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(54) **HYDRAULIC WEDGE DEVICE.**

(57) The invention relates to mining, in particular to hydraulic mechanisms for cleaving monolithic blocks from rock masses during rock extraction operations. The proposed hydraulic wedge device comprises a wedge-shaped working unit designed in the form of a main wedge (1) arranged between separable jaws (2, 3), an auxiliary wedge (8) with a hydraulic cylinder (14) between support elements (5, 6) which are mounted on a beam (4) connected to the main wedge (1) and arranged in such a way that they can cooperate with the main wedge and the separable jaws (2, 3). The design of the hydraulic wedge device makes it possible to use the hydraulic wedge power unit to supply a number of wedge-shaped working units inserted in more than one borehole.

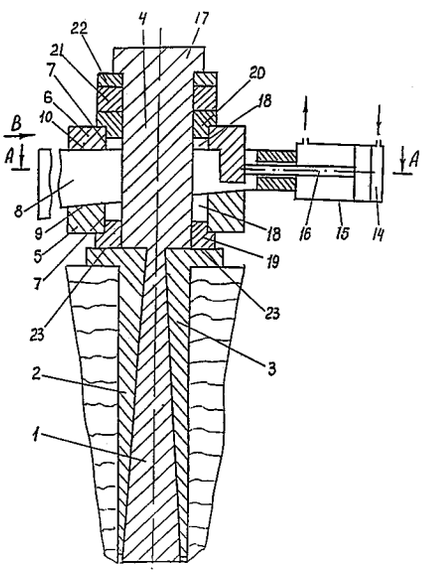

FIG. 1

EP 0 664 375 A1

Technical Field

The invention relates to mining engineering and more specifically to hydraulic mechanisms for disaggregating rocks and can be utilized for detaching stone blocks from the massive rock along a row of holes or crevices in obtaining natural stones for building and architectural ends. The invention can also be used to destroy strong monolithic bases and foundations of man-made structures that are to be demolished.

Background Art

In quarrying to obtaine large, regular blocks of building stones; labor-saving devices for detaching stone blocks fro the massive rock have always been of special significance as they make it possible to obtain stone blocks of required dimensions and to preserve ornamental properties of the stones. With these objects in view it has been the practice to utilize various means for mechanical detachment of stone blocks from the massive rock, cutting machines, percussive machines, end mills as well as diversified devices for wedging down stone blocks from a face which are more preferred among others.

In mining the strongest rock, such as granite, use of various stone-cutting machines has not been known to be economically justified due to low efficiency and fast wear of the cutters in these machines. Under such conditions preference is given to the wedging down process performed by various hydraulic wedge devices.

Known in the art is a hydraulic wedge apparatus (SU, A1, 662,712) comprising a main hydraulic cylinder interacting with a wedge arranged between movable jaws, and a hydraulic intensifier communicating with the head end of the main hydraulic cylinder and constructed as two rigidly interconnected portions slidable in respective cylinder sleeves and having different diameters. The head end of the main cylinder and the head end of the hydraulic intensifier on the side of the piston having a greater diameter are in communication with a pressure line. The rod end of the hydraulic intensifier on the side of the piston having a smaller diameter is in communication with the head end of the main hydraulic cylinder.

The apparatus operates as follows. A pressure fluid from the pressure line is fed through a check valve into the head end of the main cylinder. The piston of the main cylinder moves the wedge between the jaws to provide for development of a preliminary breakout force. When the piston of the main cylinder stops moving for the lack of pressure in the pressure line, the pressure fluid is fed to the head end of the hydraulic intensifier from the side of the piston having a greater diameter. Pressure in the rod end of the hydraulic intensifier on the side of the piston having a smaller diameter gets times higher as the area of the piston is less than that of the piston having a greater diameter. By the same reason, pressure in the head end of the main cylinder, with the piston thereof connected to the wedge, gets as many times higher and therefore the breakout force developed by the hydraulically operated wedge gets greater.

The above-described arrangement only provides for an increase in the breakout force either on condition that the pressure in the hydraulic cylinders is increased or that the dimensions of the hydraulic cylinders are increased. Also, this arrangement requires a considerable volume of the pressure fluid to be circulated to only result in an increase in the weight and overall dimensions of the arrangement and in a decrease in the efficiency of utilizing thereof, this being especially so in the case of high-pressure hydraulic equipment.

Known in the art is a hydraulic wedge apparatus for disintegrating rock (SU, A1, 883,425) which allows shorter block removal cycles and an increased breakout force without a considerable increase in the weight of the apparatus.

The prior art hydraulic wedge apparatus consists of a housing where main and auxiliary hydraulic cylinders are mounted, each comprising a cylinder sleeve and a piston with a piston rod, while the piston rod of the main cylinder being the cylinder sleeve of the auxiliary cylinder wherein a piston and a piston rod of the same auxiliary cylinder are arranged together with a return spring placed between the piston of the auxiliary cylinder and a thrust bushing on the piston rod of the main cylinder. Such arrangement is substantially composed of two hydraulic cylinders connected in tandem, the piston diameter of the first (main) hydraulic cylinder being considerably greater then that of the second (auxiliary) cylinder. The piston rod of the auxiliary cylinder is connected to the wedge which is arranged between movable jaws. The jaws are fixed by a union nut on the housing. The head end of the main cylinder is communicating with the pressure line of the hydraulic system, while the rod end thereof is in communication with the drain line. The head end of the auxiliary cylinder is also in communication with the pressure line via a stop valve.

The above apparatus operates as follows. The tool of the apparatus (the movable jaws with the wedge arranged therebetween) is inserted in the hole that was predrilled in the rock. The pressure fluid is delivered at some rate of flow to the head end of the auxiliary cylinder through the open stop valve. The pressure fluid at the same rate of flow is simultaneously delivered to the head end of the

main cylinder. Since the piston diameter of the auxiliary cylinder is considerably smaller than that of the main cylinder, the piston of the auxiliary cylinder at the same flow rate of the pressure fluid travels much faster than that of the main cylinder. In this way the piston rod of the auxiliary cylinder moves the wedge connected thereto between the movable jaws to preliminarily insert the wedge into the hole to thereby adjust clearance between the wedge and the jaws as well as between the jaw surfaces and the hole walls. Following the clearance adjustment, the preliminary movement of the wedge comes to an end due to an insufficiency of the push exerted by the auxiliary cylinder. The stop valve is closed to lock the auxiliary cylinder. The pressure fluid, being fed to the head end of the main cylinder, provides for a further travel of the wedge, this time under the action of the main cylinder. As the piston area of the main cylinder is much greater than that of the auxiliary cylinder, the separating force of the tool appears to be sufficient to crack the rock. As the preliminary insertio of the wedge into the hole is by the auxiliary cylinder, the stroke of the piston of the main cylinder which is required to crack the rock is not long. By this token the piston diameter of the main cylinder can be increased and therefore the breakout force exerted by the apparatus can be also increased without a substantial increase in the weight thereof because no lengthy main cylinder is required. Nevertheless, this apparatus as well as the one described above can exert the breakout force, the angle of the wedge being known, which force can be defined by two variables, namely, by the pressure in the pressure line and by the piston diameter of the main cylinder, both of which cannot be increased infinitely. Thus an increase in the pressure within the pressure line of the hydraulic system involves use of a special high-pressure hydraulic equipment and high-pressure delivery hoses which are the most critical components of the arrangement. An increase in the piston diameter involves an increase in the dimensions and the weight, which is unacceptable due to the fact that hydraulic wedges, as a rule, are a portable equipment and are often used in a restricted space. That is why the efficiency of the prior art hydraulic wedge apparatus is limited in that the build up of the breakout force cannot be further increased wuthout an increase in the dimensions and the weight of the arrangement or without an increase in the pressure within the hydraulic system. Also the prior art apparatus is such that the power pack thereof (the hydraulic system, the main cylinder, the auxiliary cylinder) providing for movement of the main wedge between the movable jaws cannot be used to operate several tools inserted in several holes to detach stone blocks from the massive rock in the direction along the row of holes when a simultaneous application of the breakout force in several holes is required along the line of separation of the stone block. Such mode of operation of the prior art hydraulic wedge apparatus requires several complete hydraulic wedges, which makes quarrying complicated and of low efficiency taking into account a relatively complicated design of the subject hydraulic wedge.

Known in the art is a hydraulic wedge apparatus (SU, A3, 1,774,994) of a design that permits, compared with the above-described apparatus, an increase in the breakout force applied by the tool without an increase in the pressure within the hydraulic system and without an increase in the dimensions of the actuating hydraulic cylinders. This apparatus is deemed to be bearing closely on the invention.

The prior art hydraulic wedge apparatus comprises a housing, a tool in the form of movable jaws and a main wedge arranged therebetween, a main hydraulic cylinder, the cylinder sleeve thereof being connected to the housing, while the piston rod being connected to an upper thrust member, a crosspiece connected to a lower thrust member and the main wedge which is arranged at right angles to the crosspiece axis, auxiliary wedges oppositely arranged between the upper and the lower thrust members for interaction by wedge surfaces thereof with one another and with said upper and lower thrust members, auxiliary hydraulic cylinders, the cylinder sleeves thereof being pivotally connected to said crosspiece, while the piston rods thereof being connected to said auxiliary wedges. Said movable jaws are connected to the housing through racks which are constructed in a manner to interact with toothed shoes of a lock joint mounted on the upper thrust member to provide, upon the lock joint operation, for connection of the upper thrust member via the racks to the housing and, hence, for locking the piston rod of the main cylinder relative to the cylinder sleeve thereof. The apparatus also comprises a hydraulic system with means for manual and automatic control of the main and auxiliary hydraulic cylinders.

The hydraulic wedge apparatus operates as follows. The tool constructed as movable jaws and a main wedge arranged therebetween is inserted into a hole predrilled in a massive rock. The pressure line of the hydraulic system is connected to the head end of the main cylinder, the rod end thereof is connected to the drain line. Such connection provides for movement of the piston rod of the main cylinder in the direction of the main wedge and via the upper thrust member, the auxiliary wedges, the lower thrust member, and the crosspiece for application of a load to the main wedge to move it between the movable jaws, which

being moved apart by the main wedge, apply the breakout force radially towards the walls of the hole. Upon reaching a predetermined limit pressure in the head end of the main cylinder, the pressure line of the hydraulic system is automatically connected to the head ends of the auxiliary cylinders, while the rod ends of the latter are cannected to the drain line. The auxiliary cylinders, with their piston rods, begin to move the auxiliary wedges towards each other between the upper and the lower thrust members. As the auxiliary wedges are moved, one of them is interacting with the lock joint until it operates the lock joint and brings into engagement the toothed shoes with the racks and, hence, connects the upper thrust member with the housing. This provides for locking of the piston rod of the main cylinder relative to the cylinder sleeve thereof, i.e, locking of the main cylinder. A further movement of the auxiliary wedges produces an increase in the axial load which is applied from the auxiliary wedges through the lower thrust member and the crosspiece to the main wedge which, in its turn, results in an increase in the breakout force applied by the tool up to splitting of the massive rock. In other words, from the begining the main cylinder adjusts clearance in the following chain "the piston rod of the main cylinder - the upper thrust member - the auxiliary wedges - the lower thrust member - the crosspiece - the main wedge - the jaws - the walls of the hole" and preloads the hole with the breakout force the intensity of which is defined by the pressure in the pressure line of the hydraulic system and the diameter of the piston in the main cylinder. A further increase in the breakout force is ensured by a further movement of the main wedge under the action thereupon of the auxiliary wedges moved between the thrust members by the action of the auxiliary cylinders. Such an arrangement makes it possible to substantially increase the axial load on the main wedge and, therefore, to increase the breakout force without an increase in the pressure within the hydraulic system and an increase in the dimensions of the hydraulic cylinders.

The prior art apparatus compared to the one of the invention has common features as follows: a wedge-shaped tool constructed as a main wedge arranged between movable jaws, an auxiliary wedge-shaped means operated by a hydraulic drive means and arranged between thrust members capable of interaction with the main wedge and the movable jaws.

The apparatus bearing closely on the invention provides for development of a considerable breakout force without an increase in the pressure within the hydraulic system and in the dimensions of the hydraulic cylinders, and yet it is complicated in design due to a multiplicity of functional units in a kinematic relationship therebetween (the housing, the crosspiece, three hydraulic cylinders, the lock joint, the mechanism for operating the lock joint), it has a complex hydraulic system providing for the required operation of the three cylinders, it would not let use a power pack of the apparatus, providing for movement of the main wedge between the movable jaws, to attend several tools inserted into several holes in separating stone blocks from the massive rock along a predetermined direction of the row of holes when a simultaneous application of the breakout force in several holes is required prior to the stone block detachment, which complicates quarrying and lowers efficiency taking into account the complicated design of the above-described hydraulic wedge apparatus.

Disclosure of the Invention

The invention is based on the technical problem to provide a simple hydraulic wedge apparatus the design of which would offer to use the power pack of the apparatus for operating several wedge tools inserted into several holes and, by virtue of this, would increase the output and efficiency in detaching stone blocks from the massive rock along the row of holes with simultaneous application of the breakout force at several points along the line of detachment. In doing this, the apparatus should offer a considerable breakout force without an increase in the hydraulic pressure and in the dimensions of the hydraulic cylinders.

The above problem is solved in that in a hydraulic wedge apparatus comprising a wedge-shaped tool constructed as a main wedge arranged between movable jaws, an auxiliary wedge-shaped means operated by a hydraulic drive means and arranged between thrust members capable of interaction with the main wedge and the movable jaws according to the invention the thrust members are mounted on a rod for movement along the axis thereof, one end of said rod being connected to the main wedge on the side of the crest thereof, at the free end of the rod there are means for stopping the second, as viewed from the wedge, thrust member, the auxiliary wedge-shaped means is constructed as an auxiliary wedge mounted for interaction by wedge surfaces thereof with the bearing surfaces of the thrust members while the hydraulic drive means is constructed as a hydraulic cylinder, the cylinder sleeve thereof being connected to the auxiliary wedge while the piston rod being connected to one of the thrust members and extending in parallel with the bearing surface of the thrust member.

The above features of the invention together are deemed essential and sufficient for resolving the problem as it was formulated above, i.e. the

provision of a simple hydraulic wedge apparatus offering the possibility of using a single power pack for attending to several holes wherein the wedge tools are inserted, in other words, a single power pack may be used to wedge the tools in several holes, one after another.

The technical problem is resolved by a design of the hydraulic wedge apparatus which makes it possible, upon wedging the tool in the hole, to unlock the means for stopping the thrust members on the rod, to remove the power pack comprising the thrust members and the auxiliary wedge means with the hydraulic drive means from the rod and to use the removed power pack for wedging the tool in another hole, the tool in the previous hole being wedged.

The use of such apparatus enhances efficiency of detaching stone blocks from the massive rock along a predetermined direction of a row of holes when insertion of the wedge-shaped separation means are required in several holes for simultaneous application of the breakout force at several points along the breakout line.

It is advisable that each thrust member be constructed as a plate having an opening whereby each thrust member is mounted on the rod, the means for stopping the second, as viewed from the main wedge, thrust member be constructed as a thrust head at the free end of the rod between the thrust head and the second, as viewed from the main wedge, thrust member, while the auxiliary wedge has a through slot on the side of its bevelled surfaces and extending from the base to the crest of the auxiliary wedge whereby the auxiliary wedge is mounted on the rod for movement along the axis thereof and relative to the thrust members.

Such arrangement of the main structural members of the appatatus of the invention is due to simplicity, reliabilty in operation, and ease in mounting of the power pack on the rod and dismounting it.

Brief Description of the Drawings

The invention is further described by way of example with reference to the accompanying drawings on which:

Fig.1 is a sectional view of the hydraulic wedge apparatus of the invention;

Fig.2 is a cross-sectional view along the line A-A of Fig. 1;

Fig. 3 is a view along arrow B in Fig.1.

Best Mode for Carrying Out the Invention

The hydraulic wedge apparatus consists of a tool constructed as a main wedge 1 arranged between movable jaws 2 and 3, a rod 4 which is connected to the main wedge 1 on the side of its crest. Thrust members 5 and 6 are mounted on the rod 4 for movement along the axis thereof and each has the form of a plate with an opening 7 through which the rod 4 is extending. An auxiliary wedge 8 is arranged between the thrust members 5 and 6. An angle between bearing surfaces 9 and 10 of the thrust members 5 and 6 in the direction of movement of the auxiliary wedge 8 is equal to the angle of the auxiliary wedge 8. The auxiliary wedge 8 on the side of its bevelled surfaces has a through slot 11 which separates two wedge portions 12 and 13 rigidly connected one with the other and arranged on both sides of the rod 4 to balance thereby loads on the structural members of the apparatus. Such form of the auxiliary wedge 8 facilitates symmetrical arrangement of the same about the rod 4 and allows the same wedge to be moved along the rod axis in relation to the thrust members 5 and 6 and in the lateral direction. The hydraulic drive means of the auxiliary wedge 8 comprises a hydraulic cylinder 14 having a cylinder sleeve 15 rigidly connected to the auxiliary wedge 8 on the side of its crest, while the piston rod 16 is connected to the bracket of the thrust member 6. The hydraulic cylinder 14 is mounted in a manner that the axis of the piston rod 16 is extending in parallel with the bearing surface 10 of the thrust member 6, i.e. of the thrust member with which the piston rod 16 of the cylinder 14 is associated. Such arrangement provides for movement of the auxiliary wedge 8 with respect to the thrust members 5 and 6 under the action of the cylinder 14. The free end of the rod 4 terminates in a thrust head 17 having a diameter which is greater than that of the rod 4 but less than the diameter of the opening 7 in the thrust members 5 and 6. To adjust clearance 18 between the rod 4 and the thrust members 5 and 6 each thrust member is arranged for interaction with split centering bushings 19 and 20. The centering bushings 19 and 20 provide for a skewless movement of the thrust members 5 and 6 along the rod 4. Between the split centering bushing 20 and the thrust head 17 there are arranged split bushings 21 and 22 adapted to adjust clearance between the tool and the walls of the hole. Upon dismounting of the split centering bushings 19 and 20 as well as split bushings 21 and 22, the thrust members 5 and 6 together with the auxiliary wedge 8 and the cylinder 14 can also be dismounted from the rod 4 due to the diameter of the opening 7 in the thrust members 5 and 6 and to the diameter of the thrust head 17. Mounting of the thrust members 5 and 6, of the auxiliary wedge 8 and the cylinder 14 on the rod 4 can be accomplished by passing the rod 4 through the opening 7 in the thrust members 5 and 6 and consequently arranging in place the split centering bushings 19 and 20. Thus the power

pack (the thrust members 5 and 6, the auxiliary wedge 8, the hydraulic cylinder 14) can be used for operating several tools inserted into various holes. The thrust member 6 interacts, through the centering bushing 20 and split bushings 21 and 22, with the thrust head 17 on the free end of the rod 4. The thrust member 5 through the centering bushing 19 interacts with the end faces 23 of the movable jaws 2 and 3.

The apparatus operates as follows. The main wedge 1 together with the rod 4 and movable jaws 2 and 3 are inserted into a hole drilled in the rock to be broken. By the use of split bushings 19 and 20 the thrust members 5 and 6, the auxiliary wedge 8, and the cylinder 14 are mounted on the rod 4. In doing this, the centering bushing 19 should be in contact with the end faces 23 of the movable jaws 2 and 3, and between the centering bushing 20 and the thrust head 17 there should be arranged split bushings 21 and 22 of the length sufficient to set the minimal clearance between the movable jaws 2 and 3 and the wall of the hole. Thereupon, a pressure fluid is delivered to the head end of the cylinder 14, while at the rod end thereof it is drained. Under hydraulic pressure, the cylinder sleeve 15 travels with respect to the piston rod 16 and, consequently, with respect to the thrust member 6 which is rigidly connected to the piston rod 16. The cylinder sleeve 15 actuates the auxiliary wedge 8 between the thrust members 5 and 6 because the cylinder sleeve 15 is rigidly connected to the auxiliary wedge 8. Movement of the auxiliary wedge 8 causes the thrust member 6 to move in the direction from the auxiliary wedge 8 because the thrust member 5 remains stationary due to the thrust against the end faces 23 of the movable jaws 2 and 3 through the split centering bushing 19. The thrust member 6 moves the rod 4 and the main wedge 1 with respect to the movable jaws 2 and 3, because of the thrust against the thrust head 17 through the split centering bushing 20 and split bushings 22 and 21, and being moved by the auxiliary wedge 8. Thus, wedging of the tool and an increase in the breakout force applied to the walls of the hole up to the splitting of the rock are achieved.

In detaching stone blocks along the row of holes with a simultaneous application of the breakout force at several points along the line of detachment, a tool that consists of the main wedge 1 with the rod 4 and the movable jaws 2 and 3 is inserted into each hole. The power pack (the thrust members 5 and 6, the auxiliary wedge 8, and the cylinder 14) is thereafter assembled in the manner described above on the rod 4 of the first hole to wedge the tool, as described, and to develop the required breakout force; then the power pack is disassembled. The tool that has been left in the hole remains under wedging conditions without the power pack. This procedure is repeated at other holes, thus operating many tools with one power pack.

It will be obvious to those skilled in the art that various changes may be made in the invention without departure from the scope thereof as indicated in the appended claims.

Claims

1. A hydraulic wedge apparatus comprising a wedge-shaped tool constructed as a main wedge (1) arranged between movable jaws (2 and 3), an auxiliary wedge-shaped means operated by a hydraulic drive means and arranged between thrust members (5 and 6) capable of interaction with the main wedge (1) and the the movable jaws (2 and 3) **characterized** in that the thrust members (5 and 6) are mounted on a rod (4) for movement along the axis thereof, one end of said rod (4) being axially connected to the main wedge (1) on the side of the crest thereof, at the free end of the rod (4) there are means for stopping the second, as viewed from the wedge, thrust member (6), the auxiliary wedge-shaped means is constructed as an auxiliary wedge (8) mounted for interaction by wedge surfaces thereof with the bearing surfaces (9 and 10) of the thrust members (5 and 6), and the hydraulic drive means is constructed as a hydraulic cylinder (14), the cylinder sleeve (15) thereof being connected to the auxiliary wedge (8), while the piston rod (16) being connected to one of said thrust members (6) and extending in parallel with the bearing surface (10) of the same thrust member (6).

2. A hydraulic wedge apparatus as claimed in Claim 1 **characterized** in that each thrust member (5 and 6) is constructed as a plate having an opening (7) whereby each thrust member (5 and 6) is mounted on the rod (4).

3. A hydraulic wedge apparatus as claimed in Claim 1 **characterized** in that the means for stopping the second, as viewed from the main wedge, thrust member (6) is constructed as a thrust head (17) at the free end of the rod (4) and axially split bushings (21 and 22) mounted on the rod (4) between the thrust head (17) and the second, as viewed from the main wedge, thrust member (6).

4. A hydraulic wedge apparatus as claimed in Claim 1 **characterized** in that the auxiliary wedge (8) has a through slot (11) on the side

of its bevelled surfaces and extending from the base to the crest of the auxiliary wedge (8) whereby the auxiliary wedge (8) is mounted on the rod (4) for movement along the axis thereof and relative to the thrust members (5 and 6).

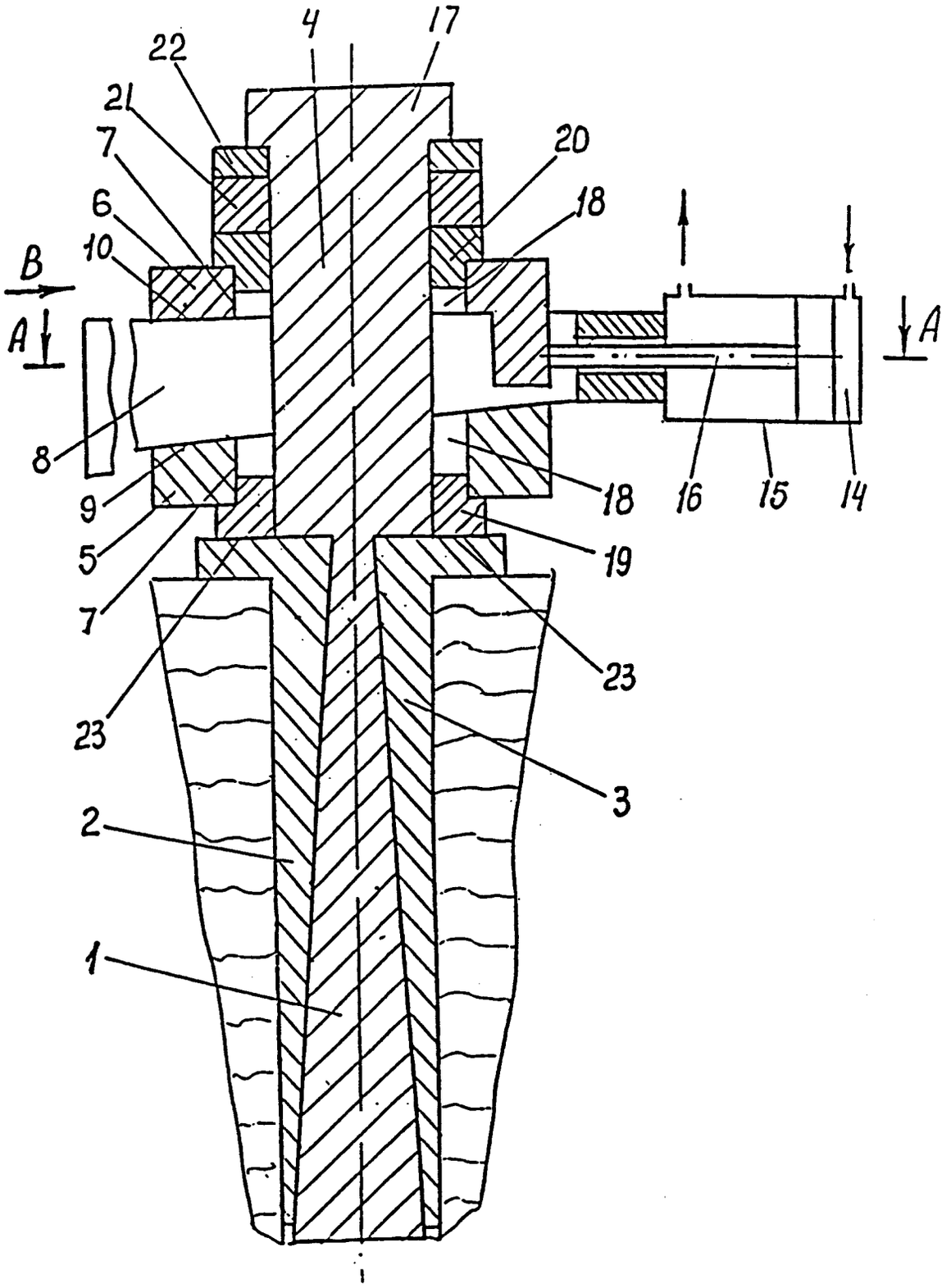

FIG. 1

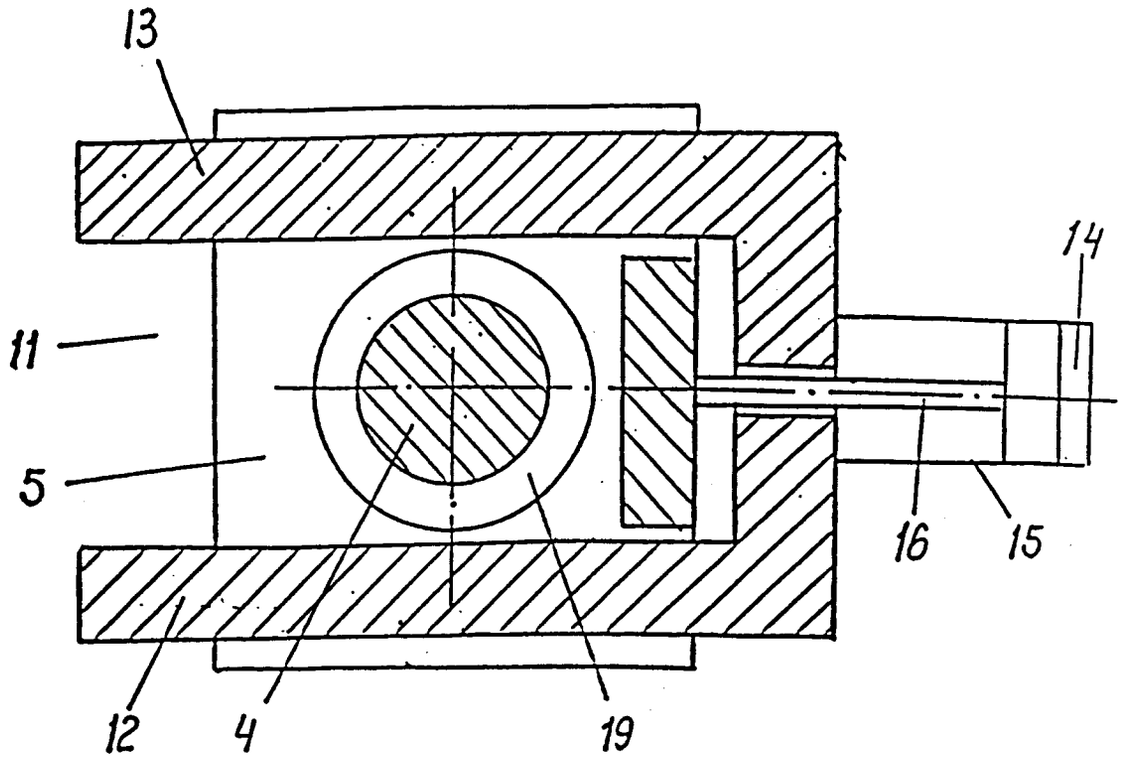

FIG. 2

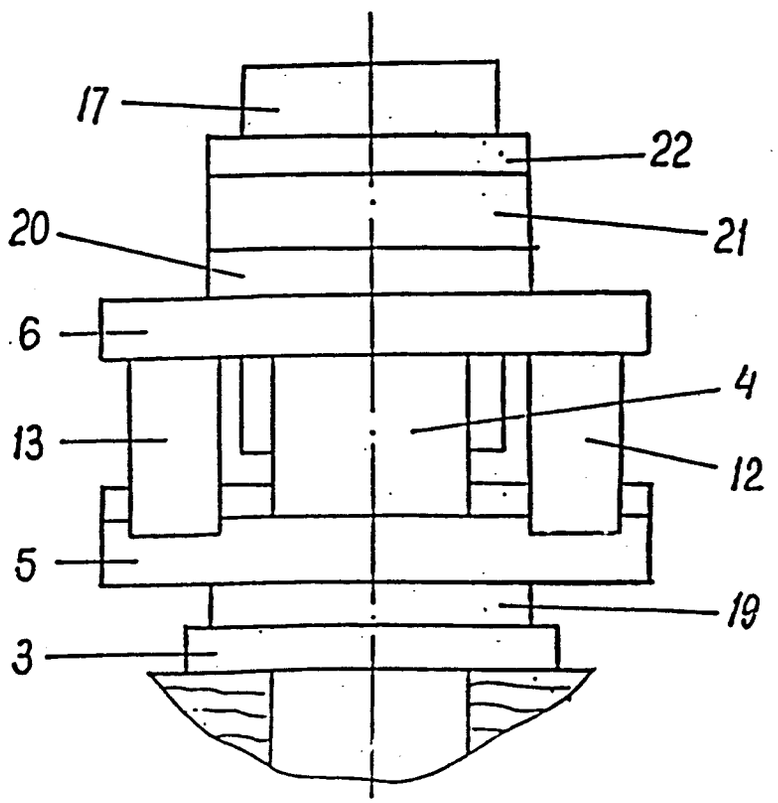

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/UA94/00007

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 5: E21C 37/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl. 5: E21C 37/00, 37/02 - 37/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SU, A, 1059172 (VSESOJVZNY NAUCHNO-ISSLEDO-VATELSKY INSTITUT NERUDNYKH STOITELNYKH MATERIALOV I GIDROMEKHANIZATSII), 7 December 1983 (07.12.83)	1
A	SU, A1, 1377387 (KARAGANDINSKY POLITEKH-NICHESKY INSTITUT), 29 February 1988 (29.02.88)	1
A	SU, A3, 1774994 (V.S. BURDOV et al), 7 November 1992 (07.11.92)	1
A	GB, B, 1239181 (WM. PARK & CO. FORGE-MASTER LIMITED), 7 July 1971 (07.07.71)	1
A	US, B, 4026602 (H. BIERI AG, LIEBE-FELD), 31 May 1977 (31.05.77)	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 August 1994 (04.08.94)	26 August 1994 (26.08.94)
Name and mailing address of the ISA/ Russian Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)