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(71) Applicant: **Josef Kihlberg AB**
54422 Hjo (SE)

(72) Inventors:
- **Zachrisson, Jonas**
542 31 Mariestad (SE)
- **Torstensson, Martin**
541 39 Skövde (SE)

(74) Representative: **Klein, Friedrich Jürgen**
Patentanwälte Klein & Klein
Grienbachstrasse 17
6300 Zug (CH)

(54) **Pneumatic fastener driving tool**

(57) A pneumatic fastener driving tool comprising a housing assembly (2) including a main housing portion (3) and a handle portion (4) extending from the main housing portion (3), whereas a cylinder (62), a piston (63) which is movable arranged within the cylinder (62), and a fastener driving element (77) which is operatively connected to the piston are included in the main housing portion, said fastener driving element (77) is provided for driving fasteners which are successively feadable into a fastener driving track from a magazine assembly (5), a trigger assembly (20) having an actuatable trigger (21) which is operatively connected with a trigger valve (22) for opening and sealing a pressure reservoir (25), a main valve (26) for closing and opening a passageway between said pressure reservoir (25) and said piston(63), whereas said main valve (26) is arranged in the passageway for compressed air between the pressure reservoir (25) and the piston (63), a power adjustment unit (61) for regulating the power of said piston (63), said power adjustment unit is provided with a movable valve body of a throttle valve which can be lowered onto and raised from a valve seating (64) in order to form a restriction of an adjustable size for the fluid. In order to increase the pressure of the fluid behind the valve fast the tool is provided with a main valve (26) which is movable arranged and can be moved during a cycle of ejecting a fastener between a first position, in which said means seals the passageway to the valve body of the power adjustment unit, and a second position, in which said means releases at least partly said passageway, and by means of a force-biased valve body (74) of said power adjustment unit (61), which forms during a cycle of ejecting a fastener with its valve seating (64) a restriction with a variable size.

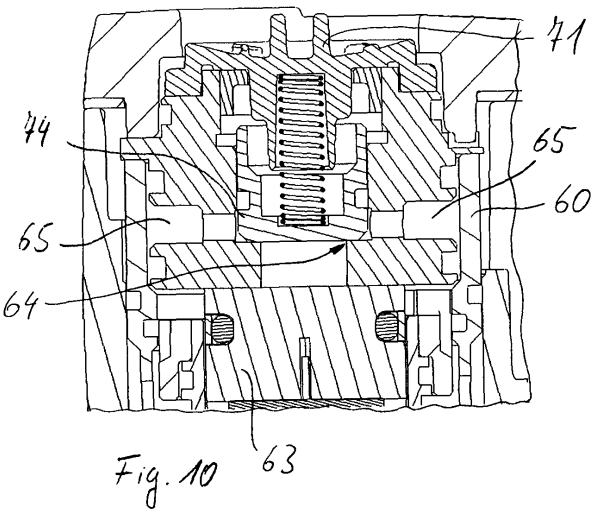

Fig. 10

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Description

[0001] The invention concerns a pneumatic fastener driving tool comprising a housing assembly including a main housing portion and a handle portion extending from the main housing portion, whereas a cylinder, a piston which is movable arranged within the cylinder, and a fastener driving element which is operatively connected to the piston are included in the main housing portion, said fastener driving element is provided for driving fasteners which are successively feadable into a fastener driving track from a magazine assembly, a trigger assembly having an actuatable trigger which is operatively connected with a trigger valve for opening and sealing a pressure reservoir, a main valve for closing and opening a passageway between said pressure reservoir and said piston, whereas said main valve is arranged in the passageway for compressed air between the pressure reservoir and the piston, a power adjustment unit for regulating the power of said piston, said power adjustment unit is provided with a movable valve body which can be lowered onto and raised from a valve seating in order to form a restriction of an adjustable size for the fluid.

[0002] Portable fastener driving tools which use a fluid, particularly compressed air, for accelerating fasteners like staples, headed and headless nails, clamp nails and the like and for driving them into items, are well known. Such fastener driving tools are used for example in the production of furniture for affixing overlays, for example leather covers, at furniture. Such fastener driving tools have a piston which is movable in a cylinder between a top and an upper dead center. A fastener driving element is arranged within the line of motion of the piston and is used for contacting and ejection the fasteners which are fed into the fastener driving track from a magazine assembly. Such fastener driving tools are known which are provided with means for changing between two modes, whereby in one mode each activating of the trigger leads to a single shot of a fastener and in the other mode each activating of the trigger leads to a plurality of successive shots as long as the trigger is activated.

[0003] In connection with such fastener driving tool it is already known to provide them with a possibility to regulate the amount of power generated by the tool for driving a fastener without changing the line pressure. Such a tool is prior known for example from EP 0 683 015 B1. In EP 0 683 015 B1 a pneumatic fastener driving tool is disclosed which is provided with a power adjustment unit uses an adjustable restriction. The size of the restriction can be adjusted by means of a screw, but the size of the restriction is fixed during a cycle, in which a fastener is ejected by the tool. So the restriction acts as a throttle in order to create a pressure drop behind the restriction. Such a regulation has the advantage that for the fastener driving tool no external pressure regulation is necessary. But it has found out that particularly at the beginning of a stroke the pressure in the driving chamber of the piston is relatively low which can lead to problems with the acceleration of the piston. A further disadvantage can be seen in the fact that such prior known solutions have a not satisfying safety against unintentional firing of fasteners, particularly after a service and a dissembling of the tool. After an assembling of the tool and a connection of the tool to an air supply, it could take a short time until the movable parts find their correct position in the tool and then, when the restriction is already open, air can flow into the cylinder and cause a stroke.

[0004] It is therefore an object of the present invention to provide an improved fastener driving tool which avoids these disadvantages.

[0005] A fastener driving tool as initially mentioned and according to the invention comprises a means of said main valve which is movable arranged and can be moved during a cycle between a first position, in which said means seals the passageway to the valve of the power adjustment unit, and a second position, in which said means releases at least partly said passageway, and by means of a force-biased valve body of said power adjustment unit, which forms during a cycle of ejecting a fastener with its valve seating a restriction with a variable size. Preferably said force-biased valve body can be lifted from said valve seating in dependency from the amount of a force biasing said valve body and from the amount of a force resulting from the pressure of the fluid in order to form a restriction of variable size during a cycle of ejecting a fastener. The Specific advantages with respect to the regulation of the power of the tool can be reached by a preferable embodiment of the invention which comprises a means for adjusting the maximum size of the restriction by adjusting the possible movement of the valve body.

[0006] According to the invention the pneumatic resp. fluidic restriction in the passageway generated by the power adjustment unit is variable during a cycle. It starts with a minimum size of the geometrical restriction resp. limitation, preferably with a value "zero" of the cross section surface through which the fluid can flow, and decreases to an adjustable maximum of the pneumatic restriction. The geometrical restriction starts to increase as soon as the main valve is open and the pressure in the passageway between the main valve and the valve of the power adjustment unit is high enough to generate a force in order to lift the valve from its valve seating against the force with which the valve is pressed against the valve seating. Therefore the fluid does not start to flow through the power adjustment unit as long as the pressure in the area of the valve has not reached a certain amount. The efficiency of the throttling function of the power adjustment unit increases therefore with respect to prior known solutions. A further advantage of the invention can be seen in the circumstance that the pressure of the fluid behind the valve increases faster than by prior known tools, for example the tool of EP 0 683 015 B1, it is necessary that the fluid has in comparison with those tools a comparatively high amount. This leads to a more efficient use of the stroke length in order to accelerate the

piston.

[0007] A preferred embodiment of the fastener driving tool according to the invention can be provided with a main valve which is arranged in flow direction behind the trigger assembly and which releases the passageway automatically in dependency from the actuating status of the trigger assembly. It is further preferred that the main valve is loadable with pressure of the fluid at least at two different areas of the main valve, preferably at two end areas of the main valve, and that the movement of said main valve occurs in dependency of the pressure difference of the at least two different areas. As long as the trigger is not activated, the main valve closes the passageway to the valve of the power adjustment unit. In this status the trigger assembly opens a supply channel which is connected with a first area of the main valve. Said first area is sealed against a second area of the main valve. The hose pressure of the fluid, which acts upon the first area of the main valve and generates here a force which exceeds a force generated in the second area, pushs and holds the main valve in a position in which it closes the passageway to the piston. It is therefore preferred, that in the first area, the surface which is responsible for the holding force of the main valve in its closed position, is larger than the surface of the second area, which is responsible for the counter-force with respect to the holding force. An actuating of the trigger closes the supply channel, takes the pressure from the first area of the main valve. Then the pressure of the fluid, which acts preferably all the time and simultaneously in the second area against the main valve, starts to open the passageway,which was closed before by the valve means The now higher force generated by the pressure in the second area and acting against the second area of the main valve leads to a movement of the main valve which opens now the passageway to the valve of the power adjustment unit. An actuating of the trigger assembly results therefore also in automatically opening movement of the main valve.

[0008] The power adjustment unit, which is provided with a spring-forced valve body and which also closes the passageway to the piston when there is no pressure in the tool higher than the atmospheric pressure solves also a safety problem in connection with services for the tool. Usually prior known fastener driving tools have the disadvantage that they can unintentionally shoot a fastener when they are connected after a service to the host pressure. In order to avoid this risk relatively complicated and expensive solutions were necessary. The tool according to the invention solves this problem without the necessity of including any further parts. Because the spring-forced valve of the power adjustment unit closes always the passageway way as long as there is no pressure in the tool and as long as the trigger assembly is not actuated an unintentionally shoot of a fastener can be avoided.

[0009] In connection with the present invention it has also found as advantageous if the trigger assembly interacts automatically by means of the fluid not only with said main valve but rather also with the valve body of the power adjustment unit. For this purpose the valve body of the power adjustment unit can be provided with a surface which is loadable with pressure of the fluid and which effect then a pressure-dependent force with at least a force-component having an effective-direction which is opposite to the effective-direction of the spring force. In dependency of the amount of pressure this counterforce to the spring-force exceeds the latter. As a result the valve body is lifted and opens a restriction through which the fluid can flow. As a further result of the lifting movement of the valve body the compression of the spring increases. In a preferred embodiment of the present invention the lifting movement stops as soon as the valve body reaches a stop. The position of the stop with respect to the direction of the lifting movement of valve body should be adjustable, in order to have a possibility for adjusting the maximum size of the (geometrical) restriction generated by the valve of power adjustment unit. The power, which can be generated by the piston is therefore dependent from the amount of the maximum cross section surface which can be used by the fluid for flowing through the valve of the power adjustment unit.

[0010] A means for adjusting the position of the stop can be designed as a screw with an external thread which is arranged in an internal thread. The spring is arranged and compressed between the valve and the thread, whereby revolving of the screw leads to a change of the position of the stop with respect to the valve body in its closed position.

[0011] In another preferred embodiment of the invention the size of the resulting restriction could depend from the amount of a pre-adjusted spring-force. In this embodiment the lifting movement of the valve body stops as soon as a balance between the spring-force and the pressure-based counterforce is reached. The size of the restriction and therefore also the power of the piston is in this preferred embodiment a result of a self-regulation between the spring-force and the force resulting from the fluid-pressure. According to this embodiment of the invention it can be preferred that the power adjustment unit comprises a means for adjusting said spring force. That means can be designed as a screw with an external thread which is arranged in an internal thread. The spring is arranged and compressed between the valve and the thread, whereby revolving of the screw leads to a change of length of the spring and therefore to an alteration of the spring force.

[0012] In a further preferred and advantageous embodiment of the present invention the main valve comprises a movable hollow-cylindrical means which surrounds the valve of the power adjustment unit. Although such an embodiment of the main valve allows a compact design it is possible to achieve a high operational reliability.

[0013] According to the invention it is further preferred that the valve of the power adjustment unit is arranged

as near as possible to the piston, preferably directly in front of the piston. A possibility to realize that is to use a face of the part of the power adjustment unit which builds the valve seat as an upper face of the driving chamber of the piston. Such embodiments according to the invention reduce any "dead volume" behind the throttle which reduces the efficiency of the power adjustment.

[0014] Further aspects and preferred embodiments are disclosed in the following detailed description, drawings and claims. A possible embodiment of the invention will be described, by way of example only, with reference to the accompanying drawings. These drawings show in a schematical illustration:

Fig. 1 a preferred embodiment of a pneumatic fastener driving tool in a cross-section view;

Fig. 2 housing parts of the fastener driving tool of fig. 1 in a cross-section view;

Fig. 2a the housing parts of fig. 2 in a partly assembled situation;

Fig. 2b a cross-sectional view according to the line II - II of fig. 2a;

Fig. 3 said housing parts of fig. 2 in a perspective view;

Fig. 4 a trigger assembly of the tool of fig. 1 in an enlarged illustration;

Fig. 5 a housing part of the tool together with means of an single and automatic fire control in an exploded view;

Fig. 6 a housing part of the tool together with means of a single and automatic fire control in a second arrangement;

Fig. 7 the means of the single and automatic fire control in the single fire modus shown in a crossection view;

Fig. 8 the means of the single and automatic fire control in the automatic fire modus shown in a crossection view;

Fig. 9 a detail of fig. 1;

Fig. 10-12 a power adjustment unit of the tool of fig. 1 in different modes;

Fig. 13 a cross-section view through a cylinder and the single and automatic fire control;

Fig. 14 a cross-section view through the trigger assembly and the single and automatic fire control;

Fig. 15 a muffler means in a perspective view;

Fig. 16 the muffler means in a cross-section view;

Fig. 17 a detail of fig. 1 concerning the muffler means.

[0015] Fig. 1 shows a portable pneumatically actuated fastener driving tool 1 having a housing assembly 2. The housing assembly 2 has a main housing portion 3 and a handle part 4, to which a hollow magazine assembly 5 for receiving a supply of fastener is connected. The handle part 4 and the magazine 5 assembly are aligned essentially parallel to each other, whereby the main housing portion 3 is orientated essentially perpendicular with respect to the handle part 4. The handle part 4 contains a connection 6 for an air supply.

[0016] The handle part 4 is provided with a kind of lattice work 10 which is build by the metallic housing in order to provide the handle part 4 with a good torsional and bending strength (Fig. 2). As shown in Fig. 2, 2a, 2b and 3 a hollow one piece plastic part 11 which is build us an adapting sleeve and is slid onto an over the lattice work 10 of the handle part 4. As can be seen in Fig. 2b the lattice work 10 has an outer shape particularly with an extension 10a which is provided with edges, which allows with respect to the radial position of the hollow plastic part 11 a form-locking arrangement onto the the lattice work 10. The tub-shaped plastic part 11 can be manufactured as an injection molding part out of an appropriate plastic material, for example TPE (thermoplastic elastomer), PUR (polyurethane) or EPDM (ethylene propylene diene M-class rubber). Such materials are particularly in the form of a hollow-cylindrical gap-free part with respect to its mechanical stability strength as plastic although it is soft as rubber with respect to its ability to adapt its shape in a certain amount to the shape of handle part of the metallic housing. The plastic part 11 should fit on the handle part 4 of the metallic housing preferably without clearance and can be fastened to the handle part with only one screw. As shown in Fig. 1, 2 and 2a in the transition area between the handle part 4 and the main housing portion 3 the metallic housing can be provided with a shoulder 12 resp. border, which in circumferential direction of the handle part at least partly surrounds the handle part 4. The plastic part 11 can rest with its front side against said shoulder 12 in order to allow a predefined position of the plastic part 11 onto the handle part. At the other end of the plastic part a locking piece 13 is partly inserted into the free end of the handle part 4 and of the plastic part 11. The locking piece 13 is also provided with a shoulder 14 and rests with said shoulder 14 against the handle part 4 and plastic part 11. The plastic part 11 is therefore clamped between these two shoulders 12, 14. As can be seen in Fig. 1 - 3 the locking piece 13 is

provided with a lug 15 which is used to fasten the magazine assembly 5 at the housing.

[0017] A manually actuatable trigger assembly 20 is arranged in an intersection part between the handle part 4 and the main housing portion 3. The trigger assembly 20 can be actuated by a user of the tool by means of a trigger 21. A trigger valve 22 acts as a barrier between a pressure reservoir 25 for compressed air (Fig. 1), and a main valve 26 of the tool. The pressure reservoir 25 can be connected by means of a hose (not shown in the drawings) to an external supply of compressed air. A trigger assembly 20 connects the pressure reservoir 25 with a supply channel 28 which ends in a lower area of the main valve 26. The pressure reservoir is also connected via a connecting channel 27 with the main valve 26. The connecting channel leads to an upper area of the main valve which is sealed against the lower area. By actuating the trigger assembly 20 the supply channel 28 is disconnected from the pressure reservoir 25. As long as the trigger is not actuated the trigger assembly connects the pressure reservoir 25 with a supply channel 28.

[0018] An assembly group of a means for single fire control and of a means for automatic frequency fire control 40 (hereinafter called "SFCAFC") is arranged in flow direction of the compressed air behind the trigger assembly 20. The assembly group is arranged in the handle part 4 of the housing assembly in a through hole 41 and is provided with a single fire control means 42, a frequency control means 43 and a valve 44, which are inserted at the same side of the housing (Fig. 5). At the opposite side of the housing a throttle valve 45 of the SFCAF is inserted in the housing. The actuatably single fire control means 42 has the function to allow a limitation of the amounts of shots of fasteners by actuating the trigger to only one shot. Contrary to that, the frequency control means 43 has the function to allow an adjustment of the frequency in a certain range of frequencies with which a plurality of fasteners are successively shoot out of the tool in case that the single fire control is not actuated. A typical adjustable range of frequencies are from 0 to 1800 fasteners per minute, In order to adjust the fastener driving tool to a single shot it is necessary to push the single fire control means 42 inside the frequency control means 43. Simultaneously the function of the frequency control means 43 is switched off. In case that the single fire control is not actuated the frequency of the fasteners which are shoot out of the tool can be adjusted by revolving the frequency control means 43 at the knurl 46, which is a one-piece part of the frequency control means.

[0019] In order to allow right-handed persons as well as left-handed persons an ergonomic use of the fastener driving tool it is possible to interchange the sides on which the throttle valve 45 on one hand and the single fire control means 42, the frequency control means 43 and the valve 44 on the other hand are arranged in the fastener driving tool. The possible two different configurations of the SFCAFC are shown in the exploded views of Fig. 5 and 6 as well as in the intersection views of the Fig. 7 and 8. For this adaptation according to the preferences of left- or right-handed persons it is necessary to remove the throttle valve 45 and also the single fire control means 42, the frequency control means 43 and the valve 44 from the housing. These parts can be removed from the handle part 4 as assembled. Then the throttle valve 45 is inserted at the other side of the housing where the single fire control 42 means, the frequency control means 43 and the valve 44 have been arranged before. Furthermore the single fire control means 42, the frequency control means 43 and the valve 44 are inserted at the opposite side of the housing where the throttle valve 45 has been arranged before. As soon as the parts of the SFCAFC are interchanged and connected to each other in the subsequent described manner the SFCAFC is ready for use.

[0020] The throttle valve 45 is provided with a conical plug 50 which interacts with an also conical valve seat 51 of the frequency control means 43. By means of varying the penetration depth of the plug 50 into the opening of the valve seat 51 the restriction between the valve seat 51 and the plug 50 can be varied. As can be seen in Fig. 7 and 8 the frequency control means 43 is provided at one of its ends with an outer thread which can be screwed into an inner thread of the valve 44, whereby the valve 44 can be screwed with its outer thread into an inner thread of the throttle valve 45. The inner thread of the throttle valve 45 is situated at the inner surface of a hollow cylindrical part of the throttle valve 45 which surrounds the plug 50 with distance. The wall of the hollow cylindrical part of the throttle valve is provided with openings 52 through which air can flow in direction to the supply channel 28 via the trigger assembly 20.

[0021] At the other end of the frequency control means 43 the pin-shaped single fire control means 42 is coaxially inserted into the hollow cylindrical frequency control means 43. The single fire control means 42 can be displaced in the frequency control means in longitudinal direction between two end positions. In one of these two end positions the front end of the single fire control closes openings 53 in the wall of the frequency control means 43 so that the passageway of the frequency control means is closed for air coming through openings 52 of the throttle valve and through the supply channel 28. This position of the single fire control means is shown in Fig. 7, whereby the flow direction of the air is illustrated by dotted lines 57. This is the position in which the single fire control is switched on.

[0022] The other possible end-position of the single fire control means 42 is shown in Fig. 8. towards the throttle valve 45 and its restriction. In its other position the single fire control means is partly retreated in the frequency control means so that the passageway of the frequency control means is free for air which flows from the openings 54, 53 through the wall of the frequency control means 43 towards the throttle valve 45 and its restriction and openings 52.

[0023] A cage 60, which is part of the main valve 26 can be moved between an upper and a lower position.

In Fig. 9 the cage 60 is shown in its lower position. The cage 60 is arranged in flow-direction behind the throttle valve 45 of the SFCAFC and at the end of the supply channel 28. The cage 60 is also arranged at the end of the connecting channel 27. In its upper position the cage closes openings 65 which acts as passageways and connects the connecting channel 27 with the power adjustment unit 61, whereby in its lower position the cage opens the openings 65 for a flow-through. The cage 60 surrounds the upper part of a cylinder 62 which contains a piston 63 and surrounds also the lower part of a valve seating 64 of the main valve.

[0024] If the trigger 21 is not activated the cage 60 is loaded with the hose pressure at its lower front side, the cage is held in its upper position (Fig. 1 and 10). In said upper position the cage seals openings 65 which lead to the power adjustment unit 61. By actuating the trigger 21 the air pressure under the cage is taken away and the cage 60 is moving down in direction towards its lower position, which is shown in Fig. 9 and 11. Now the cage releases the openings 65 and air can flow now to a throttle valve 70 of the power adjusting assembly.

[0025] The throttle valve 70, which is part of the power adjustment unit 61 is shown in Fig. 10 - 12. The valve 70 includes a screw 72 which is screwed in a hollow cylindrical part 76 which is provided with a inner thread and which is fixed at main housing portion 3 of the housing assembly. The screw 72 can be moved up or down by revolving an actuating part 71 in one of the two rotating directions. The screw 72 acts as a stop for the valve body 74. A helical spring 73 is arranged between the actuating part 71 and the valve body 74 of the throttle valve 70. The force of the spring 73 presses the valve body 74 with its cone-end onto the valve seating 64. As deeper the screw 72 is screwed into the main housing as shorter is the length of the maximum lifting movement of the valve body. In order to get a high resolution of the adjustable position of the the screw 72, the screw 72 is provided with a relatively low pitch and it can be adjusted over several revolutions.

[0026] The valve body 74 is provided with an outer inclined peripherally surface 75. A normal of said surface has a component parallel to the direction of the spring force. The air pressure acting against said surface 75 leads therefore to a lifting of the valve body 74 from the valve seating 64 in case that the air pressure is high enough. This lifting movement proceeds until the valve body 74 reaches the screw and gets into contact with the screw 72 which stops the movement of the valve body 74. By means of the possibility to adjust via the position of the screw 72 it is possible to vary for each cycle the maximum restriction of the throttle valve and therefore the possible discharge flow-through which can reach in flow-direction the piston and affects pressure onto a surface of the piston. The pressure in the piston chamber accelerates than the piston 63 downwards in its cylinder 62 from its top dead center (Fig. 10 - 12) to the direction of its bottom dead center (Fig. 9). Near at the end of this movement a fastener driving element 77 (Fig. 1) which is operatively connected the piston 63 acts with its contact surface onto a fastener which will therefore be accelerated and shot out of the tool 1 in order to be driven into a subject. Than the next fastener is fed from the magazine assembly 5 for fasteners into the fastener driving track, which is the line of motion of the fastener driving element 77.

[0027] As soon as the piston reaches the area of its bottom dead center (Fig. 9) the air can leave the cylinder 62 through an orifice 78 in the wall of the cylinder 62 near the position of the piston bottom dead center, as indicated by a dotted arrow 79. The air flows from there into a return chamber 80, which is arranged as a hollow cylinder around the cylinder 62 of the piston 63. This enables to vent the piston chamber of the cylinder 62. The lower pressure in the piston chamber supports to fastening the movement of the piston back at its return stroke to its top dead center. Additionally the return chamber acts as a pressure chamber for the return stroke.

[0028] As can be seen in Fig. 13 and is indicated by dotted line 81 the high pressure air flows from the return chamber 80 with direction to the frequency control means 43. Before the air reaches the frequency control means 43 it has to flow through the restriction of the throttle valve 45 of SFCAF. The time it takes for the air to flow through the restriction and to fill the chamber of the frequency control means 43 depends from the size of the restriction. The size of the restriction is adjustable by revolving the throttle valve 45, which therefore influences the frequency with which the tool 1 ejects fasteners. Behind the frequency control means the air flows into the trigger valve 22. When the pressure is high enough under the automatic cage, the automatic cage moves to its upper position. Because in Fig. 8 the SFCAFC is assembled for right handed persons and in Fig. 13 the SCAFC is assembled for left handed persons in these two illustrations are shown two different flow directions of the air as a result of the two different assembly possibilities.

[0029] Then the air flows through the trigger valve under a cage 85 of the trigger valve 22 and moves it to its upper position (Fig. 14). Also the piston 63 returns to its upper position. When the piston is at its upper position the pressure in the return chamber 80 flows out. When the piston 63 leaves the bottom the air can flow out through a guide of the fastener driving element 77. The pressure can therefore be lowered in two ways, namely leaving through the guide of the fastener driving element 77 and by expanding when it pushes the piston upwards. When the return pressure is gone, the (automatic) cage 60 moves to its lowest position, because at the same time the trigger valve 20 closes supply channel 28 which takes the pressure from the lower side of the cage 60. This activates the cage 60 of the main valve and it moves to its lowest position. Air flows now into the cylinder and starts a new stroke. The piston strokes down and stays at its lowest position. Now, the higher pressure in the return chamber supports to bring the piston back to its

upper position. This will go on as long as the trigger is activated. If the trigger is not activated the air stops inside the trigger valve, which results in an automatic fire and tool stop. Without de-activating the trigger there will be no automatic fire and tool stop.

[0030] For the modus of "single fire" the initial situation is the same as shown in Fig. 9. In order to start a single fire shot the singe fire control means 42 has to be activated which means that the single fire control means 42 has to be pushed inside the bushing of frequency control means 43 - as shown in Fig. 7 - which closes the passage way from the return chamber 80 to the cage 85. Therefore the air which comes from the return chamber 80 remains in the frequency control means 43. No air can lift the automatic cage 85. In order to cause a new shot, first the trigger 21 has to be deactivated and than the trigger 21 has to be activated again.

[0031] As shown in Fig. 1 a tubular muffler means 90 is arranged in the handle part 4 of the tool 1. By means of the muffler means 90, which shown in more detail in Figs. 15 - 17, the noise of the compressed air can be reduced which exhaust the fastener driving tool 1 after its flow through the tool. The muffler means 90 has two parts, a tubular passage way pipe 91 and a tubular muffler pipe 92. The passage way pipe 91 and the muffler pipe 92 are preferably connected to each other as one piece part. The muffler pipe 92 is provided in its ring-shaped wall 93 with a plurality of geometrically predefined recesses 94. With respect to a certain length of the muffler pipe 92 and also with respect to its circumferential direction the recesses 94 are equally allocated at the muffler pipe. In the preferred embodiment the recesses 94 have a circular cross-sectional form, whereby the diameter of the recesses should be as big as possible. The size of the recesses is limited by the circumstance that too large recesses do not reduce the noise anymore. In a preferred embodiment the diameters of the recesses can have a value out of a range from 1 mm to 4 mm. In the embodiment shown in Fig. 17 the recesses have a diameter of 1,8mm. In case that non-circular recesses are used the largest aperture of those non-circular openings can also be out of this range of values. The front wall of the tubular muffler pipe is closed.

[0032] As can be seen in Fig. 1 and 17 the muffler pipe 92 is arranged in a tubular hole 95 of the locking piece 13. The muffler means 90 is provided at its outer peripheral surface with a plurality of ring-shaped extensions 96, with which the muffler means 90 rests again the inner surface of the tubular hole 95 of the locking piece. In the space between two extensions a sealing can be arranged, for example an o-ring. The outer peripheral surface of the muffler pipe 92 is arranged with clearance to the inner peripheral surface of the hole 95. The compressed air, which enter with high energy, particularly in form of a high velocity, the muffler means 90 flows through the passage way pipe 91 and will be therefore guided to the free end of the handle part 4. In the muffler pipe 92 the compressed air strikes against the closed front wall 97 of the muffler pipe 92. The compressed air has therefore the tendency to be retained within the muffler pipe 92, which means the air looses velocity. In the following the air can exit the muffler pipe through the plurality of recesses 94 in the wall of the muffler pipe as a result of a deflection of its flow direction. The air, which is now located in the hollow cylindrical area between the outer surface of the muffler pipe 92 and the surface of the hole 95 can leave the handle part through the open end of the hole 95.

Reference numbers

[0033]

1	Fastener driving tool
2	Housing assembly
3	Main housing portion
4	Handle part
5	Magazine assembly
6	Connection
10	Lattice work
11	Plastic part
12	Shoulder
13	Locking piece
14	Shoulder
15	Lug
20	Trigger assembly
21	Trigger
22	Trigger valve
25	Pressure reservoir
26	Main valve
27	Connecting channel
28	Supply channel
40	Single fire and automatic fire control
41	Through hole
42	Single fire control means
43	Frequency control means
44	Valve
45	Throttle valve
46	Knurl
50	Conical plug
51	Conical valve seat
52	Opening
53	Opening
54	Opening
57	Dotted line
60	Cage
60a	Lower front side
61	Power adjustment unit
62	Cylinder
63	Piston
64	Valve seating
65	opening
70	Throttle valve
71	Actuating part
72	Screw
73	Spring

74 Valve body
75 Surface
76 Hollow cylindrical part
77 Fastener driving element
78 Orifice
79 Arrow
80 Return chamber
81 Dotted line
85 Cage
90 Muffler Means
91 Passage way pipe
92 Muffler pipe
93 Wall
94 Recess
95 hole
96 Extension
97 Front wall

Claims

1. A pneumatic fastener driving tool comprising
a housing assembly (2) including a main housing portion (3) and a handle portion (4) extending from the main housing portion (3), whereas a cylinder (62), a piston (63) which is movable arranged within the cylinder (62), and a fastener driving element (77) which is operatively connected to the piston are included in the main housing portion, said fastener driving element (77) is provided for driving fasteners which are successively feadable into a fastener driving track from a magazine assembly (5),
a trigger assembly (20) having an actuatable trigger (21) which is operatively connected with a trigger valve (22) for opening and sealing a pressure reservoir (25),
a main valve (26) for closing and opening a passageway between said pressure reservoir (25) and said piston(63), whereas said main valve (26) is arranged in the passageway for compressed air between the pressure reservoir (25) and the piston (63),
a power adjustment unit (61) for regulating the power of said piston (63), said power adjustment unit is provided with a movable valve body of a throttle valve which can be lowered onto and raised from a valve seating (64) in order to form a restriction of an adjustable size for the fluid,
characterized by
a means of said main valve (26) which is movable arranged and can be moved during a cycle of ejecting a fastener between a first position, in which said means seals the passageway to the valve body of the power adjustment unit, and a second position, in which said means releases at least partly said passageway, and
by means of a force-biased valve body (74) of said power adjustment unit (61), which forms during a cycle of ejecting a fastener with its valve seating (64) a restriction with a variable size.

2. Pneumatic fastener driving tool according to claim 1, **characterized by** said force-biased valve body (74) which can be lifted from said valve seating (64) in dependency from the amount of a force biasing said valve body (74) and from the amount of a force resulting from the pressure of the fluid in order to form a restriction of variable size during a cycle of ejecting a fastener.

3. Pneumatic fastener driving tool according to one or both of the preceding claims, **characterized by** a means for adjusting the maximum length of a lifting movement of the valve body (74) from its valve seating (64).

4. Pneumatic fastener driving tool according to claim 3, **characterized in that** the amount of a lifting movement of said means of the power adjustment unit varies in dependency of the amount of said force, particularly of the amount of a spring force.

5. Pneumatic fastener driving tool according to one or more of the preceding claims, **characterized in that** the main valve releases the passageway automatically in dependency from the actuating status of the trigger assembly.

6. Pneumatic fastener driving tool according to one or more of the preceding claims, **characterized in that** said main valve is movable in a longitudinal direction, preferably in a direction parallel to the movement direction of the piston.

7. Pneumatic fastener driving tool according to claim 6, **characterized in that** said main valve moves during a cycle in two opposite directions.

8. Pneumatic fastener driving tool according to one or more of the preceding claims, **characterized in that** said main valve is loadable with pressure of compressed air at least at two different areas of the main valve, preferably at two end areas of the main valve, and that the movement of said main valve occurs in dependency of the pressure difference of the at least two different areas.

9. Pneumatic fastener driving tool according to one or more of the preceding claims, **characterized by** a connecting channel (27) connecting the pressure reservoir with one area of the main valve (26) and a supply channel (28) connecting the trigger valve (20) with the other area of the main valve.

10. Pneumatic fastener driving tool according to one or more of the preceding claims, **characterized in that** said main valve is provided with a cage which is ar-

ranged around the valve body of the power adjustment unit.

11. Pneumatic fastener driving tool according to one or more of the preceding claims, **characterized by** said valve of the power adjustment unit, which is provided with a surface which is loadable with pressure of a fluid which effects a pressure-dependent force with at least a force-component having an effective-direction which is opposite to the effective-direction of the force biasing the valve body (74).

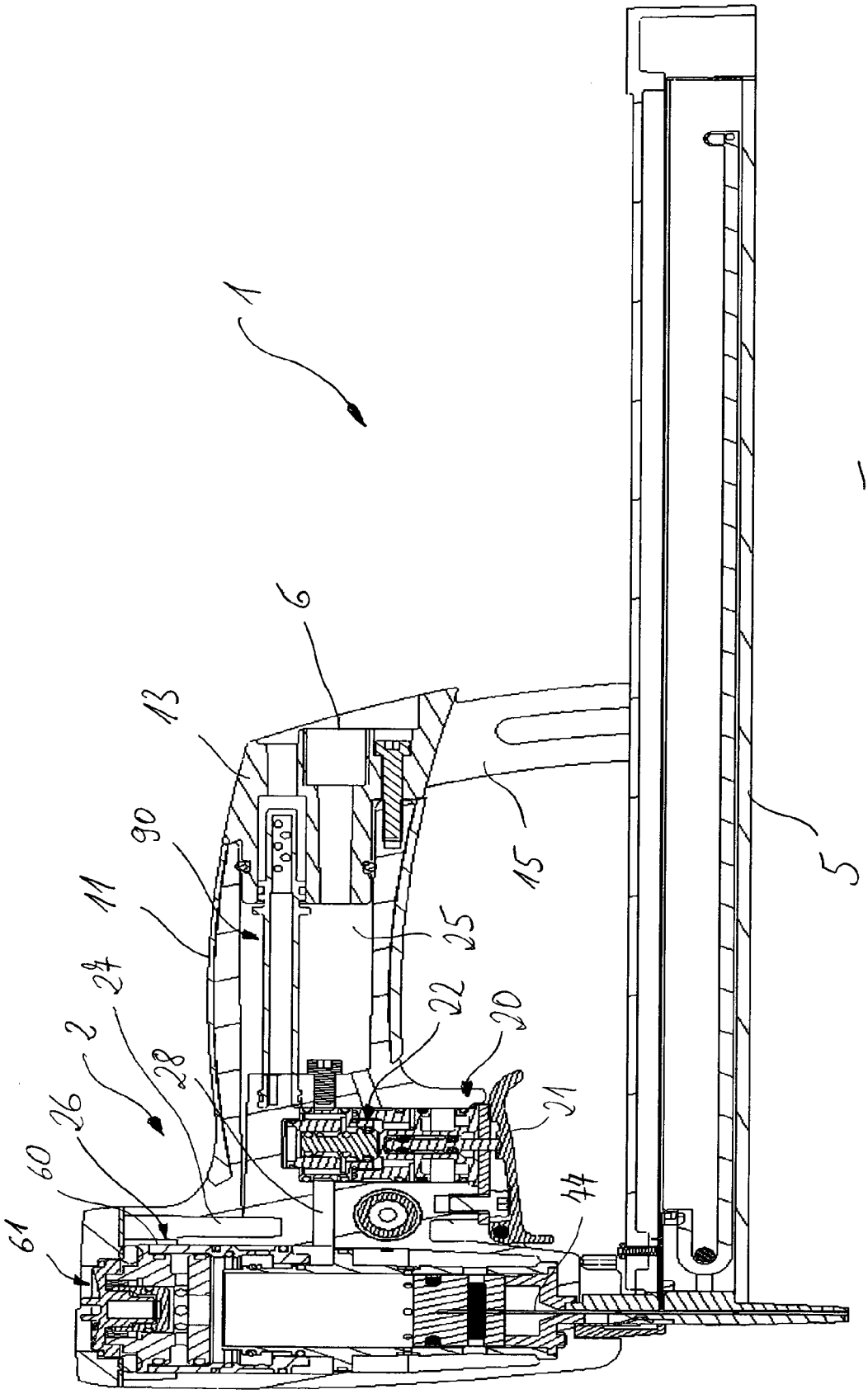


Fig. 1

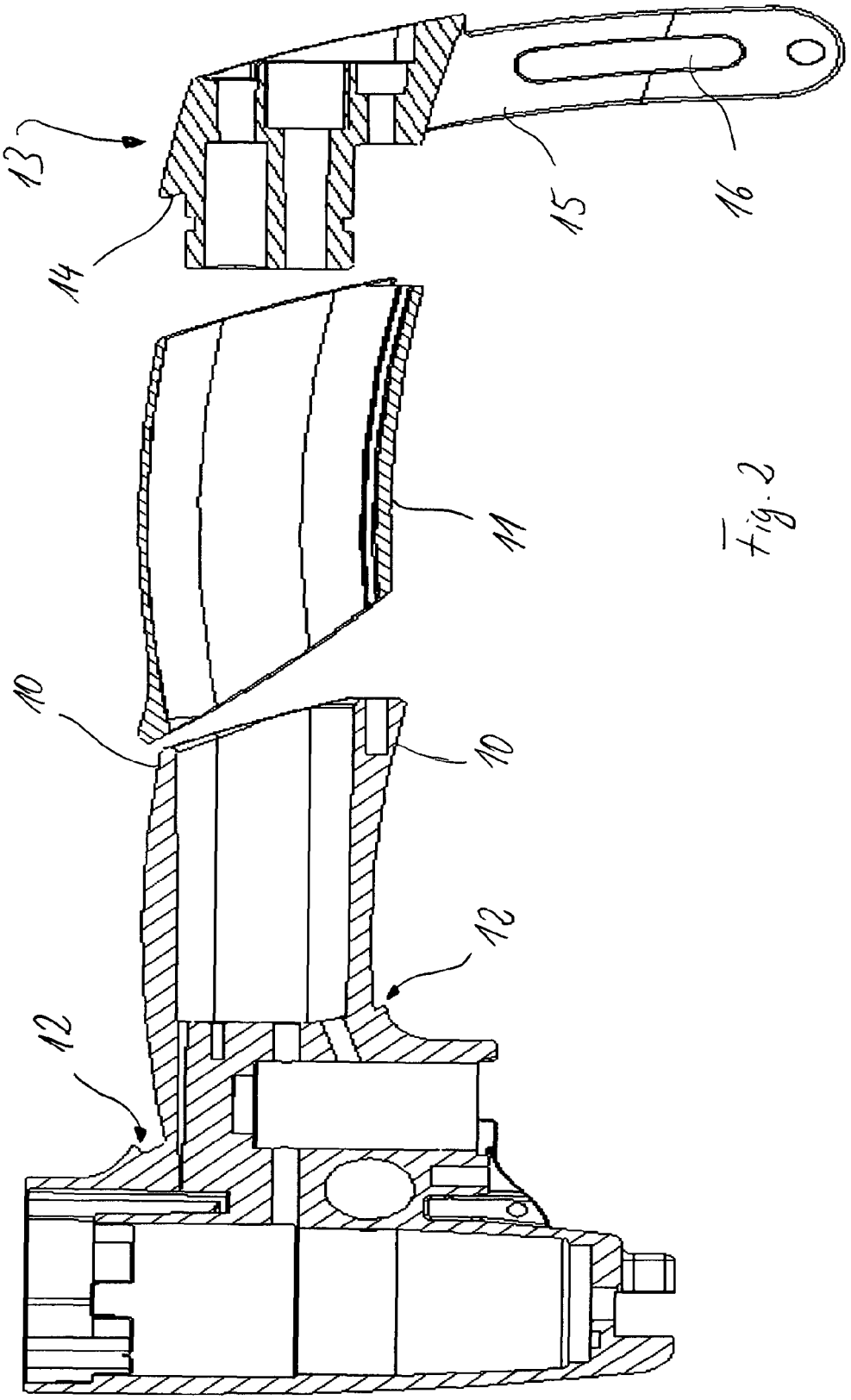


Fig. 2

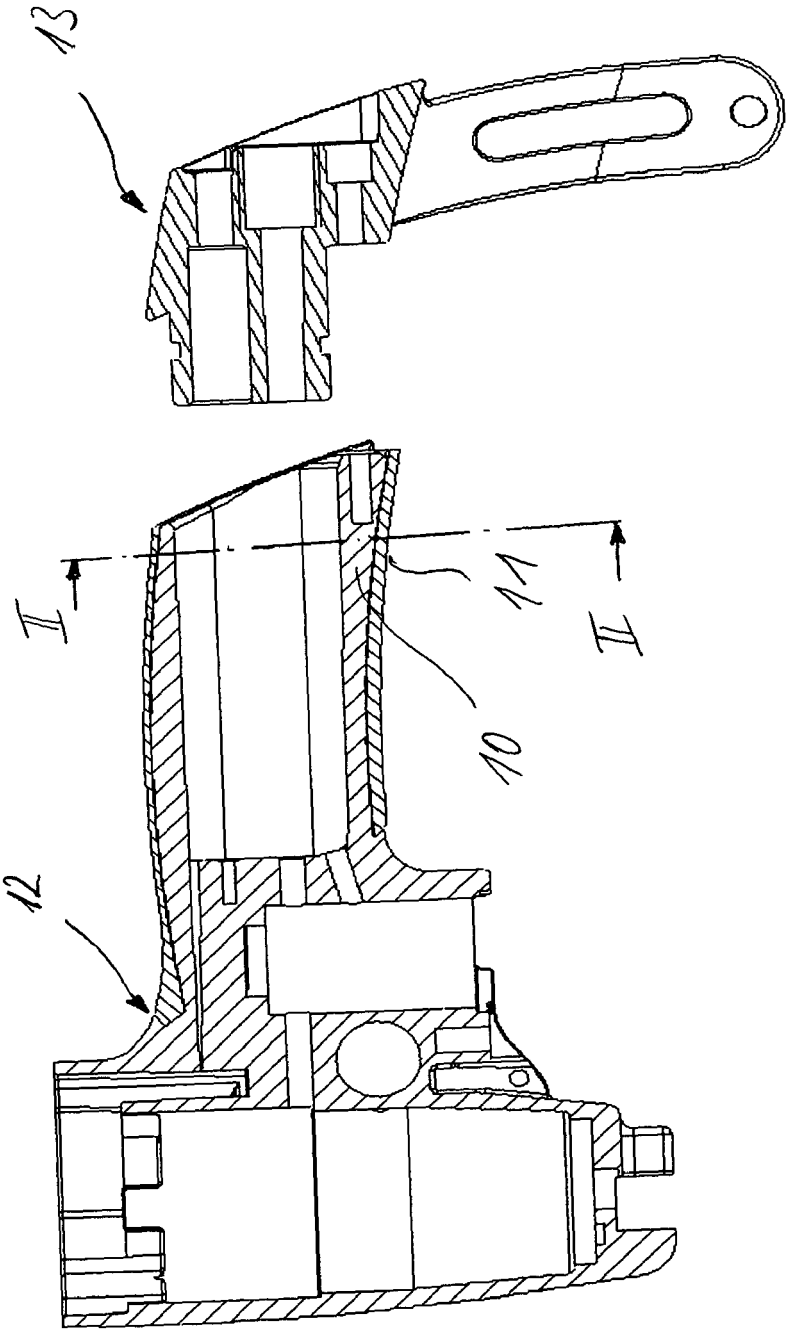


Fig. 2a

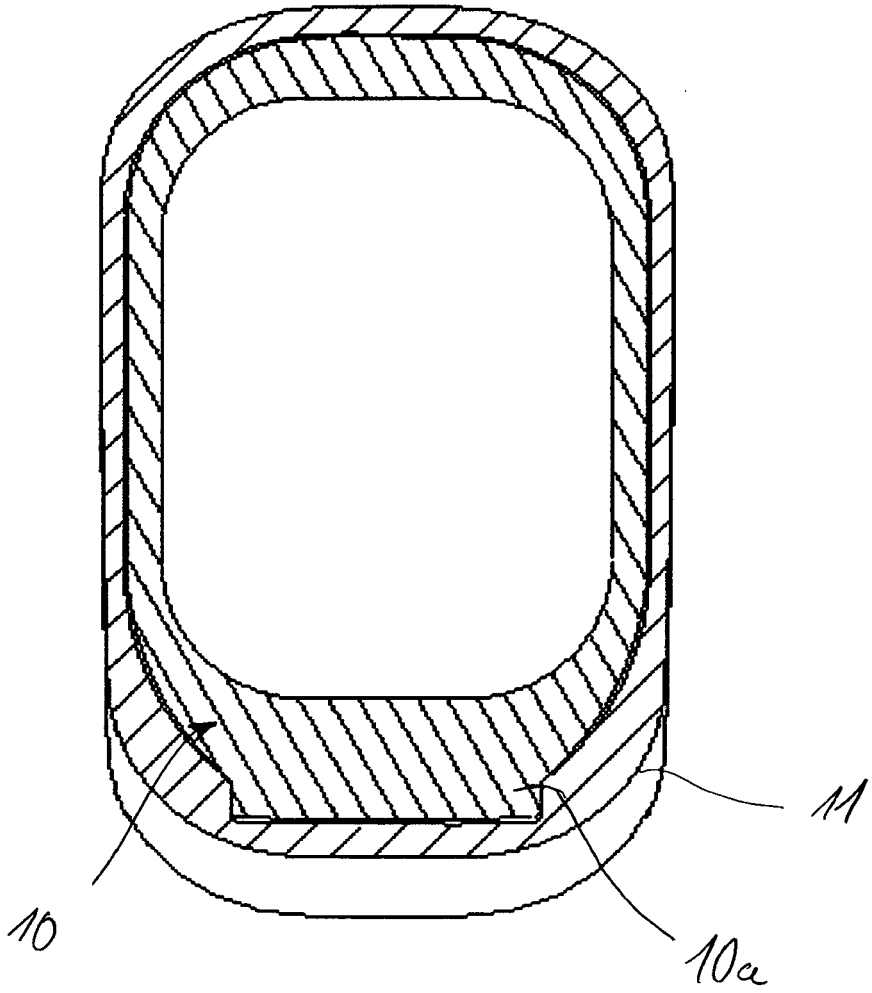


Fig. 2b

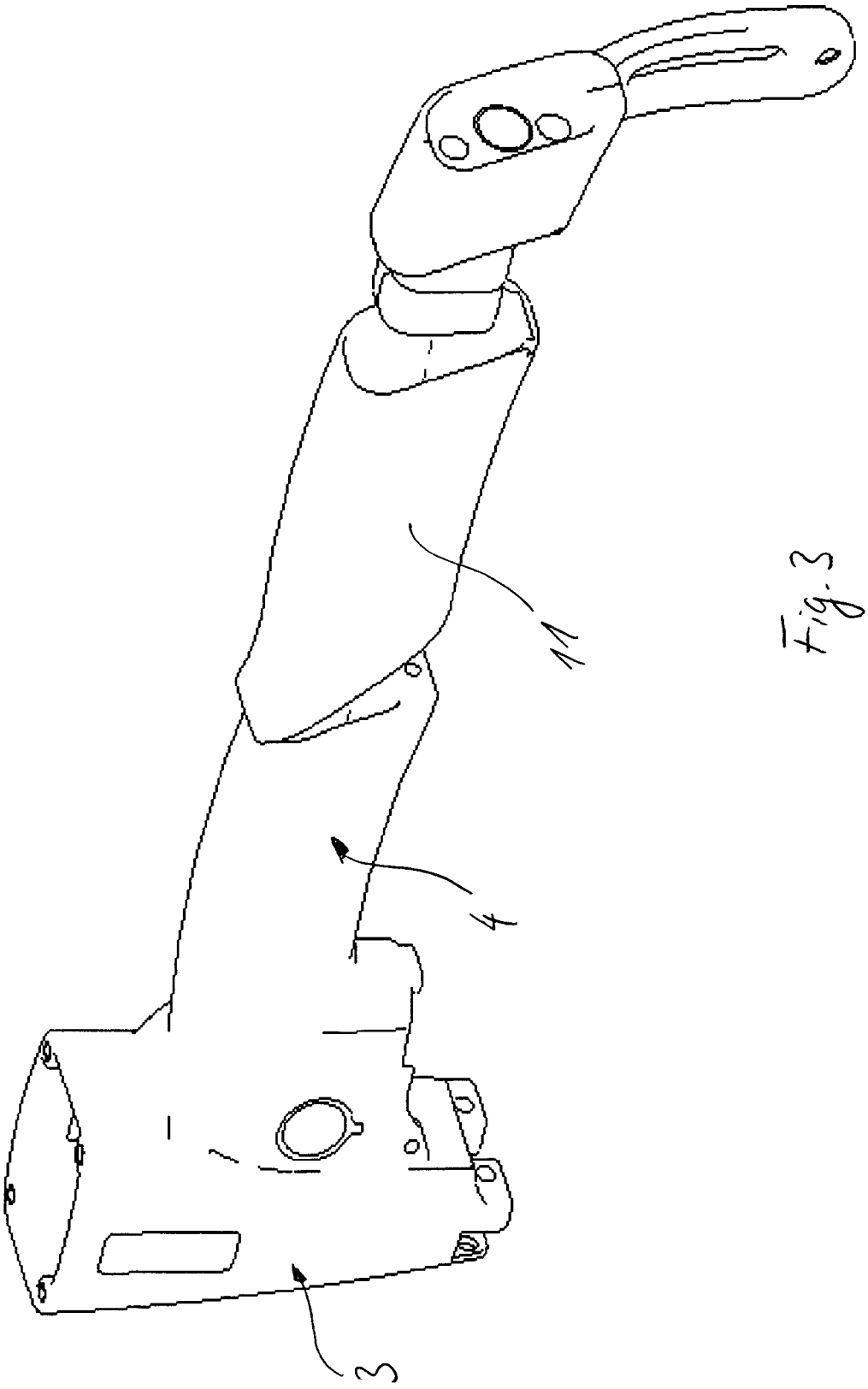


Fig. 3

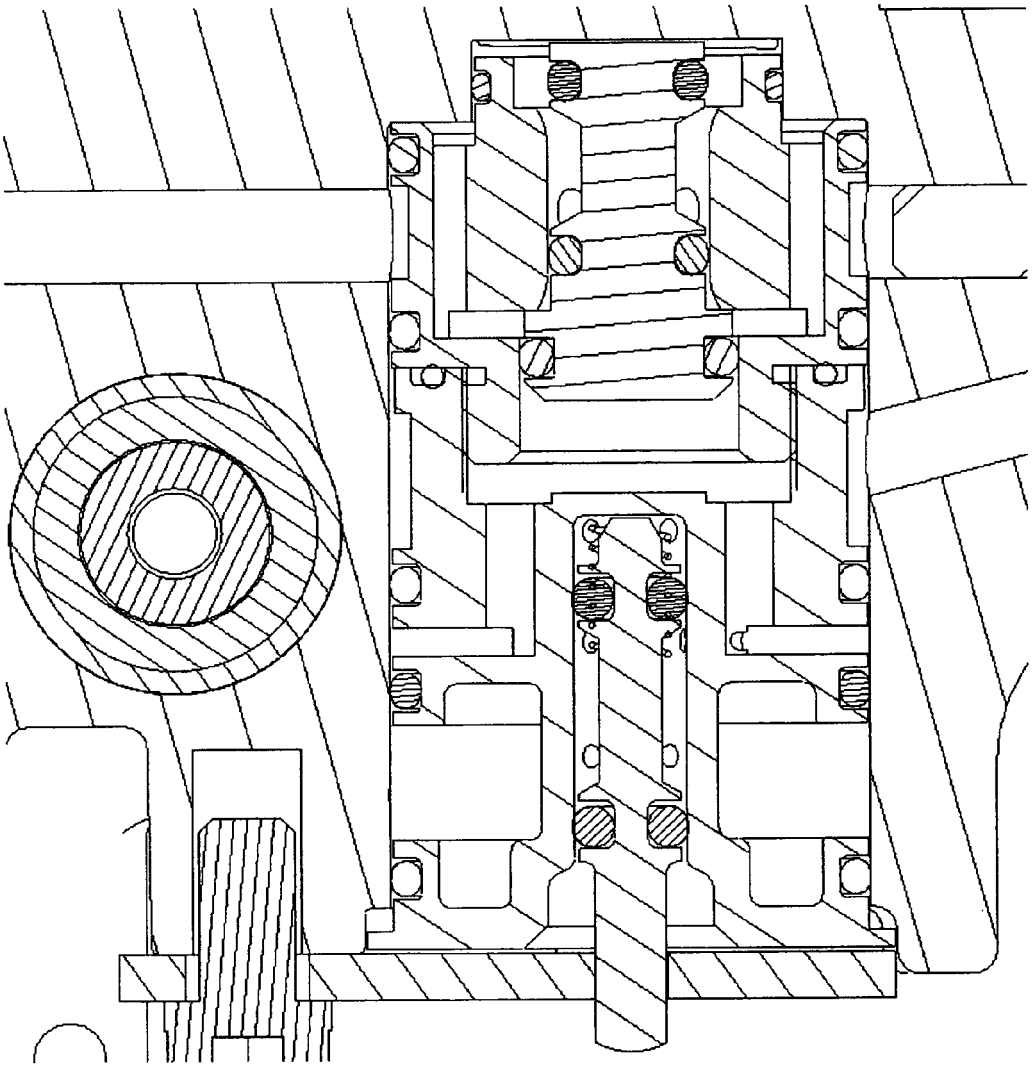
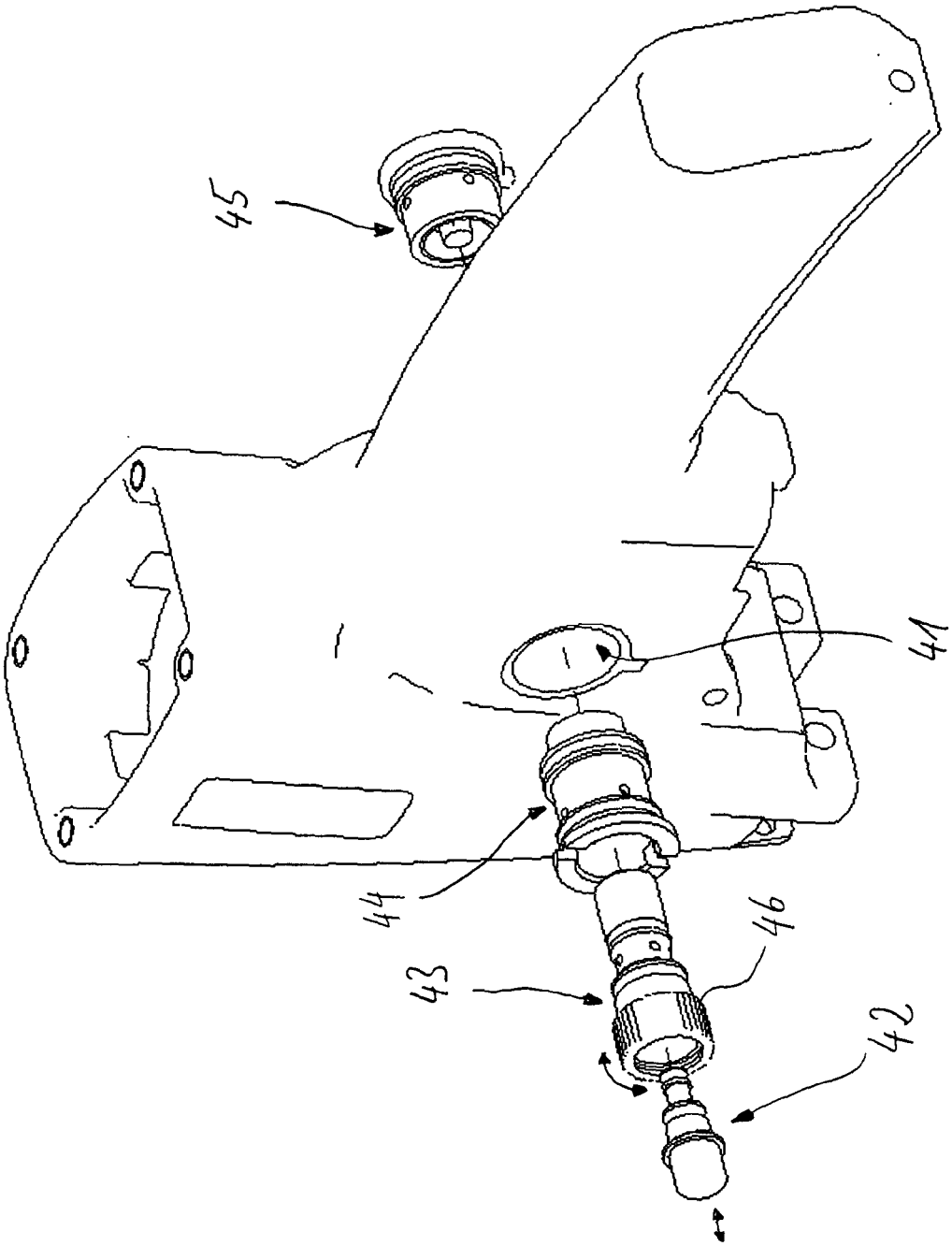


Fig. 4

Fig. 5



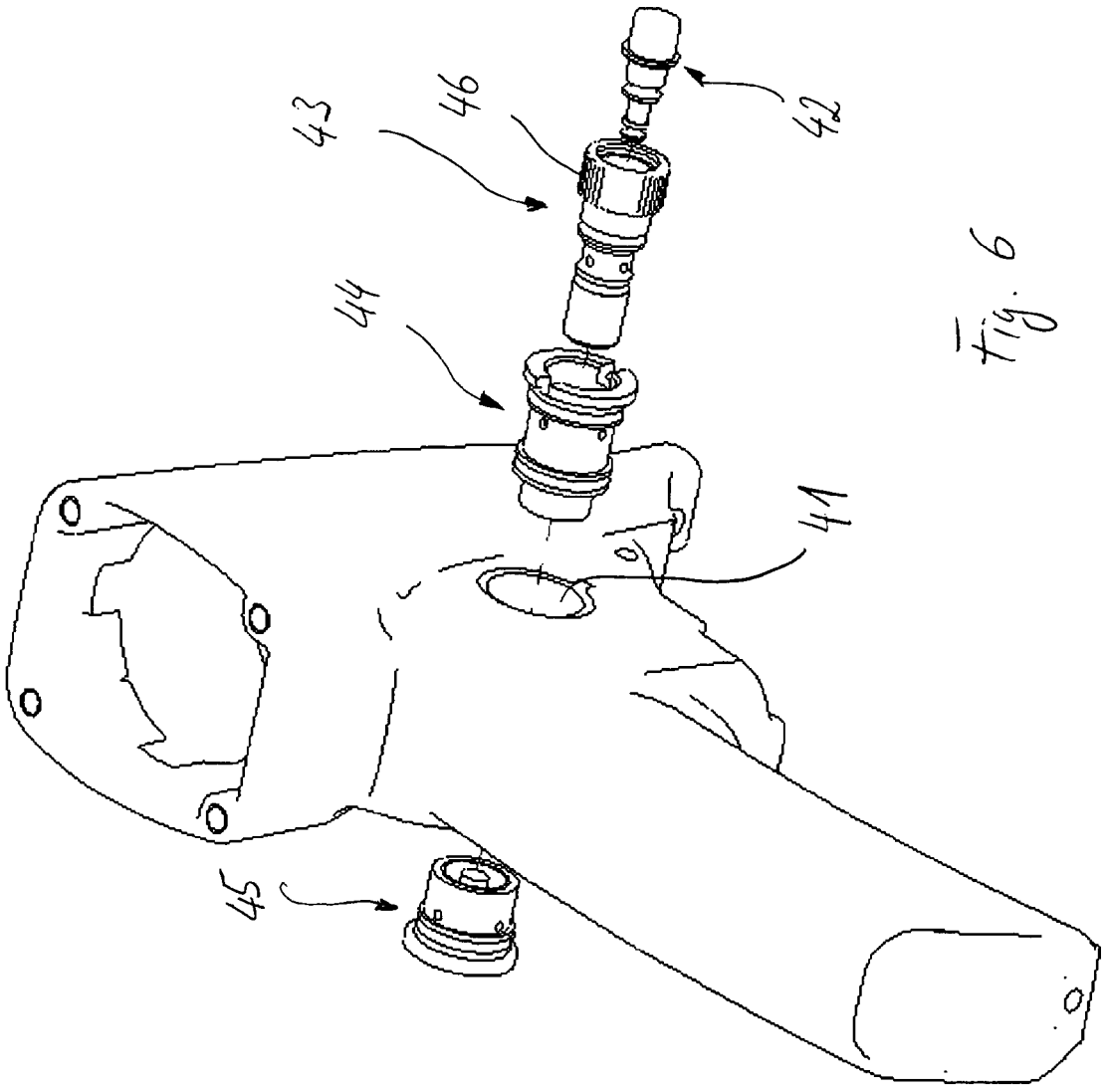


Fig. 6

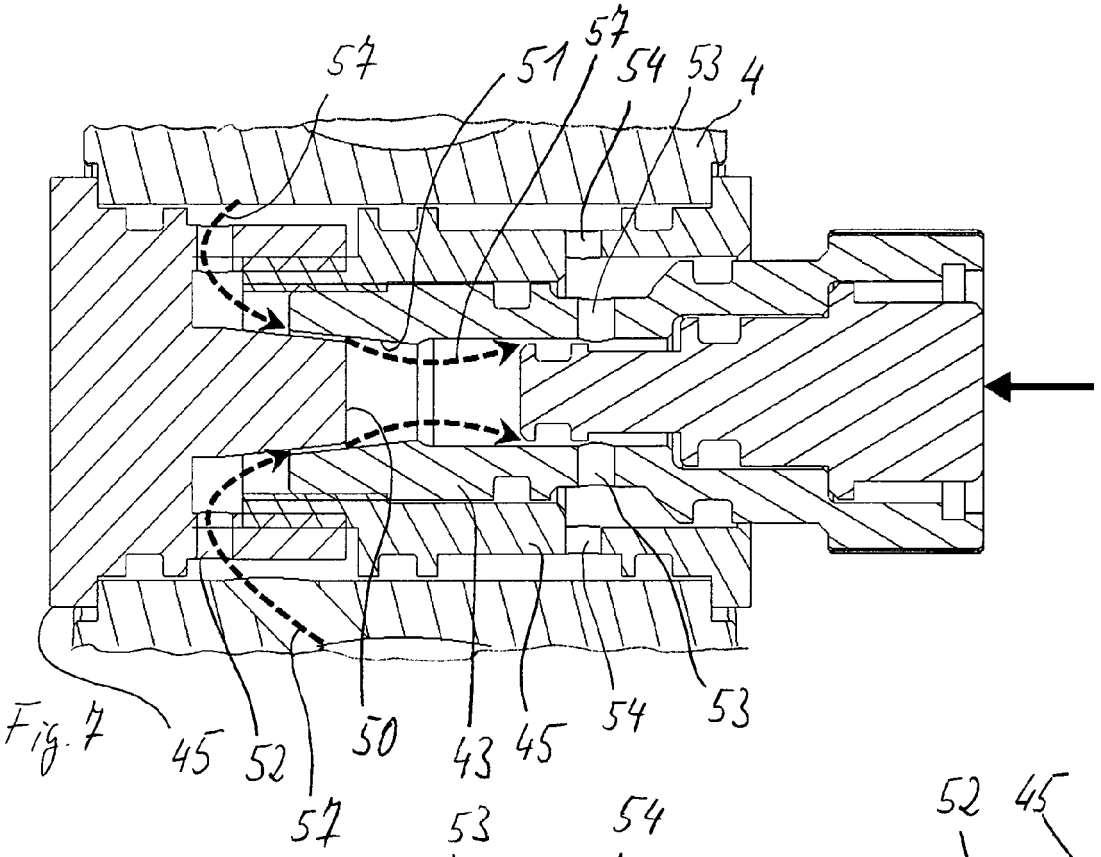


Fig. 7

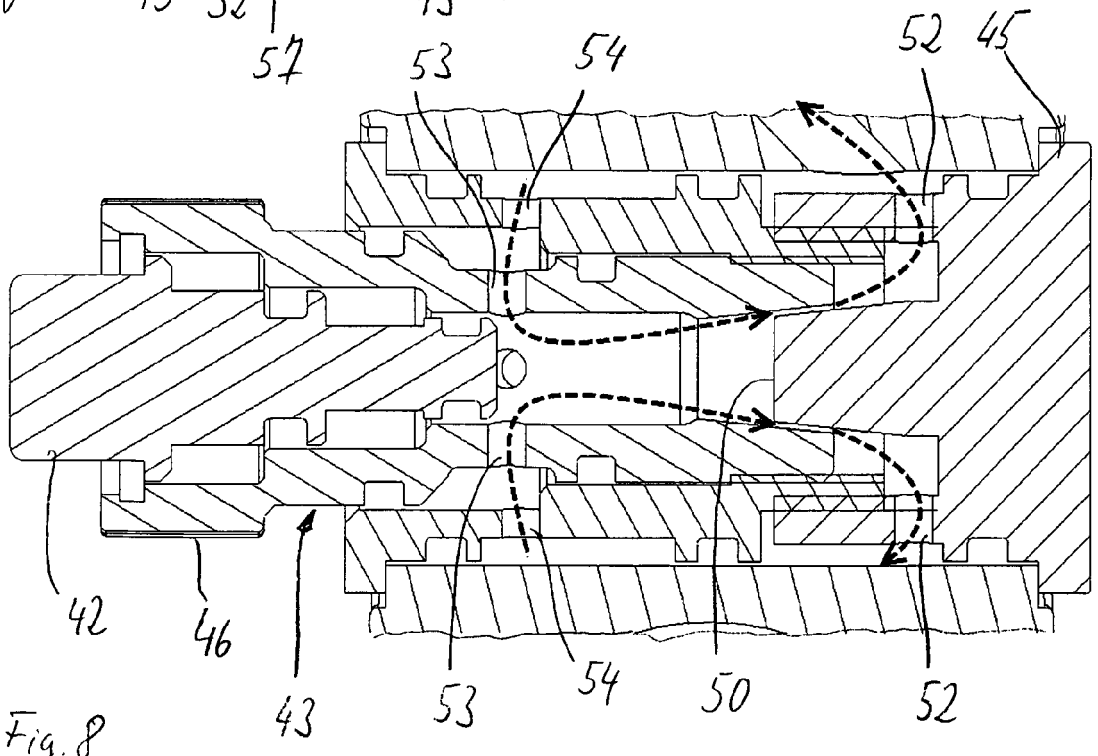


Fig. 8

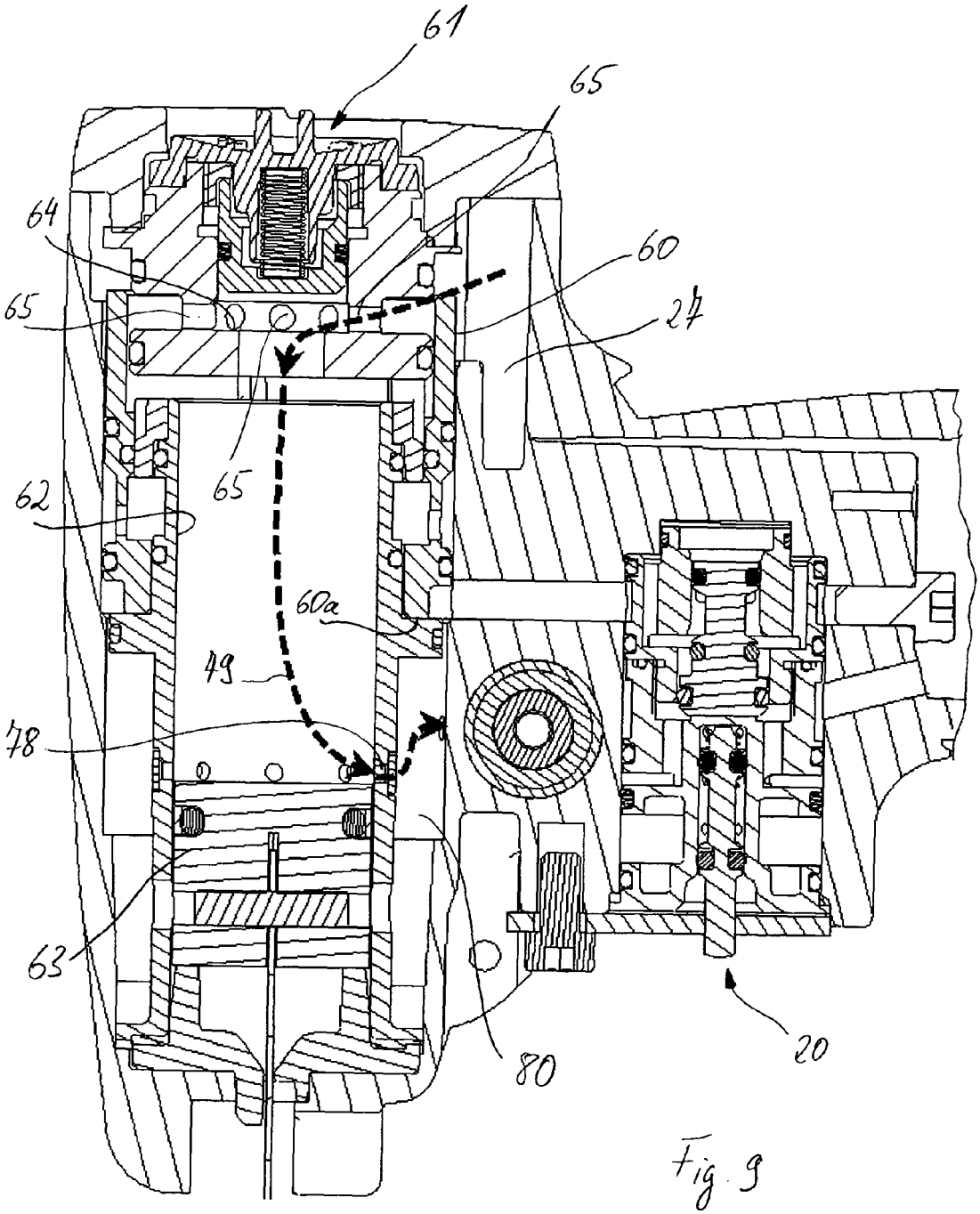


Fig. 9

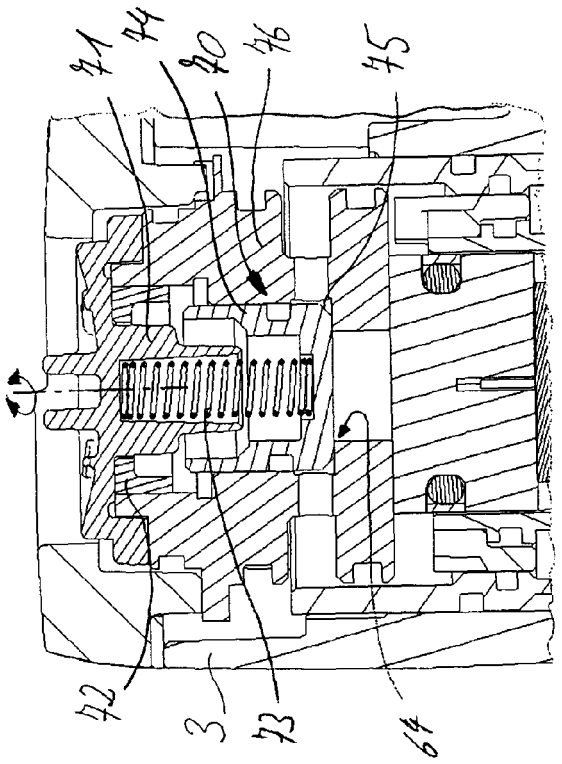


Fig. 11

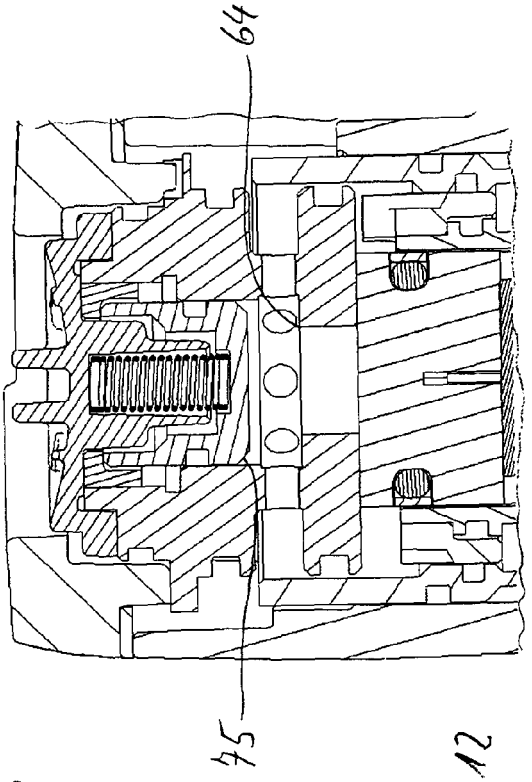


Fig. 12

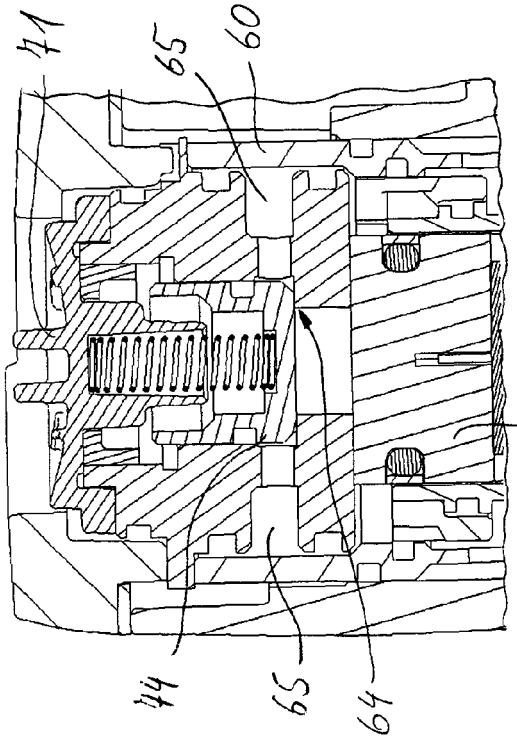


Fig. 10

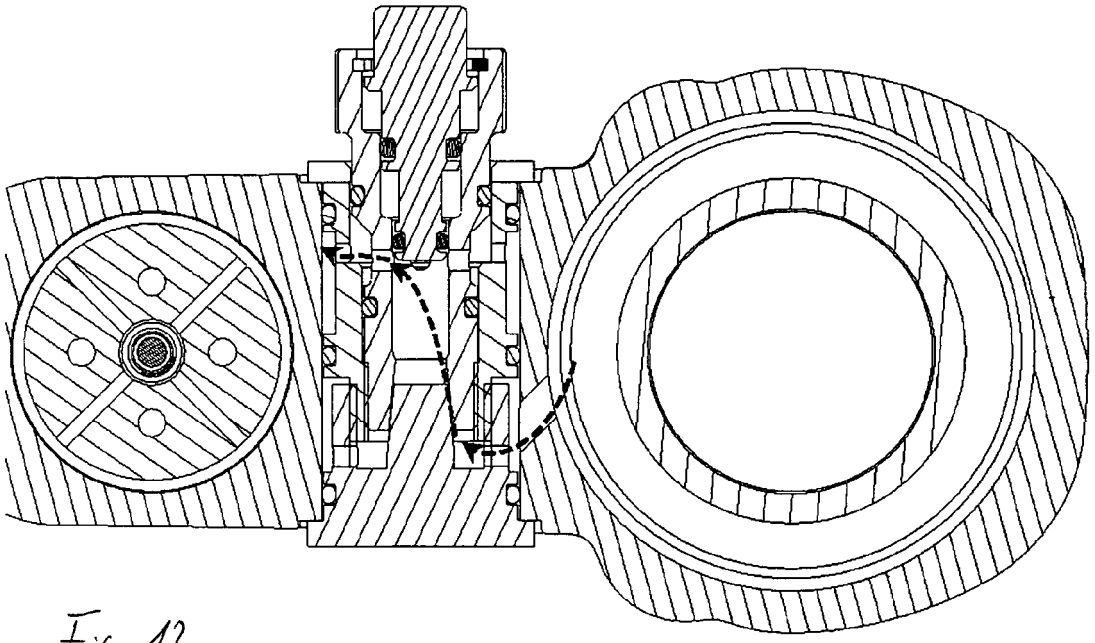


Fig. 13

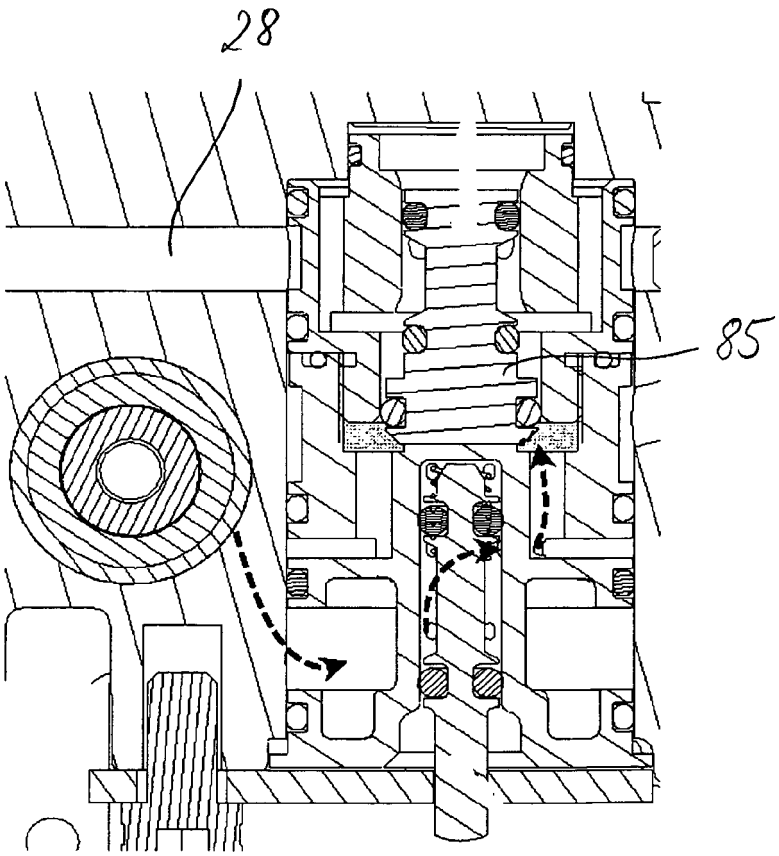


Fig. 14

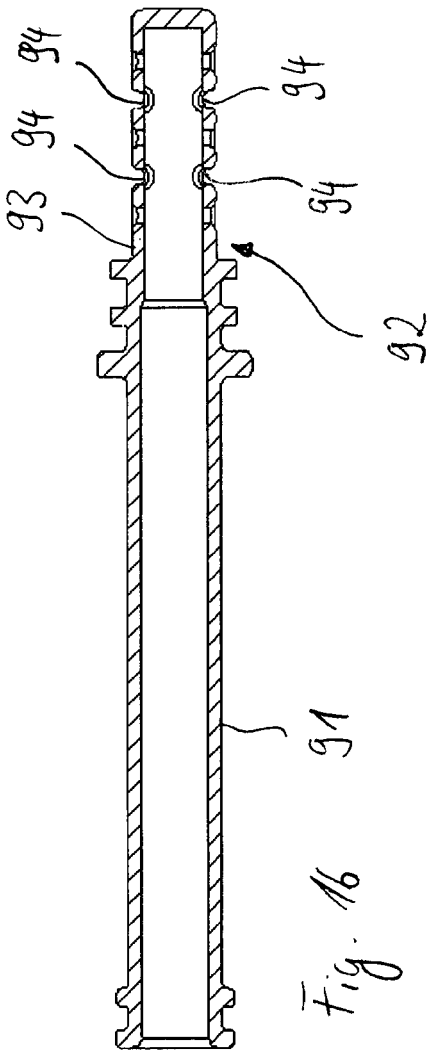


Fig. 16

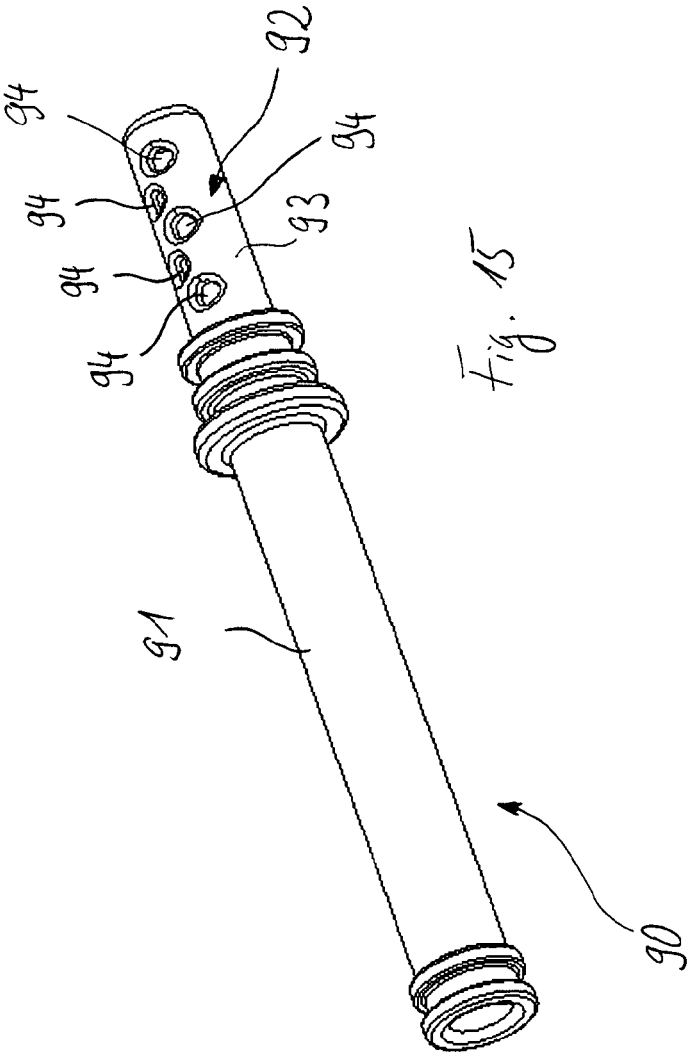


Fig. 15

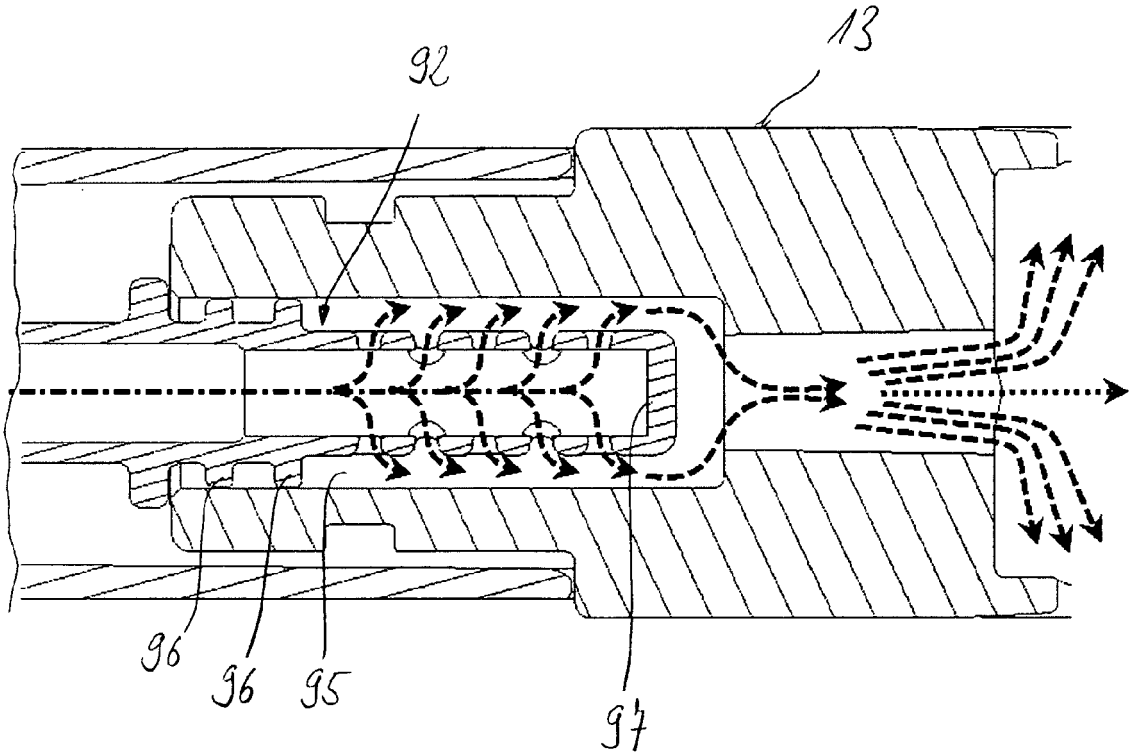


Fig. 17

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EUROPEAN SEARCH REPORT

Application Number
EP 08 01 5754

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 March 2009	David, Radu

CATEGORY OF CITED DOCUMENTS

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