Jan. 13, 1942. J. OLSSON ET AL 2,269,548

CONTROL MECHANISM FOR REVERSIBLE INTERNAL COMBUSTION ENGINES

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Fig. 1

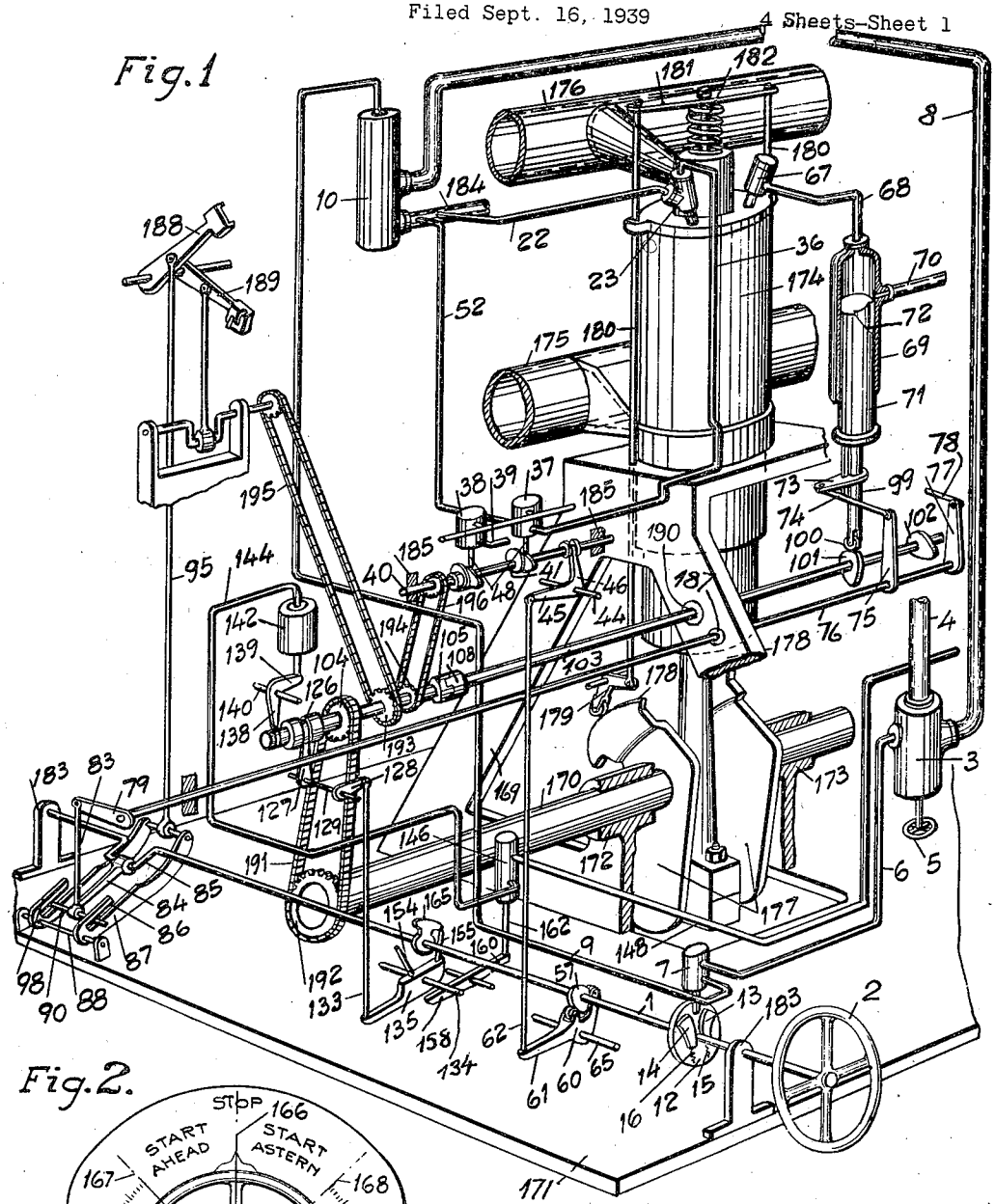
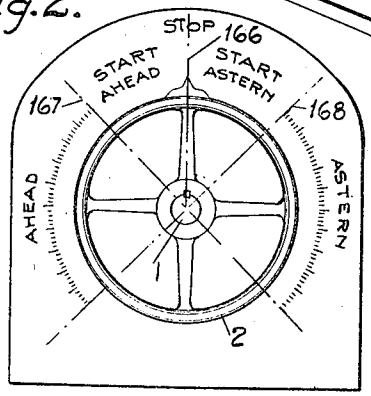


Fig. 2.



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Fig. 7.

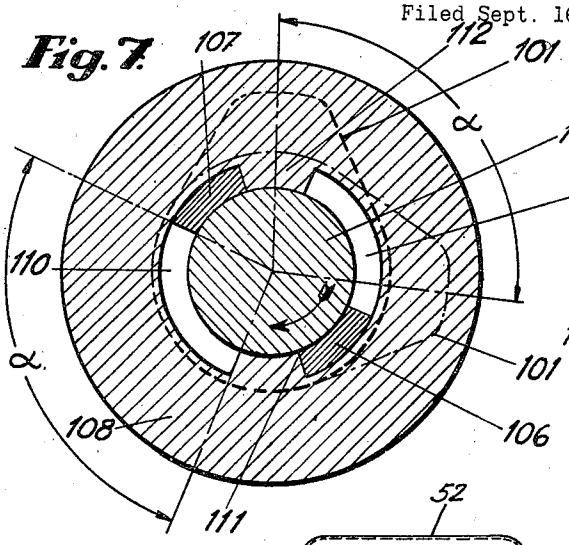


Fig. 8.

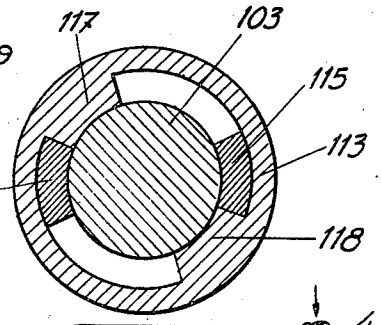


Fig. 3.

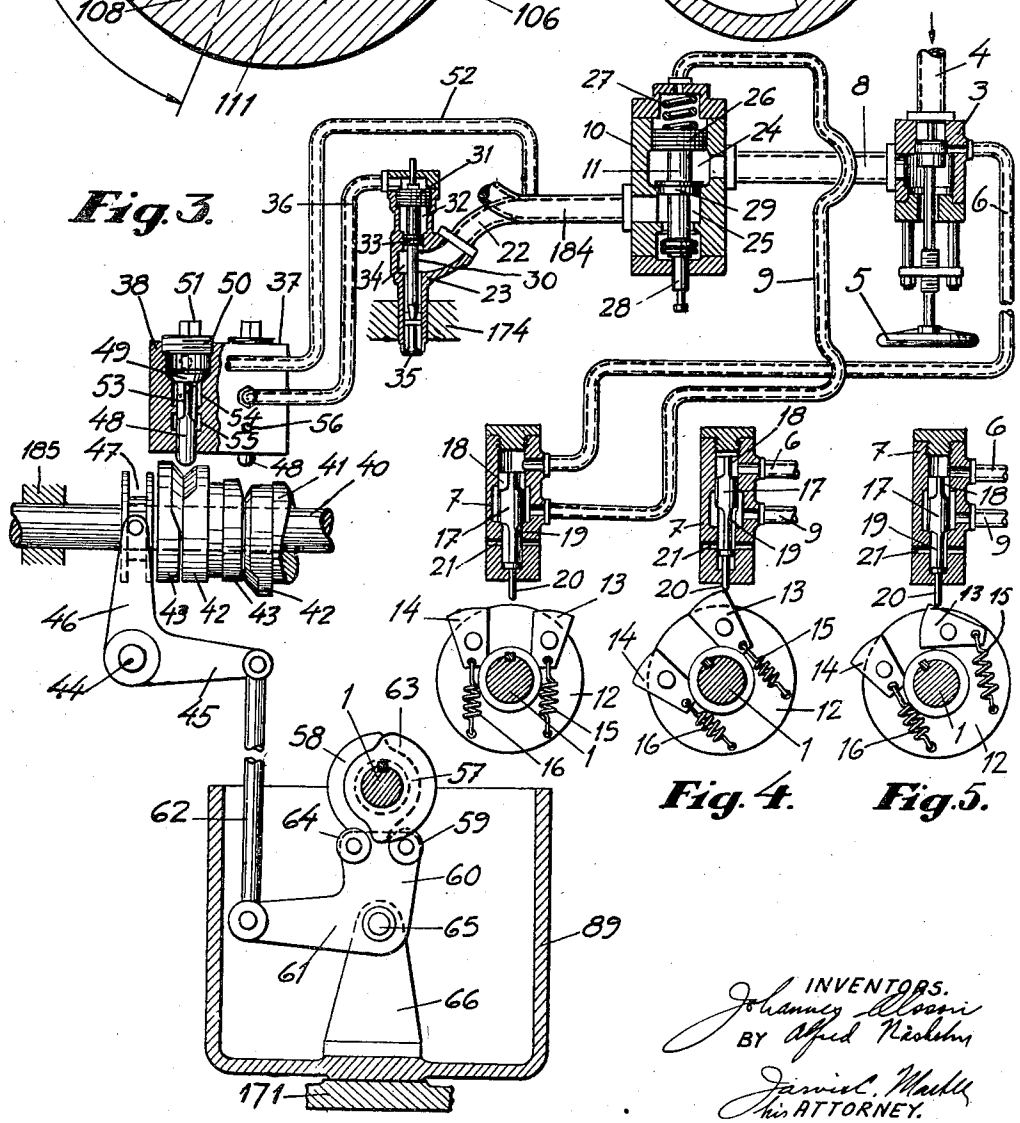


Fig. 4.

Fig. 5.

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CONTROL MECHANISM FOR REVERSIBLE INTERNAL COMBUSTION ENGINES

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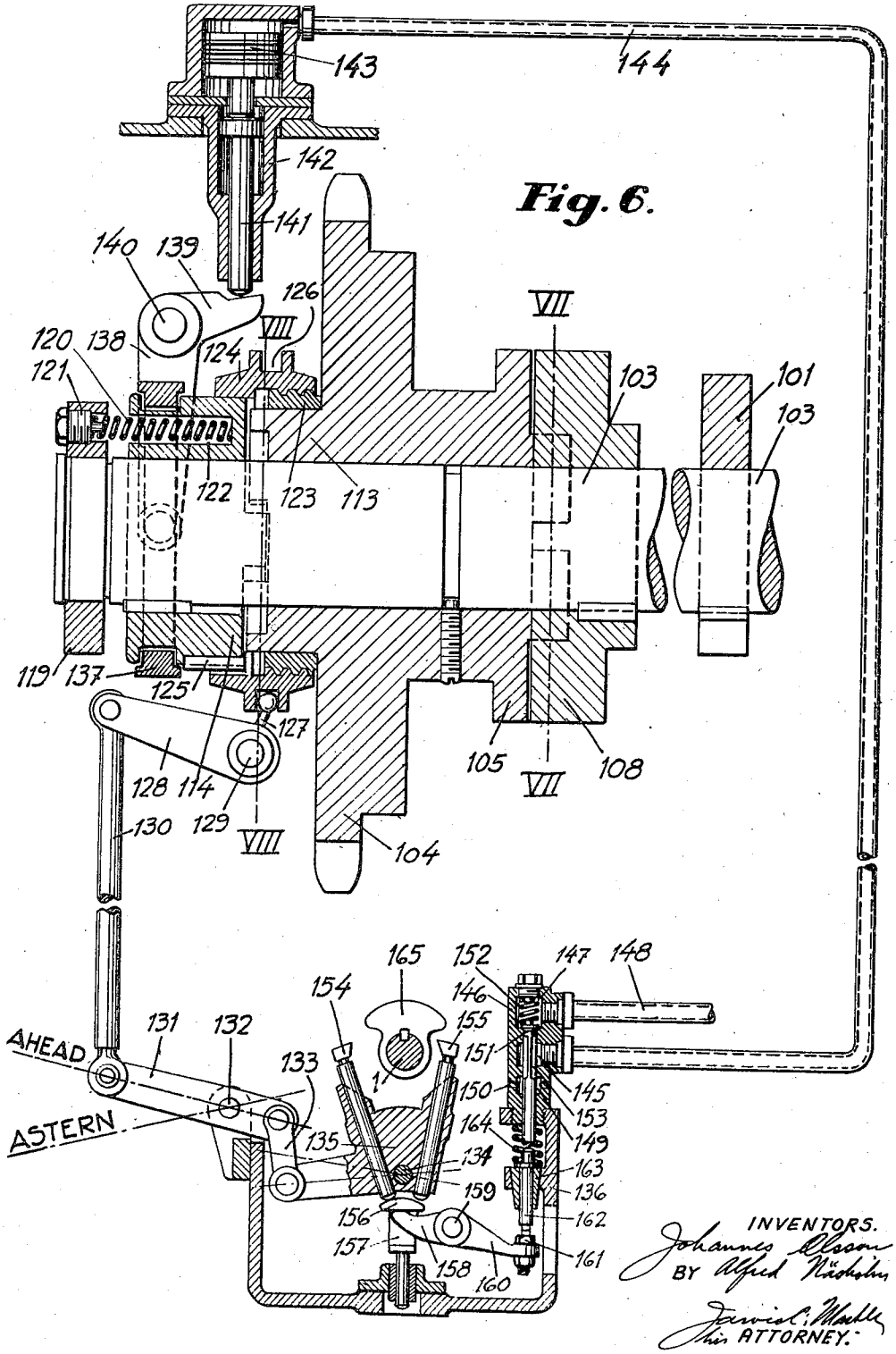


Fig. 6.

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CONTROL MECHANISM FOR REVERSIBLE INTERNAL COMBUSTION ENGINES

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Fig. 9.

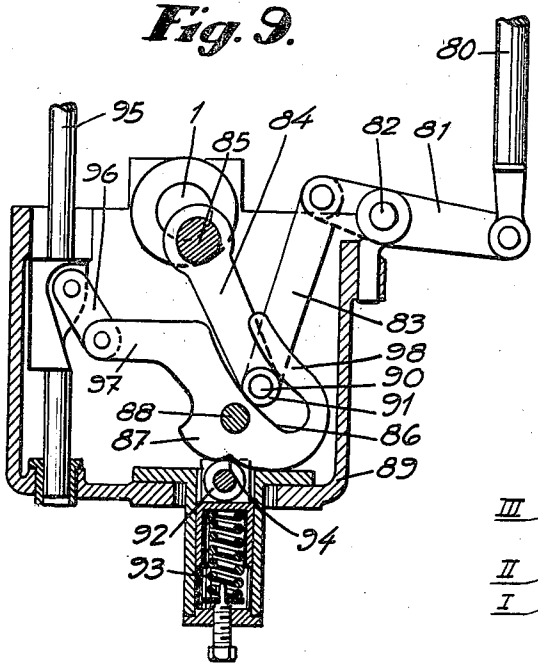


Fig. 11.

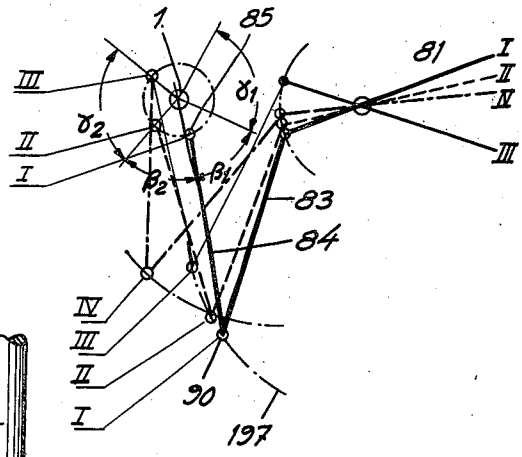
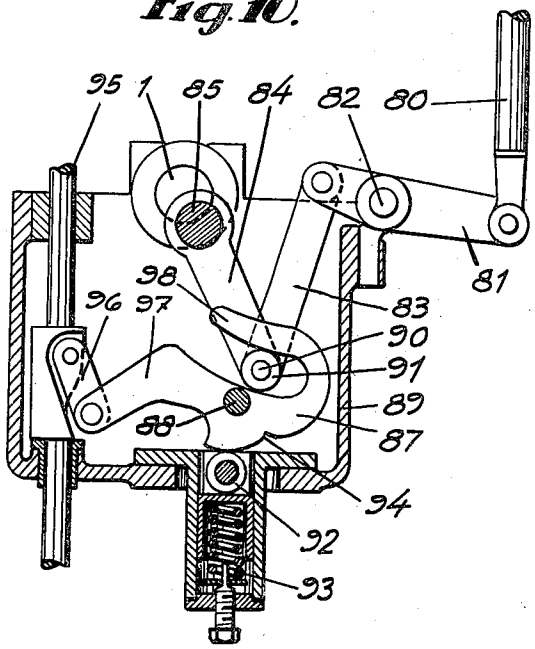


Fig. 10.



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UNITED STATES PATENT OFFICE

2,269,548

CONTROL MECHANISM FOR REVERSIBLE INTERNAL COMBUSTION ENGINES

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Application September 16, 1939, Serial No. 295,212
In Sweden September 17, 1938

5 Claims. (Cl. 60—16)

This invention relates to control mechanisms for reversible internal combustion engines provided with a control member movable in two different directions from a stop position.

One object of the invention is to provide a simple, effective and reliable control mechanism of this type for actuating starting, reversing and fuel control gears of the engine.

For this and other purposes we provide a rotatable control shaft and actuating means for starting, reversing and fuel control mechanisms, so arranged that at the first portion of the turning of the control shaft from the stop position in either direction a reversing gear causes setting of a starting air valve control gear known per se for operation ahead or reverse, that upon continued turning in either direction a reversing gear causes release of a fuel injection control gear, which is locked in both directions of rotation, if said gear is in a position corresponding to a direction of rotation contrary to the intended, and a starting device causes supply of starting air to the starting air valves, and that upon still further continued turning of the control shaft in either direction fuel supply control devices cause adjustment of the fuel supply for operation ahead or reverse, respectively, to a quantity corresponding to said last mentioned turning.

The invention may be employed in connection with any type of reversible internal combustion engines, for instance engines working on the two stroke or four stroke principle and operating with solid injection or any other fuel supply system, and, furthermore, the invention may be employed in connection with single acting as well as double acting engines.

In the accompanying drawings one embodiment of the invention is illustrated by way of example.

Fig. 1 is a diagrammatic perspective view of a two stroke solid injection internal combustion engine provided with a control mechanism according to the invention.

Fig. 2 is a front view of a control wheel.

Fig. 3 illustrates the starting gear in detail on a larger scale.

Figs. 4 and 5 are details of the starting gear in different positions.

Fig. 6 illustrates the reversing gear, and

Figs. 7 and 8 are sections on lines VII—VII and VIII—VIII in Fig. 6.

Figs. 9 and 10 illustrate a portion of the fuel supply control gear in operative and unoperative position, respectively, and

Fig. 11 is a diagrammatic view of the fuel supply control gear in different positions.

In Fig. 1, 171 designates a portion of a bed of a single acting two stroke solid injection internal combustion engine and 169 a partly broken away crank case of one cylinder of said engine. A main crank shaft 170 of the engine is mounted in bearings 172 and 173 carried by supports provided on the bed 171. In the drawing one cylinder 174 only is illustrated, but the engine may naturally comprise two or several cylinders. 175 indicates a manifold for charging and scavenging air and 176 is an exhaust manifold connected with the engine. The crank shaft 170 is provided with crank arms 177 carrying cams 178, which actuate bell crank levers 179 connected by means of rods 180 with a cross beam 181 mounted on top of the cylinder and carrying an exhaust valve 182.

The control mechanism of the illustrated internal combustion engine comprises a control shaft 1, which may be turned to the left and to the right by means of a control wheel 2 and which is mounted in bearings 183 supported by the bed 171. The control shaft 1 carries actuating means for the starting, reversing and fuel control gears. In Fig. 1 all parts are illustrated in the position which they take when the engine is at rest after having been operated ahead.

A main starting air valve 3 is connected through a conduit 4 with a not illustrated container or other source of compressed air. The main air valve 3 is operated by means of a wheel 5, the operation of which causes starting air to be firstly supplied to a conduit 6 leading to a pilot valve 7 and upon further rotation of the wheel 5 to a conduit 8. The pilot valve 7 is connected with a valve housing 10 of a slide valve 11, Fig. 3, by means of a conduit 9. A disk 12 is wedged onto the control shaft 1 and carries two cams 13 and 14 disposed symmetrically and mounted pivotally on said disk. Said cams are normally kept in the position illustrated in Figs. 1 and 3 by springs 15 and 16. A piston valve 17 is displaceable in the pilot valve housing 7 and has grooves 18 and 19, respectively, in the upper and lower ends, said piston valve being actuated by a tappet 20 guided in the lower portion of the pilot valve housing 7. In the lower position of the valve 17 the grooves 18 form a connection between the conduit 6 and the conduit 9, as obvious from Fig. 3. The pilot valve housing 7 is provided with air outlet openings 21 in the lower portion. When the valve 17 is in the lower position, the connection between the interior of the pilot valve hous-

ing 7 and said air outlet openings 21 is interrupted and the piston valve 17 is pressed downwards by the air pressure above the valve. When the wheel 2 is turned to the left from the position illustrated in Figs. 1 and 2 the tappet 20 rides over the cam 13, as illustrated in Fig. 4, during the first portion of the turning of the control wheel, that is during the portion of the turning, which in Fig. 2 is indicated by "Start ahead." The piston valve 17 is then forced upwards by the tappet 20 and the connection between the conduits 6 and 9 is interrupted, and the conduit 9 is instead connected with the atmosphere through the groove 19 and the air outlet openings 21, Fig. 4. Upon continued turning of the control wheel 2 to the left the corner of the cam 13 passes the valve tappet 20 and the compressed air above the piston valve 17 forces the piston valve and the valve tappet 20 downwards causing the piston valve to shut off the connection between the conduit 9 and the atmosphere and to re-establish the connection between the conduit 6 and the conduit 9 through the grooves 18. Upon continued turning of the control wheel 2 to the left the pilot valve 7 is not further affected. When the control wheel is returned to the stop position the cam 13 is only moved away from the valve tappet 20 due to the weakness of the spring 15 without actuating said valve tappet, as illustrated in Fig. 5.

When the control wheel 2 is turned to the right from the stop position, the pilot valve 7 is actuated in a manner corresponding to the above described operation by the cam 14 of the disk 12.

The upper portion of the housing 10 of the slide valve 11 is connected with the conduit 9 and at one side of the housing the conduit 8 is connected. A conduit 184 is connected with the lower portion of the slide valve housing 10 and connects said portion with conduits 22 leading to starting air valves 23 disposed on the motor cylinders 174. The slide valve housing 10 comprises an upper chamber 24 and a small lower chamber 25 and the slide valve 11 forms a comparatively large piston 26 movable in the upper chamber 24 above the inlet of the conduit 8. A spring 27 is provided between the piston 26 and the top of the slide valve housing 10, which spring and the air pressure in the conduit 9 normally keeps the slide valve 11 depressed in the lower position, in which it is illustrated in Fig. 3. The slide valve 11 is provided with a guide 28 at the lower portion and at an intermediate portion with a valve member 29, which in the lower position of the slide valve interrupts the connection between the chambers 24 and 25 of the slide valve housing 10 and thereby prevents the compressed air in the conduit 8 from passing the slide valve and from flowing through the conduits 184, 22 to the starting air valves 23. When the pilot valve 7 due to the turning of the wheel 2 to the left or to the right is actuated by one of the cams 13 or 14 and connects the conduit 9 with the atmosphere the air pressure in the conduit 8 is capable of moving the slide valve upwards against the action of the spring 27, so that the valve piston 29 opens the connection between the chambers 24 and 25. Then the compressed air has free passage from the conduit 8 through the slide valve housing 10 to the conduits 184 and 22 and the starting air valves 23.

The starting air valve 23 comprises a spindle 30 provided with a large upper piston 31 displaceable in a chamber 32, a piston 33 displaceable in a chamber 34 and at the lower end with a valve member 35 serving to close or open the connection between the chamber 34 and the motor cylinder 174. The conduit 22 is in constant communication with the chamber 34. A conduit 36 is connected at the top of the starting air valve 23 and connects the starting air valve 23 with a starting air distributor 37. In Figs. 1 and 3 a second starting air distributor 38 is also illustrated, which in the same manner as the starting air distributor 37 is connected to a not illustrated starting air valve of another motor cylinder through a conduit 39. A starting air distributor shaft 40 driven from a motor shaft and mounted in bearings 185 carries a sleeve 41, which is longitudinally displaceable but not rotatable on said shaft. Said sleeve is provided with a cam 42 for each starting air distributor adapted to control the starting air distributor when the engine is started ahead and with a cam 43 controlling the starting air distributor, when the engine is started for movement in reverse direction. A bell crank lever 45, 46 is mounted on a pivot 44, and one arm 46 of said lever engages a groove 47 in the sleeve 41 and is adapted to cause displacement of the sleeve to a position in which the ahead cams 42 or the astern cams 43 are disposed beneath the valve stems 48 of the starting air distributor valves 49. In order to enable the sleeve 41 always to be moved to the desired position in spite of the momentary position of the cams 42, 43 the high portions of the cams are chamfered, as indicated in Fig. 3. An upper chamber 50, which is closed by a cover 51 in the starting air distributors, is in continuous communication with the conduit 184 from the slide valve 10 through a conduit 52, and as soon as compressed air is admitted to said conduit the valves 49 are pressed downwards by the compressed air, which flows into the chambers 50. The stems 48 of the valves 49 are provided with recesses 53, which in the lowermost position of the valve form a connection between chambers 54 and 55 of the starting air distributors. The chambers 55 are continuously connected with the atmosphere through ducts 56. Consequently, when the valves 49 are in bottom position, the top of the piston 31 of the starting air valve 23 is connected with the atmosphere through the conduit 36, the chamber 54, the recess 53, the chamber 55 and the duct 56. The starting air valve is then pressed upwards by the compressed air and thus kept closed. When the valve stem 48 is lifted by one of the cams 42 or 43 the connection between the starting air valve 23 and the atmosphere is interrupted and the upper side of the starting air valve is instead connected with the compressed air conduit 52, and, if said conduit is under pressure, the valve spindle 30 is pressed downwards so that the valve member 35 gives the compressed air free admission to the motor cylinder.

The displacement of the sleeve 41 on the starting air distributor shaft 40 is produced by turning of the control wheel 2 to the left or to the right by means of a double cam disk 57 secured on the control shaft 1, as illustrated in Figs. 1 and 3. The cam disk 57 is provided with a cam 58 co-operating with a roller 59 mounted on a bell crank member 60. The arm 61 of the bell crank member 60 is connected with the arm 45 of the bell crank lever 45, 46 by means of a rod 62. The cam disk 57 is provided with a second cam 63 and the bell crank member 60 has a roller 64 mounted thereon and co-operating with the last mentioned cam. The bell crank member is mounted on a shaft 65 carried by a suitable sup-

port 66 in a housing 89 provided on the bed 171. When the control wheel 2 is turned to the left, the roller 59 travels up the cam 58 and the roller 64 moves towards the lower portion of the cam 63 while the bell crank member 60 is turned to the right. The arm 61 and the arm 45 are then moved upwards and the sleeve 41 is displaced to the left in Fig. 3 so that the ahead cams 42 are disposed just beneath the valve stems 48. If the control wheel 2 is instead moved to the right, the roller 64 travels up the cam 63 and the roller 59 moves towards the lower portion of the cam 58 so that the arms 61 and 45 are moved downwards and the sleeve 41 is moved to the right in Fig. 3 causing the astern cams 43 to be set just beneath the valve stems 48. Naturally, the invention is not limited to the employment of the above described starting air valve control gear and the described reversing gear for the starting air distributors, and instead of pneumatic control of the starting air valves mechanical control of said valves may be used comprising for instance a cam shaft, which may be set in two different ways for opening and closing of the starting air valves for starting ahead or reverse by means of actuating means provided on the control member 1.

A fuel injection valve 67 of conventional design is connected through a conduit 68 with a fuel pump 69, for instance of the Bosch type. Fuel is supplied to said pump through a conduit 70. As usual, the pump comprises a plunger 71 provided with a sloping recess 72 and adapted to be turned around its longitudinal axis by means of a lever 73, a rod 74 and a lever 75 on a shaft 76 mounted in bearings 187 in the crank case 169. The effective stroke of the plunger 71 is varied by turning the plunger, and consequently the fuel quantity injected at each stroke is varied in such a manner that a turning movement of the lever 73 to the right in Fig. 1, after the sloping edge of the recess 72 has reached a position just opposite the opening of the fuel supply conduit 70, results in an increased fuel injection per stroke of the fuel pump, since the effective length of the pump stroke is thereby increased from zero to maximum. The shaft 76 carries one or several additional levers 77, which actuate not illustrated fuel injection pumps for the other cylinders of the motor by means of rods 78. The shaft 76 is provided with a lever 79, which is connected with one end of a rod 83 by means of a rod 80 and a double armed lever 81 mounted on a pivot 82, Figs. 9 and 10. In Fig. 1 the lever 79 is shown connected directly with the end of the rod 83 for the sake of simplicity, it being understood that this modification does not materially change the operation of the disclosed mechanism. The rod 83 is connected with the free end of a connecting rod 84 pivotally mounted on a crank 85 formed by the control shaft 1. The free end of the connecting rod 84 is guided along a sloping guide 86 formed by a slot in a member 87, which is mounted on a pivot 88 in the housing 89, Figs. 9 and 10. The pin 90 of the connecting rod 84 is provided with a roller 91, which is guided in the slot 86. In Figs. 1 and 9 the control shaft 1 is illustrated in a position in which no fuel supply takes place. Due to the design of the recess 72 in the pump plunger 71, illustrated in Fig. 1, fuel supply is prevented until the control wheel has been turned to the right or to the left over the whole starting period, Fig. 2. Obviously, the turning of the control wheel 2 in either direction past the starting period causes the free end of the connecting rod 84 to move further and further up the slot 86 so that the rod 83 is moved upwards and the fuel injection per stroke of the fuel pump increased. In order to maintain the member 87 in a fixed position on the pivot 88, a catch 92 is provided in the housing 89 and forced by a spring 93 into a notch 94 in the member 87. 95 is a rod connected by a link 96 with an extension 97 of the member 87. The rod 95 may, for instance, be connected with an over speed governor 188, Fig. 1, which may, for instance, be of the well known Aspinall type having a swinging arm 189 moved up and down by the engine and provided with two detent means, movable by mass forces, said means being adapted to engage a normally passive arm 138, one detent means forcing the arm 188 downwards, for cutting out or reducing the fuel supply of the engine, when a predetermined speed is exceeded, and the other detent means being adapted to force the arm 188 upwards for restoration of the fuel supply of the engine as soon as the speed of the engine has decreased below a predetermined value. Thus, if the internal combustion engine speeds the arm 189 forces the arm 188 and the rod 95 downwards. The member 87 is then tilted on the pivot 88 and an extension 98 of the member 87, which forms one side of the guide way 86, then forces the free end of the connecting rod 84 downwards and simultaneously pulls the rod 83 downwards so that the levers 75, 77 are turned to the left in Fig. 1 and fuel supply is substantially shut off.

The plungers 71 of the fuel pumps are provided with push rods 99 bearing with rollers 100 on cams 101, 102 on a shaft 103, which is mounted in suitable bearings 190 in the crank case 169 and drives the fuel pumps. As illustrated in Fig. 7, the cams 101 are of symmetric design and consequently the cams actuate the fuel pumps in the same manner upon rotation in either direction. A sprocket 104 is mounted on the shaft 103 so that it can rotate on the shaft but is fixed longitudinally thereon. The sprocket 104 is driven by a chain 191 from a sprocket 192 on the crank shaft 170. The sprocket 104 is connected with further sprockets 193 and 194, which through chains 195 and 196, respectively, drive the Aspinall governor 189 and the starting air distributor shaft 40, respectively. The right end of the hub of the sprocket 104 forms a clutch member 105, which is provided with two sector shaped jaws 106 and 107, as illustrated in Fig. 7. The clutch member 105 co-operates with another clutch member 108, which is secured on the shaft 103 and provided with sector shaped recesses 109 and 110, which are partly occupied by the jaws 106 and 107, respectively. The portions of the recesses 109 and 110 not occupied by the jaws 106 and 107 subtend an angle α and are confined by jaws 111 and 112 formed in the clutch member 108. Obviously, the shaft 103 may be turned the angle α relatively to the sprocket 104, while the cam 101 moves from the position illustrated in dotted lines to the position illustrated in chain dotted lines in Fig. 7. The sprocket 104 is driven from the motor shaft as above indicated, and for locking it relatively to the clutch member 108 in either of the indicated positions the left end of the hub forms a clutch member 113 adapted to co-operate with a clutch member 114, Fig. 6, which is longitudinally displaceable but non-rotatable on the shaft 103. The clutch member 114 is provided with

jaws 115, 116 adapted to co-operate with jaws 117, 118 in the clutch member 113 formed by the sprocket 104, see Fig. 8. A ring 119 is secured on the shaft 103. Said ring carries three springs 120 secured on studs 121 and extending into bores 122 in the clutch member 114 and serving to bring said member into engagement with the clutch member 113. A screw threaded collar 123 is secured on the clutch member 113 and co-operates with another screw threaded collar 124, which is displaceably but non-rotatably guided relatively to the clutch member 114, as indicated by the key 125. A groove 126 in the collar 124, Fig. 6, co-operates with one arm 127 of a bell crank lever 127, 128 mounted on a pivot 129. The arm 128 of the bell crank lever is connected with a link 133 by means of a rod 130 and a double armed lever 131, which is mounted on a pivot 132, Fig. 6. In Fig. 1 the linkage 128—130—131—133 is illustrated in a somewhat modified form, in which the rod 130 and the lever 131 for the sake of greater simplicity have been omitted. The link 133 is connected with a swingable angle member 135, which is mounted on a pivot 134 and movable into two different positions depending upon the position of the collar 124 on the collar 123. The pivots 132, 134 are carried by a suitable housing 136, Fig. 6, which also forms bearings for the control shaft 1. The clutch member 114 is provided with a groove and a ring 137 engages said groove and is connected with a fork shaped arm 138 of a bell crank lever 138, 139 mounted on a pivot 140. The arm 139 of the bell crank lever is adapted to be actuated by a spindle 141 slidable in a housing 142 under the action of a piston 143. The upper portion of the housing 142 is provided with a conduit 144, which connects the housing with a chamber 145 in a pilot valve 146 disposed at the housing 136 and provided with a second chamber 147, which is connected to the compressed air conduit 8 between the main air valve 3 and the slide valve housing 10 by means of a conduit 148. The pilot valve housing 146 contains a second chamber 149 connected through openings 150 with the atmosphere. A piston valve 151 is slidable in the pilot valve housing 146 against the action of a spring 152 in the chamber 147. The piston valve 151 is provided with grooves 153, which in the lower position of the piston valve connect the housing 142 and the conduit 144 with the chamber 149 and the atmosphere. In the upper position of the piston valve the connection between the conduit 144 and the atmosphere is interrupted, and then the grooves 153 form a connection between the conduit 148 and the conduit 144 through which compressed air may flow to the housing 142 and depress the piston 143 and the spindle 141 and thus through the bell crank lever 138, 139 bring the clutch member 114 to disengage the clutch member 113 on the sprocket 104.

The angle member 135 carries two stops or tappets 154 and 155, which are slidably mounted in the angle member, as obvious from Fig. 6. The lower ends of the tappets 154, 155 continuously rest on a sliding member 156 mounted in the housing 136, whereas the upper ends of the tappets form stops. The sliding member 156 is provided with an opening 157, in which one arm 158 of a double armed lever 158, 160 mounted on a pivot 159 is inserted. The lever arm 160 carries a set screw 161, which bears against a valve tappet 162 co-operating with the piston valve 151 and longitudinally displaceable in a guide 163, against which the valve tappet 162 is pressed by a spring 164. A double faced cam 165 is secured on the control shaft 1 and adapted to co-operate with the tappet 154 or 155, when the control shaft is turned.

The control mechanism above described and illustrated in the drawings operates in the following manner:

In the drawings the control mechanism is illustrated in the position, which it takes, when the engine is at rest ready for starting ahead.

Before starting the main air valve 3 is completely opened. During this opening movement the conduit 6 is at first brought under pressure and compressed air flows through the conduit 6, the pilot valve 7, which is in the position illustrated in Fig. 3, and the conduit 9 to the top of the slide valve 11, which is consequently at first subjected to the downward action of the starting air pressure and the spring 27 so that the slide valve with the valve piston 29 is sure to keep the connection between the chamber 24 and the chamber 25 in the slide valve housing 10 interrupted before compressed air is admitted to the chamber 24. During the continued opening movement of the main air valve the opening to the conduit 8 is successively uncovered and compressed air is admitted through said opening into the chamber 24 of the slide valve housing 10. Then the same air pressure prevails on top and beneath the upper piston 26 of the slide valve and the slide valve is still kept closed in the lower position through the action of the spring 27. When compressed air is admitted to the conduit 8 the compressed air flows through the conduit 148 to the chamber 147 in the pilot valve 146 (see Fig. 6). Assuming that the angle member 135 is in the position illustrated in Fig. 6 the control mechanism is now ready for starting the engine ahead or reverse.

If the engine is to be operated ahead, the following operations are carried out:

The control wheel 2 is turned to the left, Figs. 1 and 2. During the first portion of said turning movement the roller 59 on the bell crank member 60, Fig. 3, travels up the cam 58 on the control shaft 1 and the roller 64 simultaneously moves towards the lower portion of the cam 63. The arm 61 is consequently moved upwards as is also the rod 62 and the arm 45 of the bell crank lever 45, 46. The cams of the sleeve 41 on the starting air distributor shaft 40 are then moved to the left in Fig. 3 or to the right in Fig. 1, respectively, so that the ahead cams 42 are disposed below the valve stems 48. Upon further turning of the control wheel 2 to the left the cam 13 on the disk 12 actuates the valve tappet 20 of the pilot valve 7. At the end of the starting period, Fig. 2, the cam 13 has forced the valve tappet 20 and the piston valve 17 to the position illustrated in Fig. 4. By this movement the conduit 9 and the chamber on top of the piston 26 in the slide valve housing 10, which was previously under the influence of the starting air pressure through the grooves 19 and the openings 21 of the pilot valve 7, has been connected with the atmosphere. Simultaneously, the piston valve 17 has shut off the conduit 6. When the pressure is relieved on top of the slide valve piston 26 the compressed air in the chamber 24 forces the slide valve 11 upwards against the action of the spring 27, Fig. 3. The piston 29 then opens a passage for the compressed air from the chamber 24 to the chamber 25 in the slide valve housing 10, and compressed air flows

through the conduit 22 to the chamber 34 in the starting air valve 23. If a sufficient number of cylinders of the internal combustion engine are provided with starting air valves and corresponding starting air distributors, there will always be a starting air distributor in such a position that the pertaining valve 49 has been forced upwards at the above mentioned movement of the sleeve 41. The connection between the conduit 36 and the atmosphere through the chamber 54, the recesses 53, the chamber 55 and the ducts 56 is always interrupted in said starting air distributor, and the pertaining conduit 36 instead communicates with the conduit 52, through which compressed air is supplied to the starting air distributor. Consequently, compressed air flows through the conduit 36 into the space above the piston 31 in the starting air valve 23 and forces said piston downwards so that the valve member 35 is opened. The compressed air then flows from the conduit 22 through the chamber 34 into the motor cylinder and moves the working piston of said cylinder. The motor is now driven on the starting air, and the starting air distributors 37, 38 etc., in turn open and close the compressed air supply to the motor cylinders, which are provided with starting air valves. Closing of the starting air valves 23 is then produced by the starting air distributors, which at proper moments bring the top of the respective starting air valve piston 31 in connection with the atmosphere.

If an insufficient number of motor cylinders are provided with starting air valves, it may occur that the starting air distributor shaft 40, when the compressed air is admitted to the conduit 52, is in such a position that no valve 48, 49 is lifted, and to start the motor in such a case it is obviously necessary to turn the motor shaft by means of suitable devices to a position, in which one of the valve stems 48 is lifted by the corresponding cam.

When the control wheel 2 is in the stop position the parts 85, 84, 90, 83 and 81 take the position I indicated in full lines in Fig. 11. The member 87 is then kept in the position illustrated in Fig. 9 by the catch 92, which engages the notch 94. During the turning of the control wheel 2 from the stop position 166 to the position 167, the angle β_1 in Fig. 11, the motor has been started, and if the control wheel is not turned further, the motor runs ahead on the starting air. During this turning movement the crank 85 has been turned so far that the plunger 71 of the fuel pump is just about to reach operative position. Upon further rotation of the control wheel 2 past the position 167, i. e. within the angle γ_1 in Fig. 11, the plungers 71 of the fuel pumps are additionally turned, since the free end of the connecting rod 84 with the roller 91 moves higher up in the guide way 86 so that the rod 80 is pulled downwards and by means of the levers 79 and 75, the rod 74 and the lever 73 turn the pump plunger 71 still more so that the fuel injection starts. At this continued turning of the control wheel 2 the pin 90 moves along the curve 197, Fig. 11. When the wheel 2 has been turned past the position 167 the cam 13 passes the valve tappet 20 and the pressure in the conduit 6 then forces the piston valve 17 in the pilot valve housing 7 downwards so that the connection between the conduit 9 and the atmosphere is interrupted. A connection is instead opened between the conduit 6 and the conduit 9 in the pilot valve 7 so that the pressure of the starting air again prevails above the piston 26 of the slide valve 11. The spring 27 then forces the slide valve downwards so that the valve piston 29 of the slide valve shuts off the supply of compressed air to the starting air valves 23. The fuel supply to the fuel injection valve 67 is then controlled by more or less turning of the control wheel 2 to the left within the angle γ_1, Fig. 11. The cam 165 is then free to move past the tappet 154, as obvious from Fig. 6.

It is now desired to reverse the engine, the control wheel 2 is turned to the right past the position 166 and the engine is stopped by means of the starting air or by other known means. During the return motion to the position 166 the cam 13 due to the weakness of the spring 15 passes the valve tappet 20 without actuating the same, as shown in Fig. 5. When the control wheel has returned to the stop position 166, the cams 58 and 63 have returned the bell crank lever 60 to the position illustrated in Fig. 3, in which the sleeve 41 on the starting air distributor shaft 40 has also returned to the position illustrated in Fig. 3. In this position the starting air distributors do not admit compressed air to the conduits 36, 39, which are instead connected with the atmosphere, and consequently the starting air valves 23 are kept closed. If the control wheel 2 is now turned to the right from the position 166, the roller 64 at first travels up the cam 63, the roller 59 moves towards the lower portion of the cam 58 and the bell crank member 60 is swung to the left in Fig. 3 so that the arm 61 is swung downwards. The rod 62 and the arm 45 are then pulled downwards and the arm 46 moves the sleeve 41 to the right in Fig. 3 and to the left in Fig. 1, respectively, so that the astern cams 43 are disposed just below the pertaining valve stems 48 and one of the cams 43, if a sufficient number of cylinders are provided with starting air valves, forces the pertaining valve stem 48 upwards.

The turning of the control wheel 2 to the right past the position 166 causes the cam 14 on the disk 12 to actuate the valve tappet 20 of the pilot valve 7. The piston valve 17 is thereby forced upwards and the conduit 9 is connected with the atmosphere in the same way as at the above described start ahead. The chamber on top of the piston 26 is then no longer under the pressure of the starting air but under atmospheric pressure and the starting air in the chamber 24 forces the slide valve 11 upwards against the action of the spring 27. The slide valve piston 29 opens the air passage to the conduits 184, 22 and compressed air is admitted to the starting air valves 23 and through the conduit 52 to the starting air distributors. The engine is then at first braked by the starting air supplied to the cylinders, and after having stopped the engine starts in reverse direction in the same manner as at the start ahead, and runs in reverse direction on the starting air.

During the above mentioned turning of the control shaft 1 to the right past the position 166 the cam 165, Fig. 6, at first forces the tappet 155 downwards so that the sliding member 156 is moved downwards together with the arm 158, whereas the arm 160 forces the valve tappet 162 and the piston valve 151 upwards. However, as long as the cams of the fuel pumps are in position for operation ahead the tappet 155 prevents the wheel 2 from being turned so much to the right that fuel injection starts with the engine running in reverse direction, i. e. the control

shaft 1 is prevented from turning past the position II in Fig. 11. The displacement of the piston valve 151 upwards causes interruption of the connection between the housing 142 and the atmosphere, and instead a connection is established from the housing 142 through the conduit 144, the chamber 145, the grooves 153, the chamber 147 and the conduit 148 to the conduit 8, which is under the pressure of the starting air. The starting air then acts upon the piston 143 and forces said piston downwards together with the spindle 141, Fig. 6, which in turn depresses the arm 139 and thereby forces the clutch member 114 to the left in Fig. 6 out of engagement with the clutch member 113 against the action of the springs 120. As soon as the motor starts to run in the reverse direction on the starting air, the sprocket 104 turns the angle α relatively to the shaft 103 in opposite direction to the arrow in Fig. 7. The jaws 106, 107 are then contrary to the prior conditions brought into engagement with the jaws 112 and 111, respectively. Simultaneously, the jaws 117 and 118 of the sprocket 104 move across the jaws 116 and 115, respectively, so that said jaws are just clear of each other. During this mutual rotation of the sprocket 104 and the clutch member 114 the collar 124, which by the key 125 is prevented from turning relatively to the clutch member 114, is screwed away a distance on the collar 123 and thereby displaced to the left in Fig. 6. During this displacement the bell crank lever 127, 128 is swung to the left and the rod 130 moved downwards so that the double armed lever 131 is brought to the position "Astern." Fig. 6. The angle member 135 is then turned to the right so that the cam 165 is free of the tappet 155. The springs acting upon the piston valve 151 and the valve tappet 162 and the air pressure acting upon the piston valve then displace the sliding member 156 and consequently the tappet 155 upwards to normal position. When the piston valve 151 is moved downwards, the connection between the conduits 144 and 148 is interrupted and a connection is instead established from the housing 142, through the conduit 144, the chamber 145, the grooves 153, the chamber 149 and the openings 150 to the atmosphere. The pressure on the piston 143 is thus relieved and the springs 120 are able to move the clutch member 114 into engagement with the clutch member 113 but with the jaws 115, 116 disposed on opposite sides of the jaws 117, 118 with regard to the position disclosed in Fig. 8. When the springs 120 move the clutch member 114 to the right the bell crank lever 138, 139 forces the spindle 141 and the piston 143 back to the position, in which said parts are illustrated in Fig. 6. During the movement of the clutch member 114 to the right said member is displaced axially relatively to the collar 124, which remains in the screwed out position. The sprocket 104 is now locked on the shaft 103 in the new position, in which the cams 101 of the fuel pumps are displaced the angle α relatively to the position, which they had, when the motor was operated ahead. The rod 130 also remains locked in the lower position, since the collar 124 is still screwed out from the sprocket 104 and the screw threaded collar 123, and the angle member 135 consequently remains locked in the position, in which it is swung to the right in Fig. 6 so that the cam 165 is free to move past the tappet 155 whereas the tappet 154 is now in the path of the cam 165 and prevents turning of the cam 165 to the left past the position 167.

The control wheel 2 is now free to be turned further to the right past the position 168, in which fuel injection starts in the same manner as at the operation ahead. The fuel supply is then controlled by movements of the control shaft 1 from the position II to the position III, i. e. within the angle γ_2 in Fig. 11. The roller 91 makes the same movements in the guide way 86, when the control shaft 1 is turned to the left and to the right, and consequently when the control wheel 2 is turned to the left or to the right the pump plungers of the fuel injection pumps are actuated in the same manner. When fuel injection has started, the cam 14 on the disk 12 has passed the valve tappet 20 and the compressed air in the conduit 6 has forced the piston valve 17 downwards. The compressed air is then again admitted to the slide valve 11 so that the same air pressure prevails above and beneath the slide valve piston 26. Consequently, the spring 27 moves the slide valve downwards so that the supply of compressed air to the starting air valves and the starting air distributors is interrupted.

The adjustment or control of the fuel supply to the motor during operation in reverse direction is hereafter achieved in the same manner as described hereinabove in connection with the operation of the motor ahead, the only difference being that an increase of fuel supply during operation in reverse direction is produced by an increased turning of the control wheel 2 to the right from the position 168, Fig. 2.

During the return of the control wheel to the stop position 166 from operation astern, the cam 14 passes the valve tappet 20 without actuating the same. During the return movement from the operation astern to the stop position 166 the starting air distributor cams are returned to the normal position illustrated in Fig. 3, whereas the angle member 135 remains in astern position as does also the reversing gear, Fig. 6, and the cams for the fuel pumps, since the collar 124 remains screwed out from the screw threaded collar 123 on the sprocket 104. When the control wheel is thereafter turned to the left, in order to start the engine ahead, the cams 42 are moved just before the valve stems 48 and the pilot valve 7 brings the conduit 9 in connection with the atmosphere so that the pressure of the starting air may displace the slide valve 11 downwards. Thus starting air is admitted to the starting air valves 23 and the starting air distributors as above described. Furthermore, the cam 165 actuates the tappet 154 thereby causing the sliding member 156 to be displaced downwards and the clutch 113, 114 to be released. When the motor then starts to run ahead, the sprocket 104 turns the angle α on the shaft 103 and returns to the position illustrated in Figs. 7 and 8. The collar 124 is then screwed towards the sprocket 104 and the angle member 135 is returned to the position illustrated in Fig. 6. Since the tappet 154 is now free of the cam 165 the piston valve 151 closes and the clutch member 114 is brought into engagement with the clutch member 113 by the springs 120 and thereby locks the sprocket 104 in the position illustrated in the drawings. The further operations at the operation of the motor ahead are identical with the operations above described in connection with operation of the motor ahead.

The control mechanism above described and il-

lustrated in the drawings should only be considered as an example and the details of the invention may naturally be modified in several different ways within the scope of the following claims.

The mechanical devices on the control shaft or the like adapted for effecting starting, reversing and fuel supply control may naturally be carried out with other means than those illustrated, and they may also be arranged to co-operate with other means for starting, reversing and fuel control than those illustrated. For instance, instead of pneumatically controlled starting air valves mechanically controlled starting air valves may be employed, which may be operated by cams provided on a cam shaft adapted to actuate the starting air valves for start ahead or astern. The means controlling the fuel injection may, for instance, comprise relief valves for the compression chambers of fuel pumps, which valves may be cam controlled in similar manner as the illustrated fuel pump plungers, and which valves in open position prevent fuel injection. The above described control mechanism may, if the relation between the numbers of revolutions of the motor shaft and the shafts for controlling the fuel pumps and the starting air distributors is changed correspondingly, be employed for two stroke engines as well as for multiple stroke engines.

What we claim is:

1. A control mechanism for reversible internal combustion engines including a starting air valve control gear, a starting device for supplying starting air to the starting valves of the engine, adjustable fuel supplying devices, a fuel injection control gear including means for locking said fuel injection control gear in different positions for different directions of rotation of the engine, reversing mechanisms for said starting air valve control gear and for said fuel injection control gear, a rotatable control shaft movable from a stop position in either of two directions to selectively effect ahead or reverse operation of the engine and actuating means operatively associated with said shaft, said actuating means being so arranged that in the first range of movement of the control shaft from said stop position in selected direction the reversing mechanism for said starting air valve control gear sets the same for operation of the engine in the appropriate direction, that in a second range of movement in the selected direction the reversing mechanism for said fuel injection control gear releases the locking means for the fuel injection control gear in the event the same is locked in a position for operation of the engine in a direction other than the direction corresponding to the selected direction of movement of the control shaft, and said starting device is operated to supply starting air to said starting valves and that in a third range of movement in the selected direction said adjustable fuel supplying devices are adjusted to supply fuel at rates corresponding to the extent of movement of the control shaft in said third range of its movement.

2. Apparatus according to claim 1 in which said starting air valve control gear has an inoperative normal position, the actuating means associated with said control shaft includes two cams in the form of reflected images of each other, and there is provided a member pivoted about an axis parallel to that of the control shaft and arranged to be swung in one or the other of two directions by said cams when said control shaft is turned for starting ahead or in reverse, respectively, said member cooperating with said starting air valve control gear to move the same from said normal position to the appropriate position for starting ahead or in reverse in accordance with the selected movement of said control shaft from its stop position.

3. Apparatus according to claim 1, in which the means for actuating the starting device for causing starting air to be supplied to the starting air valves upon turning of the control shaft in one direction or the other comprises two cams movably disposed on the control shaft and designed as reflected images of each other and so arranged that the respective cam upon the turning of the control shaft in one direction actuates a starting means for admitting starting air to the starting air valves but upon rotation in the opposite direction leaves the last mentioned starting means uninfluenced.

4. Apparatus according to claim 1 in which the means for actuating the starting device for causing starting air to be supplied to the starting air valves upon turning of the control shaft in one direction or the other comprises a disc or the like secured on the control shaft and two cams pivotally mounted on said disc and designed as reflected images of each other, each of said cams being swingable in one direction only from a normal position to which the cam always tends to return due to the action of a yielding returning device acting on the cam and said cams being so arranged that the respective cam upon turning of the control shaft in one direction actuates a starting device for admitting starting air to the starting valves but upon rotation in the opposite direction leaves said starting device unactuated.

5. Apparatus according to claim 1, characterized by the provision of movable stops positioned in accordance with the direction of rotation of the fuel injection control gear and an actuating member on said control shaft and located to cooperate with said stops upon rotation of the engine in either direction to prevent injection of fuel in the event the fuel injection control gear is positioned for a direction of rotation of the engine other than the desired direction.

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