

(19)



Europäisches Patentamt

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(11)

EP 0 733 153 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

15.03.2000 Bulletin 2000/11

(21) Application number: **95919255.0**

(22) Date of filing: **13.12.1994**

(51) Int Cl.7: **E21B 4/14**

(86) International application number:
PCT/SE94/01196

(87) International publication number:
WO 95/16847 (22.06.1995 Gazette 1995/26)

(54) **A HYDRAULIC IMPACT MOTOR**

HYDRAULISCHER SCHLAGANTRIEB

MOTEUR A PERCUSSION HYDRAULIQUE

(84) Designated Contracting States:
DE ES FR GB IE IT

(30) Priority: **13.12.1993 SE 9304124**

(43) Date of publication of application:
25.09.1996 Bulletin 1996/39

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WO-A-89/00638 **DE-C- 3 343 565**

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Description

[0001] This invention relates to a hydraulic impact motor of the kind defined in the precharacterizing part of claim 1. In particular, it relates to an in-hole rock drilling machine.

[0002] An in-hole rock drilling machine, also called down-the-hole rock drilling machine, of this kind is known from applicant's patent US-A-5,107,944. In the machine described therein, the valve is a spool valve with two control surfaces for shifting the valve between its two stable positions. One of the control surfaces is continuously pressurized during the drilling operation and the other is pressurized and depressurized through a control passage that has ports against the surface of the piston hammer that is in sliding contact with the cylinder. The sliding surface of the piston hammer has a control groove that is axially long, which makes the guided surface of the hammer piston long. A long guided surface is detrimental to the expected life. Further, the leakage from the two cylinder chambers for driving the hammer piston reduces the power efficiency.

[0003] It is objects of the invention to provide for shorter guiding surfaces of the piston hammer, longer expected life of the piston hammer and its guiding surfaces and an increased power efficiency. To these ends, the invention has been given the characteristics defined in the claims.

[0004] The invention will be described with reference to the drawings which show an embodiment of the invention. Figures 1 and 2 are together a side view of an in-hole rock drilling machine in accordance with the invention; Figure 1 shows the rear part of the machine and Figure 2 shows the front part, An intermediate part of the machine is not shown.

[0005] The in-hole rock drilling machine shown in the Figures has a housing, the main part of which is a cylindrical tube 12 that has an interior shoulder 13 and interior threads in each end.

[0006] A drill bit 14 is maintained in the housing by means of a sleeve 15 screwed into the tube 12. The sleeve 15 is in splined connection with the drill bit. The drill bit is guided in the housing by the sleeve 15 and a guiding bushing 16 and a stop ring 17 prevents the drill bit from falling out. The drill bit 14 is thus axially movable a limited distance in the housing 12 and it cannot turn relative to the housing. In a conventional way, the drill bit 14 has an axial flushing fluid passage that ends in flushing fluid ejecting holes in its front surface.

[0007] A guide bushing 18 takes support against the shoulder 13 and a distance sleeve 19 takes support against the guide bushing 18. A valve housing 20 with a back head 38 takes support against the distance sleeve 19. and and a tube formed filter support 21 with a filter 21a takes support against the back head 38 of the valve housing 20. A backhead 22 of the machine housing is screwed into the rear end of the tube 12 and it is arranged to axially clamp the parts 18,19,20,38,21

against the shoulder 13. These parts 18,19,20,38,21 act together as a spring and their cumulative length is such that they are compressed when the backhead 22 is screwed into place. Preferably, the overall axial compression is 0.4 - 2 mm. The distance sleeve 19 contributes most to this compression because of its dominating length and its comparatively small steel area in its cross section. It is adapted to be compressed at least 0.3 and preferably 0.8 - 3 pro mille of its length. The filter support 21 may have about the same cross section area of steel as the distance sleeve 19, but it is shorter and its contribution to the spring action is therefore smaller. The back head 38 of the valve housing 20 is thus clamped against the main part of the valve housing 20. The back head 22 of the machine housing is arranged to be screwed to a conventional drill tubing that transmits rotation to the drilling machine and also transmits hydraulic drive fluid in the form of pressure water to the drilling machine. In operation, the annular space 58 at the back of the valve housing 20 is thus continuously filled with filtered water under pressure. When assembling the machine, one puts all the parts 18,19,20,38,21 loosely on top of one another which makes the assembling simple and reduces the demand on axial tolerances. The added tolerance is taken up by the axial elastic compression. All the parts slide easily in the machine housing and are therefore easy to remove when the machine is to be disassembled.

[0008] A tube 23 forms part of the valve housing 20. A piston hammer 24 with a through channel 25 has its front end guided in the guide bushing 18. The rear end 27 of the piston hammer 24 extends into an annular cylinder chamber 26 (drive chamber) that is formed in the valve housing 20 between the sleeve-like front portion 35 of the valve housing and the tube 23 of the valve housing. The rear end of the piston hammer 24 is thus guided by the walls of the cylinder chamber 26, that is, by the valve housing 20. The rear end 27 of the piston hammer 24 has a groove 28 with a rear end wall 29 so that the piston hammer 20 has a defined outer guiding surface 30 behind the end wall 29. The piston hammer 24 has also an interior guiding surface 31 of defined length. Suitably, the outer and inner guiding surfaces 30,31 could have about the same length. The actual length of the guiding surfaces is defined by the guiding surfaces 18 (at the front end of the piston hammer) and 30,31 (at the rear end of the piston hammer) and it takes up only a minor part of the length of the piston hammer 24. The actual length of guiding is less than 20% of the length of the piston hammer. The major part 32 of the piston hammer 24 is between these guiding surfaces and it has a wide clearance to the distance sleeve 19 of the machine housing 12. Suitably, in order to get as heavy a piston hammer as possible, the major part 32 of the piston hammer 24 can be radially enlarged as compared with its guided end portions.

[0009] The guiding surface 33 of the piston hammer sliding against the guide bushing 18 has a smaller di-

ameter than the guiding surface 30 against the valve housing 20 so that the piston hammer will have a differential piston area in the front drive chamber 34 that is formed axially between the guide bushing 18 and the valve housing 20. If the groove 28 and the front guiding surface 33 have the same diameter, then this differential area is represented by the area 36, that is, by the area of the rear wall 29 of the groove 28. This differential area is smaller than the annular piston area 37 in the rear cylinder chamber 26.

[0010] The valve housing 20 contains a spool valve 40 with three control surfaces A1, A2, A3 that are in three annular control chambers 45, 46, 47. The effective area of surface A3 is a differential area since the diameter of the sliding surface of the valve 40 close to the surface A1 is greater than the diameter of the sliding surface close to the surface A2. The relation between these areas is $A3 < A1 < A2 + A3$. The area A2 is greater than the area A3 and suitably, A1 and A2 can be equal or about equal and about twice as large as A3. There is another annular chamber 48 and it is open to the annular chamber 47 when the valve 40 is in its illustrated position. When the valve 40 is in its other position, a shoulder 49 in the valve housing separates the chambers 47 and 48. The valve 40 has a row of large holes 50 and two small holes 51.

[0011] A control conduit 52 leads between the annular chamber 46 and the rear cylinder chamber 26 and it has a control port 53 into the rear cylinder chamber 26. Another control conduit 54 leads between the annular chamber 45 and the rear drive chamber 26 and it has control ports 55 and 56 to the drive chambers 26 and 34 respectively. A number of parallel channels 57 lead axially through the valve housing 20 and connect the front drive chamber 34 with the continuously pressurized space 58 at the rear of the valve housing 20. A number of channels 59 connect a row of ports 60 into the rear drive chamber 26 with a row of ports 61 into the annular chamber 48. A number of channels connect a row of ports 62 into the annular chamber 47 with the continuously pressurized space 58 at the back of the valve housing 20.

[0012] A cycle of the operation of the machine will now be described.

[0013] Presume that the valve 40 is in its illustrated position and that the piston hammer 24 has just begun its work stroke forwardly in order to strike the drill bit 14. (The piston hammer 24 is shown in its impacting position.) Through the ports 62, 61 and 60, the valve 40 connects the rear cylinder chamber 26 with the chamber 58 that is continuously under pressure. The control surface A1 of the valve is under pressure during the entire work stroke of the piston hammer 24 since the control port 56 of the control passage 54 is at first open to the continuously pressurized front drive chamber 34 and then, shortly after the closing of the port 56, the control port 55 of the control passage 54 is instead opened to the rear drive chamber 26 which is under pressure. As shown, the length of the guide surface 30 of the piston

hammer can be such that both ports 56 and 55 are closed during a short period, which, however, will be so short that it will not influence the pressure in the control passage 54. As long as the control port 53 of the control passage 52 is closed, the valve 40 will therefore remain stable in its illustrated forward position because the area A1 overcomes the area A3. The leakage from the annular chamber 46 prevents a pressure build up in the annular chamber 46.

[0014] When the piston hammer in its work stroke opens the control port 53 of the control passage 52 just after it has opened the control port 55 of the control passage 54, the passage 52 and the annular chamber 46 are pressurized, and since the area A2 that is then put under pressure equals the area A1 that is already under pressure, these areas balance each other and the area A3 will force the valve into its rearward position which is not illustrated. The holes 51 in the valve 40 will be open into the annular chamber 46, but they are so small that they do not prevent the pressurization of the annular chamber 46. The leakage through the holes 51 is so small that it does not significantly influence the overall power efficiency. The valve 40 is dampened by its nose 65 cutting off a damping chamber so that the valve is retarded before it lands in its rear non-illustrated position and it will therefore not tend to rebound. The annular chamber 48 is cut off from the annular chamber 47 and is instead coupled to the interior of the valve through the holes 50 in the valve. Through the tube 23, the interior of the valve is continuously open to the channel 25 in the piston hammer and the channel 25 is always open to the flushing fluid passage in the drill bit 14. The rear drive chamber 26 will therefore be depressurized simultaneously with the piston hammer reaching its impacting position, and the continuously pressurized front drive chamber 34 starts to drive the piston hammer rearwardly in its return stroke.

[0015] The relative axial positions of the control ports 53 and 55 can be varied and the control port 53 need not be axially forwardly of the port 55.

[0016] The water that flows out of the rear drive chamber 26 during the return stroke of the piston hammer 24 is thus utilized as a flushing fluid for flushing the debris out of the borehole.

[0017] When the rear drive chamber 26 is depressurized, the control surfaces A1 and A2 are both depressurized since both the port 55 of the control passage 52 and the port 53 of the control passage 52 will be open to the rear drive chamber 26.

[0018] During its return stroke, the piston hammer 24 will close the ports 55 and 53. The annular chamber 46 will however remain drained; now through the small holes 51 through the valve. Then the piston hammer 24 opens the port 56 of the control passage 54 so that the control passage 54 and the annular chamber 45 will be pressurized from the front drive chamber 34 and the surface A1 will be pressurized. Since the surface A2 is not pressurized, the surface A1 will force the valve 40 to

switch to its forward position in which it is shown. During the last portion of the forward movement of the valve 40, the two small holes 51 in the valve are cut off from the annular chamber 46 and the water closed in the chamber 46 and the control passage 53 retards the valve before the valve lands since a pressure will build up against the control surface A2. This pressure cannot be so high that it jeopardizes the valve staying stably in its forward position since the row of large holes 50 in the valve is close to the annular chamber 46. The leakage out through the holes 50 together with the leakage past the end of the valve 40 will be comparatively big and bigger than the leakage into the closed port 53. The valve will now pressurize the rear drive chamber 26 via the ports 62, 61, 60 and the passages 59 between the ports 61 and 60 so that the piston hammer decelerates, turns and accelerates in its work stroke as previously described and the cycle is repeated.

Claims

1. A hydraulic impact motor comprising

a housing (12),
a piston hammer (24) reciprocable in said housing and driven to reciprocate by the pressure in two pressure chambers (26, 34),
a valve (40) for alternately pressurizing and draining at least one of said pressure chambers so as to reciprocate the piston hammer, said valve having a first control surface (A1) in a first control chamber (45) and a second control surface (A2) in a second control chamber (46) and opposite directed relative to said first control surface,
said first and second control chambers (45, 46) being arranged to be pressurized and depressurized, in response to the position of the piston hammer, through control ports (53, 55, 56) controlled by the hammer piston and control conduits 52, 54,

characterized by a third control surface (A3) on the valve in a continuously pressurized chamber (47) and acting in the same direction as said second control surface (A2),
said second and third control surfaces (A2, A3) being greater than said first control surface (A1) and the first control surface (A1) being greater than the third control surface (A3) so that the valve (40) is moved in the one direction when the first control chamber (45) is pressurized and the second control chamber (46) is depressurized and moved in the other direction when the first and second control chambers (45, 46) have equal pressure.

2. An impact motor according to claim 1, **character-**

ized in that said first control chamber (45) is arranged to be pressurized from one of the drive chambers (26) for the piston hammer (24) for initiating the movement of the valve (40) in said one direction, and said second control chamber (46) is arranged to be pressurized from the other one of said drive chambers (34) for initiating the movement of the valve (40) in the other direction.

3. An impact motor according to any one of the preceding claims, **characterized** in that the piston hammer (24) is guided at its front end and at its rear end and is unguided therebetween,

a rear control surface for controlling the valve (40) is defined between a surface (37) in said one drive chamber (26), that is a rear drive chamber, and a surface (36) in the other drive chamber (34), that is a continuously pressurized front drive chamber,
the control conduit (54) to the first control chamber (45) has a port (56) arranged to be opened to the front drive chamber (34) and a port (55) arranged to be opened to the rear drive chamber (26), and
the control conduit (52) to said other control chamber (46) has a port (53) arranged to be opened into the rear drive chamber (26).

4. An impact motor according to any one of the preceding claims, **characterized** in that it is an in-hole rock drilling machine and the spent drive fluid expelled from the valve (40) is conveyed through a channel (25) in the piston hammer (24) to the drill bit (14) of the drilling machine as a flushing fluid.

Patentansprüche

1. Hydraulischer Schlagantrieb, bestehend aus:

- einem Gehäuse (12)
- einem Kolbenhammer (24), der sich in diesem Gehäuse hin- und herbewegen kann und durch den Druck in zwei Druckkammern (26, 34) in einer Hin- und Herbewegung getrieben wird,
- einem Ventil (40) zum abwechselnden Unter-Druck-Setzen und Druck-Ablassen in mindestens einer dieser Druckkammern, um den Kolbenhammer hin- und herzubewegen,

wobei dieses Ventil in einer ersten Steuerkammer (45) eine erste Steuerfläche (A1) und in einer zweiten Steuerkammer (46) eine zweite Steuerfläche (A2), die entgegengesetzt zu dieser ersten Steuerfläche gerichtet ist, aufweist, wobei diese erste und diese zweite Steuerkammer (45, 46) so angeordnet sind, daß sie je

nach Position des Kolbenhammers unter Druck gesetzt und drucklos gemacht werden, und zwar durch Steueröffnungen (53, 55, 56), die vom Kolbenhammer gesteuert werden, und Steuerleitungen (52, 54),

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dadurch gekennzeichnet, daß eine dritte Steuerfläche (A3) des Ventils in einer ständig unter Druck stehenden Kammer (47) vorgesehen ist, die in der gleichen Richtung wirkt wie die zweite Steuerfläche (A2), wobei diese zweite und diese dritte Steuerfläche (A2, A3) größer sind als diese erste Steuerfläche (A1), und die erste Steuerfläche (A1) größer ist als die dritte Steuerfläche (A3), so daß das Ventil (40) sich in die eine Richtung bewegt, wenn die erste Steuerkammer (45) unter Druck gesetzt wird und die zweite Steuerkammer (46) drucklos gemacht wird, und sich in die andere Richtung bewegt, wenn die erste und die zweite Steuerkammer (45, 46) unter dem gleichen Druck stehen.

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2. Schlagantrieb nach Anspruch 1, **dadurch gekennzeichnet, daß** diese erste Steuerkammer (45) so angeordnet ist, daß sie von einer dieser Antriebskammern (26) für den Kolbenhammer (24) unter Druck gesetzt wird, um die Bewegung des Ventils (40) in die genannte erste Richtung einzuleiten, und daß die zweite Steuerkammer (46) so angeordnet ist, daß sie von der anderen dieser Antriebskammern (34) unter Druck gesetzt wird, um die Bewegung des Ventils (40) in die andere Richtung einzuleiten.

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3. Schlagantrieb nach einen der vorherigen Ansprüche, **dadurch gekennzeichnet, daß** der Kolbenhammer (24) an seinem vorderen Ende und an seinem hinteren Ende geführt wird und zwischen diesen nicht geführt wird, daß zwischen einer Fläche (37) in dieser einen Antriebskammer (26), die die hintere Antriebskammer bildet, und einer Fläche (36) in der anderen Antriebskammer (34), die eine ständig unter Druck stehende, vordere Antriebskammer ist, eine hintere Steuerfläche zur Steuerung des Ventils (40) gebildet wird, daß die Steuerleitung (54) zur ersten Steuerkammer (45) eine Öffnung (56) aufweist, die dergestalt angeordnet ist, daß sie sich zu der vorderen Antriebskammer (34) hin öffnet, und eine Öffnung (55) aufweist, die dergestalt angeordnet ist, daß sie sich zu der hinteren Antriebskammer (26) hin öffnet, und daß die Steuerleitung (52) zu dieser anderen Steuerkammer (46) eine Öffnung (53) aufweist, die dergestalt angeordnet ist, daß sie sich zu der hinteren Antriebskammer (26) hin öffnet.

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4. Schlagantrieb nach einen der vorherigen Ansprüche, **dadurch gekennzeichnet, daß** er eine Loch-Gesteinsbohrmaschine ist und das aus dem Ventil

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(40) ausgestoßene, verbrauchte Antriebsfluid als Spülfluid durch einen Kanal (25) in dem Kolbenhammer (24) zu dem Bohrmeißel (14) der Bohrmaschine befördert wird.

Revendications

1. Moteur à percussion hydraulique comprenant :

un logement (12),
un marteau piston (24) apte à effectuer un mouvement de va-et-vient dans ledit logement et entraîné pour se déplacer selon un mouvement de va-et-vient par la pression dans les deux chambres de pression (26, 34),
une vanne (40) pour mettre alternativement en pression et drainer au moins l'une desdites chambres de pression de manière à déplacer selon un mouvement de va-et-vient le marteau piston,
ladite vanne comprenant une première surface de commande (A1) dans une première chambre de commande (45) et une deuxième surface de commande (A2) dans une deuxième chambre de commande (46) et orientée d'une manière opposée relativement à ladite première surface de commande,
lesdites première et deuxième chambres de commande (45, 46) étant agencées pour être mises en pression et dépressurisées, en réponse à la position du marteau piston, par des orifices de commande (53, 55, 56) commandés par le piston marteau et les conduits de commande (52, 54),

caractérisé par une troisième surface de commande (A3) sur la vanne dans une chambre continuellement pressurisée (47) et agissant dans la même direction que ladite deuxième surface de commande (A2), lesdites deuxième et troisième surfaces de commande (A2, A3) étant plus grandes que ladite première surface de commande (A1), et la première surface de commande (A1) étant plus grande que la troisième surface de commande (A3) de telle sorte que la vanne (40) est déplacée dans une direction lorsque la première chambre de commande (45) est pressurisée et la deuxième chambre de commande (46) est dépressurisée et déplacée dans l'autre direction lorsque les première et deuxième chambres de commande (45, 46) ont une pression égale.

2. Moteur à percussion selon la revendication 1, caractérisé en ce que ladite première chambre de commande (45) est agencée pour être pressurisée à partir d'une des chambres d'entraînement (26) du marteau piston (24) pour initier le mouvement de la

vanne (40) dans une direction précitée, et ladite deuxième chambre de commande (46) est agencée pour être pressurisée à partir de l'autre desdites chambres d'entraînement (34) pour initier le mouvement de la vanne (40) dans l'autre direction.

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3. Moteur à percussion selon l'une des revendications précédentes, caractérisé en ce que le marteau piston (24) est guidé à son extrémité frontale et à son extrémité arrière et n'est pas guidé entre celles-ci, une surface de commande arrière pour commander la vanne (40) est définie entre une surface (37) dans une chambre d'entraînement précitée (26), c'est-à-dire une chambre d'entraînement arrière, et une surface (36) dans l'autre chambre d'entraînement (34) qui est une chambre d'entraînement avant continuellement pressurisée,

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le conduit de commande (54) à la première chambre de commande (45) a un orifice (56) agencé pour être ouvert vers la chambre d'entraînement avant (34) et un orifice (55) agencé pour être ouvert à la chambre d'entraînement arrière (26) et le circuit de commande (52) à l'autre chambre de commande (46) précitée a un orifice (53) agencé pour être ouvert dans la chambre d'entraînement arrière (26).

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4. Moteur à percussion selon l'une des revendications précédentes, caractérisé en ce que celui-ci est une machine à forer la roche dans le trou, et le fluide d'entraînement usé expulsé de la vanne (40) est transporté à travers un canal (25) dans le marteau piston (24) au foret (14) de la machine à forer comme fluide de rinçage.

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Fig 1

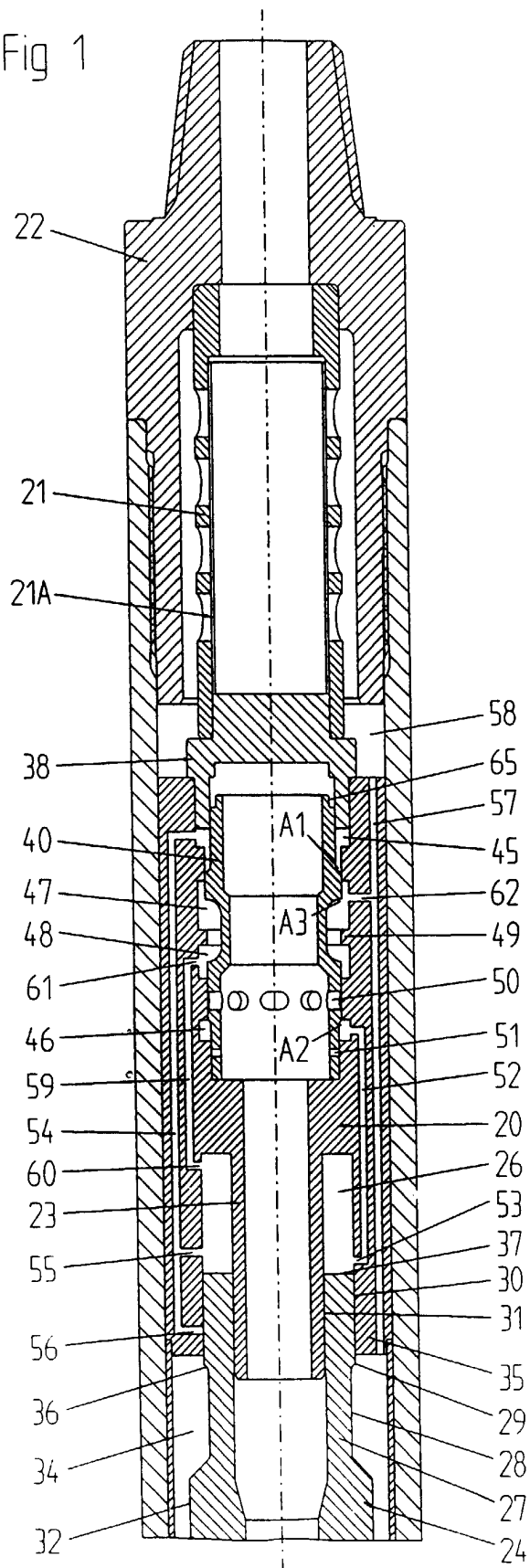


Fig 2

