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(54) Title: PERCUSSION DEVICE

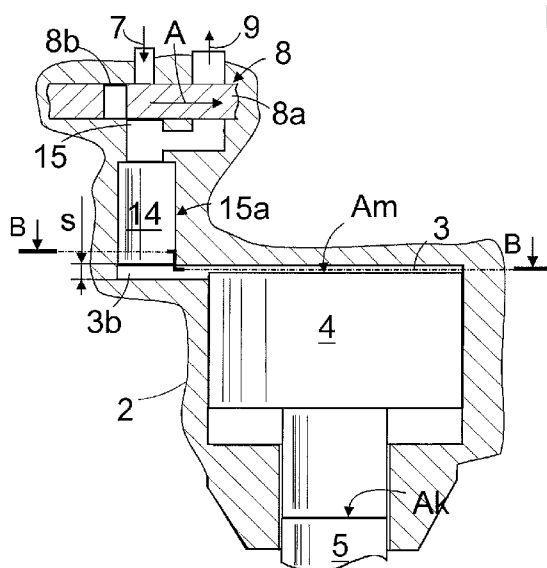


Fig. 2

(57) Abstract: The invention relates to a percussion device, to which a tool (5) is mountable movable in its longitudinal direction relative to the frame (2) of the percussion device, the percussion device containing a work chamber (3) having a transmission piston (4) to compress the tool (5) suddenly by the pressure of the pressure fluid acting on the transmission piston (4) to generate a longitudinal stress pulse to the tool (5), inlet and outlet channels (7, 9) for conducting the pressure fluid to the percussion device and away from it and a control valve (8) for connecting the inlet and outlet channels (7, 9) to alternately conduct the pressure fluid to act on the transmission piston (4) and, correspondingly, to discharge the pressure fluid from the percussion device. The percussion device comprises a closure member (14) located in the pressure fluid channel (15) between the control valve (8) and transmission piston (4) and mounted movable along the pressure fluid flow, and it has a mechanical limiter for limiting the length of movement of the closure member (14) so that when the closure member (14) stops at the limiter, it at the same time cuts off the pressure fluid flow in it from the control valve (8) toward the transmission piston (4).

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Percussion device

Background of the invention

[0001] The invention relates to a percussion device, to which a tool is mountable movable in its longitudinal direction relative to the frame of the percussion device, the percussion device containing a work chamber having a transmission piston mounted movable in the axial direction of the tool to compress the tool suddenly in its longitudinal direction by the pressure of the pressure fluid acting on the transmission piston to generate a longitudinal stress pulse to the tool, which propagates through the tool to the material being crushed, inlet and outlet channels for conducting the pressure fluid to the percussion device and away from it and a control valve that has a movably mounted switch member with at least one channel for connecting said inlet and outlet channels to alternately conduct the pressure fluid from the inlet channel along at least one pressure fluid channel to act on the transmission piston and, correspondingly, to discharge the pressure fluid that acted on the transmission piston from the percussion device.

[0002] In the percussion device of the invention, a stress pulse is provided by arranging the pressure of a pressure fluid to act on a transmission piston in a separate work chamber preferably relatively suddenly. The pressure effect pushes the transmission piston toward the tool. As a result of this, the tool is compressed, whereby a stress pulse is formed in the tool to run through the tool and, when the tool bit is in contact with rock or some other targeted hard material, to break it. In the percussion device, it is possible to use to control its percussion operation a rotating or linearly reciprocating switch member that typically has consecutive openings that alternately open a connection from a pressure fluid source to the transmission piston of the percussion device and, correspondingly, from the transmission piston to the pressure fluid container. In known solutions, the operating efficiency of the device is a general problem. Even though it has been possible to improve the operating efficiency by using various solutions, it is always preferable to improve it yet further. The adjustment of the length and amplitudes of the stress pulses is also not easy in all solutions, and easy adjustability is always aimed at.

Brief description of the invention

[0003] It is an object of this invention to provide a percussion device which provides a better than before operating efficiency and which allows the

adjustment of the length and amplitude of the stress pulse in a desired manner. The percussion device of the invention is characterised in that

it comprises a closure member that is mounted movable along the flow of the pressure fluid and positioned into each pressure fluid channel between a control valve and transmission piston, and

it has a mechanical limiter to limit the length of movement of each closure member toward the transmission piston so that when the closure member stops at the limiter, it also stops the flow of the pressure fluid in the pressure fluid channel from the control valve toward the transmission piston so that the movement of the transmission piston toward the tool stops before the switch member closes the pressure connection between the inlet channel and the pressure source.

[0004] The idea of the invention is that the formation of the stress pulse is done using a separate closure member having a mechanically limited length of movement to stop the flow of the pressure fluid in the direction of the transmission piston, whereby the length of the stress pulse is determined on the basis of the duration of the closure member movement.

[0005] The invention provides the advantage that the length of the stress pulse may be adjusted without essentially weakening the operating efficiency. In practice, the operating efficiency is clearly better than in known solutions, because the open time of the control valve may be made longer than in the present solutions. The shape of the thus formed stress pulse is also advantageous, because the opening of the control valve increases all the time along with the pulse formation, and the opening may be dimensioned so that it is at its largest as the formation of the stress pulse ends, in other words, when the control valve is completely open. This way, both the work chamber pressure acting on the transmission piston and the amplitude of the stress wave can be made largest at the final stage of the pulse formation. The invention also provides the advantage that the length of the stress pulse may be adjusted either by adjusting the length or time of movement of the closure member or directly the pressure of the used pressure fluid.

Brief description of figures

[0006] The invention will be described in greater detail in the attached drawings, in which

Figure 1 is a schematic representation of the prior-art principle of a percussion device,

Figure 2 is a schematic view of an embodiment of the invention.

Figure 3 is a schematic view of an embodiment of the invention cut along line B–B of Figure 2,

Figure 4 shows curves depicting the operation of a percussion device of the invention,

Figures 5a and 5b are schematic views of some other embodiments of the invention,

Figures 6a and 6b are schematic views of a detail of yet another embodiment of the invention,

Figures 7a and 7b are schematic views of yet other embodiments of the invention, and

Figures 8a and 8b are schematic views of yet other embodiments of the invention.

Detailed description of the invention

[0007] Figure 1 is a schematic sectional view of a prior-art percussion device 1 with a frame 2, inside which there is a work chamber 3 and inside the work chamber 3 a transmission piston 4. The transmission piston 4 is coaxial with a tool 5 and they may move axially so that the transmission piston 4 touches the tool 5 directly at least when the stress pulse begins to form and during its formation or indirectly through a shank fastened to the tool and known per se. On the side of the transmission piston 4 opposite to the tool, there is a pressure surface facing the work chamber 3. For forming a stress pulse, pressurized pressure fluid is led to the work chamber 3 from a pressure source, such as a pump 6, along an inlet channel 7 through a control valve 8. The control valve has a moving switch member 8a with one or, as shown in the figure, several channels, such as openings or grooves 8b. As the switch member 8a of the control valve 8 moves, the pressure fluid acts on the transmission piston 4 through the openings or grooves 8b and, correspondingly, as the switch member 8a continues to move, the pressure of the pressure fluid that acted on the transmission piston 4 discharges through an outlet channel 9. A stress pulse is formed when the pressure fluid pressure pushes the transmission piston 4 toward the tool 5 and through this compresses the tool 5 against the material being crushed. As it moves through the tool's 5 tip, such as a drill bit, to the material being crushed, such as stone, in a manner known per se,

the stress pulse breaks the material. When the switch member of the control valve 8 prevents the pressure fluid from entering the percussion device and then allows the pressure fluid that acted on the transmission piston 4 to discharge through the outlet channel 9 to a pressure fluid container 10, the stress pulse stops, and the transmission piston 4, which has moved a short distance, only a few millimetres, toward the tool 5, is allowed to return to its initial position. This is repeated as the switch member 8a of the valve 8 moves and alternately switches the pressure to act on the transmission piston and then allows the pressure to discharge, whereby, as the switch member 8a moves continuously, a series of consecutive stress pulses is formed.

[0008] During the use of the percussion device, it is pushed in a manner known per se by a feed force F toward the tool 5 and, at the same time, toward the material being crushed. To push the percussion device, it is possible to use in a manner known per se just the boom of a power tool or a feed beam and its feed devices mounted on the boom. These are generally known per se to a person skilled in the art and, thus, need not be described in more detail. To return the transmission piston 4, pressure medium may be supplied to the chamber 3a as necessary between stress pulses or the transmission piston may be returned by mechanical means, such as spring, or by pushing the percussion device with the feed force in the drilling direction, whereby the transmission piston moves backward in relation to the percussion device, that is, to its initial position. The tool may be a part that is separate from the piston or integrated to it in a manner known per se. The piston may also be integrated to the drill shank so that the drill rod is fastened in a manner known per se with threads to the threads at the end of such a configuration.

[0009] In the case of Figure 1, the control valve 8 has a rotatably moving switch member 8 coaxial with the tool 5, which is rotated around its axis in the direction of arrow A by using a suitable rotating mechanism, such as a motor 11, by means of power transmission shown schematically by dashed line. Alternatively, the switch member 8 is turned rotatably back and forth using a suitable mechanism. A rotatably moving switch member may also be mounted otherwise, for instance on the frame 2 on the side of the work chamber 3. Instead of a rotatably moving switch member, the control valve 8 may also have a reciprocating switch member. Further, it is possible to use in all cases a control valve, whose switch member has only one channel to conduct the pressure fluid toward the work chamber and, correspondingly, away from it.

However, the switch member 8a of the control valve 8 preferably has several parallel channels.

[0010] Figure 1 further shows a control unit 12 that may be connected to control the rotating speed of the control valve or the rate of movement of a reciprocating control valve by means of control channels or signal lines 13a and 13b. This type of adjustment may be implemented by several different techniques known per se by using desired parameters, such as drilling conditions, the hardness of the stone being crushed, for instance.

[0011] Figure 2 is a schematic view of a general embodiment of the invention. It shows only part of the control valve 8 equipped with a reciprocating switch member 8a and the frame 2 of the percussion device. It has between the control valve 8 and transmission piston 4 a separate closure member 14 that moves in a valve space 15a in the pressure fluid channel between the control valve 8 and transmission piston 4. The stress pulse is formed in such a manner that the pressurized pressure fluid is directed by the control valve 8 to flow toward the transmission piston 4, and the closure member moves essentially along the flow in the channel. In this situation, nearly the same pressure prevails on both sides of the closure member. As a result of this, the transmission piston 4 moves toward the tool 5 and compresses it and, consequently, a stress pulse is formed in the tool. The formation of the stress pulse continues until the closure member 14 stops at a barrier that mechanically limits its movement and, at the same time, cuts off the flow of the pressure fluid toward the transmission piston 4. It is thus possible to adjust the length of the stress pulse by altering the length of movement of the closure member 14.

[0012] After the formation of the stress pulse, the switch member 8a of the control valve, when moving, opens a connection from the pressure fluid channel between the control valve 8 and transmission piston 4 to the pressure fluid return channel 9 and the pressure is released, and as the transmission piston 4 moves back to its initial position under the effect of the return force, the closure member 14 correspondingly goes back to its initial position.

[0013] Figure 2 shows a general solution in which the time the pressure acts on the transmission piston depends on the length of movement s of the closure member 14, which is the mechanically limited possible length of movement of the closure member 14 in the direction of the transmission piston 4. In the case shown in Figure 2a, the closure member 14 stops when it con-

tacts the bottom surface of the pressure fluid space 3b. Because the closure member 14 is substantially equal in size to the pressure fluid channel where it moves, the closure member 14, when it stops, also stops the flow of the pressure fluid toward the transmission piston 4. The stress pulse is then at its strongest. The open time of a connecting member to the inlet pressure may be significantly longer than the movement time of the closure member, that is, the formation time of the stress pulse. The formation of the stress pulse begins as soon as pressure fluid enters from the channel 7 through opening 8b to the pressure fluid channel 15 and, thus, acts on the closure member 14. Because the size of the flow opening affects the flow of the pressure fluid in the pressure fluid channel 15 and thus also the increase in pressure in the work chamber 3, the pressure increases all the time when the switch member 8a moves and the opening 8b moves closer to the channel 7 and pressure channel 15 and opens the flow opening wider all the time. The length of movement s of the closure member 14 is most preferably dimensioned in such a manner that the movement of the closure member 14 stops when the flow channel through the control valve is at its largest, that is, the opening 8b is completely open at the pressure fluid channels 7 and 15 and the control valve is thus completely open.

[0014] Figure 3 is a schematic sectional view of an embodiment of the invention along the line B–B marked in Figure 2, in which, instead of one pressure fluid channel and closure member 14, several pressure fluid channels are used and, correspondingly, closure members 14 in each channel. In this embodiment, there are eight closure members positioned around the transmission piston 4 so that the supply of pressure fluid is implemented as easily and efficiently as possible. Even though eight closure members are shown herein by way of example, there may be one or more, even more than eight, if this is considered necessary due to constructive reasons.

[0015] Figure 4 shows schematically pressure curves depicting the operation of a percussion device of the invention. The horizontal axis shows the pressure of the pressure fluid (bar) and the vertical axis shows correspondingly the length of the stress wave in milliseconds by using two different length of movement values for the closure member. The surface areas A_m , A_k and A_s mentioned in the equations are shown in Figures 2 and 3, for example.

[0016] The length of the formed stress wave may roughly be estimated as follows. Let us assume that the surface area of the transmission piston is $A_m=4500 \text{ mm}^2$ and the surface area of the tool is $A_k=1000 \text{ mm}^2$. The

surface area of the inlet channels (10 pcs) is $A_s=300 \text{ mm}^2$. The length of movement of the closure members is limited to $s=1 \text{ mm}$, for instance. If pressure level p is used, then in theory a stress wave is produced with an amplitude of

$$\sigma = \frac{A_m}{A_k} p = 4.5 p \quad (1)$$

[0017] The transmission piston then obtains the speed of

$$v_m = \frac{1}{c\rho} \sigma = \frac{A_m}{A_k c\rho} p, \quad (2)$$

wherein c is the speed of the stress wave in the tool and ρ is the density of the material. The corresponding flow in a single inlet channel is

$$q = \frac{A_m}{N} v_m = \frac{A_m^2}{A_k N c\rho} p \quad (3)$$

and the mean speed of the fluid in the channel is

$$v_{fluid} = \frac{q}{A_s} = \frac{A_m^2}{A_k N A_s c\rho} p \quad (4)$$

[0018] When the temporal duration of the stress wave is t_p and the closure member moves at substantially the same rate as the fluid, the closure member displacement in the inlet channel is

$$x_s = v_{fluid} t_p = \frac{A_m^2 p}{A_k N A_s c\rho} t_p \quad (5)$$

[0019] When the length of movement x_s of the closure member is limited to the value s , the temporal duration of the pulse is

$$t_p = \frac{A_k N A_s c \rho s}{A_m^2 p} \quad (6)$$

[0020] By placing the given numerical values, we obtain

$$t_p = \frac{c \rho s}{6.75 p} \quad (7)$$

[0021] The result also shows that the length of the stress wave is inversely proportional to the pressure; the higher the pressure, the shorter the pulse. Figure 4 shows the lengths of the stress wave by using two different values of the length of movement s at different pressure levels. In other words, the length of the pulse may also be adjusted solely by the percussion pressure level.

[0022] Figure 4 shows curves calculated on the basis of what is stated above by using two different lengths of movement of the closure member, that is, length of movement 1 mm and 1.5 mm, respectively. As shown in Figure 4, the length of the stress wave is the larger, the longer the length of movement of the closure member 14 is. Further according to Figure 4, the length of the stress wave is inversely proportional to the used pressure of the pressure fluid. Thus, by using a fixed length of movement for the closure member(s) 14, the length of the pulse may be adjusted solely by means of the pressure of the used pressure fluid. When requiring a shorter stress pulse, the pressure is increased, whereby the closure member moves faster to cut off the flow of the pressure fluid and, correspondingly, when requiring a longer stress pulse, the pressure is lowered, whereby the closure member moves more slowly to cut off the flow of the pressure fluid.

[0023] In practice, it is necessary that the pressure fluid in the work chamber of the transmission piston 4 is allowed to change, because otherwise it will heat up too much. Similarly, one should take into account the fact that in this type of solution, some oil leaks always occur regardless of the sealings.

[0024] Figures 5a and 5b show some embodiments of the invention, in which these matters have been taken into account. In these embodiments, through the closure member 14 a channel 16 is formed, an opening of which is in a projection 14a and through which a small amount of pressure fluid is allowed to flow from the pressure fluid channel 15 to the work chamber 3 after the valve 8 has switched the pressure fluid to act on the closure member 14.

The amount of pressure fluid that flows through the channel 16 is quite small in volume. As the stress pulse propagates when the closure member 14 moves toward the pressure fluid space 3b, the projection 14a at the front end of the closure member on the pressure fluid space 3b side pushes into a recess 3c, which corresponds to it in shape and size, and prevents the flow of the pressure fluid from the channel 16 to the pressure fluid space 3b. When the stress pulse is formed, the transmission piston 4 and closure member 14 return to their initial positions in the manner described earlier, whereby the extra pressure fluid that flowed into the pressure fluid space 3b and thus also to the work chamber 3 exits again through the channel 16. In the embodiment shown in Figure 5a, the percussion piston is returned to its initial position by utilising the feed force of the percussion device, whereby the feed force pushes the percussion device forward and the transmission piston supported on the tool 5 remains stationary while the frame of the percussion device pushes toward the tool 5. In this case, the pressure fluid space 3a in front of the transmission piston 4 is connected to the pressure fluid container through the channel 9 without pressure.

[0025] The switch member 8a of the control valve 8, in turn, has a groove or the like, such as an opening 8c that connects the pressure fluid channel 15 between the closure member 14 and control valve 8 to the channel 17. The transmission piston 4, in turn, has an inner channel 18 that opens a connection between the pressure fluid space 3a and channel 17 when the transmission piston 4 moves toward the tool 5 during the formation of the stress pulse. When the transmission piston 4 is pushed relative to the frame 2 of the percussion device 1 back into its initial position, the pressure fluid flows from the work chamber 3 first pushing the closure member 14 backward and then flowing through the channel 16 of the closure member 14 to the pressure fluid channel 15 and through the groove or the like 8c to the channel 17 and on through the channel 18 to the pressure fluid space 3a. When the transmission piston 4 has moved to its initial position, that is, to the position shown in Figure 5a, the connection between the channels 17 and 18 has closed and the pressure fluid is no longer allowed to flow out from the work chamber 3. The transmission piston 4 is then stopped hydraulically to its initial position. The transmission piston 4 may naturally also be stopped mechanically to its initial position as shown in Figure 5b. In this embodiment, the pressure fluid may run directly through the channel 9 to the pressure fluid container 10.

[0026] Figures 6a and 6b show yet another detail of an embodiment of the invention. It is a solution suitable for evening out pressure spikes caused by feeding pressure fluid and reflected from the tool. In this embodiment, the closure member 14 is formed of a spherical piece that may be applied per se to all embodiments of the invention. In the situation shown in Figure 6a, the formation of the stress pulse has ended when the closure member 14 has stopped at a shoulder 20 and the closure member and a stop face together prevent the flow of the pressure fluid. In a valve space 15a of the closure member 14, there is a check valve 21 that is connected to the valve space 15a of the closure member 14 so that depending on the position of the closure member 14, it is connected either to the pressure fluid channel 15 or pressure fluid space 3b. During the operation of the percussion device, operating pressure p of the percussion device acts on a valve member 21a of the check valve 21 on one side and pushes the valve member 21a to cut off the pressure fluid flow from the pressure fluid channel 15 and correspondingly from the pressure fluid space 3b, in both of which the pressure is at most equal to the operating pressure.

[0027] In the case of Figure 6a, the closure member 14 is at the end of the formation of the stress pulse tightly against the stop face of the shoulder 20 and cuts off the flow of the pressure fluid together with the stop face. The opening of the check valve 21 connected to the valve space 15a is then connected to the pressure fluid channel 15. When the pressure fluid flow to the pressure fluid channel 15 stops suddenly, a strong pressure pulse is formed whose pressure value may exceed the normal operating pressure considerably. On the opposite side of the valve member 21a of the check valve, a normal operating pressure p prevails, and the pressure caused by the pressure spike pushes the valve member 21a of the check valve away from the closure position and, this way, the pressure spike may discharge into the normal feed pressure without damaging the percussion device or its parts in any way.

[0028] Figure 6b, in turn, shows a situation in which the transmission piston 4 has returned after the formation of the stress pulse and the closure member 14 has returned to its initial position. In this situation, the opening leading to the check valve 21 in the valve space 15a is connected to the work chamber 3 of the transmission piston 4 through the pressure fluid space 3b. When the percussion frequency of the percussion device is suitably dimensioned according to the tool and other conditions, the stress wave reflected to

the tool from the rock returns to the transmission piston 4 at this very moment. This stress wave produces in the work chamber 3 and the related pressure fluid spaces a pressure spike that also exceeds the normal operating pressure p of the percussion device. The effect provided by the pressure spike in the check valve 21 opens its valve member 21a and the pressure spike discharges into the normal operating pressure without damaging the percussion device or its parts. At the same time, at least part of the energy of the reflected stress wave is recovered as hydraulic energy.

[0029] It is advantageous for the invention that the distance between the closure member 14 and transmission piston 4 is as short as possible to produce as small a loss as possible in the pressure fluid flow.

[0030] Figures 7a and 7b show yet other embodiments of the invention. A closure member 14 having a smaller cross-section than that of the surrounding valve space 15a is used in them. Therefore, both during the supply of the pressure fluid and during the return flow, the pressure fluid can flow in them through the gap between the closure member 14 and valve space 15a. The pressure fluid in the work chamber 3 then changes to some extent and cooling takes place in this manner. In these embodiments, the flow of the pressure fluid ends when a conical or curved, for instance spherical, surface 14b of the closure member contacts a conical or concave sealing surface 15b at the end of the valve space 15a.

[0031] Figures 8a and 8b show yet another embodiment of the invention. In it, a separate pre-controlled auxiliary valve has been used to provide the return movement of the piston.

[0032] In this solution, the exit of the pressure fluid from the work chamber 3 is controlled by an auxiliary valve 23 that is, in turn, controlled by the switch member 8a of the control valve 8. The auxiliary valve 23 has a groove or opening 23a, with which the auxiliary valve 23 may open a connection from the channel 15 to the outlet channel 9. Further, on one end of the auxiliary valve 23 that is opposite to the channel 22, there is a projection 23b with an end having a surface area that is smaller than the surface area of the channel 22 side end of the auxiliary valve 23. The pressure of the pressure fluid, preferably the pressure that prevails in the channel 7, acts on this end of the projection 23b.

[0033] After the formation of the previous stress pulse, the percussion piston remains in its tool 5 side position. After the formation of the stress

pulse, the switch member 8a moves in the direction of arrow A and connects the inlet channel 7 of the pressure fluid to the channel 22 of the auxiliary valve. The auxiliary valve 23 then moves against the force caused by the pressure acting on its projection 23b and a connection from the channel 15 opens through the opening 23a of the auxiliary valve 23 to the outlet channel 9 as shown in Figure 8a. Thus, the pressure fluid is allowed to flow from the channel 15 to the outlet channel 9, and under the force acting on the transmission piston 4, the transmission piston 4 starts to move back to its initial position pushing the pressure fluid out of the work chamber 3.

[0034] The pressure fluid is then allowed to flow from the channel 15 through the opening 23a of the auxiliary valve 23 to the outlet channel 9. Under the force acting on the transmission piston 4, the transmission piston 4 starts to move back to its initial position pushing the pressure fluid out of the work chamber 3. Because of this, the closure member 14 moves back toward the channel 15 until its movement stops as described earlier. The transmission piston 4 is then in its rearmost position and stops there.

[0035] Before the formation of the next stress pulse, the channel 22 of the auxiliary valve is connected through the groove 8c of the switch member 8a to the channel 15 and on through the channel 23a of the auxiliary valve to the outlet channel 9. As a result of this, the pressure in the channel 22 of the auxiliary valve decreases and the pressure acting on the projection 23b pushes the auxiliary valve toward the channel 22 and closes the pressure connection 23 in the manner shown in Figure 8b.

[0036] As the switch member 8a moves on in the direction of arrow A, the pressure of the pressure fluid is connected from channel 7 through the opening 8b to act on the transmission piston 4 and a stress pulse is formed.

[0037] Figures 8a and 8b further show a solution in which the piston 4 is integrated with a drill shank known per se. This part of the piston 4 which corresponds to the drill shank is marked with reference number 4a. The part 4a is equipped with a thread known per se but not shown, to which the tool 5 is screwed. Part 4a may also be equipped with cogging or some other suitable means to rotate it and through it the tool 5 with a rotating motor known per se but not shown. In a manner corresponding to a drill shank, the part 4a extends out of the front end of the frame 2 of the percussion device so that it is easy to screw the tool on and off.

[0038] Above, the invention is described in the specification and drawings by way of example only and it is in no way limited to the description. Different details of embodiments may be implemented in different ways and they may also be combined with each other. Thus, details in different figures, Figures 1 to 3b and 5a to 6b, may be combined with each other in different manners to obtain the required embodiments in practice. The rotation or reciprocal movement of the switch member 8a of the control valve 8 may be implemented in any manner known per se mechanically, electrically, pneumatically or hydraulically. Even though the control valve having a rotating switch member 8a has, by way of example, been presented in a form, in which it has a cylindrical valve part, it may also correspondingly be implemented in a disc-like or conical form or in any corresponding form. Further, instead of the openings running through the switch member 8a of the control valve, it is also possible to use groove-like channels formed in the switch member 8a. The pressure fluid inlet and outlet channels also need not be on opposite sides of the switch member, as long as they are at different locations. The closure member may also have a cross-section that is smaller than that of the valve space, in which case its closing capability is based on interaction with a stop face in the manner shown in Figures 6a and 6b, for instance.

Claims

1. A percussion device, to which a tool is mountable movable in its longitudinal direction relative to the frame of the percussion device, the percussion device containing a work chamber having a transmission piston mounted movable in the axial direction of the tool to compress the tool suddenly in its longitudinal direction by the pressure of the pressure fluid acting on the transmission piston to generate a longitudinal stress pulse to the tool, which propagates through the tool to the material being crushed, inlet and outlet channels for conducting the pressure fluid to the percussion device and away from it and a control valve that has a movably mounted switch member with at least one channel for connecting said inlet and outlet channels to alternately conduct the pressure fluid from the inlet channel along at least one pressure fluid channel to act on the transmission piston and, correspondingly, to discharge the pressure fluid that acted on the transmission piston from the percussion device, characterised in that

it comprises a closure member that is mounted movable along the flow of the pressure fluid and positioned into each pressure fluid channel between a control valve and transmission piston, and

it has a mechanical limiter to limit the length of movement of each closure member toward the transmission piston so that when the closure member stops at the limiter, it also stops the flow of the pressure fluid in the pressure fluid channel from the control valve toward the transmission piston so that the movement of the transmission piston toward the tool stops before the switch member closes the pressure connection between the inlet channel and the pressure source.

2. A percussion device as claimed in claim 1, characterised in that the movement of the closure member(s) is limited so that the movement of the transmission piston toward the tool stops at substantially the same moment as the control valve opens fully.

3. A percussion device as claimed in claim 1 or 2, characterised in that the limiter is a limiting surface on the transmission piston side in the direction of movement of the closure member and the closure member pushes against it under the effect of the pressure fluid.

4. A percussion device as claimed in claim 3, characterised in that the limiting surface together with the closure member cuts off the flow of the pressure fluid toward the transmission piston.

5. A percussion device as claimed in any one of the preceding claims, characterised in that the closure member has a projection on the transmission piston side so that when the closure member is at its rear-most position, there is a clearance between the projection and the surface at the closure member on the transmission piston side, that on the surface located on the transmission piston side at the corresponding location, there is a recess that is substantially equal in size and shape to the projection and able to accommodate the projection, and that the closure member has a channel running through it and opening at the location of the projection, along which the pressure fluid flows into the work chamber and, correspondingly, back from the work chamber, when the projection is outside the recess.

6. A percussion device as claimed in any one of claims 1 to 4, characterised in that the closure member is spherical.

7. A percussion device as claimed in any one of the preceding claims, characterised in that it has a check valve and along the length of movement of the closure member at least one opening that is connected to the check valve so that when the closure member is at its frontmost position, the pressure fluid channel coming from the control valve is connected through at least one opening to the check valve, and when the closure member is at its rearmost position, the work chamber is connected through at least one opening to the check valve, and during the operation of the percussion device, the operating pressure of the percussion device acts on the valve member of the check valve and pushes the valve member to cut off the pressure fluid flow from pressure fluid channel coming from the work chamber and correspondingly from the control valve, the pressure of these being at most equal to the operating pressure.

8. A percussion device as claimed in any one of the preceding claims, characterised in that the inlet and outlet channels are connected to conduct the pressure fluid to the switch member and away from it and that the switch member has at least one channel to switch the inlet and outlet channels alternately to conduct the pressure fluid from the inlet channel along at least one pressure fluid channel to act on the transmission piston and

correspondingly to conduct the pressure fluid that has acted on the transmission piston away from the percussion device through the switch member.

9. A percussion device as claimed in any one of claims 1 to 7, characterised in that the inlet channel is connected to conduct the pressure fluid to the switch member, that it has a separate auxiliary valve that is connectable to conduct the pressure fluid that acted on the transmission piston from the percussion device to the outlet channel, that the switch member has at least one channel to switch the inlet channel alternately to conduct the pressure fluid from the inlet channel along at least one pressure fluid channel to act on the transmission piston and, correspondingly, at least one channel, through which the pressurized pressure fluid is allowed to act on the auxiliary valve so that it opens a connection to the outlet channel to allow the pressure fluid that acted on the transmission piston to exit through the auxiliary valve.

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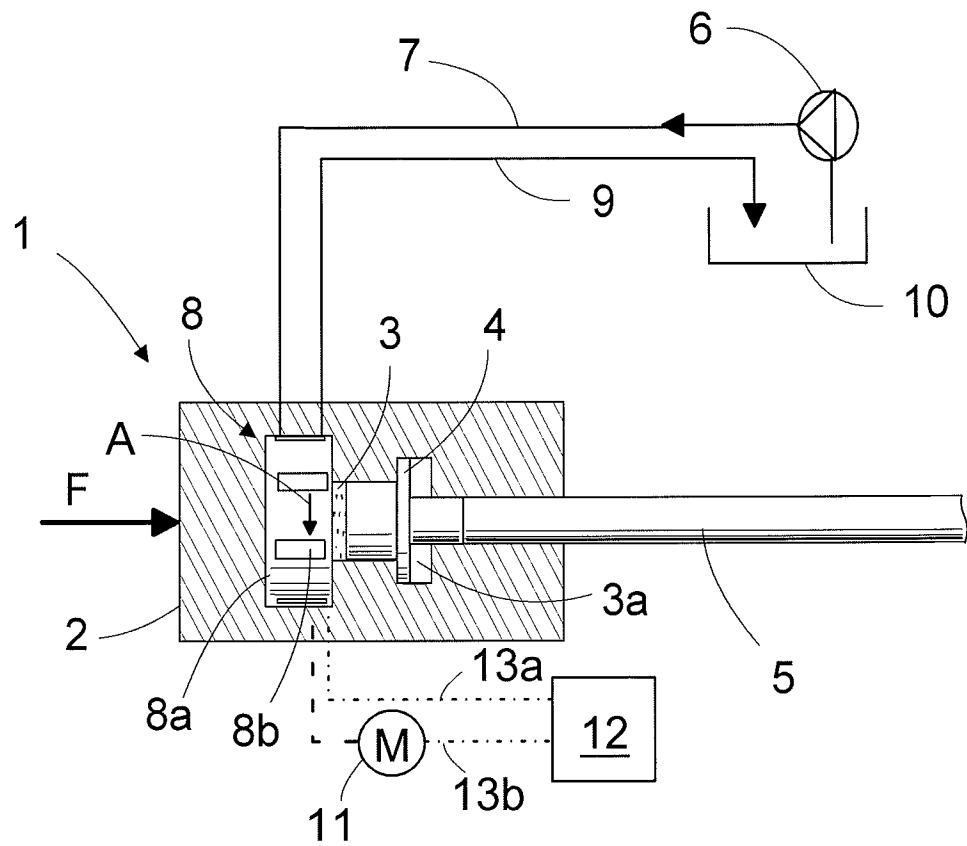


Fig. 1

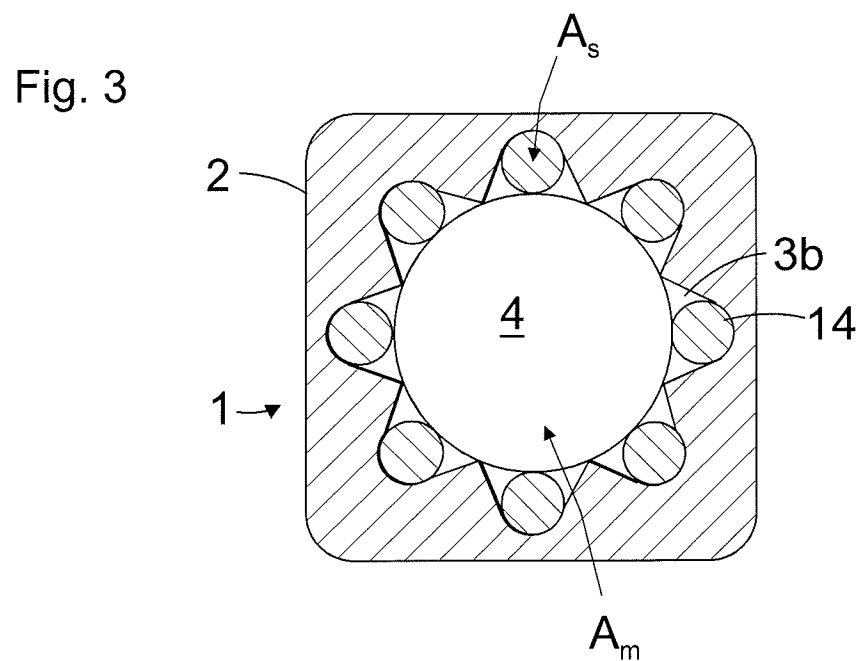


Fig. 3

Fig.2

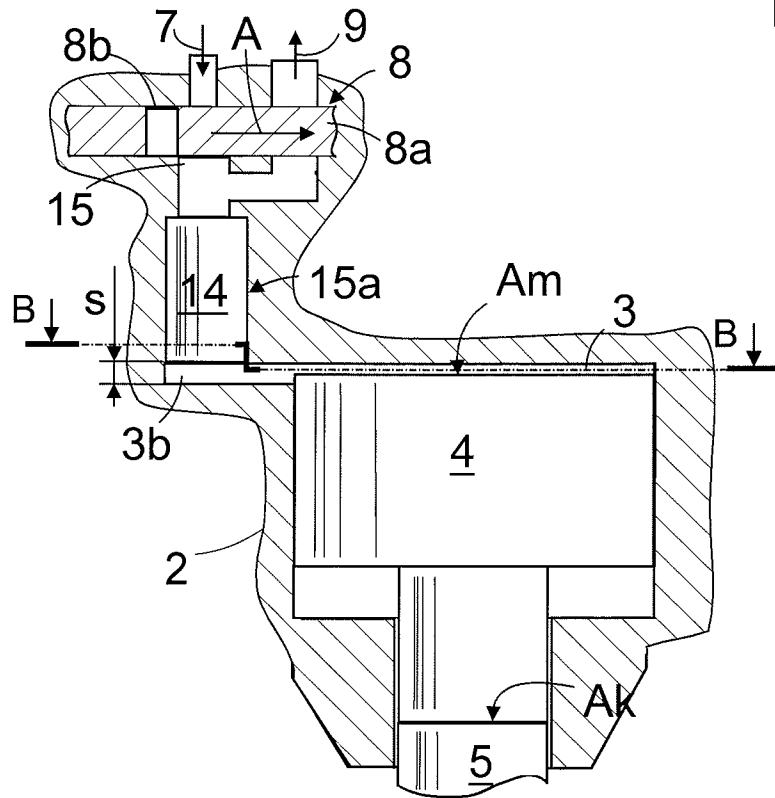
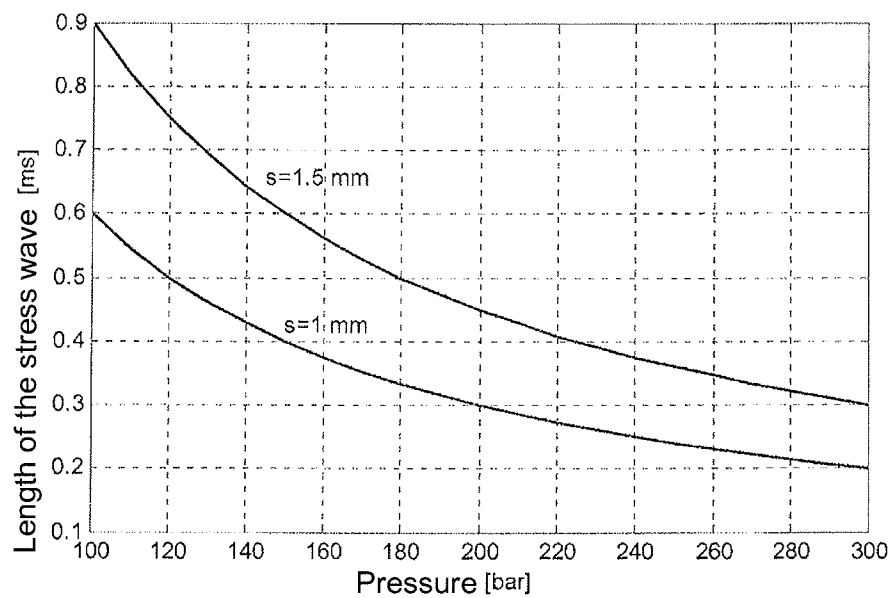


Fig. 4



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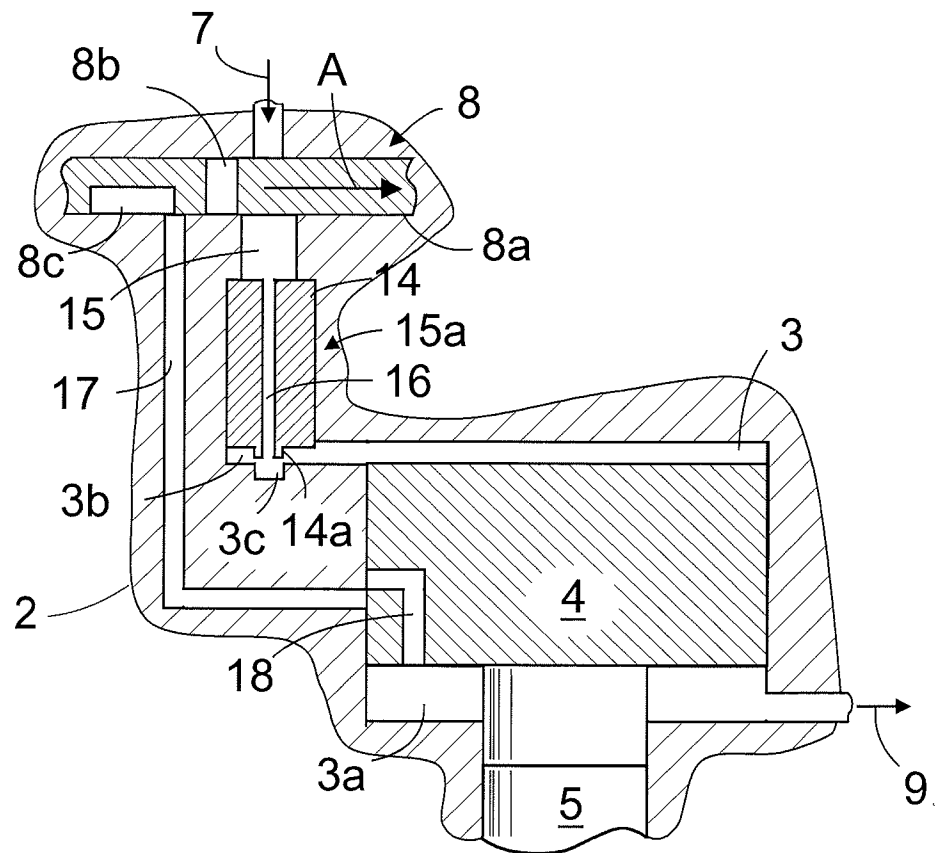


Fig. 5a

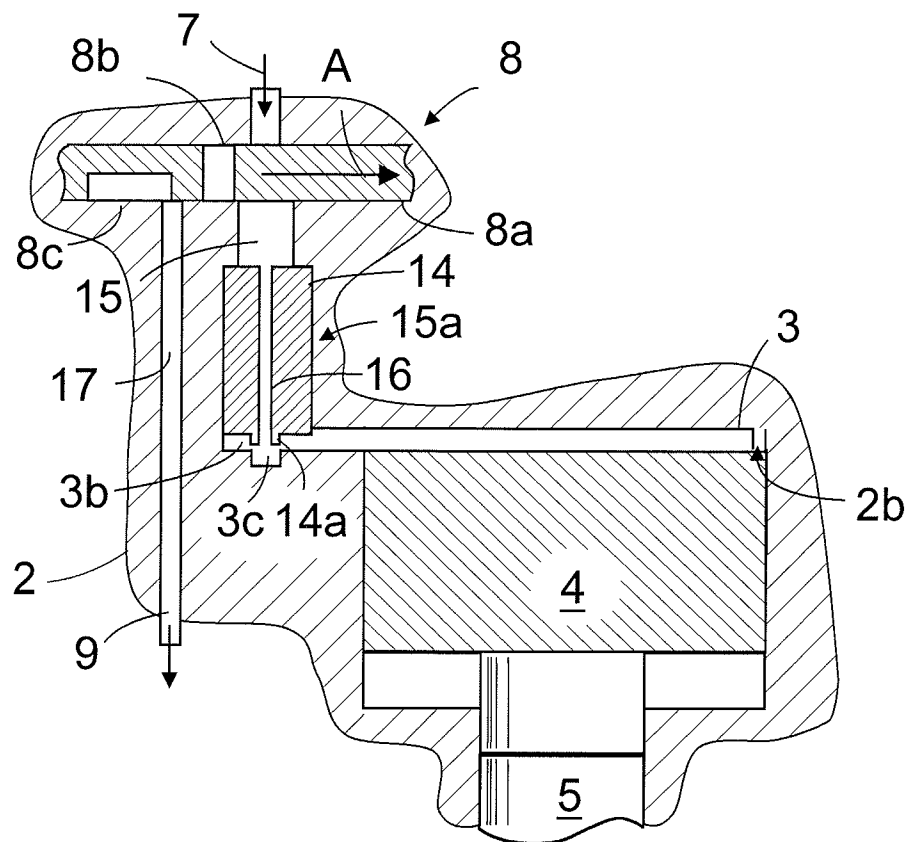


Fig. 5b

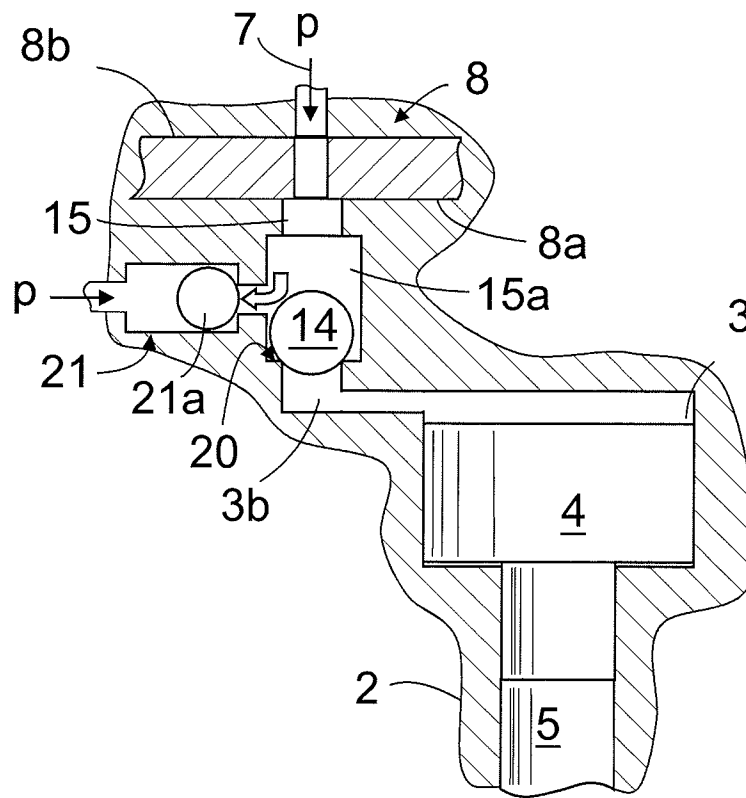


Fig. 6a

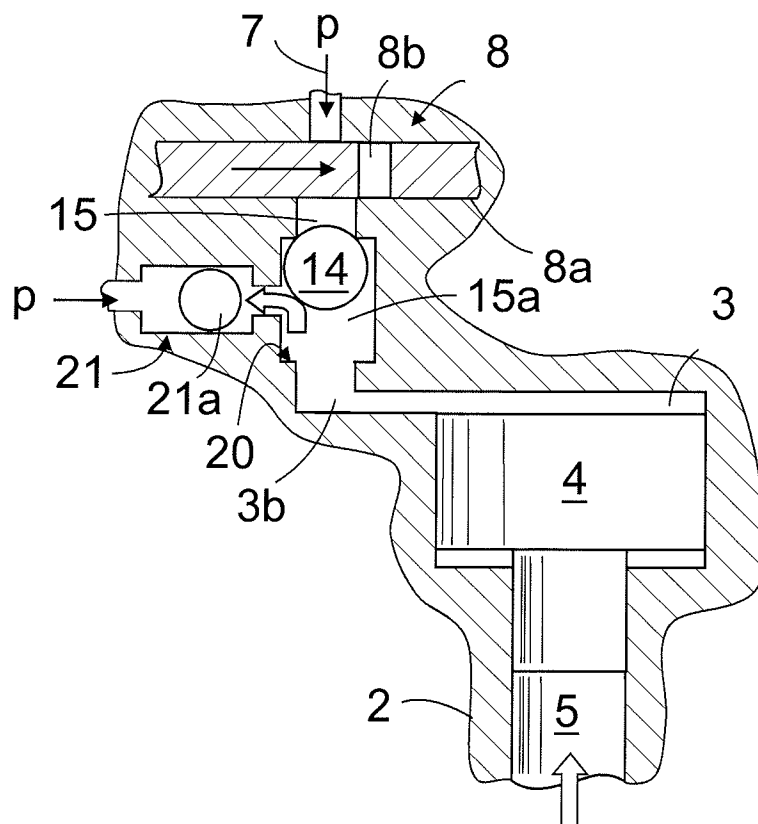


Fig. 6b

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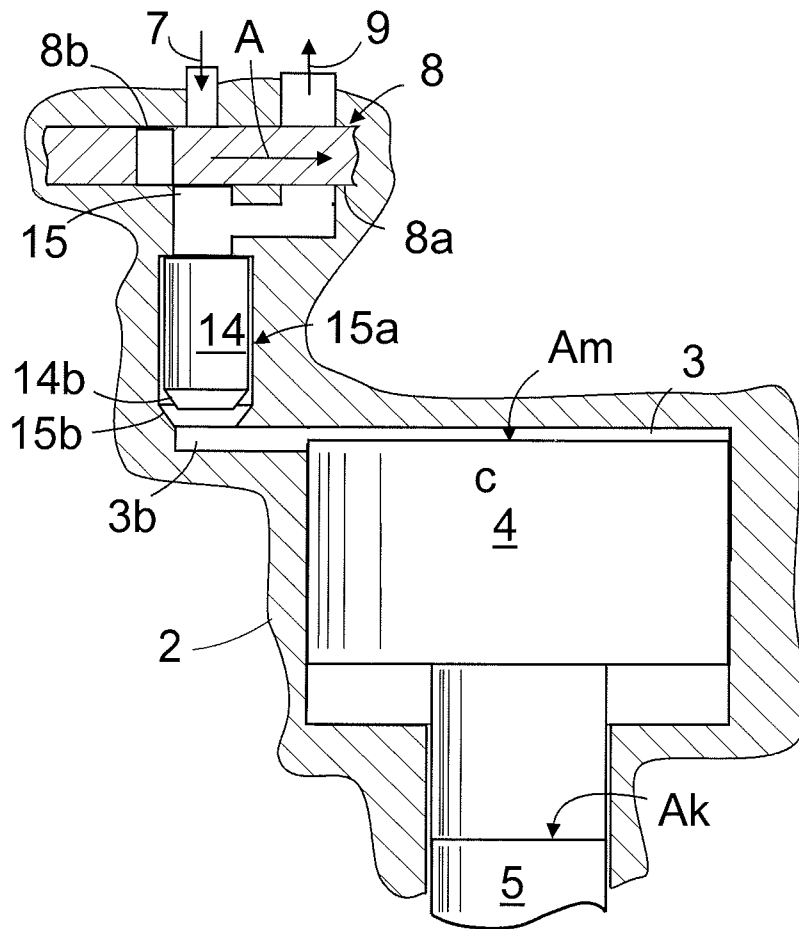


Fig.7a

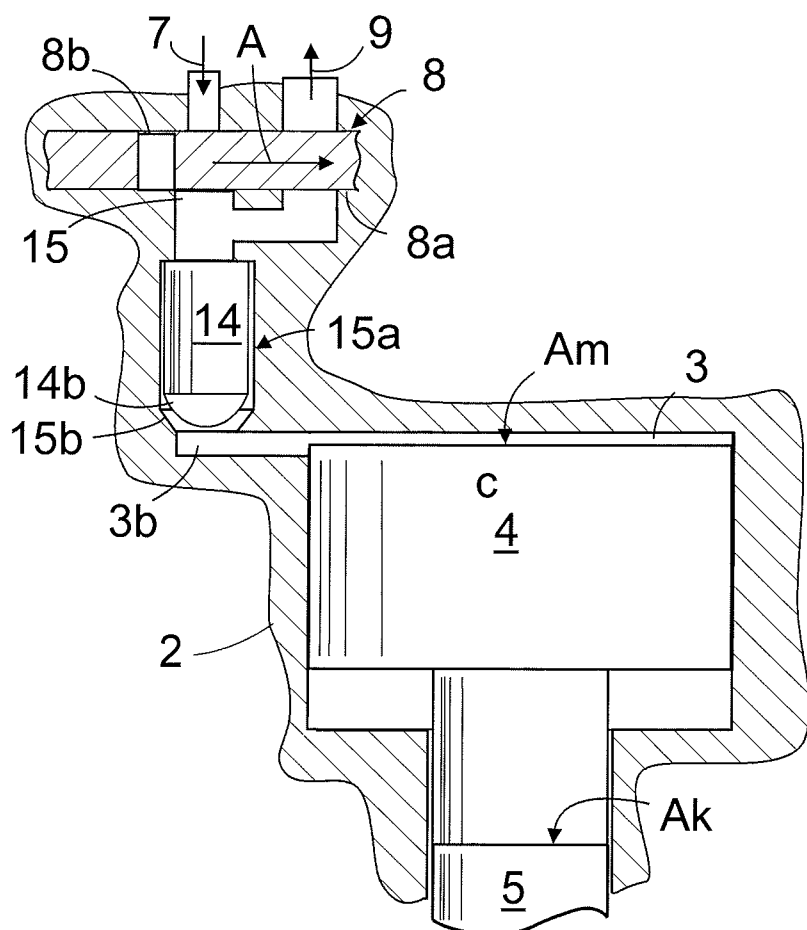


Fig.7b

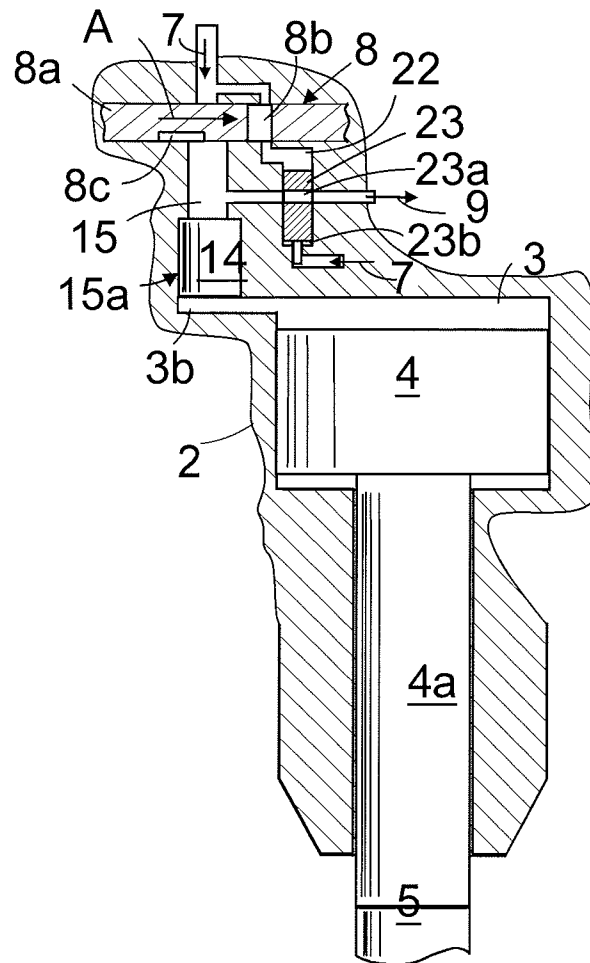


Fig.8a

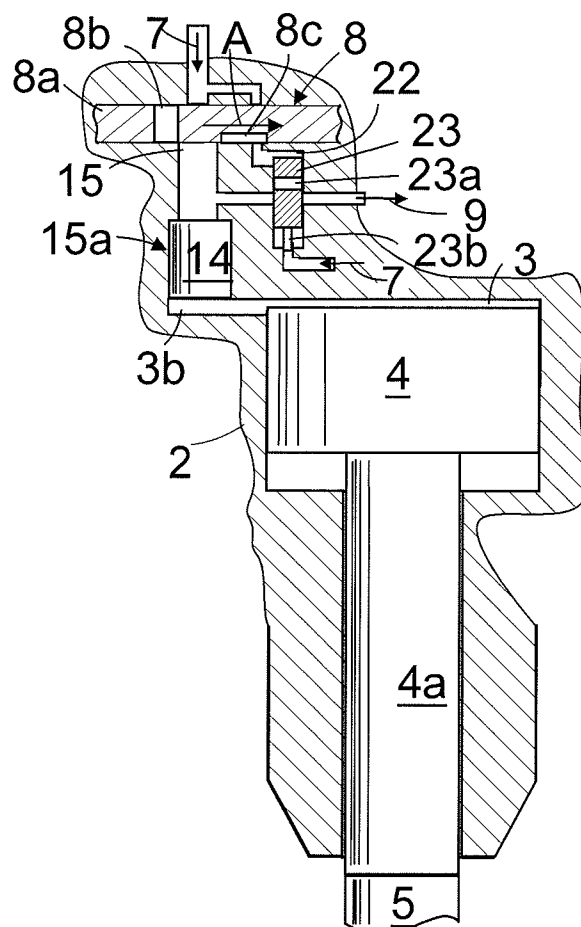


Fig.8b

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2010/050230

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: B25D

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

FI, SE, NO, DK

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

EPO-Internal, WPI, COMPDX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2006185864 A1 (KESKINIVA MARKKU et al.) 24 August 2006 (24.08.2006)	1-9
A	FI 116513 B (SANDVIK TAMROCK OY et al.) 15 December 2005 (15.12.2005)	1-9



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

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"&" document member of the same patent family

Date of the actual completion of the international search

22 June 2010 (22.06.2010)

Date of mailing of the international search report

24 June 2010 (24.06.2010)

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2010/050230

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2010/050230

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

B25D 9/16 (2006.01)