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(71) Applicant: **Kao, Haw-Ran**
2 Fl., No. 64, Lane 103, Nei Hu Road, Sec. 2
Taipei(TW)

(72) Inventor: **Kao, Haw-Ran**
2 Fl., No. 64, Lane 103, Nei Hu Road, Sec. 2
Taipei(TW)

(74) Representative: **Williams, John Francis et al**
WILLIAMS, POWELL & ASSOCIATES 34
Tavistock Street
London WC2E 7PB (GB)

(54) Cylinder with multiple pistons.

(57) A cylinder having a plurality of cylinder chambers of which each one contains a piston mounted on a common piston rod produces an output force larger than a conventional cylinder unit with one cylinder chamber containing one piston of the same diameter does. The cylinder unit has a first fluid supply passage for simultaneously supplying a working fluid to an acting side of the piston in each one of the plurality of cylinder chambers for performing a power stroke of the piston rod, and a second fluid supply passage for supplying the same working fluid to a back side of the piston in only one of the plurality of the cylinder chambers for performing a return stroke of the piston rod. The piston rod moves faster in the return stroke than it does in the power stroke to perform a quick return.

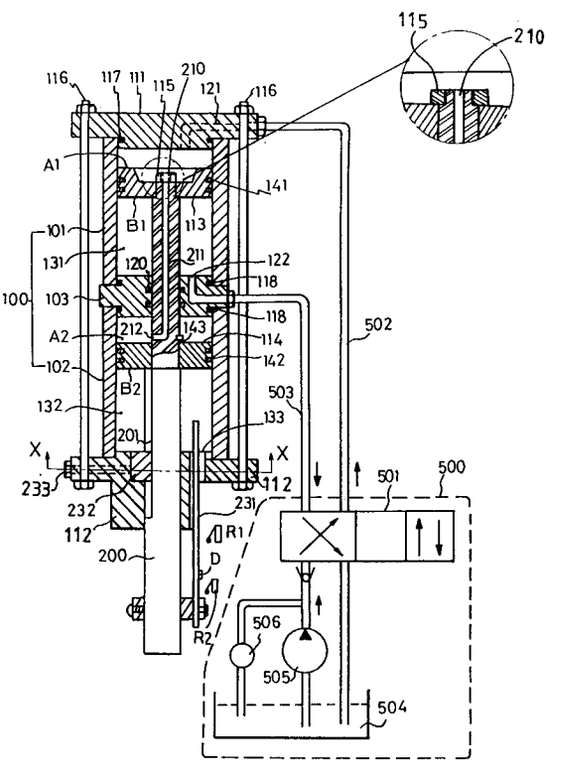

FIG.1

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This invention relates to a piston/cylinder device operating with a working fluid. Conventionally, a single piston is mounted on a single piston rod in a cylinder.

In such conventional cylinders, when one wishes to increase the power (output) produced by the cylinder, there are only two alternatives; one is to increase the pressure of the working fluid, and another is to enlarge the diameter of the cylinder. Nevertheless, a problem arises when the pressure of the working fluid is increased because the increase of the pressure of the working fluid will require a re-design of the entire system to assure that the piping system of the working fluid supply system can withstand the increased pressure of the working fluid, and at the same time, the cylinder body, the cylinder cover, and the seals must also be re-designed to assure that they withstand the increased pressure. When the diameter of the cylinder is enlarged, one must investigate and assure that the cylinder covers withstand the total pressure exerted on the cylinder covers because of the increase of the cylinder diameter, or the cross-sectional area (an effective acting area) of the cylinder, and such an enlargement of the cylinder diameter also requires additional space for accommodating the entire cylinder unit.

In view of the aforementioned problems with conventional cylinder, the present invention offers a new and improved cylinder having multiple pistons which provides more power without the need of increase in the pressure of working fluid or the enlargement of the cylinder diameter.

Accordingly, the invention proposes a piston/cylinder device which has a cylinder unit provided with a partition member or partition members to define a plurality of cylinder chambers arranged in series in axial alignment, and a plurality of pistons, each one of which is slidably contained in one of the plurality of cylinder chambers, fixedly mounted on to a common piston rod which slidably passes through the partition members and one of two cylinder covers. The cylinder is also provided with a first fluid supply passage for supplying a working fluid to each cylinder chamber to act on an acting side of each piston, and a second fluid supply passage for supplying the working fluid to one of the cylinder chambers to act on an opposite side of the piston in the same one of the cylinder chambers. The cylinder chambers other than the above said one cylinder chamber are each provided with a vent hole which communicates the space facing the opposite side of the piston in the respective cylinder chamber with the outside of the cylinder.

In a preferred embodiment of the cylinder of this invention, the above-mentioned first fluid supply passage includes a first passage hole in the cylinder cover at one end of a first cylinder chamber of the cylinder, and a central hole axially provided in the piston rod and openings provided in the piston rod to communicate the space of each cylinder chamber facing the acting side of each piston with the central hole. In this embodiment, the second fluid supply passage includes a second passage hole provided in the partition member at an opposite end of the first cylinder chamber.

In another embodiment of the cylinder of this invention, the first fluid supply passage includes a piping which communicate the spaces facing the acting sides of the pistons in the plurality of cylinder chambers, and the second fluid passage includes a passage hole provided in the partition member facing the back side of the piston of one of the plurality of cylinder chambers.

When a working fluid is supplied from a working fluid supply system through the first fluid passage, the working fluid is admitted to all spaces facing the acting sides of the pistons in all of the plurality of cylinder chambers to push the piston rod to move outwards. The piston rod thus produces an output force equivalent to the sum of the force exerted on all pistons. When the working fluid is supplied from the working fluid supply system through the second fluid supply passage to the space facing the back side of the piston on one of the plurality of cylinder chambers, the piston rod is forced to move in a reversed direction to perform a return stroke, while the working fluid previously admitted to the spaces facing the acting sides of the pistons in the cylinder chambers are allowed to return through the first fluid passage to the working fluid supply system. In such return stroke, the rate of supply of the working fluid from the working fluid supply system remains the same as that in the working stroke, however; working fluid is supplied to only one cylinder chamber in the return stroke while the same amount of the working fluid is supplied to the plurality of cylinder chambers in the power stroke, therefore, the piston moves faster in the return stroke in comparison with the power stroke so as to perform a quick return.

Exemplary embodiments of the invention will now be described, and contrasted with the prior art.

Fig. 1 is a longitudinal cross-sectional view of the cylinder of a first embodiment of this invention, with a schematic illustration of a working fluid supply system.

Fig. 2 is a schematic drawing of the working fluid supply system showing the switching valve in a return stroke position.

Fig. 3 is a schematic cross-sectional drawing of a lower part of the cylinder to show a device to prevent the piston from rotating.

Fig. 4 is a longitudinal cross-sectional view of the cylinder of a second embodiment of this inven-

tion

Fig. 5 is a longitudinal cross-sectional view of the cylinder of a third embodiment of this invention.

Fig. 6 is a cross-sectional view of a conventional cylinder.

Fig. 7 is a cross- sectional view of another conventional cylinder.

A conventional cylinder, as shown in Fig. 6, for operating a mechanical member or a device is generally provided with a cylindrical cylinder body having flanges 10A and 10B at opposite two ends, wherein each end is covered by a cylinder cover or fixedly connected with cylinder body 10 by means of bolts 16. Each one of cylinder cover 11 and 12 is respectively provided with a fluid passage hole 21 or 22 to be connected to a working fluid supply system with an appropriate piping to enable the entry or exit of the working fluid from or to the working fluid supply system. Cylinder body 10 contains therein a piston 13 provided with a piston rod 14 which is fixedly fastened to piston 13 by means of a nut 15, piston 13 being provided with piston rings 19 to maintain a slidable, sealed contact with the inner well of the cylinder body 10. Piston rod 13 passes through a cylinder cover 12 with a seal 18 provided between cover 12 and piston rod 13 to form a slidable, sealed contact. In operation, a working fluid which may be a hydraulic oil, is supplied through passage hole 21 of a cylinder cover 11 to a working chamber 31 of cylinder body 10 to act on an acting side A of piston 24 so as to push piston rod downwardly to perform a power stroke. As soon as the power stroke is completed, the supply of the working fluid is changed by a switching valve, not shown, such that the working fluid is supplied through passage hole 22 of another cylinder cover 12 into cylinder chamber 21 to act on the back side B of piston 13 to perform a return stroke and at the same time the working fluid in the working chamber 31 is forced to return to the working fluid supply system through passage hole 21 of cylinder cover 11. During the return stroke, the rate of the supply of working fluid to cylinder chamber 32 is approximately the same as that of the working fluid supply to the working chamber 31 during the power stroke, therefore the speed of piston 13 at the return stroke is about the same of that of the power stroke.

Fig. 7 shows another conventional cylinder which is provided with cylinder covers 11 and 12 connected to the cylinder body 10 by means of tie bolts 16A, and the flanges 10A and 10B of the cylinder shown in Fig. 6 are eliminated; however, its operation is the same as the cylinder of Fig. 6.

By contrast the invention will now be described with reference to the other drawings.

As shown in Fig. 1. the cylinder of this invention includes a cylinder unit 100 which is composed of a first cylinder body 101, a partition member 103, and a second cylinder body 102 assembled into one unit with partition member 103 disposed in between the first cylinder body 101 and the second cylinder body 102 to define two cylinder chambers, namely a first cylinder chamber 131 and a second cylinder chamber 132, in series in an axial direction. Cylinder unit 100 is provided with a first cylinder cover 111 at one end (an upper end) and a second cylinder cover 112 at another end (a lower end), the first cylinder cover 100 and the second cylinder cover are assembled to cylinder unit 100 with a plurality of tie bolts 116. It should be understood in this embodiment the flanges 10A and 10B of conventional cylinder shown in Fig. 6 are eliminated; however, the first cylinder body 101 and second cylinder body 102 may be provided with such flanges and fastened together by appropriate bolts. A seal 117 is provided between first cylinder cover 111 and first cylinder body 101; similarly, seals 118 are provided between the partition member 103 and the first cylinder body 101 arid second cylinder body 102. Each one of partition member 103 and second cylinder cover 112 has a central hole for allowing a piston rod 200 to slidably pass therethrough, with sealing members 120 provided between the partition member 103 and piston rod 200 to form a sealed, slidable contact. In first cylinder chamber 131 is disposed a first piston 113 which is fixedly mounted onto an upper end of piston 200 by fitting first piston 113 on the upper end of piston 200 having a shoulder to position first piston 113. A nut 115 is used to engage with a threaded part, not shown, extending from the upper end of piston rod 200 to fasten first piston 113 in place. Piston rings 141 are provided around first piston 113 to provide a slidable and sealed contact between piston 113 and first cylinder body 101. Similarly, in second cylinder chamber is disposed a second piston 114 which is also fixedly mounted onto piston rod 200 with piston rings 142 provided around piston 114 to form a slidable, sealed contact between second piston 114 and second cylinder body 102. Second piston 114 is positioned against a shoulder formed on piston rod 200 and retained in place by a clip 143. First piston 113 has an acting side A1 and back side B1, similarly, second piston 114 has an acting side A2 and a back side B2. First cylinder cover 111 is provided with a first passage hole 121 open to the space in first cylinder chamber 131 facing acting side A1 of first piston 113, and partition member 103 is provided with a second passage hole 122 open to the space in first cylinder chamber 131 facing the back side B1 of first piston 113. First passage hole 121 and second passage hole 122 are connected respectively to a working fluid supply system 500 with first supply pipe 502

and second supply pipe 503, the working fluid supply system 500 including a hydraulic pump 505, a reservoir 504, an unloading valve 506 and a switching valve 501.

Piston rod 200 has a central hole 211 having first opening 210 at the upper end of piston rod 200 and a second opening 212 at the vicinity of acting side A2 of second piston 114, so that the space facing acting side A1 of first piston 113 in first cylinder body 101 always communicates with the space facing acting side A2 of second piston 114 in second cylinder body 102.

Second cylinder cover 112 has a vent hole 133 which communicates the space in second cylinder chamber 132 facing back side B2 of second piston 114 with the outside of cylinder unit 100. Vent hole 133 also allows an elongate rod 231 mounted onto a lower part of piston rod 200 and parallel with piston rod 200to extend through vent hole 133, the elongate rod 231 carrying a dog D for operating an upper limit switch R1 arid a lower limit switch R2. The upper limit switch R1 is adapted to operate a control circuit, not shown, in one way when piston rod 200 has moved to a predetermined upper position, an the lower limit switch R2 is adapted to operate the control circuit in another way when piston rod 200 has moved to a predetermined lower position.

Second cylinder cover 112 is optionally provided with a stopper block 232 to slidably engage with a flat part 201 formed on one side of piston rod 200 as shown in Fig. 3, so as to prevent piston rod 200 from rotating. Stopper block 232 is retained in place by a bolt 233.

In operation, hydraulic fluid in reservoir 504 is pressurized by hydraulic pump 505 and supplied to first passage hole 121 through switching value 501 and first supply pipe 502, whereby the pressurized hydraulic fluid is supplied to the space facing acting side A1 of first piston 113 in first cylinder chamber 131 through first passage hole 121; then the pressurized hydraulic fluid is further admitted to the space facing acting side A2 of second piston 114 in second cylinder body 102 through first opening 210 at the upper end of piston rod 200, central hole 211, and second opening 212 at the acting side A2 of second piston 114 in second cylinder chamber 132. As a result first piston 113 and second piston 114 are pushed by the pressurized hydraulic fluid to produce a force which is equivalent to the sum of the total pressure applied to the area of acting side A1 of first piston 113 and the total pressure applied to the area of acting side A2 of second piston 114, the force being exerted on piston rod 200 to move outwards to perform a power stroke. At the same time, the fluid in the space facing back side B1 of first piston 113 in first cylinder chamber 131 is allowed to return to reservoir 504 through second passage hole 122, second supply pipe 503 and switching valve 501, and the air in the space facing back side B2 of second piston 114 is allowed to escape through vent hole 133 in second cylinder cover 112.

In this power stroke, an output which is two times larger than the output of a conventional cylinder of the same diameter is produced.

As soon as the power stroke is finished, hydraulic pump 504 stops and the supply of the pressurized hydraulic fluid is stopped.

When switching valve 501 is operated to the position shown in Fig. 2 and hydraulic pump 501 is re-started, the pressurized hydraulic fluid is supplied to second passage hole 122 in partition member 103 through switching valve 501 and second supply pipe 503, whereby the pressurized hydraulic fluid is admitted to the space facing back side B1 of first piston 113 in first cylinder chamber 131, to act on back side B1 of first piston 113, to produce a force equivalent to the total pressure of the pressurized hydraulic fluid applied on the area of back side B1 of first piston 113 in first cylinder chamber 131, the fore being exerted onto piston rod to move inwards, to perform a return stroke. At the same time the fluid in the space facing acting side A2 of second piston 114 in second cylinder chamber 132 is caused to return to reservoir through second opening 212, central hole 211, first opening 210, first passage hole 121, first supply pipe 502. and switching valve 501; and the fluid in the space facing acting side A1 of first piston 113 is caused to return to reservoir 504 through first passage hole 121. first supply pipe 502, and switching value 501.

During the above described return stroke, hydraulic pump 505 supplies the pressurized hydraulic fluid at the same rate (a certain volume per minute) as in the power stroke, and the fluid is only supplied to second cylinder chamber 132 while in the power stroke the fluid is supplied to first cylinder chamber 131 and second fluid chamber 132, thus piston rod 200 moves two times faster than that moves in the power stroke. As a result a "quick return" of piston rod is performed.

As soon as the return stroke is finished, the hydraulic pump 505 stops and the supply of the pressurized hydraulic fluid is stopped.

A second embodiment of the present invention will now be described with reference to Fig. 4.

In the second embodiment, cylinder unit 100 is composed of a first cylinder body 101, a first partition member 103 having one side fitted onto one end of first cylinder body 101, a second cylinder body 102 having one end fitted on an opposite side of first partition member 103, a second partition member 105 having one side fitted onto an opposite, second end of second cylinder body

102, and a third cylinder body 104 having one end fitted onto an opposite side of second partition member 105. A fist cylinder cover 111 is fitted onto an opposite end of first cylinder body 101, and a second cylinder cover 112 is fitted onto an opposite end of third cylinder body 104. Tie bolts 116 are used to fasten first cylinder cover 111, first cylinder body 101, first partition member 103, second cylinder body 102, second partition member 105, third cylinder body 104, and second cylinder cover 112 together to define three cylinder chambers, namely, first cylinder chamber 131, second cylinder chamber 132, and third cylinder chamber 152 in series in an axial direction.

First cylinder cover 111, first cylinder body 101, first piston 113, second cylinder body 102, second piston 114, and second cylinder cover 112 are identical with those of the above described first embodiment shown in Fig. 1, and first partition member 103 is the same partion member 103 of the first embodiment; their constructions are the same and the description of these parts will be omitted.

Third cylinder body 104 contains a third piston 151 which is fixedly mounted at a predetermined position on piston rod 200 which slidably passes a central hole provided in first partion member 103 and a central hole provided in second partion member 105, and is retained in place with a clip 144. Third piston 151 has an acting side A3 and an opposite, back side B3, and also piston rings 145 to provide a slidable, sealed contact with the inner wall of third cylinder body 104.

Piston rod 200 has a central hole 211 having a first opening 210 and a second opening 212 as the piston rod 200 of the fist embodiment, and a third opening 213 at the vicinity of acting side A3 of third piston 151. First opening 210, central hole 211. second opening 212, and third opening 213 are adapted to communicate the space facing acting side A1 of first piston 113 in first cylinder chamber 131, the space facing acting side A2 of second piston 114 in second cylinder chamber 132, and the space facing acting side A3 of third cylinder chamber 152 with each other.

Second partition member 105 has a vent hole 123 communicating the space facing back side B2 of second piston 114 of second cylinder chamber 132 with outside of cylinder unit 100. Seals 128 are provided at the joints of second partition member 105 and second cylinder body 102 and third cylinder body 104 to assure a fluid-tight connection between these parts.

Seals 129 are provided in the central hole of second partition member 105 to assure a sealed, slidable contact between piston rod 200 and second partition member 105.

In operation, the pressurized hydraulic fluid is supplied to first passage hole 121 in first cylinder cover 111 through first supply pipe 502, whereby the pressurized hydraulic fluid is supplied to the space facing acting side A3 of third piston 151 in third cylinder chamber 152 through first opening 210, central hole 211 and third opening 213; the space facing acting side A2 of second piston 114 in second cylinder chamber 132 through first opening 210, central hole 211, and second opening 212; and the space facing acting side A1 of first piston 113 in first cylinder chamber 131. The pressurized hydraulic fluid thus acts simultaneously on acting side A1 of first piston 113, acting side A2 of second piston 114, and acting side A3 of third piston 151, to produce a force equivalent to the sum of the total pressure of the pressurized hydraulic fluid acting on the areas of acting cides A1, A2 of A3 of first piston 113, second piston 114, and third piston 151. Such force is exerted on piston rod 200 to cause piston rod 200 to move outwards, to perform a power stroke. In this power stroke, an output which is three times larger than the output of a conventional cylinder of the same diameter is produced.

During the power stroke, the fluid in the space facing back side B1 of first piston 113 in first cylinder chamber 131 is caused to return to reservoir through second passage hole 122 in first partion member 103 and second supply pipe 503; the air in the space facing back side B2 of second piston 114 in second cylinder chamber 132 is allowed to escape through vent hole 123 in second partition member 105, and the air in the space facing back side B3 of third piston 151 is allowed to escape through vent hole 133 in second cylinder cover 112.

The return stroke is performed in the same manner as that in the first embodiment; however, in the second embodiment the speed of the return stroke will be about three times faster than the speed of the power stroke.

Fig. 5 shows a third embodiment of this invention. In this embodiment, a third passage hole 321 is provided in second partition partion member 103 of the cylinder unit 200 of the above described second embodiment of Fig. 4, and a first piping 508 connecting third passage hole 321 with first supply pipe 502 is provided to communicate the space facing acting side A2 of second piston 114 in second cylinder chamber 132 with the space facing acting side A1 of first piston 113 of first cylinder chamber 131 through first passage hole 121 in first cylinder cover 111; at the same time a fourth passage hole 313 is provided in second partition member 105 of the second embodiment and a second piping 507 is provided to connect fourth passage hole 313 with first piping 508, so

that the space facing acting side A3 of third piston 151 in third cylinder chamber 152 also communicates with the space facing acting side A2 of second piston 114 in second cylinder chamber 132 and the space facing acting side A1 of first piston 113 in first cylinder chamber 131 though first piping 508 and second piping 507. The first opening 210, central hole 211, second opening 212, and third opening 213 of piston rod of the cylinder unit 100 of the second embodiment are replaced by third passage hole 321, fourth passage hole 313, first piping 508, and second piping 507 in the third embodiment. The remaining parts of the cylinder of the third embodiment are the same as the corresponding parts of cylinder of the second embodiment of Fig. 4.

The operation of the cylinder of the third embodiment is the same as that of the cylinder of the second embodiment.

While the preferred embodiments of the cylinder with multiple pistons of this invention have been described as above; however, it should be understood that the above embodiments are for illustration purposes and are not intereded to be considered as limitations to the scope of this invention. Modifications are possible without departing from the scope of this invention as defined in the appended claims.

Claims

1. A cylinder operable with a working fluid, comprising:

a cylinder unit comprising a plurality of cylinder bodies and a partition member between a first cylinder body and a second cylinder body to define a plurality of cylinder chambers arranged in series in an axial direction, each one of said plurality of cylinder bodies containing one piston having an acting side and an opposite, back side;

a first cylinder cover fixedly connected to a first end of said cylinder unit;

a second cylinder cover fixedly connected an opposite, second end of said cylinder unit;

a piston rod slidably passing through a central hole in said partition member and a central hole in said second cylinder cover, said piston in each one of said plurality of cylinder bodies being fixedly mounted on said piston rod;

a first fluid supply passage for simultaneously supplying the working fluid from a working fluid supply system to each one of said cylinder chambers to act on said acting side of each piston in said plurality of said cylinder bodies; and

a second fluid supply passage for supplying the working fluid from said working fluid supply system to said first cylinder body to act on said back side of said piston in said first cylinder body.

2. A cylinder as recited in claim 1, wherein: said first cylinder cover is fixedly connected to one end of said first cylinder body and said first fluid supply passage comprises:

a first passage hole in said first cylinder cover for communicating a space facing said acting side of said piston in said first cylinder body with a first fluid supply pipe,

a central hole in said piston rod having a plurality of openings respectively open to a space facing said acting side of said piston in each one of said plurality of cylinder bodies;

said second fluid supply passage comprises a second passage hole in said partition member for communicating a space facing said back side of said piston in said first cylinder body with a second fluid supply pipe.

3. A cylinder as recited in claim 1, wherein said first cylinder cover is fixedly connected to one end of said first cylinder body, and said first fluid supply passage comprises:

a first passage hole in said first cylinder cover for communicating a space facing said acting side of said piston in said first cylinder body with a first fluid supply pipe, and

piping means for communicating the space facing said acting side of said piston in each one of said plurality of cylinder bodies with each other;

and wherein:

said second fluid supply passage comprises a second passage hole in said partition member for communicating a space facing said back side of said piston ill said first cylinder body with a second fluid supply pipe.

4. A cylinder as recited in claim 2 or 3, wherein said second cylinder cover has an air vent hole and said piston rod has an outer portion extending from said second cylinder cover, said outer portion being provided with an elongate rod parallel with said piston rod and extending through said air vent hole of said second cylinder cover, said elongate rod having a dog for operating a limit switch.

5. A cylinder as recited in claim 2 or 3, wherein said second cylinder cover is provided with a stopper block to slidably engage with a flat surface formed on said piston rod to prevent said piston rod from rotation.

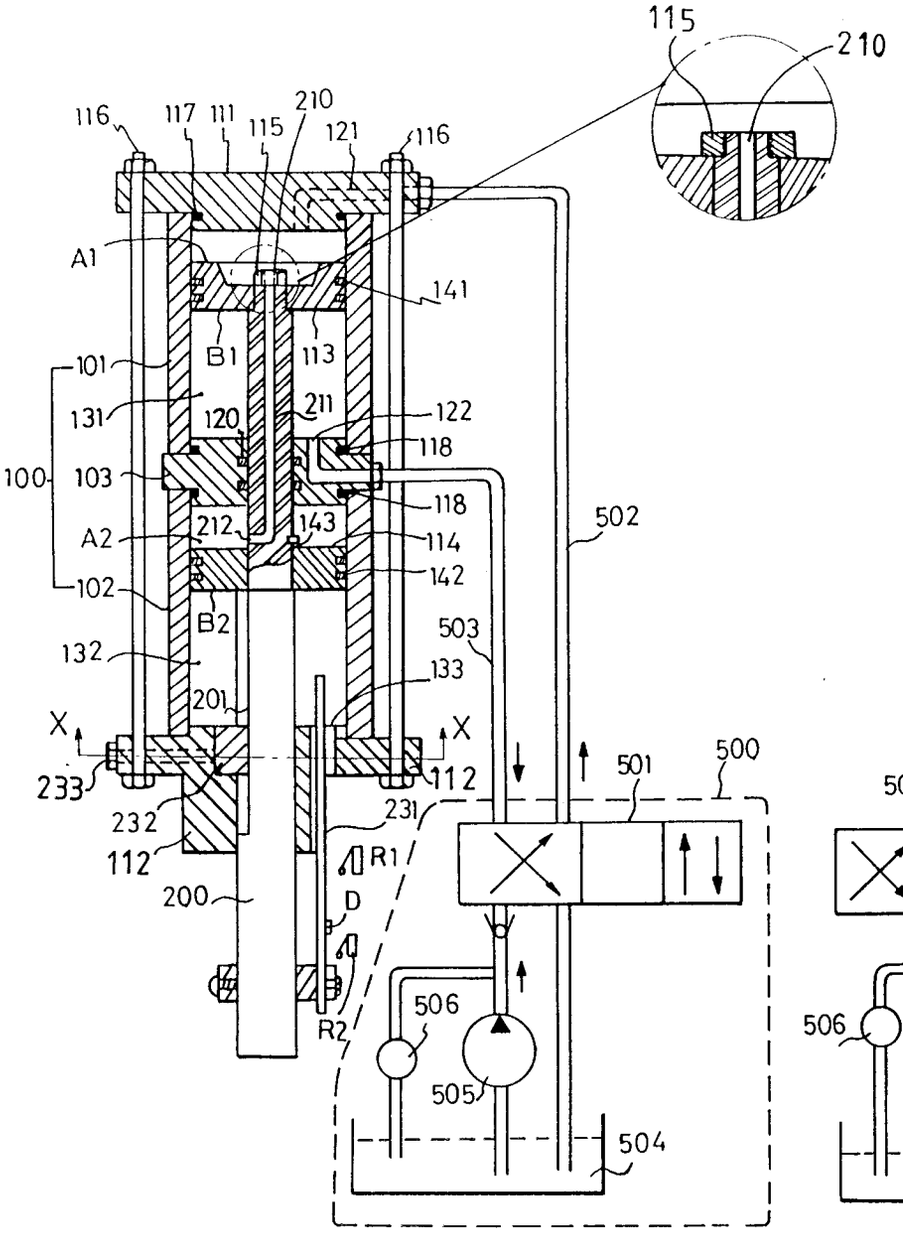

FIG.1

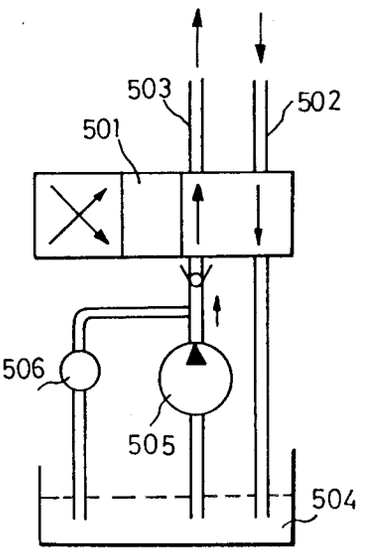

FIG.2

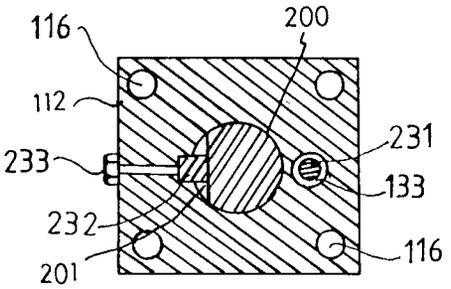

FIG.3 (Section X—X)

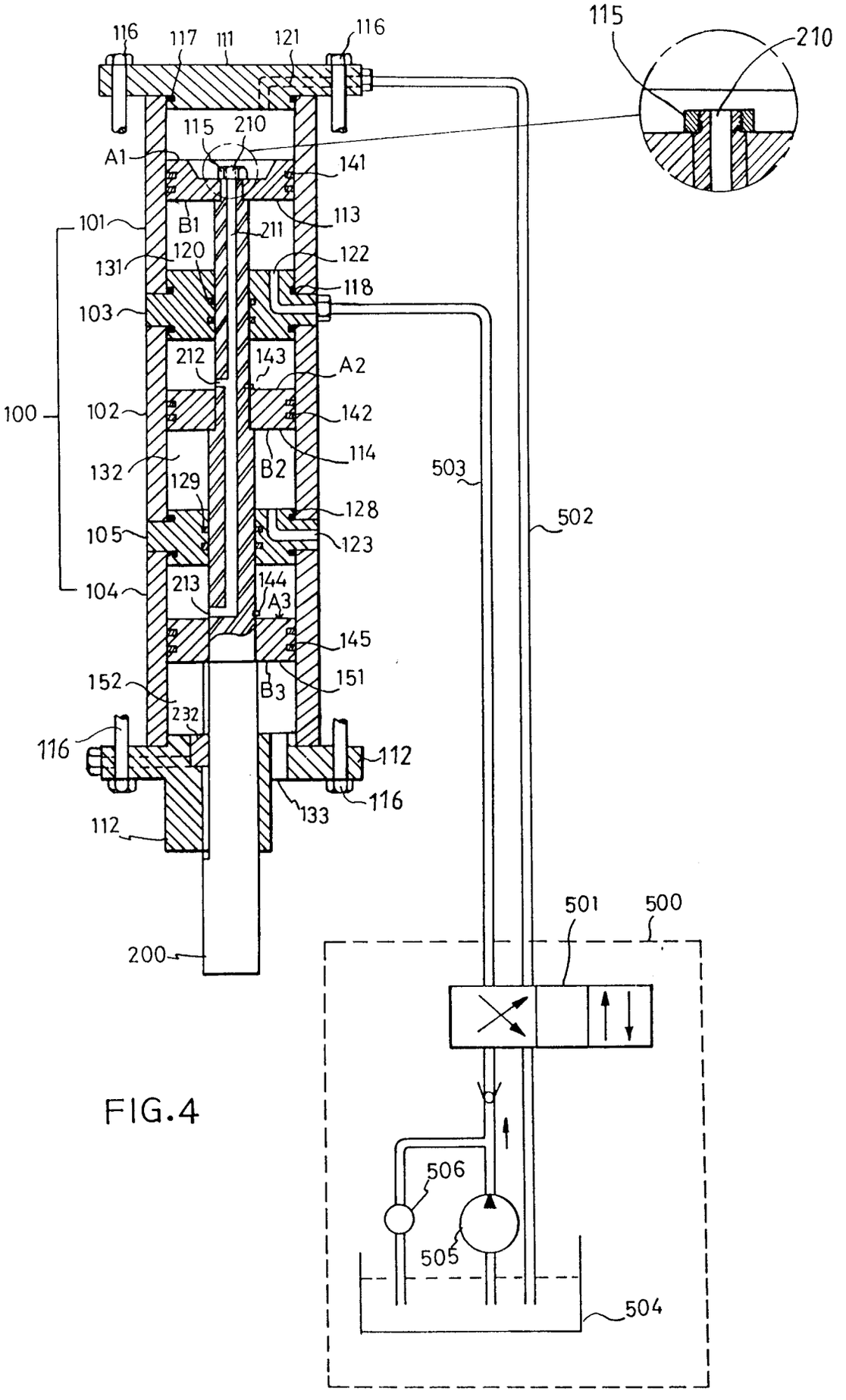
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FIG.4

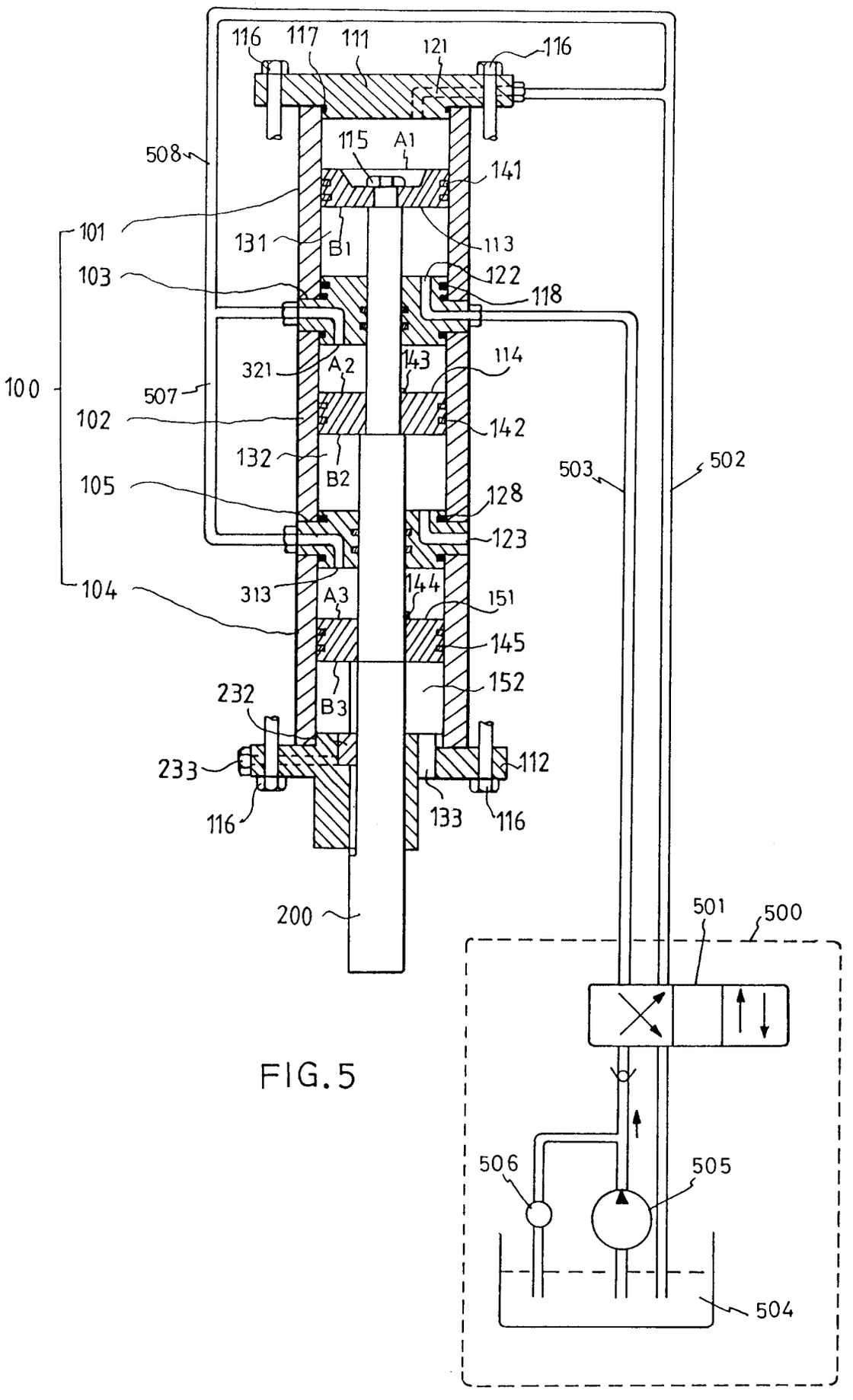
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FIG.5

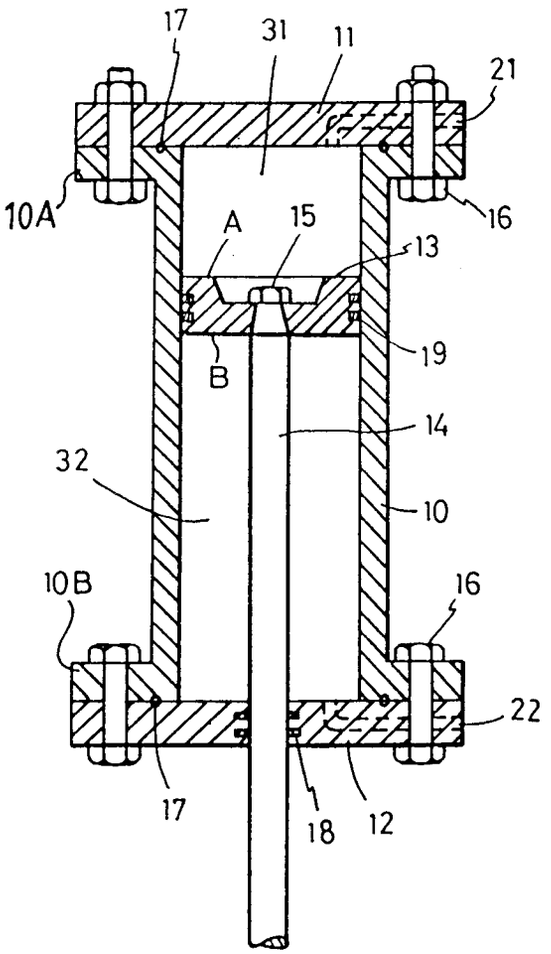
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FIG. 6

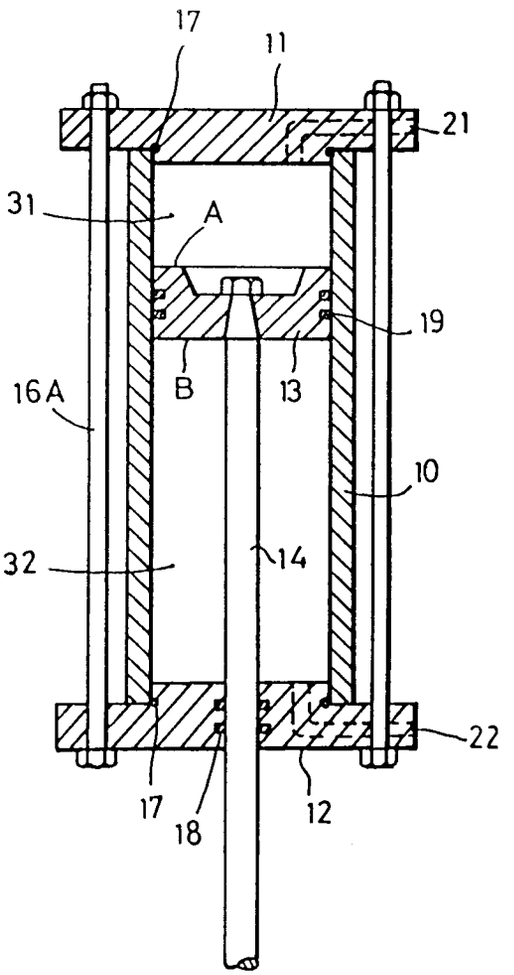
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FIG. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 30 7748

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	FR-A-2 529 624 (WACK) * the whole document *	1-5	F15B15/14
X	DE-U-8 901 476 (TUNKERS) * the whole document *	1-5	
X	US-A-2 956 549 (MALPASS) * the whole document *	1-5	
A	DE-U-9 111 366 (HAGMANN)		
A	US-A-3 485 141 (OTT)		
A	US-A-3 457 841 (TREGASKISS)		
A	FR-A-1 603 850 (FIAT)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
F15B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	08 MARCH 1993	KNOPS J.

CATEGORY OF CITED DOCUMENTS

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