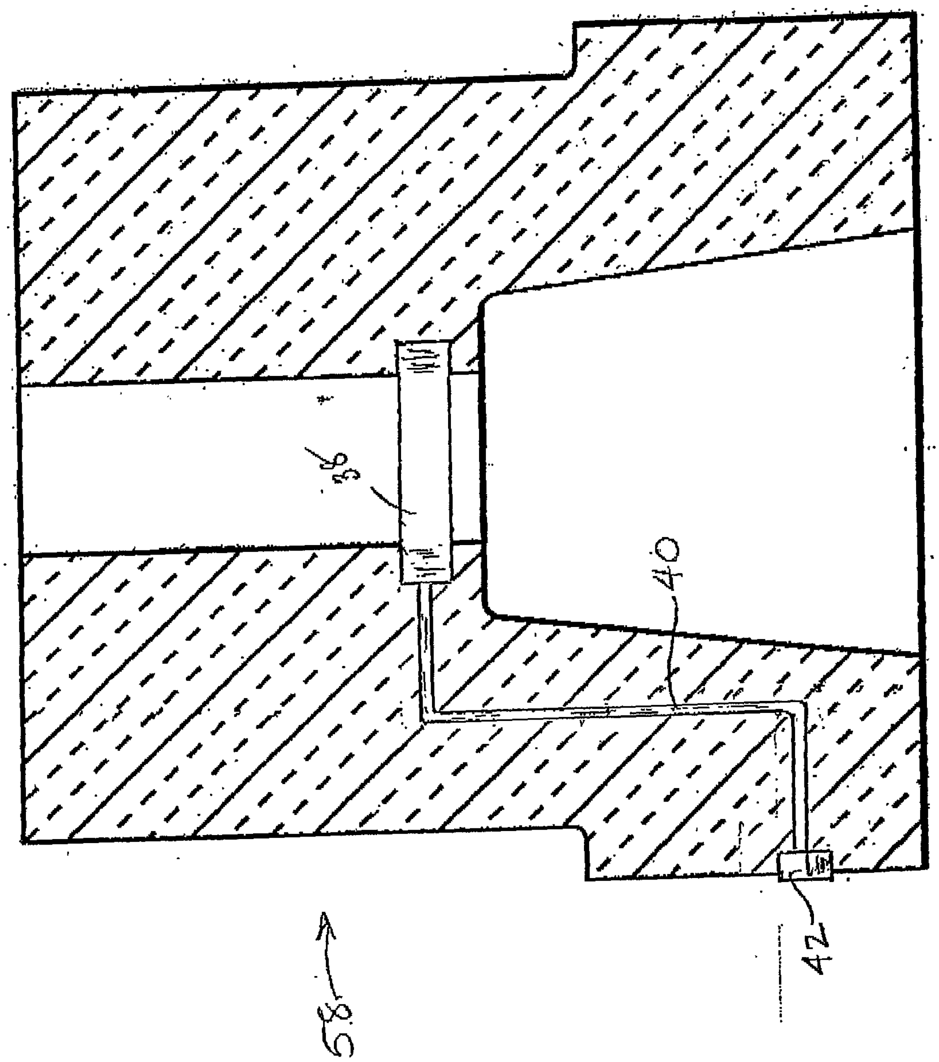


FIG. 3B

FIG. 4



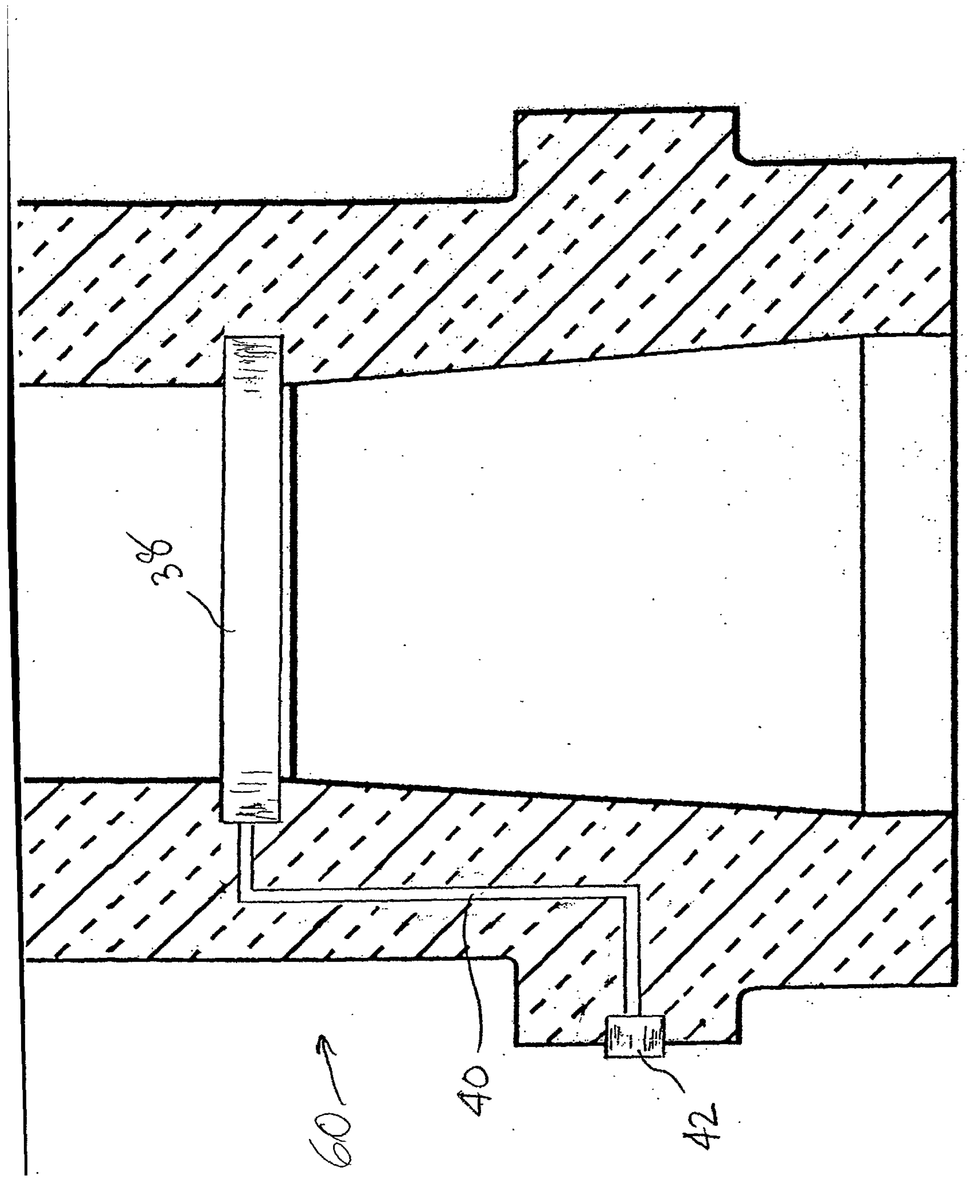


FIG.5

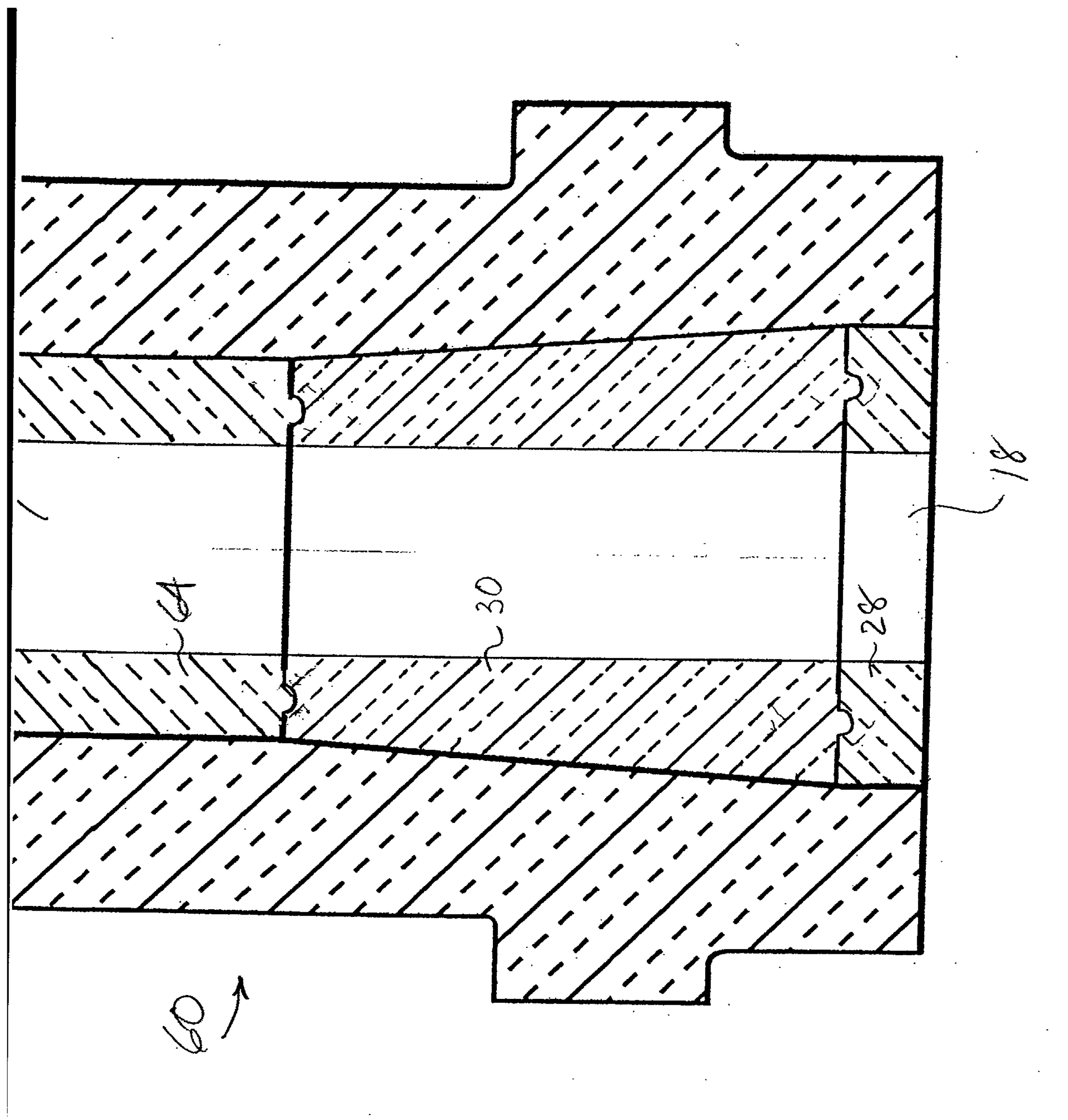


FIG.6

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EUROPEAN SEARCH REPORT

Application Number
EP 02 25 0302

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)
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X Y	EP 0 187 924 A (COMETUS AG) 23 July 1986 (1986-07-23) * page 5, last paragraph - page 11, line 10; figures 1-4 *	1,4,8, 11,12,17 3,6,7, 10,14	
X	US 3 253 307 A (GRIFFITHS DAVID K ET AL) 31 May 1966 (1966-05-31) * column 2, line 36 - line 72; figures 2,3 *	5	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	7 June 2002	Mailliard, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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X	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 13, 30 November 1999 (1999-11-30) & JP 11 207457 A (TOSHIBA CERAMICS CO LTD), 3 August 1999 (1999-08-03) * abstract *	15	
X	US 3 464 598 A (CURRY WILLIAM J JR) 2 September 1969 (1969-09-02) * the whole document *	16	
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