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CONTROL APPARATUS

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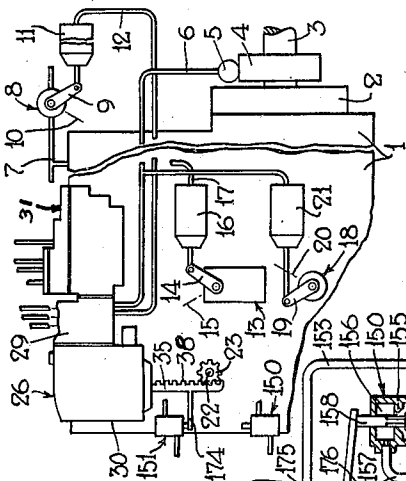


Fig. 2

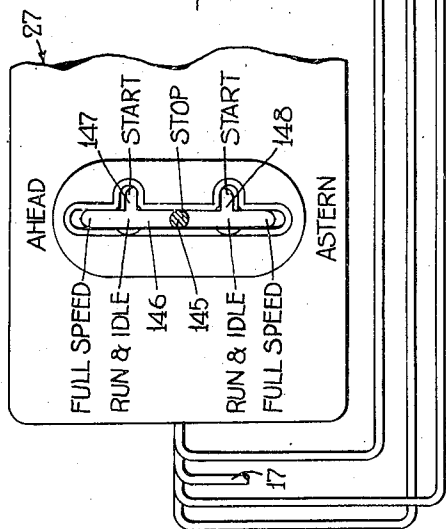
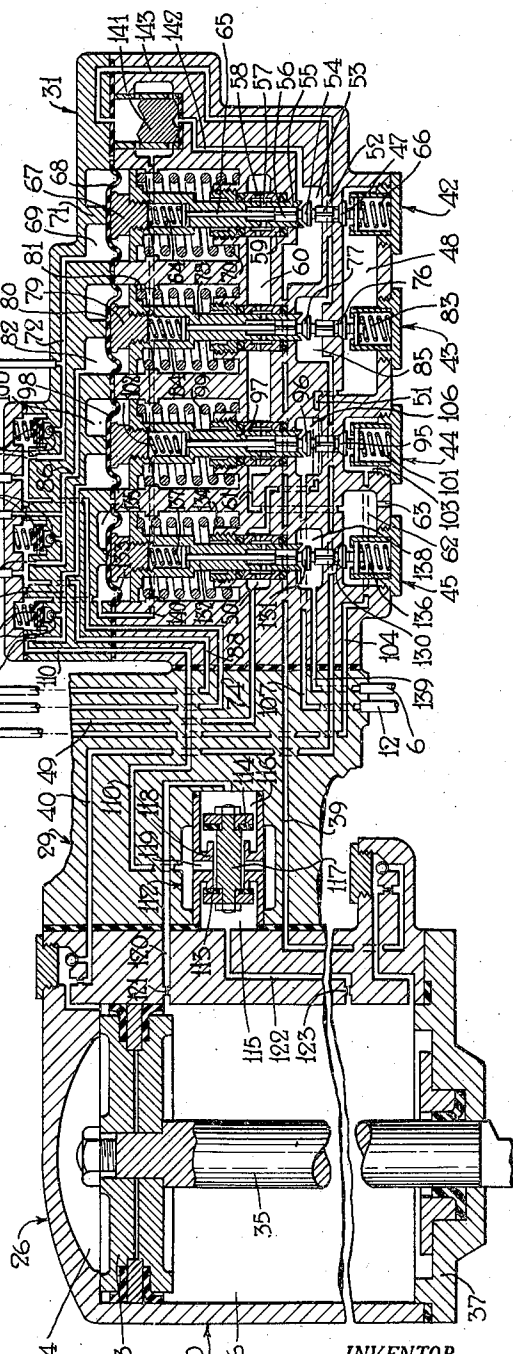


Fig. 1



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CONTROL APPARATUS

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12 Claims. (Cl. 192—3.0)

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This invention relates to control apparatus and more particularly to the fluid pressure type for controlling a plurality of different operations in a desired sequence, such as required in controlling a reversible Diesel engine.

In the copending application of Harry C. May and myself, Serial No. 521,798, filed February 10, 1944, there is disclosed a fluid pressure system of the above type which embodies a power piston adapted to be operated by fluid under pressure supplied to act on one side to condition the reverse gear or timing of a reversible engine to provide for operation of the engine in one direction, and adapted to be operated by fluid under pressure supplied to act on the opposite side to condition said gear to provide for operation of said engine in the reverse direction. An operator's control device is operative to selectively provide fluid pressure on either the one side or on the opposite side of the power piston. The structure further embodies means for delaying the supply of fluid to actuate the power piston for a certain period of time, such as 6 seconds, after operation of the operator's control device to provide such fluid, and the purpose of this delay is to insure the stopping of the engine in one direction of operation before permitting operation of the power piston to reverse the engine's reverse gear or timing to provide for operation of the engine in the opposite direction.

This delay in supplying fluid to act on the power piston is effective under all conditions of engine control, even when the operator desires to restart and operate the engine in the same direction that it last operated. Under this latter condition the delay is not necessary, however, since the engine's reversing gear is already conditioned to allow starting of the engine.

The principal object of the invention is therefore the provision of means for rendering the delay means above described ineffective upon starting the engine in the same direction that it last operated.

Other objects and advantages will be apparent from the following more detailed description of the invention.

In the accompanying drawing; Fig. 1 is a diagrammatic view of a control system embodying one form of the invention; and Fig. 2 is a view of the portion of the structure shown in Fig. 1 and embodying another form of the invention.

Description

Referring first to Fig. 2. The reference numeral 1 indicates a reversible Diesel engine which

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is arranged to be connected through suitable coupling means 2 to a drive shaft 3, said engine being operable to turn said shaft in either one direction or in the opposite direction according to the direction of operation of the engine. The reference numeral 4 designates a brake for the drive shaft 3 and thereby the engine. The numeral 5 indicates a brake cylinder device adapted to be operated by fluid under pressure supplied through a pipe 6 to actuate the brake 4 for braking the shaft 3 and the engine 1, and adapted to operate upon release of fluid under pressure from said pipe to release said brake. The numeral 7 indicates a starting air pipe through which compressed starting air is adapted to be supplied to certain or all of the cylinders of the engine in order to effect starting of the engine in the direction determined by the timing or condition of the engine's valve gear. The supply of starting air to pipe 7 is arranged to be controlled by a starting air valve device 8 which is adjustable by a lever 9. With lever 9 in the position in which it is shown in the drawing the supply of starting air to the starting air pipe 7 will be cut off, while upon movement of said lever to a position such as indicated by a dot and dash line 10, starting air will be admitted to pipe 7 and thereby to the engine.

Movement of lever 9 to its different positions may be controlled by a starting control motor 11 which is operative upon supply of fluid under pressure to a pipe 12 to move the control lever 9 to the position indicated by the dot and dash line 10 and which is operative upon release of fluid under pressure from said pipe to return the lever 9 to the position in which it is shown in the drawing.

The reference numeral 13 indicates a speed governor of any conventional type arranged to be driven by and to operate at a speed proportional to that of the engine 1 for limiting the fuel supply to and thereby the speed of the engine in accordance with the adjustment of a governor control lever 14. This lever may have an engine idling position in which it is shown in the drawing and may be adjusted to any position between said idling position and a maximum speed position such as indicated by a dot and dash line 15 to thereby provide for any degree of speed of the engine.

The adjustment of the speed control lever 14 may be controlled by a speed control motor 16 which is operable upon supply of fluid under pressure to a speed control pipe 17 to adjust said lever out of the idling position to a position cor-

responding to the pressure of such fluid. A certain maximum pressure of fluid in control pipe 17 will cause operation of the motor 16 to move the speed control lever 14 to the maximum speed position indicated by the dot and dash line 15, while opening said pipe to atmosphere will cause operation of said motor to move the speed control lever 14 to idling position in which it is shown in the drawing.

The reference numeral 18 indicates a fuel cut-off device which is arranged to cut off the supply of fuel to the engine, in any conventional manner, to allow stopping of the engine. Operation of the fuel cut-off device may be controlled by a lever 19 having a fuel cut-off position in which it is shown in the drawing and a fuel supply position indicated by a dot and dash line 20. The lever 19 is connected to a fuel cut-off motor 21 which is arranged to be controlled by pressure of fluid in pipe 6 and which is operable upon supply of fluid under pressure to said pipe to move lever 19 to its fuel cut-off position and which is operable upon release of fluid pressure from said pipe to effect movement of said lever to its fuel supply position.

The engine 1 is provided with a rotatable shaft 22 for effecting, in any conventional manner as by means of gears and racks (not shown), the reversing of the engine's valve gear or timing to provide for starting and operation of the engine in either one direction or in the reverse direction. A gear 23 is secured to shaft 22 for turning same.

The structures so far described for controlling the operation of engine 1 are arranged to be controlled by a maneuvering control valve device 26 mounted on the engine and which is arranged to be controlled by an operator's control valve device 27.

The maneuvering control device 26 comprises a bracket 29 upon which is removably mounted a fluid reversing motor 30 for actuating the reversing shaft 22, and also comprises a timing or interlock valve device 31 for controlling the operation of said motor, and for also controlling the operation of the starting motor 11, the fuel cut-off motor 21 and the brake 4.

The reversing motor 30 comprises a cylinder containing a double acting piston 33, at one side of which is a pressure chamber 34. The piston 33 is provided with a rod 35 projecting from the opposite side through a pressure chamber 36 and a pressure head 37, closing one end of said cylinder, to the exterior of said head. Exteriorly of the pressure head 37, the rod 35 is provided on one side with gear teeth 38 which mesh with the teeth on gear 23 on the reversing shaft 22, whereby reciprocation of piston 33 in its cylinder will turn the reversing shaft 22. The piston 33 has two operating positions, namely, an astern position in which it is shown in the drawing, and which is defined by contact between said piston and the closed end of the cylinder, for conditioning the engine's reversing shaft 22 to provide for operation of the engine in an astern direction, and the second position which is defined by contact between said piston and the pressure head 37 to condition the reversing shaft 22 to provide for operation of the engine in the opposite or an ahead direction. Movement of the piston 33 to its astern position is adapted to be effected by fluid under pressure supplied to chamber 36 by way of a passage 39, when chamber 34 is open to atmosphere through a passage 40, while movement of said piston to the ahead position defined by contact with the pressure head 37 is adapted

to be obtained by fluid under pressure supplied through passage 40 to chamber 34 when fluid pressure is released from chamber 36 by way of passage 39.

The supply and release of fluid under pressure to and from passages 39 and 40 is controlled by astern and ahead pilot valve devices 42 and 43, respectively, which constitute a part of the timing or interlock valve device 31. The timing or interlock valve device 31 further comprises a starting control valve device 44 for controlling the supply and release of fluid under pressure to and from the starting control motor 11, and also comprises a fuel and brake control valve device 45 for controlling the supply and release of fluid under pressure to and from pipe 6, the brake cylinder device 5 and fuel cut-off motor 21.

The astern pilot valve device 42 comprises a fluid pressure supply valve 47 contained in a chamber 48 which is adapted to be constantly supplied with fluid under pressure from any suitable source by way of a passage 49, a chamber 50 and a passage 51. The valve 47 has a fluted stem 52 extending through a bore in a partition wall 53 separating chamber 48 from a chamber 53, which latter chamber is connected to passage 39 leading to chamber 36 below the power piston 33. In chamber 53 the supply valve stem 52 engages a release valve 54 arranged to seat on the end of a movable plunger 55. The release valve has a fluted stem 56 extending into a bore in plunger 55, which bore is in constant communication with the atmosphere through ports 57 in the plunger, ports 58 in a sleeve 59 secured in the casing, a chamber 60, a passage 61, a chamber 62 and a vent port 63. In plunger 55 there is a spring 64 which is connected through a pin 65 to the release valve stem 56 for urging said valve out of seating contact with the end of said plunger. A spring 66 having greater precompressed force than spring 64 is provided in chamber 48 and acts on the supply valve 47 for urging said valve in the direction of its seat.

The end of plunger 55 which is opposite the release valve 54 is connected to a follower 67 engaging one side of a flexible diaphragm 68. At the opposite side of diaphragm 68 is a fluid pressure control chamber 69. A precompressed coil spring 70 acts on follower 67 for deflecting the diaphragm 68 in the direction of chamber 69, such movement being limited by contact between said diaphragm and a stop 71. When diaphragm 68 is subjected, in chamber 69, to fluid at a pressure sufficient to overcome spring 70, said diaphragm will deflect against the opposing force of said spring as will be apparent. Upon movement of diaphragm 68 against the opposing force of spring 70, the plunger 55 will initially move relative to the release valve 54, due to the fact that the pressure of spring 66 exceeds that of spring 64. After a certain degree of such movement plunger 55 will engage the release valve 54 for closing communication between chamber 53 and chamber 60, and further movement of the diaphragm 68 will then act through said valve to unseat the fluid pressure supply valve 57. Conversely, upon release of fluid pressure from chamber 69, and movement of diaphragm 68 and plunger 55 by spring 70 back to the position defined by stop 71, the fluid pressure supply valve 47 will be seated by spring 66 ahead of the opening of the release valve 54 by spring 64.

The pressure chamber 69 above diaphragm 68 is connected through a passage 72, a choke 73, and a communication by-passing said choke and

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containing serially arranged check valves 91, to a passage 74 which is connected to an astern control pipe 75 leading to the operator's control valve device 27. The check valves 91 are provided to render choke 73 effective to regulate the rate of flow of fluid under pressure from pipe 75 to chamber 69, while said valves will open upon reverse flow of fluid under pressure to provide for a relatively fast release of fluid under pressure from said chamber to pipe 75.

The ahead pilot valve device 43 is structurally identical to the astern pilot valve device 42, just described, and briefly described, comprises a supply valve 76, a release valve 77, a plunger 78 having a seat for said release valve, a follower 79 engaging one side of a flexible diaphragm 80, a control spring 81 acting through said follower on said diaphragm in opposition to pressure of fluid in a chamber 82, a spring 83 for closing the supply valve 76 and a spring 84 for unseating the release valve 77 from the end of plunger 78. The supply valve 76 is contained in the fluid pressure supply chamber 48, while the release valve 77 is contained in a chamber 85 which is connected to passage 40 leading to chamber 34 at the upper side of the reversing piston 33.

The chamber 82 above diaphragm 80 is connected through a passage 86, a choke 87 and a passage 88 to an ahead control pipe 89 leading to the operator's control valve device 27. The choke 87 is provided to restrict flow of fluid under pressure in the direction from pipe 89 to pressure chamber 82, while a faster rate of outflow of fluid from said chamber is provided for through a communication by-passing choke 87 and containing two serially arranged check valves 90.

The starting control valve device 44 is structurally identical to the astern and ahead control valve devices 42 and 43 and, briefly described, comprises a fluid pressure supply valve 95, a release valve 96, a plunger 97, a flexible diaphragm 98, a spring 99 acting on said diaphragm in opposition to pressure of fluid in a control chamber 100, a spring 101 for closing the supply valve 95 and a spring 102 for opening the release valve 96. The supply valve 95 is contained in a chamber 103 which is connected by a passage 104 to a starting control pipe 105 leading to the operator's control valve device 27. The release valve 96 is contained in a chamber 106 which is connected by a passage 107 to pipe 12 leading to the starting control motor 11. The diaphragm chamber 100 is connected through a passage 108 and a choke 109 to a control passage 110.

The control passage 110 leads to the side outlet of a double check valve device 112 which comprises two check valves 113 and 114 contained in chambers 115 and 116, respectively. These check valves are connected together for movement in unison by a stem 117 which loosely extends through a bore provided in a wall 118 which separates chambers 115 and 116. At the opposite ends of this bore, the wall 118 is provided with seats for contact with the valves 113 and 114, respectively, said valves being spaced apart by stem 117 a distance exceeding that between said seats whereby when either valve is seated the other will be unseated. The bore through the wall 118 containing stem 117 is connected by one or more radial bores 119 to passage 110.

The chamber 116 containing check valve 114 is open through a passage 120 containing a choke 121 to chamber 36 below the power or reversing piston 33 when said piston is in contact with the closed end of the cylinder. Upon movement

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of piston 33 out of contact with the closed end of the cylinder in the direction of pressure head 37, the passage 120 is first disconnected from chamber 36 and then opened past said piston to pressure chamber 34.

The chamber 115 containing check valve 113 is connected by a passage 122 containing a choke 123 to pressure chamber 36 with the piston 33 in the astern position as shown in the drawing, and said passage is adapted to be opened to chamber 34 upon movement of piston into contact with the pressure head 37.

The fuel and brake control valve device 45 is also structurally identical to the astern and ahead control valve devices 42 and 43 and to the starting control valve device above described and, briefly described, comprises a valve 130, a second valve 131, a plunger 132 having a seat for valve 131, a flexible diaphragm 133, a spring 134 acting on one side of said diaphragm in opposition to pressure of fluid in a chamber 135 at the opposite side, a spring 136 acting to close the valve 130 and a spring 137 acting to open the valve 131. The valve 131 is contained in a chamber 138 which is connected through a passage 139 to pipe 6 leading to the brake cylinder device 5 and fuel cut-off motor 21 and is arranged to control the flow of fluid under pressure from chamber 50 to chamber 138. The valve 130 is contained in chamber 62 which is open to atmosphere through the vent 63 and is provided to control communication between said chamber and chamber 138.

Pressure chamber 135 above diaphragm 133 is connected to a passage 140 which leads to the side outlet of a double check valve 141 which is subject on its opposite ends to pressure of fluid from chambers 53 and 85 in the astern and ahead pilot valve devices 42 and 43, by way of passages 142 and 143, respectively. Upon supply of fluid under pressure to passage 142, the double check valve will be moved by such pressure to a position the reverse of that shown in the drawing for opening communication between said passage and passage 140 while closing communication between passages 140 and 143. Upon supply of fluid under pressure to passage 143, the double check valve 141 will move to the position in which it is shown in the drawing for opening communication between passages 143 and 140 and for closing communication between passages 140 and 142. The diaphragm chamber 135 is also connected through a communication including two serially arranged check valves 144 to passage 108 leading to pressure chamber 100 above diaphragm 98 in the starting control valve device 44, said check valves being arranged to prevent flow of fluid under pressure from chamber 135 to passage 108 but to permit flow in the opposite direction.

The operator's control valve device 27 is provided for controlling through pipes 75, 89 and 105 supply of fluid under pressure to and its release from diaphragm chambers 69, 82 and 103 in the astern and ahead pilot valve devices 42 and 43 and in the starting control valve device 44, respectively, and for also controlling through pipe 17 supply and release of fluid under pressure to and from the speed control motor 16. The operator's control valve device therefore comprises valve means (not shown) for controlling the pressure of fluid in the pipes just mentioned and a lever 145 for controlling the operation of said valve means.

The lever 145 extends through guide slot 146 and has a "Stop" position intermediate the ends

of said slot. At one side of "Stop" position indicated in the drawing by a legend "Ahead," the lever 145 has a "Run and idle" position which is located substantially midway between "Stop" position and the end of the slot where said lever has a "Full speed" position. Adjacent the "Run and idle" position the slot 146 opens to a side slot 147 to allow movement of lever 145 to a "Start" position. At the opposite side of "Stop" position, indicated by the legend "Astern," the lever 145 has oppositely arranged "Run and idle" and "Full speed" positions, and adjacent said "Run and idle" position a "Start" position in a side slot 148.

In "Stop" position of lever 145 the valve means (not shown) controlled by said lever are operable to open the several pipes 75, 89, 105 and 17 to atmosphere. In "Run and idle" position at the "Ahead" side of "Stop" position the valve means controlled by lever 145 are operative to supply fluid under pressure to the ahead control pipe 89 while maintaining the astern control pipe 75, the starting control pipe 105 and the speed control pipe 17 open to atmosphere, while upon movement of said lever into the side slot 147 fluid under pressure is adapted to be additionally supplied to the starting control pipe 105. In the "Run and idle" position of lever 145 at the opposite or astern side of "Stop" position, fluid under pressure is adapted to be supplied to the astern control pipe 75 while the ahead control pipe 89, the starting pipe 105 and the speed control pipe 17 will be open to atmosphere, while upon movement of said lever into slot 148 fluid under pressure will also be supplied to the starting control pipe 105.

When the lever 145 is in either of the "Run and idle" positions the speed control pipe 17 is adapted to be open to atmosphere as above described, for rendering the speed control motor 16 effective to move the governor control lever 14 to the idle position in which it is shown in the drawing, while upon movement of the operator's lever 145 to either of the "Full speed" positions fluid at a maximum degree of pressure is adapted to be provided through pipe 17 to the speed control motor 16 for operating said motor to move the governor control lever 14 to the maximum speed position indicated by the dot and dash line 15, to thereby provide for operation of the engine at maximum speed. Any desired degree of speed or output of the engine, between idle and maximum may be obtained by suitable adjustment of the operator's control lever 145 between either "Run and idle" position and the adjacent "Full speed" position.

The control apparatus as so far described is substantially identical to corresponding parts of the control apparatus fully disclosed and described in the copending application hereinbefore referred to, in view of which, a more detailed disclosure and description of such parts is not considered essential in the present application to a clear understanding of the invention.

The operation of the apparatus as so far described is as follows:

Let it be initially assumed that the operator's control lever 145 is in "Stop" position opening the astern and ahead control pipes 75 and 89, respectively, to atmosphere, and also opening the starting control pipe 105 and the speed control pipe 17 to atmosphere. Chambers 69 and 82 in the astern and ahead pilot valve devices 42 and 43 will thus be open to atmosphere so that the parts of said devices will be in the position in which they are

shown in the drawing with the release valves 54 and 77 open. Chamber 34 above the reversing piston 33 will therefore be open to atmosphere through passage 40 and past valve 77, while chamber 36 below said piston will also be open to atmosphere through passage 39 and past valve 54. The reversing piston 33 will therefore be in a static condition, and let it be assumed that it is in the position in which it is shown in the drawing conditioning the engine's valve gear for operation of the engine in the astern direction.

With diaphragm chambers 69 and 82 in the astern and ahead pilot valve devices 42 and 43 open to atmosphere, chamber 135 in the fuel and brake control valve device 45 will also be open to atmosphere past either one end or the other of the double check valve 141 and thence through either passage 142 or 143 and past the release valve 54 or 77, respectively. The parts of the fuel and brake control valve device 45 will therefore be positioned as shown in the drawing with valve 131 open, so that fluid under pressure supplied through passage 49 to chamber 50 will flow past said valve to chamber 138 and thence through passage 139 and pipe 6 to the brake cylinder device 5 and to the fuel cut-off motor 21. The brake cylinder device 5 will therefore be operated to cause the brake 4 to brake the drive shaft 3 of the engine, while the fuel cut-off motor 21 will be operated to hold lever 19 in its fuel cut-off position in which it is shown in the drawing for cutting off the supply of fuel to the engine.

With diaphragm chamber 135 in the fuel and brake control valve device 45 open to atmosphere as above described, fluid under pressure will also be vented from diaphragm chamber 100 in the starting control valve device 44 by way of the check valves 144, chamber 135 and passage 140, so that the parts of the starting control valve device 44 will be positioned as shown in the drawing with the release valve 96 open. With valve 96 open chamber 106, passage 107, and thereby pipe 12 and the starting control motor 11 will be open to atmosphere so that lever 9 of the starting air valve device 8 will be in its starting air cut-off position in which it is shown in the drawing.

Let it now be assumed that the operator desires to re-start the engine in the astern direction, in which it last operated, as determined by the position of the reversing piston 33 in contact with the closed end of its cylinder as shown in the drawing.

In order to start and operate the engine in the reverse or astern direction, the operator will move the control lever 145 from "Stop" position to the "Astern" "Start" position in slot 148. This operation of lever 145 will effect a supply of fluid under pressure to the starting control pipe 105 and to the astern control pipe 75, while maintaining the ahead control pipe 89 and the speed control pipe 17 open to atmosphere.

Fluid under pressure thus supplied to the starting control pipe 105 will flow to chamber 103 in the starting control valve device 44 where for the present it will stop since the supply valve 95 is closed. Fluid under pressure supplied to the astern control pipe 75 will however flow through passage 74, choke 73 and passage 72 to diaphragm chamber 69 in the astern pilot valve device 42. When a sufficient pressure of fluid is then obtained in chamber 69 acting on diaphragm 58 to overcome the opposing force of spring 70, said diaphragm will deflect in a downward direction and move plunger 55 into contact with the re-

lease valve 54 and then move said valve to open the supply valve 47. Fluid under pressure will then flow from chamber 48 past the supply valve 47 to chamber 53 and thence through passage 39 to chamber 36 below the reversing piston 33 to act on said piston for urging it to its astern position, which it already occupies as shown in the drawing.

Fluid under pressure supplied past the supply valve 47 to chamber 53 in the astern pilot valve device will also flow through passage 142 to the lower end of the double check valve 141, the upper face of which is at this time open to atmosphere through passage 143 and past the open release valve 77 in the ahead pilot valve device 43. The pressure of fluid provided through passage 142 and acting on the lower face of the double check valve 141 will therefore shift said valve to its upper position for opening communication between said passage and passage 140 to permit flow of fluid under pressure from passage 142 to passage 140 and thence to chamber 135 above diaphragm 133 in the fuel and brake control valve device 45.

When sufficient pressure is thus obtained in chamber 135 to overcome the opposing force of spring 134 on diaphragm 133, said diaphragm will deflect in a downward direction and shift the plunger 132 first into contact with valve 131 for closing off the supply of fluid under pressure from chamber 50 to chamber 138. Further deflection of diaphragm 135 will then act through valve 131 to open valve 130, whereupon fluid under pressure will be released from chamber 138 to chamber 62 and thence to atmosphere through port 63. Upon this release of fluid under pressure from chamber 138, fluid will also be released from passage 139 and pipe 6 and thus from the brake cylinder device 5 and from the fuel cut-off motor 21. The brake cylinder device 5 will then operate to release brake 4 on shaft 3, while the fuel cut-off motor 21 will operate to move lever 19 of the fuel cut-off valve device 18 to the position indicated by the dot and dash line 20 for admitting fuel to the engine.

At substantially the same time that the brake 4 on shaft 3 is released and the fuel cut-off valve device 18 is operated to admit fuel for running the engine, the fluid under pressure supplied to chamber 36 below the reversing piston 33 will flow through passage 122 to chamber 115 for acting on the check valve 113 to maintain said check valve seated, and fluid under pressure will also flow from chamber 36 through passage 120 to chamber 116 containing the unseated check valve 114. This condition of the two check valves 113 and 114 is the same as during last operation of the engine and will not change upon simultaneous supply of fluid under pressure to the two chambers 115 and 116, as occurs in the particular operation being described.

Fluid under pressure supplied to chamber 116 in the double check valve 112 will flow past the check valve 114 and through the radial ports 119 to passage 110 and thence through choke 109 to chamber 100 above diaphragm 98 in the starting control valve device 44. When the pressure of fluid thus obtained in chamber 100 becomes sufficient to overcome the opposing force of spring 99 on diaphragm 98, said diaphragm will deflect downwardly and move stem 97 into engagement with release valve 96 and then shift said release valve to open the supply valve 95. Upon opening of valve 95, fluid under pressure supplied to chamber 103 through the starting control pipe 105 with

the operator's control lever in the "Astern" "Start" position in recess 148, will flow past said valve to chamber 106 and thence through passage 107 and pipe 12 to the starting control motor 11 and actuate said motor to move the starting air valve lever 9 to the supply position indicated by the dot and dash line 10, whereupon starting air from any conventional source will be supplied to the starting air pipe 7 for supply to the engine cylinders for starting the engine to turn in the astern direction, as determined by the position of the reversing piston 33. As soon as the engine starts to turn under the influence of starting air provided in pipe 7, the fuel supplied to the engine by operation of the cut-off valve device 18 will fire and cause the engine to run on fuel. After the engine fires and is running on fuel the operator will then move the control lever 145 out of the "Astern" "Start" position in recess 148 to the "Astern" "Run and idle" position and the engine will then continue to run on fuel at an idling speed. This movement of lever 145 to the "Astern" "Run and idle" position will however cut off the supply of fluid under pressure to and will release fluid under pressure from the starting control pipe 105, and since said pipe is open past valve 95 in the starting control valve device 44 to the starting air motor 11, fluid under pressure will be released from said motor to effect operation of the starting air valve device 8 to cut off the supply of starting air to the engine.

To now increase the speed of the engine operating in the astern direction, the operator may adjust lever 145 between the "Run and idle" position and the "Full speed" position at the "Astern" side of "Stop" position, as will be apparent.

When the operator desires to stop the engine he will move the control lever 145 to "Stop" position for releasing fluid under pressure from the astern control pipe 75 and thus from diaphragm chamber 69 in the astern pilot valve device 42, this release of fluid under pressure from chamber 69 occurring at a relatively rapid rate through the communication, including the check valves 91, which by-passes the choke 73. When the pressure in diaphragm chamber 69 is sufficiently reduced, spring 70 will return the diaphragm 68 and plunger 55 to the positions in which they are shown in the drawing, permitting closure of the supply valve 47 by spring 66 and opening of the release valve 54 by spring 64. Upon opening the release valve 54 fluid under pressure will be released from chamber 53 and the connected chamber 36 below the reversing piston 33, and also from diaphragm chamber 135 in the fuel and brake control valve device 45, by way of passage 140, past the double check valve 141 and through passage 142. When the pressure in chamber 135 is thus sufficiently reduced, spring 134 will return the diaphragm 133 and plunger 132 to the positions in which they are shown in the drawing to permit closure of valve 130 by spring 136 and opening of valve 131 by spring 137. Upon opening of valve 131 fluid under pressure will be supplied from passage 49 and chamber 50 to chamber 138 and thence through pipe 6 to the brake cylinder device 5 and to the fuel cut-off motor 21. The brake cylinder device 5 will then operate to actuate brake 4 to stop the drive shaft 3 and the engine while the fuel cut-off motor 21 will operate to move lever 19 of the fuel cut-off valve device 18 to the fuel cut-off position in which it is shown in the drawing for cutting off the supply of fuel to the engine, so that the engine may be stopped by brake 4.

When fluid under pressure is released from diaphragm chamber 135 in the fuel and brake control valve device 45, fluid under pressure will also be released from diaphragm chamber 100 in the starting control valve device 44 by way of the communication including the two check valves 144 and thence through diaphragm chamber 135, so that the parts of the starting control valve device will return to the position in which they are shown in the drawing and in which position the supply valve 95 will be closed and the release valve 96 is opened.

Now let it be assumed that with the engine at rest and with the reversing piston 33 in the position in which it is shown in the drawing providing for astern operation of the engine, the engineer desires to start the engine in the ahead direction. To accomplish this, the operator will move lever 145 to the "Ahead" "Start" position in the side slot 147 to supply fluid under pressure to the ahead control pipe 89 and to the starting pipe 105, while maintaining the astern pipe 75 and speed control pipe 17 both open to atmosphere.

The fluid pressure supplied to pipe 105 will flow to chamber 103 in the starting control valve device 44 but the valve 95 in said device will be closed at this time as previously mentioned. The fluid pressure supplied to the ahead control pipe 89 will however flow through choke 87 and passage 86 to chamber 82 above diaphragm 80 in the ahead pilot valve device 43, and when sufficient pressure is thus obtained in said chamber to overcome the opposing force of spring 81 on diaphragm 80 said diaphragm will deflect in a downward direction and move plunger 78 into seating engagement with valve 77 and then actuate said valve to open the fluid pressure supply valve 76.

Fluid under pressure from chamber 48 will then flow past the supply valve 76 to chamber 85 and thence through passage 40 to chamber 34 above the reversing piston 33. Chamber 36 below the reversing piston is at this time open to atmosphere through passage 39 and past the open release valve 54 in the astern pilot valve device 42, so that when sufficient pressure of fluid is obtained in chamber 34 on the reversing piston 33, said piston will start moving in the direction of the pressure head 37.

As the piston 33 is moved toward the pressure head 37 it will first close communication between chamber 36 below the piston and passage 120, and then after a slight further movement open said passage to chamber 34 above the piston which is being supplied with fluid under pressure. Fluid under pressure from chamber 34 will then flow through passage 120 to chamber 116 containing the check valve 114. Chamber 115 containing the check valve 113 is at this time open to atmosphere by way of chamber 36 below the reversing piston 33, as a result of which, the pressure of fluid provided in chamber 116 and acting on the check valve 114 will move said check valve toward the left-hand and into contact with its seat, this movement shifting the check valve 113 out of contact with its seat.

Finally, when the reversing piston 33 obtains its ahead position defined by contact with the pressure head 37, and in which position the engine's reversing gear will have been reversed to provide for operation of the engine in the ahead direction, the passage 122 will be opened past said piston to chamber 34 which is supplied with fluid under pressure. Fluid under pressure will then flow from chamber 34 through passage 122 to chamber 115 and thence past the open check

valve 113 to passage 110 and thence through choke 109 and passage 108 to diaphragm chamber 100 in the starting control valve device 44. When a sufficient pressure of fluid is thus obtained in chamber 100 to overcome the opposing force of spring 99 on diaphragm 98 said diaphragm will deflect in a downward direction and move plunger 97 into engagement with the release valve 96 and then act through said valve to open the supply valve 95. When the supply valve 95 is opened fluid supplied to chamber 103, with the operator's control valve device in the "Ahead" "Start" position, will flow past said valve to chamber 106 and thence through passage 107 and pipe 12 to the starting air motor 11 and operate said motor to actuate the starting air valve device 9 to supply starting air to pipe 7 and thence to the engine cylinders for starting the engine to turn in the new or ahead direction, as determined by the position of the reversing piston 33 in contact with pressure head 37.

At the same time as the reversing piston 33 is operating to reverse the engine's valve gear or timing to provide for ahead operation of the engine, as just described, fluid under pressure supplied to chamber 85 in the ahead pilot valve device 43 will also flow through passage 143 to the upper end of the double check valve 141. The lower end of the double check valve is at this time open to atmosphere through passage 142 and past the open release valve 54 in the astern pilot valve device 42, as a result of which, the pressure of fluid provided in passage 143 will shift said valve to its lower position for opening communication between said passage and passage 140. Fluid thus supplied to passage 140 will then flow to chamber 135 in the fuel and brake control device 45 and when this pressure becomes sufficient to overcome the opposing force of spring 134 on diaphragm 133, said diaphragm will deflect in a downward direction and move plunger 132 into contact with valve 131 for cutting off the supply of fluid under pressure from chamber 50 to chamber 138, and then act through said valve to open valve 130. When valve 130 is opened fluid under pressure will be vented from the brake cylinder device 5 and from the fuel cut-off motor 21 to thereby release the brake 4 and effect operation of the fuel cut-off valve device 18 to supply fuel to the engine. When the engine starts turning under the influence of compressed starting air supplied through the pipe 7 as above described, the engine will then fire and run on the fuel supplied thereto in the ahead direction as determined by the reversing piston 33 in contact with the pressure head 37.

After the engine is started in the ahead direction and is running on fuel as just described, the operator will move the control lever 145 out of the slot 147 to the "Run and idle" position at the "Ahead" side of "Stop" position for releasing fluid under pressure from the starting control pipe 105 and thereby from the starting air motor 11 to cause operation of the starting air supply valve 8 to cut off the supply of starting air to the pipe 7. The engine will then continue to run on fuel, and by proper adjustment of the operator's control lever 145 between the "Ahead" "Run and idle" position and the "Ahead" "Full speed" position any desired degree of engine speed may be obtained, as will be apparent.

In order to stop the engine from operation in the ahead direction, the operator will move lever 145 to "Stop" position to release fluid under pressure from the speed control pipe 17 to permit the

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engine speed to reduce to idling, and to also release fluid under pressure from the ahead control pipe 89 and from chamber 82 in the ahead pilot valve device 43. The ahead pilot device 43 will then operate to release fluid under pressure from chamber 135 in the fuel and brake control valve device 45 to permit operation of the latter device to cause operation of the fuel cut-off motor 21 to actuate the fuel cut-off valve device 18 to cut off the fuel supply to the engine, and to also cause operation of brake 4 to stop the engine, as will be apparent from the above description.

With the operator's control lever 145 in a position between the "Run and idle" and "Full speed" positions at the "Ahead" side of "Stop" position causing operation of the engine in an ahead direction, let it be assumed that the operator desires to reverse the direction of operation of the engine. To accomplish this he may move lever 145 from the position it may be in at the "Ahead" side of "Stop" position directly to the opposite side of "Stop" position and into the side slot 148 to the "Astern" "Start" position.

This movement of the operator's control lever 145 to the "Astern" "Start" position will release fluid under pressure from pipe 17 and thereby from the speed control motor 16 to permit movement of the governor control lever 14 to its engine idling position in which it is shown in the drawing, and will also release fluid under pressure from the ahead control pipe 89 and supply fluid under pressure to the astern control pipe 75 and to the starting control pipe 105. Upon the release of fluid under pressure from the ahead control pipe 89, the fluid pressure will be promptly released from diaphragm chamber 82 in the ahead pilot valve device 43 by way of the serially arranged check valves 90 and spring 81 will then deflect diaphragm 80 to the position in which it is shown in the drawing. This movement of diaphragm 80 and thereby of stem 78 will permit closing of the supply valve 76 by spring 83 and opening of the release valve 77 by spring 84, so as to release fluid under pressure from chamber 34 above the reversing piston 33, and for at the same time, releasing by way of the double check valve 141 fluid under pressure from chamber 135 above diaphragm 133 in the fuel and brake control valve device 45. The fuel and brake control valve device will then operate to supply fluid under pressure from chamber 50 to chamber 138 and thence through pipe 6 to the brake cylinder device 5 and fuel cut-out motor 21 for applying brake 4 to shaft 3 and for actuating the fuel cut-out valve device 18 to cut off the supply of fuel to the engine. With the supply of fuel to the engine cut off and brake 4 applied to shaft 3, said brake will cause deceleration and the eventual stopping of the engine.

When fluid under pressure is released from diaphragm chamber 135 in the fuel and brake interlock valve device 45 as just described, fluid under pressure will also be released from diaphragm chamber 100 in the starting control valve device 44 by way of the check valves 144 and chamber 135, so as to permit operation of the starting control valve device 44 to effect closure of valve 95. With the operator's control lever in the "Astern" "Start" position supplying fluid under pressure to the starting control pipe 105, this closing of valve 95 will prevent flow of this fluid from chamber 103 to the starting control motor 11; at this time.

At the same time as the structure operates to cut off the supply of fuel to the engine and to

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apply brake 4 to the engine drive shaft 3 to bring the engine to a stop from operation in the ahead direction, fluid under pressure supplied to the astern control pipe 75 will flow through choke 73 and passage 72 to diaphragm chamber 69 in the astern pilot valve device 42. When a sufficient pressure of fluid is thus obtained in chamber 69 of the astern pilot valve device to overcome the opposing force of spring 70 on diaphragm 68, said device will operate as above described to supply fluid under pressure to chamber 36 below the reversing piston 33 to effect movement of said reversing piston from its ahead position to contact with pressure head 37, to its astern position in which it is shown in the drawing.

In the operation just described, it is desired to point out that the flow capacity of choke 73 with respect to the volume of chamber 69 in the astern pilot valve device 42 is such as to prevent sufficient pressure being obtained in said chamber for deflecting diaphragm 68 against the opposing force of spring 70 for a certain period of time after movement of the operator's control lever 145 from the "Ahead" side of "Stop" position to the "Astern" "Start" position in slot 148. This period of time, for instance 6 seconds, is such as to allow the engine to be brought substantially to a stop by brake 4 before the astern pilot valve device 42 will operate to supply fluid under pressure to chamber 36 for moving the reversing piston out of its astern position. In other words, the choke 73 prevents operation of piston 33 to reverse the engine's valve gear or timing for an interval of time of sufficient duration to insure the engine being brought to a stop by brake 4.

At the same time as fluid under pressure is supplied to chamber 36 below the reversing piston 33 for moving said piston to its astern position, fluid under pressure will also flow from chamber 53 in the astern pilot valve device 42 through passage 142, past the double check valve 141 and through passage 140 to diaphragm chamber 135 in the fuel and brake control valve device 45. The fuel and brake control valve device 45 will then operate as before described to release fluid under pressure from the brake cylinder device 5 and from the fuel cut-off motor 21, for thereby releasing the brake 4 on the propeller shaft 3 and for causing operation of the fuel cut-off valve device 18 to again supply fuel to the engine. It will be noted that since the astern pilot valve device 42 will not operate to supply fluid under pressure to effect reversing movement of the reversing piston 33 until after the engine is brought to a stop, the brake 4 will not be released and fuel will not be supplied to the engine until after the engine has been brought to a stop.

After a certain degree of movement of the reversing piston 33 away from its ahead position in contact with pressure head 37, fluid will be supplied from chamber 36 through passage 122 to chamber 115 for closing the check valve 113 and for opening the check valve 114. Then when the piston 33 attains its astern position, in which it is shown in the drawing, fluid under pressure will flow from chamber 36 to passage 120 and thence past the open check valve 114 to passage 110 and to the starting control valve device 44. The starting control valve device 44 will then operate to open communication between chamber 103, supplied with fluid under pressure from the operator's control valve device with lever 145 in the "Astern" "Start" position, and chamber

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106 for supplying fluid under pressure to pipe 12 and thence to the starting control motor 11 to effect operation of said motor and thereby of the starting air valve 8 to supply starting air to pipe 7 to effect starting of the engine to turn in the new or astern direction, as determined by the position of the reversing piston 33, which piston will be in contact with the closed end of its cylinder as shown in the drawing.

It will now be seen that in reversing the engine from ahead to astern the structure operates in response to movement of the operator's control lever from the "Ahead" side of "Stop" position to the "Astern" "Start" position in slot 148, to first cut off the supply of fuel to the engine and to apply brake 4 to the drive shaft 3 in order that the engine may be brought to a stop after a period of time determined by the flow capacity of choke 73 with respect to the volume of chamber 69 in the astern pilot valve device 42, which period of time is of sufficient duration to insure the engine being substantially stopped by brake 4. The pilot valve device 42 then operates to cause movement of the reversing piston 33 to its astern position for conditioning the engine to operate in the astern direction, and at substantially the same time causes operation of the fuel and brake control valve device 45 to release the brake 4 on the shaft 3 and to resupply fuel to the engine. After the reversing piston 33 obtains its astern position, the starting control valve device 44 operates to supply starting air to the engine for causing it to start turning in the new or astern direction. With fuel supplied to the engine at this time the engine will then fire and run on fuel. After the engine fires and is running on fuel the operator will move lever 145 out of the "Astern" "Start" position in slot 148 to the "Astern" "Run and idle" position for releasing fluid under pressure from the starting motor 11 to permit operation thereof to actuate the starting air valve device 8 to cut off the supply of starting air to pipe 7 and to the engine. The engine will then continue to run on fuel, and the operator may accelerate the engine to any desired degree by moving lever 145 out of the "Astern" "Run and idle" position in the direction of the "Astern" "Full speed" position, as will be apparent.

With the engine operating in the astern direction as just described, let it be assumed that the operator desires to cause operation of the engine in the ahead or forward direction. To accomplish this he will move the control lever 145 from whatever position it may be occupying at the "Astern" side of "Stop" position to the "Ahead" "Start" position in slot 147, for effecting release of fluid under pressure from the astern control pipe 75 and from the speed control pipe 17, and for supplying fluid under pressure to the ahead control pipe 89 and to the starting control pipe 105.

Upon this release of fluid under pressure from the astern control pipe 75 and from diaphragm chamber 69 in the astern pilot valve device 42 by way of the check valves 91, said pilot valve device will operate to release fluid under pressure from chamber 36 below the reversing piston 33 and from diaphragm chamber 135 in the fuel and brake control valve device 45. The fuel and brake control valve device 45 will then operate as before described to supply fluid under pressure to the brake cylinder device 5 and to the fuel cut-off motor 21 for applying the brake

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4 to shaft 3 and for cutting off the supply of fuel to the engine in order that the engine may be brought to a stop by operation of said brake.

At the same time as the fuel is cut off to the engine and the brake 4 is applied, fluid under pressure supplied to the ahead control pipe 89 will flow through choke 87 to diaphragm chamber 82 in the ahead pilot valve device 43. The choke 87 restricts this supply of fluid under pressure to chamber 82 to such an extent however as to prevent operation of the ahead pilot valve device 43 by fluid under pressure for a period of time sufficient to bring the engine to a substantial stop by brake 4. At the termination of this time period, such as six seconds, a sufficient pressure will be obtained in chamber 82 to operate the ahead pilot valve device 43 to supply fluid under pressure to chamber 34 above the reversing piston 33 and also to chamber 135 in the fuel and brake control device 45. The reversing piston 33 will then move to its ahead position in contact with the pressure head 37 for reversing the engine's valve gear or timing, and at substantially the same time the fuel and brake control valve device 45 will operate to release the brake 4 on shaft 3 and effect operation of the fuel cut-off motor 21 and thereby of the fuel cut-off valve device 18 to resupply fuel to the engine, it being noted that the engine is stopped before the fuel is resupplied thereto.

After the reversing piston 33 obtains its ahead position in contact with the pressure head 37, the starting control valve device 44 will operate to supply air to the starting motor 11 to effect operation of the starting air valve device 8 to supply starting air through pipe 7 to the engine to cause said engine to start rotating in the new or ahead direction, which direction is determined by the reversing piston 33 being in contact with pressure head 37. When the engine is thus started, the fuel supplied to the engine will fire and cause the engine to run on fuel. The operator will then move the control lever 145 out of "Ahead" "Start" position in slot 147 to the adjacent "Run and idle" position to cut off the supply of starting air to the engine and then by suitable adjustment of said lever between said "Run and idle" position and the "Ahead" "Full speed" position, the operator may cause the engine to operate in the ahead direction at any desired speed.

It will now be noted that in reversing the engine from ahead to astern the choke 73 and diaphragm chamber 69 in the astern control valve device 42 provide for the engine being brought to a substantial stop from operation in the ahead direction before causing operation of the reversing piston 33 to reverse the valve timing or gear of the engine to provide for operation in the astern direction. The choke 87 and chamber 82 in the ahead pilot valve device 43 accomplishes the same end when reversing the direction of operation of the engine from astern to ahead.

It should also be noted however that with the engine stopped with the reversing piston 33 in the reverse position in which it is shown in the drawing, the restarting of the engine in the same or astern direction is also delayed by choke 73 and chamber 69 the same as in reversing the engine from operation in the ahead direction to the astern direction. Likewise, with the engine stopped from last operation in an ahead direction, under which condition the reversing piston 33 will be in contact with the pressure head 37, the restarting of the engine in the same direc-

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tion will be delayed by choke 87 and chamber 82 above diaphragm 80 in the ahead pilot valve device 43, the same as if reversing the engine from astern to ahead direction. The time delays provided by chokes 73 and 87 are desired in reversing the direction of operation of the engine from astern to ahead or vice versa, for reasons above brought out, but such delays are not essential in restarting the engine in the same direction that it last operated, and according to the invention means are provided for automatically eliminating the delay periods incident to these chokes under the last named condition.

One embodiment of the invention is associated with the timing or interlock valve portion 31 of the maneuvering control valve device 26, as shown in Fig. 1, while the other embodiment of the invention is associated with the reversing piston rod 35, as shown in Fig. 2.

According to the embodiment of the invention shown in Fig. 1, I provide two like but separate valve devices 150 and 151 for opening fluid pressure supply communications around chokes 73 and 87 to chambers 69 and 82, respectively, said communications having greater flow capacity than said chokes so as to eliminate the delay effect thereof in restarting the engine in the last direction of operation.

The valve device 150 comprises a casing having a chamber 152 which is connected by a pipe 153 to passage 72 leading to diaphragm chamber 69 in the astern pilot valve device 42. The chamber 152 contains a poppet valve 154 having a stem 158 extending through an opening in a wall 155 separating said chamber from a chamber 156 which is open through a pipe 157 to passage 74. It should be noted that pipe 157 is connected to passage 74 at one side of choke 73 while pipe 153 is connected to passage 72 at the opposite side of said choke, the valve 154 thus controlling a communication between these passages by-passing said choke.

The valve stem 158 extends from wall 155 through chamber 156 and the outer end wall of chamber 156 to the exterior of the casing. The portion of stem 158 extending through the wall 155 is fluted to allow flow of fluid under pressure from chamber 156 to chamber 152 when the valve 154 is out of engagement with a seat provided on said wall, but the portion beyond this fluted portion is cylindrical to minimize leakage of fluid under pressure from chamber 156 through the outer end wall of chamber 156 to atmosphere. A spring 159 in chamber 152 acts on the valve 154 for urging it to its closed position in which it is shown in the drawing.

The valve device 151 is identical in structure to the valve device 150 and, briefly described, comprises a valve 160 arranged to control communication between a chamber 161 and a chamber 162. A spring 163 in chamber 161 acts on valve 160 for urging it to its closed position. The valve 160 is provided with a stem 164 projecting to beyond the exterior of the casing. The chamber 161 is connected by a pipe 165 to passage 86 at one side of the choke 87, while chamber 162 is connected by a pipe 166 to passage 88 at the opposite side of said choke, the communication through these pipes being controlled by valve 160 and having greater flow capacity than said choke so that with said valve open said choke will be rendered ineffective.

The two valve devices 150 and 151 are arranged with their stems 158 and 164, respectively, in spaced parallel relation. A lever 167 fulcrumed

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intermediate its ends on a fixed pin 168 has one arm arranged to engage the end of valve stem 158 for opening valve 154 and another arm arranged to engage stem 164 of valve 160 for opening the latter valve. The lever 167 also has a third arm connected at its end to a rod 169 projecting from a piston 170 contained in a cylinder 171. At one side of piston 170 is a chamber 172 open to pipe 153 and at the opposite side a chamber 173 open to pipe 165. Upon the supply of fluid under pressure to chamber 172, with chamber 173 open to atmosphere, piston 170 will move to the position in which it is shown in the drawing for thereby operating the lever 167 to open valve 154 in the valve device 150 and to allow closing of valve 160 in the valve device 151 by spring 163. Upon the supply of fluid under pressure to chamber 173 with the chamber 172 open to atmosphere, the piston 170 will move to the opposite end of its cylinder to actuate lever 167 to open valve 160 in the valve device 151 and to permit closing of valve 154 in the valve device 150 by spring 159.

One end of a tensioned toggle spring 175 is connected to the connection between lever 168 and the piston rod 169, while its other end is anchored on a fixed pin 176, this spring being effective to prevent movement of piston 170 from either one of its two positions to the other position by fluid at a pressure less than required to deflect diaphragms 68 or 80 against the opposing force of their respective spring 70 or 81.

Now let it be assumed that the engine is operating in the astern direction, under which condition the reversing piston 33 will be in the position in which it is shown in the drawing, fluid will be effective through the astern control pipe 75 in diaphragm chamber 69 of the astern pilot valve device 42 at a pressure sufficient to deflect diaphragm 68 against the opposing force of spring 70. This fluid pressure is diaphragm chamber 69 will also be effective through pipe 153 in piston chamber 172 of the cylinder device 171 to operate piston 170 to unseat valve 154 in the valve device 150, for thereby opening the by-pass communication around choke 73.

Now let it be assumed that the engine has been stopped from operation in the astern direction by movement of the operator's control lever 145 to "Stop" position in which fluid under pressure is released from the astern control pipe 75 and chamber 69 in the astern pilot valve device 41, as hereinbefore described. With fluid thus released from the astern control pipe 75, fluid under pressure will also be released from chamber 172 at the left-hand face of piston 170, but with chamber 173 at the opposite side open to atmosphere through the ahead control pipe 89, at this time, said piston will remain in the position in which it is shown in the drawing under the action of toggle spring 175, so that the valve 154 will remain open while valve 160 will be closed.

With the engine stopped as just mentioned, if the operator desires to restart the engine in the astern direction, i. e. the last mentioned direction of operation, he will move control lever 145 to the "Astern" "Start" position in slot 148 as above described, and as a result, fluid under pressure will be supplied to the astern control pipe 75 and thence to passage 74 in the maneuvering control valve device 26. The fluid pressure supplied to passage 74 will then flow through pipe 157 past the open valve 154 to pipe 153 and thence through passage 72 to diaphragm chamber 69 to the astern pilot valve device 42, it being noted that this flow is through a communication by-

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passing the choke 73, so that said choke is ineffective to delay the supply of fluid under pressure to said chamber. As a result, pressure of fluid in chamber 69 will promptly increase to the degree required to deflect diaphragm 68 against spring 70 to cause restarting of the engine in the astern direction. It will thus be seen that in starting the engine in the astern direction after last operation in said direction, the open valve 154 in the valve device 150 nullifies the effect of choke 73 so that the engine restarts without the delay incident to said choke, above described.

Now let it be assumed that the engine has been stopped from operation in an ahead direction, under which condition the reversing piston 33 will be in contact with the pressure head 37. With the engine last operating in the ahead direction, diaphragm chamber 82 will have been charged with fluid under pressure and this pressure effective through pipe 165 in chamber 173 at the right-hand side of piston 170 will have moved the piston 170 to the left-hand end of its cylinder for opening the valve 160 in the valve device 151. The valve 154 in the valve device 150 will be closed. If the operator now actuates the control valve device 27 to restart the engine in the last direction of operation, i. e. in the ahead direction in the present instance, fluid under pressure supplied to pipe 89 and passage 88 will flow past the open valve 160 in the valve device 151 to diaphragm chamber 82 in the ahead pilot valve device 43, this flow being around the choke 87 thus rendering said choke ineffective to delay response of the ahead pilot valve device 43 to operation of the operator's control lever 145. The ahead pilot valve device 43 will therefore promptly operate to restart the engine in the last mentioned direction of operation.

It should be noted that while the valve devices 150 and 151 eliminate the delay periods incident to the control of the rate of flow of fluid through chokes 73 and 87 when the engine is restarted from stop in its last direction of operation, as just described, the toggle spring 175 ensures that the valve 160 will be closed during reversing of the direction of operation of the engine from astern to ahead, and that valve 154 will be closed during reversing of the direction of operation of the engine from ahead to astern, so that upon reversing the direction of operation of the engine the chokes 87 and 73 will be effective the same as before described.

As shown in Fig. 2, the valve devices 150 and 151 may, if desired, be arranged for control by an arm 174 projecting from one side of the reversing piston rod 35, said arm being arranged to open valve 160 in the valve device 151 when the reversing piston 33 is in the astern position in which it is shown in Fig. 1, and to open valve 154 with the reversing piston in its ahead position defined by contact with pressure head 37. Thus, when the engine is stopped with the reversing piston in its astern position the valve device 151 will be conditioned to render choke 73 ineffective in case the engine is restarted in its last direction of operation or in the astern direction. On the other hand, in case the reversing piston 33 is in its ahead position the valve device 150 will be conditioned to render choke 87 ineffective in case the engine is restarted in the ahead direction, as will be apparent.

Summary

From the above description it will now be noted that the fluid pressure control apparatus provides

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for automatic control, in a desired sequence, of a plurality of different operations, such as incident to the control of starting, stopping and reversing, and the control or speed of power output of a reversible Diesel engine. The apparatus embodies pneumatic means operable automatically to delay reversing of the engine's valve timing or gear while the engine is in motion. This delay is desirable when the direction of operation of the engine is being changed from ahead to start or vice versa, but it is not desirable upon restarting the engine in the last direction of operation and means are therefore provided to automatically eliminate the delay under the last named condition.

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

1. An apparatus for conditioning a reversible prime mover for operation in either one direction or in the opposite direction comprising in combination, a reversing member movable to first and second positions for conditioning said prime mover for operation in, respectively, either said one or opposite directions, operator's control means operable to selectively effect movement of said reversing member to either one or the other of its different positions, delay means for preventing response of said reversing member to operation of said control means for a chosen interval of time after operation of said control means, and means automatically adjustable in accordance with the position of said reversing member to render said delay means either effective or ineffective to delay said response of said reversing member.

2. An apparatus for conditioning a reversible prime mover for operation in either one direction or in the opposite direction comprising in combination, a reversing control member movable to one position for conditioning said prime mover for operation in one direction and movable to a second position for conditioning said prime mover for operation in the opposite direction, a first fluid pressure sensitive means operable by fluid under pressure to effect movement of said member to said one position, a second fluid pressure sensitive means operable by fluid under pressure to effect movement of said member to said second position, an operator's control device having first and second control positions, corresponding to the said positions of said reversing control member, and being operable upon movement thereto to supply fluid under pressure to, respectively, said first and second pressure sensitive means, each pressure sensitive means comprising means operable to prevent operation thereof to effect movement of said reversing member by fluid at less than a chosen pressure, timing means operable to delay for a chosen interval of time, after movement of said control device to its first or second position, obtaining said chosen pressure of fluid, and means operable upon operation of said first pressure sensitive means by fluid under pressure to render the respective timing means ineffective and the other timing means effective, and operable upon operation of said second pressure sensitive means to render the respective timing means ineffective and the other timing means effective.

3. An apparatus for controlling the conditioning of a reversible prime mover for operation in either one direction or in the opposite direction and for also controlling the starting of said prime mover comprising in combination, reversing

means movable to one position to condition said prime mover for operation in one direction and movable to another position to condition said prime mover for operation in the opposite direction, an operator's control device comprising a lever having a neutral position, a first position at one side of said neutral position and a second position at the opposite side of said neutral position and being operable upon movement of said lever to said first position to effect movement of said reversing means to said one position and upon movement of said lever to said second position to effect movement of said reversing means to said other position, starting means for said prime mover, means operable by said control device in said first and second positions of said lever to effect operation of said starting means when said reversing means is in, respectively, said one and other positions, means associated with said reversing means operable to prevent operation of said starting means upon movement of said lever to effect movement of said reversing means and during movement of said reversing means, control means preventing response of said reversing means to operation of said lever for a chosen interval of time after operation of said lever, and means operable automatically to render said control means effective to delay response of said reversing means to movement of said lever upon movement of said lever to a position to effect movement of said reversing means and ineffective to delay response of said reversing means to movement of said lever upon movement of said lever to either its first or second position when said reversing means is in, respectively, its said one or other position.

4. An apparatus for controlling the conditioning of a reversible prime mover for operation in either one direction or in the opposite direction and for also stopping said prime mover comprising in combination, reversing means movable to one position to condition said prime mover for operation in one direction and movable to another position to condition said prime mover for operation in the opposite direction, an operator's control device comprising a lever and being operable upon movement of said lever to a first position to effect movement of said reversing means to said one position and upon movement of said lever to a second position to effect movement of said reversing means to said other position, control means for preventing response of said reversing means to operation of said lever for a chosen interval of time after operation of said lever, means operable automatically to render said control means effective to control response of said reversing means to movement of said lever upon movement of said lever to a position to effect movement of said reversing means and ineffective upon movement of said lever to either its first or second position when said reversing means is in, respectively, its said one or other position, braking means for said prime mover, means responsive to operation of said control device in each of said positions of said lever upon movement of said lever from its other position to effect operation of said braking means to stop said prime mover, and means operable upon response of said reversing means to operation of said lever to render said braking means ineffective.

5. An apparatus for controlling the conditioning of a reversible prime mover for operation in either one direction or in the opposite direction and for controlling the supply of fuel to said prime mover comprising in combination, revers-

ing means movable to one position to condition said prime mover for operation in one direction and movable to another position to condition said prime mover for operation in the opposite direction, an operator's control device comprising a lever and being operable upon movement of said lever to a first position to effect movement of said reversing means to said one position and upon movement of said lever to a second position to effect movement of said reversing means to said other position, control means for preventing response of said reversing means to operation of said lever for a chosen interval of time after operation of said lever, means operable automatically to render said control means effective to delay response of said reversing means to movement of said lever upon movement of said lever to a position to effect movement of said reversing means and ineffective upon movement of said lever to either its first or second position when said reversing means is in, respectively, its said one or other position, fuel control means for said prime mover, means responsive to operation of said control device in each of said positions of said lever upon movement of said lever from its other position to effect operation of said fuel control means to cut off the supply of fuel to said prime mover, and means operable upon rendering said control means ineffective to effect operation of said fuel control means to supply fuel to said prime mover.

6. An apparatus for conditioning a reversible prime mover for operation in either one direction or in the opposite direction comprising in combination, reversing means movable to one position to condition said prime mover for operation in said one direction and to a second position to condition said prime mover for operation in said opposite direction, an operator's control device comprising a lever having a stop position and being operable upon movement of said lever in one direction from said stop position to effect movement of said reversing means to said one position and in the opposite direction from said stop position to effect movement of said reversing means to said second position, delay means comprising structure for rendering said reversing means non-responsive to operation of said control device, upon movement of said lever out of stop position in a direction to effect movement of said reversing means, for a chosen interval of time after movement of said lever out of said stop position, and means conditionable automatically in accordance with the position of said reversing means operable to render said structure ineffective upon movement of said lever from stop position in either said one direction or said opposite direction when said reversing means is in, respectively, either said one position or said second position.

7. An apparatus for conditioning a reversible prime mover for operation in either one direction or in the opposite direction and for also controlling the supply of fuel to said prime mover comprising in combination, reversing means, fuel control means, reversing control means operable upon supply of fluid at a chosen pressure to one chamber to effect operation of said reversing means to condition said prime mover for operation in one direction and to also effect operation of said fuel control means to supply fuel to said prime mover for operating same, and operable upon supply of fluid at a like pressure to another chamber to effect operation of said reversing means to condition said prime mover

for operation in the reverse direction and to also effect operation of said fuel control means to supply fuel to said prime mover for operating same, said reversing control means being operable upon a reduction in pressure of fluid in either one of said chambers to below said chosen degree with fluid under pressure released from the said chamber to effect operation of said fuel control means to cut off the supply of fuel to said prime mover, an operator's control device comprising a lever, and means controlled by said lever and operable in a stop position thereof to release fluid under pressure from both of said chambers, and in a second position of said lever to supply fluid under pressure to one of said chambers and to release fluid under pressure from the other chamber and in a third position of said lever to supply fluid under pressure to said other chamber and to release fluid under pressure from said one chamber, delay means arranged to control the supply of fluid under pressure to said chambers and comprising means operable to delay for an interval of time obtaining said chosen pressure of fluid in said one chamber upon movement of said lever from said second position to said third position, and in said other chamber upon movement of said lever from said third position to said second position, and means conditionable by fluid in each chamber at a pressure not less than said chosen pressure to render the delay means ineffective for the respective chamber and effective for the other chamber.

8. An apparatus for conditioning a reversible prime mover for operation in either one direction or in the opposite direction comprising in combination, reversing control means operable upon supply of fluid at a chosen pressure to one chamber to condition said prime mover for operation in one direction and operable upon supply of fluid at a chosen pressure to a second chamber to condition said prime mover for operation in the reverse direction, an operator's control device comprising a lever and operable with said lever in a stop position to release fluid under pressure from both of said chambers, and in a second position to supply fluid under pressure to said one chamber and to release fluid under pressure from said other chamber, and in a third position to supply fluid under pressure to said other chamber and to release fluid under pressure from said one chamber, delay means for each of said chambers operable to delay for an interval of time obtaining the said chosen pressure of fluid therein, and means operable by fluid supplied to each chamber at a pressure not less than said chosen pressure to render the respective delay means ineffective and operable to render the last named delay means effective upon supply of fluid to the other chamber at a pressure not less than the said chosen pressure.

9. An apparatus for conditioning a reversible prime mover for operation in either one direction or in the opposite direction comprising in combination, reversing control means for said prime mover operable upon supply of fluid at a chosen pressure to one chamber to condition said prime mover for operation in one direction and operable upon supply of fluid at a chosen pressure to a second chamber to condition said prime mover for operation in the reverse direction, an operator's control device comprising a lever and operable with said lever in a stop position to release fluid under pressure from both of said chambers, and in a second position to supply

fluid under pressure to said one chamber and to release fluid under pressure from said other chamber, and in a third position to supply fluid under pressure to said other chamber and to release fluid under pressure from said one chamber, delay means for each of said chambers operable to delay for an interval of time obtaining the said chosen pressure of fluid therein, and means operable automatically, upon conditioning of said prime mover for operation by fluid under pressure supplied to either one of said chambers, to render the delay means for the last named chamber ineffective and the other delay means effective.

10. An apparatus for conditioning a reversible prime mover for operation in either one direction or in the opposite direction, comprising in combination, a reversing piston movable to one position upon supply of fluid under pressure to one chamber to condition said prime mover for operation in one direction and movable to a second position upon supply of fluid under pressure to a second chamber to condition said prime mover for operation in the reverse direction, an operator's control device comprising a lever and operable upon movement of said lever to a stop position to effect a release of fluid under pressure from both of said chambers, to a second position to effect a supply of fluid under pressure to said one chamber and to a third position to effect a supply of fluid under pressure to said second chamber and being operable with said lever in said second and third positions to effect a release of fluid under pressure from the chamber not being supplied with fluid under pressure, delay means for each of said chambers arranged to control the supply of fluid under pressure thereto and being operable to prevent, for an interval of time after movement of said lever from said second position to said third position, or vice versa, the supply of fluid under pressure to the respective one of said chambers and being then automatically operable to permit supply of fluid under pressure to the respective chamber, means operable to control said interval of time, and valve means controlled by said piston and operable in the said one position of said piston to render the delay means for said one chamber ineffective and the delay means for said second chamber effective and operable in said second position of said piston to render the delay means for said second chamber ineffective and the delay means for said one chamber effective.

11. An apparatus for controlling operation of a reversible prime mover in either one direction or in the opposite direction, comprising control means operable upon supply of fluid under pressure to one passage to provide for operation of said prime mover in one direction and upon supply of fluid under pressure to a second passage to provide for operation of said prime mover in the opposite direction and operable upon release of fluid under pressure from both of said passages to render said prime mover non-operable, an operator's control device operable to supply fluid under pressure to either one of said passages and at the same time, release fluid under pressure from the other passage, or to release fluid under pressure from both of said passages at the same time, delay means interposed in the connection between said control device and said passages operable to delay supply of fluid under pressure to each of said passages by operation of said control device to thereby delay for an interval of time the operation of said control

means by such fluid pressure, and means operable automatically in accordance with the one of said passages last supplied with fluid under pressure to render said delay means ineffective upon operation of said operator's control device to supply fluid under pressure to the one of said passages last supplied with fluid under pressure subsequent to operation of said control device to release fluid under pressure from both passages.

12. An apparatus for controlling the starting, stopping and reversing of a reversible prime mover, comprising in combination, starting means for said prime mover, reversing means movable to a first position to condition said prime mover for operation in one direction and movable to a second position to condition said prime mover for operation in the opposite direction, an operator's control device comprising a lever and being operable upon movement of said lever to a first position to effect movement of said reversing means to its said first position and being operable upon movement of said lever to a second position to effect movement of said reversing means to its said second position, means controlled by both said reversing means and operator's control device operable upon movement of said reversing means to the position determined by the position of said lever to effect operation of said starting means to start said prime mover, brake means operable to effect stopping of said prime mover, effective means for rendering said brake effective by said control device upon movement of said lever to a third position and also upon movement of said lever to its

said first position with said reversing means in its said second position and upon movement of said lever to its said second position with said reversing means in its said first position, delay means including timing structure operable upon movement of said lever from its said second position to its said first position and from its said first position to its said second position to prevent response of said reversing means to operation of said control device for a chosen interval of time after movement of said lever, means operable upon operation of said reversing means in response to operation of said delay means to effect operation of said brake means to free said prime mover for operation, and means conditionable automatically in accordance with the position of said reversing means for rendering said delay means ineffective to delay response of said reversing means to operation of said lever upon movement of said lever to its said first position with said reversing means in its said first position and also upon movement of said lever to its said second position with said reversing means in its said second position.

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The following references are of record in the file of this patent:

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