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CONTROL APPARATUS

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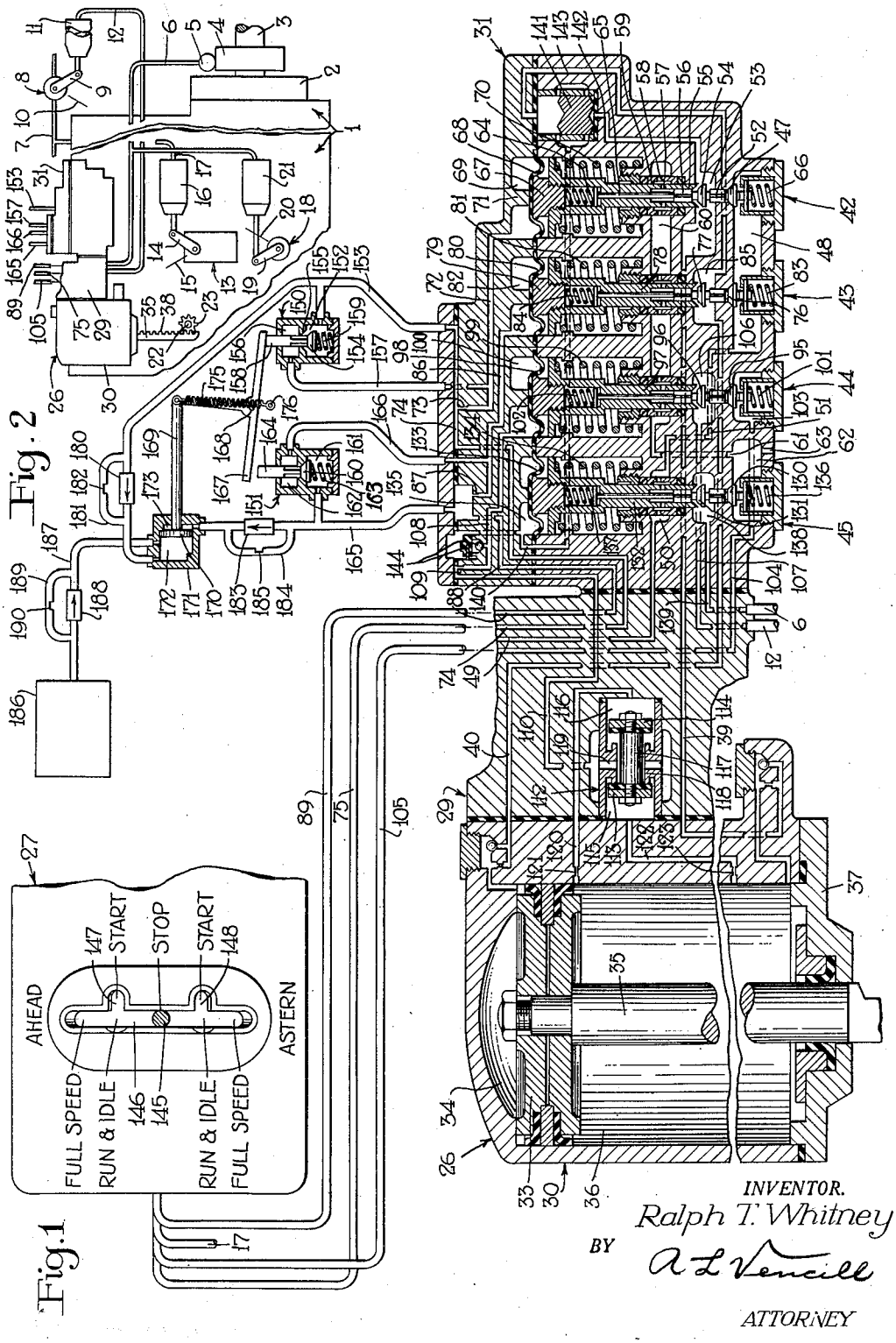


Fig. 2

Fig. 1

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CONTROL APPARATUS

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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 Roy R. Stevens, 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 under pressure to actuate the power piston for a certain period of time, such as six 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 from operation in one direction 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 start the engine from an already stopped condition. With the engine stopped the delay is not necessary, however, and in fact may be objectionable in that it delays engine starting.

The principal object of the present invention is the provision of means for automatically rendering the delay means above described ineffective upon starting the engine from an already stopped condition.

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 apparatus embodying the invention; and Fig. 2 is a side elevational view of a portion of said apparatus as applied for controlling the starting, stopping, reversing and speed of a reversible Diesel engine.

Description

Referring first to Fig. 2 in the drawing. The reference numeral 1 indicates a portion of a reversible Diesel engine which 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 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.

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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 or power output 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 correspond-

ing 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 a 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 under pressure from said pipe to effect movement of said lever to its fuel supply position.

The engine 1 is provided with a rockable shaft 22 for effecting, in any conventional manner, 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 structure so far described for controlling the operation of engine 1 is arranged to be controlled by a maneuvering control device 26 mounted on the engine and said maneuvering control device 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 cylinder device 5.

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 of the reversing shaft 22, whereby reciprocation of piston 33 in its cylinder will turn the reversing shaft 22.

The reversing piston 33 has two operating positions, namely, an astern position in which it is shown in the drawing and which it defined by contact between said piston and the closed end of the cylinder, for conditioning the engine reversing shaft 22 to provide for operation of the engine in an astern direction, and a 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 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 and thereby 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 separating chamber 48 from a chamber 53 and is arranged to cooperate with a seat encircling said bore for controlling communication between said chambers. Chamber 53 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 atmosphere through ports 57 in the plunger, a port 58 in a sleeve 59 secured in the casing, a chamber 60, a passage 61, a chamber 62 and a vent port 63. A spring 64 contained in plunger 55 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 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 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 diaphragm 68 will then act through said valve to unseat the fluid pressure supply valve 47. Conversely, upon release of fluid under 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 opening of the release valve 54 by spring 64.

The pressure chamber 69 above diaphragm 68

is connected through a passage 72 and a choke 73 to a passage 74 which is connected to an astern control pipe 75 leading to the operator's control valve device 27.

The ahead pilot valve device 43 is structurally identical to the astern pilot valve device 42 just described, and briefly 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. 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 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 seating 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 separating 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.

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 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, when the piston 33 in the astern position in which it is shown in the drawing, and said passage is adapted to be opened to chamber 34 upon movement of said piston into contact with the pressure head 37.

The fuel and brake control valve device 45 is structurally identical to the astern and ahead control valve devices 42 and 43 and to the starting control valve device 44 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 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 port 63 and is provided to control communication between said chamber and chamber 138.

The pressure chamber 135 above diaphragm 133 is connected to a passage 140 leading 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 141 will be moved by such pressure to a position the reverse of that in which it is 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 be moved by such pressure 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 in the fuel and brake control device 45 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 24, 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 the supply of fluid under pressure to and its release from diaphragm chambers 69, 82 and 100 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 a 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 the legend "Ahead," the lever 145 has a "Run & idle" position which is located substantially midway between "Stop" position and the end of said slot where said lever has a "Full speed" position. Adjacent the "Run & 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 & idle" and "Full speed" positions, and adjacent said "Run & 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 & 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 & 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 additionally be supplied to the starting control pipe 105.

When the lever 145 is in either of the "Run & 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 & 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.

According to the invention 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 of said chokes in starting the engine from an already stopped condition, as will be more fully described hereinafter.

The valve device 150 comprises a casing having a chamber 152 which is connected by a pipe 153 to passage 74 leading to the astern control pipe 75. 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 72 leading to diaphragm chamber 69. It should be noted that pipe 157 is connected to passage 72 at one side of choke 73 while pipe 153 is connected to passage 74 at the opposite side of said choke, the valve 154 thus controlling a communication between said passages by-passing said choke and said communication has a greater flow capacity than said choke.

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

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 in which it is shown in the drawing. The valve 160 has a stem 164 projecting to beyond the exterior of the casing. Chamber 161 is connected by a pipe 165 to passage 88 at one side of the choke 87, while chamber 162 is connected by a pipe 166 to passage 86 at the opposite side of said choke, the communication through these pipes controlled by valve 160 having greater flow capacity than said choke so that when said valve is 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 intermediate its ends on a fixed pin 168 has one arm arranged to engage the end of the 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 which is open to pipe 153, and at the opposite side is a chamber 173 which is open to pipe 165.

When pressure of fluid in chamber 172 sufficiently exceeds that in chamber 153, in operation to be later described, the piston 170 will move to the position in which it is shown in the drawing for thereby operating 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. On the other hand, when pressure of fluid in chamber 173 exceeds that in chamber 172 to a sufficient degree the piston 170 will move to the opposite end of cylinder 171 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 coil 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. One purpose of this spring is to maintain the valve 154 open by holding lever 167 and piston 170 in the position in which they are shown in the drawing when chambers 172 and 173 at opposite sides of said piston are open to atmosphere, and to also maintain the valve 160 open when the lever 167 is in its opposite position defined by contact between piston 170 and the left hand end of its cylinder 171, when said chambers are open to atmosphere, as will be later brought out. Another reason for the spring 175 is to prevent rocking of lever 167 from the position in which it is shown in the drawing to its

opposite position, or vice versa, by a differential between pressures of fluid in chambers 172 and 173 acting on the piston 170 of less than a certain degree, as will also be brought out later.

In pipe 153 there is disposed a check valve 180 arranged to permit flow of fluid under pressure through said pipe in the direction to piston chamber 172 but to prevent flow in the opposite direction. A passage or pipe 181 by-passing the check valve 180 is provided to permit flow of fluid under pressure from chamber 172 and a choke 182 in this pipe is provided to restrict such flow for delaying release of fluid under pressure from said chamber for reasons which will be later described. A similar check valve 183 is disposed in pipe 165 and a communication 184 by-passing said check valve and including a choke 185 is provided for restricting release of fluid under pressure from piston chamber 173, said check valve being arranged to permit a relatively rapid flow of fluid in the direction to said chamber but to prevent flow in the opposite direction.

A volume reservoir 186 may be connected by a pipe 187 to the cylinder 171, the connection to said cylinder being so arranged that said pipe will be open to chamber 172 when piston 170 is at the right hand end of said cylinder, as shown in the drawing, and open to chamber 173 when said piston is at the opposite end of said cylinder. A check valve 188 in pipe 187 is arranged to permit flow of fluid under pressure from reservoir 186 through pipe 187 in the direction to the cylinder 171 but to prevent flow in the opposite direction. A communication 189 by-passing the check valve 188 and containing a choke 190 is provided to permit flow of fluid under pressure at a relatively slow rate in the direction from cylinder 171 to the volume reservoir 186.

Operation

In operation, let it be initially assumed that the operator's control level 145 is in "Stop" position causing operation of the control valve device 27 to open the astern and ahead 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 opened. 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 opened 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 for conditioning the engine's valve gear for operation of the engine in the astern direction.

With diaphragm chamber 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 crank shaft 3 and 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 device 45 open to atmosphere as just 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 opened. 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 the cut-off position in which it is shown in the drawing. Since chambers 172 and 173 in the cylinder 171 are open, respectively, through pipes 153 and 165 to the astern and ahead control pipes 75 and 89 which are open to atmosphere as above mentioned, said piston chambers will also be open to atmosphere and let it be assumed that the piston 170 is occupying the position in which it is shown in the drawing in which the valve 154 will be open and the valve 160 will be closed.

This position of piston 170 is that which it will assume when the engine is operating in the astern direction and in which it will remain upon stopping the engine from such operation, as will be apparent from the description to follow.

Assuming that the engine was stopped from operation in the astern direction, the reversing piston 33 will also occupy the position in which it is shown in the drawing. With the engine stopped and the various parts of the control apparatus positioned as just described, let it be assumed that the operator desires to restart the engine in the last direction of operation, that is, in the astern direction in the present instant.

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 45 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 and pipe 153 to piston chamber 172 in the cylinder 171 and since chamber 173 at the opposite side of piston 170 is at this time open to atmosphere through the ahead pipe 89, the pressure of fluid in chamber 172 will maintain the piston 170 in the position in which it is shown in the drawing for thereby holding the valve 154 open.

Fluid under pressure supplied through the astern control pipe 75 and passage 74 to pipe 153 as just described will also flow to the valve device 150 and thence past the open valve 154 and pipe 157 and passage 72 to diaphragm chamber 69 in the astern pilot valve device 42. When a suffi-

cient pressure of fluid is then obtained in chamber 69 to overcome the opposing force of spring 70 on diaphragm 68, said diaphragm will deflect in a downward direction and move plunger 55 into contact with the release 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 in which it is shown in the drawing, and which it already occupies, due to the engine having been stopped from previous operations in an astern direction.

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 at this time is 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 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 in the particular operation being described.

Fluid under pressure thus supplied to chamber 116 in the double check valve device 112 will then flow past the check valve 114, 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 to move plunger 97 into engagement with the 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 to the starting 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 through 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 & 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 & 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 permit operation of 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 & idle" position and the "Full speed" position at the "Astern" side of "Stop" position, for supplying through pipe 17 to the governor control motor 16 fluid at a pressure required to cause operation of the engine at any speed he may select.

When the operator desires to stop the engine from operation in the astern direction 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 past the open valve 154. 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 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 153 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 thereby be operated to actuate brake 4 to stop the drive shaft 3 and the engine 1, while the fuel cut-off motor 21 will operate to move lever 19 of the fuel cut-off device 18 to the fuel cut-off position in which it is shown in the drawing for cutting off 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 be returned 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.

From the above description it is desired to particularly note that when the engine is stopped, in which case both the ahead and astern pipes 89 and 75 are open to atmosphere, and then restarted in the astern direction the supply of fluid under pressure from the astern pipe 75 to diaphragm chamber 69 in the astern valve device 42 occurs past the open valve 154, and that in stopping the engine from operation in the astern direction the release of fluid under pressure from said chamber also occurs past the open valve 154, the communication controlled by said valve by-passing the choke 73 and rendering it ineffective during such operation. It will also be noted that when the engine is stopped from operation in the astern direction the fluid under pressure is released from chamber 172 at the left hand side of piston 170 along with the release of fluid under pressure from the astern control pipe 75.

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 conditioning the engine for operation in the astern direction, and with piston 170 also in the position in which it is shown in the drawing, the engineer desires to start and operate 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 for supplying 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 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 flow through passage 88 to pipe 165 and thence through check valve 183 to chamber 173 at the right hand side of piston 170. Chamber 172 at the left hand side of piston 170 is at this time open to atmosphere through the vented astern pipe 75, so that as soon as sufficient pressure is obtained in chamber 173, the piston 170 will move from the position in which it is shown in the drawing to its left hand position and thereby actuate lever 167 to open valve 160 and permit closing of valve 154 by spring 159. The valve 160 will thus promptly open in response to movement of the operator's control lever 145 to the "Ahead" "Start" position whereupon fluid under pressure in pipe 165 will flow past said valve to pipe 166 and thence through passage 86 to diaphragm chamber 82 in the ahead pilot valve device 43. When sufficient pressure is then obtained in chamber 82 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 open 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 thus 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 will 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 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, pressure of fluid in chamber 116 acting on check valve 114 will move said check valves toward the left hand and seat the check valve 114 and unseat the check valve 113.

Finally, when the reversing piston obtains its ahead position defined by contact with 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 release valve 96 and then act through said valve to open the supply valve 95. When the supply valve 95 is opened fluid supplied through pipe 105 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 8 to supply starting air to pipe 7 and thence to the engine cylinders. The engine will then start 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 operated 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 check valve to its lower position for opening communication between said passage and passage 140. Fluid under pressure will then flow from passage 143 to passage 140 and thence 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 to supply fuel to the engine.

When the engine starts turning under the influence of starting air supplied through pipe 7 and fuel is supplied to the engine as above described, the engine will fire and run on fuel in the ahead direction as determined by the reversing piston 33 being 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 "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 valve device 8 to cut off the supply of starting air to 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.

When the operator desires to stop the engine from operation in the ahead direction, he will move lever 145 to "Stop" position to release fluid under pressure from the speed control pipe 17 to permit the engine speed to reduce to idling, and to also release fluid under pressure from the ahead control pipe 89 and thereby from chamber 82 in the ahead pilot valve device 43, the release of fluid under pressure from chamber 82 occurring past the open valve 160 and thence through said pipe. The ahead pilot valve device 43 will then operate to release fluid under pressure from chamber 135 in the fuel and brake control valve device 45 by way of the double check valve 141 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 supply of fuel to the engine and to also cause operation of brake 4 to stop the engine as will be apparent from the above description. This operation of the ahead pilot valve device 43 will also open chamber 34 above the reversing piston 33 to atmosphere for releasing fluid under pressure therefrom, but the reversing piston will remain in contact with the pressure head 37 in its ahead position at this time.

From the above description it is desired to particularly note that when the engine is stopped from operation in the astern direction, under

which condition both the ahead and astern pipes 89 and 75 will be open to atmosphere, and the engine is then started in the ahead direction, the piston 170 promptly operates in response to movement of the operator's control lever 145 to the "Astern start" position to effect opening of valve 160 so that fluid at the required pressure may be promptly obtained in diaphragm chamber 82 of the ahead valve device 43 for effecting operation of said device, and in stopping the engine from operation in the ahead direction, fluid under pressure is released from said chamber past the open valve 163, it being noted that choke 87 is thus rendered ineffective when the valve 160 is open.

With the engine stopped from operation in the ahead direction if the operator desires to start the engine in the astern direction he will move lever 145 to the "Astern" "Start" position in slot 148 for thereby supplying fluid under pressure to the astern pipe 75 and to the starting pipe 105 while maintaining the ahead pipe 89 and speed control pipe 17 open to atmosphere. At this instant piston 170 will be at the left hand end of cylinder 171, however, fluid under pressure supplied to the astern pipe 75 will promptly flow through passage 74 pipe 153 and check valve 180 to chamber 172 at the left hand face of said piston and move said piston to the right hand end of cylinder 170 for thereby opening valve 154 and permitting closure of valve 160 by spring 163. This opening of valve 154 will then permit fluid under pressure to flow from pipe 153 to pipe 157 and thence to diaphragm chamber 69 in the astern valve device 42. The astern valve device 42 will then operate to supply fluid under pressure to chamber 36 below the reversing piston 33, and with chamber 34 above said piston open to atmosphere through the ahead valve device 43, the piston 33 will be moved from its ahead position in contact with pressure head 37 back to its astern position in which it is shown in the drawing.

This operation of the astern valve device 42 in response to fluid under pressure supplied to chamber 69 will also effect by way of the double check valve 141 operation of the fuel and brake control device 45 to release the brake 4 on the engine and to cause operation of the fuel cut-off motor 21 to supply fuel to the engine, while as soon as the reversing piston 33 obtains its astern position in which it is shown in the drawing, the starting control valve device 44 will be operated by fluid under pressure supplied from chamber 36 through the double check valve 112 to effect starting of the engine in the astern direction, in the same manner as hereinbefore described, and in view of which a more detailed description at this point is not necessary.

After the engine is started in the astern direction the operator will move lever 45 out of the "Astern start" position in slot 148 to the adjacent "Run & idle" position and then by suitable adjustment between the latter position and the adjacent "Full speed" position may cause operation of the engine at any desired degree of speed or output of power.

The description of the apparatus has so far been confined to starting of the engine from stop i. e. from a condition in which both the ahead and astern pipes 89 and 75 are open to atmosphere, and it will be noted that regardless of the direction of last operation of the engine before it was stopped the valve 154 being opened by fluid under pressure from the astern pipe

75 in piston chamber 172 insures prompt operation of the astern valve device 42 in response to movement of the operator's control lever 145 to the "Astern start" position in slot 148, and the valve 160 being opened by fluid under pressure in piston chamber 173 from the ahead pipe 89 upon movement of the operator's control lever to the "Ahead start" position in slot 147 insures prompt operation of the ahead valve device 43 in response to operation of said lever. In other words, the opening of valve 154 renders choke 73 ineffective in starting the engine from stop in the astern direction, while opening of valve 160 renders choke 87 ineffective when starting the engine from stop in the ahead direction.

The purpose of choke 73 is to delay operation of the astern valve device 42 for a sufficient period of time to permit stopping of the engine from operation in the ahead direction when the operator desires to reverse the direction of engine operation from ahead to astern in as short a time as possible, and the choke 87 functions in a similar manner and for the same purpose in reversing the engine from operation in the astern direction to operation in the ahead direction in as short a time as possible, as will now be more fully described.

Let it be assumed that the engine is operating in the ahead direction and that the operator's control lever 145 is in a position between "Run & idle" and "Full speed" position at the "Ahead" side of "Stop" position at which time the ahead control pipe 89 and thereby pipe 165 and pressure chamber 173 at the right hand side of piston 170 will be charged with fluid under pressure, while chamber 172 at the opposite side of said piston will be open to atmosphere through the astern pipe 75. As a result, piston 170 will be at the left hand end of its cylinder opening valve 160. With the ahead pipe 89 charged with fluid under pressure diaphragm chamber 82 in the ahead valve device 43 will also be charged with fluid under pressure and the release valve 77 in said device will be closed and the supply valve 76 open. Diaphragm chamber 69 in the astern valve device will be open to atmosphere through the vented astern pipe 65, and diaphragm chamber 135 in the fuel and brake control device 45 will be charged with fluid under pressure causing operation of the latter device to release brake 4 and to permit supply of fuel to the engine, and chamber 100 in the starting control valve device 44 will also be charged with fluid under pressure from chamber 34 above the reversing piston, the reversing piston 33 being at this time in its ahead position in contact with pressure head 37. With the engine thus operating in the ahead direction, if the operator desires to reverse the engine to operation in the reverse direction in as short time as possible, he will move lever 145 from whatever position it may be occupying 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 at the same time supply fluid under pressure to the astern control pipe 75 and to the starting control pipe 105.

Upon this release of fluid under pressure from the ahead control pipe 89, fluid under pressure will be promptly released from diaphragm chamber 82 in the ahead pilot valve device 43 past the open valve 160 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-off motor 21 for applying the brake 4 to shaft 3 and for actuating the fuel cut-off 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 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 45 by way of the check valves 144 to chamber 135, so as to permit operation of the starting control valve device 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 fluid from chamber 103 to the starting control motor 11 at this time.

When lever 145 is moved to the opposite side of "Stop" position to the "Astern start" position for releasing fluid under pressure from the ahead pipe 89 and at the same time supplying fluid under pressure to the astern control pipe 75 as above described, piston chamber 173 being open to the ahead pipe 89 fluid under pressure will also be released from said chamber, but such release will be at a restricted rate as controlled by choke 185 in order to retain fluid at at least a chosen pressure in said chamber for a certain interval of time after said movement of the operator's control lever. At the same time as fluid under pressure is thus being released from chamber 173 at a restricted rate, fluid under pressure from the astern pipe 75 will flow through pipe 153 and check valve 180 to chamber 172 at the opposite side of said piston, but the pressure of fluid retained in chamber 173 at this time due to the restricting effect of choke 185, plus the pressure of spring 175 opposing movement of lever 167, will prevent the piston 170 moving from its left hand position to its right hand position by pressure of fluid in chamber 172 until after the expiration of an interval of time, such as six seconds, whereby the valve 154 will remain seated for this interval of time.

At the same time as ahead valve device 43 is operated to release fluid under pressure from the reversing piston chamber 34 and to effect operation of the fuel and brake interlock valve device 45 to cut off the supply of fuel to the engine and to apply brake 4 in order to stop the engine, as above mentioned, fluid under pressure supplied

to the astern pipe 75 will flow through choke 73 to diaphragm chamber 69 in the astern valve device 42. The flow capacity of choke 73 is so related to the volume of diaphragm chamber 69 as to prevent sufficient pressure being obtained therein to deflect diaphragm 68 against spring 70 for a period of time, such as six seconds, sufficient to permit stopping of the engine by brake 4, and the pressure of fluid retained in chamber 173 by choke 185 plus the pressure of spring 175 prevents movement of piston 170 by pressure of fluid in chamber 172 for at least this same period of time as above mentioned, so as to thereby maintain valve 154 closed for rendering choke 73 effective to control operation of the astern valve device 42 under this condition of operation. After the astern valve device 42 operates in response to a sufficient pressure of fluid being obtained in chamber 69 by way of choke 73 the pressure of fluid in chamber 173 will have become reduced sufficiently through choke 185 to permit piston 170 to move to its right hand position to open valve 154 but it will be noted that this opening of said valve will be without effect since the astern valve device 42 is previously operated.

The operation of the astern valve device 42 as just described will effect a supply of fluid under pressure to chamber 36 below the reversing piston 33 to cause movement thereof to its astern position in which it is shown in the drawing, and fluid under pressure will also flow to the fuel and brake interlock valve device 45 for effecting operation thereof to release brake 4 and to supply fuel to the engine. After the reversing piston 33 obtains its astern position the starting valve device 44 will operate to supply starting air to the engine to cause starting thereof. After the engine is started and is running on fuel the operator will move his control lever 145 out of slot 148 and then by suitable adjustment between the "Run & Idle" and "Full speed" positions at the "Astern" side of "Stop" position, he may cause operation of the engine at any desired degree of speed or output, as will be clear from above description.

Now assuming that the engine is operating in the astern direction and the operator desires to reverse the direction of operation to ahead in as short a time as possible, he will move lever 145 from the "Astern" side of "Stop" position to the opposite side into the starting slot 147 for thereby releasing fluid under pressure from the astern pipe 75 and for at the same time supplying fluid under pressure to the ahead pipe 89.

In response to this venting of fluid under pressure from the astern pipe 75 fluid under pressure will be released from chamber 69 in the astern pilot valve device 42 by way of the open valve 154 and said device will operate to release fluid under pressure from the reversing piston chamber 36 and from chamber 135 in the fuel and brake control valve device 45 to effect operation thereof to cut off the supply of fuel to the engine and to apply brake 4 for stopping the engine. Also, when fluid under pressure is released from the astern pipe 75 fluid under pressure will be released from piston chamber 172 by way of said pipe, but the rate of such release will be restricted by choke 182. At the same time as fluid under pressure is being released from piston chamber 172 fluid under pressure will be supplied from the ahead pipe 89 through passage 88, pipe 165 and check valve 183 to chamber 173 at the opposite side of said piston. The choke 182 will, however, maintain sufficient pressure in chamber 172, which acting in conjunction with spring 175, will prevent movement of piston 170 to its left hand position by pressure of fluid in chamber 173 for a period of time to permit the pressure of fluid in chamber 82 in the ahead valve device 43 to increase by flow through choke 87 to a degree sufficient for operating said device, which period of time equals that required for stopping of the engine by brake 4. At the expiration of this period of time the pressure of fluid in chamber 172 will have become reduced through choke 182 to a sufficient degree to permit piston 170 to be moved to its left hand position by pressure of fluid in chamber 173 for opening valve 160. It will be noted however that this opening of valve 160 does not occur until after operation of the ahead valve device 43 by fluid under pressure obtained in chamber 82 through choke 87, so that such opening has no effect upon operation of the ahead valve device 43 under this condition of control.

When the ahead pilot valve device 43 is operated by pressure of fluid in chamber 82 fluid under pressure will be supplied to the reversing piston chamber 34 for effecting movement of the reversing piston to its ahead position in contact with pressure head 37 and fluid supplied by said device will also flow through the double check valve device 141 to the fuel and brake interlock valve device 45 for effecting operation thereof to release brake 4 on the engine and to supply of fuel to the engine. After the reversing piston then obtains its ahead position the starting valve device 44 will operate to cause starting of the engine and by movement of the operator's control lever out of slot 147 and suitable adjustment between the "Run & idle" and "Full speed" positions at the "Ahead" side of "Stop" position the supply of starting air to the engine will be cut off and said engine will be caused to operate in the ahead direction at any desired speed or degree of power output.

It will now be seen that choke 73 prevents operation of the astern pilot valve device 42 to cause reversing of the engine valve gear and to supply fuel to the engine for a period of time sufficient for brake 4 to bring the engine to a stop from operation in the ahead direction when the operator actuates lever 145 to reverse the direction of engine operation from the ahead direction to the astern direction in the shortest time possible, while choke 185 acting in conjunction with piston 170 as controlled by opposing pressures of fluid in chambers 172 and 173 aided by force of spring 175 acts to maintain valve 154 closed during this period of time in order that choke 73 may be effective. At the expiration of this period of time the valve 154 will open, however, in order to open a communication of greater flow capacity than choke 73 for dissipating fluid under pressure from diaphragm chamber 69 in the astern pilot valve device 42 when subsequently the operator desires to stop or to reverse the direction of operation of the engine. The choke 87 functions in a like manner when the operator reverses the direction of engine operation from astern to ahead in as short a time as possible, while the piston 170 as controlled by opposing pressures of fluid in chamber 172 and 173 and by pressure of spring 175 permits said choke to act as intended, but at the expiration of the chosen period of time said valve is opened in order to establish a communication by-passing said choke for quickly dissipating fluid pressure from diaphragm

chamber 82 in the ahead pilot valve device 43 when subsequently the operator desires to stop the engine or to reverse the engine operation from ahead to astern in as short a time as possible.

In order that the chokes 185 and 192 may be of relatively large flow capacity so as to reduce to a minimum the possibility of clogging, the volume reservoir 186 is employed and is connected through pipe 187 to chamber 172 when piston 170 is in the position in which it is shown in the drawing, and to chamber 173 when said piston is in its left hand position. When the engine is operating in either direction the volume reservoir 186 will be charged with fluid under pressure through choke 190 from whichever chamber 172 or 173 said volume is connected to. The choke 190 is provided for restricting out flow of fluid under pressure from either chamber 172 or chamber 173, as the case may be, to the volume reservoir 186, but flow of fluid under pressure from said volume in the opposite direction to said chamber may be at a relatively rapid rate by way of the check valve 188 which is disposed in the communication by-passing said choke.

In reversing the engine from operation in one direction to operation in the opposite direction the fluid under pressure in reservoir 186 will flow back through the check valve 188 to either chamber 172 or 173, from whichever one of said chambers fluid under pressure is being vented, and therein act in cooperation with the respective choke 185 or 192 to maintain the pressure of fluid in said chamber at a sufficient degree for preventing operation of piston 170 by the opposing pressure of fluid in the other chamber for the chosen period of time above mentioned. The instant the piston 170 is moved however by pressure of fluid in either one of the chambers 172 or 173 upon the pressure of fluid in the other chamber becoming sufficiently reduced, the volume reservoir 186 will be connected to the one of said chambers being supplied with fluid under pressure so that fluid under pressure will then flow to said reservoir 186 for recharging same. The choke 190 is effective at this time to so restrict the flow of fluid under pressure from chamber 174 or 173, as the case may be, as to maintain a sufficient pressure of fluid in said chamber to prevent reverse movement of piston 170 by the reducing pressure of fluid in the other chamber.

Summary

From the above description it will now be seen that the choke 73 is effective, in reversing the direction of engine operation from ahead to astern, to prevent operation of the reversing piston to reverse the engine valve gear or timing for a period of time sufficient to insure stopping of the engine, but said choke is rendered ineffective by opening of valve 154 when starting the engine from stop in the astern direction, regardless of the direction in which the engine last operated. Likewise, choke 87 is effective in reversing the direction of engine operation from astern to ahead to prevent operation of the reversing piston to reverse the engine valve gear or timing to provide for ahead operation of the engine for a period of time sufficient to insure stopping of the engine, but said choke is rendered ineffective by opening of valve 160 when starting the engine from stop in the ahead direction, regardless of the direction in which the engine last operated.

It is desired to point out that the terms "Ahead" and "Astern" as employed in the drawings and in connection with the description of the invention and in the appended claims are to be considered as synonymous with, respectively, forward and reverse, or one and opposite, etc.

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

1. A control apparatus comprising a reversing means having an ahead position and an astern position, operator's control means movable to a first position, a second position, and a third position, astern means for effecting movement of said reversing means to said astern position in response to movement of said operator's control means to said second position, ahead means for effecting movement of said reversing means to said ahead position in response to movement of said operator's control means to said first position, delay means for delaying operation of said astern means for a chosen interval of time after movement of said operator's control means from said first position to said second position and for delaying operation of said ahead means for a chosen interval of time after movement of said operator's control means from said second position to said first position, and means for automatically rendering said delay means ineffective upon movement of said operator's control means from said third position to either said first position or to said second position.

2. A control apparatus comprising a reversing means having an ahead position and an astern position, operator's control means movable to a first position, a second position, and a third position, astern means for effecting movement of said reversing means to said astern position in response to movement of said operator's control means to said second position, ahead means for effecting movement of said reversing means to said ahead position in response to movement of said operator's control means to said first position, delay means for delaying operation of said astern means for a chosen interval of time after movement of said operator's control means from said first position to said second position and for delaying operation of said ahead means for a chosen interval of time after movement of said operator's control means from said second position to said first position, and means conditionable by said operator's control means in said third position for rendering said delay means ineffective upon movement of said operator's control means to either said first position or to said second position from said third position.

3. A control apparatus for a reversible engine comprising ahead control means for conditioning said engine for operation in one direction, astern control means for conditioning said engine for operation in the opposite direction, an operator's control means having an ahead position for effecting operation of said ahead control means and having an astern position for effecting operation of said astern control means, ahead delay means for delaying response of said ahead control means to movement of said operator's control means to said ahead position, astern delay means for delaying response of said astern control means to movement of said operator's control means to said astern position, said operator's control means also having a stop position, and interlock means for rendering said ahead and astern delay means ineffective upon movement of said operator's control means from said stop posi-

tion to respectively either said ahead position or said astern position, said interlock means including structure conditioned by said operator's control means in said ahead or astern positions to render said ahead and astern delay means effective upon movement of said control means from said ahead position directly to said astern position or from said astern position directly to said ahead position.

4. A control apparatus comprising an ahead pipe, an astern pipe, a reversing piston movable to an ahead position upon supply of fluid under pressure to said ahead pipe when fluid under pressure is released from said astern pipe and movable to an astern position upon supply of fluid under pressure to said astern pipe when fluid under pressure is released from said ahead pipe, an operator's control valve device having one position for supplying fluid under pressure to said ahead pipe and for releasing fluid under pressure from said astern pipe and having a second position for supplying fluid under pressure to said astern pipe and for releasing fluid under pressure from said ahead pipe and having a third position for releasing fluid under pressure from both of said pipes, a first delay means for delaying movement of said reversing piston for an interval of time after supply of fluid under pressure to said ahead pipe, a second delay means for delaying movement of said reversing piston for an interval of time after supply of fluid under pressure to said astern pipe, and interlock means conditionable by said operator's control valve device in said one position for rendering said first delay means effective upon movement of said operator's control device from said one position to said second position and conditionable by said operator's control device in said second position for rendering said second delay means effective upon movement of said operator's control device from said second position to said first position, and conditionable by said operator's control device in said third position to render said first and second delay means ineffective upon movement of said operator's control device to either said first or second position from said third position.

5. A control apparatus comprising reversing means having an ahead control chamber and an astern control chamber, an ahead pipe for conveying fluid under pressure to and from said ahead chamber, an astern control pipe for conveying fluid under pressure to and from said astern chamber, an operator's control device having an ahead position for supplying fluid under pressure to said ahead pipe and for releasing fluid under pressure from said astern pipe, an astern position for supplying fluid under pressure to said astern pipe and for releasing fluid under pressure from said ahead pipe, and having a third position for releasing fluid under pressure from both of said pipes, ahead and astern delay means for restricting flow of fluid under pressure from said ahead and astern pipes to respectively said ahead and astern control chambers, and means operable by pressure of fluid supplied to either one of said pipes when fluid under pressure is released from the other pipe to render said delay means ineffective, and operable upon release of fluid under pressure from either one of said pipes and supply of fluid under pressure to the other pipe by movement of said operator's control device from either said astern position to said ahead position, or vice versa, to render said delay means effective.

6. A control apparatus comprising reversing means having an ahead control chamber and an astern control chamber, an ahead pipe for conveying fluid under pressure to and from said ahead chamber, an astern control pipe for conveying fluid under pressure to and from said astern chamber, an operator's control device having an ahead position for supplying fluid under pressure to said ahead pipe and for releasing fluid under pressure from said astern pipe, an astern position for supplying fluid under pressure to said astern pipe and for releasing fluid under pressure from said ahead pipe, and having a third position for releasing fluid under pressure from both of said pipes, ahead and astern delay means for restricting flow of fluid under pressure from said ahead and astern pipes to respectively said ahead and astern control chambers, and a movable power member subject to opposing pressures of fluid in a first control chamber connected to said ahead pipe and in a second control chamber connected to said astern pipe, means operable by said power member when the pressure in said first control chamber exceeds that in said second control chamber to open a communication from said astern pipe to said astern control chamber of greater flow capacity than said astern delay means, and operable by said power member when the pressure in said second control chamber exceeds that in said first control chamber to open a communication from said ahead pipe to said ahead control chamber of greater flow capacity than said ahead delay means, means for restricting release of fluid under pressure from said first and second control chambers to, respectively, said ahead and astern pipes, and means for providing a more rapid rate of flow of fluid under pressure from said ahead and astern pipes to respectively said first and second control chambers.

7. A control apparatus comprising reversing means having an ahead control chamber and an astern control chamber, an ahead pipe for conveying fluid under pressure to and from said ahead chamber, an astern control pipe for conveying fluid under pressure to and from said astern chamber, an operator's control device having an ahead position for supplying fluid under pressure to said ahead pipe and for releasing fluid under pressure from said astern pipe, an astern position for supplying fluid under pressure to said astern pipe and for releasing fluid under pressure from said ahead pipe, and having a third position for releasing fluid under pressure from both of said pipes, ahead choke means for restricting flow of fluid under pressure to said ahead control chamber, an ahead by-pass valve for opening a communication around and of greater flow capacity than said ahead choke means, astern choke means for restricting flow of fluid under pressure to said astern control chamber, an astern by-pass valve for opening a communication around and of greater flow capacity than said astern choke means, a movable power member movable by the greater pressure of fluid in either a first control chamber open to said ahead pipe or in a second control chamber open to said astern pipe, means operable by said power member upon movement by pressure of fluid in said first control chamber for opening said astern by-pass valve and upon movement by pressure of fluid in said second control chamber for opening said ahead by-pass valve, means for closing said ahead by-pass valve upon opening said astern by-pass

valve and for closing said astern by-pass valve upon opening said ahead by-pass valve, and means for restricting release of fluid under pressure from said first and second control chambers but providing for supply of fluid under pressure at a more rapid rate to said first and second control chambers from the respective ahead and astern pipes.

8. A control apparatus comprising reversing means having an ahead control chamber and an astern control chamber, an ahead pipe for conveying fluid under pressure to and from said ahead chamber, an astern control pipe for conveying fluid under pressure to and from said astern chamber, an operator's control device having an ahead position for supplying fluid under pressure to said ahead pipe and for releasing fluid under pressure from said astern pipe, an astern position for supplying fluid under pressure to said astern pipe and for releasing fluid under pressure from said ahead pipe, and having a third position for releasing fluid under pressure from both of said pipes, ahead and astern delay means for restricting flow of fluid under pressure from said ahead and astern pipes to respectively said ahead and astern control chambers, and means operable by fluid under pressure supplied to said ahead pipe when fluid under pressure is released from said astern pipe to render said ahead delay means ineffective, and operable by fluid under pressure supplied to said astern pipe when fluid under pressure is released from said ahead pipe to render said astern delay means ineffective, and operable by fluid under pressure supplied to either one of said pipes and simultaneous release of fluid under pressure from the other pipe to render ineffective the delay means for restricting flow of fluid under pressure from the pipe supplied with fluid under pressure to the respective one of said ahead or astern control chambers.

9. A control apparatus comprising reversing control means having an ahead control chamber and an astern control chamber and selectively operable by fluid at a chosen pressure in either one of said chambers, an ahead pipe for conveying fluid under pressure to and from said ahead control chamber, an astern pipe for conveying fluid under pressure to and from said astern control chamber, ahead choke means for restricting flow of fluid under pressure to said ahead chamber to delay for a chosen interval of time obtaining said chosen pressure of fluid therein, astern choke means for restricting flow of fluid under pressure to said astern chamber to delay for said chosen interval of time obtaining said chosen pressure of fluid therein, valve means for opening communications of greater flow capacity than and around said ahead and astern choke means for supplying and releasing fluid under pressure to and from said ahead and astern control chambers, a power member subject to opposing pressures of fluid in a first chamber connected to said ahead pipe and in a second chamber connected to said astern pipe and operable by fluid under pressure in said first chamber when fluid under pressure is released from said second chamber to effect operation of said valve means to render said ahead choke means ineffective, and operable by fluid under pressure in said second chamber when fluid under pressure is released from said first chamber to effect operation of said valve means to render said astern choke means ineffective, restricting means for restricting release of fluid under pressure

from said first chamber to said ahead pipe for maintaining a sufficient pressure of fluid in said first chamber upon release of fluid under pressure from said ahead pipe and simultaneous supply of fluid under pressure to said astern pipe and said second chamber to prevent operation of said power member to actuate said valve means to open said communication around said astern choke means for a time interval equal at least to said chosen interval of time, other restricting means for restricting release of fluid under pressure from said second chamber to maintain a sufficient pressure of fluid in said second chamber upon release of fluid under pressure from said astern pipe and simultaneous supply of fluid under pressure to said ahead pipe and to said first chamber to prevent operation of said power means to actuate said valve means to open said communication around said ahead choke means for a time interval equal at least to said chosen interval of time, means of greater flow capacity than and by-passing said restricting means for permitting flow of fluid under pressure to said first and second chambers from the respective pipe, and means selectively operable to supply fluid under pressure to either one of said pipes when fluid under pressure is released from the other pipe or to supply fluid under pressure to either one of said pipes and simultaneously release fluid under pressure from the other pipe.

10. A control apparatus comprising reversing control means having an ahead control chamber and an astern control chamber and selectively operable by fluid at a chosen pressure in either one of said chambers, an ahead pipe for conveying fluid under pressure to and from said ahead control chamber, an astern pipe for conveying fluid under pressure to and from said astern control chamber, ahead choke means for restricting flow of fluid under pressure to said ahead chamber to delay for a chosen interval of time obtaining said chosen pressure of fluid therein, astern choke means for restricting flow of fluid under pressure to said astern chamber to delay for said chosen interval of time obtaining said chosen pressure of fluid therein, an ahead by-pass valve arranged in a communication by-passing and of greater flow capacity than said ahead choke means, an astern by-pass valve arranged in a communication by-passing and of greater flow capacity than said astern choke means, a piston subject to opposing pressure of fluid in a first chamber and in a second chamber and operable by pressure of fluid in said first chamber when it exceeds that in said second chamber to open said astern by-pass valve and operable by pressure of fluid in said second chamber when it exceeds that in said first chamber to open said ahead by-pass valve, means connecting said first chamber to said ahead pipe including a choke for restricting release of fluid under pressure from said first chamber, and a one-way communication by-passing said choke and for permitting supply of fluid under pressure from said ahead pipe to said first chamber at a rate exceeding the flow capacity of said choke, said choke being effective upon release of fluid under pressure from said ahead pipe and simultaneous supply of fluid under pressure to said astern pipe and thereby to said second chamber to maintain sufficient pressure in said first chamber to prevent operation of said piston to open said astern by-pass valve for an interval of time at least equal to said chosen interval of time, means connecting

said second chamber to said astern pipe including another choke for restricting release of fluid under pressure from said second chamber, and a one-way flow communication by-passing the last named choke for permitting flow of fluid under pressure to said second chamber at a rate exceeding the flow capactiy of said other choke, said other choke being effective upon release of fluid under pressure from said astern pipe and simultaneous supply of fluid under pressure to said ahead pipe to so restrict release of fluid under pressure from said second chamber to prevent operation of said piston by pressure of fluid in said first chamber to open said ahead by-

pass valve for an interval of time equal at least to said chosen interval of time, a reservoir, a pipe connected to said reservoir for conveying fluid under pressure to and from said reservoir, a check valve for permitting rapid flow of fluid under pressure from said reservoir through said pipe, and a communication by-passing said check valve and including a choke for restricting flow of fluid under pressure to said reservoir, said piston being operable to open said pipe and thereby said reservoir to the one of said first and second chambers supplied with fluid at the greater pressure.

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