

May 22, 1962

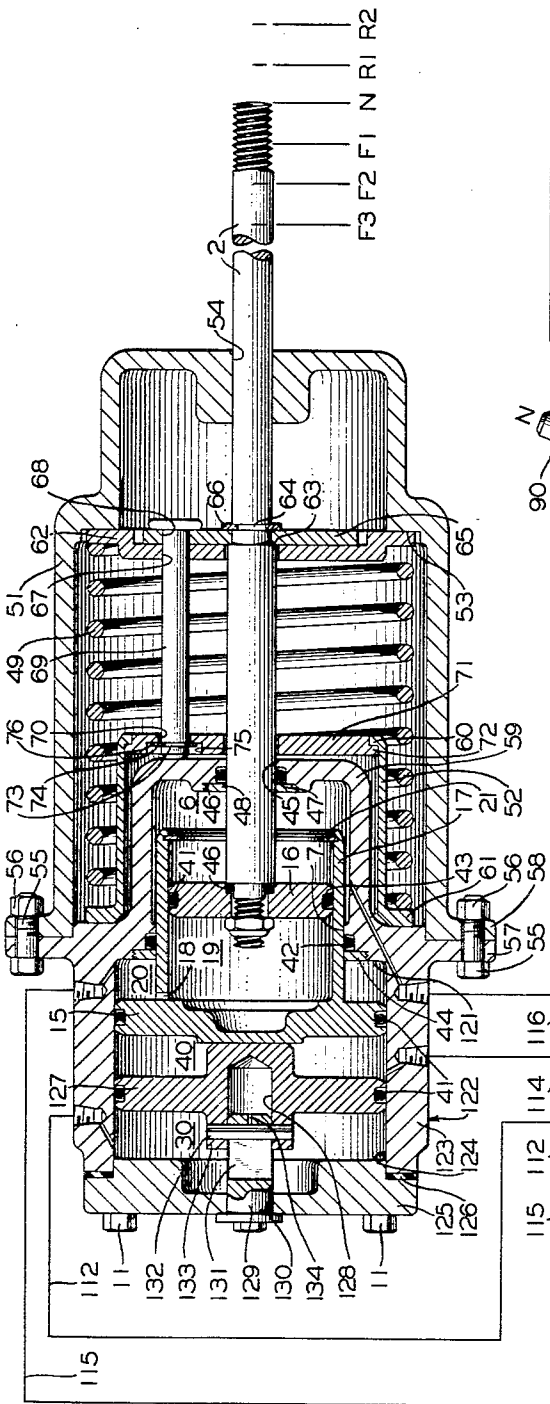
E. E. HEWITT

3,035,549

MULTI-POSITION POWER CYLINDER AND CONTROL MEANS THEREFOR

Filed May 26, 1959

4 Sheets-Sheet 2



POWER PISTON POSITION	CHAMBERS IN FLUID MOTOR					
	30	40	20	6		
R2		X				
R1	X		X			
N	X					
F1	X	X			X	X
F2	X				X	X
F3						X

X-INDICATES PRESSURIZATION
OF CHAMBER

FIG. 5

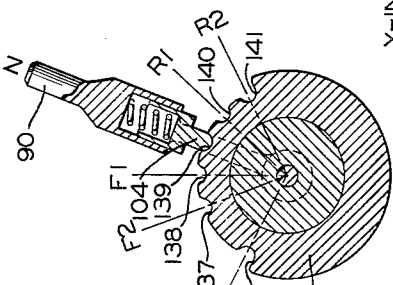


FIG. 6

FIG. 4

INVENTOR.

Ellis E. Hewitt

BY

Adelbert A. Steinmiller
Attorney

May 22, 1962

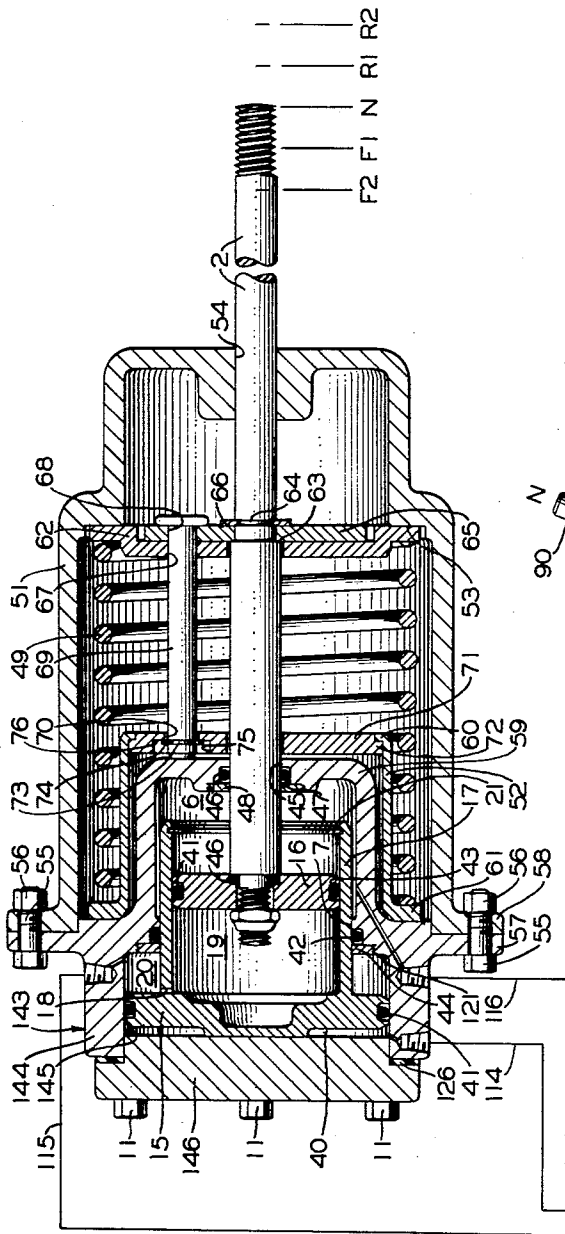
E. E. HEWITT

3,035,549

MULTI-POSITION POWER CYLINDER AND CONTROL MEANS THEREFOR

Filed May 26, 1959

4 Sheets-Sheet 3



POWER PISTON POSITION	CHAMBERS IN FLUID MOTOR			
	40	20	6	
R2	X	X		
R1		X		
N				X
F1	X			X
F2				X

X-INDICATES PRESSURIZATION
OF CHAMBER

FIG. 9

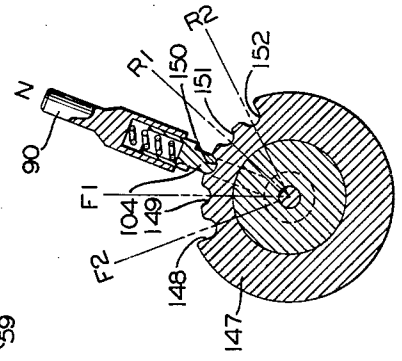


FIG. 8

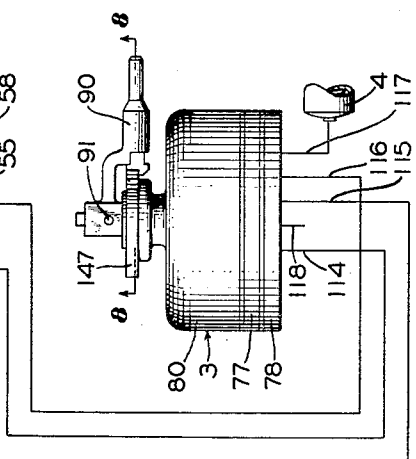


FIG. 7

INVENTOR.
Ellis E. Hewitt
BY
Adelbert A. Steinmiller
Attorney

May 22, 1962

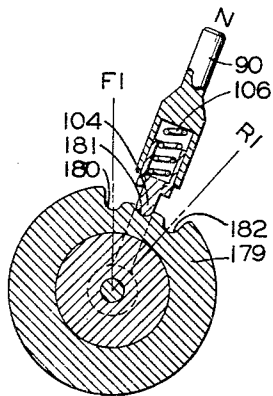
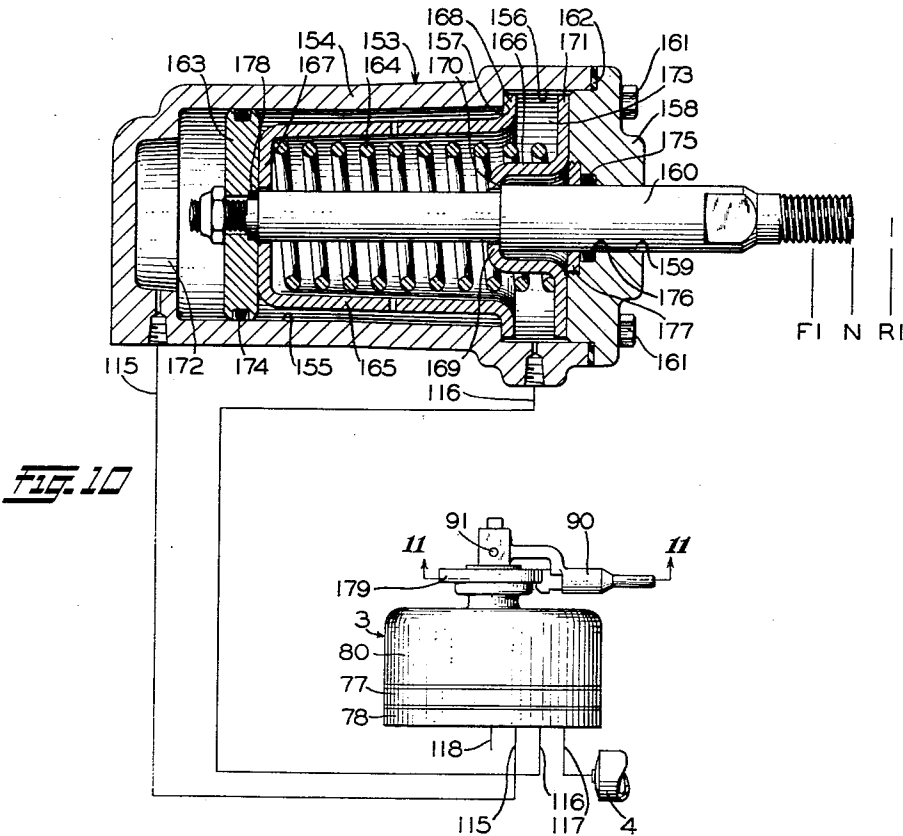
E. E. HEWITT

3,035,549

MULTI-POSITION POWER CYLINDER AND CONTROL MEANS THEREFOR

Filed May 26, 1959

4 Sheets-Sheet 4



POWER PISTON POSITION	CHAMBERS IN FLUID MOTOR	
	172	173
RI	X	
N		
FI		X

X-INDICATES PRESSURIZATION
OF CHAMBER

FIG. 12

INVENTOR.

Ellis E. Hewitt

BY

Adelbert A. Steinmiller
Attorney

1

3,035,549

MULTI-POSITION POWER CYLINDER AND CONTROL MEANS THEREFOR

Ellis E. Hewitt, Ruffsedale, Pa., assignor to Westinghouse Air Brake Company, Wilmerding, Pa., a corporation of Pennsylvania

Filed May 26, 1959, Ser. No. 815,966

13 Claims. (Cl. 121—38)

This invention relates to a multi-position power cylinder with control means therefor, and more particularly to a multi-position power cylinder of the type selectively operable by fluid pressure to any one of a plurality of fixed positions.

There are presently on the market a number of well-known multi-position fluid motors of the type having one or more cooperating pistons and pressure chambers, one or more of the pressure chambers being selectively charged with fluid under pressure to correspondingly position a piston rod rigidly connected to one of the pistons in different positions along a given line.

Some of the power cylinders or fluid motors of the above-mentioned type are very cumbersome, heavy, complicatedly constructed and relatively expensive to build and maintain. It is well known that some of these fluid motors have springs for restoring or returning them to a so-called neutral position, and others require that fluid under pressure be supplied to one or more of the pressure chambers therein to return them to their so-called neutral position. In the case of the former, the springs are often large and heavy, and in case of the latter, in the event of the loss of the supply of the actuating fluid under pressure, such as air under pressure, restoration of the fluid motor to its so-called neutral position is impossible.

Accordingly, it is the general object of this invention to provide a novel, lightweight, inexpensive, and simplified fluid motor of the multi-position type having spring means for automatically returning the fluid motor to its neutral position upon the loss of the actuating fluid pressure supply, with control means therefor.

The fluid motor of the present invention comprises a novel spring arrangement operatively connected to a piston rod attached at one end to a power piston and at the opposite end to a device to be controlled or operated. The novel spring arrangement insures movement of the device to be controlled by the fluid motor to a certain or neutral position intermediate the other definite positions to which the device may be operated, upon the loss of, or in the absence of, the actuating fluid pressure.

More specifically, the fluid motor of the present invention comprises a power piston to which is operatively connected a caged spring means for yieldingly opposing movement of the power piston in either direction from a neutral position and a novel arrangement of one or more piston stop means to limit the amount of movement of the power piston from its neutral position to a number of definite positions on either side of the neutral position. Various embodiments of fluid motors are disclosed for providing different numbers of positions of the device to be controlled such as seven, six, five, and three, together with control means therefor.

In the accompanying drawings:

FIG. 1 is a diagrammatic view, mainly in section, of a seven-position fluid motor constructed in accordance with one embodiment of the invention and in a so-called Neutral position, together with control means therefor.

FIG. 2 is a horizontal cross-sectional view taken along the line 2—2 of FIG. 1 and looking in the direction of the arrows, showing further structural details of a manually operative control valve device shown in FIG. 1 for controlling the operation of the fluid motor.

FIG. 3 is a position table to show the chambers in

2

the fluid motor shown in FIG. 1 to which fluid under pressure must be supplied to operate the fluid motor to corresponding positions.

FIG. 4 is a diagrammatic view, mainly in section, of a second embodiment of the invention with the fluid motor having six positions, shown in a so-called Neutral position.

FIG. 5 is a horizontal cross-section view taken along the line 5—5 of FIG. 4 and looking in the direction of the arrows, showing certain structural details of the manually operative control valve device for controlling the operation of the fluid motor shown in FIG. 4.

FIG. 6 is a position table to show the chambers in the fluid motor of FIG. 4 to which fluid under pressure must be supplied to operate the fluid motor to corresponding positions.

FIG. 7 is a diagrammatic view, mainly in section, of a third embodiment of the invention with the fluid motor, having five positions, shown in a so-called Neutral position.

FIG. 8 is a horizontal cross-section view, taken along the line 8—8 of FIG. 7 and looking in the direction of the arrows, showing certain structural details of the manually operative control device for controlling the operation of the fluid motor shown in FIG. 7.

FIG. 9 is a position table to show the chambers in the fluid motor shown in FIG. 7 to which fluid under pressure must be supplied to operate the fluid motor to corresponding positions.

FIG. 10 is a diagrammatic view, mainly in section, of a fourth embodiment of the invention with the fluid motor, having three positions, shown in a so-called Neutral position.

FIG. 11 is a horizontal cross-section view, taken along the line 11—11 of FIG. 10 and looking in the direction of the arrows, showing certain structural details of the manually operative control device for controlling the operation of the fluid motor shown in FIG. 10.

FIG. 12 is a position table to show the chambers in the fluid motor shown in FIG. 10 to which fluid under pressure must be supplied to operate the fluid motor to corresponding positions.

Description—Fig. 1

In FIG. 1 of the drawings, there is shown a seven-position fluid motor 1 constructed in accordance with one embodiment of the invention. The fluid motor 1 may operate a device (not shown) which, for example, may be a seven-position power transmission of a heavy duty truck or some type of earth moving machinery. The device to be operated may be connected to one end of a piston rod 2 of the fluid motor 1. A manually operative control valve device 3 is arranged for controlling supply of fluid under pressure from a reservoir 4, charged with fluid under pressure by a fluid compressor (not shown) to the fluid motor 1 and release of fluid under pressure from the fluid motor to atmosphere for controlling the operation thereof.

The fluid motor 1 comprises a cup-shaped body 5 which has formed at one end a chamber 6 connected by a bore 7 to a counterbore 8, the open end of which is closed by a flat plate 9 which rests against a shoulder 8a formed on the body 5 adjacent the open end of the counterbore 8. The plate 9 is retained in place by an end cover 10 that is secured to the body 5 by several cap screws 11 only two of which are shown. Surrounding the plate 9 and disposed within a recess in the cover 10 is a gasket ring 12 which is clamped between the cover 10 and the body 5 to provide a seal in order to prevent leakage of fluid under pressure from within the counterbore 8.

Slidably mounted in the counterbore 8 are two double-acting piston stop members 13 and 14 and the larger

of a pair of double-acting telescopically arranged piston members 15 and 16. Formed integral with the larger telescopic piston member 15 and on the side thereof opposite the piston stop members 13 and 14, is a hollow sleeve 17 which is slidably mounted in the bore 7 and in which is slidably mounted the smaller telescopic piston member 16 to constitute a double-acting power piston for operating the power transmission through the piston rod 2 which has the end thereof, opposite the end connected to the power transmission, connected by any suitable means to the power piston 16. The end of the sleeve 17 adjacent the piston member 15 is provided around its periphery with several equally spaced radially arranged holes 18 which serve to provide a fluid pressure communication between a chamber 19 formed between the piston member 15 interiorly of the sleeve 17 and the power piston 16 and a chamber 20 formed between the piston member 15 exteriorly of the sleeve 17 and the inner end of the counterbore 8 in the body 5. At the opposite ends of the sleeve 17 are stops to limit movement of the power piston 16, the piston member 15 constituting one of these stops and a snap ring 21, carried by the sleeve 17 adjacent the end thereof opposite the piston member 15, constituting the other.

In order to limit movement of the piston stop member 13 rightward, this piston stop member is provided with a central bore 22 into which is press-fitted a stem 23 having a collar 24 at the end thereof adjacent the piston stop member 14. A reduced portion 25 of the stem 23 extends from the piston stop member 13 in a direction away from the collar 24 and the stop member 14 through a bore 26 in the plate 9 with a sliding fit into a chamber 27 formed between the plate 9 and the cover 10. The reduced portion 25 of the stem 23 on the side of the plate 9 opposite the piston stop member 13 has an annular groove into which is fitted a snap ring 28 which abuts the plate 9 when the piston member 13 has moved rightward away from the plate 9 a chosen distance. The piston stop member 13 is provided on its left-hand side with several stop lugs 29 adapted to contact the right-hand side of plate 9 to limit movement of the member 13 in a leftward direction. The piston stop member 13, the wall of counterbore 8 and the plate 9 cooperate to form a first chamber 30 of variable volume.

Limited movement of the piston stop member 14 with respect to the piston stop member 13 is provided by means of a stem 31 which is press-fitted into a central bore 32 in the piston stop member 14. The stem 31 has a collar 33 at the end thereof adjacent the piston member 15 which serves as a stop to limit movement of the piston member 15 in the direction of the piston stop member 14. A reduced portion 34 of the stem 31 extends from the piston stop member 14 into a blind bore 35 formed in the end of the stem 23 adjacent the piston stop member 14. The stem 31 is connected to the collar 24 of the stem 23 by means of a pin 36 which is press-fitted into the collar 24 and passes through a slot 37 in the portion 34 of the stem. A bore 38 in the end of the portion 34 of the stem 31 prevents a dash-pot action of the portion 34 in the blind bore 35. The collar 24 of stem 23, stem 31, piston stop members 13 and 14, and the wall of the counterbore 8 in the body 5 of the fluid motor 1 cooperate to form a second chamber 39 of variable volume and to allow limited movement of each piston stop member with respect to the other as well as simultaneous movement of the two piston stop members. The collar 33, piston stop member 14, piston member 15, and the wall of the bore 8 in the body 5 cooperate to form a third chamber 40 of variable volume.

In order to prevent leakage of fluid under pressure between the chambers 30, 39, 40, 20, 19 and 6, the respective piston stop members 13 and 14, the piston member 15, and the power piston 16, are each provided with a resilient gasket ring 41 having sealing and sliding con-

tact with the wall of the respective bore in which it operates. A resilient gasket ring 42, similar to the rings 41, is disposed in a counterbore 43 formed in the body 5 and in surrounding relation to the outside periphery of the hollow sleeve 17 to prevent leakage between the chambers 20 and 6. The gasket ring 42 is clamped between the body 5 and a ring 44 having screw-threaded engagement with the body.

Leakage from the chamber 6 along the piston rod 2, which extends through a bore 45 in the body 5 to the exterior thereof, is prevented by a first resilient gasket ring 46 disposed in surrounding relation to the periphery of the piston rod and in a counterbore 47 formed in the body 5 in coaxial relation to the bore 45. This gasket ring 46 is clamped between the body 5 and a ring 48 having screw-threaded engagement with the body. A second gasket ring 46 is disposed between the power piston 16 and a shoulder formed on the piston rod 2 and serves to prevent leakage from the chamber 6 along the piston rod to the chamber 19.

Movement of the power piston 16 in either direction from a neutral position, in which position it is shown in FIG. 1 of the drawings, is yieldingly opposed by a caged spring 49 disposed within a spring cage 50. The spring cage 50 comprises a spring case 51 and a spring retainer 52. The spring case 51 comprises a cup-shaped body having a shoulder 53 and a bore 54 through which slidably projects the piston rod 2. The spring case 51 is secured to the body 5 by several bolts 55 and nuts 56, the bolts 55 being inserted through corresponding circumferentially spaced holes in corresponding flanges 57 and 58 formed, respectively, on the body 5 and the spring case 51. The spring retainer 52 comprises a hollow sleeve having an inside diameter of such size as to permit the sleeve to pass over a cupped-shaped end 59 of the body 5 and an outside diameter less than the inside diameter of the spring 49. The hollow sleeve comprising the spring retainer 52 has an in-turned flange 60 at one end and an out-turned flange 61 at the opposite end, the outside diameter of which is less than the inside diameter of the cup-shaped body comprising the spring case 51. The spring cage 50 further comprises an annular offset spring seat 62 which rests against the shoulder 53 on the spring case 51.

The spring 49 is disposed within the spring case 51 between the spring seat 62 and the flange 61 on the spring retainer 52. The spring seat 62 and the spring retainer 52 are operatively connected to the piston rod 2 in a manner now to be described.

The piston rod 2 is provided intermediate its ends with a shoulder 63 and an annular recess or groove 64. A first hollow annular plate 65 is mounted on the piston rod 2 and is retained between the shoulder 63 and a snap ring 66 inserted in the groove 64. The location of the shoulder 63 and recess 64 on the piston rod 2 is such that the left-hand side of the annular plate 65 abuts the right-hand side of the spring seat 62 when the power piston 16 and piston rod 2 occupy their neutral position, in which position they are shown in FIG. 1 of the drawings.

The spring seat 62 and annular plate 65 are respectively provided with several radially-arranged angularly-spaced corresponding bores 67 and 68 for receiving a corresponding number of headed pins 69, only one of which is shown in FIG. 1. The pins 69 extend through corresponding radially-arranged angularly-spaced bores 70 in a second hollow annular plate 71 which is mounted on the piston rod 2 and has an annular flange 72 which, when the plate 71 occupies the position in which it is shown in FIG. 1, abuts the flange 60 on the spring retainer 52. Each of the pins 69 is provided with an annular recess or groove 73 adjacent the end opposite the headed end thereof into which is inserted a snap ring 74. Each of the bores 70 is provided with a coaxially-related counterbore 75 to form therewith a shoulder 76

5

against which may rest the corresponding snap ring 74 to limit movement rightward of the corresponding pin 69 with respect to the annular plate 71 and transmit rightward movement of the power piston 16 through piston rod 2, annular plate 65, and headed pins 69 to the annular plate 71, the annular flange 72 of which in turn transmits this movement through the flanges 60 and 61 on the spring retainer 52 to the caged spring 49 to compress the spring.

Leftward movement of the power piston 16 is transmitted through the piston rod 2, snap ring 66, annular plate 65 to the spring seat 62, against which rests one end of the spring 49, to compress the caged spring 49 as the power piston 16 moves in this direction.

The control valve device 3 comprises a sectionalized casing consisting of a valve seat 77 separated from a pipe bracket 78 by a gasket 79 of some suitable material such as rubber, and a body 80 separated from the valve seat by a second gasket 81. Contained in a chamber 82 in the body 80 is a rotary valve 83 cooperating with the valve seat 77, the seat and body being secured together and to the pipe bracket 78 by any suitable means. The rotary valve 83 is adapted to be operated by a rotary stem 86 extending from an upper face 87 thereof through a bore 88 in the body 80 with a free rotating fit to the exterior of the body.

The outer end of the stem 86 has a squared portion 89 for receiving a handle 90 which is secured to the stem by a pin 91. The body 80 is provided with an upstanding portion 92 having a spindle 93 and a flange 94 through which the stem 86 projects. A cam 95 is press-fitted on the spindle 93 and rests against the flange 94. As shown in FIG. 2 of the drawings, the periphery of the cam 95 is provided with seven indents or notches 96, 97, 98, 99, 100, 101 and 102 corresponding to the seven positions of the handle 90. Slidably mounted in a counterbore 103 in the handle 90 is a plunger 104. The plunger 104 is provided with a counterbore 105 and is yieldingly urged into contact with the periphery of the cam 95 by a spring 106 interposed between the left-hand end of counterbore 103 and the right-hand end of counterbore 105. Movement of the handle 90 from one position to another is resisted by the spring 106 as the right-hand end of the plunger 104 moves from one indent to another along the periphery of the cam 95 thereby giving an operator a sense of "feeling" when the handle reaches the desired position.

Extending through the pipe bracket 78 and valve seat 77, and opening onto the upper face of the latter, are six ports and passages 112, 113, 114, 115, 116, 117 and an atmospheric exhaust port 118. While the rotary valve 83 occupies a so-called Neutral position N, in which position it is shown in FIG. 1, a first cavity 119 in the rotary valve connects the ports and passages 112, 113 and 117, and a second cavity 120 in the rotary valve connects the ports and passages 114, 115 and 116 to the atmospheric exhaust port 118. The ports and passages 112, 113, 114, 115 and 116 are each connected by a pipe bearing the same numeral, respectively, to the chambers 30, 39, 40, 19 and 6 in the fluid motor 1. The port and passage 117 is connected by a pipe bearing the same numeral to the reservoir 4.

The rotary valve 83 can be rotated by turning the handle 90 from the Neutral position N, in which the rotary valve is shown in FIG. 1, to six other positions, as indicated in FIG. 2 by the legends F1, F2, F3, F4, R1 and R2, to control the supply of fluid under pressure from the reservoir 4 through cavities (not shown) in the rotary valve to certain of the chambers 30, 39, 40, 19 and 6 in the fluid motor 1 and the release of fluid under pressure from certain other of these chambers to the atmosphere to control operation of the power piston 16 of the fluid motor whereby the device, such as the power transmission of a heavy duty truck, connected to the power piston 16 through the intermediary of the piston

6

rod 2, may be moved from a corresponding Neutral position N to six corresponding other positions which are indicated in FIG. 1 as First Reverse position R1, Second Reverse position R2, First Forward position F1, Second Forward position F2, Third Forward position F3 and Fourth Forward position F4, respectively.

Operation—FIG. 1

In operation, let it be assumed that the storage reservoir 4 is charged with fluid to some chosen pressure, such as one hundred (100) pounds per square inch. Further, assume that the handle 90 and the rotary valve 83 of the control valve device 3 and the fluid motor 1 occupy their Neutral position N in which position they are shown in FIG. 1 of the drawings. While in Neutral position N, as shown in FIG. 1, the cavity 119 in the rotary valve 83 connects the pipe 117 to the pipes 112 and 113, and the cavity 120 in the rotary valve connects the pipes 114, 115 and 116 to the atmospheric exhaust port 118. In this position of rotary valve 83, fluid under pressure is therefore supplied from the reservoir 4 to the pipes 112 and 113 and thence to the respective chambers 30 and 39 in the fluid motor 1. Furthermore, in this position of the rotary valve 83, fluid under pressure is completely vented from the chambers 40, 20, 19 and 6 in the fluid motor 1 through the respective pipes 114, 115 and 116, cavity 120 in the rotary valve 83, and exhaust port 118. The position table of FIG. 3 indicates the charged and vented chambers correspondingly for the Neutral position.

The fluid under pressure supplied to the chambers 30 and 39 acts on the opposite sides of the piston stop member 13 and on the left-hand side of the piston stop member 14. Since the fluid that is acting on the opposite sides of piston stop member 13 is at the same pressure, and is acting in opposite directions, the fluid pressure forces acting on the piston stop member 13 are balanced and ineffective to move this piston stop member. Since the chamber 40 is now vented to atmosphere through the cavity 120 in the rotary valve 83, the right-hand side of the piston stop member 14 and the left-hand side of the piston member 15 are subject only to atmospheric pressure. Consequently, the fluid under pressure present in the chamber 39 and acting on the left-hand side of the piston stop member 14 moves the piston stop members 13 and 14 and the piston member 15 to the Neutral position N in which they are shown in FIG. 1 of the drawings whenever the rotary valve 83 is rotated by the handle 90 to the position in which it is shown in FIG. 1, if the respective piston stop members 13 and 14 and piston member 15 occupied a position to the left of the position in which they are shown in FIG. 1 at the time that the rotary valve is rotated to this position.

Since the chambers 6, 19 and 20 are vented through the pipes 115 and 116 and the cavity 120 in the rotary valve 83 to the exhaust port 118 whenever the rotary valve occupies the Neutral position N in which position it is shown in FIG. 1, the caged spring 49 is effective at this time, through the spring cage 50 and the piston rod 2 operatively connected thereto, to maintain the power piston 16 in its Neutral position N, in which position it is shown in FIG. 1. Furthermore, if the piston rod 2 is connected to operate the power transmission (not shown) of a truck, the power transmission also will be correspondingly maintained in its Neutral position.

To move the power piston 16 leftward in a series of successive steps to successive positions corresponding, for example, to the First Forward position F1, Second Forward position F2, Third Forward position F3 and Fourth Forward position F4 of the power transmission (not shown), and without the possibility of overtravel of the power piston, the operator will first turn the handle 90 in a counterclockwise direction, as viewed in FIG. 2, from Neutral position N to First Forward position F1. In turning the handle 90 as just described, the rotary valve 83

is rotated from the position in which it is shown in FIG. 1 to a position corresponding, for example, to the First Forward position F1 of the power transmission of the truck. The rotary valve 83 is so constructed that, with the handle 90 now in its First Forward position F1, suitable cavities in the rotary valve connect the pipe and passage 115 to the exhaust port 118 in the valve seat 77 thus venting the chambers 19 and 20 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipes and passages 112, 113, 114 and 116 to supply fluid under pressure from the reservoir 4 to the chambers 30, 39, 40 and 6 in the fluid motor 1, as indicated by the position table of FIG. 3.

The fluid under pressure supplied to the chambers 30, 39 and 40 maintains the piston stop members 13 and 14, in the position in which they are shown in FIG. 1, or, in other words, in the same position they occupied prior to turning the handle 90 from Neutral position N to First Forward position F1. The fluid under pressure supplied to the chamber 40 moves the piston member 15 rightward until it contacts a stop shoulder 121 at the right-hand end of the counterbore 8 since the chambers 19 and 20 are now vented through the rotary valve 83 and exhaust port 118 as has been explained. The fluid under pressure supplied to the chamber 6 moves the power piston 16 leftward in the sleeve 17 against the yielding resistance of the spring 49 until the power piston reaches the left-hand end of the sleeve and contacts the right-hand side of the piston member 15. The area of the left-hand side of piston member 15 is greater than the area of the right-hand side of power piston 16, less the area of the piston rod 2. Therefore, the piston member 15 is maintained in contact with the stop shoulder 121 and the power piston 16 is maintained in contact with the right-hand side of the piston member 15 during the time that the handle 90 remains in First Forward position F1.

As shown in FIG. 1 of the drawings, the power piston 16 is spaced from the right-hand face of the piston member 15 a distance equal to twice the distance the piston member 15 is spaced from the stop shoulder 121. Therefore, the distance the power piston 16 and piston rod 2 move leftward in traveling from their Neutral position N in which position they are shown in FIG. 1 to their First Forward position F1 is equal to the distance the piston member 15 moves rightward in traveling from the position in which it is shown in FIG. 1 to the position it occupies when the right-hand side thereof is in contact with stop shoulder 121. As the power piston 16 moves from the position in which it is shown in FIG. 1 to the position in which the left-hand side thereof contacts the right-hand side of the piston member 15 when the piston member 15 is in contact with the stop shoulder 121, the piston rod 2, which may be connected to the power transmission of a truck, will shift the power transmission from its Neutral position N to its First Forward position F1.

Let it now be assumed that the operator turns the handle 90 in a counterclockwise direction, as viewed in FIG. 2, from First Forward position F1 to Second Forward position F2. As the handle 90 is turned as just described, the rotary valve 83 is rotated therewith to a position corresponding to the Second Forward position F2 of rod 2. With the rotary valve 83 now in a position corresponding to the Second Forward position F2 of rod 2, suitable cavities in the rotary valve connect the pipes and passages 114 and 115 to the exhaust port 118 in the valve seat 77 thus venting the chambers 40, 19 and 20 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipes and passages 112, 113 and 116 to supply fluid under pressure from the reservoir 4 to the chambers 30, 39 and 6 in the fluid motor 1, as indicated in the position table of FIG. 3.

The chambers 30, 39 and 6 were charged with fluid under pressure when the handle 90 and rotary valve 83 occupied the position corresponding to First Forward position F1 of the power transmission and thus remain charged

with fluid under pressure when the handle and rotary valve are turned to Second Forward position F2. However, the chamber 40 which was charged with fluid under pressure when the handle 90 and rotary valve 83 occupied their First Forward position F1, is vented to atmosphere when the handle and rotary valve are turned to the Second Forward position F2. Therefore, as the pressure in the chamber 40 between the piston stop member 14 and piston member 15 is reduced by flow to atmosphere, the fluid under pressure in the chamber 6 acting on the right-hand side of the power piston 16 will move the power piston and the piston member 15 leftward against the yielding resistance of the spring 49 away from the stop shoulder 121 until the left-hand side of the piston member 15 contacts the collar 33 on the right-hand end of the stem 31 carried by the piston stop member 14. Further movement of the piston member 15 and power piston 16 is prevented since the area of the piston stop member 14 that is subject to the fluid under pressure present in the chamber 39 is greater than the area of the power piston 16, less the area of the piston rod 2, that is subject to fluid under pressure in the chamber 6, it being understood that the degree of pressure acting in chambers 39 and 6 is the same since both are supplied with fluid under pressure from the reservoir 4.

As shown in FIG. 1 of the drawings, the left-hand side of the piston member 15 contacts the right-hand end of the collar 33 on the stem 31 and the right-hand side is spaced away from the stop shoulder 121. Therefore, the distance the power piston 16, piston member 15 and piston rod 2 move leftward in traveling from their First Forward position F1 to their Second Forward position F2 is equal to the distance the piston member 15 is shown spaced from the stop shoulder 121 in FIG. 1 of the drawings. As the power piston 16, piston member 15 and piston rod 2 move from their First Forward position F1 to their Second Forward position F2, the power transmission of a truck, if connected to rod 2, will be shifted from its First Forward position F1 to its Second Forward position F2.

To continue the movement of the power piston 16 and piston member 15 leftward within the counterbore 8 of the body 5 to shift the rod 2 from its Second Forward position F2 to its Third Forward position F3, the operator will turn the handle 90 in a counterclockwise direction as viewed in FIG. 3, from Second Forward position F2 to Third Forward position F3. As the handle 90 is turned as just described, the rotary valve 83 is rotated therewith to a corresponding position in which position suitable cavities in the rotary valve connect the pipes and passages 113, 114 and 115 to the exhaust port 118 in the valve seat 77 thus connecting the chambers 39, 40, 19 and 20 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipes and passages 112 and 116 to supply fluid under pressure from the reservoir 4 to the chambers 30 and 6 in the fluid motor 1, as indicated in the position table of FIG. 3.

The chambers 30 and 6 were charged with fluid under pressure when the handle 90 and rotary valve 83 occupied the position corresponding to Second Forward position F2 of the rod 2 and remain charged with fluid under pressure when the handle and rotary valve are turned to the position corresponding to the Third Forward position F3 of the rod 2. However, the chamber 39, which was charged with fluid under pressure when the handle 90 and rotary valve 83 occupied their Second Forward position F2, is vented to atmosphere when the handle and rotary valve are turned to their Third Forward position F3. Consequently, as the pressure in the chamber 39 between the piston stop members 13 and 14 is reduced by flow to atmosphere, the fluid under pressure supplied to the chamber 6 and acting on the right-hand side of the power piston 16 will move the power piston, the piston member 15 and the piston stop member 14 leftward against the yielding resistance of spring 49 until piston stop mem-

ber 14 moves from the position in which it is shown in FIG. 1 to a position in which the left-hand side thereof contacts the right-hand end of the collar 24 of the stem 23 carried by the piston stop member 13. Further movement of the piston stop member 14, piston member 15, and power piston 16 is prevented since the area of the piston stop member 13 that is subject to the fluid under pressure present in the chamber 30 is greater than the area of the power piston 16, less the area of the piston rod 2, that is subject to fluid under pressure in the chamber 6, it being understood that the degree of fluid under pressure acting in chambers 30 and 6 is the same.

As shown in FIG. 1 of the drawings, the left-hand end of the slot 37 in the stem 31 carried by the piston stop member 14 is in contact with the pin 36 carried by the collar 24 of the stem 23. Therefore, the distance the piston stop member 14, piston member 15, power piston 16 and piston rod 2 move leftward in traveling from their Second Forward position F2 to their Third Forward position F3 is equal to the distance the left-hand side of piston stop member 14 is shown spaced from the right-hand end of the collar 24 in FIG. 1 of the drawings. As the piston stop member 14, piston member 15, power piston 16 and piston rod 2 move from their Second Forward position F2 to their Third Forward position F3, a power transmission of a truck, if connected to rod 2, will be shifted from its Second Forward position F2 to its Third Forward position F3.

To shift the rod 2 from its Third Forward position F3 to its Fourth Forward position F4, the operator will turn the handle 90 in a counterclockwise direction, as viewed in FIG. 2 from Third Forward position F3 to Fourth Forward position F4. As the handle 90 is turned as just described, the rotary valve 83 is rotated therewith to a corresponding position in which position suitable cavities in the rotary valve connect the pipes and passages 112, 113, 114 and 115 to the exhaust port 118 in the valve seat 77 thus connecting the chambers 30, 39, 40, 19 and 20 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipe and passage 116 to supply fluid under pressure from the reservoir 4 to only the chamber 6 in the fluid motor 1. Since the chamber 30, which was charged with fluid under pressure when the handle 90 and rotary valve 83 occupied their Third Forward position F3, is now connected to the exhaust port 118, the fluid under pressure now being supplied to the chamber 6 and acting on the right-hand side of the power piston 16 will move the power piston, the piston rod 2, piston member 15 and piston stop members 13 and 14 leftward against the yielding resistance of spring 49 until the piston stop member 13 moves from the position in which it is shown in FIG. 1 to a position in which the lugs 29 on the left-hand side thereof contact the right-hand side of the plate 9 to prevent further leftward movement. As the piston stop members 13 and 14, piston member 15 and power piston 16 move from their Third Forward position F3 to their Fourth Forward position F4, the piston rod 2 is correspondingly shifted from its Third Forward position F3 to its Fourth Forward position F4.

With the handle 90 and rotary valve 83 in their respective positions corresponding to the Fourth Forward position F4 of the piston rod 2, the operator of the truck may turn the handle successively back through the previous four forward positions to move the power piston 16 and piston rod 2 in steps back to the Neutral position N in which they are shown in FIG. 1 of the drawings, or he may turn the handle 90 from the Fourth Forward position F4 to any other one of its four forward positions, or he may turn the handle to either the First Reverse position R1 or the Second Reverse position R2.

Let it be assumed that the handle 90 and the rotary valve 83 of the control valve device 3 and the fluid motor 1 occupy their Neutral position N in which position they are shown in FIG. 1 of the drawings. Let it be further

assumed that the operator desires to move the power piston 16 and piston rod 2 rightward in a series of steps corresponding to First Reverse position R1 and Second Reverse position R2. To do so, the operator will turn the handle 90 in a clockwise direction, as viewed in FIG. 2, from Neutral position N to First Reverse position R1. In turning the handle 90 from Neutral position N, in which position it is shown in FIG. 1 to its First Reverse position R1, the rotary valve 83 is rotated from the position in which it is shown in FIG. 1 to its First Reverse position R1. With the rotary valve 83 now in its First Reverse position R1, suitable cavities in the rotary valve connect the pipe and passages 114 and 116 to the exhaust port 118 in the valve seat 77 thus venting the chambers 40 and 6 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipes and passages 112, 113 and 115 to supply fluid under pressure from the reservoir 4 to the respective chambers 30, 39, 19 and 20 in the fluid motor 1, as indicated in the position table of FIG. 3.

The chambers 30 and 39 were charged with fluid under pressure when the handle 90 and rotary valve 83 occupied the position corresponding to Neutral position N and remain charged with fluid under pressure when the handle and rotary valve are turned to their First Reverse position R1. Therefore, the piston stop members 13 and 14 remain in the position in which they are shown in FIG. 1. However, the chambers 19 and 20, which were vented to atmosphere through the exhaust port 118 when the handle 90 and rotary valve 83 occupied their Neutral position N, are now supplied with fluid under pressure from the reservoir 4. Consequently, the fluid under pressure in the chambers 19 and 20 acts respectively on the right-hand side of the piston member 15 and the left-hand side of the power piston 16 to maintain the piston member 15 against the collar 33 and move the power piston 16 rightward against the yielding resistance of spring 49. Movement of the piston member 15 is prevented since the left-hand side of the piston stop member 14 and the right-hand side of the piston member 15 are of equal area and are subject to the same degree of fluid pressure, namely the pressure in the reservoir 4. The fluid under pressure present in the chambers 19 and 20 acts on the left-hand side of the power piston 16 to move the power piston rightward against the yielding resistance of the spring 49 until the power piston contacts the snap ring 21 carried by the sleeve 17. The area of the right-hand side of piston member 15 is greater than the left-hand side of the power piston 16. Therefore, the fluid pressure acting in the chambers 19 and 20 maintains the piston member 15 in contact with the collar 33 on the stem 31 and the power piston 16 in contact with the snap ring 21 during the time that the handle 90 remains in its First Reverse position R1.

Since the piston stop members 13 and 14 and the piston member 15 are not moved from the Neutral position N in which they are shown in FIG. 1 of the drawings when the handle 90 is turned from its Neutral position N to its First Reverse position R1, the distance that the power piston 16 moves rightward in traveling from its Neutral position N to its First Reverse position R1 is equal to the distance from the right-hand side of the power piston 16 to the snap ring 21 when the power piston and snap ring occupy the position in which they are shown in FIG. 1. As the power piston 16 moves from the position in which it is shown in FIG. 1 to the position in which it contacts the snap ring 21, the piston rod 2 correspondingly shifts from its Neutral position N to its First Reverse position R1.

To shift the piston rod 2 from its First Reverse position R1, to its Second Reverse position R2, the operator will turn the handle 90 in a clockwise direction, as viewed in FIG. 2, from its First Reverse position R1 to its Second Reverse position R2. In so turning the handle 90, the rotary valve 83 is rotated to its Second Reverse

11

position R2. With the rotary valve 83 in this new position, suitable cavities therein provide for the continued supply of fluid under pressure from the reservoir 4 to the chambers 19 and 20 in the fluid motor 1 and also the supply of fluid under pressure to the chamber 40. The fluid under pressure now supplied to the chamber 15 to balance the fluid under pressure present in the chambers 19 and 20 and acting on the right-hand side of the piston member 15. With the opposing fluid pressure forces acting on the piston member 15 thus balanced, the fluid under pressure present in chamber 19 acts on the left-hand side of the power piston 16 to move the power piston 16, sleeve 17 and piston member 15 rightward against the yielding resistance of the spring 49 until the right-hand side of the piston member 15 contacts the stop shoulder 121 at the right-hand end of counterbore 8 in body 5 since the chamber 6 in the fluid motor 1 remains connected through a suitable cavity in rotary valve 83 to the exhaust port 118 when the handle 90 and rotary valve 83 are in the Second Reverse position R2 as was the case when the handle and rotary valve occupied their respective First Reverse positions R1.

Since the power piston 16 was moved into contact with the snap ring 21 when the handle 90 was moved to First Reverse position R1, the distance that the power piston 16, piston rod 2, piston member 15, sleeve 17 and snap ring 21 move rightward in traveling from their First Reverse position R1 to their Second Reverse position R2 is equal to the distance from the right-hand side of the piston member 15 to the stop shoulder 121 with the piston member in its Neutral position N in which it is shown in FIG. 1 of the drawings. As the power piston 16 and the piston member 15 move from the position in which the power piston contacts the snap ring 21 and the piston member 15 is shown in FIG. 1 of the drawings to the position in which the right-hand side of the piston member 15 contacts the stop shoulder 121, the piston rod 2 correspondingly shifts from its First Reverse position R1 to its Second Reverse position R2.

With the handle 90 in the Second Reverse position R2, the operator may turn the handle successively back through the previous two reverse positions to move the power piston 16 and piston rod 2 in steps back to the Neutral position N in which they are shown in FIG. 1 of the drawings, or he may turn the handle 90 from the Second Reverse position R2 to any one of the four forward positions to cause the power piston and the piston rod 2 to move to a corresponding position.

It may be noted that movement of the power piston 16 either rightward or leftward from the Neutral position N by fluid under pressure supplied, respectively, to either the chamber 19 or the chamber 6 is yieldingly resisted by the caged spring 49. Upon movement of the power piston 16 rightward from the Neutral position N, the shoulder 63 on the piston rod 2 contacts the left-hand side of the plate 65 so that the plate is moved rightward simultaneously with the piston rod and power piston. Since the right-hand side of the plate 65 contacts the left-hand end of the heads on the pins 69, these pins in turn transmit movement through the snap rings 74 to the plate 71. The flange 72 on the plate 71 transmits movement of the plate 71 to the inturned flange 60 of spring retainer 52. Since one end of the spring 49 rests upon the out-turned flange 61 of the spring retainer 52, any rightward movement of the spring retainer from the position in which it is shown in FIG. 1 of the drawings will be yieldingly resisted by the spring 49. Consequently, if the pipe 115 is broken or the pressure in chamber 19 is lost for any other reason, the spring 49 will return the power piston 16 and the piston rod 2 to their respective Neutral positions N.

Upon movement of the power piston 16 leftward from the Neutral position N, the snap ring 66 carried in the groove 64 on the piston rod 2 contacts the right-hand

12

side of the annular plate 65 which in turn contacts the right-hand side of the spring seat 62 so that the spring seat is moved leftward simultaneously with the power piston 16 and piston rod 2. Since the right-hand end of the spring 49 rests on the spring seat 62, any leftward movement of the spring seat from the position in which it is shown in FIG. 1 of the drawings will be yieldingly resisted by the spring 49. Therefore, if the pipe 116 is broken or the pressure in chamber 6 is lost for any other reason, the spring 49 will return the power piston 16 and the piston rod 2 to their respective Neutral positions N.

In view of the above, it is apparent that the single caged spring 49 acts to return the power piston 16 and the piston rod 2 to their Neutral positions N upon the loss of the fluid pressure supply or the rupture of either of the pipes 115 and 116 when charged with fluid under pressure from the reservoir 4. Thus with the fluid motor employed to actuate a truck transmission, the transmission will be automatically restored to its Neutral position N upon loss of fluid pressure for any reason.

Description—FIG. 4

In FIG. 4 of the drawings, a six-position fluid motor 122 is shown and comprises one double-acting piston stop member and a pair of double-acting telescopically-arranged piston members, the smaller of which constitutes a double-acting power piston for operating, for example, a six-position power transmission. The six-position fluid motor 122 is similar in part and functions in substantially the same manner as the fluid motor 1 shown in FIG. 1 of the drawings. Accordingly, like reference numerals have been used to designate the structure shown in FIG. 4 which is identical with that shown in FIG. 1 and already described. Only such features of the structure and operation of the embodiment of FIG. 4 which differ from that of the embodiment of FIG. 1 will be hereinafter described.

According to the embodiment of the invention shown in FIG. 4, the fluid motor 122 comprises a cup-shaped body 123 which is similar to the body 5 shown in FIG. 1 except that it is shorter. A counterbore 124 in body 123, which corresponds to the counterbore 8 in the body 5, is thus correspondingly shorter than the counterbore 8. The open end of the counterbore 124 is closed by a cover 125 that is secured to the body 123 by several cap screws 11, only two of which are shown. A gasket 126 is clamped between the cover 125 and the body 123 to provide a seal in order to prevent leakage of fluid under pressure from within the counterbore 124.

Slidably mounted in the counterbore 124 is a double-acting piston stop member 127 and the double-acting telescopically-arranged piston members 15 and 16, the piston member 16 constituting the power piston of the fluid motor 122 for operating a device, such as a six-position power transmission, through the piston rod 2.

In order to limit movement of the piston stop member 127 rightward, this piston stop member is provided on the side thereof adjacent the cover 125 with a blind bore 128. A headed pin 129 is press-fitted into a bore 130 in the cover 125 and extends with a sliding fit into the blind bore 128 in the piston stop member 127. The pin 129 is provided with a transverse slot 131 through which passes a pin 132 which is press-fitted into the left-hand side of a hub 133 formed on the piston stop member 127. A bore 134 in the end of the pin 129 prevents a dash-pot action in the blind bore 128.

The piston stop member 127, cover 125, and the wall of the counterbore 124 in the body 123 of the fluid motor 122 cooperate to form the chamber 30, and the piston stop member 127, piston member 15 and the wall of the counterbore 124 cooperate to form the chamber 40 in the fluid motor 122.

In order to prevent leakage of fluid under pressure be-

13

tween the chambers 30 and 40, the piston stop member 127 is provided with a resilient gasket ring 41.

A manually operative control valve device 3 corresponding to that used for controlling supply of fluid under pressure from the reservoir 4 to the fluid motor 1 shown in FIG. 1 of the drawings and the release of fluid under pressure from the fluid motor 1 to atmosphere for controlling the operation thereof may be used for controlling the operation of the fluid motor 122. However, since the fluid motor 122 has no chamber corresponding to the chamber 39 in the fluid motor 1, the port and passage 113 in the pipe bracket 78 must be closed by a plug or other suitable means, and the pipe 113 is of course omitted. The ports and passages 112, 114, 115, and 116 in the pipe bracket 78 are connected by the pipes bearing the same numerals, respectively, to the chambers 30, 40, 19 and 6 in the fluid motor 122. The port and passage 117 is connected by the pipe bearing the same numeral to the reservoir 4.

Furthermore, since the fluid motor 122 has only six positions, the seven detent cam 95 (FIG. 2) of the control valve device 3 is replaced by a cam 135 (see FIG. 5) having six detents or notches 136, 137, 138, 139, 140 and 141.

Operation—FIG. 4

In operation, let it be assumed that the storage reservoir 4 is charged with fluid to some chosen pressure, such as one hundred (100) pounds per square inch. Further assume that the handle 90 and the rotary valve 83 of the control valve device 3, and the fluid motor 122 occupy their Neutral position N in which position they are shown respectively in FIGS. 4 and 5 of the drawings. While in Neutral position N, the cavity 119 in the rotary valve 83 connects the pipe 117 to the pipe 112 and the cavity 120 in the rotary valve connects the pipes 114, 115 and 116 to the atmospheric exhaust port 118. In this position of the rotary valve 83, fluid under pressure is therefore supplied from the reservoir 4 to the pipe 112 and thence to the chamber 30 in the fluid motor 122. Furthermore, in this position of the rotary valve 83, fluid under pressure is completely vented from the chambers 40, 20, 19 and 6 in the fluid motor 122 through the respective pipes 114, 115 and 116, cavity 120 in the rotary valve 83, and exhaust port 118.

The fluid under pressure supplied to the chamber 30 acts on the left-hand side of the piston stop member 127. Since the chamber 40 is now vented to atmosphere through the cavity 120 in the rotary valve 83, the right-hand side of the piston stop member 127 is subject only to atmospheric pressure. Consequently, the fluid under pressure present in the chamber 30 and acting on the left-hand side of the piston stop member 127 moves this piston stop member and the piston member 15 to the neutral position N, in which position they are shown in FIG. 4 of the drawings, whenever the rotary valve 83 is rotated by the handle 90 to the Neutral position N if the respective piston stop member 127 and the piston member 15 occupied a position to the left of the position in which they are shown in FIG. 4 at the time the rotary valve 83 is rotated to this position.

Since the chambers 6, 19 and 20 are now vented, the caged spring 49 is effective at this time, as explained in connection with the fluid motor 1, to maintain the power piston 16 and the piston rod 2 in their respective Neutral positions N.

To move the power piston 16 and the piston rod 2 leftward in a series of successive steps corresponding to the selected First Forward position F1, Second Forward position F2, and Third Forward position F3 positions, and without the possibility of overtravel of the power piston, the operator will first turn the handle 90 of the control valve device 3 in a counterclockwise direction, as viewed in FIG. 5, from Neutral position N to First Forward position F1. In turning the handle 90 as just described, the rotary valve 83 is correspondingly rotated from the

14

position in which it is shown in FIG. 1 to a second position corresponding to the First Forward position F1 of the piston rod 2. With the handle 90 and rotary valve 83 now in their First Forward positions F1, the cavities in the rotary valve connect the pipe and passage 115 to the exhaust port 118 in the valve seat 77, thus venting the chambers 19 and 20 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipes and passages 112, 114 and 116 to supply fluid under pressure from the reservoir 4 to the respective chambers 30, 40 and 6 in the fluid motor 122. The position table of FIG. 6 indicates this condition for the First Forward position F1 of the power piston.

With fluid under pressure supplied to the chambers 30 and 40 on opposite sides of the piston stop member 127, the fluid pressure forces on the piston member are balanced and consequently the piston member remains in the position in which it is shown in FIG. 4, or in other words, in the same position it occupied prior to turning the handle 90 from Neutral position N to First Forward position F1. The fluid under pressure supplied to the chamber 40, however, moves the piston member 15 rightward until it contacts stop shoulder 121 at the right-hand end of counterbore 124 since the chambers 19 and 20 are now vented to atmosphere. The fluid under pressure supplied to the chamber 6 moves the power piston 16 leftward in the sleeve 17 against the yielding resistance of the spring 49 until the power piston contacts the right-hand side of the piston member 15.

As the power piston 16 moves from the position in which it is shown in FIG. 4 to the position in which the left-hand side thereof contacts the right-hand side of the piston member 15 when the piston member 15 is in contact with the stop shoulder 121, the piston rod 2 shifts from its Neutral position N to its First Forward position F1.

To shift the piston rod 2 from its First Forward position F1 to its Second Forward position F2, the operator will turn the handle 90 in a counterclockwise direction, as viewed in FIG. 5, from First Forward position F1 to Second Forward position F2. Since the rotary valve 83 is turned correspondingly with the handle 90, the cavities in the rotary valve now connect the pipes and passages 114 and 115 to the exhaust port 118 thus venting the chambers 40, 20 and 19 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipes and passages 112 and 116, respectively, to supply fluid under pressure from the reservoir 4 to the chambers 30 and 6 in the fluid motor 122. This pressurization of chambers 30 and 6 is indicated in the position table of FIG. 6.

The chambers 30 and 6 were charged with fluid under pressure when the handle 90 and rotary valve 83 occupied their First Forward position F1, and remain charged with fluid under pressure when the handle and rotary valve are turned to their Second Forward positions F2. However, the chamber 40 which was charged with fluid under pressure when the handle 90 and rotary valve 83 occupied their First Forward positions F1, is vented to atmosphere when the handle and rotary valve are turned to their Second Forward positions F2. Therefore, as the pressure in the chamber 40 between the piston stop member 127 and piston member 15 is reduced by flow to atmosphere, the fluid under pressure in the chamber 6 acting on the right-hand side of the power piston 16 will move the power piston and the piston member 15 leftward against the yielding resistance of the spring 49 away from the stop shoulder 121 until the left-hand side of the piston member 15 contacts the right-hand side of the hub 133 on the piston stop member 127. Further movement of the piston member 15 and power piston 16 is prevented since the area of the piston stop member 127 that is subject to the fluid under pressure present in the chamber 30 is greater than the area of the power piston 16, less the area of the piston rod 2, that is subject to fluid under pressure in the chamber 6, it being

15

understood that the unit pressure acting in chamber 30 and 6 is the same since both are supplied with fluid under pressure from the reservoir 4.

As shown in FIG. 4 of the drawings, the left-hand side of the piston member 15 contacts the right-hand side of the hub 133 on the piston stop member 127 and the right-hand side is spaced away from the stop shoulder 121. Therefore, the distance the power piston 16, piston member 15 and piston rod 2 move leftward in traveling from their First Forward positions F1 to their Second Forward positions F2 is equal to the distance the piston member 15 is shown spaced from the stop shoulder 121 in FIG. 4 of the drawings. As the power piston 16 and piston member 15 move from their First Forward positions F1 to their Second Forward positions F2, the piston rod 2 is shifted from its First Forward position F1 to its Second Forward position F2.

To continue the movement of the power piston 16 and piston member 15 leftward within the counterbore 124 of the body 123 from their Second Forward positions F2 to their Third Forward positions F3, the operator will turn the handle 90 in a counterclockwise direction as viewed in FIG. 5, from Second Forward position F2 to Third Forward position F3. As the handle 90 is thus turned, the rotary valve 83 is rotated therewith to a corresponding position in which position suitable cavities in the rotary valve connect the pipes and passages 112, 114 and 115 to the exhaust port 118 in the valve seat 77 thus connecting the chambers 30, 40, 19 and 20 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipe and passage 116 to supply fluid under pressure from the reservoir 4 to only the chamber 6 in the fluid motor 122. This pressurization of chamber 6 only is indicated in the position table of FIG. 6.

Since the chamber 30, which was charged with fluid under pressure when the handle 90 and rotary valve 83 occupied the position corresponding to Second Forward position F2 is now connected to the exhaust port 118 in the valve seat 77, the fluid under pressure now being supplied to the chamber 6 and acting on the right-hand side of the power piston 16 will move the power piston, the piston rod 2, piston member 15 and piston stop member 127 leftward against the yielding resistance of spring 49 until the piston stop member 127 moves from the position in which it is shown in FIG. 4 to a position in which the pin 132 carried by the hub 133 contacts the left-hand end of the slot 131 in the pin 129 to prevent further leftward movement of stop member 127. As the piston member 15 and power piston 16 move from their Second Forward position F2 to their Third Forward position F3, the operating piston rod 2 correspondingly is shifted from its Second Forward position F2 to its Third Forward position F3, thus correspondingly operating the device with which it is connected.

With the handle 90 and rotary valve 83 in their respective Third Forward positions F3, the operator may turn the handle successively back through the previous three forward positions to move the power piston 16 and piston rod 2 in steps back to the Neutral position N in which they are shown in FIG. 4 of the drawings, or he may turn the handle 90 from the Third Forward position F3 to any other one of its three forward positions, or he may turn the handle to either the First Reverse position R1 or the Second Reverse position R2.

Let it be assumed that the handle 90 and the rotary valve 83 of the control valve device 3 and the fluid motor 122 occupy their Neutral positions N in which position they are shown in the drawings. Let it be further assumed that the operator desires to move the power piston 16 rightward in a series of steps corresponding to selected First Reverse position R1 and Second Reverse position R2. To do so, the operator will turn the handle 90 in a clockwise direction, as viewed in FIG. 5, from Neutral position N to First Reverse position R1. In turning the handle 90 from Neutral position N to its First Reverse

16

position R1, the rotary valve 83 is correspondingly rotated to its First Reverse position R1. With the rotary valve 83 now in its First Reverse position R1, suitable cavities in the rotary valve connect the pipe and passages 114 and 116 to the exhaust port 118 in the valve seat 77 thus venting the chambers 40 and 6 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipes and passages 112 and 115 to supply fluid under pressure from the reservoir 4 to the respective chambers 30, 19 and 20 in the fluid motor 122. This pressurization of chambers is indicated in the position table of FIG. 6.

The chamber 30 was charged with fluid under pressure when the handle 90 and rotary valve 83 occupied the position corresponding to Neutral position N and remains charged with fluid under pressure when the handle and rotary valve are turned to their First Reverse positions R1. Therefore, the piston stop member 127 remains in the position in which it is shown in FIG. 4. However, the chambers 19 and 20, which were vented to atmosphere through the exhaust port 118 when the handle 90 and rotary valve 83 occupied their Neutral positions N, are now supplied with fluid under pressure from the reservoir 4. Consequently, the fluid under pressure in the chambers 19 and 20 acts respectively on the right-hand side of the piston member 15 and the left-hand side of the power piston 16 to maintain the piston member 15 against the right-hand side of the hub 133 on the piston member 127 and moves the power piston 16 rightward against the yielding resistance of spring 49. Movement of the piston member 15 is prevented since the left-hand side of the piston stop member 127 and the right-hand side of the piston member 15 are of equal area and are subject to the same degree of fluid pressure, namely the pressure in the reservoir 4. The fluid under pressure present in the chambers 19 and 20 acts on the left-hand side of the power piston 16 to move the power piston rightward against the yielding resistance of the spring 49 until the power piston contacts the snap ring 21 carried by the sleeve 17. The area of the right-hand side of piston member 15 is greater than the area of the left-hand side of the power piston 16, less the area of piston rod 2. Therefore, the fluid under pressure acting in the chambers 19 and 20 maintains the piston member 15 in contact with the right-hand side of the hub 133 on the piston stop member 127 and the power piston 16 in contact with the snap ring 21 during the time that the handle 90 remains in First Reverse position R1.

Since the piston stop member 127 and the piston member 15 are not moved from the Neutral position N when the handle 90 is turned from its Neutral position N to its First Reverse position R1, the distance that the power piston 16 and the piston rod 2 move rightward in traveling from their Neutral position N, in which they are shown in FIG. 4, to First Reverse position R1, is equal to the distance from the right-hand side of the power piston 16 to the snap ring 21 when the power piston and snap ring occupy the position in which they are shown in FIG. 4. As the power piston 16 moves from the position in which it is shown in FIG. 4 to the position in which it contacts the snap ring 21, the piston rod 2 correspondingly shifts from its Neutral position N to its First Reverse position R1.

To shift the piston rod 2 from its First Reverse position R1 to its Second Reverse position R2, the operator will turn the handle 90 in a clockwise direction, as viewed in FIG. 5, from First Reverse position R1 to Second Reverse position R2. In so turning the handle 90, the rotary valve 83 is rotated to its Second Reverse position R2. With the rotary valve 83 in this position, suitable cavities therein provide for the continued supply of fluid under pressure from the reservoir 4 to the chambers 19 and 20 in the fluid motor 1 and also the supply of fluid under pressure to the chamber 40. The fluid under pressure now supplied to the chamber 40 acts on the left-

17

hand side of the piston member 15 to balance the fluid under pressure present in the chambers 19 and 20 and acting on the right-hand side of the piston member 15. With the fluid pressure forces acting in opposite directions on the piston member 15 thus balanced, the fluid under pressure present in chambers 19 and 20 acts on the left-hand side of the power piston 16 to move the power piston 16, sleeve 17 and piston member 15 rightward against the yielding resistance of the spring 49 until the right-hand side of the piston member 15 contacts the stop shoulder 121 at the right-hand end of counterbore 124 in body 123 since the chamber 6 in the fluid motor 1 remains connected through a suitable cavity in rotary valve 83 to the exhaust port 118 when the handle 90 and rotary valve 83 are turned to their Second Reverse position R2 as was the case when the handle and rotary valve occupied the First Reverse position R1.

Since the power piston 16 was moved into contact with the snap ring 21 when the handle 90 was moved to First Reverse position R1, the distance that the power piston 16, piston rod 2, piston member 15, sleeve 17 and snap ring 21 moved rightward in traveling from their First Reverse position R1 to their Second Reverse position R2 is equal to the distance from the right-hand side of the piston member 15 to the stop shoulder 121 when the piston member occupies the Neutral position N in which position it is shown in FIG. 4 of the drawings. As the power piston 16 and the piston member 15 move from the position in which the power piston contacts the snap ring 21 and in which the piston member 15 is shown in FIG. 4 of the drawings to the position in which the right-hand side of the piston member 15 contacts the stop shoulder 121, the piston rod 2 shifts from its First Reverse position R1 to its Second Reverse position R2.

With the handle 90 in the Second Reverse position R2 the operator may turn the handle successively back through the previous two reverse positions to move the power piston 16 and piston rod 2 in steps back to their Neutral position N in which they are shown in FIG. 4 of the drawings, or he may turn the handle 90 from the Second Reverse position R2 to any one of the three forward positions to cause the power piston and the piston rod 2 to move to corresponding positions.

It may be noted that movement of the power piston 16 in either direction from the Neutral position N in which it is shown in FIG. 4 of the drawings is resisted by the caged spring 49 in the manner explained in connection with the fluid motor 1 shown in FIG. 1. Consequently, upon the loss of the fluid pressure supply or rupture of either of the pipes 115 or 116 when charged with fluid under pressure, the spring 49 will return the power piston 16 and the piston rod to Neutral position.

Description—FIG. 7

In FIG. 7 of the drawings, a five-position fluid motor 143 is shown constructed in accordance with a third embodiment of the invention and comprises a pair of double-acting telescopically-arranged piston members, the smaller of which constitutes a double-acting power piston for operating, for example, a five-position power transmission. The five-position fluid motor 143 is similar to the six-position fluid motor 122 shown in FIG. 4 of the drawings except the double-acting piston stop member 127 is omitted and a simplified body and end cover is used, this being made possible by the omission of the piston stop member. The five-position fluid motor 143 functions in a manner similar to the fluid motors 1 and 122 shown, respectively, in FIGS. 1 and 4 of the drawings. Accordingly, like reference numerals have been used to designate the structure shown in FIG. 7 which is identical with that shown in FIGS. 1 and 4 and already described. Only such features of the structure and operation of the embodiment of FIG. 7 which differ from that of the embodiment of FIGS. 1 and 4 will be hereinafter described.

According to the embodiment of the invention shown

18

in FIG. 7, the fluid motor 143 comprises a cup-shaped body 144 which corresponds to the bodies 5 and 123 shown respectively in FIGS. 1 and 4 except that it is shorter so that the length of a counterbore 145 therein, which corresponds to the counterbores 8 and 124 in the bodies 5 and 123, respectively, is less than that of the last-mentioned counterbores. The open end of the counterbore 145 is closed by a cover 146 that is secured to the body 144 by several cap screws 11. The gasket 126 is clamped between the cover 146 and the body 144 to provide a seal in order to prevent leakage of fluid under pressure from within the counterbore 145.

The double-acting telescopically-arranged piston members 15 and 16, used in the fluid motors 1 and 122, are slidably mounted in the counterbore 145, the piston member 16 constituting the power piston of the fluid motor 143 for operating any device, such as a five-position power transmission, through the piston rod 2.

The piston member 15, cover 146 and the wall of the counterbore 145 in the body 144 of the fluid motor 143 cooperate to form the chamber 40.

A manually operative control valve device 3 corresponding to that used for controlling the supply of fluid under pressure from the reservoir 4 to the fluid motors 1 and 122, shown respectively, in FIGS. 1 and 4 of the drawings, and the release of fluid under pressure from these fluid motors to atmosphere for controlling the operation thereof may be used for controlling the operation of the fluid motor 143. However, since the fluid motor 143 has no chambers corresponding to the chambers 30 and 39 in the fluid motor 1, the ports and passages 112 and 113 in the pipe bracket 78 must be closed by plugs, or other suitable means, and the pipes 112 and 113 are, of course, omitted. The ports and passages 114, 115 and 116 in the pipe bracket 78 are connected by the pipes bearing the same numerals, respectively, to the chambers 40, 20 and 6 in the fluid motor 143. The port and passage 117 is connected by the pipe bearing the same numeral to the reservoir 4.

Furthermore, since the fluid motor 143 has only five positions, the seven detent cam 95 (FIG. 2) of the control device 3 must be replaced by a cam 147 (see FIG. 8) having five detents or notches 148, 149, 150, 151 and 152.

Operation—FIG. 7

In operation, let it be assumed that the storage reservoir 4 is charged with fluid to some chosen pressure, such as one hundred (100) pounds per square inch. Further assume that the handle 90 and the rotary valve 83 of the control valve device 3, and the fluid motor 143 occupy their Neutral position N, in which position they are shown in FIGS. 7 and 8 of the drawings. While in Neutral position N, the cavity 120 in the rotary valve connects the pipes 114, 115 and 116 to the atmospheric exhaust port 118.

Since the chambers 40, 6, 19 and 20 are now vented, the caged spring 49 is effective at this time, as explained in connection with the fluid motor 1, to maintain the power piston 16 and the piston rod 2 in their Neutral position N, in which position the power piston is shown in FIG. 7.

To move the power piston 16 leftward in a series of successive steps corresponding to the selected First Forward position F1 and Second Forward position F2 of the piston rod 2, and without the possibility of overtravel of the power piston, the operator of the truck will first turn the handle 90 of the control valve device 3 in a counter-clockwise direction, as viewed in FIG. 8, from Neutral position N to First Forward position F1. In thus turning the handle 90, the rotary valve 83 is rotated from the position in which it is shown in FIG. 1 to its First Forward position F1. With the handle 90 and rotary valve 83 now in their First Forward position F1, the cavities in the rotary valve connect the pipe and passage 115 to the exhaust port 118 in the valve seat 77 thus continuing to vent the chambers 19 and 20 to atmosphere while connecting the

fluid pressure supply pipe and passage 117 to the pipes and passages 114 and 116 to supply fluid under pressure from the reservoir 4 to the respective chambers 40 and 6 in the fluid motor 143, as indicated in the position table of FIG. 9.

The fluid under pressure supplied to the chamber 40 moves the piston member 15 rightward until it contacts stop shoulder 121 at the right-hand end of counterbore 145 since the chambers 19 and 20 are now vented to atmosphere. The fluid under pressure supplied to the chamber 6 moves the power piston 16 leftward in the sleeve 17 against the yielding resistance of the spring 49 until the power piston contacts the right-hand side of the piston member 15.

As the power piston 16 moves from the position in which it is shown in FIG. 7 to the position in which the left-hand side thereof contacts the right-hand side of the piston member 15 when the piston member 15 is in contact with the stop shoulder 121, the piston rod 2 is correspondingly shifted from its Neutral position N to its First Forward position F1.

To shift the piston rod 2 from its First Forward position F1 to its Second Forward position F2, the operator will turn the handle 90 in a counterclockwise direction, as viewed in FIG. 8, from First Forward position F1 to Second Forward position F2. Since the rotary valve 83 is turned to its corresponding Second Forward position F2 simultaneously with the handle 90, the cavities in the rotary valve now connect the pipes and passages 114 and 115 to the exhaust port 118 thus venting the chambers 40, 20 and 19 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipe and passage 116 to supply fluid under pressure from the reservoir 4 to only the chamber 6 in the fluid motor 143, as indicated in the position table of FIG. 9.

The chamber 40 which was charged with fluid under pressure when the handle 90 occupied the position corresponding to First Forward position F1, is vented to atmosphere when the handle and rotary valve are turned to the Second Forward position F2. Therefore, as the pressure in the chamber 40 between piston member 15 and cover 146 is reduced by flow to atmosphere, the fluid under pressure in the chamber 6 acting on the right-hand side of the power piston 16 will move the power piston and the piston member 15 leftward against the yielding resistance of the spring 49 away from the stop shoulder 121 until the left-hand side of the piston member 15 contacts the cover 146.

As shown in FIG. 7 of the drawings, the left-hand side of the piston member 15 contacts the cover 146. Therefore, the distance the power piston 16, piston member 15 and piston rod 2 move leftward in traveling from their First Forward position F1 to their Second Forward position F2 is equal to the distance the piston member 15 is shown spaced away from the stop shoulder 121 in FIG. 7. As the power piston 16 and piston member 15 move from their First Forward position F1 to their Second Forward position F2, the operating piston rod 2 is shifted from its First Forward position F1 to its Second Forward position F2.

With the handle 90 and the rotary valve 83 in their respective Second Forward positions F2, the operator may turn the handle successively back through the previous two forward positions to move the power piston 16 and piston rod 2 in steps back to the Neutral position N in which they are shown in FIG. 7 of the drawings, or he may turn the handle 90 from its Second Forward position F2 to either the First Reverse position R1 or the Second Reverse position R2.

Let it be assumed that the handle 90 and the rotary valve 83 of the control valve device 3 and the fluid motor 143 occupy their Neutral position N, in which position they are shown in FIG. 7 of the drawings. Let it be further assumed that the operator desires to move the power piston 16 rightward in a series of steps correspond-

ing to selected First Reverse position R1 and Second Reverse position R2. To do so, the operator will turn the handle 90 in a clockwise direction, as viewed in FIG. 8, from Neutral position N to First Reverse position R1. In turning the handle 90 from its Neutral position N, to its First Reverse position R1, the rotary valve 83 is correspondingly rotated to its First Reverse position R1. With the rotary valve 83 now in its First Reverse position R1, suitable cavities in the rotary valve connect the pipe and passages 114 and 116 to the exhaust port 118 in the valve seat 77 thus venting the chambers 40 and 6 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipe and passage 115 to supply fluid under pressure from the reservoir 4 to chamber 20 and thus also chamber 19 in the fluid motor 143.

The chambers 19 and 20 were vented to atmosphere through the exhaust port 118 when the handle 90 and rotary valve occupied their corresponding Neutral positions N. Consequently, the fluid under pressure now supplied to the chambers 19 and 20 acts respectively, on the right-hand side of the piston member 15 and the left-hand side of the power piston 16 to maintain the piston member 15 against the cover 146 and move the power piston 16 rightward against the yielding resistance of spring 49 until the power piston contacts the snap ring 21 carried by the sleeve 17. The fluid under pressure now acting in the chambers 19 and 20 will maintain the piston member 15 in contact with cover 146 and the power piston 16 in contact with the snap ring 21 as long as the handle 90 remains in its First Reverse position R1.

Since the piston member 15 is not moved from the Neutral position N in which it is shown in FIG. 7 when the handle 90 is turned from its Neutral position N to its First Reverse position R1, the distance that the power piston 16 and the piston rod 2 move rightward in traveling from their Neutral position N to their First Reverse position R1 is equal to the distance from the right-hand side of the power piston 16 to the snap ring 21 when the power piston and snap ring occupy the position in which they are shown in FIG. 7. As the power piston 16 moves from the position in which it is shown in FIG. 7 to the position in which it contacts the snap ring 21, the piston rod 2 shifts correspondingly from its Neutral position N to its First Reverse position R1.

To shift the piston rod 2 from its First Reverse position R1 to its Second Reverse position R2, the operator will turn the handle 90 in a clockwise direction, as viewed in FIG. 7 from First Reverse position R1 to Second Reverse position R2. In so turning the handle 90, the rotary valve 83 is rotated to its corresponding Second Reverse position R2. With the rotary valve 83 in this position, suitable cavities therein provide for the continued supply of fluid under pressure from the reservoir 4 to the chambers 19 and 20 in the fluid motor 1 and also the supply of fluid under pressure to the chamber 40, as indicated in the position table of FIG. 9.

The operation of the fluid motor 143 in moving from its First Reverse position R1 to its Second Reverse position R2 is identical with the operation of the fluid motor 122 in moving from its First Reverse position R1 to its Second Reverse position R2. Therefore, a detailed description of this operation of the fluid motor 143 is not deemed necessary of repetition.

With the handle 90 in the Second Reverse position R2, the operator may turn the handle successively back through the previous two reverse positions to move the power piston 16 and piston rod 2 in steps back to the Neutral position N in which they are shown in FIG. 7 of the drawings, or he may turn the handle 90 from the Second Reverse position R2 to any one of the two forward positions to cause the power piston and the piston rod 2 to move to corresponding positions.

It may be noted that movement of the power piston 16 in either direction from the Neutral position N, in which

it is shown in FIG. 7 of the drawings, is resisted by the caged spring 49 in the manner explained in connection with the fluid motor 1 shown in FIG. 1. Consequently, upon the loss of the fluid pressure supply or rupture of either of the pipes 115 or 116 when charged with fluid under pressure, the spring 49 will return the power piston 16 and the piston rod 2 to Neutral position N.

Description—FIG. 10

In FIG. 10 of the drawings, a three-position fluid motor 153 is shown constructed in accordance with a fourth embodiment of the invention. The fluid motor 153 comprises a double-acting power piston for operating, for example, a three-position power transmission, and a caged spring for normally biasing the power piston to a so-called Neutral position N.

According to the embodiment of the invention shown in FIG. 10, the fluid motor 153 comprises a cup-shaped body 154 having a blind bore 155 and a coaxially related counterbore 156 cooperating with the blind bore to form a shoulder 157. The open end of the counterbore 156 is closed by a cover 158 which has a bore 159 through which projects a piston rod 160. The cover 158 is secured to the body 154 by several cap screws 161, only two of which are shown. A gasket 162 is clamped between the cover 158 and the body 154 to provide a seal in order to prevent leakage of fluid under pressure from within the counterbore 156.

A power piston 163 is slidably mounted in the blind bore 155 in the body 154. One end of the piston rod 160 is connected to the power piston 163 and the opposite end, which extends through the bore 159 in the cover 158 to the exterior of the fluid motor 153, may be connected, for example, to a three-position power transmission or other device to be controlled or operated.

Movement of the power piston 163 in either direction from Neutral position N, in which position it is shown in FIG. 10 of the drawings, is yieldingly opposed by a caged spring 164 surrounding the piston rod 160 and disposed between a spring retainer 165 and a spring seat 166. The spring retainer 165 comprises a hollow sleeve having an inside diameter greater than the outside diameter of the spring 164. The hollow sleeve comprising the spring retainer 165 has, at one end, an in-turned flange 167 which rests against the piston rod side of the piston 163 and, at the opposite end, an out-turned flange 168, the outside diameter of which is less than the diameter of counterbore 156 to permit this flange to normally rest against the shoulder 157. The spring seat 166 also comprises a short hollow sleeve having an inside diameter greater than the diameter of the piston rod 160. The hollow sleeve comprising the spring seat 166 has, at one end, an in-turned flange 169, which is normally biased by the spring 164 against a shoulder 170 formed on the piston rod 160 and, at the opposite end an out-turned flange 171, the outside diameter of which is less than the diameter of counterbore 156 to permit this flange to rest against the cover 158.

The power piston 163 cooperates with the body 154 and the cover 158 to form two pressure chambers 172 and 173 on the opposite sides, respectively, of the power piston.

In order to prevent leakage of fluid under pressure between the chambers 172 and 173, the power piston 163 is provided with a resilient gasket ring 174 having sealing and sliding contact with the wall of the blind bore 155 in which the power piston operates.

Leakage from the chamber 173 along the piston rod 160, which extends through the bore 159 in cover 158 to the exterior thereof, is prevented by a first gasket ring 175 disposed in surrounding relation to the periphery of the piston rod and in a counterbore 176 formed in the cover 158 in coaxial relation to the bore 159. This gasket 175 is clamped between the cover 158 and a screw collar 177 having screw-threaded engagement with the

cover. A second gasket ring 178 is disposed between the power piston 163 and a shoulder formed on the piston rod 160 and serves to prevent leakage from the chamber 173 along the piston rod to the chamber 172.

A manually operative control valve device 3 corresponding to that used for controlling the supply of fluid under pressure from the reservoir 4 to the fluid motor 1 shown in FIG. 1, the fluid motor 122 shown in FIG. 4, and the fluid motor 143 shown in FIG. 7 of the drawings, and the release of fluid under pressure from these fluid motors to atmosphere for controlling the operation thereof, may be used for controlling the operation of the fluid motor 153. However, since the fluid motor 153 has no chambers corresponding to the chambers 30, 39, 40 and 19 in the fluid motor 1, the ports and passages 112, 113 and 114 in the pipe bracket 78 must be closed, as by plugs or other suitable means, and the pipes 112, 113 and 114 are, of course, omitted. The ports and passages 115 and 116 are connected by the pipes bearing the same numerals, respectively, to the chambers 172 and 173 in the fluid motor 153. The port and passage 117 is connected by the pipe bearing the same numeral to the reservoir 4.

Furthermore, since the fluid motor 153 has only three positions, the seven detent cam 95 (FIG. 2) of the control valve device used with the fluid motor 1 shown in FIG. 1 must be replaced by a cam 179 (see FIG. 11) having three detents or notches 180, 181, and 182. Except for the cam 179, the manually operative control valve device 3 used with the fluid motor 153 is identical with the control valve device used with the fluid motor 1 shown in FIG. 1. Accordingly, like reference numerals have been used to designate the control valve device structure shown in FIG. 10 which is identical with that shown in FIG. 1 and already described.

Operation—FIG. 10

In operation, let it be assumed that the storage reservoir 4 is charged with fluid to some chosen pressure, such as one hundred (100) pounds per square inch. Further assume that the handle 90 and the rotary valve 83 of the control valve device 3 and the fluid motor 153 occupy their Neutral position N, in which position they are shown in FIG. 10 of the drawings. While in Neutral position N, the cavity 120 in the rotary valve 83 connects the pipes 115 and 116 to the atmospheric exhaust port 118 to completely vent fluid under pressure from the chambers 172 and 173 in the fluid motor 153. With fluid under pressure completely vented from the chambers 172 and 173, the spring 164 is effective, through the spring retainer 165, to bias the power piston 163 to its Neutral position N, in which position it is shown in FIG. 10 of the drawings.

To move the power piston 163 leftward to its First Forward position F1, and without overtravel of the power piston, the operator will turn the handle 90 of the control valve device 3 in a counterclockwise direction, as viewed in FIG. 11, from Neutral position N to First Forward position F1. In thus turning the handle 90, the rotary valve 83 is turned from its Neutral position N to its First Forward position F1. With the handle 90 and rotary valve 83 now in their First Forward position F1, the cavities in the rotary valve connect the pipe and passage 115 to the exhaust port 118 in the valve seat 77 thus venting the chamber 172 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipe and passage 116 to supply fluid under pressure from the reservoir 4 to the chamber 173 in the fluid motor 153.

The fluid under pressure thus supplied to the chamber 173 moves the power piston 163 leftward in the blind bore 155 against the yielding resistance of the spring 164 until the out-turned flange 171 on the spring seat 166 contacts the out-turned flange 168 on the spring retainer 165, it being noted that, as the power piston 163

moves from the position in which it is shown in FIG. 10, this movement of the power piston is transmitted through the shoulder 170 on the piston rod 160 to the spring seat 166 upon which rests one end of the spring 164.

As the power piston 163 moves from the position in which it is shown in FIG. 10 to the position in which the out-turned flange 171 on the spring seat 166 contacts the out-turned flange 168 on the spring retainer 165, the piston rod 160 shifts from its Neutral position N to its First Forward position F1.

With the handle 90 and the rotary valve 83 in their First Forward position F1, the operator may turn the handle back to its Neutral position N, or he may turn the handle from its First Forward position F1 to its First Reverse position R1.

Let it be assumed that the handle 90 and the rotary valve 83 of the control valve device 3 and the fluid motor 153 occupy their Neutral position N, in which position they are shown in FIG. 10 of the drawings. Let it be further assumed that the operator desires to move the power piston 163 rightward to its First Reverse position R1. To do so, the operator will turn the handle 90 in a clockwise direction, as viewed in FIG. 11, from Neutral position N to First Reverse position R1.

In turning the handle 90 as just described, the rotary valve 83 is turned from its Neutral position N to its First Reverse position R1. With the handle 90 and rotary valve 83 now in their First Reverse position R1, the cavities in the rotary valve connect the pipe and passage 116 to the exhaust port 118 in the valve seat 77 thus venting the chamber 173 to atmosphere while connecting the fluid pressure supply pipe and passage 117 to the pipe and passage 115 to supply fluid under pressure from the reservoir 4 to the chamber 172 in the fluid motor 153, as indicated in the position table of FIG. 12.

The fluid under pressure thus applied to the chamber 172 moves the power piston 163 rightward in the blind bore 155 against the yielding resistance of the spring 164 until the out-turned flange 168 on the spring retainer 165 contacts the out-turned flange 171 on the spring seat 166, it being noted that, as the power piston 163 moves from the position in which it is shown in FIG. 10, this movement is transmitted through the in-turned flange 167 on the spring retainer 165 to the spring 164 to compress the spring.

As the power piston 163 moves from the position in which it is shown in FIG. 10 to the position in which the out-turned flange 168 on the spring retainer 165 contacts the out-turned flange 171 on the spring seat 166, the piston rod 160 shifts from its Neutral position N to its First Reverse position R1.

With the handle 90 and the rotary valve 83 in their First Reverse position R1, the operator may turn the handle back to its Neutral position N, or to the First Forward position F1 to cause the power piston 163 to move to a corresponding position.

Having now described the invention, what I claim as new and desire to secure by Letters Patent is:

1. A fluid motor comprising a casing having two coaxially related bores, two double-acting pistons of equal diameter slidably mounted in one of said bores, two double-acting telescopically-arranged piston members the larger of which is slidably mounted in said one bore and carries, on the side thereof opposite said two double-acting pistons, a hollow sleeve that is slidably mounted in the other of said bores, in which sleeve the smaller of said telescopic piston members is slidably mounted, a first pair of stops for said two equal diameter double-acting pistons, one of said first pair of stops comprising a hollow rod secured to one of said pistons and extending to one side thereof and having means thereon cooperating with the casing for limiting movement of said one piston with respect to said casing and the other of said first pair of stops comprising a rod rigidly secured

at one end to the other of said pistons and connected at the other end through a lost-motion connection to said hollow rod, and a second pair of stops for said two double-acting piston members, one of said second pair of stops being on said casing at one end of said one bore for limiting movement of the larger of said piston members and the other of said second pair of stops being on said sleeve for limiting movement of the smaller of said piston members away from the larger piston members, said pistons and piston members cooperating respectively with said first and said second pairs of stops to provide a series of axially spaced definite positions for said smaller piston members.

2. A fluid motor comprising a casing having two coaxially related bores, two double-acting pistons of equal diameter slidably mounted in one of said bores, two double-acting telescopically-arranged piston members the larger of which is slidably mounted in said one bore and carries, on the side thereof opposite said two double-acting pistons, a hollow sleeve, slidably mounted in the other of said bores, in which sleeve the smaller of said telescopic piston members is slidably mounted, a pressure head, said pressure head, said casing, said sleeve, said pistons and said piston members cooperating together to form a pressure chamber to the right and to the left of each piston and piston member, a plurality of port means in said casing each opening into one of said pressure chambers and adapted to be connected at one time to a supply of fluid under pressure and to be connected at another time to atmosphere to cause movement of said pistons and piston members in one direction or in an opposite direction, two stops for said two double-acting pistons of equal diameter, one of said stops comprising a hollow rod secured to one of said pistons and extending to one side thereof and having means thereon cooperating with the casing for limiting movement of said one piston with respect to said casing and the other of said stops comprising a rod rigidly secured at one end to the other of said pistons and connected at the other end through a lost-motion connection to said hollow rod, and two stops for said two double-acting piston members one of said two last-mentioned stops being on said casing at one end of said one bore for limiting movement of the larger of said piston members and the other of said last-mentioned stops being on said sleeve for limiting movement of the smaller of said piston members with respect to the larger piston member, said pistons and piston members cooperating with said stops to provide a series of axially spaced definite positions to which said smaller piston member may be moved by fluid under pressure supplied through one or more of said port means to one or more of said pressure chambers.

3. In combination, a fluid motor comprising a sectionalized casing having two coaxially related bores, two double-acting piston stop members of equal diameter slidably mounted in one of said bores, two double-acting telescopically-arranged piston members the larger of which is slidably mounted in said one bore and carries, on the side thereof opposite said two double-acting pistons, a hollow sleeve, slidably mounted in the other of said bores, in which sleeve the smaller of said telescopic piston members is slidably mounted, a first fluid pressure communication extending from one side of said power piston through the wall of said sleeve and casing to the exterior of said casing, a second fluid pressure communication extending from the other side of said power piston through the open end of said sleeve and the wall of said casing to the exterior of said casing, a third fluid pressure communication extending from the side of said larger piston member opposite said sleeve and the side of one of said two double-acting piston stop members adjacent said larger piston member through the wall of said casing to the exterior thereof, a fourth fluid pressure communication extending from the adjacent sides of said two double-acting piston stop members through the wall of

25

said casing to the exterior thereof, a fifth fluid pressure communication extending from the side of the other of said two double-acting piston stop members opposite said adjacent side through the wall of said casing to the exterior thereof, a stop member carried by said casing for said larger piston member for limiting movement thereof in one direction, another stop member carried on said sleeve for limiting movement of the smaller of said telescopic piston members in a direction away from said larger telescopic piston member, two stop means for said two double-acting piston stop members of equal diameter, one of said two stop means operable to limit movement of one of said two double-acting piston stop members with respect to said casing and the other of said two stop means operable to limit movement of the other of said two double-acting piston stop members with respect to said one double-acting piston stop member, a manually operative control valve device operative to a plurality of positions, a pipe connecting each of said fluid pressure communications to said control valve device for conveying fluid under pressure from said control valve device to the sides of said piston stop members and said smaller telescopic piston member and releasing fluid under pressure from said sides to effect movement of said piston members to a degree limited by said stop means and to effect movement in one direction of said smaller telescopic piston member into contact with said another stop member carried on the interior of said sleeve and in the opposite direction into contact with the larger of said piston members.

4. A fluid motor comprising a casing having two coaxially related bores, a double-acting piston member slidably mounted in one of said bores and carrying, on one side thereof, a hollow sleeve that is slidably mounted in the other of said bores, a double-acting power piston slidably mounted in said sleeve, a piston rod rigidly connected to said power piston, two stops formed on said casing in spaced relation for contact by said double-acting piston member upon movement thereof in said one bore in opposite directions and serving to define two different positions of said double-acting piston member, two stops on said sleeve in spaced relation for contact by said power piston for limiting movement of said power piston in opposite directions with respect to said double-acting piston member, a spring, caging means for said spring, and means connecting said piston rod to said caging means whereby said spring yieldingly opposes movement of said power piston in said sleeve in either direction from a certain position intermediate the two stops on said sleeve to which the power piston is biased when free from fluid pressure forces.

5. A fluid motor comprising a casing having two coaxially related bores, a double-acting piston slidably mounted in one of said bores, a double-acting piston member slidably mounted in said one bore and provided, on the side thereof opposite said double-acting piston, with a hollow sleeve that is slidably mounted in the other of said bores, a double-acting power piston slidably mounted in said sleeve, a piston rod rigidly connected to said power piston, a stop for said double-acting piston to limit movement of said piston in the direction of said double-acting piston member, said stop comprising a rod rigidly secured at one end to said casing and connected at the other end through a lost-motion connection to said double-acting piston, two stops on said sleeve for limiting movement of said power piston with respect to said double-acting piston member, a spring, caging means for said spring, and means connecting said piston rod to said caging means whereby said spring yieldingly opposes movement of said power piston in said sleeve in either direction from a certain position intermediate the two stops on said sleeve to which said power piston is biased when free from fluid pressure forces.

6. In combination, a fluid motor comprising a casing

26

having two coaxially related bores, two double-acting telescopically-arranged piston members the larger of which is slidably mounted in one of said bores and carries, on one side thereof, a hollow sleeve that is slidably mounted in the other of said bores, in which sleeve the smaller of said telescopic piston members is slidably mounted, movable stop means for variably limiting movement of said larger piston member in one direction, and a plurality of fluid pressure responsive double-acting pistons of equal diameter slidably mounted in said one bore for varying the position of said stop means, one of said pistons having a lost-motion connection with said casing and the other of said pistons having a lost-motion connection with an adjacent one of said pistons, and a single control means for selectively controlling the supply of fluid under pressure to said telescopically-arranged piston members to effect movement thereof and to said double-acting pistons of equal diameter to correspondingly vary the position of said movable stop means, whereby the smaller of said telescopically-arranged piston members may be moved selectively to a selected one of a plurality of positions.

7. A fluid motor comprising a casing having two coaxially related bores, two double-acting telescopically-arranged piston members the larger of which is slidably mounted in one of said bores and carries, on one side thereof, a hollow sleeve that is slidably mounted in the other of said bores, in which sleeve the smaller of said telescopic piston members is slidably mounted, a piston rod connected to said smaller telescopic piston member, a spring disposed in surrounding relation to said piston rod, caging means for said spring, and means connecting said piston rod to said caging means whereby said spring yieldingly opposes movement of said smaller telescopic piston member in said sleeve in either direction from a certain neutral position.

8. A fluid motor comprising a casing having two coaxially related bores, two double-acting telescopically-arranged piston members the larger of which is slidably mounted in one of said bores and carries, on one side thereof, a hollow sleeve that is slidably mounted in the other of said bores, in which sleeve the smaller of said telescopic piston members is slidably mounted, a piston rod rigidly connected to said smaller telescopic piston member, a plurality of fluid pressure responsive double-acting pistons of equal diameter slidably mounted in said one bore, one of said pistons having a lost-motion connection with said casing and the other of said pistons having a lost-motion connection with an adjacent one of said pistons whereby said pistons are variably movable in the direction of said larger double-acting telescopically-arranged piston member to limit the degree of movement of said larger piston member in the opposite direction in accordance with the position of said plurality of pistons in said one bore, a fixed stop means carried by said casing for limiting the movement of said larger telescopic piston member in a direction away from said plurality of interconnected pistons, two stops on said sleeve in spaced relation for contact by said smaller telescopic piston member for limiting movement of said smaller telescopic piston member in opposite directions with respect to said larger telescopic piston member, a spring, caging means for said spring, and means connecting said piston rod to said caging means whereby said spring yieldingly opposes movement of said smaller telescopic piston member in said sleeve in either direction from a certain position intermediate said two stops on said sleeve to which said smaller telescopic piston member is biased when free of fluid pressure forces.

9. A fluid motor comprising a casing having two coaxially related bores of different diameters respectively, two double-acting telescopically-arranged piston members the larger of which is slidably mounted in the one of said bores of larger diameter and carries, on one side thereof, a hollow sleeve that is slidably mounted in the

other of said bores of smaller diameter, in which sleeve the smaller of said telescopic piston members is slidably mounted, a movable stop means for limiting movement of the larger of said telescopic piston members in one direction, piston means slidably mounted in said one bore of larger diameter for controlling the position of said movable stop means, a fixed stop means carried by said casing for limiting movement of the larger of said telescopic piston members in the opposite direction, and two stops on said sleeve for respectively limiting movement of the smaller of said piston members in said one direction and in said opposite direction with respect to said larger telescopic piston member.

10. A fluid motor as claimed in claim 9, further characterized by having a piston rod connected to the smaller of said piston members, a spring disposed in surrounding relation to said piston rod, caging means for said spring, and means connecting said piston rod to said caged means whereby said spring yieldingly opposes movement of the smaller of said piston members in said sleeve in either direction from a certain position intermediate the two stops on said sleeve to which said smaller piston member is biased when free of fluid pressure forces.

11. A fluid motor comprising a casing having two coaxially related bores, two double-acting telescopically-arranged piston members the larger of which is slidably mounted in one of said bores and carries, on one side thereof, a hollow sleeve that is slidably mounted in the other of said bores, in which sleeve the smaller of said telescopic piston members is slidably mounted, two stops for the larger of said piston members each formed on said casing, two stops on the sleeve for limiting movement of said power piston with respect to the larger of said telescopic piston members, a piston rod rigidly connected to the smaller of said piston members, a spring disposed in surrounding relation to said piston rod, caging means for said spring, said caging means comprising two movable spring seats operably connected to said piston rod to move alternatively therewith upon movement of said piston rod in one direction or in the opposite direction, one of said spring seats adapted to rest upon said casing

upon movement of the other by movement of said piston rod in said one direction and the other of said spring seats adapted to rest upon said casing upon movement of said one spring seat by movement of said piston rod in the opposite direction.

12. A fluid motor as claimed in claim 11, further characterized in having means to limit outward movement of said spring seats with respect to each other.

13. A fluid motor comprising a casing having a bore and a coaxial counterbore with a shoulder therebetween formed on said casing, a pair of pressure heads one of which closes said bore at the end opposite the shoulder and the other of which is removably secured to said casing at the end of said counterbore opposite said shoulder, a double-acting power piston slidably mounted in said bore, a piston rod having a shoulder intermediate the ends thereof, said piston rod being connected to said double-acting power piston and projecting slidably through said other pressure head, a spring disposed in said bore in concentric relation to said piston rod, and caging means cooperating with said spring and comprising two hollow cylindrical members, each having an inturned flange at one end and an outturned flange at the opposite end, the inturned flanges having abutting contact respectively with one face of said double-acting power piston and said shoulder on said piston rod, and the corresponding outturned flanges having abutting contact respectively with said shoulder on said casing and said other pressure head, said flanges cooperating with said double-acting power piston, said piston rod, said other pressure head, and said casing to render said spring effective to yieldingly oppose movement in said bore of said double-acting power piston in either direction from a neutral position.

References Cited in the file of this patent

UNITED STATES PATENTS

2,299,211	Clench	Oct. 20, 1942
2,630,786	Poore	Mar. 10, 1953
2,396,643	De Ganahl	Mar. 19, 1956
2,792,813	Fixman	May 21, 1957
2,893,209	Colley	July 7, 1959