Nov. 7, 1961 R. ERIKSSON ET AL 3,007,450

OPERATING MECHANISM FOR RECIPROCATING TOOLS

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FIG. 2

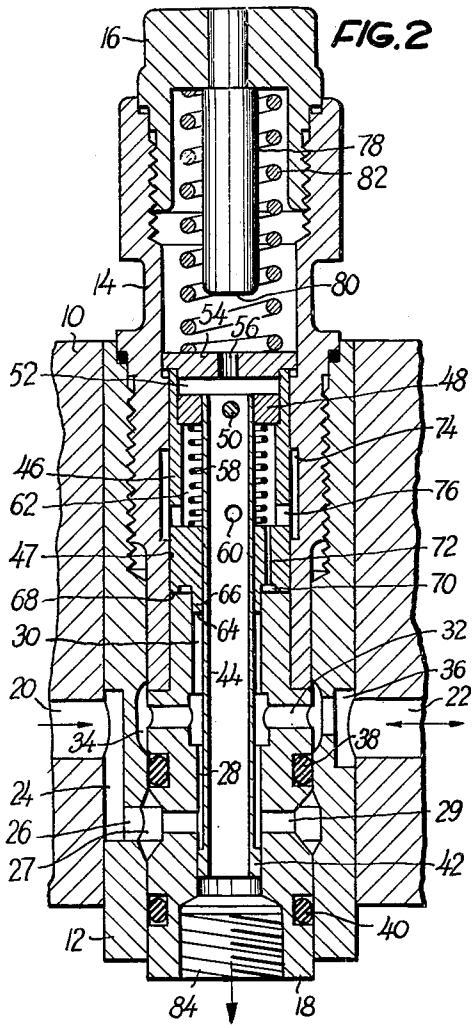


FIG. 3

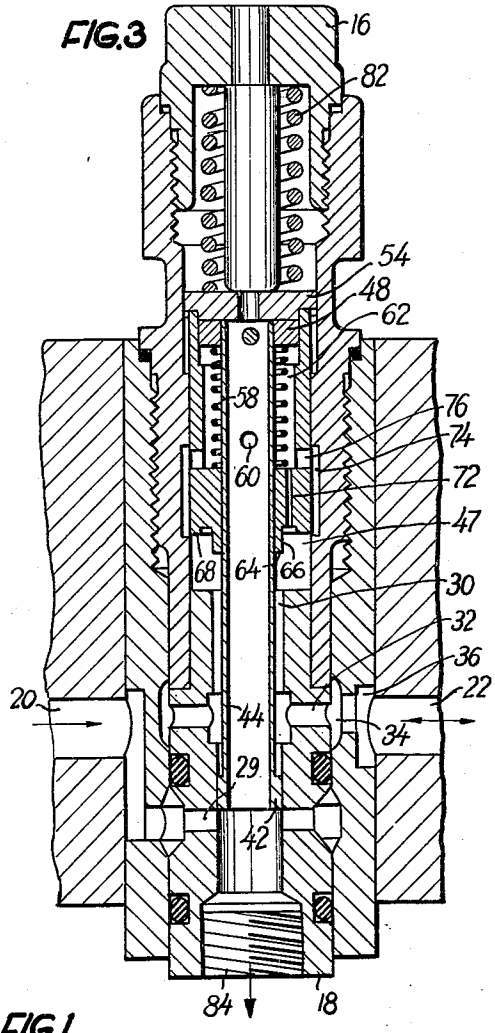
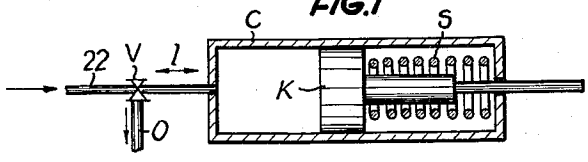


FIG. 1



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FIG. 4

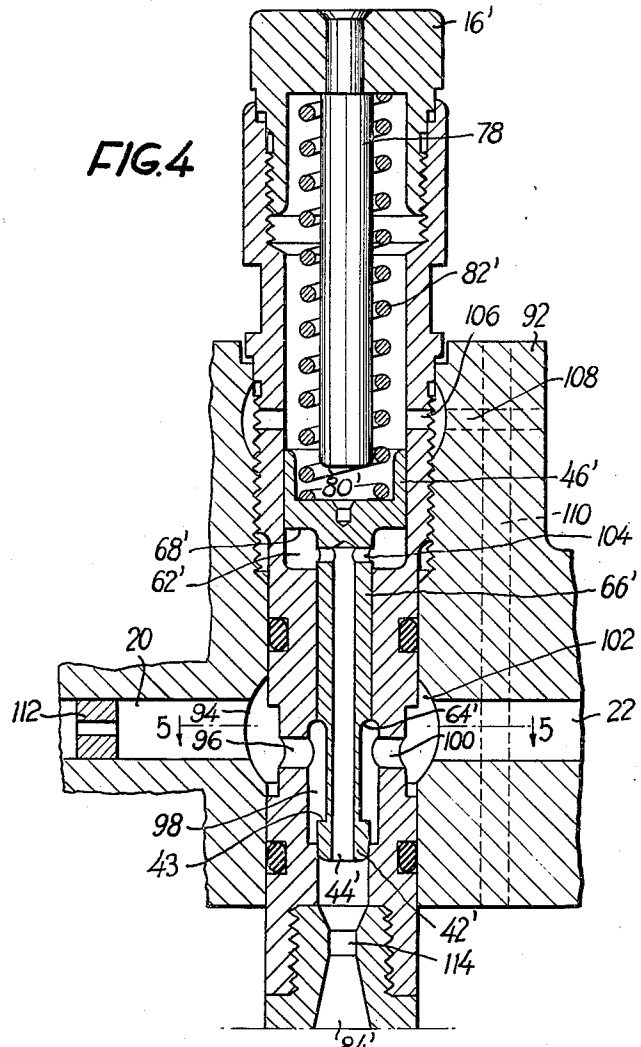
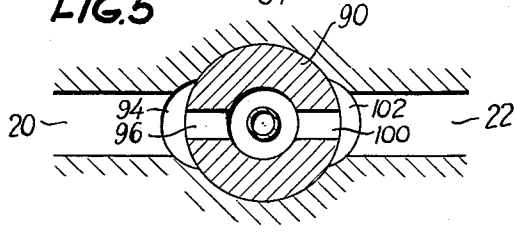


FIG. 5



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OPERATING MECHANISM FOR RECIPROCATING TOOLS

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9 Claims. (Cl. 121—46.5)

In the operation of certain tools and apparatuses, particularly hand-tools for surgical work, such as scissors or other tools for cutting plaster bandages or casts, it is highly desirable to be able to impart to the tool regular and distinct reciprocating movements. The object of the present invention is to provide an operating mechanism which meets the above named requirement.

In accordance with the invention, the operating mechanism comprises a working piston arranged to reciprocate in a working cylinder having an opening at one end for the supply and discharge of a pressure fluid, said piston being subjected to a counter-acting force for returning the piston after its working stroke, said working cylinder communicating with a valve device including a valve piston and a control piston, the two last named pistons having pressure-exposed faces the areas of which are proportioned to each other such as to cause the two pistons automatically to be shifted at the end of the working stroke and return stroke of the working piston in response to an increase and decrease, respectively, of the pressure in said opening in the working cylinder.

In order to ensure that the communication between the valve device and the working cylinder can be quickly shut off, the valve piston which is coupled to the control piston may be axially movable relative to the control piston so as to be movable to a certain extent independently of the last-named piston. The movement of the valve piston relative to the control piston may be performed under the action of a spring and may be controlled by pressure variation. To this end, use may be made of the difference between the pressure prevailing during entrance of the pressure fluid into the working cylinder and the pressure prevailing as the fluid is discharged from the cylinder, the first-named pressure being somewhat higher than the last-named pressure, which is due to the fact that during the supply of the pressure fluid the working piston performs a working stroke against a resistance which is greater than the resistance acting on the piston during the return stroke.

The construction may be considerably simplified if the valve piston is rigidly connected to the control piston. This is possible if the temperature of the working fluid can be maintained approximately constant, in such a construction the valve device must be provided with flow restriction members for the pressure fluid both in the inlet and the outlet. The effect of such restriction members varies with varying temperature of the pressure fluid.

Further features of the invention and advantages obtained thereby will appear from the following description of two embodiments of the invention with reference to the annexed drawing. FIG. 1 is a diagrammatic longitudinal sectional view of a working cylinder for a reciprocating piston and a valve device provided in the inlet for the pressure fluid.

FIG. 2 is a detailed longitudinal sectional view of the valve device according to a first embodiment comprising a valve piston which is movable relative to the control piston, and FIG. 3 a similar sectional view of the same valve device with the control piston and valve piston in other positions. FIG. 4 is a longitudinal sectional view of the second embodiment in which the valve piston and

control piston are rigidly connected to each other, and FIG. 5 a cross-sectional view taken on the line 5—5 in FIG. 4.

FIG. 1 shows a working cylinder *c* having a reciprocating working piston *k* the rod of which extends through one end of the cylinder and is adapted to be connected to a tool or other working member. The other end of the cylinder communicates with a duct 1 provided with a valve device *v*. The piston is subjected to the action of a helical spring *s* or other counter-acting force which tends to move the piston towards the left as viewed in FIG. 1. If a pressure fluid, such as air under pressure, is supplied from a source of pressure through the duct 1, the piston *k* will be moved to the right in FIG. 1 and the spring *s* will be compressed. If the valve device *v* is shifted such that the supply of the pressure fluid is shut off and the pressure fluid can escape from the working cylinder *c*, for instance through an outlet *o* of the valve device opening into the ambient air, the working piston *k* will be returned under the action of the spring *s*. The valve device is constructed such as to open into the atmosphere after the piston has reached its right-hand end position and after a subsequent further increase of the pressure to a predetermined value. As the piston moves to the left under the action of the spring, air is expelled at a slight super-atmospheric pressure in the duct end valve. Only after the piston has reached its left-hand end position the pressure falls to a minimum value whereupon the valve shuts off the connection with the atmosphere and communicates the cylinder with the source of pressure.

The valve device illustrated in FIGS. 2 and 3 comprises a supporting shell 10 which encloses a valve casing comprising a lower portion 12, an upper portion 14 screwed into the portion 12 in sealing engagement therewith, a sealing closure 16 screwed into the upper portion 14, and an inner valve cylinder 18 which tightly fits the lower portion 12 and the top end of which extends into the lower end of the upper portion 14. On one side of the valve casing the shell 10 has an inlet duct 20 to be connected to a source of a gaseous or liquid pressure fluid. On the other side of the valve casing, the shell has a duct 22 which communicates with the working cylinder *c*. The duct 20 opens into an axial groove 24 in the outer face of the valve casing. A bore 26 connects the groove 24 with an annular passage 27 on the inner side of the valve casing portion 12. By means of radial ports 29 the passage 27 communicates with the cylinder space of the valve cylinder 18. Said cylinder space has a lower narrow portion 28 and an upper wider portion 30. At the place where the cylinder portions 28 and 30 meet each other the wall of the valve cylinder 18 has a number of radial holes 32 which open into an annular groove 34 in the inner surface of the valve casing portion 12. Through a hole 36, the groove 34 is in open communication with the duct 22 to the working cylinder *c*. Sealing members 38 and 40 located respectively above and below the holes 29 effect a seal between the valve cylinder 18 and the valve casing portion 12.

In the bore of the valve cylinder 18 there is provided a piston-type slide valve having a valve piston 42 at the bottom end of a tubular piston rod 44 which displaceably extends through a control piston 46 which slidably fits a bore 47 in the valve casing portion 14.

At its upper end, the slide valve is provided with an auxiliary piston 48 which is locked to the piston rod 44 by means of a cross pin 50. The auxiliary piston fits slidably a bore 52 in the upper portion of the control piston. The top end of the cylinder space in the control piston is closed by a cover 54 which has a hole 56. A helical spring 58 acts on the lower side of the auxiliary

piston 48 and tends to move the auxiliary piston upwards toward the cover 54. A hole 60 in the wall of the piston rod 44 connects the interior of the piston rod with a space 62 in the control piston 46, which space contains the spring 58.

The control piston 46 is a differential area type piston having a relatively smaller pressure-exposed face 64 at its lower end 66 which fits the cylinder bore 30 and a larger annular face 68 the area of which is equal to the area of the bottom of the cylinder space in the casing portion 14. The face 68 has a groove 70 which via a narrow passage 72 communicates with the space 62 within the control piston. The bore in the casing portion 14 has an enlarged intermediate section forming a passage 74 which through radial openings 76 communicates with the space 62 in the control piston 46.

The closure 16 at the top of the valve casing has a downwardly extending pin 78 the lower end of which forms an abutment 80 for the control piston in the top end position thereof. Between the top face of the control piston and the closure 16 there is inserted a helical spring 82 which tends to maintain the control piston in a lower end position in which the annular face 68 of the control piston bears on the bottom of the cylinder space in the casing portion 14.

The lower end of the valve cylinder 18 is open and forms an outlet 84 which may communicate with the ambient air if the pressure fluid is air under pressure, or it may communicate with a tank if the pressure fluid is a liquid.

The mode of operation of the valve device described with reference to FIGS. 2 and 3 is as follows:

If the control piston 46 and the valve piston 42 assume their lowermost positions, as shown in FIG. 2, the working piston *k* is in its starting position for a working stroke, that is, in its left-hand end position as viewed in FIG. 1.

In the position shown in FIG. 2, pressure fluid supplied through the duct 20 from a suitable source of pressure can flow down through the groove 24 and through the bore 26 into the annular groove 27 and hence through the bores 29 into the passage 28. The pressure fluid than continues its way through the radial openings 32 into the annular groove 34 and through the holes 36 into the duct 22 which communicates with the working cylinder. As a result thereof, the working piston *k* is moved to the right by the pressure fluid in the cylinder *c* against the action of the spring *s* which is compressed. During this movement the control piston 46 and the valve piston 42 maintain their positions shown in FIG. 2 under the action of the spring 82. The force exerted by the pressure fluid on the valve piston 42 is proportional to the upper annular face of this piston and is smaller than the force exerted by the pressure fluid on the face 64 of the control piston. Consequently, the resultant force acting on the control piston and slide valve assembly is directed upwardly but is balanced by the downwardly directed force of the spring 82. The pressure in the passages leading to the working cylinder *c* rises as a result of the compression of the spring *s* and the work performed by the working piston *k*.

When the working piston *k* reaches its end position at the end of the working stroke, the pressure will rise quickly. The rate of the spring 82 of the valve device is such that this spring will be compressed as soon as the desired final pressure prevails in the working cylinder *c* and the associated passages, resulting in that the control piston and slide valve assembly will move upwards. When the lowermost face 64 of the control piston leaves the cylinder space 30, this space is put into communication with the cylinder space 47 below the control piston 46. Consequently, the effective pressure-exposed face of the control piston is abruptly increased by the face 68 so that the upwardly directed force will be increased many times over. The entire movable assembly is urged upwards to its top end position in which the control piston comes into contact with the abutment 80, this position being shown in FIG. 3. During the rapid upward movement the valve piston 42 has passed the openings 29 and is now in a position above said openings so as to shut off the communication between the inlet duct 20 and the duct 22 leading to the working cylinder *c*. Instead thereof, the duct 20 communicates through the openings 29 with the outlet 84 through which the pressure fluid is discharged.

In order to prevent the valve piston 42 from assuming an indefinite intermediate position in which the communication between the ducts 20 and 22 is not entirely interrupted, the slide valve is displaceable in the control piston 46 in the manner described above. To begin with, the valve piston 42 remains in the position shown in FIG. 2 relative to the control piston, in which the auxiliary piston 48 is in its lower end position and the spring 58 is compressed. The upper side of the auxiliary piston 48 is not subjected to super-atmospheric pressure, since the space 52 communicates through the tubular piston rod 44 with the outlet 84, but the pressure in the passage 28 above the valve piston 42 creates a downwardly directed force which keeps the slide valve in its lower end position. As soon as the valve piston 42 during its upward movement has interrupted the inflow through the radial holes 29 the pressure in the passage 28 is reduced as a result of the fact that the pressure fluid in the upper passages and cylinder spaces now can flow through the outlet 84, as will be described later on. This reduction in pressure is sufficient to cause the spring 58 acting on the lower side of the auxiliary piston 48 to move the slide valve upwards in the cylinder space 52 against the action of the downward pressure on the valve piston 42 until the auxiliary piston comes into contact with the cover 54, FIG. 3. During this movement, the valve piston 42 definitively moves past the openings 29.

The communication between the passage system located above the valve piston 42 and the outlet 84 will be apparent from FIG. 3. The duct 22 communicates with the outlet through the passages 36, 34, 32, 30, 47, 74, 76, 62, 60 and through the tubular piston rod 44. Since this position has been attained at the end of the upward movement of the movable system, the pressure will drop to approximately atmospheric pressure, and the working piston *c* will begin its return stroke.

Since the control piston is no longer subjected to an upwardly directed pressure, it will be quickly urged by the spring 82 into the position in which the communication between the passage 74 and the cylinder space 47 is throttled due to the fact that the outer edge of the piston face 68 passes beyond the edge of the bottom of the cylinder space 74. For some time the narrow passage 72 maintains the communication with the space 62 below the auxiliary piston 48, resulting in a slower movement. The slide valve accompanies the auxiliary piston 48 to the upper end position. During the slow movement, the openings 29 are covered by the valve piston 42 and are still covered when the lower face 64 of the part 66 of the control piston reaches the upper mouth of the cylinder space 30. Immediately thereafter, the upper edge of the valve piston 42 arrives at the upper end of the opening 29, and pressure fluid enters the space 30 causing the pressure therein to raise. As a result the upper face of the valve piston 42 is subjected again to a downwardly directed pressure so that the valve piston and the piston rod 44 and the auxiliary piston 48 will be urged downwards against the action of the spring 58. The valve piston 42 is moved entirely past the openings 29 and uncovers these openings and finally reassumes the position shown in FIG. 2. The communication between the ducts 20 and 22 and the working cylinder is now open again and the working piston *k* is moved again to its right-hand end position, whereupon the cycle is repeated.

The comparatively slow movement of the control piston during that part of the return stroke during which pressure fluid can leave the cylinder space 47 merely through

the narrow passage **72** results in that the working piston *k* will stand still for some time in its left-hand end position before it begins its next working stroke. This period of rest can be extended or shortened by decreasing or increasing the cross-sectional area of the passage **72**.

As compared with the embodiment just described, the slide valve and the control piston shown in FIG. 4 may be considered to form an integral unit or to be rigidly interconnected. This construction consequently comprises a triple piston having a valve piston **42'** and a control piston composed of a small-diameter piston **66'** and a large-diameter piston **46'**. The pressure-exposed face **43** of the valve piston **42'** is smaller than the lower face **64'** of the piston **66'** which in turn is considerably smaller than the lower annular face **68'** of the piston **46'**. The triple piston is inserted in a single-piece valve casing **90** which is surrounded by a supporting shell **92** and formed with cylindrical bores for the various pistons. The inlet duct **20** for the pressure fluid opens into a recess **94** in the shell. A transverse bore **96** connects the recess with a passage **98** formed between the bores for the pistons **42'** and **66'**. A transverse opening **100** connects the passage **98** with a recess **102** located opposite the recess **94** and communicating with the duct **22** to the working cylinder *c*. Numeral **62'** denotes the cylinder space below the piston **46'**. An axial passage **44'** extends from the lower end face of the piston **42'** through the piston **66'** and communicates through radial openings **104** with the cylinder space **62'**. A spring **82'** acts on the upper side of the piston **46'** the upper end position of which is defined by an abutment face **80'** at the end of a pin **78** which is connected to a closure **16'**. Pressure fluid which might leak upwards past the piston **46'** can be removed through passages **106**, **108** and **110** and may be collected in a tank.

A flow restriction member **112** is provided in the inlet duct **20**, and a flow restriction member **114** is provided in the outlet **84'**.

The mode of operation of the embodiment illustrated in FIGS. 4 and 5 is as follows:

When the working piston *k* performs its working stroke in the cylinder *c* (FIG. 1) the valve piston is in the position shown in FIG. 4. Pressure fluid flows from the inlet **20** through the flow restriction member **112**, recess **94**, opening **96**, passage **98**, opening **100**, recess **102** and duct **22** into the working cylinder. In this position, the spring **82'** maintains the triple piston in the lower position illustrated. When the pressure rises at the end of the working stroke of the working piston *c*, the upwardly directed force resulting from the difference of the pressures acting on the large face **64'** and the small face **43** is increased. The rate of the spring **82'** is such that the triple piston is moved upwards when the pressure in the passage **98** attains its maximum value. After the piston **42'** has been moved upwards to a position in which it opens the connections between the ducts **20**, **22** and the outlet **84'**, pressure fluid can be discharged through this outlet both from the source of pressure and the working cylinder *c*, but this discharge takes place against the resistance exerted by the flow restriction member **114**. Consequently, a certain superatmospheric pressure will still be present below the piston **42'**, and this pressure is transmitted through the passage **44'** into the cylinder space **62'** below the control piston **46'** which will be rapidly moved upwards into contact with the abutment face **80'** against the action of the spring **82'** which will be compressed. In this position the connection to the outlet **84'** is entirely opened. Meanwhile, the working piston *k* performs its return stroke. The cross-sectional areas of the restriction members **112** and **114** are so proportioned to each other that the pressure prevailing in the cylinder space **62'** can keep the valve piston **42'** in open position.

After the working piston *k* has completed its return stroke pressure fluid flows no longer from the duct **22** to the outlet **84'**. As a result thereof, the pressure in the cylinder space **62'** is decreased so that the spring **82'** can return the triple piston to the lower end position thereof. When the valve piston **42'** enters its bore, the superatmospheric pressure in the cylinder space **62'** falls to about zero, since this space is in open communication with the outlet **84'** through the openings **104** and the axial passage **44'**.

In the embodiment illustrated in FIGS. 4 and 5 there are also obtained distinct opening and closing movements, provided that the springs and the cross-sectional areas of the flow restriction members are properly related to each other and that the temperature of the pressure fluid is maintained approximately constant so that the pressure conditions are not changed by variations of the viscosity of the pressure fluid.

What is claimed is:

1. A fluid-operated mechanism for reciprocating tools, comprising a work cylinder, a work piston mounted in the cylinder for reciprocation therein to effect a working stroke and a return stroke, one end of said cylinder including an opening for supplying and discharging working fluid to and from said cylinder at one side of the work piston, spring means acting on the other side of the piston to effect the return stroke thereof after having been compressed during the working stroke, a valve device including a valve housing having an inlet for pressure fluid and a passage for communication with said opening, and a valve piston and a control piston slidable in said valve housing for controlling the supply and the discharge of pressure fluid to and from the working piston, said control piston including restriction means for retarding the movement thereof in one direction, said valve and control pistons having pressure-receiving areas proportioned to cause the latter two pistons to be shifted automatically at the end of the working stroke and of the return stroke of the work piston in response to an increase and a decrease, respectively, of the pressure in the opening of the work cylinder.

2. A fluid-operated mechanism for reciprocating tools, comprising a work cylinder formed at one end with an opening for supplying pressure fluid to the cylinder and for discharging fluid therefrom, a work piston mounted in said cylinder for reciprocation therein to effect a working stroke during the supply of pressure fluid through said opening to the cylinder and a return stroke during discharge of the fluid therefrom, spring means actuating the piston for returning the piston during the return stroke thereof, said spring means being adapted to be compressed during the working stroke of the piston, and a valve device for controlling the supply of pressure fluid to and discharge of said fluid from the work cylinder through said opening, said valve device comprising a valve housing having an inlet for pressure fluid, a passage communicating with said opening and an outlet to the atmosphere including ports, a valve piston and a control piston slidable in said housing and operative to control the flow of fluid through said ports, said control piston being of the differential area type having a small face and an annular face adapted to be exposed to the fluid pressure successively to obtain a slow initial motion of said control piston and of said valve piston in one direction and a continued quick motion thereof as both of said faces are exposed to the fluid pressure.

3. A valve device for reciprocating tools comprising in combination with a tool-driving motor, a valve cylinder having inlet ports and passages for the supply of a pressure fluid to said tool-driving motor and outlet ports and passages for the discharge of the fluid therefrom, a valve piston having a hollow piston rod, a control piston slidable on said piston rod, and spring means adapted to keep the combined valve piston and control piston in one end position to allow inflow of pressure fluid, the valve piston and the control piston having pressure areas exposed to the pressure of the pressure fluid, said areas being designed to give a resulting pressure force in said one end position opposing said spring but being smaller

than the latter, said spring being designed to yield for a definite increase of the fluid pressure on said areas to permit displacement of the valve piston and the control piston to a second end position for interruption of the inflow of pressure fluid to the tool-driving motor and for opening the outlet passages to allow escape of the fluid to the atmosphere.

4. A valve device for controlling the supply and discharge of fluid to and from pressure fluid-operated mechanisms for reciprocating tools, comprising a valve cylinder having an inlet port for pressure fluid, a common passage for supplying the fluid to the mechanism and discharging the fluid therefrom and an outlet for the fluid to the atmosphere, a valve piston including a piston rod slidably mounted in said valve cylinder, a valve casing portion having a cylinder bore coaxial with said valve cylinder and open thereto, the inner diameter of said valve casing portion being larger than that of said valve cylinder, a control piston slidable in said valve casing portion and having a cylinder space formed therein, an auxiliary piston secured to said piston rod and slidably mounted in said cylinder space, said valve piston having a pressure area and said control piston having a pressure area opposite that of the valve piston but larger than the latter, spring means to maintain said valve piston together with said control piston in one end position for admitting pressure fluid to said common passage against the resulting force of the fluid pressure on said pressure areas, said spring means being designed to yield for a definite increase of fluid pressure on said areas to permit displacement of said valve piston and said control piston means to a second end position of said pistons for interruption of the supply of pressure fluid to said common passage and for opening said outlet to allow escape of fluid to the atmosphere, and an auxiliary spring acting against said auxiliary piston to cause displacement thereof relatively to said control piston to effect a rapid movement of the valve piston past the inlet port of the valve cylinder.

5. A valve device as recited in claim 4 and further characterized in that the bore of said valve cylinder has a narrow portion and a wide portion, said narrow portion being engaged by said valve piston, and that the control piston is of the differential area type having a small pressure-exposed face fitting the said wide bore portion and

having an annular face in the bore of said valve casing portion whereby said control piston will have a slow initial movement from the first end position and a further quick movement as the said annular face is also exposed to fluid pressure.

6. A valve device as recited in claim 4, wherein said valve casing portion is formed integral with said valve cylinder.

7. A valve device as recited in claim 4, wherein said control piston is provided with a narrow throttle passage forming communication between the cylinder spaces of said valve cylinder and said valve casing portion on one hand and the cylinder space of said control piston to effect a slow return of said control piston from the said second end position to the said first end position.

8. A fluid-operated mechanism as recited in claim 2, wherein said control piston is of the differential area type having a small end face and a large annular face, said faces being adapted to be exposed successively to the fluid pressure for effecting a quick movement of said pistons in one direction, and said control piston has a narrow throttle passage restricting the flow of the pressure fluid between said opening and the atmosphere to effect a slow return of said valve and control pistons to the initial position whereby said work piston is compelled to dwell in one end position before beginning a working stroke.

9. A fluid-operated mechanism for reciprocating tools as recited in claim 2, wherein said valve piston and said control piston are rigidly interconnected, restriction members are mounted in the inlet and the outlet of the valve device to control the fluid pressure, and said valve piston includes an axial bore communicating with the cylinder space for said control piston.

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