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(19)

(54) STARTER SYSTEM FOR AN ENGINE

(71) We, LUCAS INDUSTRIES LIMITED, A British Company of Great King Street, Birmingham, B19 2XF England do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:–

This invention relates to a starter system for an engine, such as diesel engine.

According to the present invention, there is provided a starter system for an engine comprising an electrical starter mechanism, an hydraulic starter mechanism, first operating means actuable to operate selectively the electrical and hydraulic starter mechanisms independently of each other, second operating means actuable to operate the electrical and hydraulic starter mechanisms in synchronism, means for selectively actuating the first and second operating means, a first control arranged to prevent the electrical starter mechanism from operating at full power when driving element of the hydraulic starter mechanism is not engaged with a rotatable part of the engine, and a second control arranged to prevent the hydraulic starter mechanism from operating at full power when a driving element of the electrical starter mechanism is not engaged with the same or another rotatable part of the engine, the first and second controls being operative when the second operating means is actuated but being rendered inoperative when the first operating means is actuated.

Preferably, the electrical starter mechanism includes electrically driven means for rotating the respective driving element, and the first control includes a limit switch which controls the supply of electricity to the electrically driven means and which is operated so as to enable the electrically driven means to operate at full power when the driving element of the hydraulic starter mechanism engages its associated rotatable engine part.

Conveniently, the hydraulic starter mechanism includes hydraulically operated means for advancing the respective driving element into engagement with its associated rotatable engine part, and the first control also includes a member which is moved hydraulically into a predetermined position when the driving element of the hydraulic starter mechanism engages said associated engine part, the limit switch being operated by said member as it moves into its predetermined position.

Said member can be constituted by the driving element of the hydraulic starter mechanism. Alternatively, where the hydraulic starter mechanism includes a hydraulic motor for rotating the driving element and an hydraulic pump which drives the motor and which has a swash plate whose inclination relative to the pump pistons can be varied, said member can be constituted by a lever which is movable to alter the inclination of the swash plate. Where the hydraulic starter mechanism includes a pump and hydraulically operated means for advancing the driving element into engagement with the rotatable engine part, said member can be constituted by a movable lever by means of which hydraulic pressure is transmitted from the pump to the advancing means.

Desirably, the hydraulic starter mechanism includes hydraulically driven means for rotating the driving element and the second control includes a solenoid-operated valve which controls the supply of hydraulic fluid to the hydraulically driven means and which includes a solenoid connected to the electrical starter mechanism and operable so as to permit the hydraulically driven means to operate at full power when the driving element of the electrical starter mechanism engages its associated rotatable engine part.

Advantageously, the first operating means, the second operating means and the means for selectively actuating the first and second operating means are constituted by a switch which is movable between a first position in which the electrical and hydraulic starter mechanisms are operated in synchronism, a second position in which the electrical mechanism is operated alone, and a third position in which the hydraulic starter mechanism is operated alone.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:–

Figure 1A and 1B are schematic diagrams of respective parts of a first embodiment of a starter system according to the present inven-

tion for use with a diesel engine; and

Figures 2A and 2B are schematic diagrams of respective parts of a second embodiment of a starter system according to the present invention also for use with a diesel engine.

Referring to Figures 1A and 1B, the starter system shown therein comprises generally an electrical starter mechanism and an hydraulic starter mechanism which can be operated either singly or together by operation of a three-position switch 10. In a first position of the switch 10, the electrical and hydraulic starter mechanisms are operable together in synchronism; in a second position of the switch 10, the electrical starter mechanism is operable and the hydraulic starter mechanism is rendered inoperative; and in a third position of the switch 10, the hydraulic starter mechanism is operable and the electrical starter mechanism is rendered inoperative. As can be seen in the drawing, the switch 10 includes three movable contacts 11, 12 and 13 which are ganged together.

The electrical starter mechanism is entirely conventional, and only those parts thereof which are relevant to the present invention will be described in detail. The electrical starter mechanism includes a pinion (not shown) which is engageable with a gear rim 15 on a flywheel 16 of a diesel internal combustion engine (also not shown), and an electric motor 17 for rotating the pinion. The pinion is advanced to a position in which it engages the flywheel 16 by means of a mechanism which includes a draw-in coil 19 and a holding coil 20. The draw-in coil 19 is connected in series with the motor 17, and the holding coil 20 is connected in parallel with the series connection of coil 19 and motor 17. Positive and negative voltage supplies are derived from a battery (not shown) of the vehicle, and are provided as positive and negative voltage supply line 21 and 22 respectively. The motor 17 is connected between the supply lines 21 and 22, on the one hand *via* draw-in coil 19 and a movable contact 23 of a solenoid switch 24, and on the other hand *via* a movable switch contact 25 and a movable contact 26 of a solenoid switch 27. Contacts 23, 25 and 26 are all biassed away from a position in which they complete a circuit between the voltage supply and the motor 17. In particular, contact 25 is biassed away from a first position into a second position, in which it completes another circuit to be described later, and is arranged to be moved from its second position into its first position when the electrically driven pinion engages the flywheel 16.

The solenoid switch 24 also includes a coil 29 which is connected between the negative voltage supply line 22 and a common terminal 30 of the contact 12 of the switch 10. In both the first and second positions of the switch 10, contact 12 connects the terminal 30 to the positive voltage supply line 21 *via* a movable contact 31 of a starter button 32. Contact 31 is biassed into an open position by a spring 32*a*.

The solenoid switch 27 also includes a coil 33 which has one side thereof connected to the negative voltage supply line 22 and the other side thereof connected to a fixed contact 34 of the switch 10 *via* an electrical line 35. The fixed contact 34 is engaged by movable contact 11 when the switch 10 is in its second positon, the contact 11 being in turn connected to the positive voltage supply line 21 *via* a further movable contact 36 of the starter button 32. The contact 36 is biassed into an open position by the spring 32*a* of switch 32.

The hydraulic starter mechanism is also of a conventional form, and only those parts thereof which are relevant to the present invention will be described in detail. The hydraulic starter mechanism includes a pinion 40 which is engageable with the gear rim 15 on flywheel 16, an hydraulic axial piston motor 41 for rotating the pinion 40, and an hydraulically operated mechanism for advancing the pinion 40 into a position in which it engages the flywheel 16. The motor 41 is driven in an axial piston pump 42 *via* an hydraulic circuit comprising a supply line 43 and a return line 44. The motor 41 and pump 42 are provided with respective drain lines 45 and 46, and hydraulic fluid lost from the above-mentioned hydraulic circuit to these drain lines is replenished by means of a boost pump 47 and associated hydraulic lines 48 and 49. The pump 42 is itself driven by means of an auxiliary engine (not shown).

The boost pump 47 also supplies hydraulic fluid to a solenoid-operated valve 50 *via* an hydraulic line 51. When a solenoid 52 of the solenoid-operated valve 50 is energised, the valve 50 connects line 51 to an hydraulic transmission line 53 which terminates at a piston 54. When the solenoid 52 is de-energised (as shown in the drawing), the valve 50 connects the transmission line 53 to drain *via* an hydraulic line 55.

The piston 54 is pivotally connected to one end of a lever 56, and to the other end of lever 56 there is pivotally connected a further piston 58, which acts on a further hydraulic transmission line 59. The transmission line 59 terminates at an end thereof remote from piston 58 at a plurality of pistons 60 which, act on the pinion 40. The lever 56 is rotatable about a pivot 57 between a first position which it occupies when hydraulic line 53 is unpressurised, as shown in the drawing, and a second position which it occupies when line 53 is pressurised. The solenoid-operated valve 50, transmisson lines 53 and 59, pistons 54, 58 and 60 and the lever 56 together constitute the hydraulically operated mechanism for advancing the pinion 40 mentioned previously.

One side of the solenoid 52 is connected to the negative voltage supply line 22 *via* an electrical line 62, the other side of the solenoid 52

being connected to fixed contact 63 and 64 of the switch 10 *via* an electrical line 65. The fixed contact 63 is engaged by the movable contact 11 of switch 10 when the latter is in its first position, and the fixed contact 64 is engaged by the movable contact 11 when the switch 10 is in its third position. As described above in relation to the electrical starter mechanism, the contact 11 of switch 10 is itself connected to the positive voltage supply line 21 *via* the movable contact 36 of the starter button switch 32.

The axial piston pump 42 is provided with a swash plate 70 whose inclination relative to the pistons of the pump 42 can be varied by movement of an actuator piston 71, in order to increase or decrease the stroke of the pump 42. A first pressurisation chamber 72 is provided at the upper end of actuator piston 71, as viewed in the drawing, and is connected to the boost pump 47 by means of an hydraulic line 73. A second pressurisation chamber 74 is provided at the lower end of actuator piston 71, as viewed in the drawing, and communicates with the chamber 72 *via* a passage 75 formed in the actuator piston 71, the passage 75 having a constriction 76 therein. The chamber 74 is connected to drain *via* an hydraulic line 77 and a valve 78 disposed in the pivot 57 of lever 56. The valve 78 is arranged so as to be open when the lever 56 is in its said first position, as shown in the drawing, and to close as soon as the lever 56 moves out of its first position towards its said second position.

The axial piston pump 42 is also provided with a conventional movement feedback system for the actuator piston 71.

The starter system also comprises an interlock mechanism which is operable when the electrical and hydraulic starter mechanisms are operated together, but which is rendered inoperative when either of the electric and hydraulic starter mechanisms is operated on its own. The interlock mechanism includes a first control which prevents the electric motor 17 from operating at full power until the hydraulically driven pinion 40 is engaged with the flywheel 16, and a second control which prevents the hydraulic motor 41 from operating at full power until the electrically driven pinion is engaged with the flywheel 16.

The first control comprises a limit switch 80 which is disposed in the path of movement of the lever 56. Contacts of the limit switch 80 are biassed into an open position, but are closed by the lever 56 as it moves into its second position. One side of the limit switch 80 is connected to the positive voltage supply line 21 *via* an electrical line 81, and the other side thereof is connected to the negative voltage supply line 22 *via* an electrical line 82 and the coil 33 of solenoid switch 27.

The second control comprises a solenoid-operated valve 83 which is disposed in an hydraulic line 84 connecting the pressurisation chamber 74 for the actuating piston 71 to drain. The valve 83 is arranged to be closed when a solenoid 85 thereof is de-energised, and open when solenoid 85 is energised. One side of the solenoid 85 is connected to the negative voltage supply line 22 *via* an electrical line 86 and the previously mentioned electrical line 62. The other side of solenoid 85 is connected to a common terminal 87 of the movable contact 13 of the switch 10 *via* an electrical line 88 and the previously-mentioned movable switch contact 25. Contact 25 completes this connection when it is in its aforesaid second position, and is arranged to break the connection when the electrically driven pinion engages the flywheel 16. The terminal 87 is connected to the positive voltage supply line 21 *via* the starter button contact 31 by the movable contact 13 when the switch 10 is in its first position.

To operate the electrical and hydraulic starter mechanisms together in synchronism, the switch 10 is moved into its first position and the starter button 32 is depressed with the auxiliary engine running and driving the pump 42. Considering operation of the electrical starter mechanism first, depression of starter button 32 causes current to flow through the coil 29 of solenoid switch 24 *via* starter button contact 31 and movable contact 12 of the switch 10. This in turn causes the contact 23 of solenoid switch 24 to close, enabling current to be supplied to the holding coil 20 and to the draw-in coil 19 and the motor 17. Energisation of the draw-in coil 19 causes the electrically driven pinion to be advanced, and the pinion is rotated by the electric motor 17, through not at full power.

Simultaneously with the above, on depressing starter button 32, the solenoid 85 of valve 83 is energised *via* starter button contact 31, movable contact 13 of switch 10, contact 25 and electrical lines 88, 86 and 62, thereby opening the hydraulic line 84 to drain. Solenoid 52 of valve 50 is also energised, *via* starter button contact 36, movable contact 11 of switch 10 and electrical lines 65 and 62, thereby connectiong hydraulic transmission line 53 to the boost pump 47. Boost pressure then acts on the piston 54, causing the lever 56 to rotate out of its first position, thereby closing the valve 78. Rotation of lever 56 also causes the piston 58 to act on the hydraulic transmission line 59 so as to advance the hydraulically driven pinion 40. During the above, the swash plate 70 is inclined relative to pump 42 in such a manner that the pump 42 produces a low stroke delivery to the hydraulic motor 41, causing the pinion 40 as it is advanced to be rotated slowly at very low torque and in the opposite direction to that in which it is rotated to effect starting of the engine. This is to avoid stripping of the pinion gear teeth which might otherwise occur.

The lever 56 reaches its second postion when the hydraulically driven pinion 40 engages the

flywheel 16, and as it moves into its second position the lever 56 closes the contacts of the limit switch 80. Current can then flow through the coil 33 of solenoid switch 27 *via* the electrical lines 81 and 82, thereby closing the movable contact 26 of the solenoid switch 27. When the electrically driven pinion engages the flywheel 16, the contact 25 is moved to its aforesaid first position, and thereby connects the electric motor 17 directly between the postitive and negative voltage supply lines. The motor 17 can now operate at full power.

It will be manifest that the electric motor 17 cannot be operated at full power unless the contact 25 is in its first position and the contact 26 is closed. Since movement of contacts 25 and 26 are respectively controlled by engagement of the electrically driven pinion and the hydraulically driven pinion 40 with the flywheel 16, the electric motor 17 cannot be operated at full power unless both pinions are engaged with the flywheel 16.

When the contact 25 is moved out of its first position into its second position by engagement of the electrically driven pinion with the flywheel 16, the solenoid 85 of the solenoid-operated valve 83 is disconnected from the positive voltage supply line 21 and is thereby de-energised. The valve 83 then closes the hydraulic line 84. Hydraulic fluid supplied to the upper pressurisation chamber 72 for the actuator piston 71 flows into the lower pressurisation chamber 74 by means of a passage formed in the actuator piston 71 at a rate which is determined by the construction 76. Since the chamber 74 is closed off from drain by both the valve 83 and the valve 78, pressure then builds up in the chamber 74 and causes the actuator piston 71 to move upwardly, as viewed in the drawing. This in turn alters the inclination of the swash plate 70, so that the pump 42 operates at a high stroke delivery and the hydraulic motor 41 is operated at full power. During movement of the actuator piston 71, the swash plate 70 moves through a dead centre position in which the pump 42 operates at zero stroke delivery. It will thus be manifest that, while the pinion 40 is being advanced, it rotates in a direction opposite to that in which it rotates when the motor 41 is operated at full power.

It will also be manifiest that pressure cannot build up in the chamber 74 until both the valve 78 and the valve 83 are closed. Valve 78 is closed by the advance of the hydraulically driven pinion 40. Valve 83 is closed by engagement of the electrically driven pinion with the flywheel 16. Thus, the hydraulic motor 41 cannot be operated at full power until and unless the electrically driven pinion is engaged with the flywheel 16.

To operate the electrical starter mechanism alone, the switch 10 is moved into its second position and the starter button 32 is depressed. The electrical starter mechanism operates in substantially the same manner as described above, except that the coil 33 of solenoid switch 27 is energised *via* movable contact 11 of switch 10 and electrical line 35 immediately upon depression of the starter button 32, rather than when limit switch 80 is closed. Limit switch 80 is therefore inoperative. The contact 26 of solenoid switch 27 is therefore immediately closed, and the electric motor 17 will operate at full power as soon as the contact 25 is moved into its first position by engagement of the electrically driven pinion with the flywheel 16.

To operate the hydraulic starter mechanism alone, the switch 10 is moved into its third position and the starter button 32 is depressed with the auxiliary engine running and driving the pump 42. Operation of the hydraulic starter mechanism is substantially identical to that described above, except that solenoid 85 of the solenoid-operated valve 83 remains de-energised at all times, so that valve 83 always closes the hydraulic line 84. Thus, hydraulic pressure can build up in pressurisation chamber 74 as soon as the valve 78 closes, rather than after valve 83 has closed also.

Referring now to Figure 2A and 2B, an alternative embodiment of the starter system of the present invention is shown therein and is generally similar to the embodiment described above in relation to Figure 1, similar parts being accorded the same reference numerals with 100 added. However, the embodiment of Figure 2 differs from that of Figure 1 in the following respects.

The switch 110 includes a fourth movable contact 200 which is ganged with the contacts 111, 112 and 113.

In the electrical starter mechanism, movable contact 125 does not complete a further circuit when biassed away from its first position. Also, the coil 133 of solenoid switch 127 is connected between the negative voltage supply line 122 and a common terminal 201 of the movable switch contact 200. When the switch 110 is in its second position, the movable contact 200 connects the terminal 201 to the positive voltage supply line 121 *via* an electrical line 202, a fixed contact 203 of the switch 110, movable contact 111 of switch 110 and the movable contact 136 of starter button 132.

In the hydraulic starter mechanism, the hydraulic transmission line 153 from the solenoid-operated valve 150 is arranged to act directly on the hydraulically driven pinion 140 by means of a plurality of pistons 205, rather than through the intermediary of a lever and a further hydraulic transmission line. Thus, the hydraulically operated mechanism for advancing pinion 140 is now constituted by the solenoid-operated valve 150, transmission line 153 and the pistons 205. Also, the second pressurisation chamber 174 is no longer connected to drain *via* a valve which is closed by pressurisation by the hydraulically operated mechanism

for advancing pinion 140.

In the interlock mechanism, the first control (i.e. for preventing the electric motor 117 from being operated at full power until the hydraulically driven pinion 140 is engaged with flywheel 116) is formed by a limit switch 206 disposed in the path of advancement of pinion 140. A movable contact 207 of limit switch 206 is biassed into an open position, but is closed by engagement of a cam surface 208 on pinion 140 with a cam follower 209 fixed to the contact 207. The limit switch 206 is arranged to be closed only when pinion 140 is engaged with the flywheel 116. One side of the limit switch 206 is connected to the positive voltage supply line 121 *via* movable contact 131 of starter button 132 and an electrical line 210. The other side of the limit switch 206 is connected to a fixed contact 211 of switch 110 *via* an electrical line 212. The fixed contact 211 is engaged by movable contact 200 when the switch 110 is in its first position, thereby connecting contact 211 to the coil 133 of solenoid switch 127 and thence to the negative voltage supply line 122. Fixed contact 211 is also connected to a further fixed contact 213 of switch 110 *via* an electrical line 214, the fixed contact 213 being engaged by movable contact 113 when the switch 110 is in its third position.

In the second control of the interlock mechanism (i.e. for preventing the hydraulic motor 141 from being operated at full power until the electrically driven pinion is engaged with flywheel 116), the solenoid 185 of the solenoid-operated valve 183 has one side thereof connected to the negative voltage supply line 122 *via* an electrical line 186, in the same manner as in the embodiment of Figure 1. However, the other side of solenoid 185 is now connected to a common terminal 216 of movable switch contact 113 via an electrical line 217. In a first position of switch 110, the movable contact 113 connects terminal 216 to the positive voltage supply line 121 *via* an electrical line 218, movable contact 125 and movable contact 126 of solenoid switch 127. In a third position of the switch 110, movable contact 113 connects terminals 216 to the fixed contact 213 mentioned above. Also, the solenoid-operated valve 183 is arranged to connect hydraulic line 184 to drain when de-energised and to close off line 184 when energised, in contrast to the embodiment of Figure 1 where the reverse is the case.

Operation of the starter system of Figure 2 is essentially similar to that of the starter system of Figure 1, and consequently only those respects in which the two differ will be described in detail.

In the embodiment of Figure 2, in order to operate the electrical and hydraulic starter mechanisms together in synchronism, the switch 110 is moved into its first position and the starter button 132 is depressed with the auxiliary engine running and driving the pump 142. The electrically driven pinion is then advanced by the electrical starter mechanism in the same way as described above in relation to Figure 1. The electric motor 117 is prevented from operating at full power at this time because limit switch 206 is open, thereby preventing the coil 133 of solenoid switch 127 from being energised so as to close contact 126, which in turn prevents the motor 117 from being connected directly between the positive and negative voltage supply lines.

Simultaneously with the above, solenoid valve 150 is energised *via* starter button contact 136, movable contact 111 of switch 110, and lines 165 and 162, thereby connecting the hydraulic tranmission line 153 to the boost pump 147. Boost pressure then acts on the pistons 205 so as to advance the hydraulically driven pinion 140. At this time, the hydraulic motor 141 is prevented from being operated at full power because solenoid-operated valve 183 is open, thereby preventing hydraulic pressure from buidling up in pressurisation chamber 174 and hydraulic line 184.

When the hydraulically driven pinion 140 engages the flywheel 116, limit switch 206 is closed, thereby energising coil 133 of solenoid switch 127 and closing contact 126. When the electrically driven pinion engages the flywheel 116, the contact 125 is also closed. The electric motor 117 is thereby connected directly between the positive and negative voltage supply lines and thus operates at full power. At the same time, solenoid-operated valve 183 is energised *via* contacts 126 and 125, movable contact 113 switch 110 and lines 217 and 186, thereby enabling pressure to build up in pressurisation chamber 174 so as to enable the hydraulic motor 141 to operate at full power.

It will thus be manifest that neither the electrically driven pinion nor the hydraulically driven 140 can be driven at full power unless both contacts 125 and 126 are closed. Contact 125 is closed by engagement of the electrically driven pinion with the flywheel 116; contact 216 is closed when the limit switch 206 is closed by engagement of the hydraulically driven pinion 140 with the flywheel 116.

To operate the electrical starter mechanism alone, the switch 110 is moved into its second position and the starter button 132 is depressed. The limit switch 206 is now by-passed by contacts 111 and 200 of switch 110 and electrical line 202. This has the effect of causing the movable contact 126 of solenoid switch 127 to be closed immediately upon depression of the starter button 132. The electric motor 117 then operates at full power as soon as the contact 125 is closed by engagement of the electrically driven pinion with a flywheel 116.

To operate the hydraulic starter mechanism alone, the switch 110 is moved into its third position and the starter button 132 is depressed. Solenoid switch 127 is now by-

passed by electrical line 210, limit switch 206, electrical lines 212 and 214 and movable contact 113 of switch 110. The solenoid-operated valve 183 energised when limit switch 206 is closed by engagement of the hydraulically driven pinion 140 with the flywheel 116 thereby enabling the hydraulic motor 141 to operate at full power.

It is preferable in each of the above-described embodiments to arrange for the hydraulically driven pinion to engage its respective flywheel before the electrically driven pinion engages its respective flywheel. This is because of the different speeds at which the two pinions are advanced, for it takes longer for the hydraulically driven pinion to move into engagement with the respective flywheel than it takes for the electrically driven pinion to move into engagement with its associated flywheel. Also, the compressibility of the hydraulic fluid gives rise to a slight delay between the advance mechanism for the hydraulically driven pinion being energised and the pinion actually beginning to move. The above-described arrangement can be achieved by deriving signals from the hydraulically driven pinion which indicate when the latter has engaged its flywheel, engagement of the electrically driven pinion being effected in dependence upon these signals.

It is also preferable to keep the volume of hydraulic fluid used in the hydraulic starter mechanism to a minimum to reduce the compressibility effect mentioned above.

In a further embodiment (not shown), the starter system is provided with a delay mechanism such that, when changing from one mode of operation to another, a predetermined delay of approximately 5 seconds occurs before the starting sequence can be re-initiated by depression of the starter button 32 and 132. This predetermined delay is sufficient to ensure that the flywheel 16 to 116 is brought to rest before the starting sequence can be re-initiated.

It has been found that using the starter system of the present invention the number of successful pinion engagements compared with the number of times that the starter button is actuated can be made very high.

WHAT WE CLAIM IS:—

1. A starter system for an engine, comprising an electrical starter mechanism, an hydraulic starter mechanism, first operating means actuable to operate selectively the electrical and hydraulic starter mechanisms independently of each other, second operating means actuable to operate the electrical and hydraulic starter mechanisms in synchronism, means for selectively actuating the first and second operating means, a first control arranged to prevent the electrical starter mechanism from operating at full power when a driving element of the hydraulic starter mechanism is not engaged with a rotatable part of the engine, and a second control arranged to prevent the hydraulic starter mechanism from operating at full power when driving element of the electrical starter mechanism is not engaged with the same or another rotatable part of the engine, the first and second controls being operative when the second operating means is actuated but being rendered inoperative when the first operating means is actuated.

2. A starter system as claimed in claim 1, wherein the electrical starter mechanism includes electrically driven means for rotating the respective driving element, and the first control includes a limit switch which controls the supply of electricity to the electrically driven means and which is operated so as to enable the electrically driven means to operate at full power when the driving element of the hydraulic starter mechanism engages its associated rotatable engine part.

3. A starter system as claimed in claim 2, wherein the hydraulic starter mechanism includes hydraulically operated means for advancing the respective driving element into engagement with its associated rotatable engine parts, and the first control also includes a member which is moved hydraulically into a predetermined position when the driving element of the hydraulic starter mechanism engages said associated engine part, the limit switch being operated by said member as it moves into its predetermined position.

4. A starter mechanism as claimed in claim 3, wherein said member is constituted by the driving element of the hydraulic starter mechanism.

5. A starter system as claimed in claim 3, wherein the hydraulic starter mechanism includes an hydraulic motor for rotating the driving element and an hydraulic pump which drives the motor and which has a swash plate whose inclination relative to the pump pistons can be varied, and said member is constituted by a lever which is movable to alter the inclination of the swash plate.

6. A starter system as claimed in claim 3, wherein the hydraulic starter mechanism includes a pump and hydraulically operated means for advancing the driving element into engagement with the rotatable engine part, and said member is constituted by a movable lever by means of which hydraulic pressure is transmitted from the pump to the advancing means.

7. A starter system as claimed in any preceding claim, wherein the hydraulic starter mechanism includes hydraulically driven means for rotating the driving element, and the second control includes a solenoid-operated valve which controls the supply of hydraulic fluid to the hydraulically driven means and which includes a solenoid connected to the electrical starter mechanism and operable so as to permit the hydraulically driven means to operate at full power when the driving element of the electrical starter mechanism engages its associated rotatable engine part.

8. A starter system as claimed in any preceding claim, wherein the first operating means, the second operating means and the means for selectively actuating the first and second operating means are constituted by a switch which is movable between a first position in which the electrical and hydraulic starter mechanisms are operated in synchronism, a second position in which the electrical starter mechanism is operated alone, and a third position in which the hydraulic starter mechanism is operated alone.

9. A starter system for an engine, substantially as hereinbefore described with reference to Figures 1A and 1B or Figures 2A and 2B of the accompanying drawings.

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1585665 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1a.

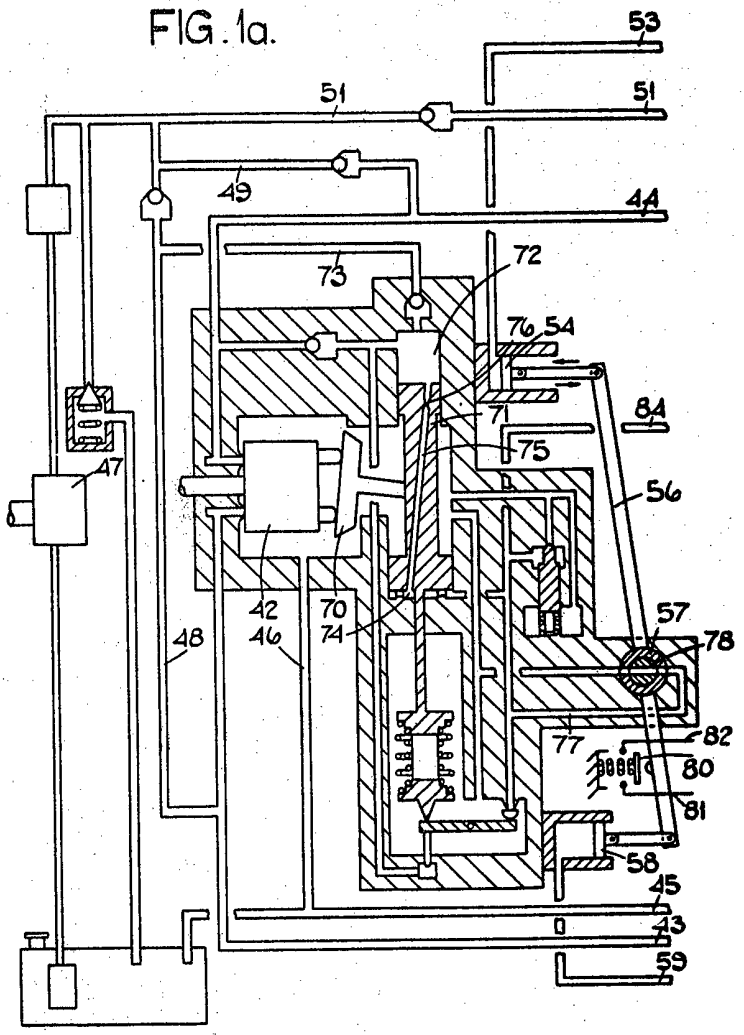

FIG.1b.

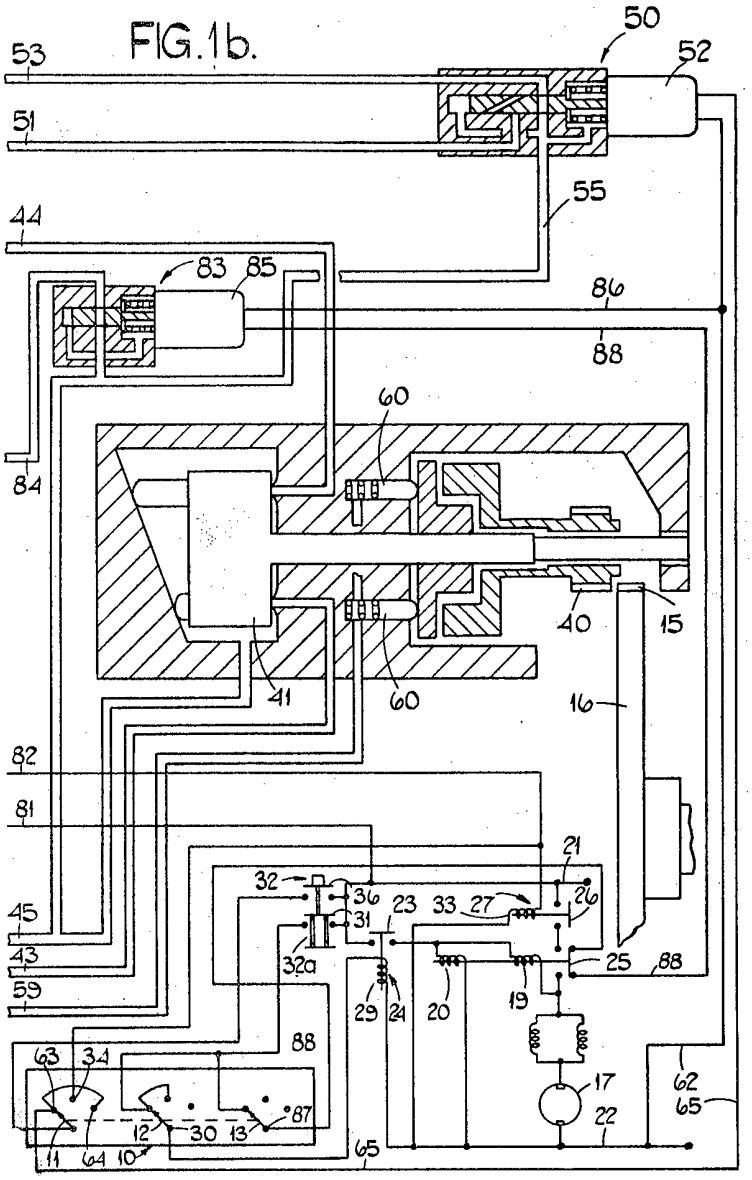
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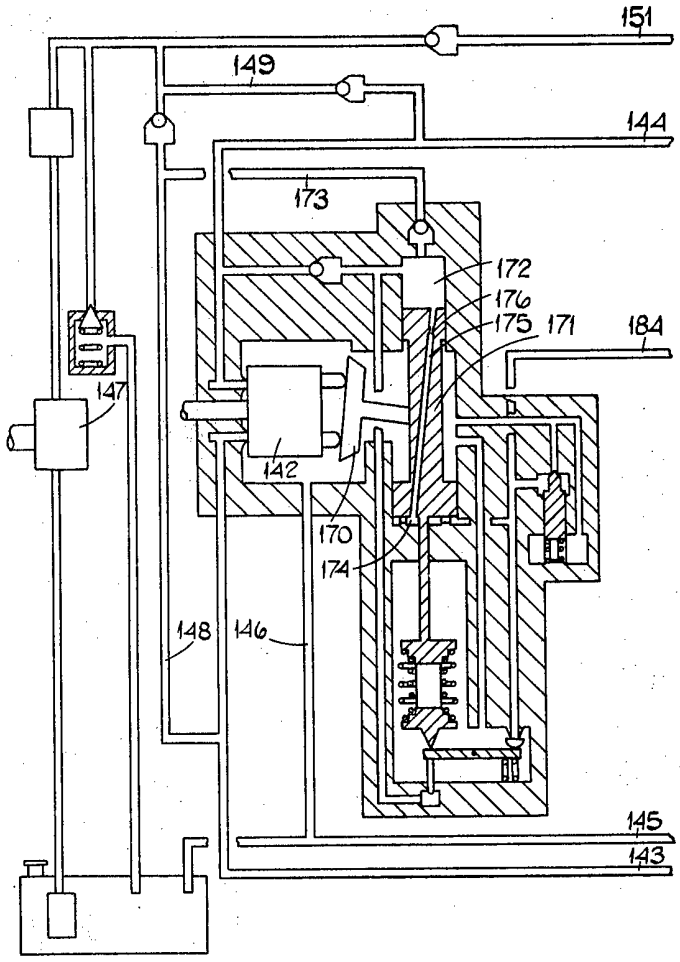
FIG.2a.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1585665 COMPLETE SPECIFICATION
4 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 4

FIG.2b.