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ENGINE CONDITIONING CONTROL APPARATUS FOR STARTING, STOPPING, AND REVERSING

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Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 1

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ENGINE CONDITIONING CONTROL APPARATUS FOR STARTING, STOPPING, AND REVERSING

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This invention relates to control apparatus and more particularly to a fluid pressure control apparatus for controlling a plurality of different operations in a desired sequence, such for example, as operations incident to reversing the direction of operation of a reversible internal combustion engine.

In Patent No. 2,395,202, issued on February 19, 1946, to Erik G. Erson and myself, and assigned to the assignee of the present application, there is disclosed a fluid pressure control apparatus which is operable automatically to control the starting, stopping and reversing of an internal combustion engine in response to appropriate operations of a manual controller. In reversing the engine, the apparatus operates automatically to first cut off the supply of fuel to the engine, to then reverse the valve timing or valve gear of the engine to provide for operation thereof in the reverse direction, to next supply starting air to the engine for causing it to start turning in the new direction, following which fuel is supplied to the engine to cause it to run in the new direction.

One object of the invention is to provide a simplified control apparatus of the above mentioned type.

In the above described apparatus power means are employed for reversing the engine valve timing or gear, and interlock means are associated with said power means to prevent supplying starting air to the engine until after the valve gear has been reversed. This interlock means also prevents supply of fluid under pressure necessary for cutting in fuel to the engine until after the valve gear has been reversed. This interlock means may however be dispensed with since starting air may if desired be supplied to the engine immediately upon operation of the manual control means to initiate reversal of the engine, and since a directional control device disclosed in the above described structure and constituting a part of the present invention, prohibits cutting in the fuel to the engine until after the engine has started to turn in the reverse or new direction. According to the above object, the interlock means in the above described structure has therefore been dispensed with and, incident to this simplification, the number of control valves and control pipes has been reduced.

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

In the accompanying drawing, Fig. 1 is a diagrammatic view, partly in section and partly in outline, of a control apparatus embodying the invention; Fig. 2 is a partial plan view of an operator's control device shown in vertical section in Fig. 1; Figs. 3 and 4 are sectional views taken on the lines 3—3 and 4—4, respectively, in Fig. 1; and Fig. 5 is a sectional view, on an enlarged scale, of a directional control device shown in side elevation in Fig. 1 and taken on a line 5—5 therein.

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Description

In the drawing, the reference numeral 1 indicates a portion of one end of a crank shaft of an 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 1 by meshing gears 3 and 4 for operating engine valve mechanisms and fuel injection mechanisms 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 either 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 the one or ahead direction and reverse cams (not shown) to provide for operation of the engine in the reverse or astern direction and may be shiftable longitudinally relative to the crank shaft 1 for rendering either the forward cams or the reverse cams effective for controlling the engine valves or timing gear in a well known manner. In the drawing the cam shaft is shown in what may be considered the position to provide for operation of the engine in an astern direction and may be shifted by a lever 5 from this position to an ahead position in which said lever may occupy a position such as indicated by a dot and dash line 5*a*.

The reference numeral 6 indicates a fuel control member or shaft which may be rockable by a lever 7 to control the supply of fuel to the engine through the medium of controlling operation of a speed governor on the engine, or independently of said governor. It is sufficient to point out that 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.

A fuel cut-off device 10 is provided for mov-

ing the fuel control lever 7 from the fuel supply position to the fuel cut-off position. This device may comprise a cylinder containing a piston 11 having at one side a pressure chamber 12 open to a control pipe 13 and having at the opposite side a non-pressure chamber 14. Projecting from piston 11 through the non-pressure chamber 14 is a piston rod 15 in the end of which is an elongated slot in which is disposed a pin 16 secured to the fuel cut-off lever 7. The non-pressure chamber 14 contains a spring 17 encircling the rod 15 and acting on the piston 11 for urging same in the direction of the right hand away from a stop shoulder 18. Movement in the direction of the right hand is arranged to be limited by contact between the piston 11 and a stop 19. Upon supply of fluid under pressure to pressure chamber 12 the force created on piston 11 will cause the piston and thereby the fuel cut-off lever 7 to move to its fuel cut-off position shown in the drawing. Upon release of fluid under pressure from chamber 12 the spring 17 will move the piston into contact with stop 19 and this movement transmitted through the piston rod 15 will turn the fuel control lever 7 to the fuel supply position indicated by line 8.

A relief valve device 20 is provided for releasing fluid under pressure from chamber 12 in the fuel cut-off device 10. The relief valve device 20 comprises a casing having a chamber 21 open to control pipe 13 and containing a valve 22 for opening said chamber to a chamber 23 which is open to atmosphere through a port 24. A spring 25 in chamber 21 acts on the valve 22 for urging it to its closed position shown in the drawing. A piston 26 subject on one side to atmospheric pressure in chamber 23 and on the opposite side to pressure of fluid in a pressure chamber 27 is operatively connected to the valve 22. Supply of fluid under pressure to chamber 27 will actuate the piston 26 to open the valve 22, while release of fluid under pressure from chamber 27 will allow closing of said valve by spring 25. The supply and release of fluid under pressure to and from pressure chamber 27 is arranged to be controlled through a pipe 28 by means which will be later described.

The reference numeral 30 indicates the starting air valve device arranged to operate upon supply of fluid under pressure to a control pipe 31 to supply starting air from a supply pipe 32 to a pipe 33 which may convey it to the starting valves of the engine for supply to the engine's cylinders to place the engine in motion in the direction determined by the position of the cam shaft 2. Upon release of fluid under pressure from pipe 31 starting air valve device 30 will operate to cut off the supply of starting air to the starting air pipe 33. The control of the supply and release of fluid under pressure to and from the control pipe 31 will be hereinafter described.

A power motor 40 is provided for shifting the cam shaft 2 to its two different positions. This motor is preferably of the follow-up type and comprises a power cylinder 41 containing a power piston 42 which is operatively connected through a rod 43, and a link 44 to the free end of the cam shifting lever 5. Upon supply of fluid under pressure to the right hand face of the power piston 42 and release of fluid under pressure from the left hand face said piston will move to the position in which it is shown in the drawing for actuating arm 5 to shift the cam shaft 2 to the astern position as shown in the drawing. Upon supply of

fluid under pressure to the left-hand face of the power piston 42 with fluid released from the right-hand face, said piston will move to the opposite end of the power cylinder 41 for thereby drawing lever 5 to the ahead position indicated by the dot and dash line 5a.

The power motor 40 further comprises a control valve mechanism 45 containing an astern valve device 46 and an ahead valve device 47 arranged to be controlled by a lever 48 for controlling the supply and release of fluid under pressure to and from the chambers at the right-hand and left-hand sides, respectively, of the power piston 42. Movement of lever 48 in the direction of the left-hand will actuate the valve device 46 to supply fluid under pressure to the right-hand face of the power piston 42 and at the same time permit operation of the valve device 47 to open the left-hand face of said piston to atmosphere. Movement of lever 48 in the direction of the right-hand will effect operation of the valve device 47 to supply fluid to act on the left-hand face of power piston 42 and at the same time permit operation of the valve device 46 to open the right-hand face of said piston to atmosphere. With the lever 48 in the neutral position as shown in the drawing, the pressure of fluid on the opposite faces of the power piston 42 will be balanced, and to attain such balancing both of the valve devices 46 and 47 may, if desired, be conditioned in this position of said lever to open the opposite faces of the power piston to atmosphere.

The power motor 40 further comprises a pilot portion 50 associated with the power cylinder 41 and containing a pilot piston 51 having at its left-hand side a chamber open to an ahead control pipe 52 and having at the right-hand side another control chamber open to an astern control pipe 53. The piston 51 is connected to a rod 54 which projects through the chamber at its left-hand face to the exterior of the device. In the outer end of rod 54 is a cross-head 55 which is disposed to slide in a slot provided in an operating lever 56. One end of this lever is operatively connected by a pin 57 to the power piston rod 43, while the opposite end is connected by a pin 58 to one end of a rod 59. The opposite end of rod 59 is connected by a pin 48a to the end of lever 48 in the control valve mechanism 45.

The operation of the power motor 40 is briefly as follows: With the parts of the motor positioned as shown in the drawing, under which condition the cam shaft 2 will be in its astern position also as shown, if it is desired to reverse the position of cam shaft 2 to provide for operation of the engine in the reverse or ahead direction, fluid under pressure will be supplied through the ahead pipe 52 to act on the left-hand face of the pilot piston 51. The pilot piston 51 will thereby be moved in the direction of the right-hand and such movement will turn lever 56 in a clockwise direction about its connection with the power piston rod 43; this connection remaining stationary at this time due to the relatively great reluctance to movement of the power piston 42. This rocking of lever 56 acts through the connecting rod 59 to turn lever 48 of the control valve mechanism from its neutral position in a clockwise direction for thereby supplying fluid under pressure to act on the left-hand face of the power piston 42. The power piston 42 will thus be moved in the direction of the right-hand, and after the pilot piston 51 attains its right-hand position, this movement of the power piston 42 will actuate lever 56 to draw lever 48 of the control valve mechanism 45

back toward its neutral position which will be attained when the power piston 42 reaches its right-hand position in the power cylinder 41. With the lever 48 thus returned to its neutral position, the opposing pressures of fluid on the power piston will be balanced. This movement of the power piston 42 from its left-hand to its right-hand position will draw the lever 5 to the position indicated by the dot and dash line 5a and, as will be apparent, this operation will shift the cam shaft 2 from its astern position, that is to say, from the position in which it is shown in the drawing to its ahead position hereinbefore described.

If it is now desired to return the cam shaft 2 from its ahead position to its astern position, fluid under pressure will be supplied to the astern pipe 53 to act on the right-hand face of the pilot piston 51. The pilot piston 51 will then move in the direction of its left-hand position to thereby effect operation of the control valve mechanism 45 to supply fluid to act on the right-hand face of the power piston 42. Power piston 42 will then move to its left-hand position and the control valve mechanism 45 will operate in response to such movement to equalize the opposing pressures on the opposite sides of the power piston 42 at the time it attains its left-hand position. This movement of the power piston 42 will turn lever 5 and cam shaft 2 back to their astern position in which position they are shown in the drawing.

The parts of the apparatus as so far described may be identical to corresponding parts fully disclosed and described in the patent hereinbefore referred to and since reference may be had to said patent, a more detailed showing of these parts in the drawing and a more detailed description thereof are not deemed essential in the present application.

The supply and release of fluid under pressure to and from pipe 28 for controlling operation of the relief valve device 20 is arranged to be controlled by a directional control valve device 60 which may also be identical to a corresponding device employed for the purpose of illustration in the copending application above referred to, but which constitutes a part of the present invention.

The directional control valve device 60 comprises (Fig. 5) a casing containing a double check valve 61 arranged to control communication between pipe 28 and two passages 62 and 63. In one position of the double check valve 61 passage 28 will be disconnected from passage 63 and opened to passage 62, while in another or upper position of said double check valve said pipe will be disconnected from passage 62 and opened to passage 63. The passages 62 and 63 lead, respectively, to an astern valve device 64 and an ahead valve device 65.

The valve devices 64 and 65 are identical in structure, each comprising a supply valve 66 contained in a chamber 67 and arranged to control communication between said chamber and a chamber 68. A spring 67a in chamber 67 acts on valve 66 to seat same. In the ahead valve device 65, chamber 67 is connected by pipe 52a to pipe 52, while in the astern valve device 64, chamber 67 is connected by pipe 53a to pipe 53.

In each of the valve devices 64 and 65 the chamber 68 contains a release valve 69 in constant contact with a fluted stem projecting from the supply valve 66 and having a fluted stem 70 slidably mounted in a plunger 71 which in turn

is mounted to slide in a bore in the casing. The casing is provided with an annular recess encircling plunger 71 and containing a ring seal 72 having sealing and sliding contact with the peripheral surface of the plunger for preventing leakage of fluid under pressure from chamber 68 past said plunger. The bore in plunger 71, in which bore stem 70 of the release valve is slidably mounted, opens to a larger bore 73 the outer end of which is closed by a plug 74. The bore 73 is constantly open to the atmosphere through one or more ports 75 provided adjacent the closed end of plug 74. A plunger 76 loosely mounted in bore 73 extends into bore 73 and therein is provided with an enlarged head 77 which may be of smaller diameter than bore 73 to allow flow of fluid from one side to the opposite side. Against head 77 bears one end of a spring 78 the opposite end of which is supported by contact with the inner end of plug 74. This spring is under compression and therefore constantly effective to urge the plunger 71 in a direction away from and thus out of seating engagement with the release valve 69.

The casing of the directional control device is provided midway between the outer ends of the two plugs 74 with a depending lug 80 carrying a pin 81 upon which is fulcrumed a lever 82 having two oppositely arranged arms 83 one disposed over the end of each of the two plugs 74. In the end of each arm 83 is secured an adjustable actuating screw 84 which engages the respective plug 74. With the parts of the directional control valve device in the position in which they are shown in Fig. 5, the two screws 84 are so adjusted as to permit springs 67a to move the two supply valves 66 into contact with their seats and to permit movement of the two plungers 71 by springs 78 out of contact with the respective release valve 69.

The lever 82 is also provided with a depending operating arm 85 the end of which is loosely accommodated in a slot 86 provided in and open to the periphery of a friction disc 87. This disc is carried on one end of a plunger 88 which is slidably mounted in a bore provided in a casing 89 which is rigidly supported with respect to the engine so as to support the friction disc in coaxial relation with the end of the engine crank shaft 1. The plunger 88 is also effective 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 there is provided at its inner end a pressure chamber 90 which is open to the starting control pipe 31.

The reference numeral 94 indicates an operator's fluid pressure control valve device which may be located immediately adjacent the engine or at any desired remote control station. This device comprises a body 95 and a cover 96 mounted on said body, and in said body there are disposed, what may be called, an ahead run valve device 97 and an astern run valve device 98 for controlling through pipes 52 and 53, respectively, operation of the pilot piston 51 in the power motor 40 to select the direction of operation of the engine. The body 95 also contains a start valve device 99 for controlling operation of the starting air valve device 30 and of the plunger 88 associated with the directional control device 60, and a stop valve device 100 for controlling operation of the fuel cut-off device 10 to effect stopping of the engine.

The ahead and astern run valve devices 97 and 98 and the stop valve device 100 are arranged

in spaced parallel relation with their axes shown diagrammatically in the same plane, while the start valve device 99 is arranged with its axis also in said plane but at right angles to the axes of the other valve devices.

All of the valve devices 97, 98 and 99 and 100 may be identical in construction, each comprising a fluid pressure supply valve 102 contained in a chamber 103 and arranged to control communication between said chamber and a chamber 104 through an opening encircled by a seat provided for engagement by said valve to close said communication. A spring 105 in chamber 103 acts on valve 102 for urging it into contact with its seat. The valve 102 is connected by a stem 106 which loosely extends through the valve seat to a plunger 107 which is slidably mounted in a suitable bore in the body, said plunger being of substantially the same area as the seat on the valve 102 and subject on one face to pressure of fluid in chamber 104 and on the opposite face to atmospheric pressure in a chamber 108 which is open to atmosphere by way of a passage 109. The valve 102, stem 106 and plunger 107 are provided with an axial bore 110 open at one end to chamber 103, and a release valve 111 disposed in chamber 108 is arranged to control communication between the opposite end of said passage and the latter chamber. The release valve 111 is provided with a plunger 112 extending to the exterior of the body.

Chamber 104 in the several valve devices 97, 98, 99 and 100 is connected directly to a fluid pressure supply reservoir 113 and thus arranged to be constantly supplied with fluid under pressure when the system is in use. Since the area of plunger 107 subject to pressure of fluid in chamber 104 equals substantially that of valve 102 also subject to the pressure of fluid in said chamber, it will be noted that the pressure of fluid acting in one direction is substantially counterbalanced by its effect in the opposite direction, so that pressure of spring 105 on valve 102 need only be relatively small to provide a sufficient bias for seating said valve.

Chambers 103 in the ahead and astern valve devices 97 and 98 are connected to pipes 52 and 53, respectively, leading to the pilot portion 50 of the power motor 40. Chamber 103 in the start valve device 99 is connected to pipe 31 leading to the starting air valve device 30 and to plunger actuating chamber 90, while chamber 103 in the stop valve device 100 is connected by a pipe 114 containing a check valve device 115 to pipe 13 leading to the fuel cut-off device 10.

Disposed over the plungers 112 of the valve devices 97, 98 and 100 and arranged in the same vertical plane but at right angles to the axes of said plungers is a horizontally disposed hollow control shaft 116 which is suitably journaled at its opposite ends in the cover 96. A plunger 117 is slidably mounted in the control shaft 116 with its left-hand end projecting outwardly beyond the adjacent end of the control shaft above plunger 112 of the start valve device 99. A hollow cam shaft 118 is telescoped over and secured to the control shaft 116 and bears at opposite ends against the cover 96 for holding both shafts against axial movement.

The two shafts 116 and 118 are provided with aligned longitudinally extending slots, and the plunger 117 is provided with a like slot and through these slots extends the lower end portion 119 of an operator's control lever 120 which is pivotally mounted on a pin 121 carried by a lug 122 projecting upwardly from the cam shaft 118. In the lower end portion 119 of the control lever is a slot 123 within which is disposed a transversely extending pin 124 which is secured to plunger 117. It will be seen that rocking of the operator's control lever 120 about the pin 121 in a direction longitudinally of the cam shaft 118 will shift the plunger 117 lengthwise within the control shaft 116, while movement of said lever in a direction about the axis of said cam shaft will rotate said cam shaft without effecting endwise movement of plunger 117.

The control lever 120 extends through a guide slot in cover 96 which provides a definite path for movement of said lever. This slot is shown in plan in Fig. 2 and comprises a central portion 125 to permit movement of lever 120 in a direction circumferentially of the cam shaft 118. One end of the slot 125 opens into a short slot 126 arranged at right angles to the slot 125, while at the opposite end of slot 125 is another short slot 127 extending in the same direction and parallel to slot 126. The slots 126 and 127 provide for movement of the operator's control lever 120 in a clockwise direction about the fulcrum pin 121 for moving the plunger 117 outwardly of the control shaft 116.

The operator's control lever 120 may have five different operating positions in the slots 125, 126 and 127 including a "Stop" position intermediate the ends of slot 125, in which position said lever is shown in Fig. 2 of the drawing. At the end of slot 125 adjacent the short slot 126 the lever 120 has a "Run" position, while at the opposite end of slot 125 said lever has another "Run" position, and at the outer ends of each of the slots 126 and 127 said lever has a "Start" position. These positions are indicated in Fig. 2 by appropriate legends, and it will be noted that beyond the short slot 127 is the legend "Ahead," while beyond the short slot 126 is the legend "Astern." The "Start" position in slot 126 is for starting the engine in an "Astern" direction, while the adjacent "Run" position is for running the engine in said direction after being started. The "Start" position in slot 127 is for starting the engine in an "Ahead" direction, while the adjacent "Run" position is that in which the operator's control lever will be carried while the engine is running in the "Ahead" direction after being started, as will be hereinafter described in greater detail.

The body 95 of the operator's control valve device has an exterior lug 129 disposed between plunger 112 of the start valve device 99 and the plunger 117 slidably mounted in the control shaft 116. A lever 130 fulcrumed intermediate its ends on a pin 131 carried by lug 129 has one end in contact with stem 112 of the release valve 111 in the start control valve device 99, while its opposite end is operatively connected to the projecting end of plunger 117. With the operator's control lever 120 in slot 125 the plunger 117, lever 130 and parts of the start control valve device 99 will occupy the positions shown in the drawing in which pipe 31 leading to the starting air valve device 30 will be open to atmosphere through chamber 103 in said valve device, bore 110 and past the release valve 111. Movement of lever 120 into either one of the short slots 126 or 127 will however operate plunger 117 and lever 130 to first seat the release valve 111 and then open the supply valve 102 in the start control valve device 99 for thereby supplying fluid under pressure to pipe 31.

The cam shaft 118 is provided with three cams 135, 136 and 137, the peripheral surfaces of which are arranged to contact plungers 112 of the valve devices 97, 98 and 100, respectively, for controlling the operation of said valve devices. The cams 135 and 136 may be of identical structure but are reversely arranged on the cam shaft 118. The cam 135 is so designed as to effect closure of the release valve 111 and opening of the supply valve 102 in the ahead valve device 97 with the operator's handle 120 in the "Ahead," "Run" and "Start" positions and to permit closing of said supply valve 102 and opening of said release valve in all other positions of said handle. The cam 136 is operative to close the release valve 111 and open supply valve 102 in the astern valve device 98 in the "Astern," "Run" and "Start" positions of lever 120 and to permit closure of said supply valve and opening of said release valve in all other positions on said lever. The cam 137 is so designed as to effect closure of the release valve 111 and opening of supply valve 102 of the stop control valve device 100 only in the "Stop" position of the operator's control lever and to permit closure of said supply valve and opening of said release valve in all other positions of said lever.

In operation, let it be assumed that the operator's control lever 120 is initially in "Stop" position effecting operation of the ahead and astern run valve devices 97 and 98, and of the start valve device 99 to open the respective pipes 52, 53 and 31 to atmosphere, and also effecting operation of the stop valve device 100 to supply fluid under pressure to pipe 114.

Fluid thus supplied to pipe 114 will flow through the check valve device 115 to pipe 13, and with valve 22 in the relief valve device 20 closed, this pressure will become effective in chamber 12 of the fuel cut-off device 10 to move the piston 11 and thereby the control lever 7 to fuel cut-off position in which the engine will be stopped.

With control pipes 52 and 53 both open to atmosphere, the parts of the power motor 40 will be in the condition previously assumed, which for example may be the position in which the parts are shown in the drawing with the lever 5 and cam shaft 2 conditioned to provide for operation of the engine in the reverse or astern direction. With pipe 31 open to the atmosphere the starting air valve device 30 will be conditioned to prevent supply of starting air to the starting air pipe 33, and the plunger 88 will be relieved of pressure to relieve the driving friction between the disc 87 and the end of the crank shaft 1. With disc 87 thus conditioned, the parts of the directional control valve device 60 will assume the position in which they are shown in Fig. 5 due to the actions of springs 67a on the supply valves 66 and springs 78 on the plungers 71.

If the operator now desires to restart the engine in the same direction as last operated, that is, in the astern direction, he will move lever 120 from "Stop" position directly to the "Astern," "Start" position. In this position of lever 120 the astern run valve device 98 will operate to supply fluid under pressure through pipe 53 to the right-hand face of the pilot piston 51 in the power motor 40, but since said piston is already in its astern position the parts of the power motor 40 will not change position. Fluid supplied to pipe 53 will also flow through branch pipe 53a to supply valve chamber 67 in the astern valve device 64 of the directional control valve device 60, but since valve 66 in said valve device is closed at this time flow of fluid out of said chamber can not occur.

When the operator's control valve device is moved from the "Stop" position to the "Astern" "Start" position cam 137 permits operation of the stop valve device 100 to release fluid under pressure from pipe 114, but the check valve 115 prevents the release of fluid under pressure from piston chamber 12 in the fuel cut-off device 10 upon such release of fluid from pipe 114, so that said cut-off device will maintain the fuel control lever 7 in its fuel cut-off position. Movement of the operator's control lever to the "Astern" "Start" position also actuates the starting valve device 99 to supply fluid under pressure to pipe 31 and thence to the starting air valve device 30 to effect operation thereof to supply starting air to pipe 33 through which it will flow to the cylinders of the engine in the proper sequence to cause said engine to start turning in the direction determined by the position of the cam shaft 2.

Fluid pressure supplied to pipe 31, as just described, will also flow to pressure chamber 90 wherein it will act on plunger 88 to urge the disc 87 into close frictional contact with the end of the crank shaft 1. After the engine has started to turn by the starting air supplied thereto, the rotation of the crank shaft 1 will then turn the friction disc 87 in a corresponding direction, which in the present instance is in the astern direction as indicated by the legend "Astern" applied to said disc in Fig. 5. This rotation of disc 87 will actuate the lever 82 to first close the release valve 69 and to then open the supply valve 66 of the astern valve device 64 whereupon fluid under pressure supplied from pipe 53a to chamber 67 in said device will flow from said chamber to chamber 68 and thence through passage 62 to the upper end of the double check valve 61. If the check valve 61 is not in the position in which it is shown in the drawing at this time, the pressure of fluid supplied to passage 62 will shift it to said position whereupon fluid will flow from passage 62 to pipe 28 and thence to the relief valve device 20.

The fluid under pressure thus supplied to the relief valve device 20 will actuate same to release fluid under pressure from the fuel cut-off device 10 whereupon spring 14 in said device will shift piston 11 to its right-hand position thereby pulling or allowing movement of the fuel control lever 7 from its fuel cut-off position to its fuel supply position. This operation of the fuel control lever 7 will cause fuel to be supplied to engine, and with the engine turning under the influence of starting air supplied by the starting valve device 30, the engine will then fire and run on fuel.

After the engine is running on fuel the operator will move his control lever 120 out of the "Astern" "Start" position back to the "Astern" "Run" position to effect operation of the starting valve device 99 to open pipe 31 to the atmosphere. The consequent release of fluid under pressure from pipe 31 will permit operation of the starting air valve device 30 to cut off the supply of starting air to the engine, and will also relieve plunger 88 of pressure of fluid, in order to relieve pressure of the friction disc 87 against the end of the engine crank shaft 1. Upon this release of force between friction disc 87 and the crank shaft 1, the force of spring 67a will seat the supply valve 66 and the force of spring 78 on plug 74 will move plunger 71 out of seating

engagement with release valve 69, in the astern valve device 64 of the directional control valve device 60, to prevent further flow of fluid under pressure from pipe 53a and to release fluid under pressure from pressure chamber 27 in the relief valve device 20. As a result, valve 22 in the release valve device 20 will close, but piston 11 will remain in its full cut-in or right-hand position since in the "Astern" "Run" position of lever 120 the stop valve device 100 opens pipe 114 to atmosphere.

If the engine is operating in an astern direction and the operator desires to stop the engine he will turn lever 120 to "Stop" position, thus actuating the stop control valve 100 to supply fluid under pressure to pipe 114. From pipe 114 fluid under pressure flows past the check valve 115 to the fuel cut-off device 10 for actuating same and thereby the fuel control arm 7 to cut off the supply of fuel to the engine, whereupon the engine will cease to operate.

If, however, with the engine operating in the astern direction, the operator desires to reverse its direction of operation, i. e. cause it to operate in an ahead direction, he will move the lever 120 from the "Astern" "Run" position to the "Ahead" "Run" position and then, if he desires, immediately into the "Ahead" "Start" position.

Movement of the operator's control lever from the "Astern" "Run" position to the "Ahead" "Run" position will release fluid under pressure from pipe 53 and cause operation of the ahead valve device 97 to supply fluid under pressure to pipe 52. The fluid pressure thus supplied to pipe 52, with pipe 53 vented, will then cause operation of the fluid motor 40 to move the control arm 5 to the ahead position indicated in Fig. 1 by the dot and dash line 5a for thereby shifting the cam shaft 2 to the position to provide for operation of the engine in the ahead direction. Fluid under pressure supplied to pipe 52 for causing operation of the power motor 40 as just described will also flow through pipe 52a to supply valve chamber 67 in the ahead valve device 65 of the directional control valve device 60, but since the supply valve 66 in said chamber is closed at this time further flow of fluid under pressure will be prevented.

Movement of the operator's control handle 120 from the "Astern" "Run" position through "Stop" position to the "Ahead" "Run" position will also cause operation of the stop valve device 100 to supply fluid under pressure to pipe 114 through which it will flow past the check valve 115 to the fuel cut-off cylinder 10 for effecting operation thereof to move the lever 7 to its fuel cut-off position to thereby cut off the supply of fuel to the engine while it is being stopped and until it is started in the opposite direction.

It will now be seen that if the operator moves lever 120 from the "Astern" "Run" position only to the "Ahead" "Run" position he will effect operation only of the stop valve device 100 to cut off the supply of fuel to the engine to allow it to stop, and of the ahead valve device 97 to cause operation of the power motor 40 to reverse the position of the cam shaft in the engine. To start the engine in the new or ahead direction, the operator must move the control lever 120 into the "Ahead" "Start" position.

Movement of the control lever 120 into the "Ahead" "Start" position will cause operation of the starting valve device 99 to supply air to pipe 31 and thence to the starting air valve device 30 to effect operation of said valve device to supply starting air to the engine to place it in motion in the direction selected by the new or ahead position of the cam shaft 2. Fluid pressure thus supplied to pipe 31 will also flow to chamber 90 to act on plunger 88 for moving the friction disc 87 into close contact with the end of the crank shaft 1. Then as soon as the engine starts turning in the new direction, rotation of the crank shaft 1 will cause operation of the disc 87 and thereby of lever 82 to close the release valve 69 and open the supply valve 66 of the ahead valve device 65 of the directional control valve device 60. Fluid under pressure will then flow from pipe 52a to pipe 28 and thence to pressure chamber 27 in the relief valve device 20 for effecting operation of said device to release fluid under pressure from piston chamber 12 in the fuel cut-off device 10. The piston 11 in the fuel cut-off device 10 will be then moved by spring 14 back to its right-hand position to allow movement of the fuel control lever to its fuel supply position for supplying fuel to the engine to permit it to fire and run on fuel.

After the engine starts running on fuel the operator will then move control lever 120 from the "Ahead" "Start" position back to the "Ahead" "Run" position for releasing fluid under pressure from pipe 31 to effect operation of the starting air valve 30 to cut off the supply of starting air to the engine and to also relieve plunger 88 of pressure of fluid in chamber 90. The friction disc 87 being thus relieved of actuating pressure will become disengaged from the end of the crank shaft 1 and the supply valve 66 will close and the release valve 69 will open under action of springs 67a and 78 respectively, in the ahead valve device 65 of the directional control valve device 60. Further flow of fluid under pressure from pipe 52a to the release valve device 20 will thus be prevented and the fluid will be released from pressure chamber 27 in said device to thereby allow closure of the valve 22. The operator will then allow lever 120 to remain in the "Ahead" "Run" position as long as it is desired that the engine continue running in the ahead direction.

As before described, in reversing the engine from astern to ahead the operator may move the control lever 120 first to the "Ahead" "Run" position for effecting operation of the power motor 40 to reverse the cam shaft 2, after which he may move it to the "Ahead" "Start" position for starting the engine, or if he so desires, he may move the lever 120 directly to the "Ahead" "Start" position without hesitation in "Ahead" "Run" position. In case he moves the lever directly to the "Ahead" "Start" position to effect reversal in direction of operation of the engine, it will be noted that the starting air valve device 30 will operate to supply starting air to the engine at substantially the same time that the power motor 40 operates to change the position of the cam shaft and thus while the engine is still operating in the astern direction. This is satisfactory however since the valve gear on the engine may be reversed while the engine is being operated by starting air, and is advantageous in that as soon as the cam shaft has become reversed starting air effective on the pistons in the engine will oppose movement thereof to promptly bring the engine to a stop and at the instant of stopping be effective to start the engine turning in the reverse direction.

It is however desired to point out, that if the operator moves his control lever directly to the "Ahead" "Start" position to effect reversal in the direction of operation of the engine, fuel will not be supplied to the engine until after it starts

turning in the ahead direction, due to operation of the directional control valve device 60 as will now be described.

As before mentioned, upon movement of the operator's control lever to the "Ahead" "Start" position, fluid pressure will be supplied to pipe 52 to effect reversal of the cam shaft and also to pipe 52a through which it will flow to the ahead valve device 65 in the directional control valve device 60. The simultaneous supply of air to pipe 31 will move the friction disc 87 into close contact with the crank shaft 1 and with the engine still operating in the astern direction will cause operation of the lever 82 in a counterclockwise direction, as viewed in Fig 3. This will effect opening of the supply valve 66 in the astern valve device 64, which however is immaterial since pipe 53a is at this time open to the atmosphere through the astern valve device 98 in the operator's control valve device. Valve 66 in the ahead valve device 65 of the directional control valve device will thus remain closed until the engine stops and then starts to turn in the new or selected direction, whereupon the direction of action of disc 87 will be reversed and open said valve. Fluid under pressure will then flow from pipe 52a to actuate the relief valve device 20 to cause fuel to be supplied to the engine to cause it to run in the ahead direction. After the engine is running on fuel the operator may return lever 120 from the "Ahead" "Start" position to the "Ahead" "Run" position in which fluid will be released from pipe 31 to effect operation of the starting air valve device 30 to cut off the supply of starting air to the engine and to also relieve plunger 88 of pressure of fluid, whereupon the friction disc 87 may become disengaged from the crank shaft 1 to permit return of the parts of the directional control valve device 60 to the position shown in the drawing. With the parts of the ahead valve device 65 thus returned to their normal position closing valve 66, further flow of fluid from pipe 52a to the relief valve device 20 will be prevented and fluid pressure will be released from piston chamber 27 in said device to thereby allow closure of the valve 22. The fuel cut-off piston 11 and fuel cut-off lever 7 will then remain in their fuel supply positions as long as the operator's lever remains in the "Ahead" "Run" position, providing for operation of the engine in the ahead direction.

If the operator now desires to stop the engine from running in the ahead direction he will move the control level 120 back to "Stop" position for effecting operation of the stop valve device 100 to supply fluid under pressure to the fuel cut-off device 10 to effect movement of the fuel control lever 7 to its fuel cut-off position shown in the drawing, whereupon the engine will stop operating.

If the engine is operating in an ahead direction and the operator desires to reverse the direction of operation of the engine he may move the control lever 120 from "Ahead" "Run" position to the "Astern" "Run" position and then if desired immediately into "Astern" "Start" position, and in response to this operation the fuel supply to the engine will be cut off, the valve gear of the engine will be reversed, starting air will be supplied to the engine either at the same time as the valve gear is being reversed or after such reversal, depending upon the position of the operator's control lever, and finally, after and only after the engine starts turning in the reverse direction, fuel will be supplied to the engine for causing it to operate. After the engine is then running on fuel the operator will move the control lever from the "Astern" "Start" position back to the "Astern" "Run" position to cut off the supply of starting air to the engine and to relieve the friction disc 87 from the end of the crank shaft 1, so that the release valve device 20 may operate to condition the fuel cut-off device 10 to respond to subsequent movement of the operator's control device to "Stop" position.

Summary

It will now be seen that I have provided a relatively simple fluid pressure control system for controlling starting, stopping and reversing of a reversible internal combustion engine. Reversal of the engine is effected by fluid under pressure supplied through a control pipe to a power motor, and fluid from this same pipe is employed for cutting in the supply of fuel to the engine. The directional control valve device, however, so controls the supply of fluid for cutting in the supply of fuel to the engine as to insure that fuel will not be supplied to the engine until after the engine starts to turn in the proper direction determined by the condition of the valve gear. The supply of fluid pressure to the different valve devices in the operator's control valve device is direct from the source of supply. This direct supply of fluid under pressure to the starting air valve permits, if so desired, the supply of starting air to the engine simultaneously with reversing of the valve gear. If it is not desired to supply starting air to the engine until after reversal of the valve gear, the operator's control lever can be held in the "Run" position until after reversal is completed, and then be moved to the "Start" position.

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

1. An apparatus for controlling starting and reversing of a reversible internal combustion engine and for also controlling supply of fuel to said engine comprising in combination, reversing means operable by fluid under pressure in a control pipe to condition said engine for operation in a reverse direction, starting means operable to effect starting of said engine, fuel control means controlled jointly by rotation of a rotatable part of said engine and pressure of fluid in said control pipe and operable to provide fuel to said engine upon rotation of said part in the direction provided by said reversing means and operable to prevent supply of fuel to said engine with said part stationary or rotating in the opposite direction, and an operator's control device movable to a position for effecting a supply of fluid under pressure to said control pipe and for also effecting operation of said starting means.

2. An apparatus for controlling starting and reversing of a reversible internal combustion engine and for also controlling supply of fuel to said engine comprising in combination, reversing means operable by fluid under pressure in a control pipe to condition said engine for operation in a reverse direction, starting means operable to effect starting of said engine, fuel control means adapted to be operated by fluid under pressure from said control pipe to effect a supply of fuel to said engine, means responsive to direction of rotation of a rotatable part of said engine and operable upon rotation of said part in the direction provided by said reversing means to supply fluid under pressure from said pipe to said

fuel control means and operable upon rotation of said part in the opposite direction or with said part stopped to prevent said supply of fluid under pressure from said pipe to said fuel control means, and an operator's control device movable to a start position for supplying fluid under pressure to said control pipe and for effecting operation of said starting means.

3. An apparatus for controlling starting and reversing of an internal combustion engine and for also controlling supply of fuel to said engine comprising in combination, reversing means operable upon supply of fluid to one pipe with fluid under pressure vented from a second pipe to condition said engine for operation to one direction and operable upon supply of fluid under pressure to said second pipe with fluid under pressure vented from said one pipe to condition said engine for operation in the reverse direction, starting means for starting said engine to turn, control means operable upon supply of fluid to a third pipe to effect a supply of fuel to said engine, valve means arranged to control communication between said first or second pipe and said third pipe, control means adapted to respond to direction of rotation of a rotatable part of said engine for controlling said valve means and operable upon operation of said engine in said one direction to actuate said valve means to open said third pipe to said one pipe and operable upon operation of said engine in said reverse direction to actuate said valve means to open said third pipe to said second pipe, and an operator's control device having one start position for effecting a supply of fluid under pressure to said one pipe and for venting fluid under pressure from said second pipe and having another start position for effecting a supply of fluid under pressure to said second pipe and for venting fluid under pressure from said first pipe, said operator's control device comprising means operable in both of said start positions to effect operation of said starting means and to render said control means responsive to rotation of said rotatable part of said engine.

4. An apparatus for controlling starting and reversing of an internal combustion engine and for also controlling supply of fuel to said engine comprising in combination, reversing means operable upon supply of fluid to one pipe with fluid under pressure vented from a second pipe to condition said engine for operation to one direction and operable upon supply of fluid under pressure to said second pipe with fluid under pressure vented from said one pipe to condition said engine for operation in the reverse direction, starting means for starting said engine to turn, control means operable upon supply of fluid to a third pipe to effect a supply of fuel to said engine, control means adapted to respond to direction of rotation of a rotatable part of said engine and operable upon operation of said engine in said one direction to open said third pipe to said one pipe and operable upon operation of said engine in said reverse direction to open said third pipe to said second pipe, and an operator's control device having one start position for effecting a supply of fluid under pressure to said one pipe and for venting fluid under pressure from said second pipe and having another start position for effecting a supply of fluid under pressure to said second pipe and for venting fluid under pressure from said first pipe and operable in both of said start positions to effect operation of said starting means and to render said control means responsive to rotation of said rotatable part of said engine, said operator's control device being movable out of said start positions to stop operation of such starting means and to render said control means non-responsive to rotation of said rotatable pipe, said control means when non-responsive to rotation of said rotatable part closing communication between said third pipe and said first or second pipes.

5. An apparatus for controlling starting and reversing of an internal combustion engine and for also controlling supply of fuel to said engine comprising in combination, reversing means operable upon supply of fluid under pressure to one pipe with fluid under pressure vented from a second pipe to condition said engine for operation in one direction and operable upon supply of fluid to said second pipe with fluid under pressure vented from said one pipe to condition said engine for operation in the reverse direction, starting means for starting said engine to turn, an operator's control device having one start position for supplying fluid under pressure to said one pipe and for venting said second pipe and having a second start position for supplying fluid under pressure to said second pipe and for venting said one pipe and being movable out of said start positions, said operator's control device comprising means operable in both start positions of said control device to effect starting of said engine and rendered ineffective upon movement of said control device out of said start positions, fuel control means operable upon movement of said operator's control device from either start position to the other start position to cut off the supply of fuel to said engine, fuel cut-in means arranged to be operated by fluid under pressure to effect operation of said fuel control means to supply fuel to said engine, and operating means rendered effective in both of said start positions to respond to direction of rotation of a rotatable part of said engine and operable upon rotation of said part in the direction determined by the one of said pipes supplied with fluid under pressure to supply fluid from the last named pipe to the said fuel cut-in means, said operating means being rendered non-responsive to rotation of said part with the operator's control device out of said start positions and when non-responsive closing communication between said pipes and fuel cut-in means and releasing fluid under pressure from said fuel cut-in means.

6. An apparatus for controlling starting and reversing of a reversible internal combustion engine and for also controlling supply of fuel to said engine comprising in combination, starting means operable upon supply of fluid under pressure to a starting pipe to effect starting of said engine, fuel control means operable upon supply of fluid under pressure to a fuel control pipe to supply fuel to said engine, reversing means operable upon supply of fluid under pressure to an ahead pipe to condition said engine for operation in one direction and upon supply of fluid under pressure to an astern pipe to condition said engine for operation in the reverse direction, an operator's control device comprising a lever having a stop position and at one side of said stop position ahead run and start positions and at the opposite side of said stop position astern start and run positions, said operator's control device comprising valve means controlled by said lever and operable in said ahead start position to supply fluid under pressure to said ahead pipe and to said starting pipe and in said astern

start position to supply fluid under pressure to said astern pipe and to said starting pipe operable in both run positions to effect a release of fluid under pressure from said starting pipe, and in said stop position to effect a release of fluid under pressure from said ahead and astern pipes and from said starting pipe, and interlock means operable by fluid under pressure supplied to said starting pipe to respond to direction of rotation of a rotatable part of said engine and rendered non-responsive upon release of such fluid pressure, said interlock means comprising valve means operable upon rotation of said part in the direction corresponding to the one of said ahead or astern pipes which is supplied with fluid under pressure to open communication between the last named pipe and said fuel control pipe and operable when non-responsive to rotation of said part to release fluid under pressure from said fuel control pipe.

7. An apparatus for controlling 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 a reverse direction, starting means operable to initiate turning of said engine, fuel control means operable by rotation of a rotatable part of said engine to effect a supply of fuel to said engine, and an operator's control device movable to a position to effect operation of said reversing means and starting means, said operator's control device in said position rendering, independently of said reversing means, said fuel control means rotatable by said part and when out of said position non-rotatable by said part.

8. An apparatus for controlling 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 a reverse direction, starting means operable to initiate turning of said engine, fuel control means operable by rotation of a rotatable part of said engine to effect a supply of fuel to said engine, an operator's control device having two different control positions and comprising means operable in one of said positions for effecting operation of said reversing means, and of said starting means and for rendering said fuel control means rotatable by said part of said engine independently of operation of said reversing means, and operable in the other of said positions to render said fuel control means non-rotatable by said part.

9. An apparatus for controlling reversing of and fuel supply to an internal combustion engine comprising in combination, reversing means operable by fluid under pressure to condition said engine for operation in a reverse direction, starting means operable by fluid under pressure to initiate turning of said engine, fuel control means conditionable by fluid under pressure to operate in response to direction of rotation of a part of said engine and operable by rotation of said part in the direction determined by said reversing means to effect a supply of fuel to said engine and operable by rotation of said part in the opposite direction or with said part stationary to effect cutting off of the supply of fuel to said engine, an operator's control device having three different control positions and comprising fluid pressure control means operable in one of said three positions for supplying fluid under pressure to said reversing means and to said starting means and to at the same time supply, independently of said reversing means, fluid under pressure to said fuel control means for rendering same operable by rotation of said part of said engine, said fluid pressure control means in a second one of said three positions cutting off the supply of fluid under pressure to said starting means and fuel control means, and means operable in the third position of said operator's control device for cutting off the supply of fuel to said engine.

10. An apparatus for controlling reversing of an internal combustion engine, starting of said engine, and supply of fuel to said engine comprising in combination, a fluid motor operable upon supply of fluid under pressure to a first pipe to condition said engine for operation in one direction and upon supply of fluid under pressure to a second pipe to condition said engine for operation in the reverse direction, a starting air valve device operable by fluid under pressure to supply starting air to said engine to initiate turning thereof, fuel control means for controlling supply of fuel to said engine and operative to cut off the supply of fuel to said engine to provide for stopping thereof, an operator's control valve device having ahead run and start positions for supplying fluid under pressure to said ahead pipe, and astern run and start positions for supplying fluid under pressure to said astern pipe, means operable in each of said start positions to supply fluid under pressure to said starting valve device for effecting operation thereof, said operator's control device also having a stop position, means operable in said stop position to effect operation of said fuel control means to cut out the supply of fuel to said engine, means operable by fluid under pressure supplied to effect operation of said starting valve device to respond to direction of rotation of a rotatable part of said engine and operable upon rotation of said part in the direction determined by said reversing means to supply fluid under pressure from the respective ahead or astern pipe to a third pipe and operable upon rotation in the opposite direction or with said rotatable part stationary to prevent supply of fluid under pressure to said third pipe, and means operable by fluid under pressure supplied to said third pipe to effect operation of said fuel control means to supply fuel to said engine.

11. An apparatus for controlling reversing of a reversible internal combustion engine, starting of said engine, and supply of fuel to said engine comprising in combination, a reversing motor operable upon supply of fluid under pressure to an ahead pipe to condition said engine for operation in an ahead direction and operable upon supply of fluid under pressure to an astern pipe to condition said engine for operation in the reverse direction, starting valve means arranged to be operated by fluid under pressure to supply starting air to said engine, fuel control means arranged to be operated by fluid under pressure to cut off the supply of fuel to said engine, an operator's control valve device comprising ahead and astern valve devices, a start valve device and a stop valve device and means including a lever for controlling said valve devices, said lever having ahead run and start positions for effecting operation of said ahead valve device to supply fluid under pressure to said ahead pipe and having astern run and start positions for effecting operation of said astern valve device for supplying fluid under pressure to said astern pipe, said lever in both of said start positions also effecting operation of said start valve device to sup-

ply fluid under pressure to said starting valve means for effecting operation thereof, said lever also having a stop position for effecting operation of said stop valve device to supply fluid under pressure to said fuel control means and operable upon movement out of said stop position to effect operation of said stop valve device to release fluid under pressure, means arranged to hold fluid under pressure in said fuel control means upon operation of said stop valve device to release fluid under pressure, means operable upon supply of fluid under pressure to a third pipe to effect a release of fluid under pressure from said fuel control means to provide for supply of fuel to said engine, means for controlling the supply of fluid under pressure to said third pipe comprising a directional control device adapted to respond to direction of rotation of a rotatable part of said engine and operable upon rotation of said part in the direction determined by said reversing means to open said third pipe to the respective one of said ahead or astern pipes which is supplied with fluid under pressure and operable upon rotation of said part in the opposite direction or with said part stopped to close communication between said third pipe, and said ahead pipe or astern pipe, and means responsive to pressure of fluid supplied to effect operation of said starting valve means to render said directional control device controllable by said rotatable part and operable upon release of such fluid pressure from said starting valve means to render said directional control device non-responsive to rotation of said rotatable part.

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