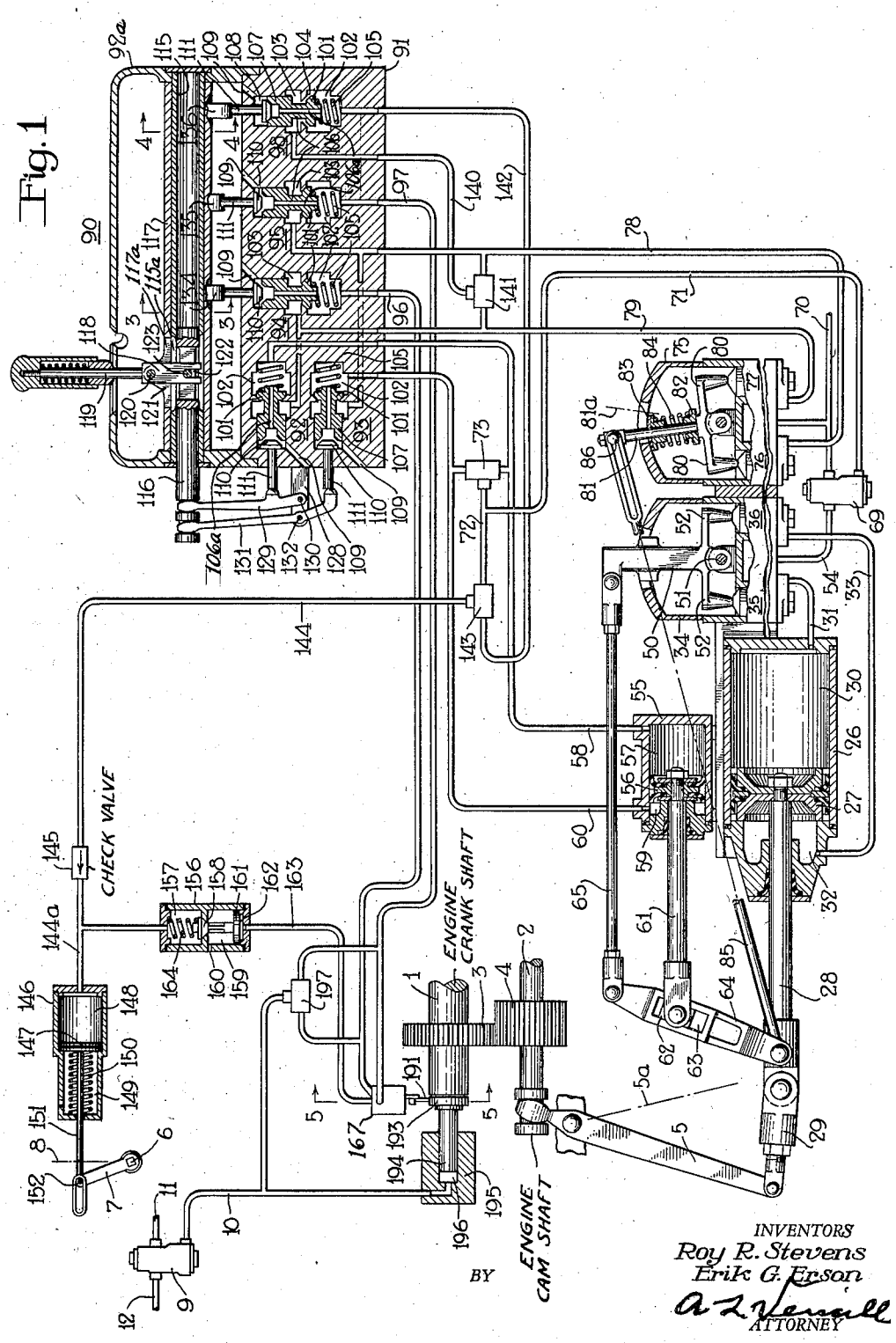
Feb. 19, 1946. R. R. STEVENS ET AL 2,395,202

CONTROL SYSTEM

Filed Jan. 29, 1944 2 Sheets-Sheet 1

Fig. 1



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CONTROL SYSTEM

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Fig. 2

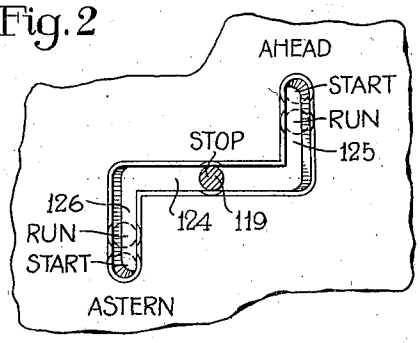


Fig. 5

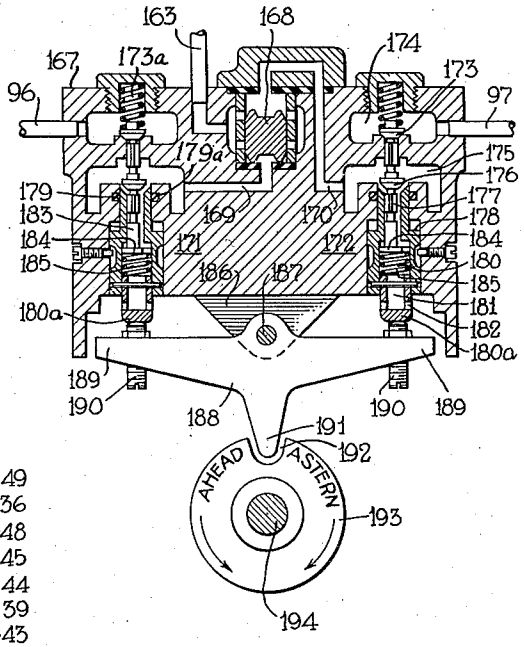


Fig. 6

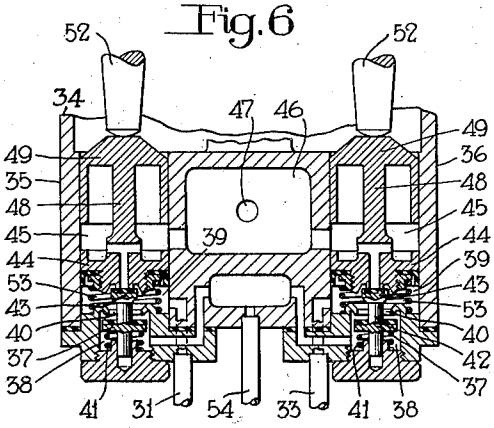
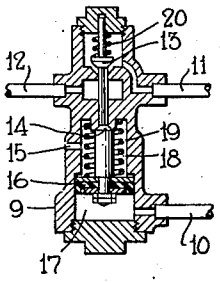


Fig. 7



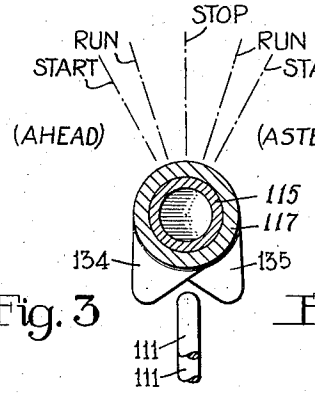


Fig. 3

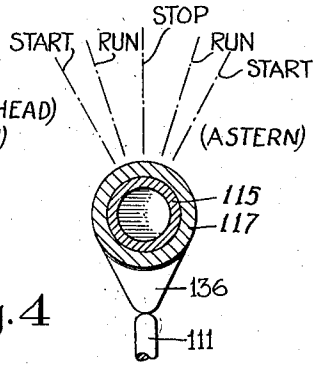
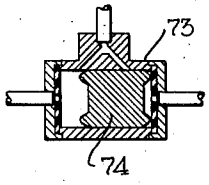


Fig. 4

Fig. 8



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UNITED STATES PATENT OFFICE

2,395,202

CONTROL SYSTEM

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Application January 29, 1944, Serial No. 520,256

27 Claims. (Cl. 60—16)

This invention relates to control systems and more particularly to a fluid pressure control system for controlling, in a desired sequence, a plurality of different operations such as starting, stopping and reversing of a reversible internal combustion engine.

Certain internal combustion engines, such as of the Diesel type, are arranged to run in either direction, the direction being determined by adjustment of the valve timing or valve gear which may control in proper sequence a supply of compressed air to the cylinders for starting the engine to turn, and a supply of fuel to the cylinders, under control of injectors or the like, for causing the engine to run.

One object of the invention is the provision of an improved control system for controlling, in proper sequence, various operations such as required for stopping, starting and reversing an engine of the type above described.

Another object of the invention is the provision of such a system arranged to be controlled from a remote control station by fluid under pressure.

Another object of the invention is the provision of a pneumatic system for controlling the starting, stopping and reversing of a Diesel engine, which system, upon operation to reverse the engine, initially acts to cut off the supply of fuel to the engine, then causes reversal of the valve gear or timing gear of the engine followed by supplying compressed air to the engine for braking same in case it is not already stopped, and which air upon stopping of the engine is immediately effective to start the engine turning in the opposite direction, and which system provides for resupplying fuel to the engine after and only after the engine is placed in motion in the new direction.

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

In the accompanying drawings; Fig. 1 is a diagrammatic view, partly in section and partly in outline, of a control system embodying the invention; Fig. 2 is a plan view of a portion of an operator's control device shown in vertical section in Fig. 1; Figs. 3 and 4 are partial sectional views of the operator's control device taken on the lines 3—3 and 4—4, respectively, in Fig. 1; Fig. 5 is a sectional view of a fuel interlock valve device taken on the line 5—5 in Fig. 1; Fig. 6 is a vertical sectional view taken through a control valve device shown partly in side elevation and partly in vertical section in Fig. 1; Fig. 7 is a vertical sectional view of a starting air supply valve device shown in elevation in Fig. 1; and Fig. 8 is a sectional view of a double check valve device several of which are shown in elevation of Fig. 1.

Description

In the drawings, the reference numeral 1 indicates a portion of one end of a crank shaft of a reversible internal combustion engine, and reference numeral 2 indicates a portion of one end of a cam shaft for said engine. The cam shaft may be driven in proper phase with the crank shaft by meshing gears 3 and 4 for operating conventional engine valve mechanisms (not shown) and fuel injection mechanisms (not shown) in a well known manner to permit the engine to be started by compressed air for operation in either direction of rotation, to for instance drive a ship ahead or astern. To provide for the different directions of operation, the cam shaft may have the usual forward cams (not shown) to provide for operation of the engine in one or an ahead direction and reverse cams (not shown) to provide for operation in the reverse or an astern direction and may be shiftable longitudinally relative to the crank shaft for rendering either the forward or the reverse cams effective for controlling the engine's valve or timing gear in a well known manner. In Fig. 1 of the drawings the cam shaft is shown in what may be considered a position to provide for operation of the engine in an astern direction, and may be shifted by a lever 5 from the astern position to an ahead position in which said lever may occupy a position such as indicated by a dot and dash line 5a.

The reference numeral 6 indicates a fuel control member or shaft which may be rockable to control conventional fuel injectors (not shown) to vary the amount of fuel supplied to the engine for controlling the speed or torque of the engine or for stopping the engine. A lever 7 is connected to rock shaft 6. The lever 7 and shaft 6 may have a fuel cut off position in which they are shown in Fig. 1 for cutting off the supply of fuel to the engine to stop same, and may be adjustable out of said position to a fuel supply position, such as indicated by a dot and dash line 8, to supply fuel to the engine to provide for operation of the engine at idling speed, and may be further adjustable in the same direction for increasing the speed or torque of the engine.

The adjustment of lever 7 and shaft 6 to vary the engine's speed may be effected in any desired

manner, as by a conventional speed governor (not shown) driven by the engine and adjusted manually for limiting the speed or torque of the engine.

The reference numeral 9 indicates an engine starting air valve device arranged to be operated by fluid under pressure supplied through a pipe 10 for supplying starting air from a supply pipe 11 to a pipe 12 which may convey it to the starting valves (not shown) of the engine for supply to the engine cylinders (not shown) to place the engine in motion in the direction determined by the position of the cam shaft 2.

As shown in Fig. 7, the starting air valve device 9 may comprise a valve 13 for controlling communication between pipes 11 and 12, a valve 14 for controlling communication between pipe 12 and an atmospheric port 15, and a piston 16 for controlling said valves and having at one side a chamber 17 open to pipe 10, and having at the opposite side a chamber 18 open to atmosphere through port 15 and containing a spring 19 under pressure and acting on said piston. In operation, when fluid under pressure is supplied to pipe 10, in a manner which will later be described, such pressure will flow into chamber 17 and therein act to move piston 16 for seating valve 14 and opening the valve 13 to thereby supply starting air from pipe 11 to pipe 12 for starting the engine. When fluid is released from pipe 10 and thus from chamber 17, spring 19 will open valve 14 and permit the closing of valve 13 by a spring 20 to cut off the supply of starting air to pipe 12 and to release air from said pipe to the atmosphere.

The invention comprises means for controlling the reversing of the valve timing or gear of the engine as by shifting of the cam shaft 2 to either its astern or ahead position, and for controlling operation of the starting air valve device 9, and operation of the fuel control shaft 6 to cut off the supply of fuel to the engine as required for the control of the starting, stopping and reversing of the engine, in view of which a more detailed showing in the drawings of the intricate well known structure of the engine, and a lengthy description thereof are deemed unnecessary in the present application to a clear understanding of the invention and hence are dispensed with.

For shifting the cam shaft 2 to either of its two different positions there is provided a power cylinder 26 containing a piston 27 having a rod 28 extending through one end of said cylinder and connected to one end of a link 29. The other end of this link may be connected to the cam shaft as through the lever 5. The piston 27 has at one side a chamber 30 connected to a control pipe 31 and at the opposite side a chamber 32 connected to a control pipe 33. The two control pipes 31 and 33 lead to a control valve device 34 mounted on one end of the power cylinder 26 and containing two fluid pressure supply and release valve devices 35 and 36 for controlling the supply and release of fluid under pressure to and from said pipes, respectively.

Both of the valve devices 35 and 36 may be identical in construction, each comprising, as shown in Fig. 6, a fluid pressure supply valve 37 contained in a chamber 38 and arranged to control communication between said chamber and a chamber 39 by way of an aperture 40. A spring 41 in chamber 38 acts on the valve 37 for closing same. The valve 37 has a stem 42 extending through aperture 40 into chamber 39 wherein it is provided on its end with a fluid pressure release valve 43 arranged to cooperate with a seat provided on a plunger 44 for controlling communication between chamber 39 and a chamber 45 at the opposite side of the plunger. The plunger 44 is connected by a stem 48 to a guide 49 which is slidably mounted in the device above said plunger.

Chamber 45 in each of the valve devices 35 and 36 is in constant communication with the atmosphere through a cavity 46 and a passage 47. Chamber 39 in the valve device 35 is connected to pipe 31 and the corresponding chamber in the valve device 36 is connected to pipe 33. The supply valve chamber 38 in both valve devices 35 and 36 is open to a pipe 54 arranged to be supplied with fluid under pressure in a manner which will be later described.

A lever 50 is pivotally mounted on a pin 51 disposed midway between the guides 49 in the two valve devices 35 and 36, and said lever has two oppositely arranged arms 52, each engaging the outer face of one of said guides. With the lever 50 in a vertical position as shown in Fig. 1, the two arms 52 position the guides 49 and thereby plungers 44 as shown in Fig. 6, in which position the respective release valves 43 are in engagement with said plungers and act through the stems 42 to open the connected supply valves 37 so that chambers 30 and 32 at opposite sides of the power piston 27 are both open to the fluid pressure supply pipe 54, and the piston 27 will be subject on opposite sides to fluid at the same degrees of pressure. Under this condition piston 27 will remain in a fixed position. Since the right-hand side of the piston has a greater area subjected to the pressure of fluid than has the left-hand side, the piston will have a tendency to move in the direction toward the left-hand, but the inherent resistance of the piston and of the several parts operatively associated therewith to such movement is sufficient to hold the piston stationary at this time.

Movement of lever 50 in a counter-clockwise direction, as viewed in Fig. 1, will actuate the valve device 35 to open the supply valve 37 thereof to a greater degree and permit movement of guide 49 and plunger 44 in the valve device 36 in an upwardly direction under the pressure of fluid in chamber 39 and action of a spring 53 and to an extent to permit closure of the supply valve 37 in said device and opening of the release valve 43 which will permit release of fluid under pressure from chamber 39 and thereby chamber 32 at the left hand side of the power piston 27 by way of pipe 33. With the pressure of fluid in chamber 32 thus reduced and the pressure of fluid in chamber 30 maintained by supply of fluid from the supply pipe 54, the piston 27 will be subjected to a differential in forces which will move it and thereby lever 50 and cam shaft 2 to the positions shown in the drawings to provide for running of the engine in a direction to cause astern movement of a ship. After the piston 27 has been moved to the position shown in Fig. 1 of the drawings, return of lever 50 to a vertical position will again open chamber 32 to the fluid pressure supply pipe 54 while maintaining chamber 30 open to said pipe, due to which the opposing fluid pressures on the piston will become balanced to substantially remove all actuating force on the piston.

Rocking of the lever 50 in a clockwise direction, as viewed in Fig. 1, from its vertical position will actuate the valve device 36 to reduce the pressure of fluid in chamber 30 while maintaining chamber 32 open to the fluid pressure supply pipe 54 through the valve device 35. Under this condition a differential in fluid pressures will be pro-

vided on piston 27 for moving same in the direction of the right-hand to thereby actuate the lever 5 to the ahead position indicated by the dot and dash line 5a, and this movement of said lever will shift the cam shaft 2 to the position for causing operation of the engine in a reverse direction to cause movement of the ship ahead. After the piston 27 obtains its right-hand position, the return of lever 52 to its vertical position will again balance and substantially remove all actuating force on said piston which will then remain in the position in which it was moved.

For controlling operation of the control valve device 34 to position the piston 27, a pilot device 55 is mounted on one side of the power cylinder 26. This device comprises a piston 56 having at one side a chamber 57 connected to a control pipe 58 and having at the opposite side a chamber 59 connected to a control pipe 60. A piston rod 61 extending through a suitable bore in the casing into chamber 59 has one end connected to the piston 56. The other end of the piston rod 61 is connected to a member 62 which is slidably mounted in a slot 63 provided in a lever 64 one end of which is pivotally connected to the piston rod 28. The opposite end of lever 64 is pivotally connected to one end of a tie rod 65 the opposite end of which is pivotally connected to lever 50.

Operation of the pilot piston 56 is controlled by fluid under pressure supplied through either one of the control pipes 58 or 60 when the other control pipe is open to the atmosphere, which conditioning of said pipes will be hereinafter described. When fluid under pressure is supplied to pipe 58 and thence to the pilot piston chamber 57, with chamber 59 and pipe 60 open to the atmosphere, the pilot piston 56, power piston 27 and lever 50 will assume the positions in which they are shown in Fig. 1 as will be apparent from the description to follow.

Now let it be assumed that pipe 58 is opened to the atmosphere and that fluid under pressure is supplied to pipe 60. This pressure of fluid acting in chamber 59 on the pilot piston 56 will move same in the direction of the right-hand, and due to the relatively greater reluctance to movement of the power piston 27, this movement of the pilot piston will rotate lever 64 about its pivotal connection with the power piston rod 28 and actuate the tie rod 65 to rock lever 50 in the control device 34 in a clockwise direction for thereby releasing fluid under pressure from the power piston chamber 30 while maintaining the fluid pressure in the power piston chamber 32. As a result, the power piston 27 will move in the direction of the right-hand and during the initial portion of such movement the pilot piston 56 will move therewith under pressure of fluid in chamber 59. After a certain degree of such movement the pilot piston 56 will contact the right-hand end of chamber 57 and thereby prevent further movement of said piston. Continued movement of the power piston 27 will then rock lever 64 about its connection with the pilot piston rod 61 and thereby actuate the tie rod 65 to rock lever 50 in the control device 34 back toward its neutral or vertical position, which position will be attained at substantially the time the power piston 27 attains the right-hand end of chamber 30. Thus with the pilot piston 56 at the right-hand end of the chamber 57, the power piston 27 will be caused to assume a corresponding position in the power cylinder 26, and the control device 34 will act to equalize the opposing fluid pressures acting on the opposite sides of said power piston. This movement of the power piston 27 will rock lever 5 to the ahead position indicated by the dot and dash line 5a for correspondingly positioning the cam shaft 2 in the engine.

Movement of the cam shaft 2 to its astern position by movement of the power piston 27 to the left-hand end of chamber 32 may be accomplished by fluid under pressure supplied to pipe 58 upon release of fluid under pressure from pipe 60 in a manner which will be apparent from the above description.

After the power piston 27 has completed its stroke to move the cam shaft 2 to either its ahead position or its astern position, it may be desirable to open both chambers 30 and 32 to the atmosphere for thereby relieving the power piston of the pressure of fluid. This may be accomplished by the use of a relief valve device 69 for controlling the supply of fluid under pressure to pipe 54 from a pipe 70 which may be constantly supplied with fluid under pressure from any suitable source in a manner which will be brought out hereinafter.

The relief valve device 69 may be identical to the starting air valve device 9 above described and shown in Fig. 7, the pipe 54 being connected to the chamber between the two valves 13 and 14, the pipe 70 being connected to the chamber containing valve 13, and the piston 16 in said device being controlled through a pipe 71. The pipe 71 is connected to a pipe 72 which in turn is connected to the side outlet of a double check valve device 73. The end outlets of the double check valve device 73 are connected to pipes 58 and 60.

As shown in Fig. 8 the double check valve device 73 may comprise a casing containing a double check valve 74 arranged to control communication between the two end connections and the side outlet; opening communication between the side outlet and the one end connection and closing communication between said side outlet and the other end connection in one position of said valve and reversing the connections between the side outlet and the end connections in the other position of said valve.

It will thus be seen that with the structure just described, whenever fluid under pressure is supplied to either pipe 58 or pipe 60 for effecting operation of the pilot piston 56 fluid will also be supplied through pipe 71 to the release valve device 69 for actuating same to open communication between fluid pressure supply pipe 70 and pipe 54 leading to the control device 34, while upon subsequent release of fluid under pressure from either control pipe 58 or 60 for relieving the pilot piston 56 for actuating force, which will be later described, the corresponding release of fluid from pipe 71 and the release valve device 69 will cause operation of said device to close communication between pipes 70 and 54 and open pipe 54 to the atmosphere for thereby releasing fluid under pressure from opposite sides of the power piston 27 past the open supply valves in the valve devices 35 and 36 and thence through pipe 54.

In order to prevent operation of the starting air valve device 9 to supply air for braking the engine and subsequently starting the engine in a reverse direction until after the cam shaft 2 has been shifted to the position for conditioning the engine's valve gear to provide for operation of the engine in such direction, there is associated with the cam shifting arrangement, including the power piston 27, a reverse and start

interlock valve device 75, which may be mounted directly on the control valve device 34.

The interlock valve device 75 may be structurally identical to the control valve device 34 with but one exception, which will be later described, and therefore comprises two fluid pressure supply and release valve devices 76 and 77 which are structurally identical to the valve devices 35 and 36 above described and which are arranged to control flow of fluid under pressure from pipe 70 to interlock pipes 78 and 79, respectively and to control the release of fluid under pressure from said pipes. The two fluid pressure supply and release valve devices 76 and 77 are arranged to be operated by oppositely extending arms 80 of a lever 81, which lever differs from the lever 50 in the valve device 34 only in that it carries a spring seat 82 and a friction shoe 83 which is arranged to slidably contact an interior surface of the device. An initially compressed coil spring 84 encircling the lever 81 is interposed between the seat 82 and friction shoe 83 and acts to press said shoe into contact with the surface of the casing with such force as to hold the lever 81 in any position to which it may be moved against opposing pressures of fluid acting on piston 44 in either one of the valve devices 76 or 77 when said piston in the other device is subject in chamber 39 to atmospheric pressure.

One end of a rod 85 is connected to the power piston rod 28. The opposite end of rod 85 is provided with a slot, and extending into this slot is a pin 86 which is secured in the outer end of lever 81. The rod 85 is operative upon movement of the power piston 27 to the position shown in Fig. 1 to move lever 81 to the position in which it is shown, and is operative upon movement of the power piston 27 to its opposite position to move the lever 81 to a corresponding position as indicated by a dot and dash line 81*a*. The slotted or lost motion connection between the rod 85 and pin 86 provides for movement of the power piston 27 relative to the lever 81 until the piston approaches the end of its stroke in either direction. Thus upon movement of the power piston 27 to the position shown in the drawings the interlock valve device 75 will maintain a supply of fluid under pressure from pipe 70 to pipe 79 and at the same time maintain pipe 78 open to the atmosphere until said piston substantially attains said position. Likewise, upon movement of the power piston 27 from this position to the opposite or right hand end of its cylinder, the interlock valve device 75 will maintain a supply of fluid under pressure from pipe 70 to pipe 78 and maintain pipe 79 open to the atmosphere until said piston substantially completes its stroke, at which time the interlock valve device will operate to open pipe 78 to the atmosphere and open pipe 79 to the fluid pressure supply pipe 70.

The reference numeral 90 indicates an operator's fluid pressure control valve device which may be located immediately adjacent the engine or at any remote control station. This device comprises a body 91 and a cover 92*a* mounted on the body, and in said body there are disposed what may be called an astern run valve device 92 and an ahead run valve device 93 for controlling, through pipes 58 and 60, operation of the structure including power piston 27 to selectively position the cam shaft 2 for a selected direction of operation of the engine, in the manner above described. The body 91 also contains an ahead start valve device 94 and an astern start valve device 95 arranged to control through pipes 96 and 97, respectively, operation of the starting air valve device 9, and a stop valve device 98 for effecting stopping of the engine in a manner and under conditions which will be later brought out.

The two run valve devices 92 and 93 are located side by side in the body 91 with their axes arranged horizontally, while the valve devices 94, 95 and 98 are arranged side by side with their axes arranged vertically. All of these valve devices may be identical in construction each comprising a fluid pressure supply valve 101 contained in a chamber 102 and arranged to control communication between said chamber and a chamber 103 through an opening 104 provided through a seat which said valve is arranged to engage for closing such communication. A spring 105 in chamber 102 acts on the valve 101 to urge it to its seated position. The valve 101 is connected by a stem 106, which loosely extends through the opening 104 into chamber 103, to a plunger 107 slidably mounted in a suitable bore in the body, said plunger being of substantially the same area as the seat on the valve 101 and subject on one face to pressure of fluid in chamber 103 and on the opposite face to atmospheric pressure in a chamber 108 which is open to the atmosphere by way of a passage 109. The valve 101, stem 106 and plunger 107 are provided with an axial bore 106*a* open at one end to chamber 102, while a release valve 110 disposed in chamber 108 is arranged to control communication between the opposite end of said bore and the latter chamber. The release valve 110 is provided with a plunger 111 extending to the exterior of the body.

In the illustration all of the valve devices 92 to 95 and 98 are disposed in the same vertical plane, and extending over the plungers 111 of the valve devices 94, 95, and 98 and arranged in the same vertical plane is a horizontally disposed hollow control shaft 115 which is suitably journaled at its opposite ends in the cover 92*a*. A plunger 116 is slidably mounted in the control shaft 115. The left hand end of this plunger projects outwardly beyond one end of the shaft above the plungers 111 of the valve devices 92 and 93. A cam shaft 117, telescoped over and secured to the control shaft 115, bears at opposite ends against the cover for holding both shafts against axial movement.

The two shafts 115 and 117 are provided through one side with aligned longitudinally extending slots 115*a* and 117*a*, respectively, and the plunger 116 is provided with a like aligned slot and through these slots extends the lower end portion 118 of an operator's control lever 119 which is pivotally mounted on a pin 120 arranged transversely of the axes of said shafts and carried by a lug 121 projecting upwardly from the cam shaft 117. The portion 118 of the control lever ends within the cam shaft 117 and in its end there is provided a slot 122 within which is disposed a transversely extending pin 123 which is secured to plunger 116. It will be seen that with this structure, rocking of the operator's control lever 119 about the pin 120 in a direction longitudinally of the cam shaft 117 will shift the plunger 116 in one or the opposite direction lengthwise within the control shaft 115 and relative to the cam shaft 117, while movement of said lever in a direction about the axis of said cam shaft will rotate said cam shaft with-

out effecting endwise movement of plunger 116.

The control lever 119 extends through a slot in cover 92a, which slot is so shaped and arranged as to guide the lever in its different directions of movement. This slot is shown in detail in Fig. 2 and may comprise a central portion 124 which allows movement of the lever 119 in either direction from a neutral position, in which it is shown in Fig. 2, lengthwise of the control shaft 115 for actuating plunger 116. One end of slot 124 is open to a slot 125 arranged at right angles to provide for movement of the lever out of slot 124 in one direction for rocking of the cam shaft 117 in a like direction. The opposite end of slot 124 is open to a slot 126 arranged parallel to slot 125 but extending in the opposite direction. The control lever 119 may have five different operating positions in these slots including intermediate the length of slot 124 a "Stop" position in which said lever is shown in Fig. 2. The other positions of the lever are shown in Fig. 2 by dotted circles designated by appropriate legends, it being noted that the lever has an "Ahead start" position at the outer end of slot 125 and an "Ahead run" position in said slot adjacent said "Start" position. Oppositely arranged "Astern start" and "Run" positions are provided in slot 126.

The body 91 has an exterior lug 128 which extends between and beyond the outer ends of the plungers 111 of the two control devices 92 and 93. A lever 129 fulcrumed in one end on a pin 130 which is carried by the lug 128 has its opposite end operatively connected to plunger 116, while intermediate its ends, it is provided with a raised portion which engages plunger 111 of the valve device 92. A lever 131 fulcrumed intermediate its ends on a pin 132 carried by the lug 128 is operatively connected at one end to plunger 116 while its opposite end is arranged for contact with plunger 111 of the valve device 93.

The parts are so constructed and arranged that, with the lever 119 in "Stop" position, the two levers 129 and 131 will be so positioned as to allow opening of the release valves 110 and closing of the supply valves 101 of the two valve devices 92 and 93. Chambers 102 in the two valve devices 92 and 93 are open respectively to control pipes 58 and 60 so that with lever 119 in "Stop" position the chambers at the opposite sides of the pilot piston 56 will both be opened to the atmosphere. Movement of lever 119 to its "Ahead run" position is arranged to actuate lever 131 to close the release valve 110 and open the supply valve 101 in the ahead run valve device 93 to thereby open communication between control pipes 60 and 78. Movement of the control lever 119 to the "Astern run" position will operate lever 129 to seat release valve 110 and open supply valve 101 in the control device 92 to thereby connect control pipe 58 to control pipe 79. The two control devices 92 and 93 will be operated as just described by movement of the operator's control lever 119 to either one or the opposite end of slot 124 and without further movement into the adjacent slot 125 or 126 to the positions indicated in Fig. 2 by the legends "Run," but in the illustration this further movement is necessary for reasons which will later be brought out.

The cam shaft 117 is provided with three cams 134, 135 and 136 arranged to control respectively the plungers 111 of the three control devices 94, 95 and 98. The cam 134 is provided for actuating plunger 111 to close the release valve 110 and open the supply valve 101 in the ahead start valve device 94 when the operator's control lever 119 is in the "Ahead start" position only, and to permit these valves to assume the positions shown in Fig. 1 in all other positions of said lever. The cam 135 is provided for closing valve 110 and opening valve 101 in the astern start valve device 95 when the operator's control lever 119 in the "Astern start" position only, and to permit movement of the valves to the positions shown in the drawings in all other positions of said lever. The cam 136 is provided for closing the release valve 110 and opening the supply valve 101 in the stop valve device 98 with the operator's control lever in the "Stop" position only and to permit closure of the supply valve 101 and opening of the release valve 110 in all other positions of said lever. It will be noted that the position of cam 136 is not changed by movement of the operator's lever 119 in the slot 124 and it is therefore necessary that the two "Run" positions be at opposite sides of slot 124 in order that in such positions the supply valve 101 will be seated and the release valve 110 opened in the stop valve device 98.

The interlock pipe 78 connected to the interlock valve device 75 is connected to chamber 103 in both the ahead run valve device 93 and the astern start valve device 95, while pipe 79 from the interlock valve device 75 is connected to chamber 103 in the astern run valve device 92 and in the ahead start valve device 94. Chamber 103 in the stop valve device 98 is connected by a pipe 140 to the side outlet of a double check valve device 141 the opposite ends of which are respectively connected to pipes 78 and 79. This double check valve device may be identical to that shown in Fig. 8 and above described whereby when fluid is supplied to either pipe 78 or 79 such fluid will flow to pipe 140 and thence to the stop valve device 98. The chamber 102 in the stop valve device 98 is connected to a pipe 142 leading to one end of a double check valve device 143 which may be of the same construction as the double check valve device 141. The opposite end of this check valve device 143 is connected to pipe 72, and the side outlet of the valve device is open to a pipe 144 which is connected through a one-way flow check valve device 145 and a pipe 144a to a fuel cutoff device 146.

The fuel cutoff device 146 may comprise a casing containing a piston 147 having at one side a chamber 148 open to pipe 144a and having at the opposite side a non-pressure chamber 149 containing a spring 150 which is under pressure and acting on piston 147 for urging same in the direction toward the right hand end of chamber 148 when pipe 144a is void of fluid pressure. The piston 147 is provided with a rod 151 extending through chamber 149 and provided in its outer end with a slot through which extends a pin 152 secured in the end of the fuel control shaft operating lever 7. Upon supply of fluid under pressure to chamber 148 piston 147 will actuate the rod 151 into contact with pin 152 and move lever 7 to the fuel cutoff position as shown in the drawings. This position may be defined by contact between said piston and the casing. Upon release of fluid under pressure from chamber 148 the spring 150 will return piston 147 to its normal position in contact with the right hand end of chamber 148 to thereby pull lever 7 out of its fuel cutoff position to its fuel supply position indicated by the dot and dash line 8. With the piston 147 in its normal position the slot in the

piston rod 151 provides for adjustment of the lever further in a clockwise direction, as by a conventional governor above mentioned, for increasing the speed or torque of the engine which however is immaterial to the invention. It will now be seen that upon operation of the operator's control lever 119 to supply fluid under pressure to either of the control pipes 58 or 60 to cause change in position of the cam shaft 2 for reversing the engine, or upon supply of fluid under pressure to pipe 142 by operation of the stop control device 98 with the operator's control lever in "Stop" position, such fluid will be supplied to pipe 144 and thence to the fuel cutoff device 146 for actuating lever 7 to turn the fuel control shaft 6 to its fuel cutoff position for cutting off the supply of fuel to the engine to allow stopping thereof.

The check valve 145 is arranged to prevent release of fluid under pressure from the fuel cutoff device 146 upon release of fluid under pressure from pipe 144 under a condition to be later described. In order to release fluid under pressure from the fuel cutoff device 146 to permit the supply of fuel to the engine a release valve device 156 is provided. This device comprises a casing having a chamber 157 which is in open communication with pipe 144*a* and which contains a valve 158 for opening communication between said chamber and a chamber 159 which is open to the atmosphere through a port 160. Chamber 159 is located at one side of a piston 161 and located at the opposite side of the piston is a pressure chamber 162 arranged to receive fluid under pressure from a pipe 163. When fluid under pressure is supplied to chamber 162, piston 161 will operate to open valve 158 against the opposing pressure of a spring 164 in order to release fluid under pressure from pipe 144*a* and thus from the fuel cutoff device 146. When piston chamber 162 is void of fluid pressure spring 164 will close the valve 158.

Pipe 163 connects the release valve device 156 for control to a directional interlock valve device 167 which is arranged to operate upon reversing of the direction of operation of the engine to prevent the supply of fuel to the engine until after the engine is started to turn by compressed air in the new direction. This interlock valve device comprises (Fig. 5) a casing containing a double check valve 168 arranged to control communication between pipe 163 and two passages 169 and 170. In one position of the double check valve, the pipe 163 will be open to passage 170 and disconnected from passage 169 as shown in Fig. 5 of the drawings. In the other position of the double check valve, passage 170 will be disconnected from pipe 163 and said pipe will be connected to passage 169. The passages 169 and 170 lead respectively to an ahead valve control device 171 and to an astern control valve device 172.

The control valve devices 171 and 172 are identical in structure, each comprising a supply valve 173 contained in a chamber 174 and arranged to control communication between said chamber and a chamber 175. A spring 173*a* in chamber 174 acts on the supply valve 173 for seating said valve. The chamber 175 contains a release valve 176 in constant contact with a stem projecting from the supply valve 173 and having a stem 177 slidably mounted in a plunger 178 which in turn is slidably mounted in a bore in the casing. The casing is provided with an annular recess 179*a* encircling the plunger 178 and containing a ring seal 179 contracted into sealing engagement with the peripheral surface of said plunger for preventing leakage of fluid under pressure from chamber 175 past said plunger. The bore in which the fluted stem 177 of the release valve 176 is mounted opens to a larger bore 180 the outer end of which is closed by a plug 180*a* and the bore 180 is open to the atmosphere through another bore 181 and one or more ports 182 provided in said plug. A plunger 183 loosely mounted in the bore containing the release valve stem 177 engages said stem and extends into bore 180 where it is provided with an enlarged head 184 which may be of smaller diameter than bore 180 to allow flow of fluid from one side to the opposite side. Interposed between the head 184 and the adjacent end of plug 180*a* is a spring 185 which is under pressure. The pressure of spring 185 against the head 184 and thereby the release valve 176 is less than the pressure of spring 173*a* against the supply valve 173, so that spring 173*a* can hold the supply valve 173 seated against the reaction of spring 185 which is provided to move plunger 178 out of seating engagement with said release valve.

The casing of the interlock device 167 is provided midway between the outer ends of the two plugs 180*a* with a depending lug 186 carrying a pin 187 upon which is fulcrumed a lever 188 having two oppositely arranged arms 189 each of which is disposed over the end of one of the plugs 180*a*. In the end of each arm 189 is secured an adjustable actuating screw 190 engaging the respective plug 180*a*. With the parts in the position in which they are shown in Fig. 5 the screws 190 are so adjusted as to permit movement of the two supply valves 173 against their seats under the action of springs 173*a* and to permit movement of the two plungers 178 by springs 185 out of contact with the respective release valves 176.

The lever 188 is also provided with a depending lever arm 191, the end of which is loosely accommodated in a slot 192 provided in and open to the periphery of a friction disc 193. This disc is carried on a plunger 194 which is slidably mounted in a bore provided in a casing 195 (Fig. 1) which is adapted to be rigidly supported with respect to the engine and to in turn support the friction disc in coaxial relation with the end of the engine crank shaft 1. The plunger 194 is also operative in the capacity of a piston for moving the friction disc into frictional contact with the end of the crank shaft 1, and to effect such movement, is subject at its inner end to pressure a fluid in a chamber 196 which is open to pipe 10 leading to the starting air valve 9. Pipe 10 is also open to the side outlet of a double check valve device 197, like the check valve device shown in Fig. 8, and which has its opposite ends connected to the pipes 96 and 97.

Operation

Let it be initially assumed that the operator's control lever 119 is in "Stop" position and that the engine has been stopped from previous operation in an astern direction, under which condition, the cam shaft 2 will be positioned for astern operation and the power piston 27, pilot piston 56, control valve device 34 and interlock valve device 75 will all be positioned as shown in Fig. 1.

With the operator's control lever in "Stop" position, the ahead and astern run control valve devices 92 and 93 will be in positions opening pipes 58 and 60 to the atmosphere, while the ahead and astern start control valve devices 94

and 95 will be in the positions opening the control pipes 96 and 97 to the atmosphere. In the "Stop" position of lever 119, the stop control device 98 will however be in the position shown for supplying fluid under pressure, supplied by the interlock valve device 75 to pipe 78 and the check valve device 141 and thence to pipe 140, to pipe 142 from which it will flow through the double check valve device 143, pipe 144 and the check valve 145 to the fuel cutout device 146 to maintain the fuel control lever 7 and shaft 6 in the fuel cutoff position for maintaining the engine stopped.

Now let it be assumed that the operator desires to restart the engine in the astern direction. To accomplish this he will move lever 119 to the "Astern start" position, which will cause operation of the stop valve device 98 to vent fluid under pressure from pipe 142 and thereby from pipe 144, and at the same time will actuate the astern run valve device 92 to open control pipe 79 to pipe 58. The control pipe 79 is at this time void of fluid under pressure. The cam shaft 2 and the cam shifting mechanism including the power piston 27 and pilot piston 56 are already in their astern positions causing operation of the interlock valve device 75 to open pipe 79 to the atmosphere so that operation of the astern run valve device 92 will be without effect. The ahead run valve device 93 remains in the condition opening pipe 60 to the atmosphere upon this operation of the operator's lever 119. With both pipes 58 and 60 thus open to the atmosphere and with fluid under pressure vented from pipe 142 by the stop valve device 98, the pipe 144 will be maintained at atmospheric pressure but the check valve 145 will maintain the fluid pressure in the cut off valve device 146 previously supplied with the operator's lever 119 in "Stop" position, in order to maintain the fuel control shaft 6 in its fuel cutoff position.

In the "Astern start" position of lever 119, the astern start valve device 95 will also be operated to supply fluid, supplied to pipe 78 by the interlock valve device 75, from said pipe to pipe 97 through which it will flow to the directional interlock valve device 167 and also through the double check valve device 197 to pipe 10. Fluid under pressure thus provided in pipe 10 will actuate the starting air valve device 9 to supply fluid under pressure to pipe 12 for starting the engine to turn in the direction determined by the position of the cam shaft 2, and at the same time, fluid supplied to pipe 10 will cause piston 194 to move the friction disc 193 into frictional contact with the end of the crank shaft 1. After the crank shaft starts turning in the chosen direction under the pressure of starting air, it will turn the friction disc 193 in a clockwise or "Astern" direction as indicated by the legend in Fig. 5, for thereby rocking the lever 188 in a counterclockwise direction about its fulcrum pin 187. Since the pressure of spring 173a exceeds that of spring 185, this movement of lever 188 will act, in the astern valve device 172, to initially move the plunger 178 relative to the release valve 176 until said release valve is seated, and then said plunger will act through said release valve to open the supply valve 185 against spring 173a. Fluid under pressure will then flow from pipe 97 to passage 170 and thence to pipe 163 for actuating the release valve device 156 to open pipe 144a to the atmosphere for venting fluid under pressure from the fuel interlock device 146 to render spring 150 therein effective to move the fuel control lever 7 and shaft 6 from their fuel cutoff position to their fuel supply position. It will thus be seen that the supply of fuel to the engine is maintained cutoff until after the engine has started to turn in the selected direction, due to operation of the fuel interlock device 167 being dependent upon the direction of rotation of the engine's crank shaft 1, but after the engine starts to turn in the selected direction said interlock device will operate to supply fuel to the engine to provide for running thereof.

After the engine has been started in the astern direction and the interlock device operates to supply fuel to the engine, the operator will move his control lever from the "Astern start" position to the "Astern run" position to permit operation of the astern starting valve device 95 to release fluid under pressure from pipe 97. This will result in operation of the starting air valve device 9 to cut off the supply of starting air to the engine and will also remove the force on piston 194 pressing the disc 193 against the crank shaft. When the pressure between disc 193 and the end of the crank shaft is thus removed, the lever 188 will be returned to the position shown in Fig. 5 under the action of spring 173a (in the valve device 172) to seat the supply valve 173, followed by the action of spring 185 to move the plunger 178 out of seating engagement with the release valve 176. With the release valve 176 thus open, pipe 163 will be open to atmosphere and the parts of the release valve device 156 will then return to the position in which they are shown in Fig. 1 due to the action of spring 164.

Now let it be assumed that instead of restarting the engine in the direction it had previously been run, that the operator desires to start and run the engine in the reverse direction which requires reversal of the cam shaft 2 from the "Astern" position shown in Fig. 1.

To thus start and run the engine in the ahead direction, the operator will move lever 119 from "Stop" position to the "Ahead start" position. This movement will effect operation of the stop valve device 98 to open pipe 142 to the atmosphere but the fuel interlock device 146 will be maintained in its fuel cut off position by fluid pressure retained in pipe 144a by check valve 145. Movement of the lever 119 through the slot 125 to the "Ahead start" position will however actuate the ahead run valve device 93 to supply fluid under pressure from pipe 78, which is supplied with fluid under pressure from the supply pipe 79 by way of the interlock valve device 75, to pipe 60 and at the same time this movement of the operator's control lever will operate the ahead start valve device 94 to open communication between pipes 79 and 96. Pipe 79 is at this time open to the atmosphere through the interlock valve device 75.

The pressure of fluid thus supplied to pipe 60 will flow through the double check valve device 73 to pipe 72 and thence through the double check valve device 143 and 144 to maintain the fluid pressure in the fuel cut off device 146 to hold the fuel supply to the engine cut off, and at the same time will flow from pipe 72 through pipe 71 and actuate the relief valve device 69 to supply fluid under pressure from the supply pipe 70 to the control valve device 34. At the same time, the fluid pressure supplied to pipe 60 will also cause operation of the pilot piston 56 and thereby of the power piston 27 to move the cam shaft 2 to its ahead position in which the actuating lever 5 will occupy the position indicated by the dash

and dot line 5a, and when said lever attains this position the position of lever 81 in the interlock valve device 75 will have become reversed to permit operation of the valve device 76 therein to open pipe 78 and thus the connected pipe 60 to the atmosphere which will relieve the pilot piston 56 of pressure of fluid. This release of fluid under pressure from pipe 60, which does not occur until after the cam shaft 2 has been shifted to its new position, also results in release of the fluid under pressure from pipe 144, but the fluid pressure will be maintained in the fuel cut off device 146 by check valve 145, so as to maintain the fuel supply to the engine cut off. The release of fluid pressure from pipe 60 also results in release of fluid pressure from pipe 71, so as to cause operation of the relief valve device 69 to relieve the power piston of pressure of fluid after said piston has completed its operation of reversing the position of the cam shaft 2.

At the same time that the valve device 76 in the interlock valve device 75 is operated to release fluid under pressure from pipes 78 and 60, the valve device 77 will be operated to open communication between the fluid pressure supply pipe 70 and pipe 79, and fluid thus supplied to the latter pipe will flow through the ahead start valve device 94 to pipe 96 leading to the fuel interlock device 167 and also through the double check valve device 197 to the starting air valve device 9 and to piston chamber 196. The starting air valve device 9 will then operate to supply air to the engine for causing it to start turning in the direction determined by the new position of the cam shaft 2. After the engine thus starts to turn, operation of the friction disk 193, pressed into contact with the end of the crank shaft 1 by pressure of fluid in chamber 196, will rock the lever 188 in a clockwise direction (Fig. 5) for thereby operating the valve device 171 to supply fluid under pressure from pipe 96 to pipe 163 for actuating the relief valve device 156 to vent fluid under pressure from pipe 144a, whereupon the fuel cut off device 146 will operate to pull the lever 7 from the fuel cutoff position to the fuel supply position to allow running of the engine on fuel. After the engine starts to run on fuel the operator will return lever 119 from the "Ahead start" position to the "Ahead run" position for releasing fluid under pressure from pipe 96. This will cause operation of the starting air valve device 9 to cut off the supply of starting air to the engine and relieve disc 193 of pressure against the end of crank shaft 1, whereupon the parts of the interlock valve device 167 and of the release valve device 156 will return to the position in which they are shown in Figs. 5 and 1, respectively, as will be apparent from previous description.

If the engine is operating in the ahead direction and the operator desires to reverse the direction of operation of the engine, he will move the control lever 119 from the "Ahead run" position to the "Astern start" position which will actuate the astern run valve device 92 to supply fluid under pressure from pipe 79, which is supplied with fluid under pressure with the cam shaft 2 in its ahead position, to pipe 58 leading to chamber 57 at one side of the pilot piston 56. At the same time fluid supplied to pipe 58 will flow through the double check valve device 73 to pipe 72 and thence through pipe 71 to actuate the relief valve device 69 to open communication between the fluid pressure supply pipe 70 and pipe 54. Fluid supplied to pipe 72 will also flow through the double check valve device 143 to the fuel cutoff device 146 for causing operation thereof to cut off the fuel supply to the engine whereby the engine may decelerate and stop.

The pilot piston 56 will respond to pressure of fluid supplied through pipe 58 to cause operation of the power piston 27 to move the cam shaft 2 from its ahead position to its astern position and to also actuate the interlock device 75 to the position shown in the drawings for releasing fluid under pressure from pipe 79 and for supplying fluid under pressure to pipe 78 leading to the astern start valve device 95. This release of fluid pressure from pipe 79 relieves the pilot piston 56 of pressure of fluid and causes operation of the relief valve device 69 to relieve the power piston 27 of pressure of fluid, and also results in release of fluid pressure from pipe 144. This release of fluid under pressure from pipe 144 will not however have any effect upon operation of the fuel cutoff device 146 to maintain the fuel cut off due to the action of the check valve 145.

With the astern starting device 95 opening communication between pipes 78 and 97 with the operator's lever 119 in the "Astern start" position, the fluid under pressure supplied to said valve device through pipe 78 will be supplied through pipe 97 to the interlock valve device 167 and also through the double check valve device 197 to the starting air valve device 9 and to piston chamber 196. The starting air valve device 9 will then operate to supply air to the engine cylinders, and if the engine has not yet come to a stop from its previous direction of running, the reversed condition of the cam shaft 2 will render such air effective on the engine's pistons to promptly stop the engine. The pressure of fluid in chamber 196 will move the friction disk 193 into contact with the end of the crank shaft 1, but in case the crank shaft has not yet come to a stop, said disk will turn in the direction indicated by the legend "Ahead" in Fig. 5 and thereby operate the valve device 171 to open pipe 96 to passage 169. Pipe 96 is at this time vented by way of the ahead start valve device 94 in the operator's control valve device so that this operation of the interlock valve device 167 will have no effect upon the condition of the fuel cutoff device 146.

After the engine is brought to a stop, the pressure of air supplied by the starting air valve device 9 is immediately effective to start the engine turning in the reverse direction. With disc 193 of the directional control device 167 in contact with the end of the crank shaft 1, the device immediately detects this change in direction of rotation of crank shaft 1 and actuates the lever 188 to operate valve device 172 to open communication between pipe 97 and pipe 163. Fluid supplied to pipe 97 will then flow to pipe 163 and actuate the release valve device 156 for relieving the fuel cutoff device 146 of fluid pressure whereupon said device will operate to pull the fuel control lever 7 and shaft 6 from their fuel cutout position to their fuel supply position for supplying fuel to the engine to provide for running of the engine. After the engine is running on fuel in the reversed direction as determined by the "Astern start" position of the operator's lever, said lever will be turned to the "Astern run" position for releasing fluid under pressure from pipe 97 to cause cutting off of the supply of starting air to the engine and operation of the interlock device 167 to release fluid

under pressure from the release valve device 156.

It will now be noted that in reversing the direction of operation of the engine, the supply of fuel to the engine is first cut off, the valve gear or timing of the engine is then reversed and this may occur before the engine stops turning, and after the valve timing is reversed, starting air is supplied to the engine which, with the engine still turning in the previous direction, will act first to bring the engine to a stop and then start the engine turning in the reverse direction, following which fuel will again be supplied to the engine to cause running thereof in the new direction.

The operation of the apparatus to reverse the direction of operation of the engine from astern to ahead in response to movement of the operator's control lever from the "Astern run" position to the "Ahead start" position will be apparent from the above description.

Whenever the operator desires to stop the engine, regardless of the direction of operation, he will move the control lever 119 back to "Stop" position for actuating the stop valve device 98 to supply fluid under pressure to pipe 142 and thence through the double check valve device 143, pipe 144 and check valve 145 and pipe 144*a* to the fuel cutoff device 146. The cutoff device 146 will thereby be operated to cut off the supply of fuel to the engine whereupon the engine will stop with the cam shaft 2 and the control parts therefore including the pilot piston 56 and power piston 27 remaining in the condition previously assumed.

Summary

It will now be seen that the improved system provides for control pneumatically, from a control station which may be either local or remote, of a plurality of different operations in a desired sequence, such as incident to starting, stopping, and reversing of a reversible internal combustion engine. Reversing of the engine is accomplished by a fluid motor embodying a power piston and control means therefor including a fluid operated pilot piston and means operable by said motor, which latter means is thus conditionable in accordance with the engine valve gear or timing, for relieving said pistons of pressure of fluid at the completion of the reversing operation. This means conditionable in accordance with the conditon of the valve gear also controls the starting of the engine so as to prevent starting power from being applied to the engine until after the valve gear has been conditioned to provide for operation of the engine in the desired direction. The starting power may be fluid under pressure, and the supply thereof to the engine immediately upon reversing of the valve gear also provides for braking of the engine in case the engine has not already been stopped, so as to more promptly stop the engine and be immediately effective upon such stopping to start the engine turning in the opposite direction.

The system includes automatic means for controlling the fuel supply to the engine. This automatic means includes an interlock device controlled by the direction of rotation of a part of the engine, such as the crankshaft, to prevent the supply of fuel to the engine until after it has started to turn in the selected direction, at which time said means operates automatically to supply fuel to the engine.

The control system embodies a number of flexible fluid connections or pipes which connect the operator's control device to the other control devices which will be associated directly with the engine, and this permits locating the operator's control device at any desired station without regard to the location of the engine. Such connections may be readily accomplished and are not subject to wear and therefore will never require adjustments due to wear, and thus constitute a relatively inexpensive and simple yet proven effective and efficient type of control.

Having now described our invention what we claim as new and desire to secure by Letters Patent is:

1. A system for controlling the starting of a reversible internal combustion engine and for also controlling the valve gear for said engine which gear is adjustable to provide for operation of said engine in either one direction or in the opposite direction, comprising in combination, a fluid motor operable by fluid under pressure to adjust said gear to provide for reverse operation of said engine, starting means for said engine, an operator's control device operative to supply fluid under pressure to actuate said motor, and means controlling said supply of fluid under pressure and operation of said starting means and operable automatically upon said adjustment of said valve gear by fluid under pressure to release the actuating fluid on said motor and to effect operation of said starting means.

2. A system for controlling the starting of a reversible internal combustion engine and for also controlling the valve gear for said engine which gear is adjustable to provide for operation of said engine in either one direction or in the opposite direction, comprising in combination, a fluid motor operable by fluid under pressure to adjust said gear to provide for reverse operation of said engine, starting means for said engine, an operator's control device operative to supply fluid under pressure to actuate said motor, and means controlling said supply of fluid under pressure and said starting means controlled by said motor and operable upon said adjustment of said valve gear by said motor to release actuating fluid from said motor and to effect operation of said starting means.

3. A system for controlling the starting of a reversible internal combustion engine and for also controlling the reversing valve gear for said engine which gear is adjustable to provide for operation of said engine in either one direction or in the opposite direction, comprising in combination, a fluid motor operable by fluid under pressure to either a first position, or to a second position for adjusting said gear to provide for operation of said engine in either said one direction or in said opposite direction, starting means for said engine, an operator's control device having first and second positions corresponding to those of said motor and operable upon movement to either position to effect a supply of fluid under pressure to said motor to effect movement thereof to the corresponding position, and means conditionable in accordance with the adjustment of said valve gear for controlling said supply of fluid under pressure and for also controlling said starting means and operable upon movement of said control device to either one of its positions other than the position corresponding to that of said motor to provide for said supply of fluid under pressure and to prevent operation of said starting means during operation of said motor, and operable with said control device and motor in corresponding positions

to relieve said motor of pressure of fluid and to also effect operation of said starting means.

4. A control system for controlling the starting of a reversible internal combustion engine and for also controlling reversing means for said engine which is adjustable to determine the direction of operation of said engine comprising in combination, a motor operable by fluid under pressure to either one of two positions to selectively adjust said reversing means, an operator's control device having positions corresponding to those of said motor and operable upon movement to either of its positions to supply fluid to said motor to effect corresponding positioning thereof, starting means operable by fluid under pressure to effect starting of said engine, and interlock means controlled by said motor operable upon positioning thereof corresponding to the position of said control device to supply fluid under pressure to effect operation of said starting means and operable with said motor out of the position corresponding to that of said control means to prevent supply of fluid under pressure to said starting means, said interlock means comprising valve means arranged to control the supply of fluid to said motor and being operable to cut off such supply and to release fluid under pressure from said motor upon movement of said motor to the position corresponding to that of said control device.

5. A control system for a reversible internal combustion engine having reversing means adjustable to provide for running of said engine in either one direction or in the reverse direction comprising in combination, reversing piston means movable to one position by fluid under pressure effective in one chamber to adjust said reversing means to provide for operation of said engine in one direction and movable to a second position by fluid under pressure effective in another chamber to adjust said reversing means to provide for operation of said engine in the reverse direction, starting means operable to effect starting of said engine, manual control means having ahead run and start positions for effecting a supply of fluid under pressure to said one chamber and having astern run and start positions for effecting a supply of fluid under pressure to the said another chamber, means controlled by said piston means operable automatically upon movement of said piston means into either one of its different positions to provide for operation of said starting means and operable to prevent operation of said starting means during movement of said piston means, said manual control means comprising starting control means operable in each of said start positions to provide for operation of said starting means upon movement of said piston means to the position corresponding to that of said manual control means and operable to prevent or stop operation of said starting means in the said run positions.

6. A control system for a reversible internal combustion engine having reversing means adjustable to provide for running of said engine in either one direction or in the reverse direction comprising in combination, reversing piston means movable to one position by fluid under pressure effective in one chamber to adjust said reversing means to provide for operation of said engine in one direction and movable to a second position by fluid under pressure effective in another chamber to adjust said reversing means to provide for operation of said engine in the reverse direction, an operator's control device having one position for effecting a supply of fluid under pressure to one of said chambers to effect corresponding positioning of said piston means and having a second position for effecting a supply of fluid under pressure to the other chamber to effect corresponding positioning of said piston means, starting means operable by fluid under pressure to effect starting of said engine, and being rendered non-operable upon release of fluid under pressure, said operator's control device comprising starting control means, and interlock means controlled by said piston means and cooperative with said starting control means for controlling the supply of fluid under pressure to said starting means, said interlock means being operable upon movement of said piston means into either one of its positions, and upon operation of said starting control means, in response to movement of and with said operator's control device in the corresponding position to effect a supply of fluid under pressure to said starting means, and being operable during movement of said piston means between its positions to effect a release of fluid under pressure from said starting means, said operator's control device being operable to effect operation of said starting control means to release fluid under pressure from starting means with said piston means in either of its positions.

7. A control system for a reversible internal combustion engine having reversing means adjustable to provide for running of said engine in either one direction or in the reverse direction comprising in combination, reversing piston means movable to one position by fluid under pressure effective in one chamber to adjust said reversing means to provide for operation of said engine in one direction and movable to a second position by fluid under pressure effective in another chamber to adjust said reversing means to provide for operation of said engine in the reverse direction, an operator's control valve device having ahead run and start positions for effecting a supply of fluid under pressure to one of said chambers and astern run and start positions for effecting a supply of fluid under pressure to the other chamber, starting control means operable by fluid under pressure to effect starting of said engine and rendered ineffective upon release of such fluid pressure, interlock means controlled by said piston means, and valve means associated with said operator's control valve device, said interlock means and said valve means cooperating for controlling said starting means being operable with said operator's control valve device in either start position and with said piston means correspondingly positioned to effect a supply of fluid under pressure to said starting control means, said interlock means being operable with said piston means out of a position corresponding to that of said operator's control valve device to effect a release of fluid under pressure from said starting control means, and said valve means being operable to effect a release of fluid under pressure from said starting control means with said operator's control valve device in the run positions thereof.

8. A system for controlling the starting, reversing and fuel supply to a reversible internal combustion engine, comprising in combination, reversing means conditionable to render said engine operable in either one direction or in the opposite direction, starting control means for starting said engine, fuel control means for controlling the supply of fuel to said engine, reverse

control means operable to effect operation of said reversing means to condition said engine for operation in the reverse direction and for at the same time effecting operation of said fuel control means to cut off the supply of fuel to said engine, means controlled by said reverse control means and operable upon conditioning of said engine to operate in said reverse direction to effect operation of said starting control means, and operable to prevent operation of said starting control means during operation of said reversing means to condition said engine for operation in said reverse direction, and means cooperable with a rotatable part of said engine upon operation of said engine in said reverse direction to effect operation of said fuel control means to supply fuel to said engine.

9. A system for controlling the starting, reversing and supply of fuel to a reversible internal combustion engine, comprising in combination, reversing means adjustable by fluid under pressure to render said engine operable in either one direction or in the opposite direction, fuel control means operable by fluid under pressure to cut off the supply of fuel to said engine and operable upon release of such fluid pressure to supply fuel to said engine, starting control means operable by fluid under pressure to effect starting of said engine, an operator's control device movable to a position for supplying operating fluid to said reversing means and to said fuel control means and for opening a fluid pressure supply communication to said starting control means, valve means having a condition providing for said supply of fluid under pressure to said reversing means and fuel control means and for opening said communication to atmosphere and being operable upon operation of said reversing means to render said engine operable in the reverse direction, to cut off the supply of fluid to and to release fluid under pressure from said reversing means and to at the same time supply fluid under pressure to said communication to effect operation of said starting means, means operable to maintain the fluid pressure in said fuel control means upon release of actuating fluid from said reversing means, and interlock means conditionable jointly by pressure of fluid supplied to said communication and by turning of a rotatable part of said engine to release fluid under pressure from said fuel control means only upon rotation of said part in the direction determined by said reversing means, said operator's control device being movable to another position for releasing fluid under pressure from said communication.

10. A system for controlling the starting, reversing and fuel supply to a reversible internal combustion engine, comprising in combination, reversing means conditionable to render said engine operable in either one direction or in the opposite direction, starting control means for starting said engine, fuel control means for controlling the supply of fuel to said engine, reversing control means operable to effect operation of said reversing means to condition said engine for operation in a reverse direction and for at the same time effecting operation of said fuel control means to cut off the supply of fuel to said engine, interlock means conditionable to operate in accordance with the direction of rotation of a rotatable part of said engine to control operation of said fuel control means and operable with said part turning in the direction determined by said reversing control means to effect operation of said fuel control means to supply fuel to said engine and operable to prevent operation of said fuel control means to supply fuel to said engine with the part turning in the opposite direction or stopped, means controlled by said reversing control means operable upon conditioning of said reversing means to provide for operation of said engine in the reverse direction, to effect operation of said starting control means and to condition said interlock means for response to turning of said part and being also operable to prevent operation of starting control means and to render said interlock means non-responsive to said part during operation of said reversing means to reverse said engine.

11. A system for controlling the starting of an internal combustion engine and for also controlling the supply of fuel to said engine, comprising in combination, starting control means operable to initiate turning of said engine, fuel control means operable to control the fuel supply to said engine, operator's control means operative to effect operation of said starting control means, interlock means arranged for control by turning of said engine and operable upon turning of said engine to effect operation of said fuel control means to supply fuel to said engine and operable with said engine stopped to cut off the supply of fuel to said engine, and means operable upon operation of said operator's control device to effect operation of said starting control means to condition said interlock means for response to turning of said engine.

12. A system for controlling the starting of an internal combustion engine and for also controlling the supply of fuel to said engine, comprising in combination, starting control means operable by fluid under pressure to effect starting of said engine, fuel control means operable by fluid under pressure and turning of a rotatable part of said engine to effect a supply of fuel to said engine, and an operator's control device operative to supply fluid under pressure to effect operation of said starting control means and fuel control means simultaneously.

13. A system for controlling the starting of an internal combustion engine and for also controlling the supply of fuel to said engine, comprising in combination, starting control means operable by fluid under pressure to effect starting of said engine and rendered ineffective upon release of fluid under pressure, fuel control means operable upon engagement with a rotating part of said engine to effect a supply of fuel to said engine and operable with said engine stopped or upon disengagement with said rotating part of said engine to prevent said supply of fuel to said engine, piston means operable by fluid under pressure to effect engagement between said fuel control means and said rotating part of said engine and upon release of such fluid under pressure disengagement, and an operator's control device operative to simultaneously effect either a supply of fluid under pressure to said starting control means and piston means or a release of fluid under pressure from said starting control means and piston means.

14. A system for controlling the starting and stopping of an internal combustion engine and for also controlling a supply of fuel to said engine, comprising in combination, starting control means operable to effect starting of said engine to turn, an operator's control device having a stop position and being movable to a start position to effect operation of said starting control means, fuel control means operable to either cut off the

supply of fuel to said engine to effect stopping thereof or to provide fuel to said engine to permit running thereof, mechanism operable when subject to pressure of fluid and turning of said engine to effect operation of said fuel control means to supply fuel to said engine and operable to prevent such supply of fuel to said engine when not subject to pressure of fluid, said operator's control device being operable in said start position to subject said mechanism to pressure of fluid and being operable in said stop position to release fluid under pressure from said mechanism.

15. A system for controlling the reversing of a reversible internal combustion engine, the supply of fuel to said engine and the starting of said engine, comprising in combination, reversing means for reversing the direction of operation of said engine, fuel control means for controlling the supply of fuel to said engine, starting control means for starting said engine, an operator's control device operable to effect operation of said reversing means, means controlled jointly by said reversing means and operator's control device and operable upon operation of said reversing means to provide for reversal of direction of operation of said engine, to effect operation of said starting control means to start said engine, and other means controlled jointly by said reversing means and turning of a rotatable part of said engine for controlling said fuel control means and operable to effect operation of said fuel control means to cut off the supply of fuel to said engine during operation of said reversing means to reverse said engine and with said engine stopped and conditionable by said reversing means upon completion of the reversing operation thereby and by rotation of said part of said engine to provide for supply of fuel of said engine.

16. A system for controlling the reversing of a reversible internal combustion engine, the supply of fuel to said engine, and the starting of said engine by compressed air, comprising in combination, reversing means for reversing the direction of operation of said engine, fuel control means operable by fluid under pressure to cut off supply of fuel to said engine and upon release of such fluid pressure ot provide for supply of fuel to said engine, starting control means operable by fluid under pressure to supply compressed air from starting said engine, an operator's control device having a stop position and operable therein to release fluid under pressure from said starting control means and to supply of fluid under pressure to said fuel control means, said operator's control device being movable from said stop position to a start position for effecting operation of said reversing means to reverse the direction of operation of said engine, means controlled jointly by said reversing means and operator's control device in the start position thereof and operable upon operation of said reversing means to provide for reversal of direction of operation of said engine to supply fluid under pressure to said starting control means, and other means operable by fluid pressure supplied to effect operation of said starting control means, to respond to rotation of a rotatable part of said engine to release fluid under pressure from said fuel control means and operable with said engine stopped to provide for fluid pressure being effective in said fuel control means.

17. A system for controlling the starting, reversing and fuel supply to a reversible internal combustion engine, comprising in combination, starting control means, reversing means operable by fluid under pressure to reverse the direction of operation of said engine, fuel control means operable by fluid under pressure to cut off the supply of fuel to said engine and operable upon release of fluid under pressure to provide for fuel being supplied to said engine, an operator's control device having a stop position for supplying fluid under pressure to said fuel control means and being movable to a start position to cut off said supply of fluid under pressure to said fuel control means and to supply fluid under pressure to said reversing means, interlock means operable upon operation of said reversing means to reverse the direction of operation of said engine to effect operation of said starting control means, means operable to maintain said fuel control means in condition cutting off the supply of fuel to said engine with said control device in said start position, other means responsive jointly to operation of said interlock means and turning of said engine to effect operation of fuel control means to provide for supply of fuel to said engine, the said other means being operative to prevent operation of said fuel control means to provide fuel to said engine with said engine stopped or operating in a direction the reverse of that provided for by said reversing means.

18. A system for controlling the starting, reversing and fuel supply to a reversible internal combustion engine, comprising in combination, starting control means, reversing means operable by fluid under pressure to reverse the direction of operation of said engine, fuel control means operable by fluid under pressure to cut off the supply of fuel to said engine and operable upon release of fluid under pressure to provide for fuel being supplied to said engine, an operator's control device having a stop position for supplying fluid under pressure to said fuel control means and being movable to a start position to cut off said supply of fluid under pressure to said fuel control means and to supply fluid under pressure to said reversing means, means providing for supply of fluid under pressure from said reversing means to said fuel control means, interlock means operable upon operation of said reversing means to reverse the direction of operation of said engine, to cut off the supply of fluid under pressure to said reversing means and to supply fluid under pressure to effect operation of said starting control means, means operable to maintain the fluid pressure in said fuel control means upon cutting off the supply of fluid under pressure to said reversing means, and other means responsive jointly to operation of said interlock means and turning of said engine to release fluid under pressure from said fuel control means, the said other means being operative to prevent release of fluid from said fuel control means with said engine stopped or turning in the direction the reverse of that provided for by said reversing means.

19. A system for controlling the starting of and supply of fuel to an internal combustion engine, comprising in combination, starting control means operable by fluid under pressure to effect starting of said engine, fuel control means operable by fluid under pressure to cut-off the supply of fuel to said engine, an operator's control device having a stop position for supplying fluid under pressure to said fuel control means, a start position for effecting a supply of fluid under pressure to said starting control means and a run position for releasing fluid under pressure from said starting control means and being operable in said run and start positions to cut off

said supply of fluid under pressure to said fuel control means, means operable to maintain said fuel control means in the position cutting off the supply of fuel to said engine in the start position of said control device, and means conditioned by pressure of fluid supplied to said starting control means, to operate upon rotation of said engine in response to operation of said starting control means to effect operation of said fuel control means to provide fuel to said engine.

20. A system for controlling the starting and supply of fuel to an internal combustion engine, comprising in combination, starting control means operable by fluid under pressure to effect starting of said engine, fuel control means operable by fluid under pressure to cut off the supply of fuel to said engine and operable upon release of fluid under pressure to provide for supply of fuel to said engine, an operator's control device having a stop position for supplying fluid under pressure to said fuel control means, a start position for effecting a supply of fluid under pressure to said starting control means and a run position for releasing fluid under pressure from said starting control means and being operable in said run and start position to cut off said supply of fluid under pressure to said fuel control means, means operable to maintain fluid under pressure in said fuel control means upon movement of said operator's control device out of said stop position, and means conditioned by pressure of fluid supplied to said starting control means to operate upon rotation of said engine in response to operation of said starting control means to effect release of fluid under pressure from said fuel control means.

21. A control system for controlling the starting, stopping and reversing of a reversible internal combustion engine and for also controlling the supply of fuel to said engine, comprising in combination, starting control means operable by fluid under pressure for effecting starting of said engine, reversing means selectively operable by fluid under pressure to provide for operation of said engine in either one direction or in the opposite direction, fuel control means operable for fluid under pressure to cut off the supply of fuel to said engine, an operator's control device having forward and reverse start positions for supplying fluid under pressure to said reversing means to effect operation thereof to provide for operation of said engine in, respectively, either a forward direction or a reverse direction and being also operable in said positions to open communication for supplying fluid under pressure to said starting control means, said reversing means also controlling said communication and cooperating with said control device to prevent supply of fluid under pressure to said starting control means during operation of said reversing means and to provide for such supply upon conditioning of said reversing means to provide for operation of said engine in the selected direction, said operator's control device also having forward and reverse run positions for releasing fluid under pressure from said starting control means, and a stop position for supplying fluid under pressure to said fuel control means and being operable in the start and run positions to cut off the supply of fluid under pressure to said fuel control means, means operable to maintain said fuel control means in the condition cutting off the fuel to said engine with said control device in said start positions, and interlock means conditionable by fluid under pressure supplied to operate said starting control means, to operate upon rotation of said engine in the direction determined by said reversing means to release said fuel control means to provide for supply of fuel to said engine, said interlock means being operable with said engine stopped or turning in a direction the reverse of that which said reversing means is adjusted for to prevent release of said fuel control means.

22. A system for controlling the starting, stopping, and reversing of and the supply of fuel to a reversible internal combustion engine, comprising in combination, reversing means at said engine selectively operable by fluid under pressure to provide for operation of said engine in either one direction or in the opposite direction, starting control means at said engine operable by fluid under pressure to effect starting of said engine, fuel control means at said engine operable by fluid under pressure to cut off the fuel supply to said engine, an operator's control valve device arranged to be located remote from said engine, pipes connecting said control valve device to said reversing means, starting means and fuel control means, said control device comprising an operator's lever having a stop position and at one side thereof an ahead start position and an ahead run position and at the opposite side an astern start position and an astern run position, said valve device further comprising valve means selectively operable by said lever in the different positions thereof for controlling said reversing means, starting control means and fuel control means.

23. A system for controlling the starting, stopping and reversing of and the supply of fuel to a reversible internal combustion engine, comprising, in combination, reversing means at said engine selectively operable by fluid under pressure to provide for operation of said engine in either one direction or in the opposite direction, starting control means at said engine operable by fluid under pressure to effect starting of said engine, fuel control means at said engine operable by fluid under pressure to cut off the fuel supply to said engine, an operator's control valve device comprising an operator's lever having a stop position and at one side thereof ahead start and run positions and at the opposite side astern start and run positions, valve means operable by said lever in said start positions to supply fluid under pressure to operate said reversing means and fuel control means and to provide for supply of fluid under pressure to said starting control means and being operable in said run positions to release fluid under pressure from said starting control means and to cutoff the supply of fluid under pressure to said fuel control means and being operable in said stop position to supply fluid under pressure to said fuel control means, and being also operable to cut off the supply of fluid under pressure to said fuel control means with said lever in either start position upon conditioning of said engine by said reversing means to operate in the reverse direction, and interlock means at said engine conditionable by fluid under pressure supplied to operate said starting control means, to turn upon operation of said engine in the direction provided for by operation of said reversing means to effect operation of said fuel control means to supply fuel to said engine, said interlock means preventing operation of said fuel control means to provide for supply of fuel to said engine with said engine operating in the opposite direction.

24. A system for controlling the starting and reversing of an internal combustion engine and for also controlling the fuel supply to said engine comprising in combination, reversing means operable to condition said engine for operation in either one direction or in the opposite direction, starting means operable by fluid under pressure to effect starting of said engine and being rendered ineffective upon release of fluid under pressure; fuel control means operable by fluid under pressure to cut off the supply of fuel to said engine and operable upon relief of fluid under pressure to provide for supply of fuel to said engine, an operator's control device having one position to provide for running of said engine in one direction and being movable to a second position for effecting a supply of fluid under pressure to said fuel control means and for also effecting operation of said reversing means to condition said engine for operation in the said reverse direction, interlock means controlled by said reversing means and operable upon conditioning of said engine for operation in said reverse direction to supply fluid under pressure to effect operation of said starting means, and means arranged to be operated by fluid under pressure supplied by said interlock means to release fluid under pressure from said fuel control means.

25. A system for controlling the starting and reversing of an internal combustion engine and for also controlling the fuel supply to said engine comprising in combination, reversing piston means operable upon supply of fluid under pressure to one chamber to provide for running of said engine in one direction and operable upon supply of fluid under pressure to a second chamber to provide for running of said engine in the reverse direction, starting means operable by fluid under pressure to effect starting of said engine and being rendered ineffective upon release of fluid under pressure, fuel control means operable to either supply fuel to said engine or to cut off the supply of fuel to said engine, an operator's control valve device having one position for effecting a supply of fluid under pressure to said one chamber and being movable from said one position to either a run position or a start position for supplying fluid under pressure to the said other chamber, means responsive to said movement of said operator's control device to either said run or said start position to effect operation of said fuel control means to cut off the supply of fuel to said engine, interlock means controlled by said reversing means operable upon conditioning of said engine for operation in the said reverse direction to supply fluid under pressure for actuating said starting means, means arranged for operation by fluid under pressure supplied to actuate said starting means to effect operation of said fuel control means to provide for supply of fuel to said engine, said operator's control device being operable in said start position to permit said supply of fluid under pressure to said starting means and in said run position to prevent such supply and to release fluid under pressure from said starting means.

26. A control system for controlling the starting of a reversible internal combustion engine and for also controlling reversing means for said engine which is adjustable to determine the direction of operation of said engine comprising in combination, a motor operable by fluid under pressure to either one of two positions to selectively adjust said reversing means, an operator's control device having positions corresponding to said positions of said motor and being operable upon movement to either one or the other of its two positions to supply fluid under pressure to said motor to effect corresponding positioning of said motor, valve means arranged to control the supply of fluid under pressure to said motor by said operation of said operator's control device and being operable to cut off such supply and to release fluid under pressure from said motor, starting means operable by fluid under pressure to effect starting of said engine, interlock mechanism having two different controlling positions for controlling said valve means and starting means and being operable in one of said positions to supply fluid under pressure to effect operation of said starting means and to also effect operation of said valve means to release fluid under pressure from said motor, and being operable in the other of said two positions to prevent supply of fluid under pressure to said starting means and to effect operation of said valve means to permit supply of fluid under pressure to said motor, and connecting means operable by said motor upon positioning of said motor corresponding to the position of said operator's control device to position said interlock mechanism in its said one controlling position and operable with said motor out of the position corresponding to that of said motor to position said interlock mechanism in its said other controlling position.

27. A control system for a reversible internal combustion engine's valve gear which is adjustable to provide for operation of said engine in either one direction or in the opposite direction comprising in combination, a power piston operable by fluid under pressure to adjust said gear, pilot means operable by fluid under pressure to establish a communication through which fluid under pressure is adapted to flow to said power piston to actuate same, valve means controlling said communication, said valve means being operable by fluid under pressure to open said communication and operable upon release of such fluid under pressure to close said communication and to release fluid under pressure from said power piston, an operator's control device operable to establish another communication through which fluid under pressure is adapted to flow to said pilot means and also to said valve means for operating said pilot means and valve means, and means controlling flow of fluid under pressure to said other communication and operable upon adjustment of said valve gear by said power piston to cut off the flow of fluid under pressure to said other communication and to release fluid under pressure from said other communication.

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