Feb. 6, 1962 F. HENNINGER 3,019,596

STARTING AND REVERSING SYSTEM FOR DIESEL ENGINES

Filed April 5, 1960 2 Sheets-Sheet 1

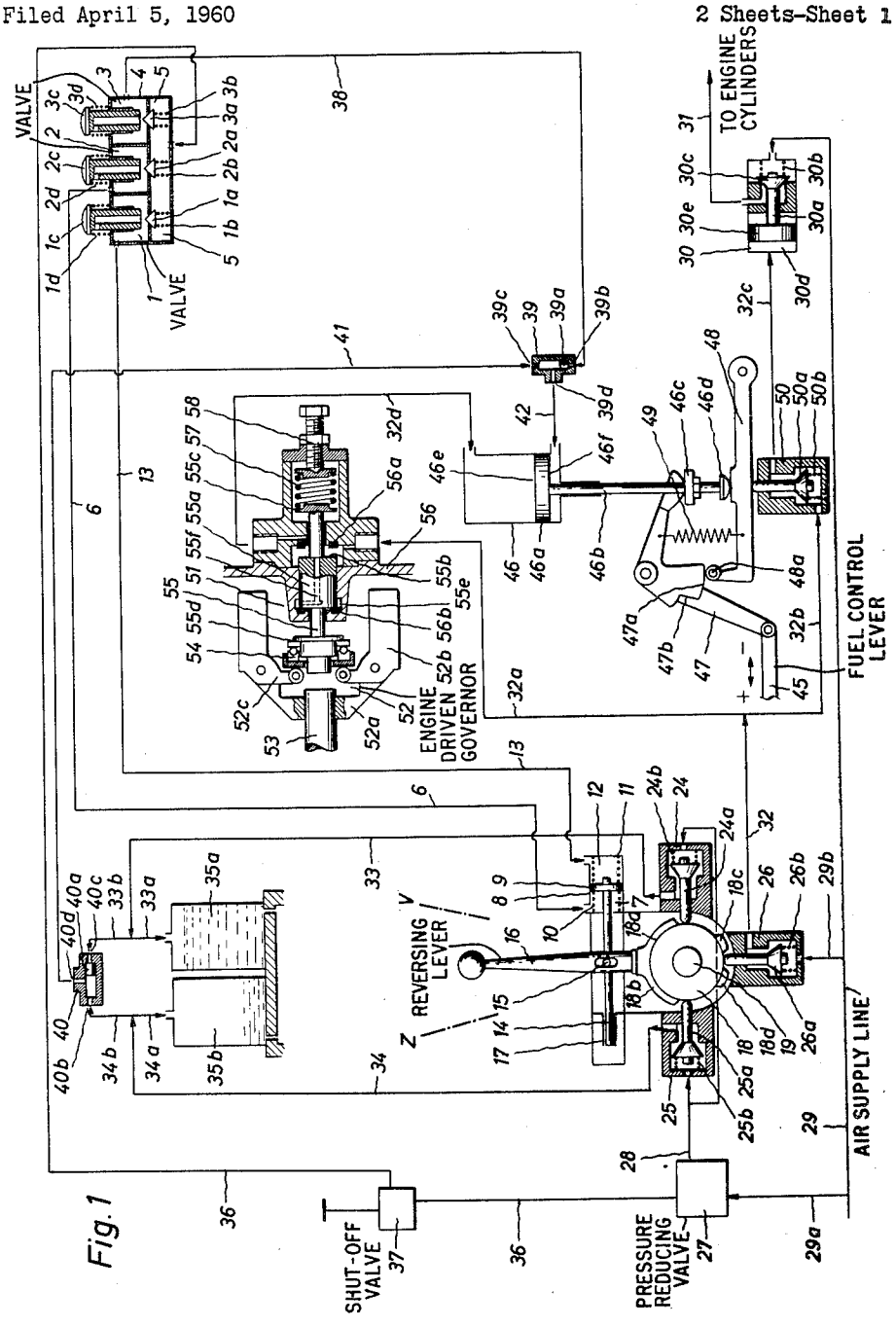

Fig. 1

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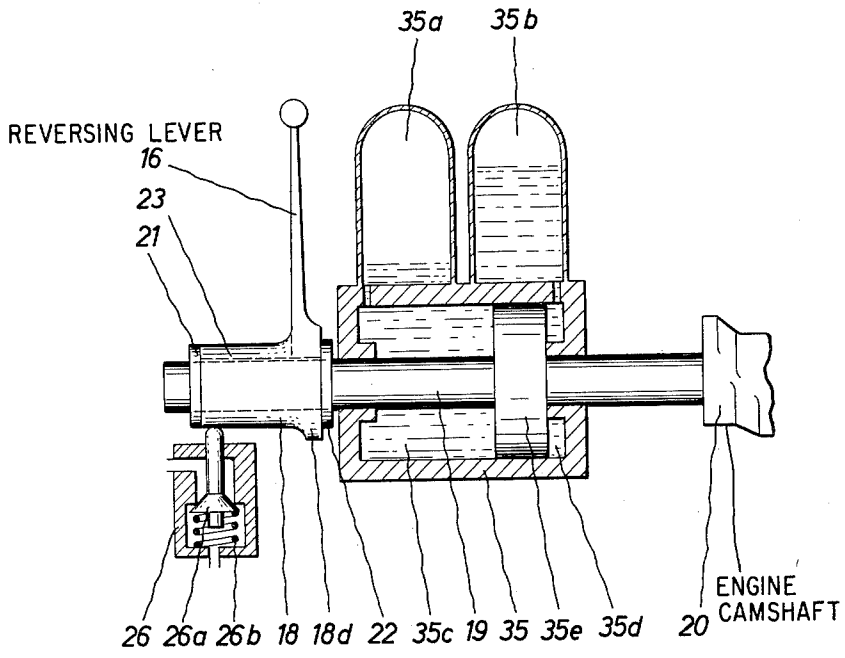
Fig. 2



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STARTING AND REVERSING SYSTEM FOR DIESEL ENGINES

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The invention relates to safety devices for reversible diesel engines, provided with compressed air reversal and compressed-air starting devices, operated alternately by valves. The safety device operates to prevent starting of the engine in the wrong direction of rotation after a reversing operation, and, on the initiation of the reversing operation, causes the injection pump to be locked in the zero delivery position by the opening of a reversing valve.

In reversible marine diesel engines, due to the wake, the propeller connected to the engine continues to drive the latter for a certain time in the old direction of rotation. The result of this is that frequently, with rapid reversal, the admission of starting air and the re-starting of the fuel supply causes the engine to start in the same direction as before. It sucks in through the exhaust pipe, and the exhaust gases escape through the inlet pipe. The disadvantage of this is that in the event of an emergency, the engine continues to run in the old direction of rotation, even though with diminished power, and instead of stopping the ship, continues to drive it further, which may result in dangerous collisions. In addition, the inlet pipes are also fouled. Heretofore, this disadvantage has generally been remedied by starting the engine only after it has been completely stopped. This procedure depends very much on the attentiveness of the attendants, and in ships which have no actual engine attendant, but operate with remote control from the bridge, it is inexpedient, since it is difficult to supervise closely the running of the engine from the bridge.

Various safety devices acting on the injection pump of a reversible diesel engine for ship propulsion have been proposed. These devices are intended to prevent fuel from being supplied to the working cylinders when, after a reversing operation, the engine continues to run in the old, and now wrong, direction of rotation, in the manner described above. These devices consist of a stop device, which stops the injection pump when the adjusted and actual directions of rotation of the engine do not agree. The principal drawback of these known devices is that the starting air is not shut off, so that in the event of inattentive supervision, it may happen that the engine is driven by the starting air in the wrong direction until the air supply is exhausted. The real object of the device is then not attained. It is the object of the present invention to obviate the aforesaid disadvantages, and in addition to provide a safety device which permits the supply of starting air to the engine cylinders only at a safe speed of rotation and then no longer interferes in the starting operation. A further object of the invention is to render such safety device as simple and reliable as possible by the exclusive use of valve-like sealing and control elements.

This object is attained according to the invention in that a speed-dependant control member provides a path for the starting air to the engine cylinders and releases the locking of the injection pump only when the engine is stopped or at a speed which is safe for the reversing operation, the shut-off member controlling the supply of air to the engine cylinders being locked in the open position, so that starting air is admitted to the engine cylinders as long as the starting valve is open.

In order that the safety device shall be ready for operation again for a new starting operation when it has been in operation, provision is made according to a further feature of the invention for the locking pawl, which holds the starting air shut-off member in the open position to be released on the opening of a reversing valve, whereupon the shut-off member closes again.

A simple and expedient construction of the speed-dependent control member is provided by its consisting of a centrifugal governor driven by the diesel engine and having connected to its plunger a shut-off valve, which is opened by the centrifugal force of the centrifugal weights of the centrifugal governor at a definite speed below the maximum engine speed, said definite speed being adjustable by the tensioning of a spring counteracting the centrifugal force, whereby on the opening of the compressed air starting valve, starting compressed air acts on the piston of an operating cylinder, which opens and locks the starting air shut-off member, and releases the locking of the injection pump.

The return of the safety device to the position of readiness is advantageously effected by the operating cylinder being double-acting, the piston side opposite the side acted upon by the starting compressed air being acted upon by compressed air on the operation of a reversing valve, whereby the locking of the starting air shut-off member is released, whereupon the latter closes again.

A definitely speed-dependent control of the operating cylinder is obtained in that the plunger of the centrifugal governor forms the valve cone of the shut-off valve, which with a first central shoulder, constructed as a sealing surface, forms with a counter-surface of the valve housing a first shut-off valve, which alternately opens a communication between the starting valve and the operating cylinder and also between the outer air and the operating cylinder, an adjustable spring engaging one end of the sleeve and the centrifugal weights the other end, and in that the sleeve forms with a second shoulder and a second counter-surface of the valve housing a second shut-off valve, which controls the communication between the first shut-off valve and the outer air and is closed when the first shut-off valve is open, and vice versa.

In view of the fact that the high starting-air pressure, even when it loads only very small surfaces, can exert very great forces on the plunger, which in their turn would necessitate a very expensive centrifugal governor having a high working capacity, it is advantageous for the central cylindrical part of the plunger to be guided approximately airtight in the valve housing, the diameter of this guide corresponding to the actual diameter of the sealing surface of the first shut-off valve, so that the compressed air in the valve housing cannot exert any axial forces on the sleeve in the closed position of the first shut-off valve.

Air losses, due to the only approximately airtight guiding of the sleeve can be prevented by the second shut-off valve being formed by a second central shoulder of the plunger, so that this second shut-off valve at the same time forms the external seal of the cylindrical guide of the plunger in the open position of the first valve.

For a better understanding of the invention and the method of carrying the same into effect, reference will now be made to the accompanying drawings, in which:

FIGURE 1 is an overall circuit diagram of a pneumatic safety device for a reversible marine diesel engine, and

FIGURE 2 is a partly sectioned elevation of a detail of the device of FIGURE 1.

On the navigating bridge of the ship or on a control station set up at another place at some distance from the engine are a valve **2** for reversing and starting in the

"ahead" direction of rotation, a valve 1 for reversing and starting in the "astern" direction of rotation and a stop valve 3. The valves are accommodated in a common housing 4 containing a chamber 5 supplied with compressed air. Instead of the individual operation by push-buttons as shown, the valves 1, 2, 3 may also be operated by means of a cam-shaft, to which is fixed a lever. Each valve consists of a valve cone 1*a*, 2*a* or 3*a*, a pressure spring 1*b*, 2*b* or 3*b*, which holds the cone on its seat, a hollow push-button 1*c*, 2*c* or 3*c* and a spring 1*d*, 2*d* or 3*d*, for returning the push-button to the inoperative position, in which the line controlled by the valve in question is exhausted.

All the other parts are mounted on the engine itself. From the valve 2, a line 6 leads to the space 7 of an operating cylinder 8, in which slides a piston 9 brought into the centre position shown by springs 10 and 11 when the spaces 7 and 12 are discharged. The space 12 of the cylinder 8 is connected by the line 13 to the valve 1. Connected to the piston 9 is a piston rod 14, which is guided by a guide 17. A pin on the rod 14 engages in a slot 15 in a reversing lever 16. The lever 16 can assume the positions V (ahead) and Z (astern), as well as the centre position shown. Connected to the reversing lever 16 is a multiple cam 18 which is fast with the lever 16 in the rotary direction but slidable relative to the lever 16 in the axial direction of the cam. The multiple cam 18 has an individual cam 18*a* for reversing "ahead," an individual cam 18*b* for reversing "astern," an individual cam 18*c* for starting "ahead" and an individual cam 18*d* for starting "astern." The cam 18 is rotatably mounted on an extension 19 of the cam-shaft 20 and is secured against longitudinal sliding by collars 21 and 22, so that it follows any longitudinal displacement of the cam-shaft 20 (see FIGURE 2). The cam-shaft 20 is shown in the "ahead" position in FIGURE 2. In the "astern" position the camshaft is displaced somewhat to the left of the position shown in FIGURE 2. The reversing lever 16 slidably engages in a logitudinal groove 23 of the multiple cam 18, and does not follow the longitudinal movement of the cam 18. The individual cam 18*a*, in the "astern" position of the cam-shaft 20, can upon rotation of the cam 18 engage a reversing valve 24 for reversal to "ahead." The individual cam 18*b*, in the "ahead" position of the cam-shaft 20, can upon rotation of the cam 18 engage a reversing valve 25 for reversal to "astern." The individual cam 18*c*, in the "ahead" position of the cam-shaft 20, is engageable with a starting valve 26. The individual cam 18*d*, in the "astern" position of the cam-shaft 20, is engageable with the starting valve 26. The valves 24, 25, 26 respectively comprise the valve cones 24*a*, 25*a* and 26*a*, and the pressure springs 24*b*, 25*b* and 26*b*, holding the valve cones on their seats. A line 28 coming from a pressure-reducing valve 27 and in which prevails a pressure of about 8 kg./cm.^{2} leads to the valves 24 and 25. A branch 29*a* of a high-pressure air line 29 leads to the valve 27, and a branch 29*b* of the same line leads to the valve 26. The line 29 itself is connected to a main starting valve 30. The main starting valve 30 comprises the piston valve 30*a*. The line 29 opens into a space 30*b* above a cone 30*c* of the piston valve 30*a*. The valve 30 is connected by a line 31 to the starting valves (not shown) mounted on the engine cylinders. A line 32*c* coming from a shut-off member 50, leads to a space 30*d* on one side of a piston 30*e*.

From the valve 24, a line 33 passes with its branch 33*a* to an oil container 35*a*. From the valve 25, a line 34 with its branch 34*a* leads to an oil container 35*b*. The oil containers 35*a*, 35*b* are in communication with spaces 35*c* and 35*d* in front of and behind a displacement piston 35*e*, fixed on the cam-shaft extension 19 and disposed in a displacement cylinder 35. The cam-shaft extension 19 is rotatable relatively to the cam-shaft 20 but is fast with it in the axial direction.

A line 36 leads from the pressure-reducing valve 27 via a shut-off valve 37 to the space 5 of the housing 4. A line 38 leads from the stop valve 3 to a port 39*b* of a doble non-return valve 39, in which a valve piston 39*a* is slidable to connect either a port 39*b* or a port 39*c* to a port 39*d*. Branches 33*b* and 34*b* of the lines 33 and 34 are connected to ports 40*c* and 40*b* of a double non-return valve 40, in which a valve piston 40*a* is slidable to connect either the port 40*b* or 40*c* to a port 40*d*. The port 40*d* is connected by a line 41 to the port 39*c* of the double non-return valve 39. A line 42 leads from the port 39*d* of the double non-return valve 39 to an operating cylinder 46, in which slides a piston 46*a*. By means of a piston rod 46*b*, a collar 46*c* and a bell crank 47, the piston 46*a* is able to shift a control rod 45 in the stop direction. On the bell crank 47 is a catch 47*b*, in which a pawl 48 having a roller 48*a* can engage under the action of a spring 49, when the control rod 45 is in the stop position. On the piston rod 46*b* is a disc 46*d* arranged for pushing the pawl 48 out of range of the catch 47*b*. The bell crank 47 has an arcuate extension 47*a* which holds the pawl 48 on starting and during operation in a position in which the pawl 48 maintains the shut-off member 50 open. The shut-off member 50 comprises a valve cone 50*a* and a pressure spring 50*b*. In the open position, the member 50 connects the space 30*d* by way of the lines 32, 32*b* and 32*c* to the starting valve 26. In its closed position, the member 50 exhausts the space 30*d* to atmosphere. A speed-dependent control member 51 is inserted in the lines 32, 32*a* and 32*d* leading from the starting valve 26 to the upper side 46*e* of the piston 46*a*. The control member 51 comprises the centrifugal governor 52 with a weight holder 52*a* and centrifugal weights 52*b*. The weight holder 52*a* is fast on a shaft 53, driven in a manner not shown by the diesel engine. The centrifugal weights 52*b* transmit the centrifugal force set up on rotation of the shaft 53 via a thrust bearing 54 to a plunger 55, which is guided by its central cylindrical part 55*a* in a valve housing 56 in an approximately airtight manner. On the central part 55*a* is a shoulder 55*b*, which together with a counter-surface on a rubber ring 56*a* carried by the housing 56 forms a first shut-off valve, which controls communication between the lines 32*a* and 32*d*. Acting on one end 55*c* of the plunger 55 is a spring 57, the spring force being adjustable by means of screw 58. This spring force is counteracted by the centrifugal force acting on the other end 55*d* of the plunger 55. On the central part 55*a* of the plunger 55 is a second shoulder 55*e*, which together with a counter-surface on a rubber ring 56*b* carried by the housing 56 forms a second shut-off valve which controls a discharge bore 55*f*. When the first shut-off valve is open, the second is closed, and vice versa.

The mode of operation of the device will be described with reference to a reversing operation.

In the drawing, the cam-shaft 20 is shown in the "ahead" position. If the push button 1*c* is pressed, compressed air is admitted to the space 12 of the operating cylinder 8 through the line 13, and the lever 16 moves to the Z position. The lever 16 can also be moved by hand to this position. The multiple cam 18 is thereby rotated in the anti-clockwise direction and the individual cam 18*b* opens the reversing valve 25, whereby compressed air is admitted to the oil container 35*b* by way of the lines 34 and 34*a*. At the same time, compressed air passes through the line 34*b* to the port 40*b* of the double non-return valve 39, where it presses the valve to the right to close the port 40*c*, whereby the port 40*d* is placed in communication with the port 40*b*. Compressed air passes via the line 41 to the port 39*c* of the double non-return valve 39, where it presses the valve piston 39*a* downwardly to close the port 39*b*, thus uncovering the port 39*d*. Compressed air thus acts via the line 42 on the side 46*f* of the piston 46*a*. The piston 46*a* moves into its upper position, and by means of the piston

rod 46*b* and the bell crank 47 moves the control rod 45 into the stop position, i.e. the position in which the fuel injection pump of the engine gives zero delivery. The roller 48*a* engages the catch 47*b* so that the control rod 45 is locked in the stop position. The engine speed therefore falls. In the meantime the air admitted to the container 35*b* has expelled oil therefrom to the space 35*d* so that the cam-shaft 20 has moved to the left (FIGURE 2), the cam 18*b* coming out of engagement with the valve cone 25*a* shortly before the left-hand end position is reached, while the individual cam 18*d* opens the valve 26. It will be assumed that due to the turbine effect of the ship's propeller, the engine speed is still so high that reliable reversal is impossible. In this case, the centrifugal weights 52*b* press the shoulder 55*b* on to the rubber ring 56*a*, so that communication is cut off between the lines 32, 32*a* and 32*d*. The piston 46*a* remains in its upper position and the shut-off member 50 remains closed. Only the centrifugal force and the force of the spring 57 are applied to the plunger 55, since the diameter of the central port 55*a* equals the effective diameter of the seal formed by the shoulder 55*b* and the ring 56*a*. The piston side 46*e* communicates with atmosphere through the line 32*d* and the bore 55*f*, since the shoulder 55*e* is lifted off the rubber ring 56*b*. When the speed drops to a value which is safe for reversal, the force of the spring 57 overcomes the force exerted by the centrifugal weights and lifts the shoulder 55*b* off the rubber ring 56*a*. The pressure of the starting air now bears on the plunger 55 and presses its shoulder 55*e* against the rubber ring 56*b*, thereby shutting the bore 55*f* off from the atmosphere. The side 46*e* of the piston 46*a* is put under pressure, the piston rod 46*b* moves downwardly and the valve 50 is opened. The roller 48*a* disengages the catch 47*b* and the control rod 45 is left to the influence of a speed governor (not shown) which brings it to the position for full injection quantity. High-pressure compressed air passes from the opened valve 26 through the valve 50 and the lines 32, 32*b* and 32*c* to the main starting valve 30 and opens the latter, thereby admitting compressed air to the engine cylinders. The engine is thereby braked and started in the "astern" direction of rotation. Upon the push-button 1*c* or the lever 16 being released, the latter returns to the central position by the action of the spring 10 and because the space 12 is discharged. The cam 18*d* is thereby brought out of engagement with the valve 26, and the latter and the main starting valve 30 close so that the supply of starting air ceases and the engine operates in the normal manner. In the meantime, the engine speed has risen to the normal value. Compressed air no longer acts on the plunger 55, since the starting valve 26 is shut, so that the force exerted by the centrifugal weights 52*b* overcomes the force of the spring 57 and presses the shoulder 55*b* on to the rubber ring 56*a*. The piston side 46*e* is thereby relieved of load, but the valve 50 remains open until a new reversing operation occurs which results in closing of the valve 50.

In reversing from "astern" to "ahead," corresponding operations take place with the difference that in this case, the individual cams 18*a* and 18*c* and the valve 2 are operative and that there is admission to the space 7, the oil container 35*a* and the space 35*c* of the displacement cylinder 35.

When the button 3*c* is pressed, compressed air passes via the valve 3 through the line 38 to the double non-return valve 39, where it presses the valve piston 39*a* upwardly to close the port 39*c*. The ports 39*b* and 39*d* are thereby connected so that compressed air passes to the operating cylinder 46. The control rod 45 is thus brought to the stop position, as already previously described. When the button 3*c* is released, the line connection described is exhausted to atmosphere the control rod 45 remaining locked in the stop position until the engine is started again.

I claim:

1. A control installation for selectively reversing the direction of operation of an internal combustion engine and for starting said engine, comprising in combination a displaceable camshaft of said engine, power operator means coupled to said camshaft for displacing said camshaft by first and second displacements according to the desired direction of said engine, first valve means for activating said power operator means to effect said first displacement of said camshaft to determine a first direction of operation of said engine, second valve means for activating said power operator means to effect said second displacement of said camshaft to determine a second and opposite direction of operation of said engine, third valve means for initiating starting of said engine, said third valve means being actuatable following operation of one of said first and second valve means and upon completion of displacement of the camshaft effected by such valve means, speed sensitive governor means preventing above a definite speed range of said engine said third valve means from becoming effective, said governor means allowing said third valve means to become effective within said speed range, locking means controlling starting of said engine, said locking means being in an engine starting position upon and during effective actuation of said third valve means, said locking means being released upon ineffectiveness of said third valve means.

2. A control installation for selectively reversing the direction of operation of an internal combustion engine and for starting said engine, comprising in combination a displaceable camshaft of said engine, a first power operator coupled to said camshaft for displacing said camshaft by first and second displacements according to the desired direction of operation of said engine, first valve means for activating said first power operator to effect said first displacement of said camshaft to determine a first direction of operation of said engine, second valve means for activating said first power operator to effect said second displacement of said camshaft to determine a second and opposite direction of operation of said engine, third valve means for initiating starting of said engine, a source of compressed fluid, said first, second and third valve means being connected for supply by said source of compressed fluid for activating said first power operator and for starting said engine under the influence of compressed air, first cam means for operating said first valve means, second cam means for operating said second valve means, means for stopping the flow of fuel to said engine upon operation of one of said first and second valve means, coupling means connecting said camshaft with said first and second cam means to cause said first and second cam means to follow said first and second displacements of said camshaft, said first and second cam means operating said third valve means upon completion of either of said first and second displacements and prior operation and release of one of said first and second valve means, said stopping means being released upon release of an operated one of said first and second valve means, a speed sensitive governor, a fourth valve means actuated by said governor and controlling starting of said engine, said governor closing said fourth valve means above a definite speed range of said engine and opening said fourth valve means inside said speed range, a line connecting said fourth valve means in series with said third valve means, locking means controlling the flow of fuel to the engine and the flow of air for initiating starting of said engine, said locking means permitting both such flows upon opening of said fourth valve means and being locked in a position preventing such flows upon actuation of said stopping means consequent upon operation of one of said first and second valve means.

3. A control installation according to claim 2, wherein said speed sensitive governor comprises a driving member operationally connected to said engine, centrifugal weights pivotally connected to said driving member, a

sleeve member abutting on said centrifugal weights, a valve member connected with said sleeve means and biased by a spring member against the centrifugal forces of said centrifugal weights.

4. A control installation according to claim 2, wherein said fourth valve means comprises a valve housing, a valve member movable in said valve housing, a first shoulder on said valve member, a first sealing face on said housing co-acting with said first shoulder, a second shoulder on said valve member, a second sealing face on said housing, co-operation between said first shoulder and said first sealing face controlling flow of compressed fluid through said line, and co-operation between said second shoulder and said second sealing face controlling venting of said line to atmosphere.

5. A control installation according to claim 2, wherein said stopping means comprises a double check valve connected to be operated upon operation of one of said first and second valve means to let compressed fluid flow from said source of said fluid via the operated valve means through a line leading to said locking means, said double check valve venting this line upon release of the operated one of said first and second valve means.

6. A control installation according to claim 2, and further comprising a third power operator controlling said first and second cam means, reversing valves remote from said third power operator and serving to control same, and a lever connected to said cam means for manual operation thereof.

7. A control installation according to claim 2, wherein the engine has a fuel rod for controlling supply of fuel, and wherein said locking means comprises a second power operator, said second power operator including a double acting cylinder and a piston sliding in said cylinder and dividing the latter into first and second working chambers on opposite sides of said piston, a piston rod fixed to said piston and connected to the fuel rod of said engine so as to shift said fuel rod into a zero delivery position upon fluid entering under pressure into said first working chamber, a locking pawl for locking said fuel rod in the zero delivery position, means causing said pawl to release said fuel rod upon compressed fluid entering into said second working chamber, fifth valve means controlling supply of starting air to the engine, a line connecting said third and fifth valve means in series, said fifth valve means being opened upon entry of compressed fluid into said second working chamber, said second working chamber being connected to the first-mentioned line on the downstream side of said second and fourth valve means the latter of which vents this line to atmosphere when not connected to supply the second working chamber with compressed fluid, said first working chamber being connected with said stopping means so as either to be set under pressure or vented by the action of said stopping means.

8. A control installation according to claim 7, and further comprising a shut-off valve remote from the stopping means, the latter being a double check valve connected to said shut-off valve whereby upon operation of the shut-off valve said first working chamber can be pressurised and subsequently vented.

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