United States Patent [19]

Ise

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[54] **VALVE SYSTEM**

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[51] **Int. Cl.** **F16k 37/00**

[58] **Field of Search** 251/28, 29, 30; 137/540, 554

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Primary Examiner—Henry T. Klinksiek
Attorney—Ernest A. Greenside et al.

[57] **ABSTRACT**

This valve system provides with a pilot valve having a valve action caused by a spool which moves within a casing providing with a pair of ports. In said pilot valve, the spool is forced to be pressed in a given direction by a compressed fluid introduced into the casing, the said compressed fluid, which is supposed to flow towards load from the feed source through the pilot valve, being changed-over by means of a change-over valve. In the case the change-over valve has been changed-over on the side of the pilot valve, therefore, said spool is not forced to be pressed but in turn forced to be pressed in the opposite direction by means of an operating means. In such a case just mentioned, a control means functions to discharge the fluid being present in the casing, said control means controls a moving speed of the spool by adjusting the amount of the discharge thereof. The pilot valve is effected to be opened or closed with said movement of spool, the operative time being controllable in proportion to the moving speed of the spool. The time to start operation of the pilot valve after receiving a control command by way of an operating signal given to the change-over valve can be controlled by the positioning relation between ports and grooves in speed, and the moving speed of spool.

11 Claims, 7 Drawing Figures

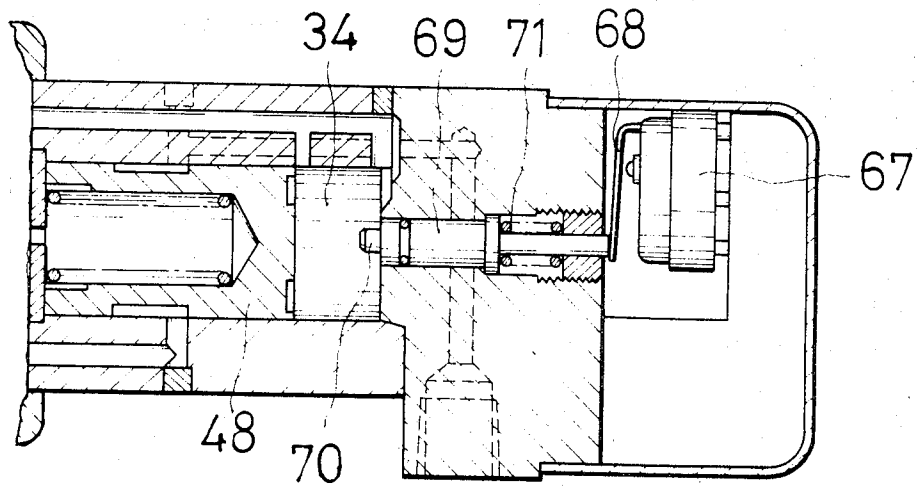


FIG 1

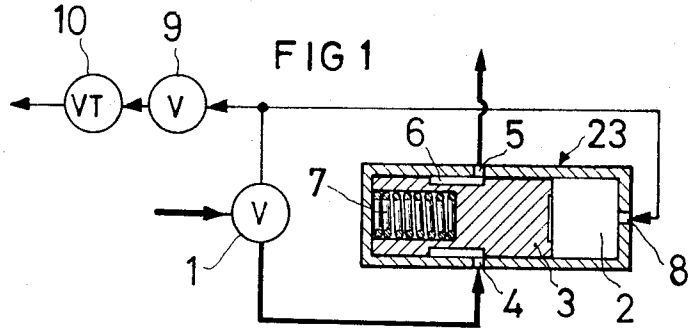


FIG 2

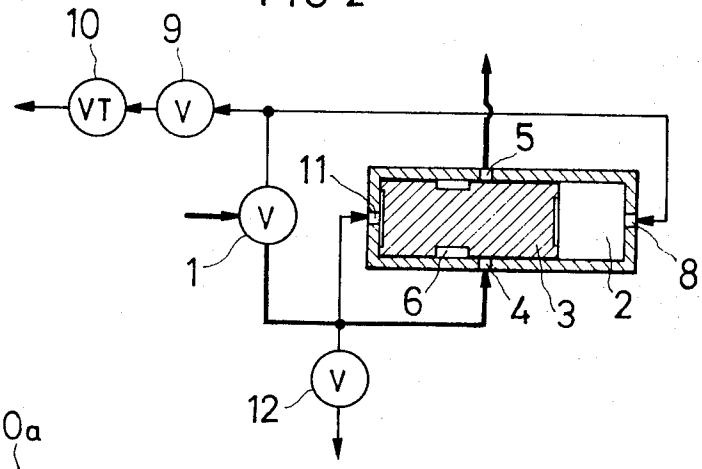


FIG 3

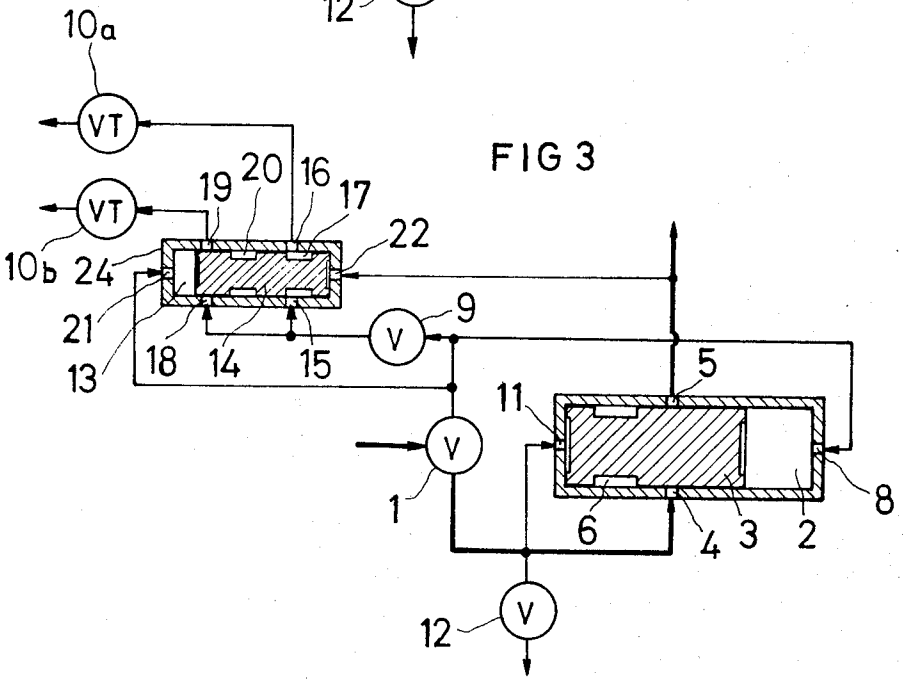


FIG 4

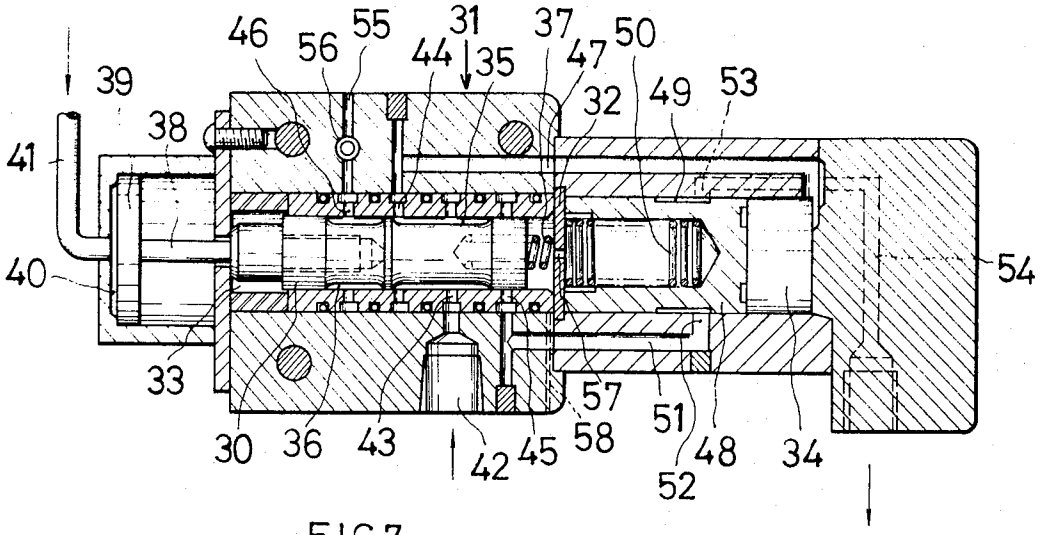


FIG 7

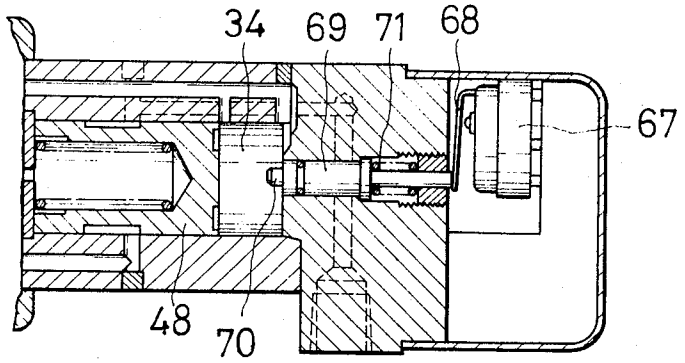
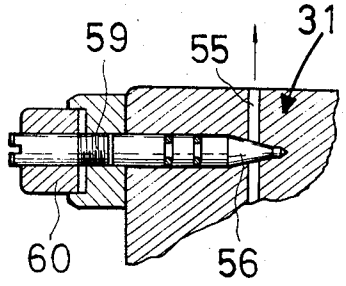


FIG 5



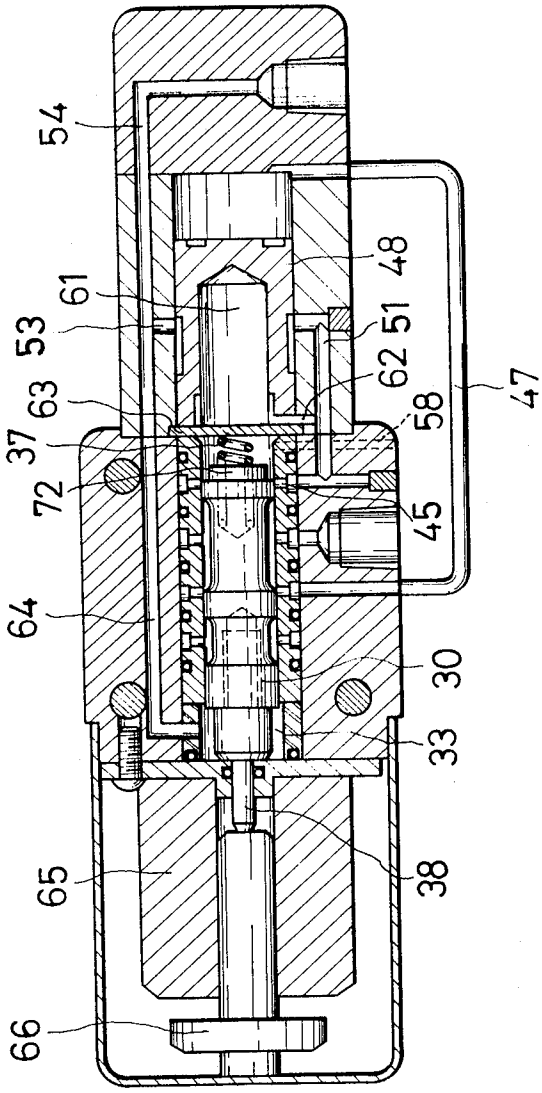


FIG 6

VALVE SYSTEM

The present invention relates to a valve system and more particularly to the valve system in which a time from a control command to operation start, and a time for operation can freely be determined.

In automatical feeding devices for lubrication or compressed air, which serves to remove shaped powder, employed in machine tools, a considerable correct control of time for feeding the fluid is prerequisit. In those automatical feeding devices as described, an operating signal is in general obtained on basis of the detection of positions of construction parts in the machine tool, a time from the detection of positions to the feed start of fluid, and its operative time must be controlled. The control of this kind has hithertofore been made in such that there are provided with a timer or a self-maintaining circuit in an operating circuit for a magnet valve, so as to make adjustment through the electric input of the magnet valve; but it has such a drawback that since a timer can not be set so extensively in its range, it may not be possible to comply with the fluid feed time as required. In addition, the magnet valve and operating devices thereof are costly, and hard to handle.

A purpose of the invention is to provide a mechanically operated control valve in which a time from a control command to operation start, and a time for operation can freely be determined.

A further purpose is to provide a time control valve which is simple in its construction and low in its price.

According to the present invention, an automatic cut-off valve can be obtained in which the operation is to be effected immediately after received of control command and only a time for operation is controlled.

According to the present invention, a valve system can also be obtained, in which the operation is to be effected after the lapse of retardation time optionally determined from the control command, and said retardation time can be controlled separately from the operation time afterwards.

Especially, according to the present invention, an automatic valve system is also obtained, which provides with a self-maintaining means which maintains the operative state after cut off an operating signal and keeps the operative time always at a value optionally determined.

In the present invention, there is provided with a pilot valve comprising a spool arranged inside the cylindrical casing providing with a pair of ports, and the moving speed of said spool is controlled by the discharge flow of fluid discharged from the casing so that valve action by the spool is controlled. According to the present invention, therefore, the fluid discharged from the casing being served as a control element, and if said fluid is controlled by a throttle valve, its operating amount can considerably optionally be determined.

Further purposes and features of the present invention will be apparent from the hereinafter detailed description with reference to several embodiments, according to the present invention, as shown in the accompanying drawings:

FIG. 1 is a schematic showing of a valve system according to the present invention.

FIG. 2 is a schematic showing of a modified form of the system in FIG. 1.

FIG. 3 is a schematic showing of other embodiments

of the valve system according to the present invention.

FIG. 4 is a sectional view of a valve system made in accordance with conception of the present invention, as shown in FIG. 1.

FIG. 5 is a sectional view of a throttle valve as shown in FIG. 4.

FIG. 6 is a sectional view showing a modified form of the system as shown in FIG. 4.

Finally, FIG. 7 is a sectional view showing a part of the valve system, according to the present invention, provided with an electric switch to detect a work completion time.

Referring to the drawings, there is shown schematically in FIG. 1 a most fundamental example of the valve system according to the present invention, in which drawing, a main fluid passage is shown by a thick line and a control fluid passage by a fine line. As is apparent from the drawing, the present system contains two valves which open and close the main fluid passage; one of which is a change-over valve 1 and the other is a pilot valve generally designated by a reference numeral 23. Said pilot valve 23 comprises a spool 3 providing with grooves 6 within a casing 2 providing with an inlet port 4 and an outlet port 5, and at one end of the casing 2 there is provided an inlet 8 for a control fluid so that compressed fluid is introduced from said inlet 8 into the casing 2. That is, the inlet 8 for a control fluid is connected with a change-over valve 1, which receives the compressed fluid in the event the compressed fluid directed towards the main fluid passage being changed over towards the control fluid passage. The drawing indicates such a state that the compressed fluid is introduced into the casing 2, consequently the spool 3 is forced to be pressed towards the end of casing opposite to that of the inlet 8 for control fluid. In this instance, the spool 3 is subject to resistance force of a spring 7, and however, if pressure of the compressed fluid is pre-set higher than the resistance force of the spring 7, the spool 3 would sit still at the position where it runs against the other end of casing 2, as shown in the drawing. Such a position of spool 3 as just described is called hereinafter an operation-start-position.

A control fluid passage between the change-over valve 1 and the casing 2 is branched, where a discharge valve 9 is provided. Said change-over valve 9 is in interlocking relation with the change-over valve so that the valve 9 is closed while the valve 1 is set on the side of control fluid passage and is opened only when the valve 1 is changed-over on the side of main fluid passage. Therefore, the compressed fluid flown towards the casing 2 from the change-over valve 1 will not pass through the discharge valve 9, while, in case the change-over valve 1 is changed-over on the side of main fluid passage, the compressed fluid in the casing 2 passes through the discharge valve 9, moving at the same time from the operation-start-position of spool 3 by means of resistance force of spring 7. In this instance, it is apparent that the moving speed of the spool 3 is determined by the resistance force of spring 7 and the flow of discharge valve 9. Therefore, it is understood that if a throttle valve 10 is installed either in front or at rear of the exhaust valve 9 to control the flow passing through the said throttle valve 10, the moving speed of spool 3 can freely be determined.

As is well known, in the pilot valve 23, the operation is effected only when the grooves 6 are made in com-

munication with inlet port 4 and outlet port 5, with the movement of spool 3 providing with grooves 6 between the inlet port 4 and outlet port 5. In this system, the pilot valve 23 is operative in case that the spool 3 is in its operation-start-position, while it is cut off in case that the spool has moved more than the length of groove 6 from said position in the spring pressing direction. It will be, therefore, understood that if a stroke of the spool 3 is longer than the length of groove 6, the main fluid passage is automatically cut off by the pilot valve. In a position, where the spool 3 moves in the spring 7 pressing direction so as to cut off communication between the inlet port 4 and the outlet port 5, the spool 3 would run against the opposite end of the casing 2. Such a position as just described is hereinafter called an operation completion position of the spool 3.

In the valve system according to the present invention, the change-over valve 1 is, in an ordinary condition, set to be on the side of control fluid passage. Therefore, the compressed fluid will not flow into the main fluid passage but is introduced through the change-over valve 1 into the casing 2, where the spool 3 is forced to be pressed towards the operation-start-position opposite to the resistance force by spring 7. In the example as shown in FIG. 1, since the pilot valve 23 is operative at the aforesaid position, the compressed fluid can directly be obtained from the outlet port 5 by changing-over the change-over valve, but is automatically cut off after the lapse of operative time for the pilot valve 23. The operative time for the pilot valve 23 is related to the length of groove 6, but it can be considerably freely determined by varying the moving speed of spool 3. It is, therefore, apparent that according to the present invention the flow passing through the throttle valve 10 may just well be controlled.

In FIG. 2, there is shown a modified form of the system in FIG. 1. According to the example here, the spool 3 is forced to be pressed by the compressed fluid instead of spring towards the operation-completion-position from the operation-start-position. That is, within the casing 2 there is provided another control fluid inlet 11 opposite to the control fluid inlet 8 putting the spool 3 therebetween. Said inlet provided is to introduce a compressed fluid branched from the main fluid passage of the change-over valve 1 into the casing 2. At the position branched from the main fluid passage between the change-over valve 1 and the casing 2 is installed a discharge valve 12, which is made in interlocking relation with the change-over valve so as to be closed when the change-over valve 1 is on the side of main fluid passage and to be opened when being changed-over on the side of control fluid passage. In other words, the discharge valve 12 is in relative operation with the discharge valve 9, and thereby it will be apparent that the spool 3 has the entirely same operation as that of previous example.

On the other hand, FIG. 2 shows an example, wherein at the operation-start-position relative to the spool 3, the grooves are so disposed that the inlet port 4 is not in communication with the outlet port 5. In this instance, even if the change-over valve 1 is changed-over on the side of main fluid passage, the pilot valve 23 is not operative; and the compressed fluid is invisible at once at the outlet port 5, retarding thereof until the inlet port 4 and outlet port 5 are made to be communicated with grooves 6, as well as movement of the spool 3. Such retardation time has a relation with the distance in difference of the groove 6 relative to the ports 4 and 5 but can be varied by the moving speed of the spool 3. According to the present invention, therefore, it is obvious that the time from the start of operating the change-over valve 1 to the start of operation in the pilot valve 23 can freely be determined. In this instance, the time before the start of operation can be controlled, but the moving speed of spool 3 is not varied during its stroke process if the opening of the throttle valve 10 is set at a given degree, therefore the relative proportion between the retardation time before the start of operation in the pilot valve 23 and its operative time can not be varied. According to the present invention, however, it is apparent that the moving speed of the spool 3 can be varied by varying the fluid discharge from the casing 2 before the start of operation of the pilot valve 23 and the discharge thereof of the start of operation.

FIG. 3 shows a valve system of the present invention in which a relative proportion between a time before the start of operation and its operation time, in the pilot valve 23, can freely determined. As is obvious from the drawing, in order to provide with a system having such a purpose, there are provided with two throttle valves 10*a* and 10*b*, each of which is connected with the discharge valve 9 through a change-over pilot valve generally denoted by the reference numeral 24. This change-over pilot valve 24 is manufactured in an almost similar conception to that of pilot valve 23 as previously explained, except one point, which is different, in that there are provided two channels, either one of which is always operative. That is, within a casing 13 there are provided two pairs of ports 15 and 16, and 18 and 19. A spool 14 is provided with two grooves 17 and 20. At one end of the casing 13 is provided with an inlet 21 for a control fluid, which is communicated with the control fluid passage between the change-over valve 1 and the casing 2, and at the opposite end of which is formed an inlet 22 for a control fluid, which is communicated with the outlet port 5 of the casing 2. Therefore, as for the change-over pilot valve 24, under such an ordinary condition that the change-over valve 1 is on the side of control fluid passage, the spool 14 is forced to be pressed towards the inlet 22 for a control fluid by the compressed fluid introduced from the inlet 21 for a control fluid, and in this case ports 15 and 16 are communicated.

In this system, the same pilot valve 23 as that shown in FIG. 2 is employed. When the change-over valve 1 is changed-over on the side of main fluid passage, the spool 3 in the pilot valve 23 starts to be moved, by the compressed fluid introduced from the inlet 11 for a control fluid, from its operation-start-position. At this time, however, the ports 4 and 5 are not communicated, and therefore, any input is invisible at the inlet 22 for a control fluid in the change-over pilot valve 24, in which ports 15 and 16 are communicated. Therefore, a fluid discharged from the inlet 8 for a control fluid in the casing 2 through the discharge valve 9 passes through the throttle valve 10*a*. When the spool 3 has stopped to move and the pilot valve 23 has been operative before long, the compressed fluid becomes visible at the outlet port 5 thereof. A part of said fluid enters the casing 13 from the inlet 22 for a control fluid in the change-over pilot valve 24 to press the spool 14. Consequently, the fluid admitted from the inlet 21 for a control fluid and stayed in the casing 13 is returned

so that ports 18 and 19 are communicated through the groove 20, the groove 17 being away from the ports 15 and 16. Thus, after the pilot valve 23 has started its operation, the fluid returned from the inlet 8 for a control fluid reaches the throttle valve 10*b* passing through ports 18 and 19 in the change-over pilot valve 24. As is obvious from the foregoing, the throttle valve 10*a* controls the time before the start of operation of the pilot valve 23, and the throttle valve 10*b* controls the operative time thereof. These throttle valves 10*a* and 10*b* are separately operatable each other.

FIG. 4 illustrates a sectional view of the valve system according to the present invention, in which all construction elements are integrated and assembled on the basis of conception in accordance with FIG. 1. A main body 31 is provided with chambers 33 and 34 separated, on both sides, by means of a partition wall 32 located in the nearly center. Within the chamber 33 is placed a spool 30 having two grooves 35 and 36. Said spool 30 is one of members constituting the change-over valve 1 and the discharge valve 9 as shown in FIG. 1. On the other hand, within the chamber 34 is also placed a spool 48 having a groove 49, said spool 48 corresponding to the spool 3 as shown in FIG. 1. The spool 30 is subject to the resistance force of spring 37 from its one end, while the opposite end is connected with the piston through the valve stem 38. Said piston is placed in the cylinder 40 and is forced to be pressed, when the driving compressed fluid is fed from a conduit 41, to move said spool 30 in the direction opposite to the resistance force by spring 37. Ports 43, 44, 45 and 46, which are in cooperation with grooves 35 and 36 of the spool 30, are formed around the chamber 33, the port 43 being communicated with a feed-in port 42 for the compressed fluid to be controlled, and the port 44 is a doorway (inlet and outlet) for the control fluid passage 47 leading to the chamber 34. These ports 43 and 44 are communicated through the groove 35 unless said spool 30 is forced to be pressed through the piston 39. On the other hand, the port 45 is in communication with the main fluid passage 51 leading to the inlet port 52 formed in the chamber 34, said port 45 is to be communicated with the port 43 through the groove 35 when the spool 30 is forced to be pressed through the piston 39. The ports 44 and 45 are to be changed-over, with the movement of spool 30, to the port 43 through the groove 35. Another port 46, which is formed in the chamber 33, is communicated with the discharge passage 55 containing a throttle valve 56, said port 46 is communicated with the port 44 through the groove 36 when the spool 30 is forced to be pressed through the piston 39. As is apparent from the foregoing, unless the piston 39 is forced to be pressed, the spool 30 stays still at one end of the chamber 33 subjecting to the resistance force of spring 37, and in such a state, the compressed fluid introduced into the feed-in port 42 enters port 44 from port 43, then flowing into the chamber 34 through the control fluid passage 47. And, when the piston 39 is forced to be pressed, the spool 30 moves and the port 43 is communicated with the port 45, while the port 44 is communicated with the port 46.

A spool 48 in the chamber 34, unless the piston 39 is forced to be pressed, is forced to be pressed by the compressed fluid fed from the control fluid passage 47.

At this time, the resistance force of the spring 50 acts on the spool 48, but the pressure of compressed fluid given to the spool 48 exceeds said resistance force so that the spool 48 stops at the operation-start-position as shown in FIG. 4. An inlet port 52 is in communication with an outlet port 53 through the groove 49 of the spool 48, said outlet port 53 being communicated with an output passage 54. The operation of the spool 48 is apparent from the detailed description given in connection with the description of FIG. 1. Here, the operation is particularly described in connection with FIG. 4. If the flow of the throttle valve 56 in the discharge valve 55 is controlled, its moving speed can freely be determined. Further, FIG. 2 shows a simplest example of the throttle valve 56, which is a rod 56 having a conical head interposed in the discharge passage. Said throttle valve 56 is provided with a knob, which projects towards the outside of main body 31, and the flow in the discharge passage 55 can be varied by turning the knob. In FIG. 4, the reference numeral 58 is an exhaust passage and 57 is a port in communication therewith.

FIG. 6 illustrates a valve system, according to the present invention, which is different from one shown in FIG. 5 in several respects.

First, this system employs a conception of the present invention as shown in FIG. 2, in which, therefore, the spool 48 is not provided with a spring but is provided with a cavity 61 instead. Said cavity 61 is communicated with main fluid passage 51 by a branch passage 62, and when the compressed fluid passes through the main fluid passage, the spool 48 is forced to be pressed by a part of said fluid. When the spool 48 is forced to be pressed by the compressed fluid from the control fluid passage 47 in the opposite direction, the other spool 30 being subject to the resistance force of spring 37 so that a gap is formed between the edge 72 of the spool 30 and the port 45, and thus the fluid in the cavity 61 is returned to the discharge passage 58 from said gap.

On the other hand, according to the system, a valve stem 38 of the spool 30 is operatively connected with the plunger 66 of a magnet means 65, and with the plunger being forced to be pressed, the spool 30 moves against the resistance force of spring 37. In the system as described with reference to FIG. 4, an operating signal is sent in the form of driving-compressed fluid for the piston 39, while in the present system, it is sent in the form of electrical signal. As is apparent from the foregoing, according to the present system, if it is an input of the type, which enables the spool 30 to move against the resistance force of the spring 37, it can be read as an operating signal irrespective of type of medium, through which input is entered. In this case, if the spool 30 is operated in an interlocking relation with the piston 39 likewise the system shown in FIG. 4, its operative time for that particular system is in accordance with either continuous time of the operating signal relative to the piston 39 or an operating time of the spool 48, whichever earlier, and therefore, in view of these facts, the continuous time for the operating signal should be taken into consideration. But, according to the present invention, a valve system can also be obtained, in which the operative time as a system is always related to the operating time for the spool 48, without attaching importance to the continuous time for the operating signal.

The greatest feature of a system shown in FIG. 6 lies, in a sense as described above, in that there is provided a self-maintaining means for the spool 30. That is, this system is such that when a plunger is once forced to be

pressed even if an operating signal sent to the magnet means **65** is instantaneous in nature, the spool **30** is to be self-maintained until the operation of the other spool has been completed. In the drawing, a self-maintaining means of this type is shown at self-maintaining passage **64** branched from an output passage **54** having an outlet port **53**. This self-supporting passage **64** is such that the compression fluid is introduced from an outlet port **53** into the chamber **33** housing the spool **30**, the spool **30** being forced to be pressed in the direction opposite to the resistance force of spring **37**. According to the system, therefore, the spool **30** is forced to be pressed by the plunger, with the input of an operating signal relative to the magnet means **65**, consequently, the compressed fluid is obtained from the outlet port **53** with the operation start of spool **48** and said compressed fluid self-maintains the spool **30**, thereby the operative time can be determined irrespective of continuous time of the operating signal relative to the magnet means **65**. Further, it is obvious that when the output is not to be present at the outlet port, the spool **30** returns to its original position by the resistance force of spring **37**.

FIG. **7** shows a valve system according to the present invention, in which a switch is provided for the electrical detection of operation completion of spool **3**. This switch is a well known type providing with an elastic operating plate **68**. Said operating plate **68** is operatively connected with an operating pin **69** having a head member which projects into the chamber **34**, so as to be operated together with the pin **69**. The pin **69** is forced to be pressed so that the head member **70** is projected into the chamber **34** by action of resistance force of a spring **71**. According to this system, therefore, the completion of the operation of spool **48** is electrically detected so that a plurality of systems can be interlocked each other.

The foregoing detailed description sets forth the invention in its preferred practical forms but the invention is to be understood with the appended claims.

Having described the invention, what is claimed is:

1. A valve system comprising a pilot valve consisting of a cylindrical casing having a pair of ports, a spool operatively connected within said casing and provided with grooves which acts a valve in cooperation with said pair of ports, a determination means for introducing compressed fluid, by which said spool is forced to be pressed to the operation-start-position, into said casing, a change-over means for feeding the compressed fluid from a feed source into either said pilot valve or determination means, an operating means for pressing said spool from its operation-start-position in the direction opposite to the pressing direction by way of said determination means when said change-over means is on the side of said pilot valve, a control means for discharging the fluid within said casing introduced by way of said determination means with the operation of said operating means; the discharge flow of fluid from said casing being controlled by said control means so as to control the moving speed of said spool by way of pressing by said operating means.

2. A valve system according to claim **1**, wherein said pilot valve is operative at the operation-start-position.

3. A valve system according to claim **1**, wherein said pilot valve is not operative at the operation-start-position but operative with the movement of the spool.

4. A valve system according to claim **1**, comprising said operating means, which is a spring mounted within the casing opposite to the determination means putting said spool therebetween.

5. A valve system according to claim **1**, comprising a means for introducing compressed fluid into the casing opposite to the determination means putting said spool therebetween and a means for discharging compressed fluid out of the casing with the pressing the spool by said determination means.

6. A valve system according to claim **5**, wherein the said introducing means introduces a part of the compressed fluid which flows from said change-over means to the pilot valve.

7. A valve system according to claim **1**, wherein said control means comprises a discharge valve in interlocking relation with said change-over means and a throttle valve connected with said discharge valve.

8. A valve system according to claim **1**, wherein said pilot valve is not operative at the operation-start-position but operative with the movement of spool, said control means comprising a discharge valve in interlocking relation with said change-over means, two throttle valves, and a valve change-over means connected between the throttle valve and the discharge valve, said valve change-over means changes over said throttle valve from one to the other with the operation start of said pilot valve.

9. A valve system according to claim **1**, further comprising a resetting means for holding said change-over means on the side of said determination means and an input means for changing over said change-over means on the side of said pilot valve against the said resetting means.

10. A valve system according to claim **9**, further comprising a self-maintaining means for holding said change-over means on the side of said pilot valve, said self-maintaining means being operated only when said pilot valve is in operation.

11. A valve system according to claim **1**, further comprising a switch for electrically detecting the operation completion of said spool, said switch being opened and closed with the movement of a pin having a head member which projects into said casing.

* * * * *