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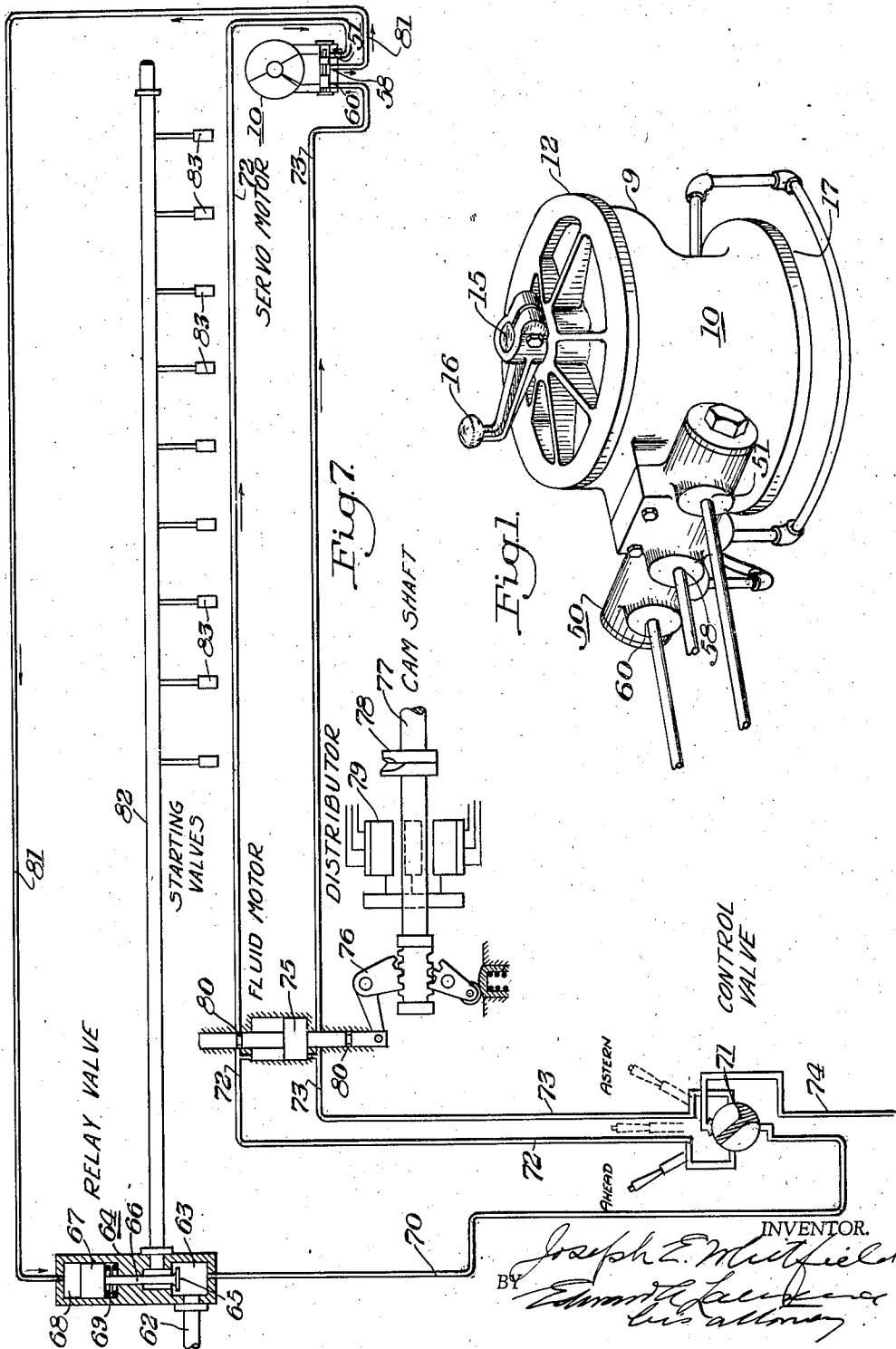
J. E. WHITFIELD

2,404,262

SERVOMOTOR AND CONTROL

Filed Sept. 27, 1943

3 Sheets-Sheet 1



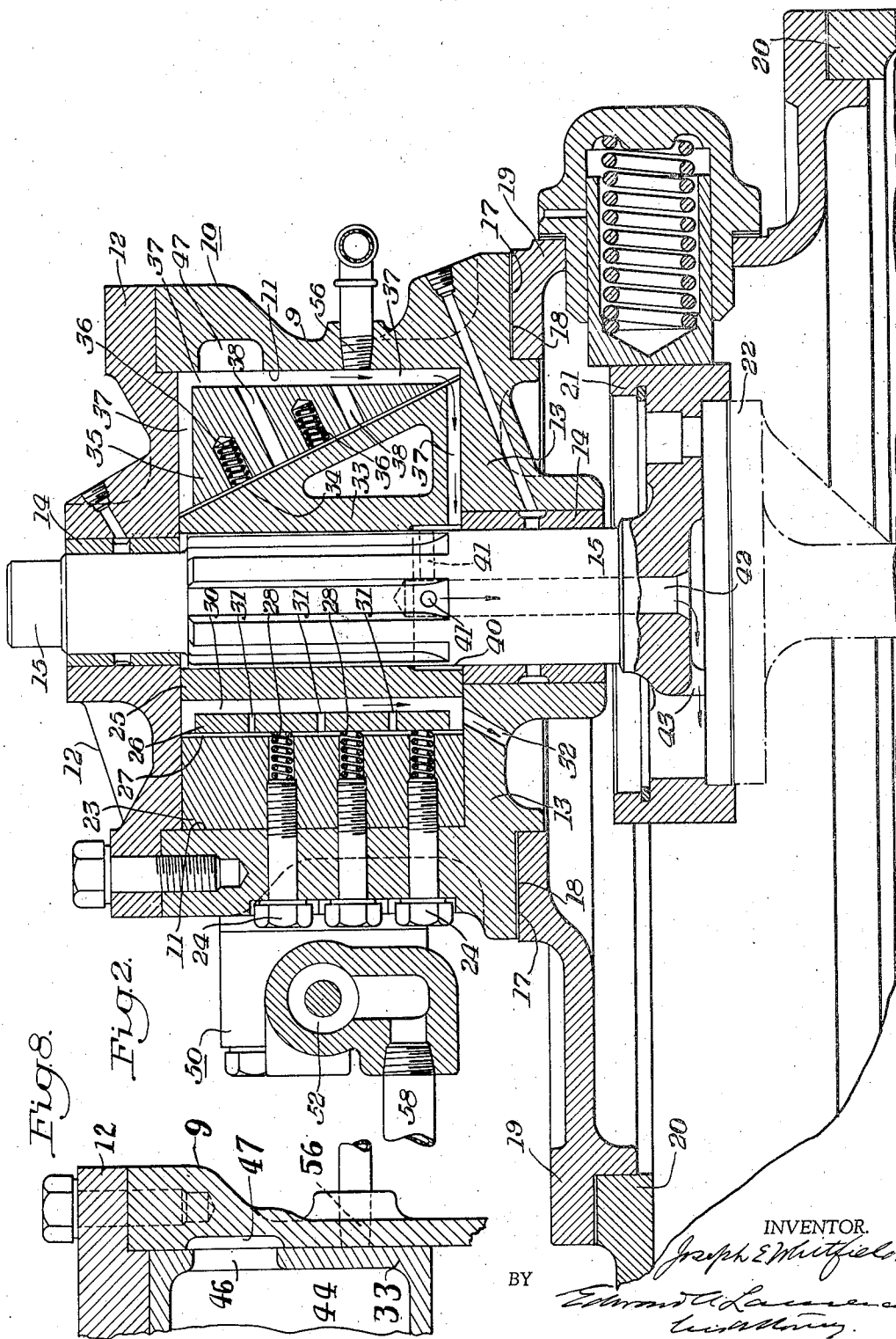
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Fig.3

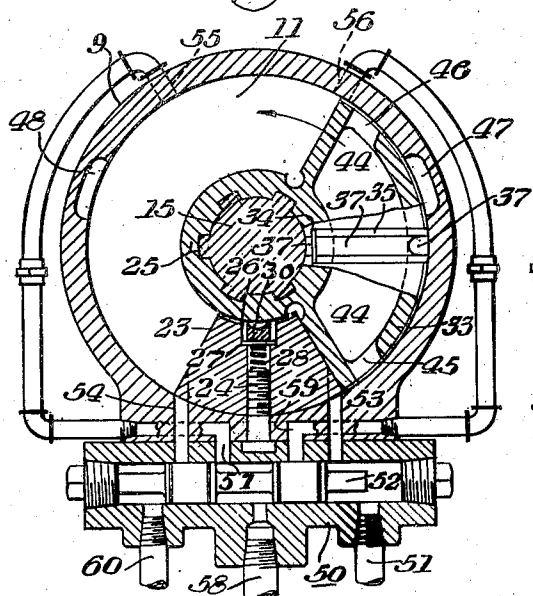


Fig.4

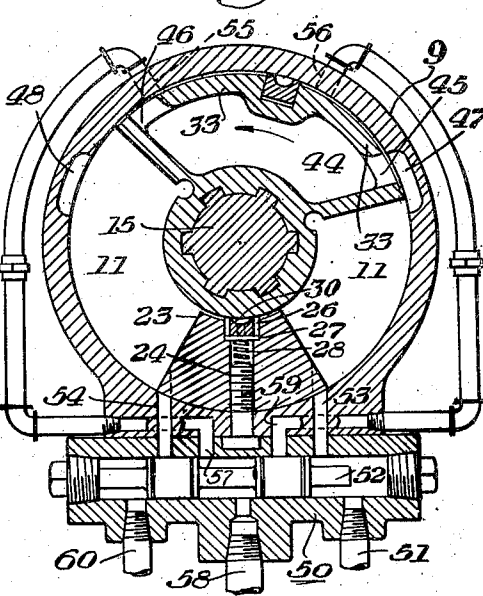


Fig.5

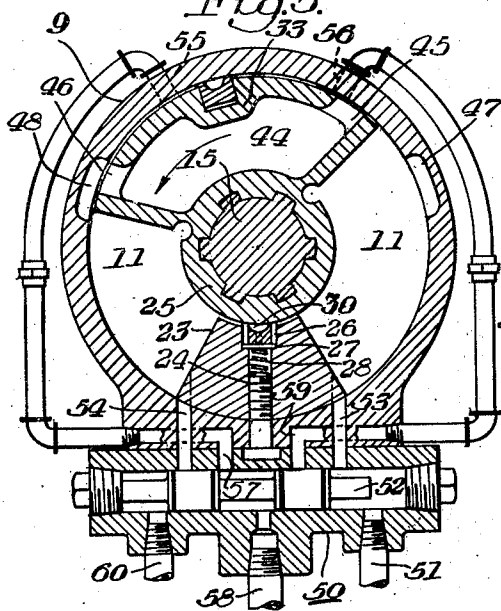
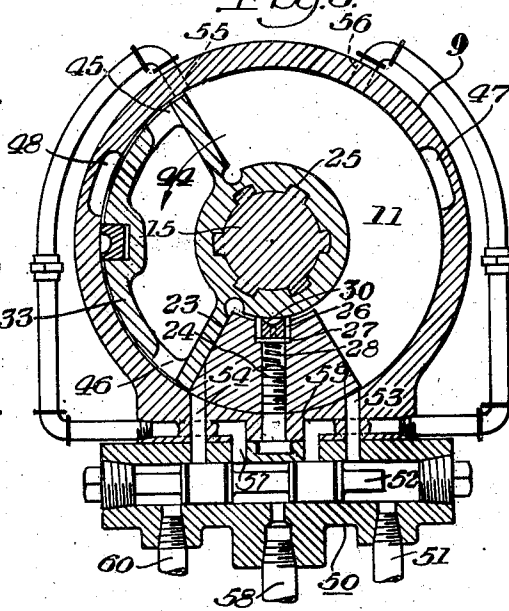


Fig.6



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UNITED STATES PATENT OFFICE

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SERVOMOTOR AND CONTROL

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14 Claims. (Cl. 60—16)

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This invention relates generally to expansible chamber motors and more particularly to a fluid pressure actuated servomotor for operating apparatus that is rotated in opposite directions to perform a function, such as operating a reversing valve.

This servomotor is adaptable to many different applications but was specifically designed for operating a reversing valve which controls the flow of scavenging or supercharging air produced by a screw blower for a reversible Diesel engine wherein the blower is driven directly from the shaft of the engine.

The principal object of this invention is the provision of a servomotor in which the diminishing chamber ahead of the vane is supplied with a charge of the motivating fluid under pressure to retard the vane adjacent the end of its stroke.

Another object is the provision of apparatus for supplying from the expanding chamber a charge of the motivating fluid under pressure to the diminishing chamber ahead of the vane to cushion the movement of the vane intermediate or adjacent the end of its stroke.

Another object is the provision of apparatus for supplying a charge of compressed fluid in the diminishing chamber of a servomotor and for venting the fluid under pressure in the expanding chamber to cushion the movement of the vane toward the end of its stroke.

Another object is the provision of a vane type expansible chamber servomotor wherein the vane functions as a valve at the end of its stroke for controlling the passage of the motivating fluid under pressure.

Another object is the provision of a Diesel engine reversing control circuit which includes a servomotor that operates a reversing valve and then completes the control circuit to start the engine in the opposite direction.

Another object is the provision of a method for charging the expanding chamber, charging the diminishing chamber, and discharging the expanding chamber in sequence of a servomotor intermediate of its complete operating stroke.

Other objects and advantages will be apparent from the disclosure shown on the drawings and in the following description and claims:

In the accompanying drawings a practical embodiment illustrating the principles of this invention is shown wherein:

Fig. 1 is a small perspective view of the servomotor.

Fig. 2 is a view in vertical section of the servomotor.

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Fig. 3 is a view in horizontal section of the servomotor showing the vane in one extreme position.

Fig. 4 is a view similar to Fig. 3 showing the vane in a first intermediate position.

Fig. 5 is a view similar to Fig. 3 showing the vane in a second intermediate position.

Fig. 6 is a view similar to Fig. 3 showing the vane in the other extreme position.

Fig. 7 is a diagrammatic view of a Diesel engine with reversing control circuit.

Fig. 8 is a vertical sectional view of the servomotor showing a portion of the vane and housing with their ports in registration.

Referring to Figs. 1 and 2 of the drawings, the housing 9 of the servomotor is provided with a cylindrical chamber 11 which is closed at the top by the removable cover 12 and at the bottom by the integral end wall 13. The cover 12 and the wall 13 are provided with axially aligned bearings 14 in which the servomotor shaft 15 is journaled. The shaft 15 is coaxial with the cylindrical chamber 11 and extends above the cover 12 to receive the hand operating arm 16 for manually rotating the servomotor shaft.

The lower side of the housing 9 and wall 13 is provided with an annular seat 17 arranged to fit the mating seat 18 which defines the upper opening of the adapter casting 19 which in turn has a stepped connecting fit with the reversing valve housing 20 which encloses a reversing valve that is employed in combination with the screw blower to change the direction of flow of scavenging air to a Diesel engine when the latter is reversed. The valve may be seen in Patent No. 2,345,780, issued April 4, 1944. The lower end of the shaft 15 is provided with the coupling member 21 which is arranged to receive the end of the upper gudgeon 22 of the valve.

The cylindrical chamber 11 in the servomotor housing is provided with a removable sector or stationary abutment 23 which is fastened to the housing by the bolts 24 as shown in Fig. 2. The outer cylindrical surface of the stationary abutment mates with the cylindrical wall of the chamber 11 and the inner cylindrical surface mates with the surface of the vane hub 25 as shown in Figs. 3 to 6.

The inner arcuate surface of the stationary abutment has a running clearance with the adjacent surface of the vane hub 25. In order to prevent fluid under pressure from leaking between these surfaces to either side of the stationary abutment, a sealing shoe 26 is placed in the vertical slot 27 of the abutment and is urged

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against the cylindrical surface of the hub 25 by means of the coil springs 28 which are inserted in the tapped holes that receive the bolts 24, which holes are aligned with the slot.

The wearing face and the upper and lower ends of the shoe 26 are grooved as indicated at 30 and small holes 31 connect the face of the long groove 30 with the bottom of the slot 27. A passageway 32 through the wall 13 of the housing connects the lower end of the groove 30 with the interior of the reversing valve housing 20. The passage 32 could extend to the atmosphere. However if compressed air is employed as the motivating fluid for the servomotor, and the reversing valve controls the flow of air under a relatively low pressure, any leakage or discharge of air passed to the abutment will flow to the chamber in the housing 20 and cannot accumulate on either side of the abutment but seeks the low pressure area through these passages.

The vane 33 with the abutment 23 occupy substantially one-half the volume of the chamber 11 and the hub 25 of the vane is splined on the shaft 15 as shown in Fig. 2. The outer arcuate surface of the hub and vane have a slight running clearance with the abutment and the walls of the chamber 11 which prevents wear between these surfaces having relative rotary movement. This clearance also permits the motivating or entrapped fluid to flow or exhaust therebetween and prevents the motivating fluid from reaching the leading face of the vane and thus check its movement. Thus the running clearance, which exhausts the fluid under pressure from either side of the vane, is a defined orifice the size of which determines the rate of discharge. A sloping or triangularly shaped radially extending slot 34 is provided in the center of the vane and is arranged to receive a similarly shaped shoe 35. This shoe is provided with a plurality of pockets for receiving the coil springs 36 which bear against the bottom of the slot 34 and force one leg surface of the triangular shaped shoe 35 into engagement with the under surface of the cover 12 and the other leg surface into engagement with the cylindrical wall of the chamber 11. A groove 37 is centered in the wearing faces of the surfaces of the triangular shoe 35, which groove matches with similar grooves in the upper and lower surfaces of the vane. The holes 38 through the shoe 35 connect the groove 37 with the bottom of the slot 34. The inner end of the groove 37 in the bottom face of the vane is connected to the enlarged bore forming an annular chamber 40 adjacent the shaft 15. A hole 41 connects the chamber 40 to the axial passageway 42 in the lower end of the shaft 15 which in turn is connected with the radial passage 43. Any fluid flowing to the center of the vane may leak into the groove 37 of the shoe and may thus flow through the passages 40, 41, 42 and 43 into the chamber of the valve housing 20. Two direct passageways for the flow of fluid are provided between the servomotor chamber 11 to the valve housing 20.

The vane 33 is hollow having the charging chamber 44 which is provided with ports 45, 46 adjacent the ends thereof. These ports are in the upper part of the vane and are arranged to connect the charging chamber with the chamber 11 through recesses 47 and 48 in the cylindrical wall of the chamber 11, as shown in Fig. 8.

The servomotor is controlled by the valve mechanism 50 secured to the front of the housing 9. As shown in Figs. 3 to 6, compressed air

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may enter the valve mechanism through the right port 51 moving the valve 52 to the left permitting the air to continue flowing through the port 53 that passes through the right end of the stationary abutment 23 into the chamber 11 in back of the vane 33 as shown in Fig. 3. The fluid under pressure moves the vane 33 to the position shown in Fig. 4 where it may flow into the recess 47 and through the port 45 into the charging chamber 44 within the vane.

The fluid under pressure continues to move the vane in a counterclockwise direction until it reaches the position shown in Fig. 5 where the charge of fluid under pressure within the charging chamber 44 escapes through the port 46 and the recess 48 to the chamber 11 on the leading side of the vane. At this instant the diminishing portion of the chamber 11 is substantially equal in volume to the charging chamber 44 in the vane. Thus a portion of the charge of fluid under pressure fills the diminishing portion of the chamber 11 and retards the movement of the vane in accordance with the differential in pressure on each side of the vane less the force of inertia of the latter.

The vane continues to move at a decreasing speed until it engages the left side of the stationary abutment 23 as shown in Fig. 6. It will be noted that the port 54 is closed by the valve 52 so the fluid in front of the moving vane is being continuously compressed even though a charge of fluid under pressure has been added thereto. Thus the fluid seeks its escape from the diminishing portion of the chamber 11 to the low pressure areas by means of the grooves 30 and 37 in the shoes 26 and 35 of the stationary abutment and vane respectively. These leakage paths act as a choke and thus cushion the movement of the vane toward the end of its stroke.

Just before the vane is about to strike the stationary abutment 23 the trailing edge of the vane uncovers one of the ports 55 or 56, depending on the direction of movement of the vane. Thus the vane acts as a valve in conjunction with these ports. These ports are in the lower part of the chamber 11 as indicated in Figs. 2 and 8 and do not mate with the ports of the charging chamber in the vane. As shown in Fig. 6 the fluid under pressure in back of the vane escapes through the port 55 and travels through a pipe to the port 57 which is opened by the setting of the valve 52 and permits the fluid to flow out the port 58. The port 56 is likewise connected by a pipe to the port 59, which in Fig. 6 is closed by the valve 52 for performing the same function when the servomotor is operated in the opposite direction.

If the servomotor is to be reversed the left hand port 60 is connected to fluid under pressure and the valve 52 is moved to the right, which admits air through the port 54 causing the vane to swing clockwise and follow the same sequence of events just described in the other direction.

If the fluid under pressure is continuously applied to the servomotor when in one position a certain portion will be continuously discharged through the dual passages in the shoes 26 and 35 to the reversing valve chamber. However it will be noted that the motivating fluid is discharged through the port 55 as soon as the latter is opened a slight amount which is prior to the end of the vane stroke, and the inertia of the mass, making up the vane and the movable parts connected thereto, is depended upon for completing the stroke of the vane. By varying or changing the

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positions of the recesses 47 and 48 and the ports 55 and 56 and controlling the pressure of the motivating fluid the desired operating characteristics of the vane and device it actuates may be obtained.

One application of the servomotor is shown in diagrammatic view, Fig. 7, where the source of fluid pressure is received by the pipe line 62 which in this case is compressed air employed for starting the Diesel engine. The supply line 62 is connected to the lower chamber 63 of the relay valve 64.

The relay valve is provided with a valve 65 attached at one end to the stem 66 which is provided with a piston head 67 at the other end. The piston is operated in the chamber 68 and is urged upwardly by the coil spring 69. Thus the fluid pressure and the spring tend to maintain the valve 65 closed but the piston 67 is larger in diameter than the valve, thus requiring a lower differential in pressure to open the valve.

Assuming that the valve 65 is closed and air under pressure is supplied to the chamber 63, this air is effective in the control line 70 to the manual control valve 71 which when in its neutral position maintains the line 70 closed and exhausts both control lines 72 and 73 but when moved to the position indicated "Ahead" admits compressed air to the line 72 and the line 73 not being charged is connected to the exhaust return line 74 and when moved to the position indicated "Reverse" admits compressed air to the line 73 and connects line 72 to exhaust.

The lines 72 and 73 are connected to opposite sides of the fluid motor piston 75 which through the linkage and sector gears 76 shift the valve actuating cam shaft 77 of the Diesel engine, thereby changing the fuel cams 78 and the starting air distributor 79 for operating the engine in either the forward or reverse direction.

Thus when the selected control line 72 is energized the piston 75 moves downwardly, causing the cam shaft 77 to move to the right. The lower sector engages a compressible check which insures a complete movement of the cam shaft in either direction.

The connecting rod which supports the piston 75 is provided with valves 80 at each end thereof for permitting the compressed air to continue to flow through the lines 72 and 73 only after the cam shaft has completed its movement to the selected position. When the manual control valve 71 is moved to a selected operating position to reverse the engine the discharge line 74 releases the pressure in the opposite control line through its corresponding valve 80 to the servomotor 10, the control line 81 and the chamber 68 of the master relay valve 64 and also continues to drain the chamber of the piston 75 before fluid under pressure is admitted to the opposite side of the second section of the control line. As previously stated the shoes 26 and 35 of the abutment and the vane respectively of the servomotor 10 are provided with restricted discharge passages that are constantly open to the atmosphere or to the chamber of the housing 20. Thus after the selected control line is closed by the movement of the piston 75 the entrapped air in front of the moving vane in the servomotor 10 escapes past the shoes 26 and 35 and passes directly to a low pressure discharge, thus preventing the vane from being blocked from movement. Initial movement of the piston 75 closes the valve 80 and thus blocks further discharge of the second section of the nonselected control line

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through the manual control valve 71. However the servomotor 10 is provided with an independent discharge or leakage path which continuously exhausts fluid under pressure simultaneously from either side of the servomotor. When the piston 75 completes its stroke the selected valve 80 admits fluid under pressure through the corresponding control line to the servomotor 10.

As shown in Fig. 7 the line 72, which is energized, with compressed air, is connected to the port 51 of a servomotor 10. The compressed air having swung the vane counterclockwise, and properly positioning the reversing valve for directing the scavenging air to the engine when the latter is set to move the boat or train ahead, it is permitted to flow out the port 58 to the pipe 11n where it travels to the chamber 68 of the relay valve 64 where it forces the piston 67 downwardly against the fluid pressure in the chamber 63 and compressing the spring 69 to open the valve 65 admitting compressed air to the air start header 82.

After leaving the servomotor the compressed air in the control line may be employed to check or operate other devices about the engine.

The header 82 is connected to a series of valves 83 that admit the compressed air to the cylinders of the Diesel engine in timed sequence by the cam shaft 77. Some of the valves 83 are open regardless of the position of the engine cam shaft and the compressed air enters the cylinders forcing the pistons down and causing the engine to turn over. As the Diesel engine gains speed as an air motor, it is switched to fuel oil and operates as an internal combustion engine. Thus each reversing device must properly function before the engine can be revolved in the opposite direction.

I claim:

1. In a fluid circuit for starting and reversing a Diesel engine as an air motor the combination of a fluid pressure supply, a normally closed fluid actuated master relay valve arranged to connect the supply to the valve-controlled cylinders of Diesel engine to operate the same, a manual control valve, a fluid motor for shifting a distributor and valve operating cam shaft reversing gear mechanism which control the operation of the Diesel engine, a fluid servomotor for controlling a blower reversing valve of said engine, a pair of fluid control lines connecting the associated sides of the servomotor, the fluid motor and the manual control valve the latter of which selectively connects one control line to said supply and the other to exhaust, and a third fluid control line connected to the master relay valve and arranged to receive fluid under pressure from the selected control line through the servomotor after the latter has functioned, to open the master relay valve and admit fluid under pressure from the supply to the valve controlled cylinders to turn over the engine.

2. The structure of claim 1 which also includes a valve in each control line leading to the servomotor and operated by the fluid motor to admit fluid to the alternate sides of the servomotor only after the fluid motor has functioned.

3. The structure of claim 1 wherein the control valve exhausts the control line circuit when neither control is connected to the supply.

4. In a fluid circuit for starting and reversing a Diesel engine equipped with a direct drive air blower the combination of a fluid pressure supply, a normally closed master relay valve arranged to connect the supply to valve-controlled cylinders of the Diesel engine to start the same, a manual

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control valve, a fluid motor for shifting a distributor and valve operating cam shaft reversing gear mechanism which control the operation of the Diesel engine in either direction, a fluid servomotor for actuating a blower reversing valve of the engine, a pair of fluid control lines in two sections connecting the associated sides of the manual control valve, the fluid motor and the servomotor in the order named, the manual control valve arranged to selectively connect the first section of one control line to exhaust and the other to said supply to energize the fluid motor and the servomotor, means operated by the fluid motor at the end of its energized movement to connect the second section to the first section of the selected control line to energize the servomotor, and a third control line connected to the master relay valve and energized by the servomotor after the latter has functioned, to open the master relay valve to admit fluid under pressure from the supply to the valve controlled cylinders to turn over the engine.

5. In a fluid circuit for starting and reversing a Diesel engine equipped with a direct drive air blower the combination of a fluid pressure supply, a differential master valve biased to close normally and arranged when opened to connect the fluid pressure supply to valve-controlled cylinders of the Diesel engine to start the same, a manual control valve, a fluid motor for shifting a distributor and valve operating cam shaft reversing mechanism which control the operation of the Diesel engine in either direction, a fluid servomotor for actuating a blower reversing valve of the engine, a pair of fluid control lines in two sections connecting the associated sides of the manual control valve, the fluid motor and the servomotor in the order named, a third control line connecting the servomotor to the differential master valve, the manual control valve arranged to selectively connect the first section of one of said pairs of control lines to the fluid pressure supply and the alternate control line to exhaust, means actuated by the completed movement of the fluid motor to energize the fluid servomotor through the second section of the selected control line, and means actuated by the completed movement of the fluid servomotor through the third control line to energize the differential master valve and open the latter to admit fluid to the valve controlled cylinders of the Diesel engine to start the same.

6. In a fluid circuit the combination of a source of fluid under pressure, a manual control valve connected thereto, a double action fluid motor, a double action fluid servomotor, a single action fluid motor, a pair of fluid control lines connecting the associated sides of the manual control valve and the double action fluid motor, a second pair of fluid control lines connecting the associated sides of the double action fluid motor and the double action fluid servomotor, a third control line connecting the double action fluid servomotor with the single action fluid motor, the manual control valve being arranged to connect the source of fluid under pressure with a selected control line to operate the double action fluid motor, means operated by the double action fluid motor as it completes its stroke to operate the double acting fluid servomotor through a selected control line of the second pair, and means operated by the double action fluid servomotor as it completes its stroke to operate the single acting fluid motor through the third control line.

7. In a fluid circuit the combination of a source of fluid under pressure, a manual control valve

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connected thereto, a double action fluid motor, a double action fluid servomotor, a single action fluid motor, a pair of fluid control lines in two sections connecting the associated sides of the manual control valve, the double action fluid motor and the double action fluid servomotor in the order named, a third control line connecting the single action fluid motor with the double action fluid servomotor, the manual control valve being arranged to selectively connect the source of fluid under pressure with one of said pair of control lines, and means to prevent the operation of the motors in the sequence named until the preceding motor has functioned.

8. The structure of claim 7 characterized in that said means includes a valve in the second section of each control line operated by the double action fluid motor as the latter completes its stroke.

9. The structure of claim 7 characterized in that said means includes a valve for directing the flow of fluid to the third control line from the double action fluid servomotor when the latter completes its stroke.

10. The structure of claim 7 characterized in that said means includes a valve actuated by the fluid flowing through the selected control line for directing the fluid flow to the third control line.

11. The structure of claim 7 characterized in that said means includes a valve actuated by the fluid flowing through the selected control line for directing the fluid flow to the third control line from the double action fluid servomotor when the latter completes its stroke.

12. In a fluid circuit the combination of a source of fluid under pressure, a discharge, a manual control valve connected with the supply and with the discharge, a double action fluid motor, a double action fluid servomotor having an independent restricted outlet constantly open to discharge, a single action fluid motor, a pair of control lines in two sections connecting the associated sides of the manual control valve, the double action fluid motor and the double action fluid servomotor in the order named, said manual control valve arranged to selectively connect one control line to the fluid source and the other to discharge or both control lines to discharge, a valve in each control line operated by the double action fluid motor for controlling the flow of fluid to the double action fluid servomotor, a third control line connecting the servomotor with the single action fluid motor, and means to direct the fluid to the third control line to operate the single action fluid motor from a selected one of the pair of control lines after the double action fluid servomotor has completed its stroke.

13. In a fluid circuit for starting and reversing a Diesel engine as an air motor which consists in a supply of air under pressure, a discharge, a manual control valve connected with the supply and with the discharge, a double action air motor for shifting a distributor and cam shaft reversing mechanism which control the operation of the engine, a double action air servomotor for actuating a blower reversing valve of said engine, a single action air motor arranged to operate a valve which connects the supply to valve-controlled cylinders of the engine to operate the same as an air motor, a pair of control lines connecting the associated sides of the manual control valve, the double action motor and the double action servomotor, said manual control valve arranged to selectively connect one control line to the supply and the other to discharge or both control lines to discharge, a valve in each control

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line operated by the double action motor for controlling the flow of air to the servomotor, a third control line connecting the servomotor with the single action motor, and means to prevent the operation of the motors in the sequence named until the preceding motor has functioned.

14. In a fluid circuit for starting and reversing a Diesel engine as an air motor which consists in a supply of air under pressure, a discharge, a manual control valve connected with the supply and with the discharge, a double action air motor for shifting a distributor and cam shaft reversing mechanism which control the operation of the engine, a double action air servomotor for actuating a blower reversing valve of said engine, a single action air motor arranged to operate a valve which connects the supply to valve-controlled

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cylinders of the engine to operate the same as an air motor, a pair of control lines connecting the associated sides of the manual control valve, the double action motor and the double action servomotor, said manual control valve arranged to selectively connect one control line to the supply and the other to discharge or both control lines to discharge, a valve in each control line operated by the double action motor for controlling the flow of air to the servomotor, a third control line connecting the servomotor with the single action motor, and means to direct the air to the third control line from a selected one of the pair of control lines after the servomotor has completed its stroke to operate the single action motor.

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