June 30, 1942. G. J. WOHANKA 2,288,173

CONTROLS FOR INTERNAL COMBUSTION ENGINES

Filed Aug. 2, 1940 2 Sheets-Sheet 1

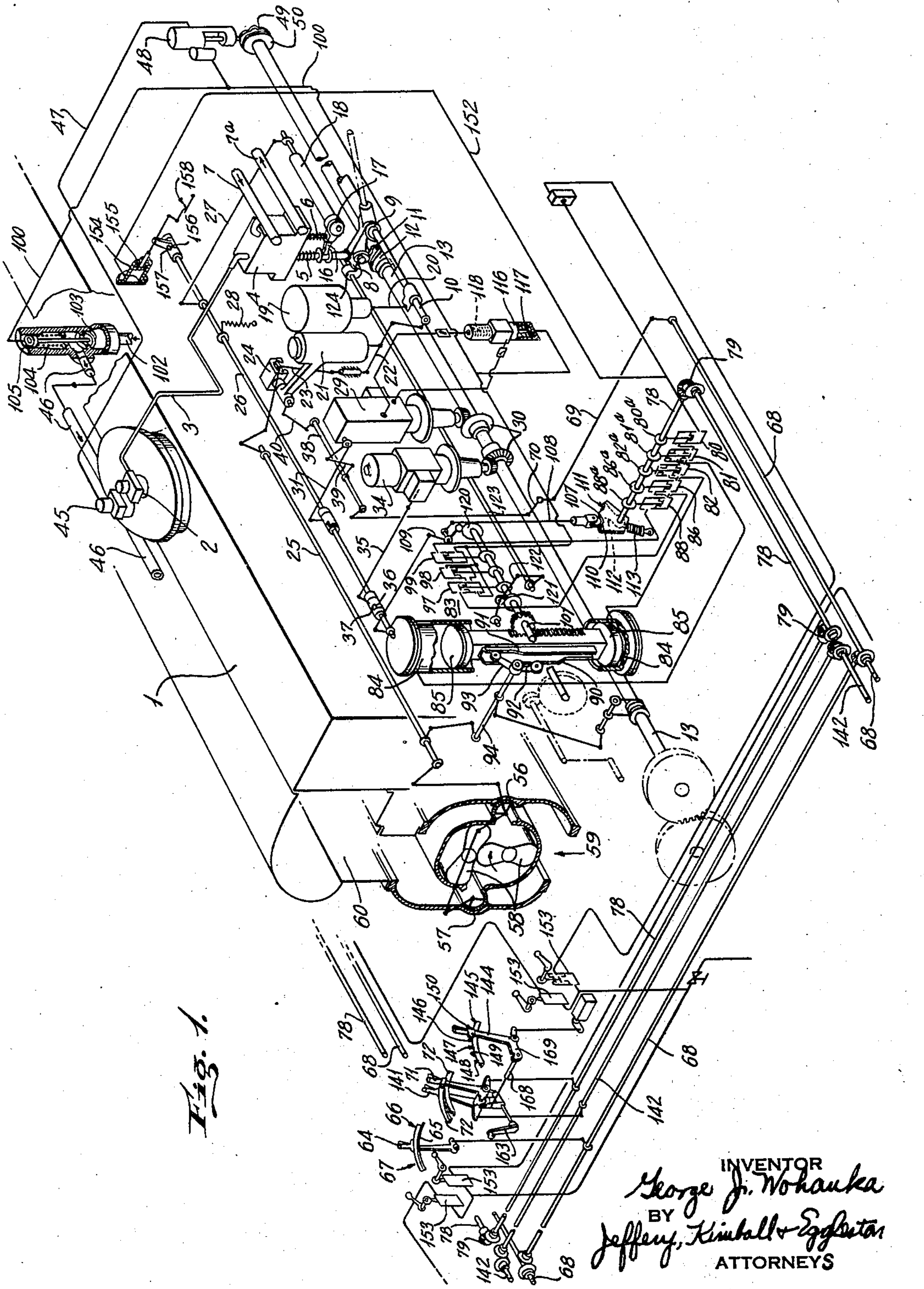

Fig. 1.

INVENTOR
George J. Wohanka
BY
Jeffery, Kimball & Eggleston
ATTORNEYS

June 30, 1942. G. J. WOHANKA 2,288,173

CONTROLS FOR INTERNAL COMBUSTION ENGINES

Filed Aug. 2, 1940 2 Sheets-Sheet 2

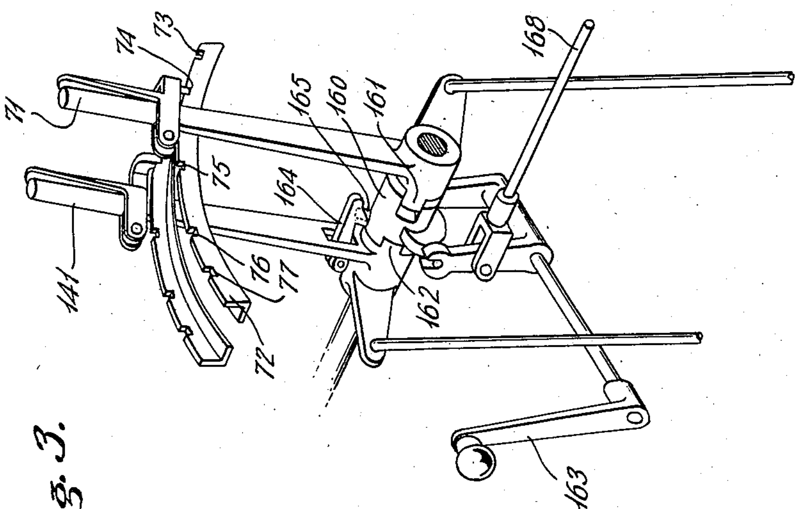

Fig. 3.

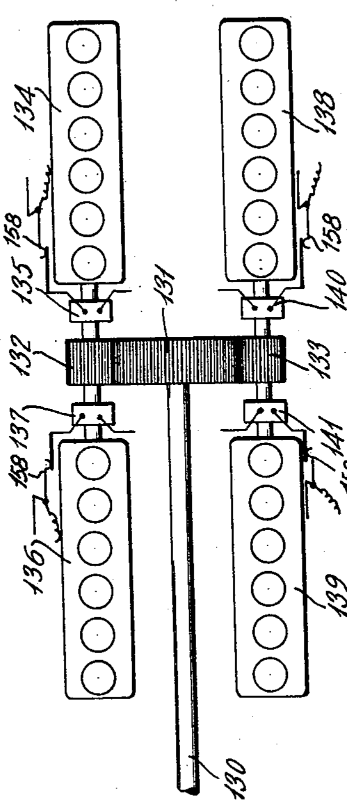

Fig. 2.

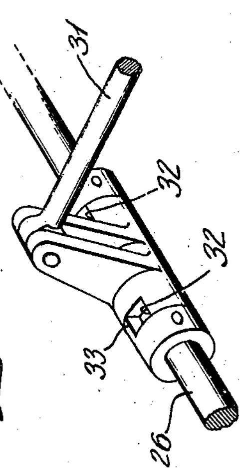

Fig. 4.

INVENTOR
George J. Wohanka
BY
Jeffery, Kimball & Eggleston
ATTORNEYS

Patented June 30, 1942

2,288,173

UNITED STATES PATENT OFFICE

2,288,173

CONTROL FOR INTERNAL COMBUSTION ENGINES

George J. Wohanka, St. Louis, Mo., assignor to Busch-Sulzer Bros.-Diesel Engine Company, St. Louis, Mo., a corporation of Missouri

Application August 2, 1940, Serial No. 349,793

12 Claims. (Cl. 60—97)

The invention relates to internal combustion engines and particularly to internal combustion engines of the fuel-injection type. Primarily the invention provides mechanism especially suitable for controlling an engine of this sort. Additionally it provides a control arrangement for an installation comprising two or more such engines.

Briefly, in controlling a single engine the invention contemplates the use of, say, a single handle having a few more or less definite positions such as "stop," "start" and "running," and power-operated mechanism to carry out automatically the operations necessary to effectuate the operator's intentions as indicated by the placement of the handle in any of these positions. If the engine is to operate in reverse at times, as well as ahead, appropriate additional handle positions may be provided such as "start astern" and "run astern," as well as "start ahead," "run ahead" and "stop." Instead of a single handle having such positions, a series of separate handles, switches, push buttons or the like, say one corresponding to each of these handle positions, might be substituted for the single handle. Preferably the speed of the engine is controlled by a separate handle; it may however be a series of levers, switches, push buttons or the like, each representing, say, a desired speed. In the case of an installation consisting of a number of engines, two or more of the engines may be placed under the control of the same start-stop-run handle or the same set of devices effectuating the same results, and two or more may be placed under the control of the same speed-controlling handle or a set of speed-controlling devices.

As appears hereafter, the invention is particularly applicable to a power plant comprising two or more engines driving a load which at times needs to be driven in the reverse of its normal direction, and where each engine is connected to the load through a releasable clutch. Engine installations for driving ships are examples.

The accompanying drawings illustrate diagrammatically the preferred form of the invention as applied to a reversible solid-injection engine of a substantially, conventional construction, and also as extended to a group of four engines for ship propulsion. It will be understood however by those skilled in this industry, that the invention is not limited either to this form of engine or to the form of multiple-engine installation illustrated, but that the drawings are simply representative in those matters.

Fig. 1 illustrates particularly the application of the invention to one such engine, but by indicated extensions of some of its elements this figure shows how the invention can be extended to control three other engines as well. Fig. 2 is a plan view illustrating a four-engine power plant driving a single ship's propeller shaft, such as may be controlled by the extended form of my invention. Figs. 3 and 4 are details of preferred construction.

Referring first to Fig. 1, and particularly to the construction of the engine to which my invention is here shown applied: At 1 is indicated the top of a multiple-cylinder engine of the Diesel type, of which however only one cylinder is indicated. Each cylinder of this engine is provided with a solid-injection fuel valve 2 to which fuel is supplied by pipe or connection 3 from an individual fuel pump 4 of which 5 is the plunger and 6 is the control valve stem. It will be understood that each cylinder has its own injection valve 2 and fuel pump. Fuel is supplied to all the pumps by the manifold 7, and the plunger 5 of each fuel pump 4 is operated through a rocker arm 8 adjustable in the usual way by its eccentric fulcrum 9 carried by the lead control shaft 10 which is common to all the pumps. This arm is operated by an individual cam 11 when the engine is being driven ahead, or by another individual cam 12 when the engine is being driven in the opposite direction, i. e. "astern." All the fuel cams 11 and 12 of the various fuel pumps will be understood to be carried by the same cam shaft 13. This cam shaft is driven in phase with and by the engine 1 crankshaft and can be moved longitudinally of itself to bring the cams 11 underneath the rockers 8 or to bring the cams 12 underneath their rockers, as the desired direction of running of the engine may require. As will be understood, the lead, or time of fuel injection with respect to the operating cycle of each engine piston is adjustable by rocking the lead shaft 10.

The control valve 6 of each pump 4 is operated by a lever 16 in the usual way; one end of each lever 16 is carried between collars on its associated pump plunger 5 and the other end of it turns on an eccentric 17 of the eccentric shaft 18 which serves similarly the suction valve levers of all the other pumps of the engine. By turning the eccentric shaft 18, the fuel supply to all cylinders of the engine 1 may be discontinued, or it can be set to any desired rate of supply up to the maximum. A manifold 7*a* serves to return surplus fuel from the control valves to the fuel tanks as will be understood.

As has been customary (since considerable power is required to shift the control gearing of large engines), the lead shaft **10** is adjusted (rocked) as needed by a power cylinder **19**, the piston rod **20** of which is operated by oil pressure under the control of a slide valve in the slide valve chamber **21**; as customary, the slide valve in chamber **21** is positioned by action of the lead shaft **10** operating through lever **22** and, jointly therewith, by a link **23** the upper end of which is positioned in a pivoted cross head or link-motion guide **24**, so that by sliding the upper end of the link **23** in cross head **24**, as by means of the rock shaft **25**, the position of the slide valve in **21** is changed correspondingly and thereby oil under pressure is admitted to one side or the other of the piston of piston rod **20** to move the latter until the reaction from the lead shaft **10** again shifts the valve to stop the motion. Fuel pump eccentric shaft **18** is rocked to adjust and control the fuel input by means of the fuel control shaft **26** through a connecting arm **27**. This fuel control shaft **26** is biased toward, i. e. tends to move to maximum fuel position, for example by the action of a spring **28**. This motion is opposed by the governor **29** allocated to the engine (i. e., in a multiple engine installation there is one such governor for each engine); this governor may be driven by the cam shaft **13** as indicated at **30**. In the present instance an increase in speed causes the governor **29** to shift the link **31** to the left, thus bringing hub abutments **32** against abutments **33** which are fixed to the fuel control shaft **26** (see Fig. 4); thereby the governor **29** fixes the position of the fuel control shaft **26** against the pull of spring **28**. Additionally an overspeed or cut-out governor **34** may be employed, being related to the control shaft **26** in the same manner as governor **29** (cf. Fig. 4); i. e. normally the link **35** of this overspeed governor **34** is held so far to the right that its hub abutment **36** is well out of contact with the abutment **37** fast on the fuel control shaft **26** so that this governor is without effect; on the occurrence of a definite unduly high speed however, the abutments **36** are thrust against the abutments **37** and thereby the fuel control shaft **26** turned definitely to a position where all fuel is cut off from the engine as will be understood.

In the present instance the engine **1** (and if desired each of the engines of Fig. 2) is started by compressed air stored in starting-air tanks as customary. Briefly, some or all of the cylinders of the engine **1** are provided with starting-air valves **45** which, when forced open, admit the flow of the compressed air from the starting-air tank, through a manifold **46**, to the respective cylinder. During the engine-starting periods, each starting valve **45** is opened at the proper times by compressed air supplied to it through an individual pipe **47**. The supply of the controlling air is under the direction of individual pilot valves **48** (one for each cylinder) each of which is operated by two cams **49** or **50** (one for use when starting the engine in the ahead direction and the other when starting the engine in the reverse or astern direction) carried by the cam shaft **13** of the respective engine. Preferably these pilot valves **48** are of such construction that the stems of the valve are held raised from their cams **49** and **50** until controlling air for the starting valves **45** is fed to them as later described; this permits the cam shaft **13** to be shifted lengthwise without the cams **49** and **50** striking the valve stems; however, it is well to bevel the side faces of these cams to take care of abnormal conditions in this respect. Preferably, too, the pilot valves **48** are so constructed that they vent, ultimately, any remnant of compressed air remaining in the pipe or pipes supplying them, after further supply to those pipes is shut off.

Preferably the combustion air is supplied to cylinders of the engine **1** by a Root type blower, as will be sufficiently understood from United States Patent No. 2,021,204. However, an intake passage, and likewise a discharge passage leading to the engine combustion air manifold, is provided at each side of the impellers, and also valves are provided to direct the air in either direction, dependent on the direction of rotation of the impellers; preferably these valves comprise two valves **56** and **57** of a semi-cylindrical rocking type as shown. This arrangement permits this type of blower to supply combustion air to reversible engines. Thus with the valves **56** and **57** in the positions indicated, rotation of the pump impellers **58** in the direction of the arrow will cause air from the atmosphere to be drawn in from the pump inlet port **59** and discharged into the combustion air manifold **60** from the engine, while reversal of the position of the valves **56** and **57** will permit the blower to supply air to the engine with the impellers **58** rotating in the opposite direction.

In applying the invention to, for example, an engine having the construction thus described, there is preferably employed a manual lever **64** to fix the speed at which the engine is to operate. From its function, such a lever can be called a throttle, and such a throttle may work along an arc **65** and at any moment be held at a maximum speed position **66**, a minimum speed position **67**, or at positions intermediate these two extremes to obtain a corresponding speed. Preferably it operates by imposing a load on the governor **29** corresponding to the throttle position in each instance, and to this end the throttle may be coupled through a shaft or shafts **68** and links and levers **69** and **70** to rock shaft **38** which, acting through a link **39**, determines the load on the governor **29**. By rocking shaft **38** by the throttle **64** therefore, to a new position, the governor **29**, acting through the control shaft **26**, is made to increase or decrease the rate of fuel supply as appropriate to secure the desired change in speed. At the same time, the rock shaft **38**, acting through the link **40** for example, may shift the cross-head **24** of the lead-controlling mechanism to change the lead of the fuel feed as may be appropriate to the change in speed.

As before indicated, the manual control of the direction of rotation of the engine crank shaft (i. e., whether it is to be driven "ahead" or, in reverse "astern" and also the starting of the engine, the changing over from air operation to operation on fuel, and the stopping of the engine, is exercised through a second or maneuvering lever **71** which may operate along an arc **72** to which it may be clutched in various positions corresponding to the direction it is desired to give. For example, it may have a "start ahead" position **73** (in which the engine will be started by and operated on compressed starting-air in the "ahead" direction), a "run ahead" position **74** (in which the engine will be operated on fuel in the "ahead" direction), a "stop" position **75** (in which position neither fuel nor air will be supplied to the engine), a "run astern" position 76 (in which the engine will be operated by fuel in the opposite or "astern" direction), and a "start astern" position 77 (in which position the engine, being stopped, may be started in motion in the "astern" direction by the use of the starting-air). The lever 71 (like the throttle 64) may be located at any convenient position, and performs its function by setting a pilot mechanism or mechanism appropriate to the control of whatever medium may be selected to adjust the engine gearing. Preferably I employ compressed air for this medium, which may be taken from, for example, the starting-air tanks, and in such a case the maneuvering pilot mechanism may consist of a set of valves as hereafter described. This maneuvering pilot mechanism, whatever its nature, can be located at any convenient place; usually I mount it on the side wall of the engine. When it is located remote from the maneuvering lever 71 (or substituted device or devices), the movements of the lever (or substituted parts) are conveyed to it by appropriate mechanism such as the shafts 78 and connecting gears 79, for example.

The maneuvering pilot mechanism consisting of a series of valves in the present instance, the last of the shafts 78 carries a cam for operating each of its valves. The first of these valves, at 80, to which the operating air first comes, is primarily a shut-off valve to help prevent leakage of the operating air; its operating cam 80*a* is so shaped as to hold the valve open whenever the maneuvering lever 71 is in "start ahead" or "start astern" position, and also (for a special reason appearing hereafter) whenever lever 71 is in "run astern" position. Shown next in order are the valves at 81 and 82. The valve or valves at 81, in one position, direct the flow from valve 80, of the air necessary to change the engine gearing from "astern" running position to "ahead" running, and in the opposite position of this or these valves permits the escape of air previously supplied for this purpose; the cam 81*a* controlling this or these valves at 81 is so shaped as to permit the flow of gearing-changing air while the maneuvering lever 71 is in its "start ahead" position, and in all other positions of the maneuvering lever, shuts off this flow, and permits the air previously supplied to escape. Likewise the valve or valves at 82, in one position, direct the flow, from valve 80 of the air necessary to change the engine gearing from "ahead" running to "astern" running, and in the opposite position permit the escape of the air previously supplied for this purpose; the operating cam 82*a* of this or these valves 82 is so shaped as to permit the flow of such air while the maneuvering lever 71 is in its "start astern" and "run astern" positions, and, in all other positions of the maneuvering lever holds open an escape passage for the air previously supplied through 82. The air flowing from valve 80 through these valves at 81 and 82 is carried to a motor device to thereby shift the engine gearing from "ahead" to "astern" and vice versa. Preferably this motor comprises a servo-motor cylinder 84 having a piston 85 appropriately connected to the engine gearing to effect the shifting as the piston moves from one end of its stroke to the other as air is supplied it through 81 or through 82. Additionally, the maneuvering pilot mechanism includes one, and preferably two other valves 86 and 88 which, when open, permit the flow, from valve 80 of the air necessary to actuate the starting-air valves 45 under the control of their pilot valves 48. The cam 86*a* controlling valve 86 is so shaped as to hold this valve open when the maneuvering lever 71 is in its "start ahead" position; the cam 88*a* controlling valve 88 is so shaped as to hold valve 88 open when the maneuvering lever 71 is in its "start astern" position; in all other positions of the maneuvering lever 71, these valves 86 and 88 are closed. The air flowing from the valves 86 and 88 (or one valve performing both functions) can be led to the air-starting pilot valves 48 direct but I prefer to insert in their (or its) line an interlocking valve, or interlocking valves 83, to prevent the flow reaching those pilot valves 48 except when the engine gearing is in position for the starting of the engine; this as a safety measure.

Generally speaking, the motor or power device 84—85 does whatever may need to be done to the engine gearing for change in direction of engine running; specifically, the things to be done will depend on the nature of the particular engine gearing employed of course. In the present instance, it lifts the fuel pump plunger rockers 8 from their cams (preferably), then shifts the cam shaft 13 lengthwise to change the cams 11 and 12 beneath the rockers and the cams 49 and 50 underneath the air starting pilot valves 48, and then lowers the plunger rockers to their new operating cams; also it rocks the reversing shaft 25 to change the position of the lead link 23 in the lead cross-head 24, to obtain the proper lead for the reverse running, and changes the positions of the blower valves 56 and 57. Conveniently, these things are done by rectangular cams 90 and 91, mounted on the piston 85, and a pair of roller arms 92 and 93, bearing on these cams respectively and fastened to a rock shaft 94 which is so connected to the reversing shaft 25 and the cam shaft 13 as to shift these as the cams 90 and 91 pass under or from the roller arms 92 and 93; for convenience the blower valves 56 and 57 are connected to shaft 25 for operation thereby. The movement of the piston 85 to its lower position shifts the gearing to its ahead running position, whereas movement of the piston to its opposite position adjusts the gearing to its astern running position. An arrangement by which the motor 84—85 may lift and lower the pump plunger rocker 8 is described hereafter. The motor 84—85 may of course be set in any position desired and convenient. If it is disposed vertically as illustrated, means may be provided, as a safety measure, to prevent it drifting from its upper to its lower position. This is the purpose of holding the maneuvering pilot valves 80 and 82 open in the "run astern" position of the maneuvering lever 71.

The interlocking valve or valve set 83 preferably comprises three valves 97, 98 and 99. Valve 97 receives air from maneuvering pilot valve 86 and, when open, permits the flow of that air to a line 100 leading to the air-starting pilot valves 48. Likewise valve 99 receives air from maneuvering valve 88 and, when open, permits the flow of such air to the same line 100. The intermediate valve 98, when open, permits the escape of air from the line 100. These valves 97, 98 and 99 are controlled by individual cams on the motor-controlled shaft 101. The cam for valve 97 is so shaped that that valve is held open only when the motor piston 85 is fully in the extreme position (illustrated in the drawing) to which it arrives after having reset the engine gearing in the "run ahead" position; the valve 99 is held open only when the motor piston 85 is in its extreme opposite position in which the engine gearing is fully set in its "run astern" position; valve 98 is held open only for a short interval during the movement of the motor piston 85 from each of its extreme positions to its opposite position. It will be seen therefore that while the maneuvering lever 71 and pilot maneuvering mechanism, can direct the flow of starting air toward the starting air valves, no starting air can actually reach these valves unless and until the engine gearing has been set for operation of the engine in the desired direction.

The starting-air for the starting-air manifold 46 is supplied from the starting-air tanks through pipe 102, and preferably a shutoff valve 103 is inserted between the starting air tanks on the manifold 46 to avoid leakage at the manifold and starting air valves when the starting air is not being used. For this purpose, I may provide a shutoff valve 103 with a spring 104 tending to close it (or depend simply on the air pressure to close it), and also provide it with a piston 105 for automatic opening on the supply of air to the line 100. When air in this line is vented, this valve 103 will close as will be understood. Air is supplied to the manifold 46 when needed therefor, but at all other times is excluded from the manifold.

As before indicated, air remaining in the line 100 after the closing of maneuvering pilot valves 86 and 88 is vented promptly at the pilot starting valves 48. If reversal of the engine gearing should be called for before line 100 is emptied, this line will be vented at the interlocking valve 98 during the reversing operation.

With the engine gearing of the construction described at least, the control of the fuel at the pilot maneuvering mechanism is effected mechanically, preferably. To this end, the last of the connecting shafts 78, for example, can be provided with a cam member 107 and a cooperating rod 108 and rocker 109, arranged to rock the fuel control shaft 26. The cam 107 is so shaped as to turn the fuel control shaft 26 to its "no fuel" position and hold it there whenever the maneuvering lever 71 is brought to either its "start ahead" or "start astern" position (thus preventing fuel being supplied to the engine simultaneously with starting air) but to release the shaft 26 to the control of the governor 29 again whenever the maneuvering lever 71 is returned from "start ahead" to "run ahead," or is returned from "start astern" to "run astern." Preferably also the cam 107 is so shaped as to turn shaft 26 to its "no fuel" position, and hold it there, when the maneuvering lever 71 is brought to its "stop" position, thereby enabling the operator to stop the engine by means of the maneuvering lever 71. In the present instance, the low spots 110 or 111 on cam 107 permit the rod 108 to fall to restore the placement of the fuel control shaft 26 in the control of the governor 29, and correspond to the "run ahead" and "run astern" positions of the maneuvering positions of the maneuvering lever 71. All elsewhere the cam 107 holds the control shaft in "no fuel" position. The interrelation between the cam 107 and the cams 86a and 88a operating therewith, prevents starting-air and fuel being supplied to any cylinder simultaneously.

To prevent the possibility of fuel being supplied to the engine inadvertently by movement of the maneuvering mechanism from stop toward "start astern" while the engine gearing is set for ahead running (or vice versa), the appropriately opposite low spot (111 or 110) may be bridged temporarily. This may be done by a followup cam 112 mounted loosely on the axis of the fuel cam 107, face to face with this fuel cam and of sufficient length to bridge, one at a time, the low spots 110, 111, assisted by a (here compressed) spring 113 tending to force this follow up cam toward the "astern" edge of the cam 107 when the engine gearing is set for ahead running, and vice versa, and the point of connection of which crosses the axial line of the two cams as cam 107 moves from one extreme position to the other. Thus when these two cams are in the positions illustrated in the drawing, movement of the maneuvering handle 71 to "start astern" will cause the followup cam 112 to be carried underneath the fuel control rod 108 and thereby this rod prevented from dropping into the low spot 111. However, at least as soon as the maneuvering lever 71 is started back toward "run astern" position, the action of spring 113 will throw the followup cam 112 to opposite the low spot 110, thus making the low spot 111 available to the control rod 108. Likewise when maneuvering lever 71 is turned to "start ahead" again, the followup cam 112 will carry the fuel control rod 108 across the low spot 110, and subsequently the return of the maneuvering lever 71 to "run ahead" will result in the followup cam 112 being returned to the position illustrated in the drawing, thus making the low spot 110 available to the fuel control rod 108.

Whenever the engine is started anew in either direction, it is desirable that it receive maximum fuel at the beginning of the operation on fuel (i. e. immediately following the period during which the engine is put in motion by starting-air). When I do this I do it, preferably, by forcing the controlling governor 29 to be in its maximum fuel (lowest speed) position at the conclusion of each starting-air period at the moment operation on fuel is begun; i. e. to this end, preferably, when the governor is of appropriate construction, I provide an oil booster 116 having a piston 117 connected to the air supply line 100 so that on the supply of air to this line 100, the piston 117 is moved to transfer oil within the governor 29 in such a manner as to force the governor to its maximum fuel position. On the release of pressure in the air supply line 100, the return of the piston 117 restores the governor 29 to its normal sensitiveness; for example a spring 118 may restore the piston 117 on the venting of the air. The form of the oil booster 116, and indeed the manner in which its function is performed, is of no considerable importance. Accordingly the foregoing description of this feature will suffice.

As an additional precaution, arrangement may be made for assuring the non-supply of fuel to the engine during the periods when the engine gearing is being shifted from "ahead" to "astern" and vice versa. To this end the supply of fuel can be put under the control of the motor 84—85 which shifts the gearing. For example, the shaft 101 driven by this motor may be provided with a cam 120 operating on a rocker 109 and so shaped as to hold the fuel control shaft 26 in its "no fuel" position except when the motor piston 85 is in one or the other of its two extreme positions.

Also the motor shaft 101 can be used to lift the fuel plunger rockers 8 from the range of their operating cams 11 and 12 prior to shifting the cam shaft 13 lengthwise, and lower them again after this movement is completed. For this the shaft 101 may be provided with a cam 121 operating on a follower 122 acting to turn a rock shaft 123 provided with a lifting finger 124 reaching underneath each of the plunger rockers 8. This cam 121 is so shaped that the initial movement of the motor piston 85 toward its opposite position rocks the rock shaft 123 to lift the rockers 8, and this is accomplished before the cam shaft 13 begins to slide longitudinally, and the completion of the movement of the piston restores the rockers to their cams, i. e. after the cam shaft 13 has fully reached its new position.

The operation of the invention as so far described is therefore, briefly, substantially as follows: Assuming the maneuvering lever 71 is in its "stop" position, the maneuvering cam 107 holds the fuel control shaft 26 in its "no fuel" position and accordingly the engine is stationary. Assuming that air under pressure is supplied to the maneuvering shut off valve 80 from some suitable source (for example, the starting-air tanks), the engine may be started in the ahead direction by moving the maneuvering lever 71 to its "start ahead" position 73. This supplies air to the top of the piston 85 (from the bottom of which air is exhausted at valve 82), and also supplies air to the interlocking valve 97. If the engine gearing is already in its "ahead" position as illustrated in the drawing, nothing happens at the motor 84—85 and air will flow through valve 97 to start the engine in motion. On the other hand, should the engine gearing be in its "astern" position, the interlocking valve 97 is closed so that no air can pass it at the moment, and the first action is the movement of the motor piston 85 to its lower position, to shift the engine gearing to its "ahead" position, and ending with the opening of valve 97. So long as the maneuvering lever 71 is held in its "start ahead" position thereafter, air will flow through pipe 100 to start and maintain the engine in motion on air from manifold 46; also air at booster 116 holds the governor 29 to its maximum fuel position. Return of the maneuvering lever 71 to its "run ahead" position stops the supply of starting air to the engine by the closing of the maneuvering pilot valve 86, and permits the supply of fuel by bringing the low spot 110 of the maneuvering cam 107 beneath rod 108. Further return of the maneuvering lever 71 to its "stop" position stops the engine by action of the maneuvering cam 107 on rod 108. In starting and operating the engine "astern," the same sort of operations is gone through as will be apparent; the followup cam 112 will carry rod 108 across the low spot 111 in moving to "start astern," and thus prevent the supply of fuel at this point at this time.

Fig. 2 serves to illustrate multiple-engine installations to which an extension of my invention as so far described is applicable. In the particular installation, shown in this Fig. 2, a ship's propeller shaft 130 is directly connected to a gear 131 which is driven by two pinion gears 132 and 133. One of the engines 134 is coupled to pinion 132 by means of a releasable clutch 135, for example a magnetic clutch of a well known kind. Likewise another engine 136 is coupled to the same pinion 132 through such a similar clutch 137, and engines 138 and 139 are similarly coupled to pinion 133 through like clutches 140 and 141. Generally speaking, this type of engine installation is well known and the foregoing will suffice to identify it.

For the present purposes it can be assumed that each of the engines 134, 136, 138 and 139 may be like the engine of Fig. 1, and that each is provided with control apparatus like that shown applied to the engine 1. Preferably, however, one maneuvering lever (or other mechanism substituted for it as before suggested) is used to control each two engines, e. g. one of the engines connected to pinion 132 and one of the engines connected to pinion 133. To this end for example, maneuvering lever 71 may be connected to and control the maneuvering pilot mechanisms of both the forward engines 134 and 138 as will be recognized by the extension of the shaft 78 to the left in Fig. 1, and similarly a maneuvering lever 141, similar in all respects to lever 71, may be arranged to control the other two engines 136 and 139, as will be recognized from the showing of rock shaft 142 controlled by lever 141 in Fig. 1. For convenience however I usually provide for locking the two maneuvering levers 141 and 71 together so that they may be operated as a unit during normal operation or for high speed maneuvering. For this purpose (Fig. 3) a sleeve 160, while always in engagement with for example lever 71 through a tooth 161 thereon, is adapted to slide into and from engagement with a tooth 162 on maneuvering lever 141; a swinging handle 163 is a convenient means for sliding the sleeve to lock the two maneuvering levers together and release them from each other. Preferably further, the speed of all the engines is controlled by a single throttle, e. g. throttle 64 of Fig. 1, as indicated by the showing of the shaft 68 and its connections in Fig. 1. Preferably too all the engine clutches are controlled by one instrumentality; for example the control lever 144 may have, say, four positions, namely position 145 in which all four couplings 135, 137, 140 and 141 are fully energized, 146 in which none of the couplings are energized, 147 in which only the two forward couplings 135 and 140 are energized, and 148 in which only the stern couplings 137 and 141 are energized. For convenience, however a position 149 in which all the couplings are deenergized is usually provided between the "ahead" and "astern" positions 147 and 148; also in order to reduce heating of the couplings when full power is not necessary (in case magnetic couplings or clutches are used), I usually provide a position 150 in which all four couplings are energized but at only part power, say half power.

It will be observed that despite the small number of instrumentalities requiring the operator's attention, he has all the control of the multiple engines required. By the single throttle 64 he can increase or decrease the speed at any time as required. For high speed maneuvering of the vehicle, he can lock the two maneuvering levers 71 and 141 together and operate them as a unit to drive the vehicle ahead or astern as he may desire. For ordinary slow speed maneuvering, he can work the clutch or coupling lever 144 to the left of its middle "stop" position 146, separate the two maneuvering levers 71 and 141 and set, say, the stern engines 136 and 139 to running "astern" while the forward engines run "ahead," and then by shifting the clutch lever 144 between its "astern," intermediate "stop" and "ahead" positions 148, 149 and 147, he can move the vehicle astern, ahead or stop it without stopping and restarting any engine.

In order that any one engine may be started and operated alone (since by preference a number of engines are controlled by each maneuvering lever, for example 71 and 141 as explained), I usually provide each engine with an individual manually-operated mechanism 153 to supply and cut off the supply of engine-starting power to the respective engine; e. g., 153 may be a manual valve through which the control air flows to the respective maneuvering pilot valve 80. By these individual valves therefore the operator can start any engine at will. To allow him to stop any engine at will by means of the same manual control valve 153, I preferably provide each engine with a device subject to the supply of engine-starting power to its engine to hold the latter in operating condition. For example, the starting power being compressed air, I provide each engine with a cylinder 154 connected by pipe 152 to the respective control valve 153, and with its piston 155, spring-pressed in opposition to the air pressure, connected to the fuel control shaft 26 so as to hold this shaft in its "no fuel" position when not supplied with air; each manual valve 153 is then so constructed as to vent its line 152 when not supplying air to this line. By actuating a valve 153 to cut off the supply of air through it, therefore, the corresponding engine is brought to rest without affecting the others. In order that the pistons 155 may not interfere with the control of their engines by the governors 29, each is connected to its fuel control shaft 26 by an arrangement substantially like that of Fig. 4; i. e. (Fig. 1), the loose sleeve connected to the piston is provided with abutments 156 to coact with abutments 157 fixed to the shaft. Preferably also I connect each piston 155 with a switch 158 in the circuit of the magnetic coupling (135, 137, 140 or 141) of its respective engine. Each of these switches is closed therefore (Fig. 1) only when air is supplied to its cylinder 154. Any engine accordingly may be stopped regardless of the position of the clutch controller 144; and regardless of the fact that this clutch controller 144 controls the clutches or couplings in groups, any one or more of the group of engines can be used to drive the load (propeller shaft 130) while the remainder are stopped.

With the switches for the electromagnetic clutches arranged as described, an interlock can be used to prevent the clutch lever 144 being moved to its half power or full power position (in which positions 150 and 145, all four clutches are energized) while the forward and stern pairs of engines are running in opposite directions. This will be effected by any arrangement that will prevent the maneuvering levers 71 and 141 being separated for independent movement except when the clutch or coupling lever 144 is at its "stop" position 146 or at the 148 side of this position, and that will prevent also the movement of this clutch lever 144 to the 145 side of its arc except when the two maneuvering levers are connected together for movement as a unit. Such an interlock is provided readily by a finger or bar 168 mounted on or at least sliding with the maneuvering lever clutch sleeve 160 and a plate 169 fastened to or at least moving with the clutch lever 144, the pin and plate being so related that the plate stands in the path of the pin except when the clutch lever is in its middle "stop" position 146 or somewhere between that position and its "astern" position 148, and the pin is in the path of the plate except for movements of the plate between these two positions 146 and 148. Preferably further the maneuvering levers 71 and 141 are so related also that maneuvering lever 71, the engines of which are usually driven ahead, can not be moved to its "astern" position unless the maneuvering lever 141 of the stern engine is in or is carried to its "astern" position simultaneously. This may be effected by a hinged pawl 164 on lever 141 and a cooperating pin 165 on the lever clutch sleeve 160 as will be understood from this drawing.

It will be understood of course that the invention is not limited to the specific details of construction and operation described above, nor to engines or engine installations constructed as shown in the drawings, but is applicable to other forms of engines and other forms of multiple-engine installations as have been indicated before and will be apparent to those skilled in this industry. In general the construction can be modified greatly and the invention embodied in other forms of apparatus, and accordingly is not limited to the matters specifically illustrated and described herein except as appears hereafter in the claims.

I claim:

1. In a power plant, the combination with an internal combustion engine having means to supply fuel, engine gearing shiftable to cause the engine to operate ahead and astern, means providing power to start the engine in motion, and a motor to shift said engine gearing from ahead to astern running position and vice versa, of a manually operable mechanism to control the supply of fuel to the engine, another mechanism manually operable independently of the first mentioned mechanism, to control the operation of both said motor and said engine-starting power means, and means to prevent the supply of fuel to the engine while said engine-starting power means is in operation.

2. In a power plant, the combination of an internal combustion engine having engine gearing to direct the operation of the engine on fuel and shiftable to direct the operation of the engine ahead and astern, of means providing power to start the engine in motion, a motor to shift the said engine gearing from ahead running to astern running and vice versa, a manually operable pilot maneuvering mechanism to control the operations of both said motor and said engine-starting power means and to shut-off and direct the supply of fuel to the engine, and means related to said engine gearing to shut-off the supply of fuel to the engine and prevent the operation of said engine-starting power means except when said gearing is in an engine operating position.

3. The subject matter of claim 1, characterized by the fact that means are provided, related to said engine gearing, to also control said engine-starting power means, said means preventing the operation of said engine-starting power means to start the engine except when said gearing is in an engine-operating position.

4. In a power plant, the combination with an internal combustion engine having engine gearing shiftable to cause the engine to operate ahead and astern, means providing power to start the engine in motion, a motor to shift said engine gearing from ahead to astern running position and vice versa, and a manually operable maneuvering mechanism to control the operations of both said motor and said engine-starting power means, said gearing including a device operable to control the rate of fuel supply to the engine,

of means to actuate said device to its maximum-fuel-supply position with the operation of said engine-starting power means to start the engine.

5. In a power plant, the combination of an internal combustion engine having engine gearing shiftable to cause the engine to operate ahead and astern, means providing power to start the engine in motion, a motor to shift said engine gearing from ahead to astern running position and vice versa, and a manually operable maneuvering mechanism to control the operations of both said motor and said engine-starting power means, said gearing including a member operable to control the rate of fuel supply to the engine, characterized by the fact that said maneuvering mechanism includes means to actuate said member to its no-fuel position when said maneuvering mechanism directs the starting of the engine by said power means.

6. In a power plant, the combination of an internal combustion engine having engine gearing shiftable to cause the engine to operate ahead and astern, means providing power to start the engine in motion, a motor to shift said engine gearing from ahead to astern running position and vice versa, and a manually operable maneuvering mechanism to control the operation of both said motor and said engine-starting power means, said gearing including a member operable to control the rate of fuel supply to the engine, characterized by the fact that said maneuvering mechanism includes means to actuate said member to its no-fuel position when said maneuvering mechanism directs the starting of the engine by said power means, said means releasing said member when said maneuvering mechanism discontinues the operation of said power means, and further characterized by the fact that mechanism is provided, related to said engine gearing, to hold said member in its no-fuel position except when said gearing is in an engine-operating position.

7. In a power plant, the combination of an internal combustion engine having engine gearing shiftable to cause the engine to operate ahead and astern, means providing power to start the engine in motion, a motor to shift said engine gearing from ahead to astern running position and vice versa, and a manually operable maneuvering mechnism to control the operations of both said motor and said engine-starting power means, said gearing including a member operable to control the rate of fuel supply to the engine, characterized by the fact that said maneuvering mechanism includes means to actuate said member to its no-fuel position when said maneuvering mechanism directs the starting of the engine by said power means, and also when said maneuvering mechanism does not direct the starting of the engine whereby the engine may be stopped by the pilot mechanism.

8. In a power plant, the combination of an internal combustion engine having engine gearing shiftable to cause the engine to operate ahead and astern, means providing power to start the engine in motion, a motor to shift said engine gearing from ahead to astern running position and vice versa, and a manually operable maneuvering mechanism to control the operations of both said motor and said engine-starting power means, said gearing including a member operable to control the rate of fuel supply to the engine and there being a governor to control the position of said member during operation of the engine on fuel, characterized by the fact that said maneuvering mechanism includes means to hold said member to its no-fuel position while said maneuvering mechanism directs the starting of the engine by said power means, said means of the maneuvering mechanism releasing said member to the control of the governor when the maneuvering mechanism discontinues the operation of the engine-starting power means.

9. The combination with a plurality of internal combustion engines each including engine gearing shiftable to cause its engine to operate ahead and astern, and means providing power to start said engines in motion, of a motor at each engine to shift the engine gearing of its engine from ahead running to astern running position and vice versa, manually operable pilot maneuvering mechanism to control the operation of said motors of all said engines simultaneously and also to control the operation of said engine-starting power means.

10. The subject matter of claim 9, characterized by the fact that manual means are provided to control the speed of all said engines simultaneously.

11. The subject matter of claim 9, characterized by the fact that a manual means is provided for each engine to control the application of said engine-starting power to the respective engine, subject to the control of said pilot mechanism, and a device is provided for each engine to direct the supply of fuel to the respective engine and to shut-off fuel therefrom responsive to the application of engine-starting power to the engine and the shutting-off of such power therefrom respectively.

12. The subject matter of claim 9, releasable clutches being provided to couple all said engines to the same load and there being clutch-actuating mechanism operable on all said clutches simultaneously, characterized by the fact that a manual means is provided for each engine to control the application of said engine-starting power to the respective engine, subject to the control of said pilot mechanism, and a device is provided for each engine to direct the closing of the clutch of the respective engine and to open the same responsive to the application of engine-starting power to the respective engine and the shutting-off of such power therefrom respectively.

GEORGE J. WOHANKA.