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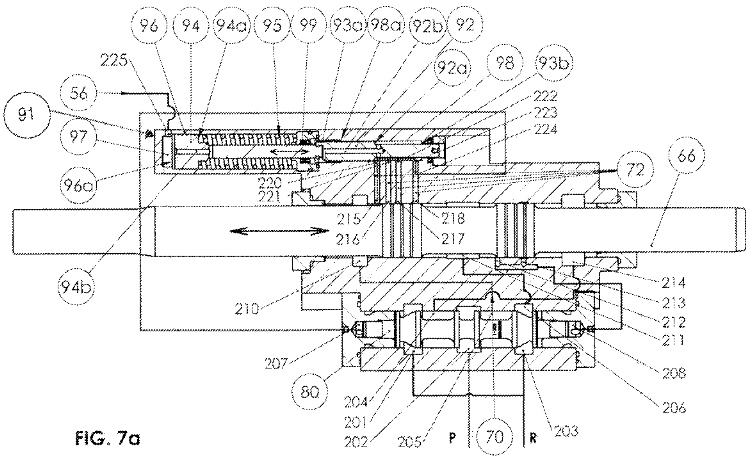


FIG. 7a

(57) **Abstract**: A rock drill including a first control valve (80), a first fluid circuit (70) suppliable with fluid via the first control valve (80), an impact piston (66) driveable by fluid pressure in the first fluid circuit, a plurality of first fluid circuit feedback paths (72) from the impact piston (66) to the control valve (80), a damping body (50) for damping backpressure from a rock face, a damping fluid chamber (52), associated with the damping body (50), characterised in a second fluid circuit (56) in fluid communication with the damping fluid chamber (52) and a stroke length control mechanism (91) actuable by fluid pressure in the second fluid circuit (56), wherein flow of fluid in said first fluid circuit feedback paths (72) is controllable by the stroke length control mechanism (91), whereby the driveable stroke length of said impact piston 66 may be adjusted.

WO 2012/031311 A1

IMPROVED ROCK DRILL

FIELD OF THE INVENTION

The present invention relates to industrial ore mining drill tools and specifically to rock drills that provide percussive and rotary energy to a drill string.

BACKGROUND

Rock drills drive a drill rod (also known as a drill shank) that transmits (via a drill string) rotary and percussive energy to a drill bit which has a working or rock facing end. The drilling tool also supplies flushing medium (commonly air or water) via the drill rod and drill string.

Typically a mining rig has a 'central' pump supplying fluid into a 'central' pressurised hydraulic system. Various parts of the rig and rock drill are operated using the pressurised hydraulic system. The 'central' pump may be driven by an electric 'central' motor.

The rock drill also has another motor (which may *receive* hydraulic supply from the 'central' hydraulic system), which generates high speed rotary motion of the drill rod via a gearing arrangement involving an offset drive shaft. Typically the drill rod rotates at speeds of up to around 220 rpm. This rotation is transmitted via the drill string to the drill bit at the rock face to enable holes to be drilled in the rock.

Rock drills also generate percussive force on the drill rod, by generating a shock wave that is transmitted via the drill string to the drill bit and rock face. This percussive force or shock wave is generated by impact force from an impact piston (housed in an impact body) aligned on the same axis as the drill rod. The impact piston is hydraulically driven back and forth so that an end impacts an end of the drill rod. The hydraulic driving circuit is usually supplied by the 'central' hydraulic system. Force on the order of 2.8 tonnes at 60 Hz is typical. To cope with the percussive shock wave returned up the drill string from the rock face, a damping body cushions the chuck holding the end of the drill rod.

Such rock drills are frequently required to drive a drill string of around 3 to 6 metres weighing around 35 kilograms. Depending on the nature of the rock, they may drill through up to around 60 metres of rock per hour.

The rock drill is advanced along a beam towards the rock face, keeping the tip of the drill bit in contact with the working face. The drill bit rotation and percussive shockwaves break up the rock face, in some circumstances fluidising the rock at the tip of the drill bit.

Rock drills suffer from numerous problems in actual operation. The operating conditions are difficult and dirty, the loads and forces involved are significantly high, and a number of failure modes are common.

It is important to match parameters including the rate the drill advances along the beam, the type of rock being drilled, rotational speed, frequency and level of percussive force being used. Otherwise the drill can become uncontrolled. The pressure experienced at the rock face is related to these parameters and also experienced by the rock drill damping body. This is known as the back pressure. The back pressure experienced by the drill is thus related to these parameters.

It is important for effective drilling that the percussive force transmitted is matched to the particular rock face. Where the rock is very hard, greater force is required to be concentrated at the rock face. This is achieved by using a longer impact piston stroke length. The longer stroke length (also known as "throw"), results in a higher final impact velocity of the piston and thus in the impact force (Force = Mass x Velocity / Time) being greatly increased than for a shorter throw. It is noted that a longer throw is associated with a lower frequency at that back pressure (i.e. fewer impacts per time period) for the impact piston cycle than a shorter throw at the same back pressure.

Where the rock is soft, a lesser force is used by using a shorter impact piston stroke length, and thus a lower final impact velocity when the impact piston impacts the drill rod and thus a reduced impact force, compared to using a longer throw.

In operation, the main way in which back pressure is affected is by a change in the actual rock – hard rock will provide high back pressure as the drill tip advances along the beam against the hard rock. Where the rock is soft, but the drill is set for hard rock and the drill tip advances at a hard rock rate, there is an almost total loss in back pressure as rock is cracked or fluidised at a greater distance in advance of the drill bit tip in soft rock than in hard rock, resulting in the drill bit tip working against a non-resistive substance rather than a surface against which pressure may be exerted.

The drill rod associated with the rock drill in use is held in a chuck. Rotation of the chuck is generated via a gear box, thus rotating the drill rod. The chuck is cushioned against backpressure and vibration by a damping body. Typically the chuck presses against a damping piston located in a hydraulic fluid chamber in the damping body, acting as the cushion. This damping fluid chamber is independent of the 'central' hydraulic fluid system – movement of the damping piston simply increases or decreases pressure to absorb the vibration and backpressure. In this way, the forces exerted during operation are, to the extent possible, isolated from the main parts of the drill or at least are damped.

The more force exerted on the chuck, the harder it will push into the damping body. Where back pressure is increased due to more pressure being applied at the rock face by the tip of the drill, more force is exerted on the chuck, and where less pressure is applied at the rock face, less force is exerted on the chuck. Pressing harder at the rock face causes higher back pressure, while softer rock face pressure reduces back pressure.

A loss in back pressure causes the chuck to move forward relative to the damping body and impact body, moving the end of the drill rod forward away from the impact body and thus changing the impact piston stroke length to a longer throw.

Thus an even higher impact force is then applied to the drill rod. This increases the force at the rock face, further reduces the back pressure and an over-stroking loop quickly develops. The impact piston throw increases but since there is no back pressure through the drill rod the frequency may also increase.

Uncontrolled over-stroking of the impact piston can result in significant and expensive damage to the drill, including damage to the 'central' hydraulic pump and its motor. Matching the impact piston throw length to type of rock is sometimes achieved by using a set of regulating pins that can be changed over in an onsite workshop or even in the field. Each pin is shaped to reconfigure the hydraulic circuit driving the impact piston, to change piston stroke length to be long, medium or short. However, this does not solve the problem where a drill tip suddenly punches through hard rock into soft. The over-stroking problem remains. Furthermore, operators forget to change pins, lose pins and in the dirty mining environment there is a risk dirt or contaminants will enter the impact piston hydraulic driving circuit and result in expensive damage.

Electronic control and monitoring systems have been attempted in the past to alleviate the over-stroking problem. However these systems are themselves prone to failure in the extreme field conditions (usually very hot or very cold, and very dirty) and they are also very expensive, in addition to causing operations to cease for a period of time.

It is an object of the invention to provide an improved or alternative means of reducing the impact of over-stroking on drilling operations.

Use of the terms 'forward', 'rearward' or other relative terms is made for ease of understanding of the relative disposition of components and is not to be taken as limiting the drill or components to operation in a particular orientation.

Any reference to prior art in this specification is not, and should not be taken as, an acknowledgement or admission that the prior art forms part of the common general knowledge of a person skilled in the relevant art or could reasonably be expected to be ascertained, understood or regarded as relevant by a person skilled in the relevant art.

SUMMARY OF THE INVENTION

A first aspect of the invention provides a rock drill including:

a) a first control valve 80;

b) a first fluid circuit 70 suppliable with fluid via the first control valve 80;

c) an impact piston 66 driveable by fluid pressure in the first fluid circuit 70;

d) a plurality of first fluid circuit feedback paths 72 from the impact piston 66 to the control valve 80;

e) a damping body 50 for damping backpressure from a rock face;

f) a damping fluid chamber 52, associated with the damping body 50;

characterised in:

g) a second fluid circuit 56 in fluid communication with the damping fluid chamber 52; and

h) a stroke length control mechanism 91 actuable by fluid pressure in the second fluid circuit 56;

wherein flow of fluid in said first fluid circuit feedback paths 72 is controllable by the stroke length control mechanism 91, whereby the driveable stroke length of said impact piston 66 may be adjusted.

Advantageously, the stroke length of the impact piston is automatically adjustable or controllable in response to a change in drill backpressure communicated to the damping body fluid chamber. Problems associated with sensitive electronic detection and control equipment are avoided. The lack of automatic response, loss of manual pins, and the dirt and contamination problems associated with manual reconfigurations are avoided – the fluid circuits may be sealed during normal field use, rather than being vulnerable to contamination when parts are changed over.

In a preferred embodiment, said stroke length control mechanism 91 is hydraulically actuable by fluid pressure in the second fluid circuit 56 to hydraulically open and/or close said plurality of first fluid circuit feedback paths 72 to adjust the driveable stroke length of said impact piston 66.

Preferably said stroke length control mechanism 91 includes an actuator piston 94 in fluid communication with and actuable by fluid pressure in the second fluid circuit 56. Preferably said stroke length control mechanism 91 includes an adjustor pin 92 driveable by the actuator piston 94, whereby movement of the adjustor pin 92 opens and/or closes said plurality of first fluid circuit feedback paths 72. Preferably said adjustor pin 92 is in fluid communication with the first fluid circuit 70. Preferably said adjustor pin 92 has a balancing port 92b. Preferably said actuator piston 94 has a balancing port 94b. Preferably said stroke length control mechanism 91 includes a return spring 95.

In a preferred embodiment, the rock drill has four forward first circuit fluid feedback paths 72 and two rearward first circuit fluid feedback paths 72.

A second aspect of the invention provides a rock drill including:

a) a first fluid circuit 70 for driving an impact piston 66;
b) a second fluid circuit 56 isolated from the first fluid circuit, the second fluid circuit in fluid communication with a damping chamber 52 for damping backpressure from a rock face; and
c) a stroke length control mechanism 91 in fluid communication with each of the first fluid circuit and the second fluid circuit, the stroke length control mechanism 91 actuable by fluid pressure in the second fluid circuit 56 to reconfigure fluid paths in the first fluid circuit 70;

whereby the driveable stroke length of the impact piston 66 is automatically adjustable in response to backpressure from the rock face.

A third aspect of the invention provides a rock drill including:

a) a first fluid circuit 70 for driving an impact piston 66;

b) a second fluid circuit 56 in fluid communication with a damping chamber 52 for damping backpressure from a rock face; and
c) a stroke length control mechanism 91 hydraulically actuable by fluid pressure in the second fluid circuit 56 to hydraulically open and/or close fluid paths in the first fluid circuit 70;

whereby the driveable stroke length of the impact piston 66 is automatically controllable in response to backpressure from the rock face.

A fourth aspect of the invention provides a method of adjusting the drivable stroke length of an impact piston 66 in a rock drill, the method including the steps of:

a) causing a pressure change in fluid in a damping chamber 52 in fluid connection with a damping fluid circuit 56, the damping chamber 52 associated with a rockdrill damping body 50;
b) in response to said pressure change, hydraulically actuating a mechanism 91 in fluid communication with both the damping fluid circuit 56 and a driving fluid circuit 70 for driving the impact piston 66; and
c) moving one or more components of the mechanism in response to said hydraulically actuation of the mechanism 91, thereby opening and/or closing fluid paths 72 in the driving fluid circuit 70;

whereby the driveable stroke length of the impact piston 66 is adjusted.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a rock drill according to an embodiment of the invention, mounted upon a cradle movable along a beam;

Figure 2 is a front elevation of the embodiment of Figure 1;

Figure 3 is a cross-sectional view of the embodiment of Figure 2, taken along the line A-A on Figure 2;

Figure 4 is a cross-sectional view of the embodiment of Figure 2, taken along the line B-B on Figure 2;

Figure 5 is a detail view of part of Figure 4;

Figure 6 is an exploded view of the embodiment of Figure 1;

Figure 7a is a sectional and schematic view of the impact piston and associated hydraulic driving circuit, in which the stroke adjustor is shown in a minimum stroke position;

Figure 7b is a sectional and schematic view of the impact piston and associated hydraulic driving circuit, in which the stroke adjustor is shown in an intermediate stroke position;

Figure 7c is a sectional and schematic view of the impact piston and associated hydraulic driving circuit, in which the stroke adjustor is shown in a maximum stroke position;

Figure 8 is a schematic of a hydraulic circuit according to an embodiment of the invention; and

Figure 9 is a block diagram of a method according to an embodiment of the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

Figures 1 and 2 show a rock drill 2 in drill operation configuration, the drill 2 having a front head 20, cover plate 30, housing of a rotation generation mechanism or gear box 40, a percussive or back pressure damping mechanism for damping a drill rod (also known as back pressure damping body 50), stroke adjustor 90 for adjusting the stroke length of an impact piston 66 and impulse generating mechanism or impact body 60. They are supported on cradle assembly 110, which in operation moves longitudinally along a beam 120.

A drill rod or shank adaptor 10 associated with the rock drill is also shown in the operational position. In use, drill rod 10 is connected to a drill string (not shown) for transmission of rotary motion and percussive force to a drill bit (not shown) working at a rock face. The rock drill 2 advances along the beam 120 to keep the tip of the drill bit (not shown) under pressure at the rock face. As rock is fluidised, the rock drill continues to move forward, drilling a hole in the rock. When the drill 2 has advanced to the forward end of the beam 120 it is repositioned at the rear end, and the beam and drill string reconfigured to recommence operations.

As shown in Figure 3, the drill rod or shank adaptor 10 is held by a drill chuck 42. The drill chuck 42 is rotatable about the central drill axis 4, and can also move through a limited range longitudinally along the drill axis 4. During operation, as the rock drill 2 advances along the beam 120, the tip of the drill bit (not shown) works at the rock face. The continued advancement of the rock drill 2 creates a back pressure along the drill string and drill rod 10 from the drill bit at the rock face to the drill chuck 42. The drill chuck 42 moves in a limited range forwardly or rearwardly relative to the back pressure damping body 50 along the longitudinal axis 4, in response to the back pressure, i.e. the pressure at the working rock face. The back pressure, and vibrational forces or percussive shock imparted to and reflecting from the working face, are as far as possible isolated or damped from the rest of the drill by back pressure damping body 50. These vibrational forces may also be known as reflex waves.

A rotary drive shaft 46 drives gearbox 40 having cover plate 30, gears 48 and tapered thrust bearings 47,49. This in turn drives chuck 42 and drill rod 10. The front head 20 has a flushing seal carrier 150 via which flushing medium is supplied to the hollow centre 12 of the drill rod 10.

Back pressure damping body 50 has or is associated with a back pressure damping fluid chamber 52, and a damping piston 54. The damping piston 54 is longitudinally aligned with the drill chuck 42 and is driven by the drill chuck 42. As the drill chuck 42 moves rearwardly along the longitudinal axis 4 due to the back pressure transmitted through the drill rod 10, the damping piston 54 also moves rearwardly and compresses the cushioning hydraulic fluid in the back pressure damping fluid chamber 52. The greater the compression, the greater the pressure in the damping fluid chamber and the greater the resistance to further movement in a rearward direction. Where the back pressure is low or none, the damping piston 54 is driven to a forward position by the hydraulic fluid. The longitudinal movement of the drill chuck 42 thus changes the position of the drill rod 10 relative to the impact body 60 and impact piston 66. It is noted that the back pressure damping fluid chamber 52 is a generally annular chamber extending around the impact piston 66, and that the damping piston 54 also extends in an annular manner around the impact piston 66. The damping body 50 and its associated back pressure damping chamber 52 are not in fluid communication with any hydraulic circuits associated with the motor for driving the gear box 40.

Turning to Figures 4 and 5, the impact piston 66 is driven by fluid in a fluid circuit 70 which in this embodiment is a hydraulic circuit receiving pressure supply from a 'central' hydraulic system (not shown). The terms "driving fluid circuit" 70 and "first fluid circuit" 70 are used herein to distinguish it from the "damping fluid circuit" 56 (also referred to as "second fluid circuit" 56) associated with the back pressure damping chamber 52. The "damping fluid circuit" 56 is isolated from the driving fluid circuit and does not receive pressure supply from the 'central' hydraulic system, but rather pressure changes are due to movement of the damping piston 54, responding to the drill chuck holding drill rod 10. Use of the term "driving fluid circuit" 70 should not be taken to require a particular fluid path of the paths within that circuit to drive an impact piston.

Turning to Figures 7a to 7c which are in a mirror image orientation compared to Figures 4 and 5, the hydraulic driving fluid circuit 70 has an associated control valve, being first spool valve 80 which is not visible in Figures 4 and 5. The impact piston 66 is driven forward and rearward within impact piston housing 60 at around

60Hz. Fluid is supplied through the first control spool valve 80 into the impact piston housing 60 via ports 210 or 214 and drives the impact piston 66. Fluid is returned from the impact piston 66 via ports 210, 211 and/or 214. The position of the 6 port, 2 position spool determines the path through which fluid is supplied and thus the direction of travel of the impact piston 66. The control spool valve 80 has pressure supply port 202, and return or drain ports 201 and 203. It also has working side ports 204, 205 and 206, through which fluid is supplied to and returned from the impact piston 66. The spool valve 80 is a directional valve in which a position change is triggered via fluid flow to end port 207 or 208.

A change in direction of the impact piston 66 is triggered by hydraulic feedback from the impact piston 66 caused by opening and closing of a forward and a rearward port such as forward ports 215, 216, 217, 218 and rearward ports 212, 213 due to movement of the impact piston 66. The feedback to a respective end 207, 208 of the spool valve 80 causes the spool to move to another position. By providing at least two forward (or rearward) hydraulic feedback ports a change in the stroke length of the impact piston 66 can be obtained depending on which of the ports is connected to an end of the spool valve. A regulating pin can be used to block or open a fluid path to reconfigure the circuit, determines which port is connected and thus the impact piston stroke length.

In prior art arrangements, provision of a regulating pin to manually reconfigure the driving circuit to a particular stroke length was of use to manually set the drill 2 to work at a known rock face hardness level. However, where for example hard rock is suddenly changed to a soft rock section, the drill 2 still suffers from over-stroking of the impact piston. The over-stroking can result in the impact piston cycling at an unreasonably high frequency and is most undesirable. While it was possible to change the regulating pin manually, this did not prevent over-stroking incidents, but rather in the event that the drill was not damaged, simply enabled the drill to be put back into service with a different regulating pin giving a new stroke length setting for the apparent new conditions. The regulating pin was manually removed from the drill housing with an associated risk that dirt and contaminants would enter the hydraulic fluid circuit driving the impact piston.

In the embodiment of the invention shown the Figures, the stroke adjustor 90 includes a stroke length control mechanism 91, in this embodiment a hydraulic control valve also referred to herein as stroke length control valve 91, second control valve 91 or switch 91. The stroke length control valve 91 includes a stroke adjustor pin 92, residing in adjustor housing 98, an actuator or stroke adjustor piston 94 for driving the pin 92 and a return spring 95. The stroke length control mechanism 91 is operable to reconfigure the driving fluid circuit. Movement of the pin 92 opens and / or closes the first fluid circuit feedback paths 72. The position of the hydraulically driven stroke adjustor pin 92 controls or switches the forward feedback fluid path through which hydraulic fluid will travel in the driving fluid circuit 70. This in turn changes the point in the impact piston's travel or stroke at which the first control spool valve 80 triggers a direction change in the movement of the impact piston 66 within impact piston housing 60. The four forward feedback ports 215, 216, 217, and 218 in impact housing 60 are spaced at a distance from the two rearward feedback ports 212, 213 that, in conjunction with the configuration of the impact piston 66, they provide an adjustment in the impact piston stroke length of 0mm, 9mm, 17.5mm, 31mm respectively. Thus in the embodiment shown the impact piston 66 may have any of four stroke lengths corresponding to the four forward fluid ports 220, 221, 222 and 223 in impact housing 98.

Each of the four forward feedback ports 215, 216, 217, and 218 has a respective fluid path connecting to respective ports 220, 221, 222 and 223 in adjustor pin housing 98. The adjustor pin position determines which of ports 220, 221, 222 and 223 are open to connect to directional feedback take-off 224 and thus to fluid path 224-207 to supply pressure to the first control valve 80 at the forward end of the spool to trigger a spool position change and thus an impact piston direction change.

Thus as shown in Figure 7a, the impact piston 66 is triggered in a direction change when the fluid path connecting ports 215-220 is open at both ends, and thus has a shorter stroke length than in Figure 7b where a direction change is not triggered until the impact piston 66 has travelled far enough to open fluid path 216-221, as in Figure 7b fluid path 215-220 is blocked by the stroke adjustor pin 92. Similarly, a maximum stroke length is obtained in Figure 7c as the impact piston 66 moves until it opens fluid path 218-224, as the adjustor pin 92 blocks fluid paths 215-220, 216-221, and 217-222.

Importantly as shown in Figures 7a to 7c, the stroke length control mechanism 91 is hydraulically operated, driven by the pressure in the damping fluid chamber 52 and damping fluid circuit 56 to reconfigure the driving fluid circuit 70. The stroke adjustor pin 92 is driven by an actuator or stroke adjustor piston 94, located in housing 96 (see Figure 5). The stroke adjustor piston 94 has an associated return spring 95. Where the pressure in the damping fluid chamber 52 is increased, fluid from the damping fluid chamber 52 will flow through damping fluid path 56 into piston housing 96 at an end zone 97 via port 225, hydraulically driving the piston 94 against the return spring 95. This also drives the adjustor pin 92. Movement of adjustor pin 92 results in switching of the forward feedback fluid paths as described above in response to the pressure in damping fluid chamber 52.

The stroke adjustor piston 94 has a working face which together with an end wall of the piston housing 96 defines an end zone 97, into which damping fluid path 56 enables passage of damping fluid from the damping chamber 52. The working face of the piston 94 is prevented from "sticking" to the end wall of the housing by the left end of stroke adjustor pin 92 reaching its maximum travel within adjustor housing 98, preventing the piston 94 from contacting the end wall.

The stroke adjustor piston 94 has a return spring 95 which seats against piston shoulder 94a. The piston 94 also has a balancing port 94b, being a hollow centre channel that functions as a passage through the piston 94, from the end zone 97 side of the piston 94 to the return spring 95 side of the piston 94. The balancing port 94b allows equalisation of fluid pressure to either side of the piston 94, which can significantly reduce the force acting on the return spring 95. The fatigue life of the return spring 95 can thus be significantly increased.

The stroke adjustor piston housing 96 has seals 99 between it and the adjustor pin housing 98, which prevent damping fluid from exiting the housing 96 while allowing the piston 94 to extend into the adjustor pin housing 98 and drive the adjustor pin 92

As best viewed in Figure 7c the adjustor pin housing 98 has a small stepped shoulder 98a which defines a first end zone 93a.

The adjustor pin 92 also has a piston shoulder 92a which in the maximum stroke position shown in Figure 7c is seated against the end wall of the housing 98. When not in the maximum stroke position the shoulder 92a and housing 98 define a second end zone 93b, as viewed in Figures 7a and 7b.

The stroke adjustor pin 92 also has a balancing port 92b as shown in Figures 7a, 7b and 7c, being a hollow centre channel that functions as a passage through the pin 92 from the first end zone 93a side to the second end zone side 93b.

The balancing port 92b allows equalisation of fluid pressure to either side of the adjustor pin 92, which alleviates the effect of high percussion pressure in the driving or first fluid circuit acting on stroke adjustor pin 92 as the impact piston 66 is operated. Thus the stroke adjustor mechanism is primarily controlled or affected by pressure in the damping or second fluid circuit i.e. back pressure.

Thus the feedback fluid ports and paths, and adjustor pin 92 have been arranged (in conjunction with return spring 95 and the sizing of the faces of piston 94 etc) to result in the stroke length of the impact piston 66 being automatically matched to the back pressure from the rock face (as back pressure determines the pressure in damping fluid chamber 52).

It should be noted for clarity that the damping fluid circuit including damping fluid chamber 52 and damping fluid path 56 is a separate fluid circuit from the driving fluid circuit 70 – the stroke adjustor piston 94 and stroke adjustor pin 92 have associated seals preventing leaks from one system to the other.

Thus the hydraulically actuated stroke length control mechanism or switch 91 (including stroke adjustor pin 92), is directly responsive to changes in pressure in the damping fluid chamber, enabling the stroke length of the impact piston to be automatically and hydraulically adjusted during operations. This can avoid the over-stroking feedback loop which causes problems in the prior art, since stroke length is continually adjusted according to back pressure. The hydraulic operation avoids the need for expensive and delicate electronic instrumentation and controls to shut down the drill if it over-strokes.

The embodiment disclosed has four fluid paths defining four stroke length settings. However, greater or fewer fluid paths could be provided to change the number of stroke length settings available, and the difference in stroke length enabled by each path may be selected to suit particular requirements.

The arrangement of driving fluid circuit 70, stroke length control mechanism 91, adjustor pin 92, impact piston 66 and spool valve 80 can be made in a variety of configurations. For example the size and location of cavities defined between the impact piston and its housing, or between the adjustor pin and its housing, type and configuration of the directional valve and the location of fluid ports, may be varied in a number of ways to achieve the same or similar result. The above is thus a description of one embodiment of such a driving fluid circuit.

The arrangement of the damping fluid circuit 56 can also be made in a variety of configurations. Depending on mechanical configuration, the stroke length control mechanism 91 could be located directly adjacent the damping fluid chamber 52 and remove the need for a conduit, fluid channel or path between chamber 52 and piston

94. Nonetheless, in such a case the damping chamber 52 is considered to comprise the second fluid circuit 56.

Pneumatic, rather than hydraulic, operation may also be feasible in some applications.

Figure 9 shows a block diagram of a method of adjusting the driveable stroke length of an impact piston. In step 1, fluid pressure in the damping chamber 52 alters in response to movement of the drill rod due to rock backpressure. In step 2, the fluid pressure change hydraulically actuates the stroke length control mechanism 92 to a new position via the damping fluid circuit 56. In step 3, movement of the adjustor pin 92 in the mechanism 92 opens and/or closes forward feedback paths 72 connected to ports 215, 216, 217 and 218 in the driving fluid circuit 70. This adjusts the paths and ports through which fluid is fed back to the control valve 80 that triggers a direction change to the impact piston, and thus the position of the impact piston when a direction change is triggered. Thus the driveable stroke length of the impact piston is hydraulically adjusted in response to rock face back pressure in the damping body.

While the above description refers to one embodiment of a rock drill, it will be appreciated that other embodiments can be adopted by way of different combinations of features. Such embodiments fall within the spirit and scope of this invention.

The term “comprises” and its grammatical variants have a meaning that is determined by the context in which they appear. Accordingly, the term should not be interpreted restrictively unless the context dictates so.

CLAIMS:

1. A rock drill including:
    a) a first control valve 80;
    b) a first fluid circuit 70 suppliable with fluid via the first control valve 80;
    c) an impact piston 66 driveable by fluid pressure in the first fluid circuit 70;
    d) a plurality of first fluid circuit feedback paths 72 from the impact piston 66 to the control valve 80;
    e) a damping body 50 for damping backpressure from a rock face;
    f) a damping fluid chamber 52, associated with the damping body 50;

    characterised in:

    g) a second fluid circuit 56 in fluid communication with the damping fluid chamber 52; and
    h) a stroke length control mechanism 91 actuable by fluid pressure in the second fluid circuit 56;

    wherein flow of fluid in said first fluid circuit feedback paths 72 is controllable by the stroke length control mechanism 91, whereby the driveable stroke length of said impact piston 66 may be adjusted.

2. A rock drill according to claim 1 further characterised in that said stroke length control mechanism 91 is hydraulically actuable by fluid pressure in the second fluid circuit 56 to hydraulically open and/or close said plurality of first fluid circuit feedback paths 72 to adjust the driveable stroke length of said impact piston 66.

3. A rock drill according to claim 1 or 2 further characterised in that said stroke length control mechanism 91 includes an actuator piston 94 in fluid communication with and actuable by fluid pressure in the second fluid circuit 56.

4. A rock drill according to claim 3 further characterised in that said stroke length control mechanism 91 includes an adjustor pin 92 driveable by the actuator piston

94, whereby movement of the adjustor pin 92 opens and/or closes said plurality of first fluid circuit feedback paths 72.

5. A rock drill according to claim 4 further characterised in that said adjustor pin 92 is in fluid communication with the first fluid circuit 70.

6. A rock drill according to claim 5 further characterised in that said adjustor pin 92 has a balancing port 92b.

7. A rock drill according to any one of claims 3 to 6 further characterised in that said actuator piston 94 has a balancing port 94b.

8. A rock drill according to any one of claims 3 to 7 further characterised in that said stroke length control mechanism 91 includes a return spring 95.

9. A rock drill according to any one of the preceding claims further characterised in four forward first circuit fluid feedback paths 72.

10. A rock drill according to any one of the preceding claims further characterised in two rearward first circuit fluid feedback paths 72.

11. A rock drill including:
    a) a first fluid circuit 70 for driving an impact piston 66;
    b) a second fluid circuit 56 isolated from the first fluid circuit, the second fluid circuit in fluid communication with a damping chamber 52 for damping backpressure from a rock face; and
    c) a stroke length control mechanism 91 in fluid communication with each of the first fluid circuit and the second fluid circuit, the stroke length control mechanism 91 actuable by fluid pressure in the second fluid circuit 56 to reconfigure fluid paths in the first fluid circuit 70;

whereby the driveable stroke length of the impact piston 66 is automatically adjustable in response to backpressure from the rock face.

12. A rock drill including:

a) a first fluid circuit 70 for driving an impact piston 66;

b) a second fluid circuit 56 in fluid communication with a damping chamber 52 for damping backpressure from a rock face; and

c) a stroke length control mechanism 91 hydraulically actuable by fluid pressure in the second fluid circuit 56 to hydraulically open and/or close fluid paths in the first fluid circuit 70;

whereby the driveable stroke length of the impact piston 66 is automatically controllable in response to backpressure from the rock face.

13. A method of adjusting the drivable stroke length of an impact piston 66 in a rock drill, the method including the steps of:

a) causing a pressure change in fluid in a damping chamber 52 in fluid connection with a damping fluid circuit 56, the damping chamber 52 associated with a rockdrill damping body 50;

b) in response to said pressure change, hydraulically actuating a mechanism 91 in fluid communication with both the damping fluid circuit 56 and a driving fluid circuit 70 for driving the impact piston 66; and

c) moving one or more components of the mechanism in response to said hydraulically actuation of the mechanism 91, thereby opening and/or closing fluid paths 72 in the driving fluid circuit 70;

whereby the driveable stroke length of the impact piston 66 is adjusted.

14. A rock drill substantially as hereinbefore described, with reference to the embodiment shown in the accompanying Figures 1 to 9.

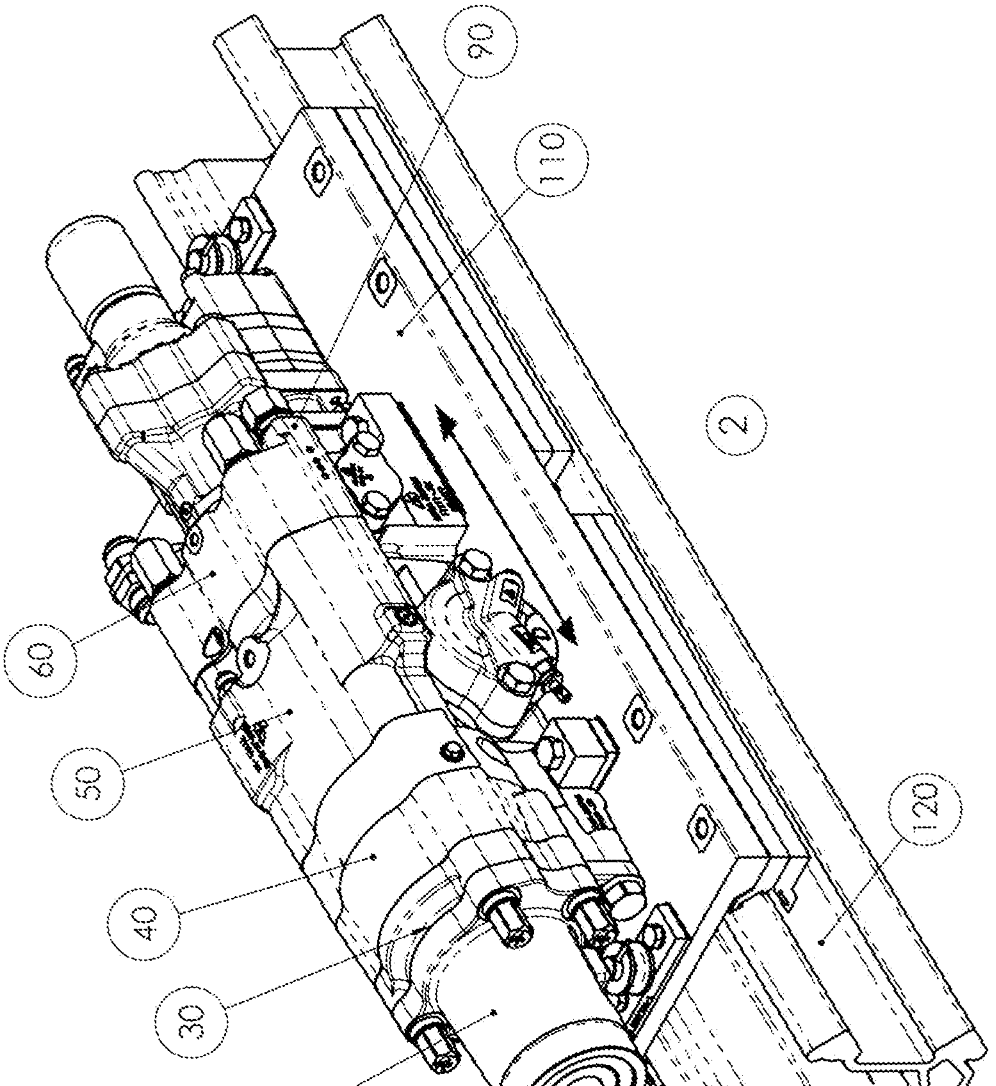


FIG. 1

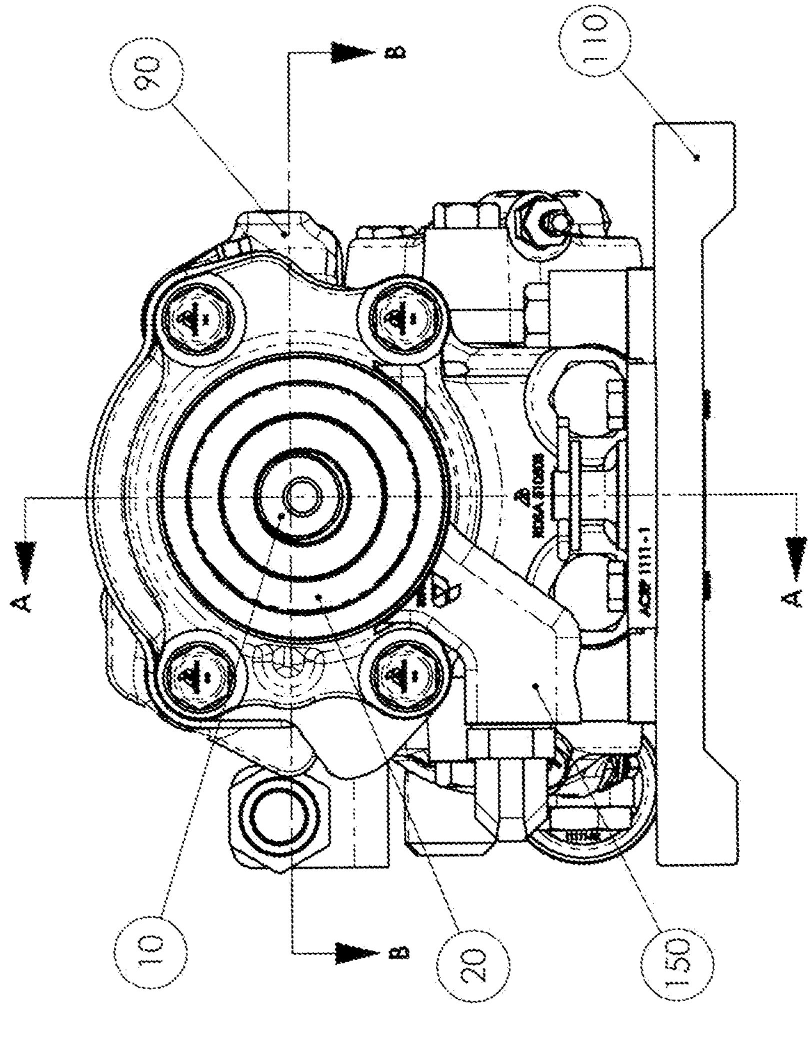
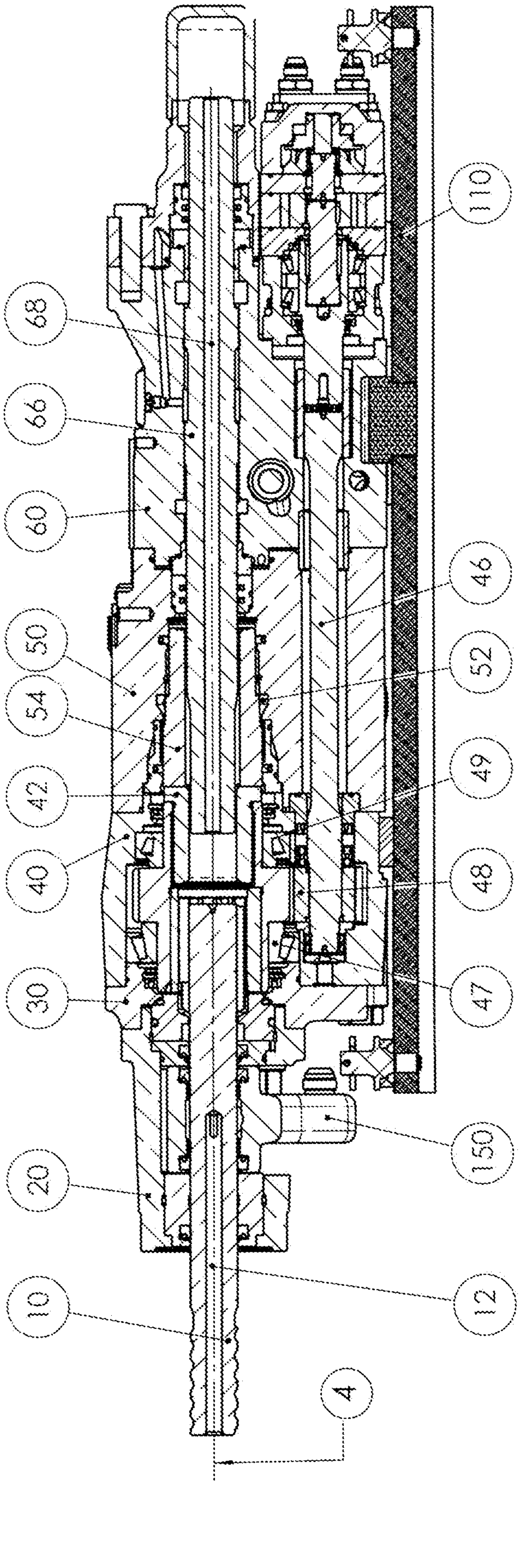
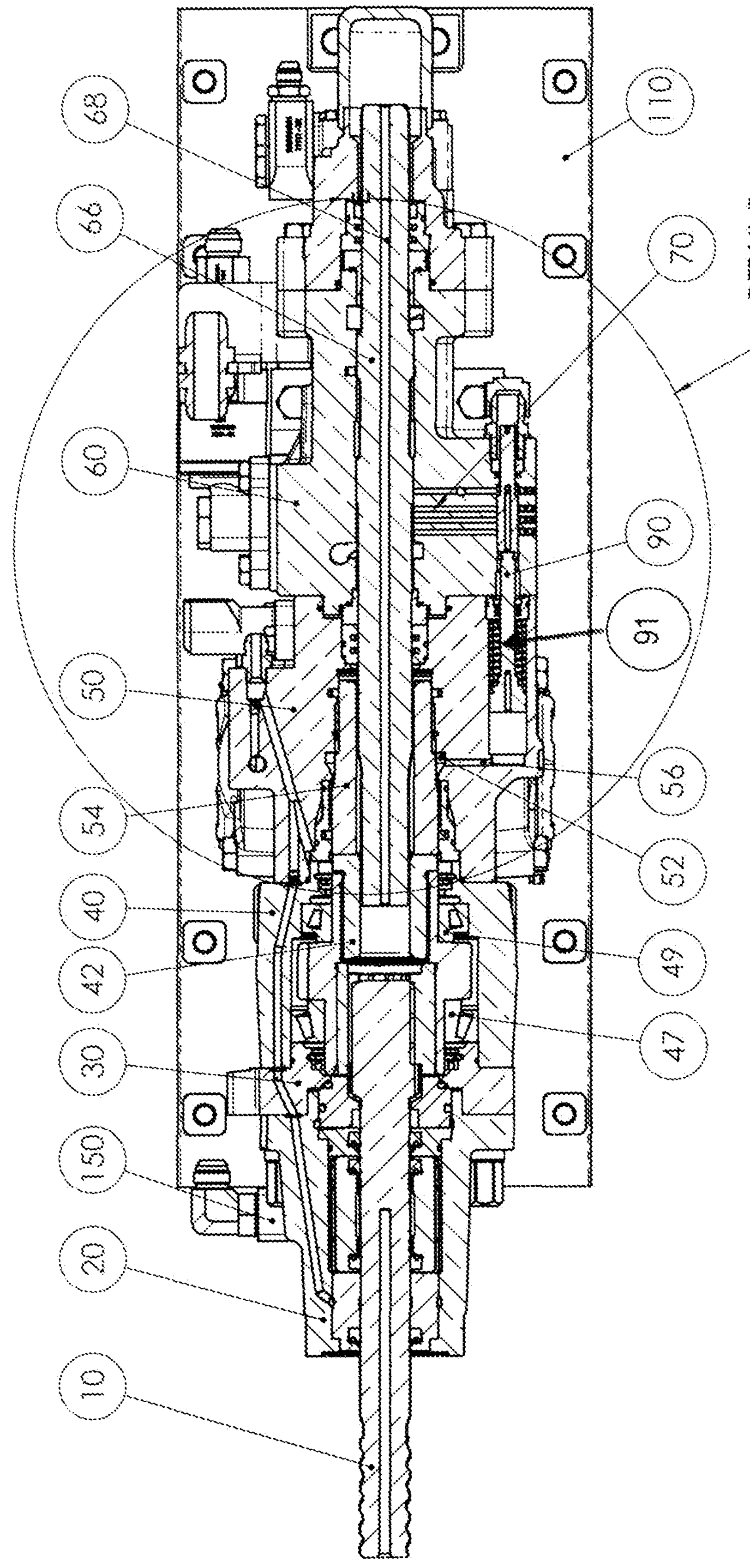


FIG. 2



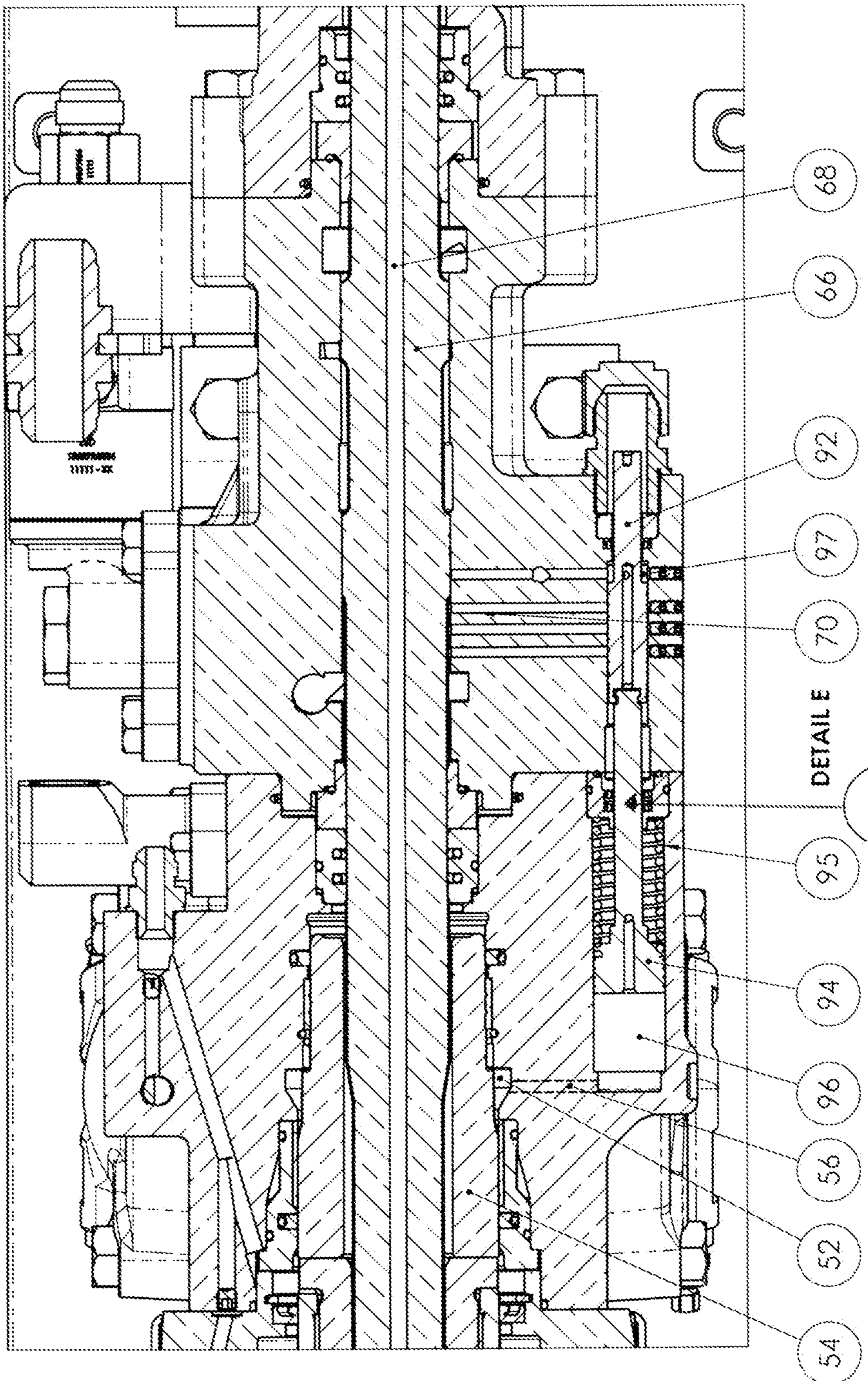
SECTION A-A

FIG. 3



SECTION B-B

FIG. 4



DETAIL E

FIG. 5

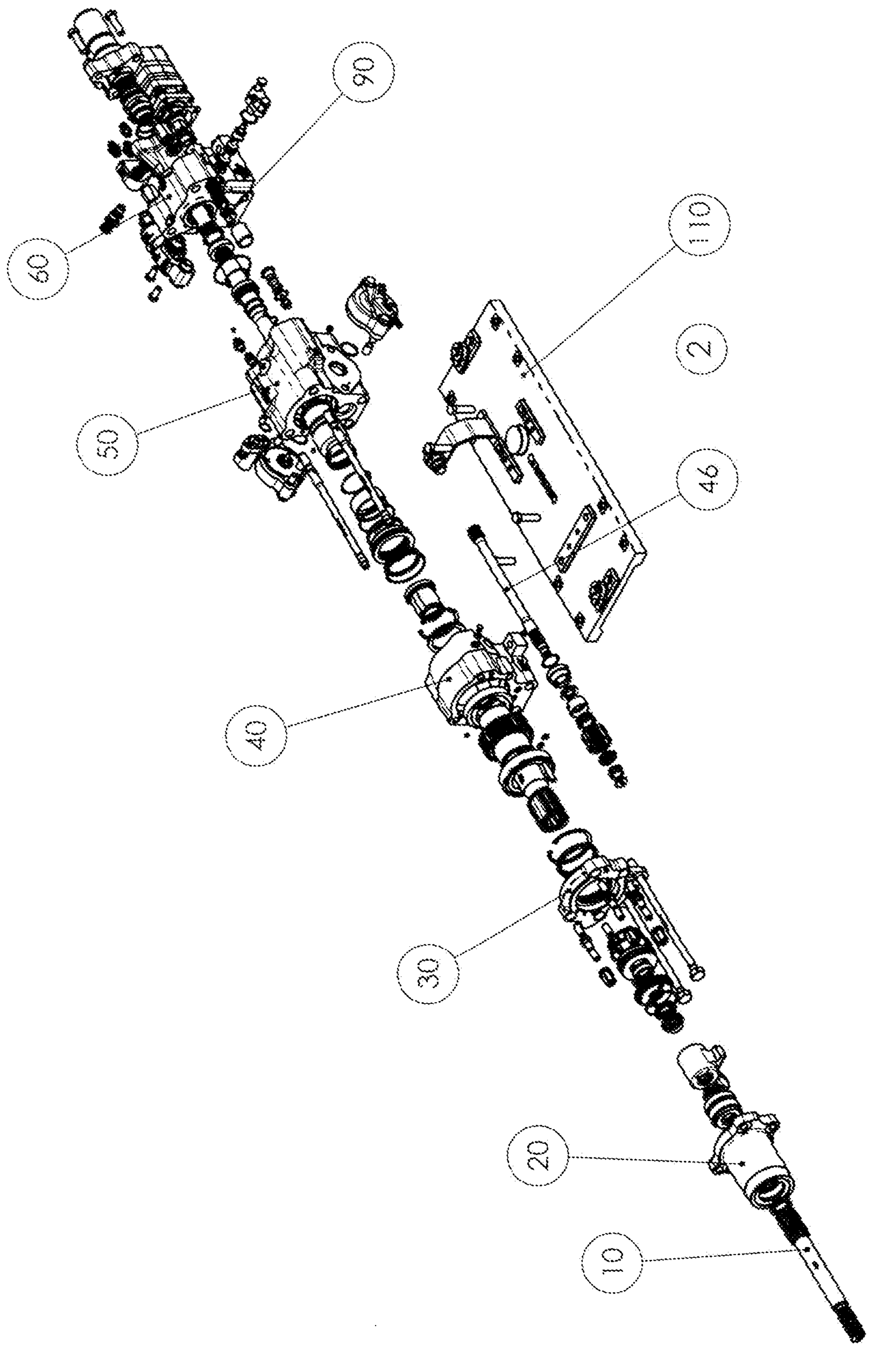
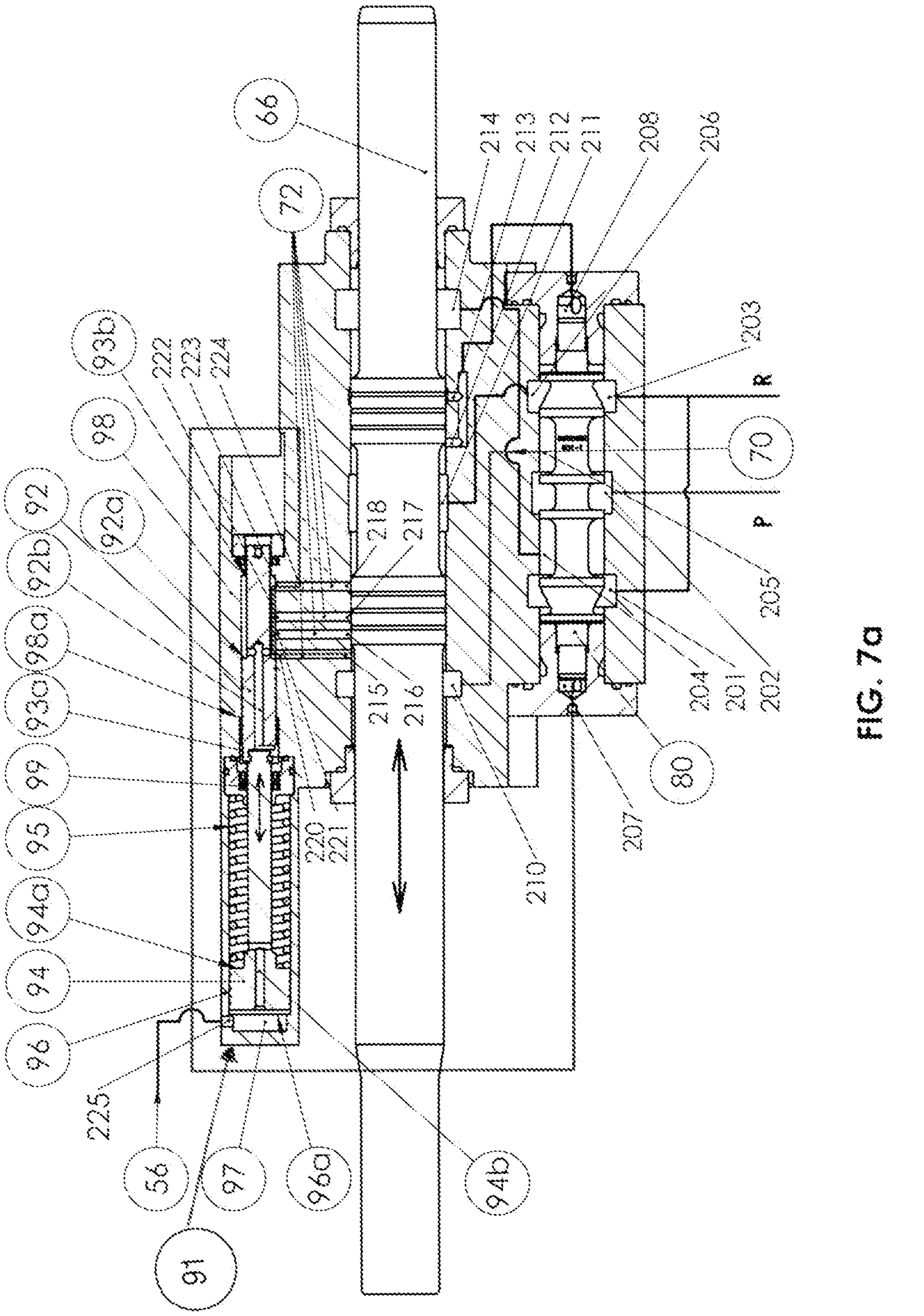


FIG. 6


66
72
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213
212
211
208
206
203
R
70
P
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202
201
204
80
207
210
216
215
217
218
220
221
93b
222
223
224
98
92
92a
92b
98a
93a
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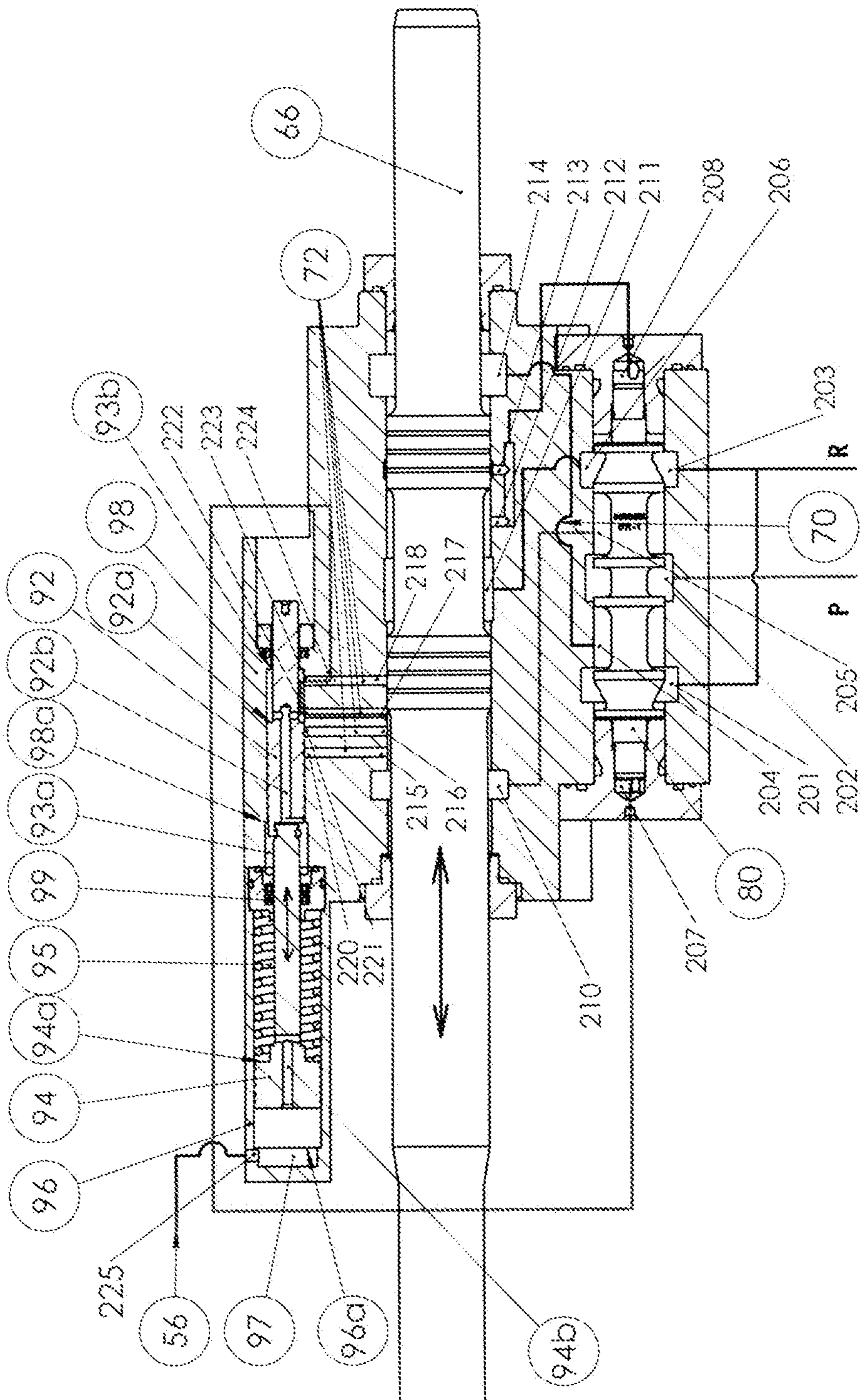
95
94a
94
96
225
56
97
96a
94b
91

FIG. 7a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70
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80
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215
217
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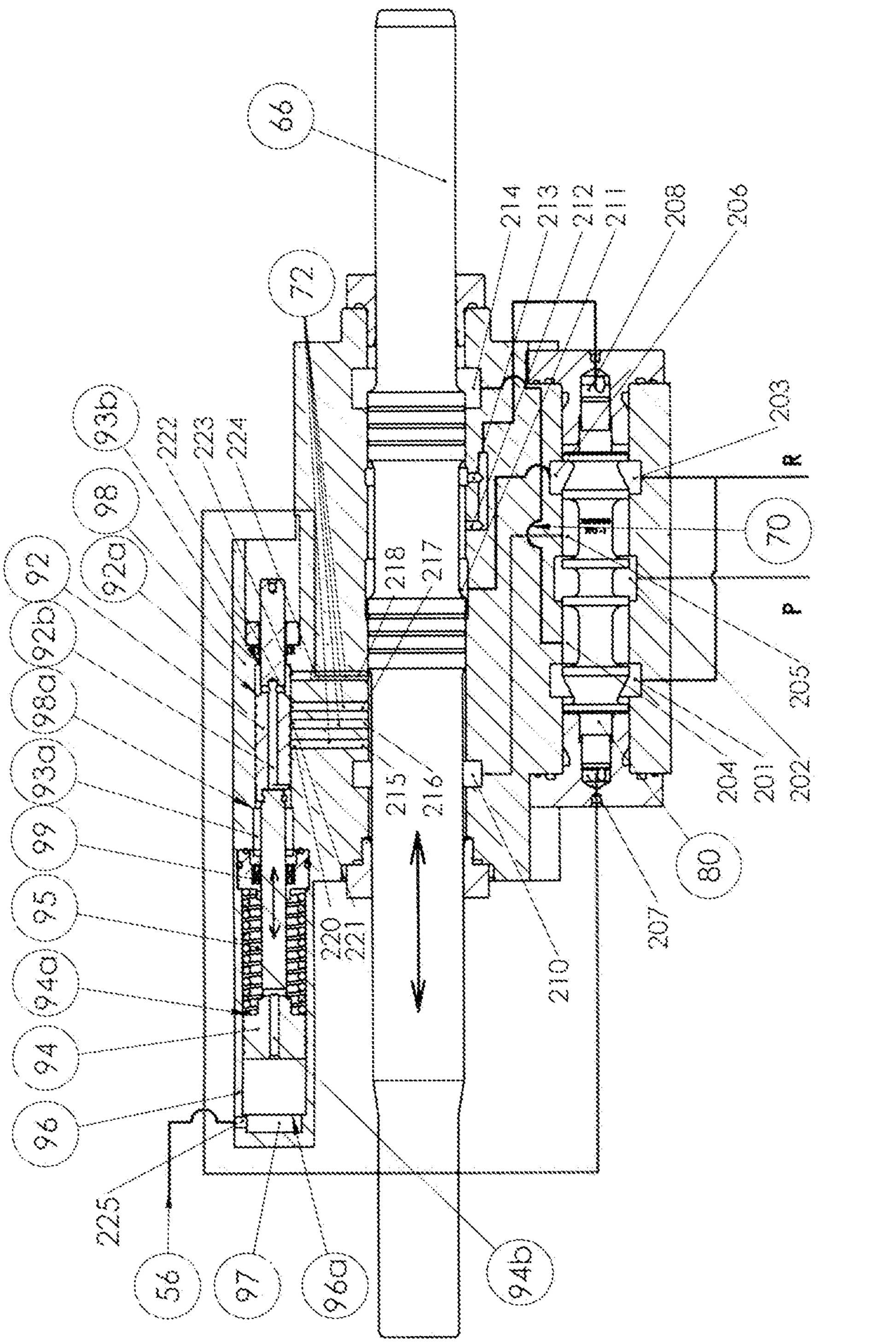
220
221
93b
222
223
224
98
92
92a
92b
98a
93a
99
95
94a
94
96
225
56
97
96a
94b

FIG. 7b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93b
222
223
224
98
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98a
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99
95
94a
94
96
225
56
97
96a
94b

FIG. 7c

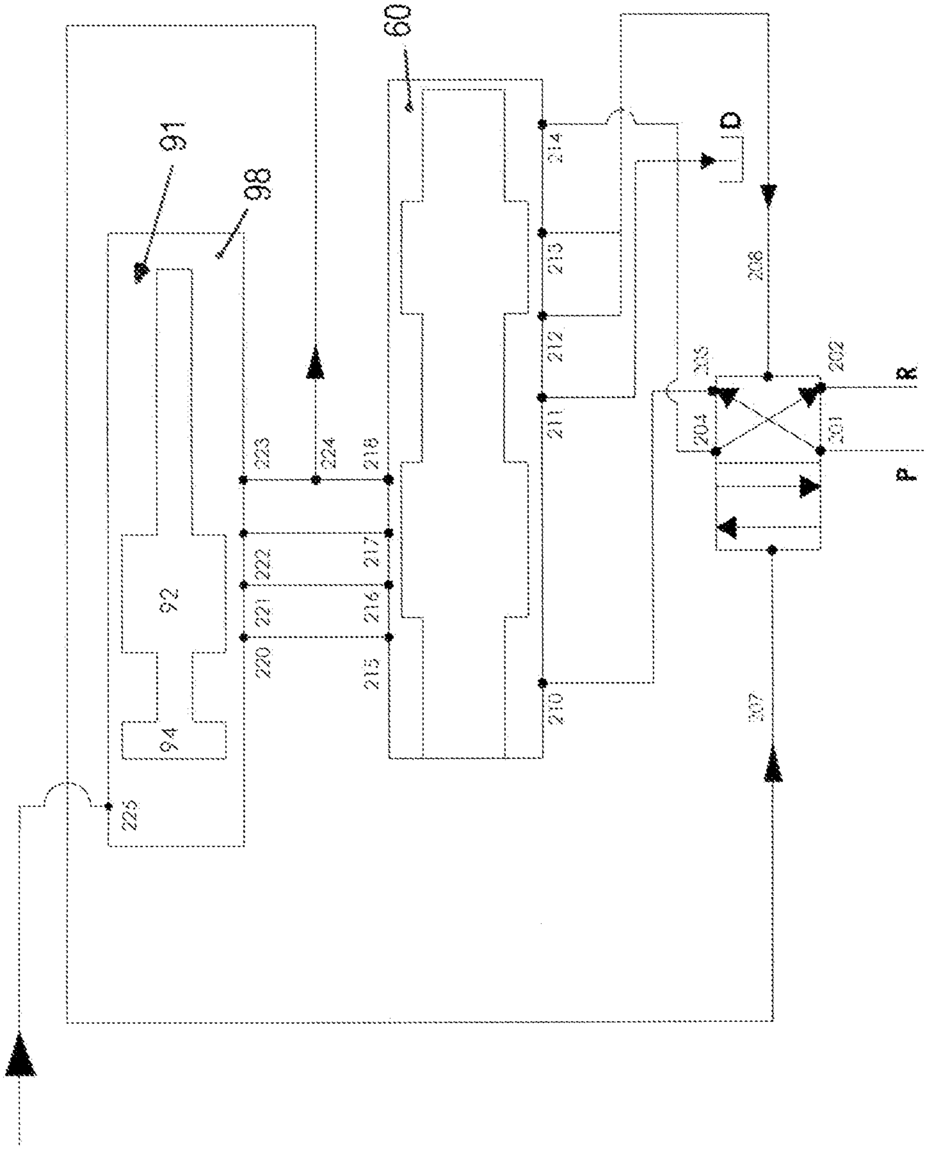
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FIG. 8

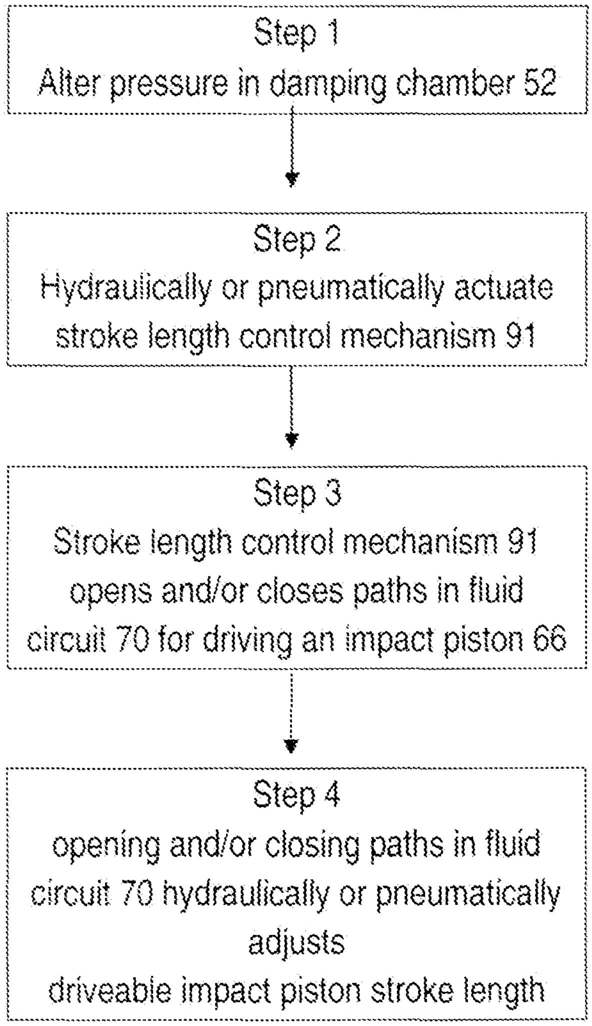
Step 1
Alter pressure in damping chamber 52
Step 2
Hydraulically or pneumatically actuate stroke length control mechanism 91
Step 3
Stroke length control mechanism 91 opens and/or closes paths in fluid circuit 70 for driving an impact piston 66
Step 4
opening and/or closing paths in fluid circuit 70 hydraulically or pneumatically adjusts
driveable impact piston stroke length

FIG. 9

INTERNATIONAL SEARCH REPORT	International application No. PCT/AU2011/000220

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

E21B 44/06 (2006.01)	***E21B 1/38*** (2006.01)
B23B 45/04 (2006.01)	***E21B 44/00*** (2006.01)

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)

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)
EPODOC & WPI - /IC/EC E21B44/00 OR E21B44/02 OR E21B44/06 OR E21B10 OR B23B45/04 OR ROCK_DRILL+ AND KEYWORDS - STROKE+, ADJUST+, PRESSURE+, BACK_PRESSURE+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/033075 A1 (ATLAS COPCO ROCK DRILLS AB) 20 March 2008 Abstract, Figure 1, page 2 lines 10-16, page 4 lines 10-11, page 5 lines 11-13, page 10 lines 1-9	1-3, 7, 9-13
Y	As above	4-6, 8
Y	US 4006783 A (GRANHOLM) 8 February 1977 Abstract, column 5 lines 11-64, Figure 1	4-6, 8
A	GB 156332 A (OLSON) 7 January 1921 Page 1 lines 9-19, page 1 lines 80 - page 2 lines 13	1-13
A	WO 2007/097677 A1 (ATLAS COPCO ROCK DRILLS AB) 30 August 2007 Page 2 lines 6-24, page 3 lines 30 - page 4 lines 19, page 8 lines 9-23, page 9 lines 27- page 10 lines 10, figures 4-5b	1-13

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

* Special categories of cited documents:

"A"	document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
31 March 2011	17 MAY 2011
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **SACHIN.MARWAHA** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6225 6136

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: **14**
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

   The claim does not comply with Rule 6.2(a) because it relies on references to the description and/or drawings.

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	2008033075	AU	2007295144	CA	2661228	CN	101500762
		EP	2059369	NO	20091346	SE	0601879
		US	2009321099	ZA	200900508		
US	4006783	AT	237575	AU	79389/75	CH	597500
		DE	2512690	FR	2307121	GB	1496562
GB	156332	NONE					
WO	2007097677	AU	2007218187	CA	2640533	CN	101370621
		EP	1986825	SE	0600369	US	2009223689
		ZA	200805512				

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX