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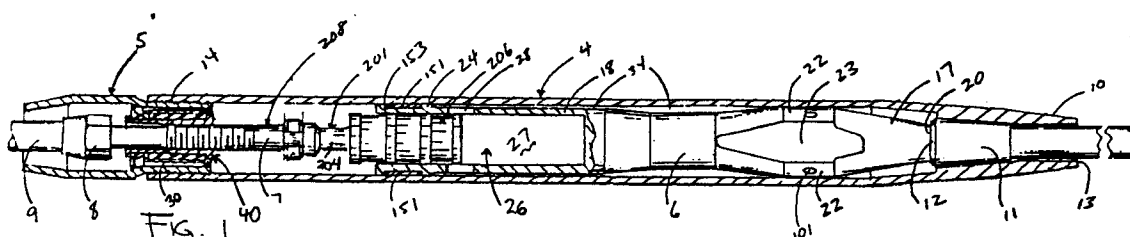
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54 **Air driven impact operated ground piercing tool.**

57 An improved ground piercing tool includes a reciprocating striker (6) having, on its posterior end, a resilient sealing bearing (151) preferably made of a long-wearing, high-lubricity material such as oil-filled nylon and, on its anterior end, two or more spot bearings (101) of relatively small surface area and made of a long-wearing, resilient, high-lubricity material such as oil-filled nylon. A tubular air inlet air valve (208) of this invention may include a sleeve - (201) constructed of a flexible, high-lubricity plastic material which sleeve (201) is connected to a metal air inlet pipe (7).



EP 0 224 859 A1

AIR DRIVEN IMPACT OPERATED GROUND PIERCING TOOL

This invention relates to improvements in air driven, impact operated ground piercing tools.

Impact-operated ground piercing tools designed for horizontal earth boring generally comprise an elongated metal housing, a striker reciprocable back and forth in the housing, and an air valve for driving the striker coaxially supported in the rear end of the housing. A hose supplying compressed air is connected to the air valve. The rear of the striker has a tubular, rearwardly opening well in which a stepped sleeve having an enlarged front end portion is received with a close sliding fit, so that the sleeve and the rear portion of the striker define a variable volume inner chamber. Pressurized air from the hose, conducted into the inner chamber through the air valve, drives the striker forward against an anvil surface at the front end of the housing. The momentum produced by this impact drives the housing forward in the ground.

As the striker nears the front of its stroke, radially opening ports through its tubular wall portion pass the front edge of the stepped sleeve, and are thus uncovered, so that pressurized air flows out of the inner chamber and into an outer chamber defined by the inside of the housing and the outside of the striker. Air pressure in this outer chamber acts upon the entire cross-sectional area of the striker to propel the striker rearwardly until its ports are behind the elongated part of the sleeve, whereupon air from the outer chamber is exhausted to the atmosphere through the ports in the striker by way of rearwardly opening exhaust passages in the housing.

The air valve and striker are usually concentrically supported in the housing. The acceleration of the housing at each advance and the inertia of the air valve and the hose attached to it transmit great force through the connection between the housing and the air valve. Therefore, a rigid connection between the air valve and the housing can break after a short period of operation unless it is strong and heavy. A shock dampening connection between the housing and the air valve and a certain amount of flexibility in the sleeve of the air valve are more likely to have a long useful life than a tool having rigid connections.

The junctures between the rear of the striker and the housing and between the sleeve and the well of the striker must be freely slidable and sealed against air leakage. In practice, obtaining optimal sliding freedom and sealing has proven extremely difficult, especially in tools with metal-to-metal contact at these junctures.

A typical metal-to-metal tool is described in Sudnishnikov U.S. Patent No. 3,756,328. In such tools, adequate sliding freedom at the junctures requires a clearance fit of about 0.385 mm at the juncture. Larger clearances cause sealing and tool efficiency to suffer, and smaller clearances increase sliding friction and reduce tool efficiency.

According to this invention, increased tool speed, efficiency, power, and reliability can often be obtained by the use of spot bearings and a sealing bearing of low surface area on respective anterior and posterior portions of the striker. These improvements reduce sliding friction between the striker and the housing and heighten air pressure retention in the outer chamber during rearward motion of the striker. While some known tools use antifriction and sealing materials on their strikers, none has achieved the simplicity, efficiency and reliability of this invention.

According to another feature of this invention, reduced sliding friction with enhanced sealing is achieved between the stepped sleeve and the interior of the striker by constructing the sleeve of a flexible plastic material having antifriction properties. This sleeve further has a series of bearing lands or ribs on its enlarged front portion. Such a sleeve reduces sliding friction between the sleeve and the striker and improves sealing between the striker and the sleeve. In addition, flexibility in the sleeve itself can reduce the effect of shock and flexure on the tool. Certain earlier tools, including one described in Sudnishnikov, et al. U.S. Patent 3,410,354, utilize a flexible hose to replace the posterior portion of the sleeve or connect the sleeve to the air inlet pipe. According to this invention, the entire sleeve may be made of flexible plastic to reduce shock and the effect of side-to-side movement of the air inlet hose.

The invention described herein is important for small tools having diameters of less than about 7.7 cm. In small diameter tools, the smaller space in the posterior end of the tool reduces the flexibility of the shock dampening coupling of the air valve. This reduces the ability of the tool to resist shock and pressure.

In the accompanying drawings, which illustrate a preferred embodiment of the invention:

Fig. 1 is a view of the borer in longitudinal section;

Fig. 2 is a view in longitudinal section of the rear portion of the borer, on a larger scale than Fig. 1;

Fig. 3 is a view of the spot bearing member in place in the striker, in longitudinal section;

Fig. 4 is a view of the spot bearing member in place in the striker, in transverse section;

Fig. 5 is an overhead view of an alternative configuration of spot bearing;

Fig. 6 is a view of the sealing bearing;

Fig. 7 is a view of the sleeve;

Fig. 8 is a view of the air valve and sleeve of a prior art tool; and

Fig. 9 is a view of the striker of another prior art tool.

An example of an impact operated earth borer of this invention as shown in the drawings comprises an elongated hollow housing 4 and a tailpiece 5, a striker 6 that reciprocates lengthwise in housing 4, and an air valve 208 comprising a threaded metal air inlet pipe 7 connected to a plastic sleeve 201. These are connected to the rear inlet pipe 7 by coupling 8 for hose 9 whereby pressurized fluid is supplied to the borer. Hose 9 is connected to a source of compressed air.

The exterior of housing 4 defines a nose 10 which tapers to a blunt or pointed front end, depending upon the nature of the ground in which the borer is to operate, but along most of its length the housing body is cylindrical and has a uniform outside and inside diameter. An anvil 11 in the front interior part of the housing 4 provides a rearwardly facing impact surface 12 which is percussively engaged, during forward operation of the borer, by the front end of striker 6. Anvil 11 can be specially hardened and its front end portion 13 projects beyond the housing 4. A rear end portion of housing 4 has internal threads 14 for connection with tailpiece 5.

Striker 6 is solid along most of its length. Its nose 17 tapers frustoconically to a forwardly facing impacting surface 20 that engages impact surface 12 of anvil 11. Along an axial, short guiding zone 22 of striker 6 behind tapered nose 17, striker 6 has a close, sliding fit in housing 4. Circumferentially spaced-apart flat faces 23 interposed between guiding zones 22 define passages through which air can flow forwardly and rearwardly between striker 6 and housing 4. Oil-filled nylon spot bearings 101 are set into the center of each guiding zone 22 to support the striker 6 in the interior of the housing 4 and reduce sliding friction. Figure 5 shows an alternative elongated spot bearing 105.

From guiding zone 22 to near its rear end, striker 6 has an outside diameter substantially smaller than the inside diameter of housing 4. A rear end portion 24 of striker 6 has an enlarged diameter and has a close sliding fit in housing 4 to provide an air seal. To reduce sliding friction, a sealing bearing 151, described further below, is fitted into an annular groove 153 in rear end portion 24 of striker 6.

Sleeve 201 of tubular air inlet 208 has a coaxial bore 203 extending through its entire length. Sleeve 201 of inlet 208 has a front portion 206 of enlarged diameter to have a close slidable and substantially sealing fit in tubular recess 26 at the rear of striker 6. Sleeve 201 is made of a tough, low-friction plastic material. Bearing lands 207 encircle the enlarged front portion 206 of sleeve 201. Sleeve 201 is connected to threaded air inlet tube 7 by threaded fitting 202. A narrowed neck 204 of sleeve 201 connects front portion 206 to threaded fitting 201.

Sleeve 201 and striker 6 cooperate to define a variable volume inner chamber 27 into which pressurized air from the hose 9 flows forwardly through the sleeve and wherein such air exerts a force on the striker that propels it forward into percussive engagement with anvil 11 in housing 4 to drive the tool forward.

Striker 6 has radially opening ports 28 in its tubular wall 18, located just forward of its enlarged diameter rear end portion 24. During part of the forward movement of the striker these ports 28 are blocked by sleeve 201, but in the final stage of that movement ports 28 pass forwardly beyond the front end of sleeve 201 to allow pressure air to escape from the inner chamber 27 into an outer variable volume chamber 34 defined by housing 4 and the part of the striker 6 forward of rear portion 24. Air in outer chamber 34 exerts a rearward force on striker 6 greater than the forward force exerted by air in inner chamber 27, and striker 6 is driven rearward. Near the end of the rearward stroke, ports 28 in striker 6 travel behind the rear edge of enlarged portion 206 of sleeve 201, permitting pressurized air in outer chamber 34 to flow radially inwardly through ports 28 and pass out of housing 4, externally of sleeve 7, through exhaust passages 30 in tailpiece 5. Tailpiece 5 is preferably one piece, and has a front connecting portion 31 and a coaxial rear portion 32 that provides a protective housing for coupling 8 that connects hose 9 to air inlet pipe 7.

The external surface of tailpiece rear portion 32 is frustoconical and tapers rearwardly to facilitate rearward movement of the borer out of a hole. The interior of rear portion 32 accommodates hose coupling 8 with substantial clearance.

Front portion 31 of tailpiece 5 is of a smaller outside diameter than rear portion 32 and has a thick tubular wall with a cylindrical inner surface 33. Front portion 31 is externally threaded for attachment to internal threads 14 in housing 4. Exhaust passages 30 extend axially through the tubular wall of front portion 31 and open into the hollow interior of its rear portion 32.

A support assembly 40 maintains air inlet 208 concentric to housing 4. In the illustrated embodiment, support assembly 40 comprises a tubular shock dampener 35 and a tubular bushing 38. Cylindrical inner surface 33 of front portion 31 closely surrounds an imperforate tubular shock dampener 35 made of an elastomeric material. The rear end of shock dampener 35 abuts against a radially inwardly projecting circumferential flange 36 on tailpiece 5. A tubular bushing 38 extends coaxially through shock dampener 35. Bushing 38 is internally threaded and has a radially outwardly projecting circumferential flange 39 at its front end. Shock dampener 35 is confined axially between flanges 36 and 39, and is confined radially between tailpiece 5 and bushing 38.

Attached to sleeve 201 by threaded fitting 202 is external threaded air inlet pipe 7 that mates with internal threads in bushing 38, so that rotation of pipe 7 moves it longitudinally between a forward operating position and a rearward reverse operating position. Pipe 7 can be rotated by hose 9, which has a rotation transmitting connection to sleeve 201. Front radial lug 205 on sleeve 201 and rear radial lug 42 on hose nut 8 engage front and rear axially projecting lugs 43, 44 on bushing 38 to limit motion of sleeve 201 relative to bushing 38.

Fig. 1 and 2 show the tool with sleeve 201 positioned for forward operation. When sleeve 201 is in its reverse operating position, it is spaced some distance to the rear of the position shown. During forward movement of striker 6, ports 28 in the striker are uncovered while the striker is still a substantial distance from anvil 11, so that the striker does not impact anvil 11, or impacts it only lightly. When striker 6 moves rearward, ports 28 do not pass sleeve 201 to communicate outer chamber 34 with exhaust passages 30 until just before the striker 6 hits the front of tailpiece 5 and thus moves housing 4 rearwards.

Pressurized air is completely exhausted from housing 4 during rearward movement of striker 6. Some air flows forwardly through exhaust passages 30 during the forward stroke, so that striker 6 is not driven against a vacuum. A resilient annular flapper valve 46 prevents dirt from being drawn forwardly into exhaust passages 30. Flapper valve 46 is made of rubber or rubber-like material and has a frustoconical forwardly tapering hub 47 that closely surrounds bushing 38 and is axially confined between shock dampener 35 and a radial circumferential flange 48 at the rear end of bushing 38. Projecting radially from hub 47 is a disc-shaped portion which acts as the valve.

Shock dampener 35 is slit axially along its length and installed laterally onto bushing 38. The inner and outer surfaces of the shock dampener, as well as the surfaces of the slit, are coated with

quick drying cement to secure shock dampener 35 to both tailpiece 5 and bushing 38 to prevent shock dampener 35 from turning when pipe 7 is rotated for reversing the direction of operation of the tool.

As shown in Figure 2, a sealing bearing 151 is fitted near the posterior end of striker 6 into an annular groove 153 in enlarged rear end portion 24 of striker 6. Sealing bearing 151 as shown in Figure 6 is preferably made of an oil-filled nylon or similar lubricated plastic and configured as a split ring by diagonal cut 152. Sealing bearing 151 reduces sliding friction between striker 6 and housing 4. This improves air sealing between rear portion 24 of striker 6 and housing 4 and affords improved tool performance and reliability in comparison to similar tools which employ no seals or bearings at this crucial juncture (other than metal-to-metal) or which employ high friction elastomeric O-rings.

Sealing bearings 151 made of oil-filled nylon work well at bearing lengths of 1 to 2 cm. Such short bearing lengths reduce sliding friction as compared to tools which utilize long teflon sleeves in conjunction with a teflon split bearing. Fig. 9 shows the striker of such a tool. In this known tool, long split teflon sleeves 401 are used at the anterior and posterior ends of the striker in conjunction with posterior teflon split ring bearing. In use these long teflon sleeves fail relatively early due to the longitudinal flexibility of the thin teflon sheet, which allows such sleeves to work out of grooves 402 during tool operation. This wears the sleeve edges and may cause tool jamming if the sleeve becomes caught between the the striker and the housing.

Sealing bearing 151 of this invention preferably has an external diameter slightly greater than the diameter of rear portion 24 of striker 6. Diagonal cut 152 has a width slightly greater than the difference between the external diameter of sealing ring 151 and the external diameter of rear portion 24 of striker 6. The resultant sealing bearing 151, which comprises a C-shaped spring, is kept in sealing contact with the inner wall of housing 4 by the natural resilience of the oil-filled nylon material. This insures sealing even under varying temperature circumstances and after wear of the inner wall of the housing. The resilience of the sealing bearing permits increased clearance between rear portion 24 of striker 6 and the inner wall of housing 4, without affecting air sealing. In practice, this helps to prevent tool slow-down and jamming. Sealing bearing 151 is preferably made of a cast oil-filled nylon such as Ertalon LFX.

Circular spot bearings 101 having slightly rounded (crowned) upper surfaces 104 are set into central circular recesses 102 in each guide zone 22 of striker 6. Tools employing such spot bearings have less internal friction. Spot bearings 101 have projections 103 at the base of each bearing 101.

Projections 103 are set in a further recess 102A in guide zones 22 of striker 6 to maintain a tight, force-fit between spot bearings 101 and recesses 102 of striker 6. Projections 103 provide additional resistance to shear forces operating on spot bearings 101 during operation. Crowned upper surfaces 104 of bearings 101 should be machined to the radius of guide zone 22 of striker 6 to insure maximum contact surface.

When greater bearing surface is desired, the spot bearings 105 having an elongated or "breadloaf" shape as shown in Figure 5 may be used. Alternatively, rows of round spot bearings 101 aligned in the lengthwise direction of the tool may be set into guide zones 22.

Such spot bearings 101 or 105 allow increased clearance between guide zones 22 of striker 6 and the interior of housing 4. Location of the forward end of striker 6 in housing 4 can be effected by the spot bearings 101 or 105 alone. These spot bearings 101, 105 are made of a durable plastic material containing a lubricant. Oil-filled nylons as described above are appropriate.

The spot bearings 101, 105 of this invention decrease sliding friction in the tool as compared to the teflon split bearing 403 shown in Fig. 9. Since oil-filled nylon is resilient and thus capable of some compression, a striker having spot bearings of this invention can be fitted with the spot bearings under compression. Friction remains low and the resilience of the oil-filled nylon material permits the spot bearings to expand and contract in response to irregularities in the inner wall of housing 4 and thus compensate for wear or distortion in the inner wall of the housing. The oil-filled nylon sealing bearing and spot bearings of this invention are both long-lasting and replaceable.

According to a further aspect of this invention, sleeve 201 is made of a flexible plastic material instead of machined steel. Applicant has also discovered that an appropriate plastic material is a phenolic resin-impregnated linen such as Linen LV. A sleeve 201 constructed of such material flexes in a limited fashion in response to flexure of hose 9 transmitted by inlet pipe 7 to sleeve 201. Pipe 7 is mounted in shock dampener 35. The flexibility and shock-dampening qualities of shock dampener 35 and the flexibility of plastic sleeve 201 results in a tool which has a high resistance to damage from flexure and shock.

This is believed to result from two aspects of such a tool. First, the combined flexibility of shock dampener 35 and sleeve 201 is more effective than dampener 35 alone, particularly in small diameter tools where dampener 35 is thin and relatively rigid. In addition, by utilizing connected members of different materials, namely steel pipe 7 and plastic sleeve 201, vibrational periods in waves

resulting from vibration of tool operation are broken up and do not build in intensity within the structure of the tubular inlet 208 comprising steel pipe 7 and plastic sleeve 201. This is quite different from all metal air valve systems common in the prior art. In such prior tools standing waves and other vibrational amplifications are possible within the structure of the air valve, even though those tools utilize a rubber dampener.

Fig. 8 illustrates a known air inlet pipe comprising a nylon sleeve 301, a forward metal compression hose fitting 302, a section of rubber hose 303, and rear metal compression hose fitting 304. A tool having this air inlet pipe has a short useful life because rear metal compression hose fitting 304 fractures in use. This prior art tool is believed to function poorly in practice because of excessive flexibility in rubber hose 303 and the rigidity of metal compression hose fitting 304.

The invention disclosed herein can avoid such problems, since the flexible plastic material of sleeve 201 can be utilized as the fitting 202 between the sleeve 201 and inlet pipe 7. Further, the prior art tool shown in Figure 8 operates erratically due to valve timing irregularities caused by excessive longitudinal stretch of hose 302. Such stretching occurs unpredictably and alters the relationship of the valve sleeve to the body of the tool, thereby making the tool's timing irregular.

According to a further aspect of this invention, one or more bearing lands 207, preferably about 0.13 to 0.39 mm in radial height, are machined on the body sleeve 201 to take advantage of the antifriction properties of the plastic and to reduce bearing length. In Figure 2, bearing lands 207 are spaced at regular intervals. One land 207 is positioned at the front end of enlarged portion 206, and another is positioned at the rear end of enlarged portion 206. Phenolic impregnated linen additionally absorbs some lubricating oil from the pressurized air stream, increasing the lubricity of sleeve 201. Although the known device shown in Fig. 8 utilizes a nylon sleeve 301, it has no bearing lands. Instead, grooves 305 leave a long, continuous bearing surface in comparison to the short bearing surfaces of bearing lands 207.

The features of this invention may be utilized either singly or in combination to provide an improved impact boring tool. Many potential variations and modifications possible to this invention as described herein are possible without departing from the essential features of this invention.

Claims

1. Impact-operated ground piercing tool comprising:

an elongated cylindrical housing (4),

an elongated striker (6) lengthwise reciprocable in the housing (4) for forward driving impacting engagement against an impact surface (12) near the front end of the housing (4),

a tubular inlet (208) connectable at a rear end thereof to a pressure fluid source, inlet (208) having an enlarged diameter front portion (206) closely slidably received in a coaxial, rearwardly opening recess (26) in the striker (6), and

a support assembly (40) for maintaining the inlet (208) substantially concentric to the housing (4), said tool being characterized by:

enlarged diameter front portion (206) of the inlet (208) is made of a lubricated flexible plastic.

2. The tool of claim 1, wherein the front portion (206) includes a first radial land (207) disposed at the front end of the front portion (206), a second radial land (207) disposed at the rear end of the front portion (206), and a third land (207) disposed intermediate the ends of the front portion (206).

3. The tool of Claims 1 or 2, wherein the air inlet (208) includes a rigid air inlet pipe (7) connected to a sleeve (201) made of lubricated flexible plastic by a threaded fitting (202) in the sleeve - (201), the sleeve (201) including an enlarged front portion (206), a neck (204) spanning the enlarged front portion (206) and the threaded fitting (202), and a bore (203) allowing communication between the inlet pipe (7) and the recess (26) in the striker - (6).

4. Impact-operated ground piercing tool comprising:

an elongated cylindrical housing (4),

an elongated striker (6) lengthwise reciprocable in the housing (4) for forward driving impacting engagement against an impact surface (12) near the front end of the housing (4),

a tubular inlet (208) connectable at a rear end thereof to a pressure fluid source, the inlet (208) having an enlarged diameter front portion (206) closely slidably received in a coaxial, rearwardly opening recess (26) in the striker (6), and

a support assembly (40) for maintaining the inlet - (208) substantially concentric to the housing (4), said tool being characterized by:

at least two spot bearings (101) located on a forward guiding zone (22) of the striker (6), which bearings (101) can slidably engage an inner wall of the housing (4).

5. The tool of claim 4, further characterized in that the striker (6) has a flat air passage surface - (23) interposed between the spot bearings (101), and the striker (6) has a forwardly tapering nose - (17) forwardly of the guide zone (22).

6. The tool of claims 4 or 5, wherein the spot bearings (101) are made of resilient plastic containing a lubricant.

7. Impact-operated ground piercing tool comprising:

an elongated cylindrical housing (4),

an elongated striker (6) lengthwise reciprocable in the housing (4) for forward driving impacting engagement against an impact surface (12) near the front end of the housing (4),

a tubular inlet (208) connectable at a rear end thereof to a pressure fluid source, the inlet (208) having an enlarged diameter front portion (206) closely slidably received in a coaxial, rearwardly opening recess (26) in the striker (6), and

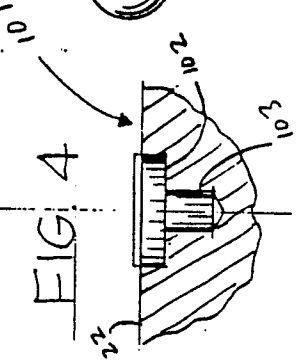
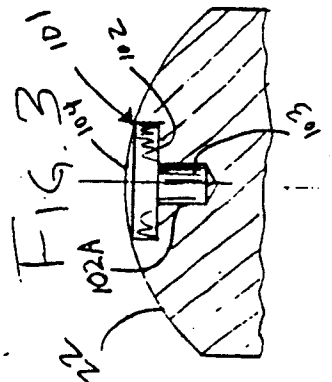
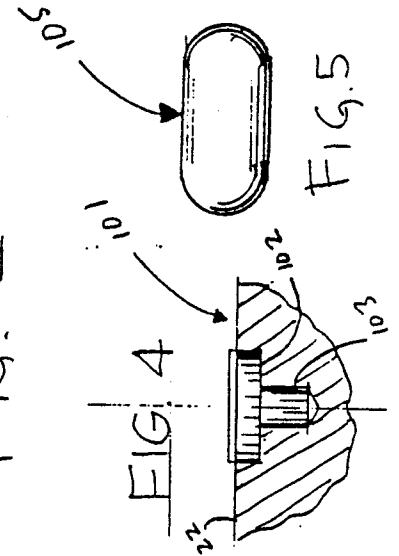
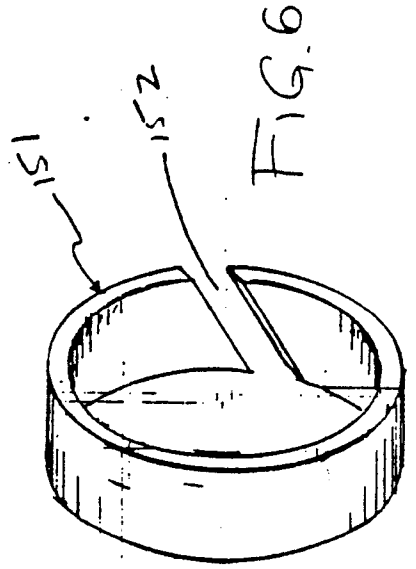
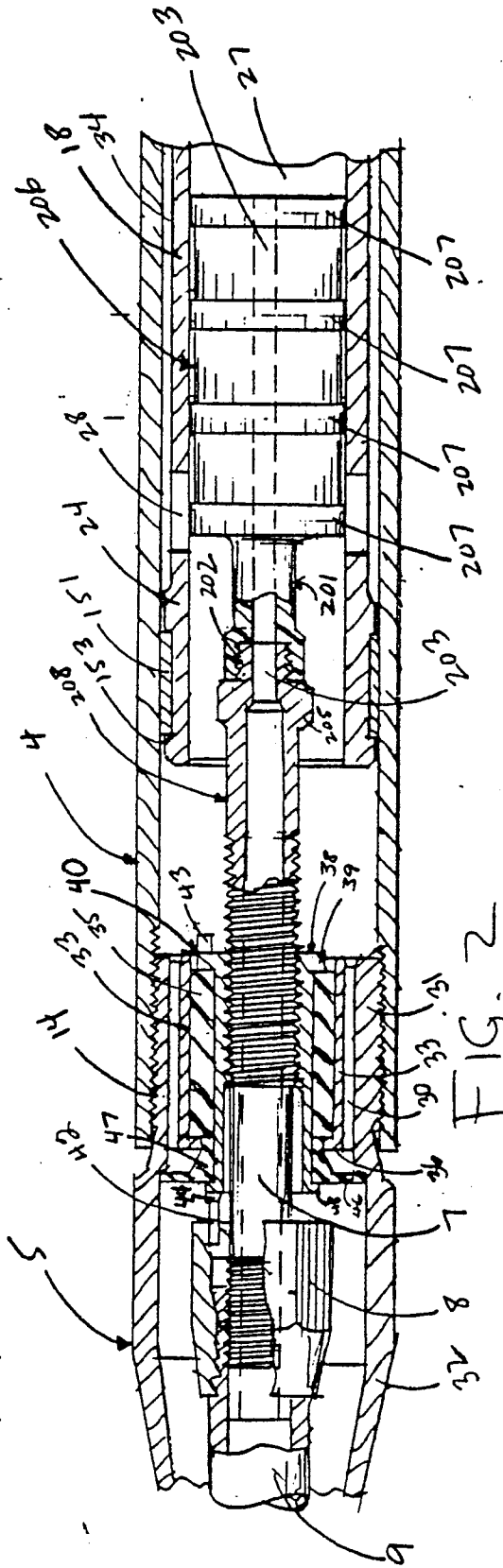
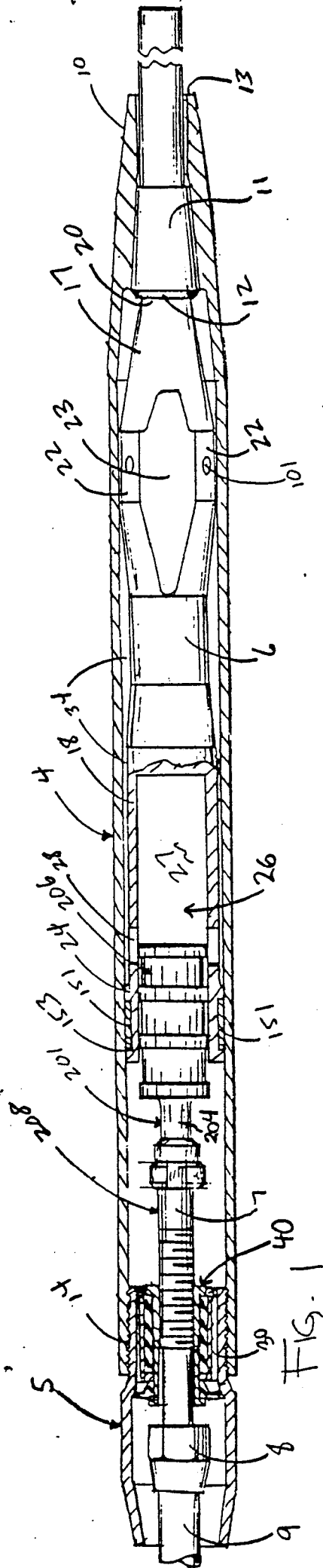
a support assembly (40) for maintaining the inlet - (208) substantially concentric to the housing (4), said tool being characterized by:

a sealing bearing (151) mounted near the posterior end of the striker (6) in resilient, slidable engagement with an inner wall of the housing (4).

8. The tool of claim 7 in which the sealing bearing (151) is made of plastic containing a lubricant.

9. The tool of claims 7-8 in which the sealing bearing (151) is a split bearing ring fitted to an annular groove (153) in an enlarged rear-end portion (24) of the striker (6).

10. The tool of claims 7-9 in which the sealing bearing (151) comprises a C-shaped spring which in split so that its compressed inner diameter is less than its uncompressed diameter, and its uncompressed diameter is greater than the internal diameter of the housing (4).



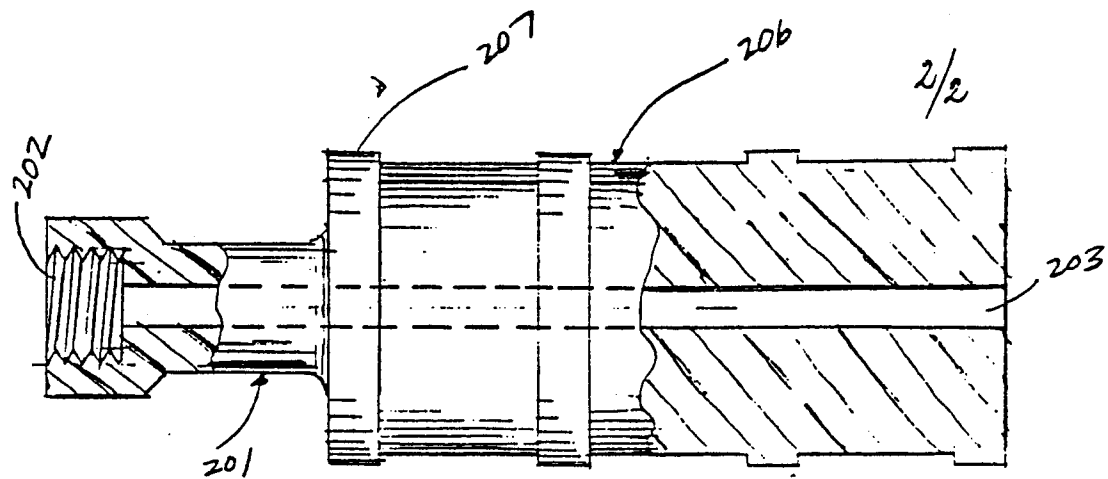


FIG. 7

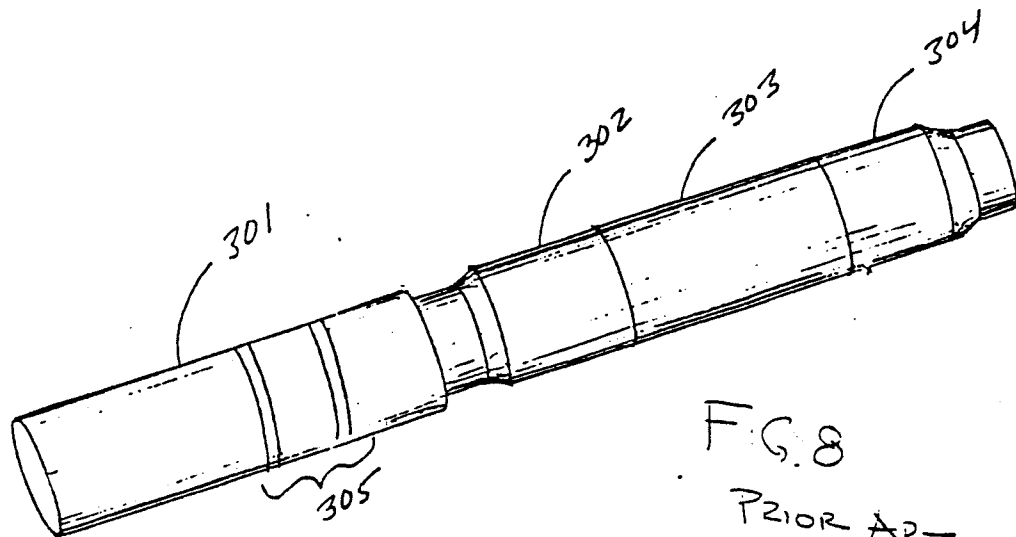


FIG. 8
PRIOR ART

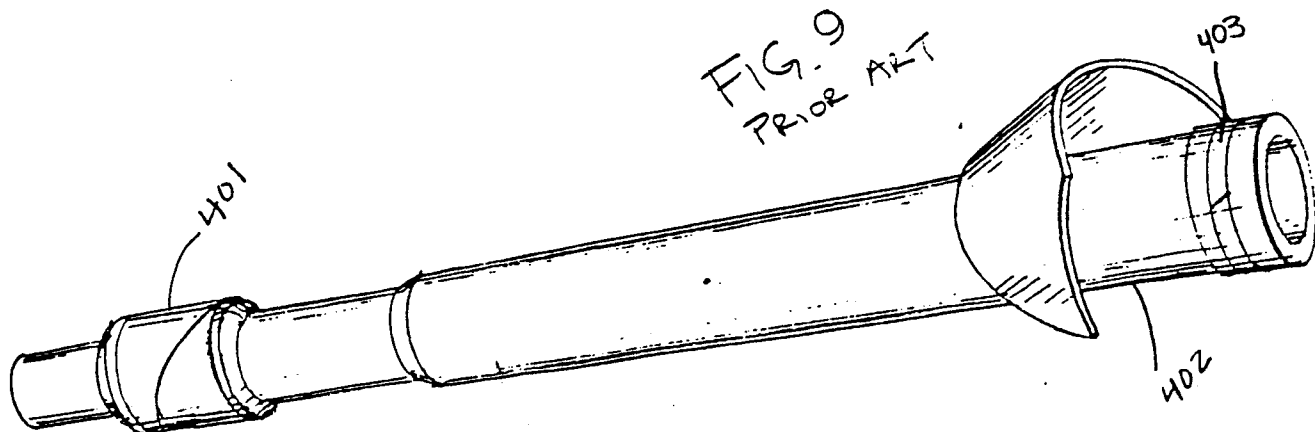


FIG. 9
PRIOR ART



EP 86 11 6382

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.4)
P	US-A-4 609 052 (LEWIN) * Column 3, lines 52-57 *	1,2	E 21 B 4/14 E 21 B 7/26 //
A,D	--- US-A-3 756 328 (SUDNISHNIKOV)		
A,D	--- US-A-3 410 354 (SUDNISHNIKOV)		
A	--- US-A-4 144 941 (RITTER) -----		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
Place of search THE HAGUE		Date of completion of the search 12-03-1987	Examiner SOGNO M.G.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		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	