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Onoda et al.

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[45] **Sept. 9, 1975**

[54] **MULTISTAGE CYLINDER**

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[51] **Int. Cl.**[2] **F01B 7/20**

[58] **Field of Search** 92/52, 62, 66, 111, 112, 92/113, 65, 163, 164, 169; 91/167, 35

[56] **References Cited**

UNITED STATES PATENTS

2,173,358	9/1939	Ernst	92/164 X
2,397,106	3/1946	Haller	92/52 X
2,510,314	6/1950	Jirsa	91/167 X
2,858,802	11/1958	Parsons et al.	92/163 X
2,933,070	4/1960	Trümper et al.	92/62 X
3,139,004	6/1964	Haumann	92/52 X
3,236,620	2/1966	Wiley	92/52 X
3,259,027	7/1966	Phillipson et al.	92/52 X
3,285,287	11/1966	Curran	92/62 X
3,602,326	8/1971	Garrison	91/413 X
3,696,712	10/1972	Sung	92/52

FOREIGN PATENTS OR APPLICATIONS

328,113	1/1902	France	92/169
1,280,935	11/1961	France	92/163

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[57] **ABSTRACT**

A multistage cylinder comprises at least a first-stage cylinder and a second-stage cylinder provided essentially in the piston rod of the first-stage cylinder, the first-stage and second-stage cylinders being capable of operating separately and independently of each other, whereby they can even operate in opposite directions.

1 Claim, 7 Drawing Figures

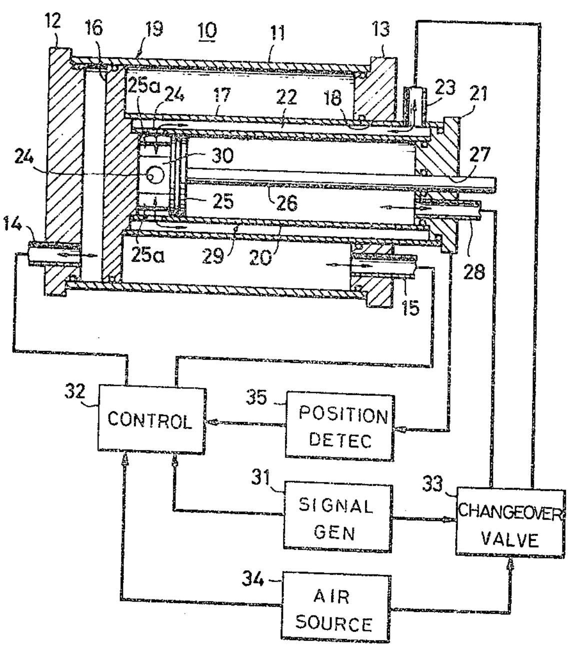

FIG. 1

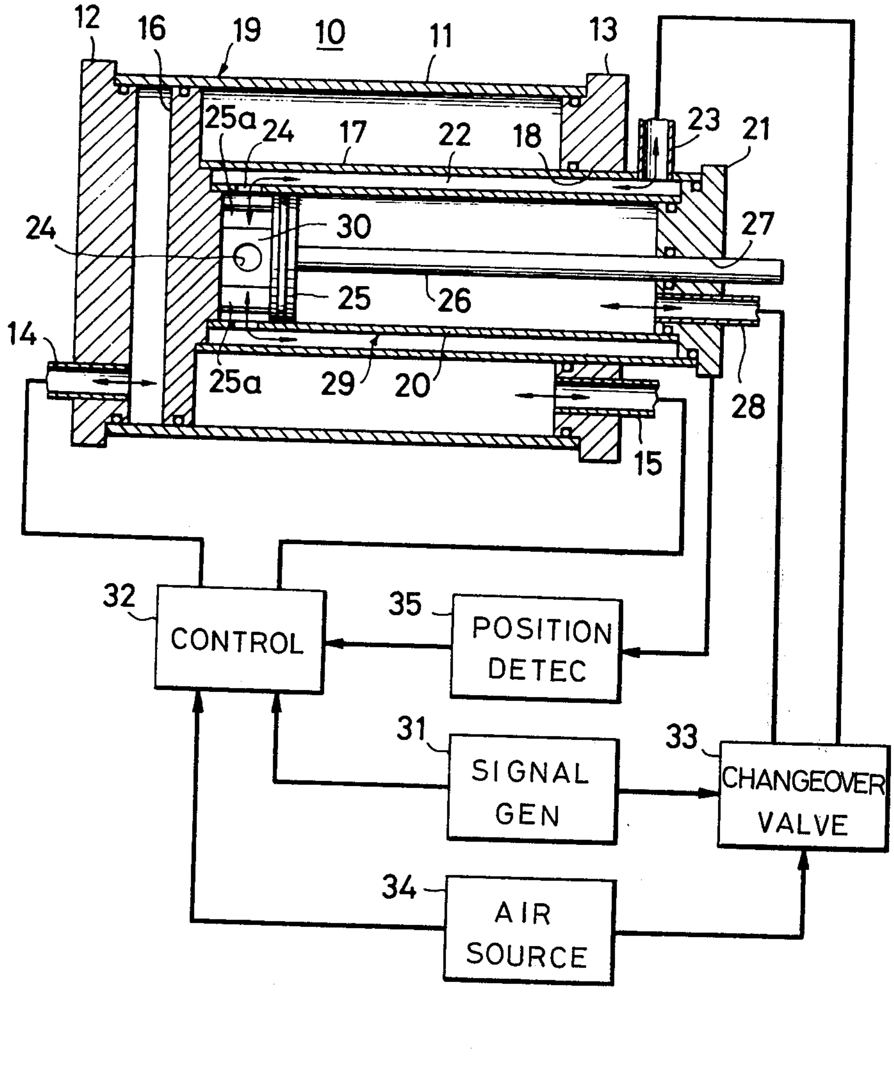
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FIG. 2A

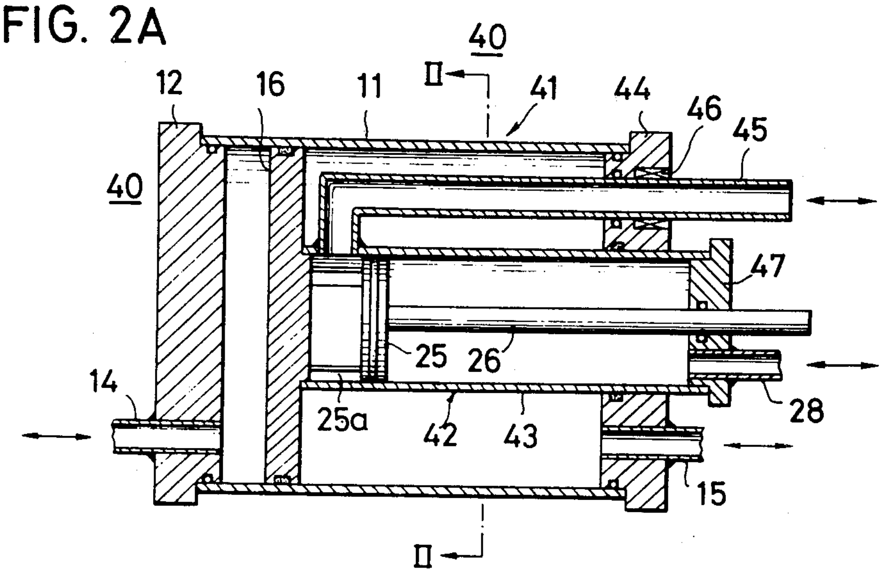

FIG. 2B

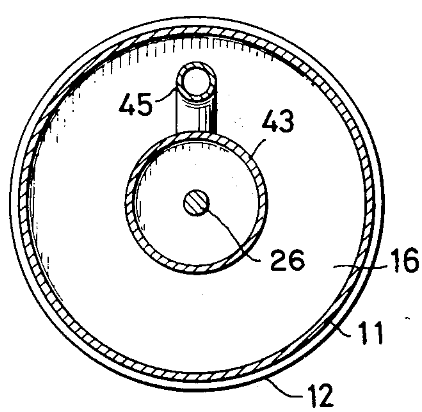

FIG. 3

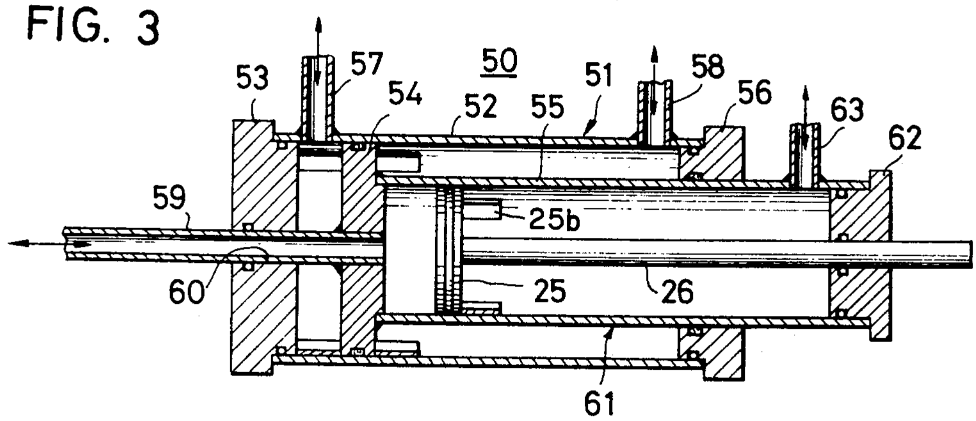

FIG. 4

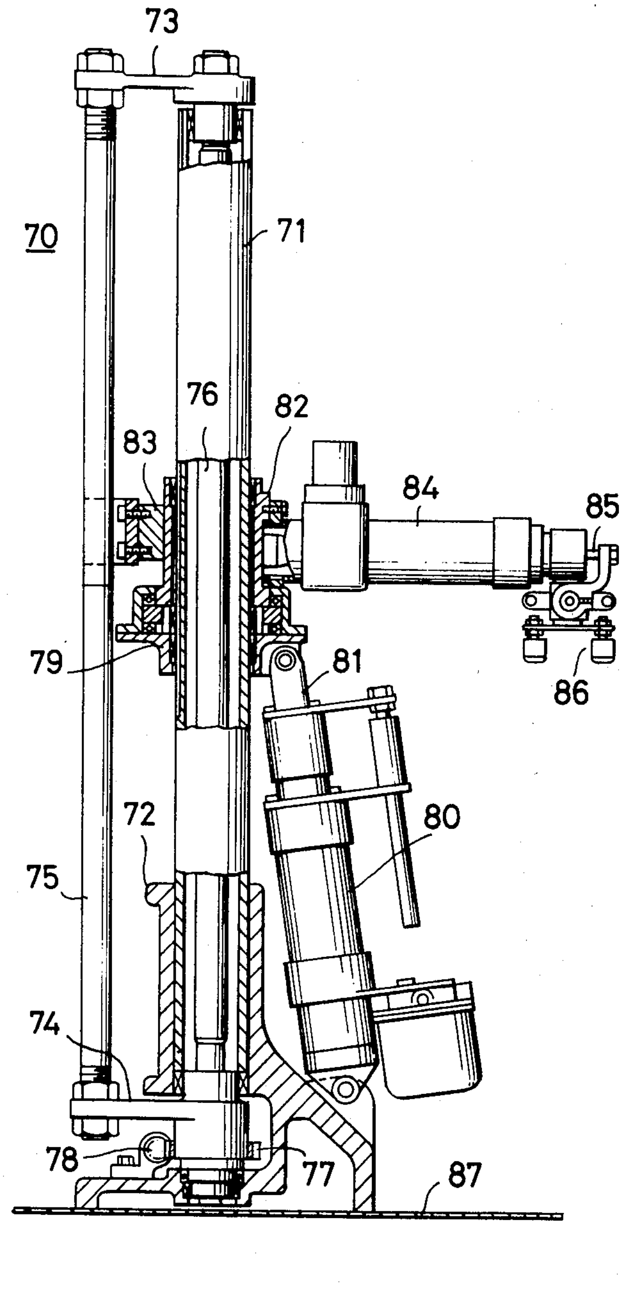

FIG. 5

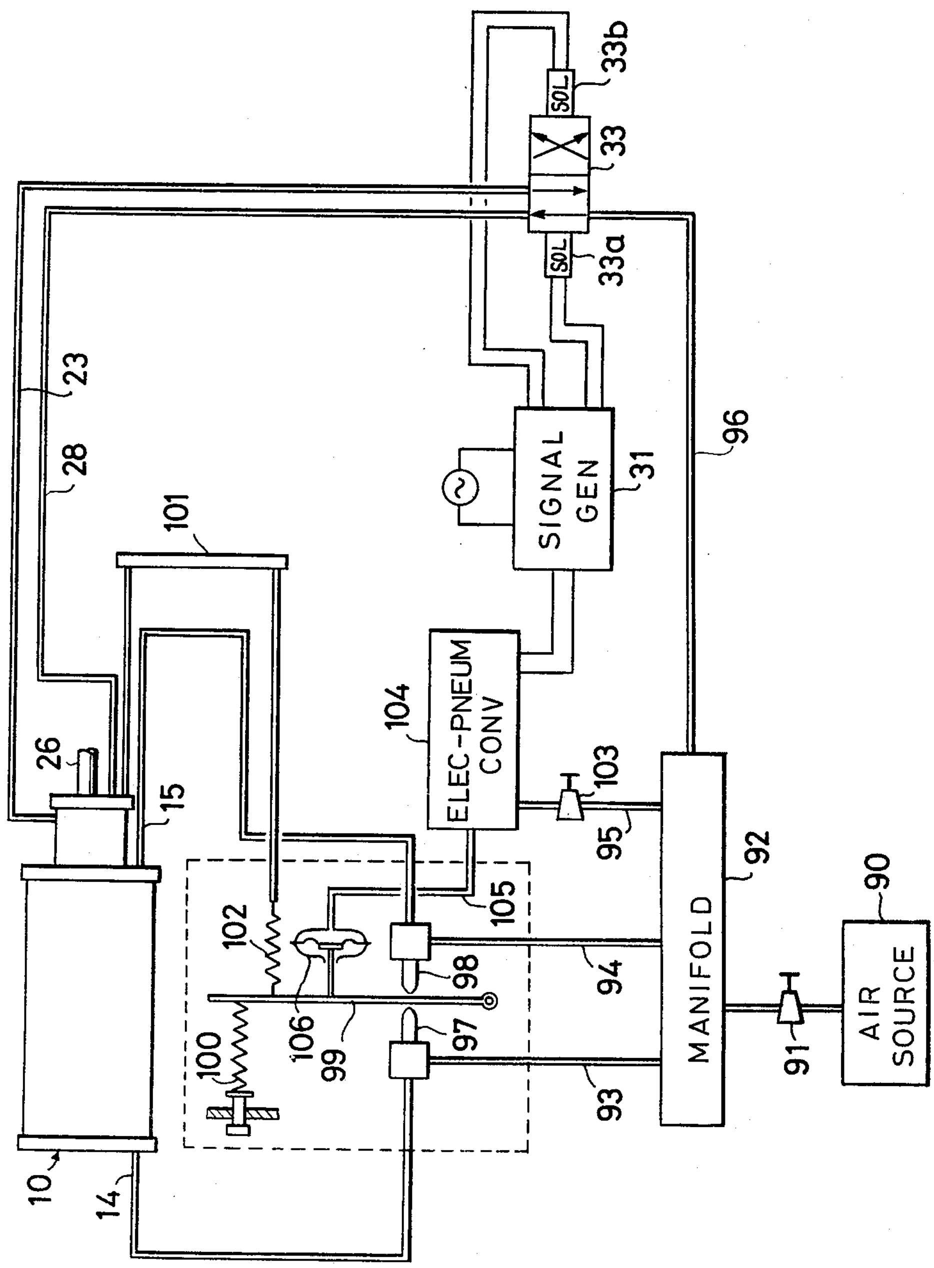
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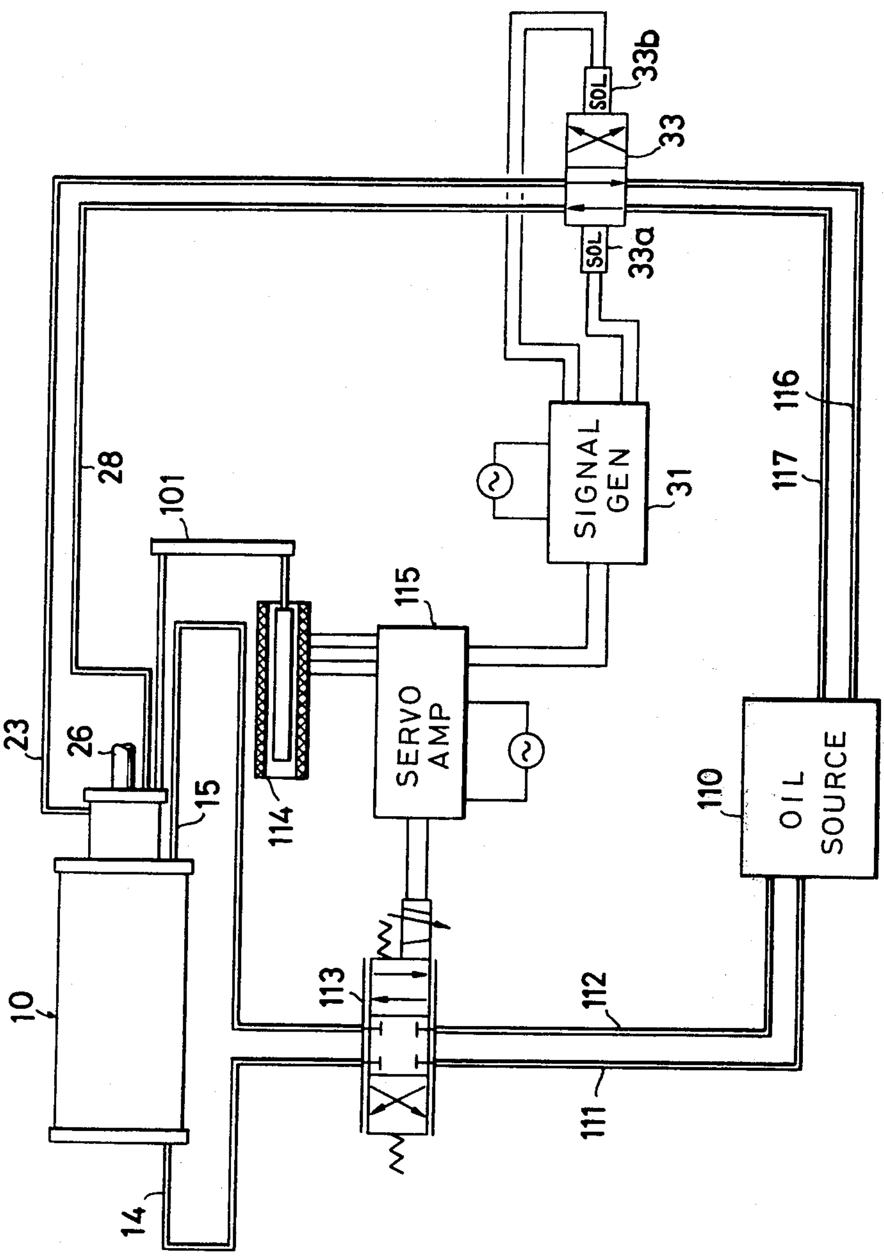
FIG. 6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MULTISTAGE CYLINDER

BACKGROUND OF THE INVENTION

This invention relates generally to a multistage cylinder and more particularly to a multistage cylinder in which a plurality of cylinder tubes can be individually actuated independently of each other by a fluid such as an oil or air.

In multistage cylinders known heretofore, the interiors of the cylinders of all stages in each case are intercommunicative, and the cylinders of the stages are adapted to elongate and contract or retract in sequence. Accordingly, the cylinders cannot be actuated independently, and the speed of elongating and contracting of the entire cylinder assembly is slow. Moreover, it is not possible to obtain readily any desired length of elongation or contraction.

Recently, there have been developments of devices for automatically accomplishing the operations of, for example, transporting certain articles from a specific supply position to a plurality of shelves of progressively varying heights and loading each shelf with a specific number of the articles. In the case where, in an automatic device of this character, multistage cylinders are used to constitute arm members for carrying out the operations of clutching the articles and loading them on the shelves, the loading position and height differs each time an article is loaded onto a shelf. For this reason, it is necessary for each cylinder, as a whole, to assume a specific different mode of extension or contraction for each operational action.

A conventional multistage cylinder, however, cannot undergo such a complicated extension and contraction action of differing mode for each operational action, and it has not been possible to use a conventional multistage cylinder in an automatic device as described above.

On one hand, among cylinders, in general, there are servo-cylinders capable of assuming any position in extension or contraction and so-called on-off cylinders capable of assuming only two positions, i.e., an extended position and a retracted position. While a servo-cylinder is capable of assuming any extension-contraction length, it requires a servo system for its operation and is therefore expensive. Another disadvantage of a servo-cylinder is that it is difficult to assembly in multiple stages. On the other hand, while the on-off cylinder is relatively inexpensive and is of a relatively simple organization, it has the drawback of not being capable of assuming any desired extension-retraction position.

SUMMARY OF THE INVENTION

Accordingly, it is a general object of the present invention to provide a new and useful multistage cylinder wherein the difficulties accompnaying the conventional multistage cylinders have been overcome.

More specifically, an object of the invention is to provide a multistage cylinder in which cylinders of a plurality of stages can operate individually and independently of each other in the same or mutually opposite directions.

Another object of the invention is to provide a multistage cylinder capable of assuming any extension-retraction position through the use of a single servo-cylinder and one or more on-off cylinders.

Still another object of the invention is to provide a multistage cylinder which is highly effective when applied to apparatuses, particularly industrial "robots" and the like.

Further objects and features of the present invention will be apparent from the following detailed description with respect to preferred embodiments of the invention when read in conjunction with the accompanying drawings, in which like parts are designated by like reference numerals.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a combination of a side view in longitudinal section of one embodiment of a multistage cylinder according to the present invention and a block diagram showing one embodiment of a control system thereof;

FIGS. 2A and 2B are respectively a side view in longitudinal section and a section taken along line II—II in FIG. 2A of a second embodiment of a multistage cylinder according to the invention;

FIG. 3 is a side view in longitudinal section of a third embodiment of a multistage cylinder according to the invention;

FIG. 4 is a side elevation, with parts cut away and parts shown in longitudinal section, showing one embodiment of an automatic carrying and loading machine to which the multistage cylinder of the invention is applied;

FIG. 5 is a simplified schematic diagram showing the essential organization of a more specific and practical embodiment of the control system shown in FIG. 1 in the case where air is used for the working fluid of system; and

FIG. 6 is a simplified schematic diagram showing the essential organization of a still more specific embodiment of the control system shown in FIG. 1 in the case where an oil is used for the working fluid of the system.

DETAILED DESCRIPTION

A first embodiment of a multistage cylinder according to the present invention will now be described with reference to FIG. 1.

To the inner and outer ends of a first cylinder tube **11** of the multistage cylinder **10** according to the invention, there are respectively fixed a head cover **12** and a first rod cover **13**, gas-tight packings being suitably provided between these covers and the cylinder tube. The head cover **12** is provided therethrough with a supply and discharge pipe **14** for inflow and outflow of pressurized fluid, while the rod cover **13** is similarly provided therethrough with a supply-discharge pipe **15**. Examples of the above mentioned pressurized fluid suitable for use according the invention are pressurized air, oil, and other gases and liquids. In the instant embodiment illustrated in FIG. **1**, pressurized air is used.

Within the first cylinder tube **11**, there is slidably fitted a first piston **16**, to which is fixed the inner end of a first piston rod **17** of hollow cylindrical shape, which is slidably fitted in and through a hole **18** formed coaxially in the rod cover **13**, a gas-tight packing being interposed between this piston rod and the rim of the hole. The above mentioned cylinder tube **11**, head cover **12**, rod cover **13**, piston **16**, piston rod **17**, and supply and discharge pipes **14** and **15** constitute a first-stage cylinder **19**.

Within the first piston rod **17**, there is coaxially disposed a second cylinder tube **20** fixed at the inner end thereof to the first piston **16**. The other ends of the first piston rod and the second cylinder tube **20** are secured to a second rod cover **21** with gas-tight packings interposed therebetween. The outer diameter of the second sylinder tube **20** is less than the inner diameter of the first piston rod **17**, and a cylindrical space **22** is formed between the first piston rod **17** and the second cylinder tube **20**. Near the outer end (the right end as viewed in FIG. **1**) of the first piston rod **17**, there is provided a supply-discharge pipe **23** for pressurized fluid communicating with the space **22**. Near the inner end of the second cylinder tube **20** fixed to the first piston **16**, a plurality of holes **24** aare formed in the cylindrical wall of the cylinder tube **20**. These holes **24** also communicate with the space **22**.

Within the second cylinder tube **20**, there is slidably fitted a second piston **25**. A second piston rod **26** is fixed at its inner end to this second piston **25** and is slidably fitted in and through a hole **27** formed in the center of the second rod cover **21** a suitable gas-tight packing being interposed therebetween. The other outer end of this second piston rod **26** is coupled to a part to be actuated by the multistage cylinder. The second rod cover **21** is provided with a fluid supply-discharge pipe **28**. The second piston **25** has leg parts **25***a* projecting inward or toward the first piston **16** and acting as stop means. When the piston **26** is in its innermost position relative to the piston **16**, the inner ends of these leg parts **25***a* are abutting against the outer side of the piston **16**, whereby the piston is stopped and a chamber **30** communicating through the holes **24** with the space **22** is formed between the first and second pistons **16** and **25**.

The above described second cylinder tube **20**, the second piston **25**, the second piston rod **26**, the outer (right-hand) wall surface of the first piston **16**, the second rod cover **21**, and the supply-discharge pipes **23** and **28** constitute a second-stage cylinder **29**.

The aforementioned supply-discharge pipe **14** communicates with a space defined and enclosed by the head cover **12**, the first cylinder tube **11**, and the first piston **16**. The supply-discharge pipe **15** communicates with a space defined and enclosed by the first piston **16**, the first cylinder tube **11**, the first piston rod **17**, and the first rod cover **13**. The supply-discharge pipe **23** communicates with a space defined and enclosed by the first and second pistons **16** and **25** and the second cylinder tube **20**. Furthermore, the supply-discharge pipe **28** communicates with a space defined and enclosed by the second piston **25**, the second cylinder tube **20**, and the second rod cover **21**.

The multistage (two-stage) cylinder of the above described construction according to the invention operates as follows. When the working fluid (air) under pressure is supplied through the supply-discharge pipe **14** into the chamber between the head cover **12** and the first piston **16**, the piston **16** and the first piston rod **17** are forced outward or toward the right as viewed in FIG. **1**. When pressurized air is supplied through the supply-discharge pipe **23**, it passes through the space **22** and holes **24** into the chamber **30**, whereby the second piston **25** and the second piston rod **26** are forced outward. On the other hand, when pressurized air is supplied through the supply-discharge pipe **28**, the second piston **25** and rod **26** are forced inward. The supply or discharge of pressurized air through the supply-discharge pipe **14** or **15** and that through the supply-discharge pipe **23** or **28** can be carried out separately and independently of each other. Accordingly, the first and second pistons **16** and **25** can be operated to slide independently of each other in the same direction or in mutually opposite directions.

The supply and discharge of pressurized air through these supply-discharge pipes **14, 15, 23,** and **28** are controlled by a control system of the following organization and operation. In this control system, a program for a prescribed operation of the multistage cylinder is previously stored, and in accordance with this program, a signal is generated by a signal generator **31** and sent to a controller **32** and changeover valve **33**. The controller **32** and the changeover valve **33** are supplied with pressurezed air from an air source **34**.

The changeover valve **33** operates in accordance with the signal from the signal generator **31** to changeover the destination of delivery of pressurized air from the air source **34**, thereby to supply the air to either the aforementioned supply-discharge pipe **23** or **28**. When the pressurized air is supplied to the pipe **23**, the second piston **25** is forced to slide outward to the outward end of its stroke, while when the pressurized air is supplied to the pipe **28**, the piston **25** is forced to slide inward to the inward end of its stroke. Thus, the piston **25** changes its position between only the two positions, namely, those of the outer end and the inner end of its stroke, and the second-stage cylinder **29** operates on an on-off cylinder.

On the other hand, as the first piston **16** of the first-stage cylinder **19** undergoes sliding movement, its position at each instant is detected by a position detector **35** as being interrelated to the varying position of the second rod cover **21**, whereupon the position detector **35** generages a detection output, which is supplied to the controller **32**. The controller **32** thereupon operates in response to this detection output in conjunction with a signal from the signal generator **31** to control the supply of pressurized air from the air source **34** to the supply-discharge pipes **14** and **15**. Therefore, depending on the state of air supply to the supply-discharge pipes **14** and **15**, the first pistion **16** can be moved to any desired position, and the first-stage cylinder **19** operates as a servo-cylinder.

Then, since this first-stage cylinder **19** is a servo-cylinder, the second piston rod **26** of the second cylinder **10** can always be caused to assume any variable position within its total stroke from the most contracted or retracted state wherein the first and second pistons **16** and **25** are at their innermost positions to the most extended state wherein the pistons **16** and **25** are at their outermost positions even though the second-stage cylinder **29** is an on-off cylinder. The degree of accuracy of this variable position in this operation is determined by the accuracy of the first-stage servo-cylinder **19** and is high.

When the piston **25** of the second-stage on-off cylinder **29** changes its position to the inner end of its stroke, and the legs **25a** of the piston **25** abut against the outer wall surface of the first piston **16**, the piston **16** is subjected to the abutment impact force of the piston **25**, but the air in the chamber formed between the first piston **16** and the head cover **12** acts as an air spring to absorb effectively the above mentioned impact force. Accordingly, there is no necessity whatsoever of providing a cushioning mechanism for this second-stage cylinder **29**.

In the embodiment described above, the cylinder is made up of two stages, but it will be apparent, of course, a third-stage and succeeding on-off cylinders can be adeed to the second-stage cylinder **29** thereby to provide a multistage cylinder of three or more stages. In such a case, also, any desired position can always be obtained by using only a single servo-cylinder and an on-off cylinders for the other cylinders. It should be required that the stroke of the rod of the servo-cylinder is at least equal to or greater than the stroke of the rod of the on-off cylinder.

Since the first-stage and second-stage cylinders **19** and **29** are adapted to operate separately, as mentioned hereinabove, it is not necessary in all case to construct them coaxially in a strict sense, an eccentric construction also being possible. Accordingly, a centering step in the assembly or fabrication of each cylinder is not necessary, whereby production of the cylinder is facilitated.

Furthermore, while pressurized air is used as the driving fluid in the above described embodiment, the invention is not so limited, another fluid such as oil also being usable.

A second embodiment of the multistage cylinder according to this invention will now be described with reference to FIG. 2A and FIG. 2B. In these figures, parts which are the same as or are equivalent to those shown in FIG. 1 are designated by the same reference numerals, and detailed description thereof will not be repeated.

The multistage cylinder shown and generally designated by reference numeral **40** has a first-stage cylinder **41** comprising a cylinder tube **11**, a head cover **12**, a piston **16**, a piston rod **43**, a rod cover **44**, and supply-discharge pipes **14** and **15** provided respectively in the head cover **12** and the rod cover **44**.

The piston rod **43** of the first-stage cylinder **41** serves doubly as the cylinder tube of a second-stage cylinder **42**. The inner end of a supply-discharge pipe **45** is secured to the piston rod and cylinder tube **43** near its inner end fixed to the piston **16**, the interior of this pipe **45** being communicative via a hole in the wall of the tube **43** with the interior thereof. This supply-discharge pipe **45**, except for its inner end, is parallel to the axis of the multistage cylinder **40** and passes through the rod cover **44**, being guided in sliding movement relative thereto by a guide **46**. The second-stage cylinder **42** comprises the cylinder tube **43**, a second pistion **25**, a second piston rod **26**, the outer (right-hand) wall surface of the piston **16**, a second rod cover **47**, the supply-discharge pipe **45**, and a supply-discharge pipe **28** connected to and passing through the rod cover **47**.

The supply-discharge pipe **14** is communicatively connected to a space defined by the head cover **12**, cylinder tube **11**, and piston **16**, while the supply-discharge pipe **15** is communicatively connected to a space defined by the piston **16**, cylinder tube **11**, piston rod **43**, and rod cover **44**. The supply-discharge pipe **45** is communicatively connected to a space defined by the pistons **16** and **25** and the cylinder tube **43**, while the supply-discharge pipe **28** is communicatively connected to a space defined by the piston **25**, cylinder tube **43**, and rod cover **47**.

The piston **16** is actuated in sliding movement by pressurized air supplied and discharged through the supply-discharge pipes **14** and **15**, while the piston **25** is similarly actuated by pressurized air supplied and discharged through the supply-discharge pipes **45** and **28**. The possibility of mutually independent operations of the pistons **16** and **25** is the same as that in the preceding first embodiment, and for their control, the control system illustrated in FIG. 1 can be applied.

In the instant embodiment, since the supply-discharge pipe **45** communicating with the cylinder tube **43** extends through the rod cover **44**, it functions to prevent rotation of the piston rod and cylinder tube **43** relative to the other parts.

A third embodiment of a multistage cylinder according to the present invention will now be described in conjunction with FIG. 3.

This multistage cylinder **50** has a first-stage cylinder **51** comprising a cylinder tube **52**, a head cover **53**, a piston **54**, a piston rod **55**, a rod cover **56**, and supply-discharge pipes **57** and **58** connected to the cylinder tube **52** respectively near the inner and outer ends thereof. A supply-discharge pipe **59** is passed through and fixed to the center of the piston **54** and extends out through a center hole **60** in the head cover **53**, being fitted slidably but in a gas-tight manner in this center hole **60**.

The piston rod **55** serves doubly as a cylinder tube of a second-stage cylinder **61** and is provided at its outer end with a rod cover **62** fixed thereto in a gas-tight manner. This cylinder tube **55** is provided near its outer end with a supply-discharge pipe **63**. The second-stage cylinder **61** comprises the cylinder tube **55**, the piston **54** serving doubly as a head cover, the rod cover **62**, a piston **25** slidably fitted within the cylinder tube **55**, a piston rod **26** fixed at its inner end to the piston **25** and extending out through the center of the rod cover **62**, and the supply-discharge pipes **59** and **63**.

The above mentioned supply-discharge pipe **57** is communicatively connected to a space defined by the head cover **53**, the cylinder tube **52**, and the inner (left-hand) wall surface of the piston **54**, while the supply-discharge pipe **58** is communicative with a space defined by the piston **54**, the cylinder tube **52**, the piston rod **55**, and the rod cover **56**. The supply-discharge pipe **59** is communicative with a space defined by the piston **54**, the cylinder tube **55**, and the piston **25**. The supply-discharge pipe **63** is communicative with a space defined by the cylinder tube **55**, the piston **25**, and the rod cover **62** the piston **25** has leg parts **25*b*** acting as the stop means.

The piston **54** of the first-stage cylinder **51** is actuated in sliding movement by pressurized air supplied and discharged through the supply-discharge pipes **57** and **58**, while the piston **25** of the second-stage cylinder **61** is similarly actuated by pressurized air supplied and discharge through the supply-discharge pipes **59** and **63**. The possibility of mutually independent operations of the pistons **54** and **25** is the same as that in the preceding embodiments, and for their control, also, the control system shown in FIG. 1 can be applied.

Next, the multistage cylinder according to the invention will be described with respect to one embodiment of its application to a "robot" for industrial use, with reference to FIG. 4.

FIG. 4 illustrates one embodiment of a robot **70** for industrial use for performing the operation of conveying and loading specific articles, which have been successively supplied to a specific supply position, in prescribed numbers successively to and onto shelves of progressively varying height.

A hollow stationary column 71 is fixedly held in upright position by a support structure 72 on a floor surface 87. At the upper and lower ends of the stationary column 71, there are respectively provided bearing means rotatably supporting the proximal end parts of upper and lower arms 73 and 74, respectively. These arms 73 and 74 are respectively fixed to the upper and lower ends of a rotatable shaft 76 disposed coaxially within the stationary column 71. The distal ends of the arms 73 and 74 are joined by a tie rod 75 fixed at its upper and lower ends thereto and disposed parallelly to the stationary column 71. A pinion 77 is provided on the proximal part of the lower arm 74 and is meshed with and driven by a rack 78 driven by motive power means (not shown).

A slider 79 is slidably fitted around the stationary column 71 at approximately its middle part and can thereby slide vertically relative to the column 71. This slider 79 is pin-connected to the outer end of a piston rod 81 of a cylinder 80 for up-and-down movement pin-connected at its head cover end to a part of the support structure 72. A rotor 82 is fitted on the stationary column 71 in a manner permitting vertical sliding and rotational movements and is resting rotatably on the slider 79. This rotor 82 is actuatable through an arm 83 to rotate unitarily with the rod 75.

The rotor 82 supports a multistage cylinder 84 according to this invention, as exemplified by any of the above described cylinders 10, 40, and 50, the multistage cylinder 84 being mounted at its head-cover end on the rotor 82. A grasping device 86 for grasping the aforementioned specific articles is mounted on the outer end of the piston rod 85 of the second-stage cylinder of this multistage cylinder 84.

In the operation of the robot machine of the above described structure, the sliding of the rack 78 causes the pinion 77, and therefore the arm 74, to rotate. Consequently, the shaft 76, arm 73, rod 75, rotor 82, and multistage cylinder 84 all rotate unitarily with the arm 74 about the axis of the shaft 76, whereby the grasping device 86 swings in a horizontal plane. Operation of the cylinder 80 causes its pistion rod 81 to move out or in thereby to actuate the slider 79, rotor 82, and multistage cylinder 84 in upward or downward movement, whereby the grasping device 86 is moved vertically up or down.

Together with or separately from the above described rotation and vertical movement, the grasping device 86 can be caused by the operation of the multistage cylinder 84 to move horizontally toward or away from the stationary column 71. By causing the grasping device 86 to carry out the operations of grasping and releasing the articles to be handled together with the combination of the above described rotation, vertical movement, and horizontal displacement, it is possible to cause the robot machine 70 to perform readily complicated operations such as loading articles at a specific height position of a prescribed number thereof on each of a plurality of shelves of successively varying height.

Specific embodiments of the cylinder control system indicated by simplified block diagram in FIG. 1 will now be described in detail with reference to FIGS. 5 and 6.

The embodiment illustrated in FIG. 5 is applied to the control of multistage cylinder actuted by pressurized air as the driving fluid. In FIG. 5, parts which are the same or equivalent to those in FIG. 1 are designated by like reference numerals, but detailed description thereof will not be repeated.

Pressurized air is supplied by a pressurized air source 90 by way of a pressure-reducing valve 91 to a manifold 92, where the pressurized air is branched and supplied through pipes 93, 94, 95, and 96. The pipe 93 is communicatively connected to a nozzle and the aforementioned supply-discharge pipe 14, and the pipe 94 is communicatively connected to a nozzle in opposed relation to the nozzle 97 and to the aforementioned supply-discharge pipe 15.

Between the nozzles 97 and 98, there is interposed a shield plate 99 pivotally supported at one end thereof. This shield plate is pulled toward one side (toward the nozzle 97) by a counter spring 100 and toward the opposite side by a spring 102 provided on a position detection member 101 fixed to the rod cover 21, which is fixed to the piston rod 17 of the first stage cylinder 19.

The pressurized air in the pipe 95 is supplied through a pressure-reducing valve 103 to an electropneumatic converter 104 where it is converted into a pneumatic signal of a pressure in accordance with an electrical signal from the signal generator 31. This pneumatic signal is supplied by way of a pipe 105 to a diaphragm chamber 106 to determine a displaced position of the shield plate 99. By the displacement of the shield plate 99, the air discharges from the nozzles 97 and 98 are controlled, whereby the manner in which air from the pipes 93 and 94 are supplied to the supply-discharge pipes 14 and 15 and the manner in which air is discharged from the pipes 15 and 15 are controlled, and the first-stage cylinder 19 shown in FIG. 1 is operated as a servo-cylinder.

On the other hand, the pressurized air in the pipe line 96 is supplied to a changeover valve 33. This changeover valve 33 comprises an electromagnetic changeover valve, for example, wherein solenoids 33*a* and 33*b* operate in accordance with an electrical signal from the signal generator 31 to carry out valve changeover. As a result of the changeover operation of the valve 33, the pressurized air is suppled to the supply-discharge pipe 23 or 28. At this time, the supply-discharge pipe which is not supplied with pressurized air is communicative by way of the changeover valve 33 with the atmosphere. Therefore, the second-stage cylinder is activated only by the existence or absence of the supply of pressurized air and operates as an on-off cylinder.

FIG. 6 illustrates an embodiment of a control system in the case where an oil is used as the driving fluid. Pipes 111 and 112 from an oil pressure source 110 are connected by way of a servovalve 113 to the supply-discharbe pipe 14 or 15. On the other hand, position detection of the piston rod 17 of the first-stage cylinder 19 is carried out by a position detector 114 comprising a differential transformer in accordance with the displacement of a position detecting member 101 fixed to the rod cover 21 which is fixed in turn to the piston rod 17 of the first-stage cylinder 19.

A servo-amplifier 115 receives an electrical signal from the signal generator and the detection output of the position detector 114 to produce a resulting output whereby the servovalve 113 is controlled, and supplying and discharging of pressurized oil through the supply-discharge pipes 14 and 15 are so carried out that the piston rod **17** of the first-stage cylinder **19** moves accurately to the position designated by the signal from the signal generator **31.** Accordingly, the first-stage cylinder operates as a servo-cylinder.

On one hand, pipes **116** and **117** are connected between the oil pressure source **110** and the changeover valve **33.** The changeover valve **33** is caused to carry out changeover switching of connections of supply-discharge pipes **23** and **28** and pipes **116** and **117** by solenoids **33***a* and **33***b* activated by a signal from the signal generator **31.** Accordingly, the second-stage cylinder is operated only in accordance with whether or not pressurized oil is being supplied thereto and operates as an on-off cylinder.

Further, this invention is not limited to these embodiments but various variations and modifications may be made without departing from the scope and spirit of the invention.

What we claim is:

1. A multistage cylinder having at least a first-stage cylinder and a second-stage cylinder, in which: the first-stage cylinder comprises

a first cylinder tube,

a head cover fixed to one end of the first cylinder tube,

a first piston of disc shape slidably disposed within the first cylinder tube,

a first piston rod of tubular shape fixed at one end thereof to the first piston,

a first rod cover fixed to the other end of the first cylinder tube and having a hole through which the first piston rod slidably extends,

a first supply-discharge pipe constituting a communicative passage through the head cover from outside of the multistage cylinder to a first space defined within the first cylinder tube by the head cover and the first piston and functioning to supply and discharge a fluid to and from said first space, and

a second supply-discharge pipe constituting a communicative passage through the first rod cover from outside of the multistage cylinder to a second space defined within the first cylinder tube by the first piston and the first rod cover and functioning to supply and discharge a fluid to and from said second space,

the supply and discharge of the fluid through the first and second supply-discharge pipes being carried out in a mutually interrelated manner; and

the second-stage cylinder comprises

a second cylinder tube disposed within the first piston rod with a specific clearance space therebetween and fixed at one end thereof to the first piston,

a second piston of disc shape slidably disposed within the second cylinder tube,

said second cylinder tube being provided with an opening near the part thereof fixed to the first piston, said opening for communicating a third space defined within the second cylinder tube by the first piston and the second piston with the specific clearance space,

a clearance member for maintaining a clearance between the first and second pistons so that the second piston does not close the opening of the second cylinder tube when the second piston is slid to the closest position to the first piston.

a second piston rod fixed at one end thereof to the second piston,

a second rod cover fixed to the other ends of the first piston rod and the second cylinder tube and having a hole through which the second piston rod slidably extends,

a third supply-discharge pipe constituting a communicative passage to the specific clearance space from outside of the multistage cylinder and functioning to supply and discharge a fluid to and from said third space through the specific clearance space, and

a fourth supply-discharge pipe constituting a communicative passage through the second rod cover from outside of the multistage cylinder to a fourth space defined within the second cylinder tube by the second piston and the second rod cover and functioning to supply and discharge a fluid to and from said fourth space,

the supply and discharge of the fluid through the third and fourth supply-discharge pipes being carried out in a mutually interrelated manner and in an individual manner with respect to the first and second supply-discharge pipes.

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