Nov. 24, 1942. J. B. DYER 2,302,680

ENGINE STARTING APPARATUS

Original Filed Jan. 29, 1932 3 Sheets-Sheet 1

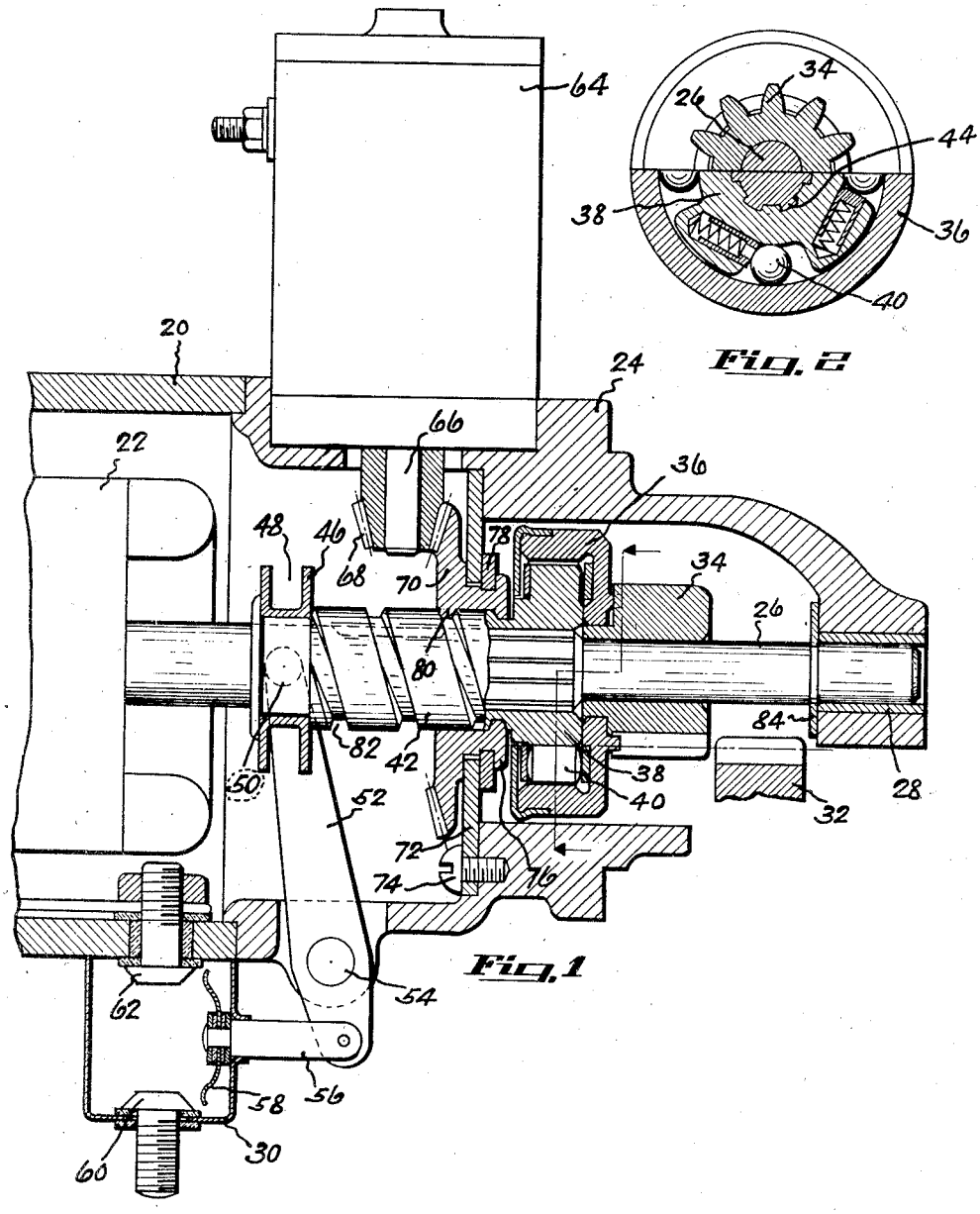


Fig. 1

Fig. 2

Inventor
John B. Dyer
By Spencer Hardman and Fehr
Attorney

Nov. 24, 1942. J. B. DYER 2,302,680

ENGINE STARTING APPARATUS

Original Filed Jan. 29, 1932 3 Sheets-Sheet 2

Fig. 1

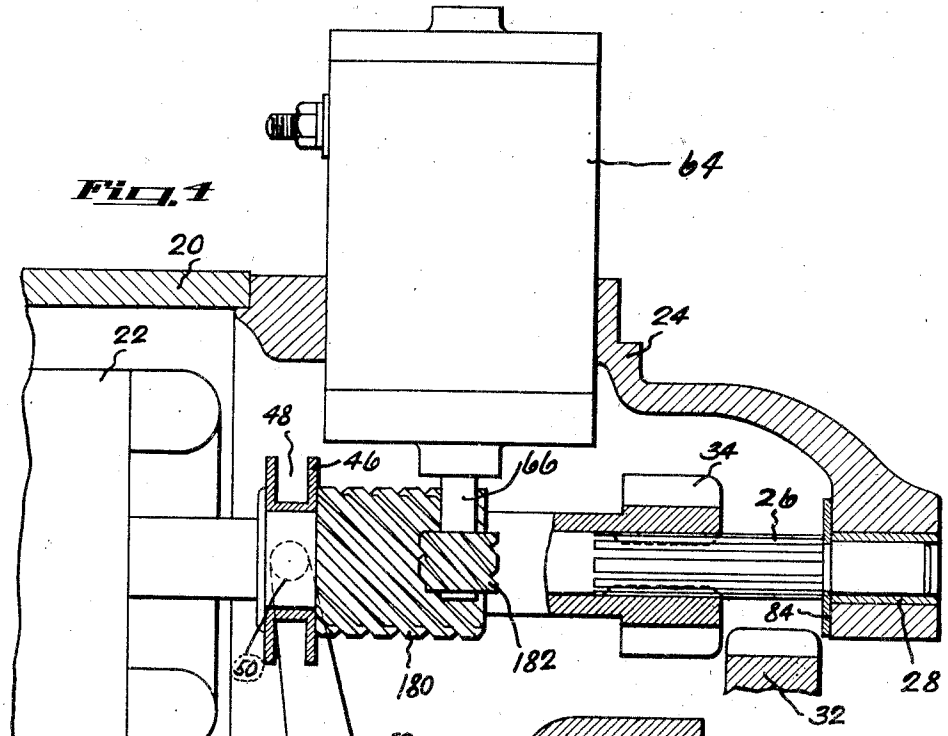
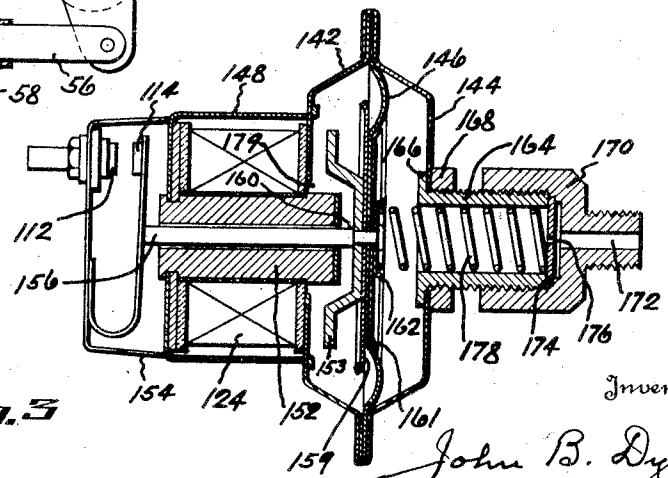


Fig. 3



Inventor

John B. Dyer

By Spencer Hardman and Fehr

Attorney

Nov. 24, 1942. J. B. DYER 2,302,680

ENGINE STARTING APPARATUS

Original Filed Jan. 29, 1932 3 Sheets-Sheet 3

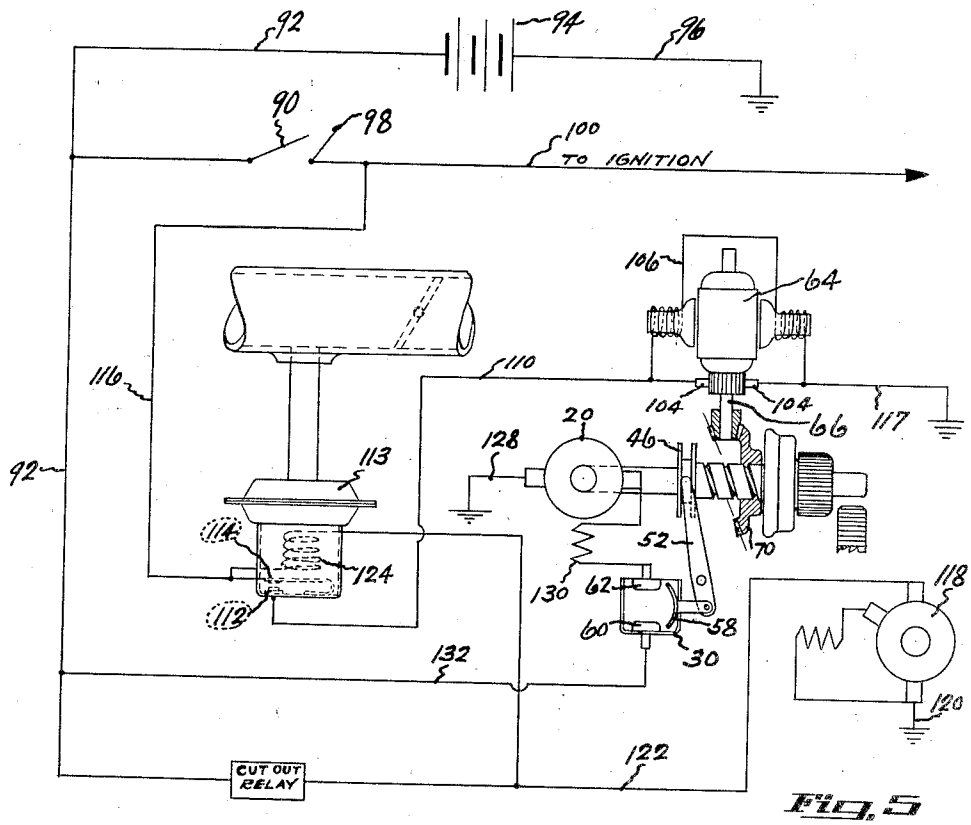


Fig. 5

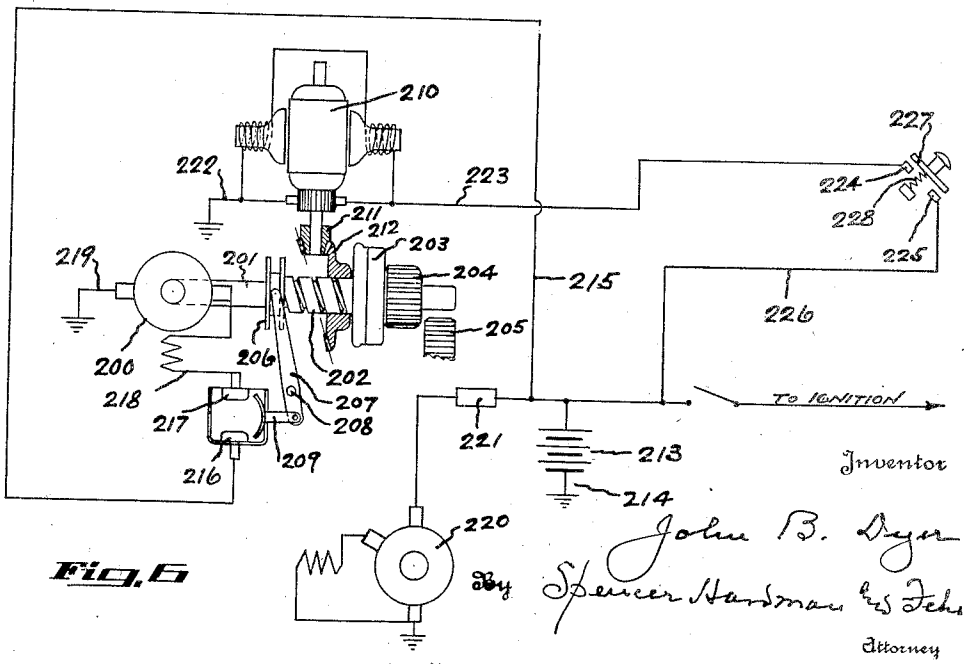


Fig. 6

Inventor

John B. Dyer

By Spencer Hardman & Fehr

Attorney

Patented Nov. 24, 1942

2,302,680

UNITED STATES PATENT OFFICE

2,302,680

ENGINE STARTING APPARATUS

John B. Dyer, Dayton, Ohio, assignor, by mesne assignments, to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application January 29, 1932, Serial No. 589,642
Renewed March 13, 1937

22 Claims. (Cl. 290—37)

This invention relates to control apparatus for internal combustion engines, particularly engines for automotive vehicles, and specifically to devices for controlling the operation of the starting apparatus for internal combustion engines.

One object of the invention is to provide improved means operable under the control of the operator of the vehicle to effect driving connection between the starting motor and a part of the engine to be driven thereby, to effect the closing of a switch controlling the starting motor, to render the driving connection between the motor and engine ineffective and open the switch when the engine starts.

Another more specific object of the invention is to provide a starting apparatus of this character which is provided with power operated means to accomplish these results.

Another object of the present invention is to provide an engine starting apparatus which may be rendered operative through the use of one of the control members used in operation of the vehicle, such, for instance, as the ignition switch and is automatically rendered effective whenever the engine stalls during the operation of the vehicle.

It is a further object of the invention to provide an engine starting device in which means is provided to prevent the starting motor becoming immediately operative on operation of the control member such as the ignition switch, which is designed to render said starting device effective, in other words, to provide means to cause a slight delay after the operation of such control before the starting motor becomes operative.

It is a further object of the invention to provide improved means for controlling the operation of the automatic starting apparatus to prevent the operation thereof during the operation of the engine under its own power.

With these objects in view, one form of the invention includes the provision of a main starting motor for driving the engine during the starting operation and an auxiliary starting motor, the circuit of which is controlled by a manually operated switch and which is effective to first cause engagement of the driving pinion with the engine flywheel, subsequently to close the switch of the main starting motor, and when the engine is started and operating under its own power, becomes effective to open the starting motor switch and cause disengagement of the driving pinion and the flywheel gear.

In another form of the invention the circuit of the auxiliary motor is closed by the ignition switch, the motor being rendered effective to perform the functions above described, while an automatic switch is also provided which is operative to prevent the closing of the auxiliary motor circuit when the engine is operating. This automatic switch is controlled jointly by engine suction and generator voltage so that it is held open at all times that the engine is running under any operating conditions, and is so constructed that an appreciable time must elapse after the engine has stalled before the switch can close to permit operation of the auxiliary motor.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of one form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a fragmentary view partly in section, of an engine starting apparatus constructed according to the present invention.

Fig. 2 is a detailed view partly in section, of the overrunning clutch shown in Fig. 1.

Fig. 3 is a detailed sectional view of the automatic switch controlling relay.

Fig. 4 is a view similar to Fig. 1 showing a modified form of the mechanism operated by the auxiliary motor.

Figs. 5 and 6 are diagrammatic views showing the wiring connections for the two forms of the invention disclosed herein.

Referring to Fig. 1 of the drawings particularly, 20 indicates the field frame of an electric motor, the armature of which is indicated at 22. The frame 20 is secured to a gear housing 24, which is adapted to be attached to the engine frame (not shown). The frame 20 carries a bearing which is not shown herein, for supporting the left end of the armature shaft 26 carrying the armature 22 and the frame 24 supports a bearing 28 for the other end of the shaft 26. The motor circuit is controlled by a switch contained in the housing 30 and more fully described later. The motor is normally disconnected from the flywheel 32 of the engine and is adapted to be placed in driving relation with said flywheel by the movement of the pinion 34 along the shaft 26 into position to engage the teeth of the flywheel gear. The pinion 34 is secured in any desirable way, to the outer member 36 of an overrunning clutch of standard construction. This clutch need not be described in detail as its specific construction is not material to this invention, but is fully illus-

trated in Fig. 2 and includes an inner member 38 having recesses therein to receive rollers 40 which are adapted to wedge between the inner and outer members of the clutch when the starting motor is operated to drive the engine flywheel, but which automatically releases when the engine operates under its own power and the outer member of the clutch is moved more rapidly than the inner member so that the pinion can turn independently of the motor shaft after the engine starts to operate. This is the ordinary construction used in the overrunning clutch type of engine starter and is in no way novel.

The inner member 38 of the clutch is secured to or integral with a sleeve 42 which is provided with interior splines adapted to engage cooperating splines 44 formed on the shaft 26 so that the inner clutch member 38 is adapted to be rotated by the shaft 26 when the motor switch is closed. On one end of the sleeve 42 is secured a collar 46 having a groove 48 formed therein which is adapted to be engaged by a pin 50 on one end of a lever 52 pivotally mounted at 54 on a stud which is fixedly secured in the housing 24. The other end of the said lever 52 is pivotally connected to a short link 56, the other end of which carries a switch contact 58 of any suitable flexible construction adapted to be moved into position to engage the fixed contacts 60 and 62 of the starting motor switch, so that said switch is closed when the sleeve 42 is moved to the right sufficiently to cause engagement of the pinion 34 with the engine flywheel 32, the construction being such that the switch is not closed until the engagement of the pinion and flywheel gear has been effected. The switch contact is of flexible construction so as to permit a slight movement of lever 52 after the contacts have been engaged so as to insure proper closing of the switch under all circumstances and to compensate for wear or manufacturing inaccuracies.

In order to move the sleeve 42 to the right, as above described, applicant has provided an auxiliary motor 64, the circuit of which is controlled in a manner hereinafter described and which is provided with an armature shaft 66 carrying a beveled gear wheel 68 suitably secured thereto and adapted to engage a correspondingly beveled gear wheel 70, which is rotatably journaled on a partition plate 72 supported by the housing 24 and secured thereto by screws 74, as indicated in Fig. 1. Received on a reduced extension of the hub of the gear 70 between the partition 72 and a flange 76 on the hub of the gear wheel is a bearing member or bushing 78. The hub of the gear wheel is internally threaded as indicated at 80, and engages a corresponding thread 82 of relatively steep pitch on the outer surface of the sleeve 42 so that when the motor 64 is caused to operate, the gear 70 is rotated and by engagement of the thread 80 with the helical thread 82 formed on the sleeve 42, the sleeve, pinion and overrunning clutch assembly are all moved to the right into position to effect engagement of the pinion 34 with the flywheel gear and to effect the closing of the switch of the starting motor subsequent to the engagement of the gears referred to as previously described. The bushing 28 is provided with a flange 84 which serves as a stop for the pinion as it is moved to the right.

The auxiliary motor 64 is a relatively small motor of the shunt wound type as indicated in the diagrammatic views in Figs. 5 and 6. This motor is so designed that its acceleration is faster than that of the starting motor but it is of the maximum speed type and has a maximum speed considerably less than that of the starting motor whereby the auxiliary motor is effective to cause demeshing of the pinion 34 and the engine flywheel when the engine begins to move under its own power and also is effective to aid the starting motor in turning the flywheel. The operation is substantially as follows: When the pinion is caused to engage the flywheel and the starting motor is rendered effective by the closing of the motor switch, as previously described, the flywheel is turned by the starting motor to cause the engine to run under its own power, the clutch being so designed that the inner member of the clutch is effective to rotate the outer member and hence rotate the pinion when the shaft 26 is operated by the starting motor. When the engine starts to run under its own power, the pinion tends to rotate at considerably higher speed than the starting motor and because of the clutch connection, the pinion is enabled to rotate freely and more rapidly than the starting motor and the inner member of the clutch. When the engine starts to run under its own power, the action of the engine suction and the generator, when operating at sufficient speed, is effective to open the automatic switch, previously referred to, which controls the circuit of the auxiliary motor so that the latter slows down and finally stops, thus operating to reduce the speed of the gear 70. When said gear begins to turn at a speed less than that of the starting motor, the action of its thread on sleeve 42 is effective to move the sleeve to the left to disengage the driving pinion from the flywheel and open the starting motor switch. Moreover, since the auxiliary motor has a maximum speed, the sleeve may be driven by the starting motor more rapidly than the speed of the gear 70 before the circuit of the auxiliary motor is broken so that the gear 68 may act as a brake tending to retard the speed of the gear 70 under these circumstances and because of the retardation of the gear 70 with respect to speed of rotation of the threaded sleeve 42, the helical thread is effective to move the gear 70, the clutch assembly and the pinion to the left before the circuit of the auxiliary motor is broken.

Also attention is directed particularly to the fact that because the acceleration of the auxiliary motor is greater than that of the starting motor, the former may aid the starting motor in cranking the engine. At the time the pinion is engaged and the starting motor switch is first closed, the auxiliary motor will be operating at a higher speed than the starting motor and since the sleeve 42 cannot be moved further to the right, the auxiliary motor tends to turn the sleeve 42 and will continue to do so as long as the speed of the starting motor is less than that of the auxiliary motor.

It will also be apparent that when an auxiliary motor of maximum speed type is employed with a manually controlled circuit such as shown in Fig. 6, and described in detail hereinafter, such motor may be effective to cause automatic disengagement of the driving pinion from the flywheel and the opening of the starting motor switch even when the manually operated switch which controls the circuit of the auxiliary motor is held closed. When the engine begins to run under its own power, the starting motor begins to operate at no load and as soon as its speed is

greater than that of the auxiliary motor, the gear 70 will not turn as fast as the sleeve 42, the auxiliary motor acting as a brake. Because of the threaded engagement of the gear and sleeve, this action will cause a movement of the sleeve to the left and consequent demeshing of the pinion and opening of the starting motor switch.

When the pinion is moved to the right to cause engagement of the pinion with the flywheel gear as previously described, it may under certain circumstances be in such position that its teeth will abut the teeth of the flywheel gear. Under these circumstances, the motion of the sleeve 42 longitudinally being stopped, the action of the thread on the gear 70 on the helical thread 82 of the sleeve 42 will cause a slight rotation of the sleeve and the starting motor shaft to rotate the pinion to such position that it may be moved into engagement with the flywheel teeth.

In one form of the invention, the control of the circuit of the auxiliary motor may be entirely automatic except for the manual operation of the ignition switch. In other words, the operator in order to start the engine merely closes the ignition switch and the auxiliary motor is rendered effective to cause the operation of the starting motor in the manner heretofore described, and the circuit of the auxiliary motor is then broken and the auxiliary motor remains ineffective as long as the engine is operating under its own power. In order to accomplish these results, means are provided which are controlled in part by the action of the generator and in part by the suction of the engine to automatically control the circuit through the auxiliary motor, this means being best understood by examination of the diagrammatic view in Fig. 5. In another form of the invention, the control of the auxiliary motor is by a manually operable switch which has no other function, as shown in Fig. 6. The form shown in Fig. 5 will be first described.

The ignition switch includes a movable contact member 90 connected through the lead 92 to a battery 94 having a connection 96 extending to ground. The movable switch member 90 is adapted to engage a fixed contact 98 connected through a lead 100 with the ignition system (not shown) and through means hereinafter described, one of the brushes 104 of the auxiliary motor 64 which is provided with a shunt field being indicated at 106. The other brush 104 of the auxiliary motor is connected through lead 110 to the fixed contact 112 of a secondary switch or relay indicated in its entirety by the reference number 113, and has a movable contact 114, normally disengaged from the contact 112, but which is adapted to be engaged therewith when the ignition switch is closed in the manner hereinafter described. The contact 114 is connected to the fixed terminal of the ignition switch by a wire 116, and the shunt motor is grounded through wire 117, as indicated in Fig. 5. A third brush generator which may be of separately excited type, is indicated at 118 and is grounded as indicated at 120. Connecting with the generator is wire 122, which extends to the usual cut-out relay which is also connected through the wire 92 to the battery and to the ignition switch. The wire 122 from the generator is connected with the relay winding 124, through said winding to the wire 116 and thence with the fixed terminal of the ignition switch. The specific construction of the relay 113 is disclosed fully in Fig. 3 and will be described in detail hereinafter.

On closing of the ignition switch, current passes from the battery to the ground and from the battery through the connection 92, the ignition switch and the wire 100 to the ignition system and to the ground in the usual manner. Current also flows from the battery through the wire 92, the ignition switch, the wire 116, the winding 124 and through the generator to the ground, the cut-out relay being closed at this time because the generator is inactive. Also current passes from the battery to the ground through the connection 96, thus exciting the relay 113 to effect closing of the switch contacts 112 and 114. This action effects closing of the circuit through the auxiliary shunt motor from the battery through the connection 92, the ignition switch, the connection 116, the connection 110, and the connection 117 to ground, so that the auxiliary motor becomes operative to move the sleeve 42 to the right as previously described to effect the meshing of the driving pinion 34 and the flywheel gear 32 as well as to close the switch of main starting motor 20. The latter is grounded as indicated at 128 and is connected through the wire 130 to one fixed contact 62 while the other fixed contact 60 is connected through the wires 132 and 92 to the battery which is grounded through the connection 96, as indicated in Fig. 5.

The specific construction of the relay 113 which is shown in detail in Fig. 3, will now be described. This relay comprises a diaphragm chamber formed of two sheet metal shells 142 and 144, which are secured together by any desirable air tight joint and secured between the shells is a non-metallic diaphragm 146, which is adapted to be moved by the suction of the engine. Another cup-shaped shell 148 is secured to the shell 142 and houses the winding 124 of an electromagnet having a core 152 and an armature 153. A bracket 154 is secured to the shell 148 in any suitable way and extends therefrom to support in contact therewith the movable contact 114 of the switch previously described, while the fixed contact 112 of such switch is also supported by but insulated from the bracket 154. One end of the winding 124 is connected to the lead 122 and through the generator to the ground while the other end of said winding is connected to the lead 116 and through the ignition switch and lead 92 through the battery to the ground. The core 152 has an axial opening therethrough and this opening receives a rod 156 connected at its upper end to the diaphragm previously mentioned, and to armature 153 received between a shoulder 160 on the rod and said diaphragm. Two metal disks 159 and 161 to give strength and rigidity to the central portion of the diaphragm and the whole assembly of the diaphragm, the armature and the disks 159 and 161 are held in position by a cup-shaped washer 162 over which the reduced end of the rod 160 is riveted, or the end of the rod may be threaded and a suitable nut employed. Extending through an orifice in the shell 144 is a nipple 164, the shell being clamped between a flange 166 on the nipple and a washer 168 threaded on the outside of said nipple. A reducing coupling 170 is screwed on the nipple 164 as indicated in Fig. 3, and is adapted to be connected to the intake manifold of the engine by a suitable form of air tight connection through which the engine suction is communicated to the diaphragm chamber, the coupling 170 having an axial passage 172 therethrough. Clamped between the nipple 164 and a shoulder on the coupling 170 is a disk 174 pro-

vided with a small hole 176 for a purpose hereinafter referred to and received between this disk and the cup-shaped washer 162 is a light spring 178 which is effective to exert only sufficient pressure on the diaphragm to hold the rod 156 in contact with the movable switch member 114, but with insufficient pressure to effect the closing of the switch.

It will be noted that in the illustrated embodiment of the invention the air gap between the armature 153 and core 152, and the leakage gap 179 between the edge of the shell 142 and core 152 are substantially equal, it having been found that satisfactory results are obtained when these gaps are about $\frac{1}{16}$ of an inch. By increasing the air gap or decreasing the leakage gap the pull of the magnet on the armature is reduced and these gaps may be varied to give whatever result is desired.

Attention is also called to the fact that the disk 161 is in effect an armature which is attracted by the metal shell 144, since the magnetic flux passes through such shell. Under certain operating conditions as will be more fully pointed out hereinafter, the disk 161 is moved into contact with said shell 144 and forms a magnetic seal therewith, for a purpose more fully described later.

The operation of the parts previously described are as follows: Normally when the engine is not running the parts are in the position shown in Figs. 3 and 5 with the ignition switch open, the relay switch open and the rod 156 in engagement therewith, the spring effort of the movable switch member and the spring 178 being balanced under these conditions. When the ignition switch is closed, current from the battery is caused to flow through the winding 150 by means of the connections above described. This will excite the magnet and cause the armature 153 to be moved to the left in Fig. 3 to effect the closing of the relay switch so that the circuit through the shunt motor 64 is completed as previously described and said motor becomes effective to cause the meshing of the pinion and the operation of the starting motor, there being no suction effective at this time within the shell 144 so that the movement of the diaphragm 146 with the armature 153 is not opposed by engine suction. In case of abutment of the gear teeth of the pinion and engine flywheel, the shaft 26 is rotated slightly as previously described to permit proper engagement of the pinion and gear so that the starting motor is effective to drive the flywheel gear and cause the engine to start.

During the cranking of the engine and before it starts to run under its own power, there is some degree of suction produced by the engine within the shell 144 but the air gap and the space between the shell 142 and the core are so proportioned that the pull of the relay magnet is sufficient under these circumstances to prevent the suction pulling the diaphragm to the right to permit the opening of the relay switch, the pull of the magnet being such that it requires from 14" to 16" of vacuum to overcome it. The generator is not being run at sufficient speed during the cranking operation to reduce the pull of the magnet by the action of counter voltage. When the engine starts to run under its own power, the generator runs fast enough to set up a counter voltage in the winding 124 of the magnet and when a predetermined speed is reached this counter voltage so reduces the pull of the magnet that the suction of the engine pulls the diaphragm 146 to the right in Fig. 3 and opens the relay switch, thus rendering the auxiliary motor ineffective and at the same time the auxiliary motor acts as a brake on the gear 170 which cause the demeshing of the driving pinion and the stopping of the starting motor as previously described.

As long as the engine is running under its own power, the suction on the diaphragm 146 and the counter voltage set up by the generator both cooperate to prevent the closing of the relay switch and hence, no subsequent operation of the auxiliary motor or the starting motor can be effected as long as the engine remains in operation under its own power. When the diaphragm is operated upon by engine suction to open the relay switch the metal disk 161 carried by the diaphragm is moved into engagement with the metal shell 144 and a magnetic seal between the shell and the disk is established as previously referred to. The action of the magnetic seal aids the engine suction in holding the relay switch open against the action of the spring 178 and the pull of the magnet which is considerable at operation at low speed and heavy load, because the counter voltage falls to a small amount and the battery current flows through the winding 124. The action of the magnetic seal is such that the vacuum may fall as low as .15 of an inch before the magnetic seal will be broken. When this takes place the armature 153 will be moved to the left by a rapidly increasing force as the armature approaches its switch closing position. Obviously, therefore the engine has to come practically to a stop before the relay switch can be closed and in that event the starting operation to be repeated because the ignition switch remains closed and conditions would be the same as the initial operation described.

The washer 174 is provided with the small hole 176 to take care of a condition which might arise under certain conditions, and if such washer were not provided, considerable damage and broken gear teeth might result. This washer is provided to cause an appreciable delay in the reoperation of the automatic starting mechanism in case the engine has been started and stalls almost immediately and before the starting motor and the driving pinion has ceased to operate, in other words, while these elements are still being operated due to the inertia of the parts. Under some conditions, the stopping of the engine might take place so quickly after it has been started that the starting motor would still be turning relatively rapidly and if the pinion were moved to engage the flywheel gear under these conditions, damage to the gear teeth would result. Because of the small hole in the washer 176, it takes an appreciable time after stopping of the engine for the suction effective on the diaphragm 146 to drop to a point where closing of the relay switch can be effected. In fact, the parts are so constructed that approximately four seconds must elapse before the magnet 124 can become effective to permit the closing of the circuit through the auxiliary motor and such a time interval is sufficient to allow the starting motor to come completely to rest under all operating conditions. There is also some delay in the meshing of the pinion and closing of the starting motor switch after the auxiliary motor has become effective, and this delay may be varied to some extent by variation in the pitch of the threads on sleeve 42.

It will be noted particularly that during the cranking operation the auxiliary shunt motor is operating and aids the main starting motor in

turning the flywheel gear so that a smaller starting motor can be used than with starting devices heretofore employed.

In Fig. 4 is shown a modified form of the invention in which all of the parts are substantially of the same construction except the driving means operated by the auxiliary motor 64 to drive the flywheel gear, the construction being somewhat simplified. Instead of employing a slidable sleeve having helical threads thereon and an intermediate gear mounted on such threads, and driven by a motor gear with the pinion mounted on one member of an overrunning clutch, this form of invention discloses the pinion as formed integrally with a sleeve splined to the starting motor shaft 26 and slidable thereon, the clutch having been eliminated, although the clutch could be employed if so desired. The sleeve is provided with a helical gear 180 on its exterior surface which is engaged directly by another helical gear 182 which is secured to the armature shaft 66 of the auxiliary motor 64. As the armature shaft 66 is rotated when the circuit is closed through the auxiliary motor, the helical teeth of the gear 182 reacting with the helical threads of the sleeve 180 effect a movement of said sleeve to the right because of the angular relation of the teeth and in the event that the pinion abuts the flywheel gear teeth, the engagement of the gear 182 with the teeth 180 is effective to rotate the sleeve which carries the pinion to proper position for the pinion to engage the flywheel gear, and then to continue the movement of said sleeve to the right as described in connection with the first form of the invention.

When the motor has been started and the speed of the flywheel is greater than the speed of the starting motor, the pinion 182 is being driven by the threaded sleeve 180 and the reaction of the gear teeth is the reverse of the action when the sleeve is being driven by the gear 182 so that the sleeve is moved in the reverse direction, or to the left in Fig. 4 to accomplish the demeshing of the pinion from the flywheel and the opening of the switch of the starting motor in substantially the same manner as previously described in connection with the other form of the invention. The wiring diagram for this type of starter drive is just the same as for the other type and need not be described. The wiring connections are shown in part in Fig. 6.

The forms of the invention shown in Figs. 1 and 4 comprise a control system for an internal combustion engine which is substantially automatic in character that is, the device is effective to cause operation of the starting motor and to effect engagement of the driving pinion with the engine flywheel gear to start the engine when the ignition switch is closed and is effective to restart the engine into operation whenever said engine stalls, under any operating conditions without further attention on the part of the driver. The invention, however, is of broader aspect and is not in any way limited to an automatic control system as above described, but comprises a novel and improved means for causing operation of the starting motor and engagement of the motor driven pinion with the engine flywheel gear, which may be controlled by a manually operated switch as well as by the automatic devices shown in Figs. 1 and 4. Such an arrangement is shown diagrammatically in Fig. 6 and will now be described.

The starting motor is indicated at 200 and has an armature shaft 201 on which is splined the sleeve 202 secured to one member of the over running clutch 203, the other member of which is secured to or integral with the driving pinion 204, which is adapted to be moved into engagement with the flywheel gear 205 to turn said gear and start the engine when the starting motor is operated. A grooved collar 206 is carried by the sleeve 202 and engages a pin projecting from a lever 207, pivoted at 208 to operate a movable switch contact 209 to close the starting motor switch whenever the pinion is moved to its gear engaging position. The sleeve 202 is moved to engage the pinion 204 with gear 205 and to close the motor switch by an auxiliary motor 210 such as previously having a gear 211 mounted on its armature shaft and engaging a gear 212, having threaded engagement with the sleeve 202, the construction of all of the parts above described being the same as in the embodiment of the invention shown in Fig. 1, so that further detailed description is not necessary.

A battery 213 is grounded at 214 and connected through the wire 215 with one contact 216 of the motor switch which has another contact 217 connected by a wire 218 with the starting motor 200 which is grounded at 219. A generator is shown at 220 and is provided with the usual cut-out relay 221. Whenever the switch contact 209 is moved by the auxiliary motor 210 to engage the contacts 216 and 217 it will be obvious that the starting motor circuit is completed and the motor will rotate the pinion 204 to start the engine if the pinion is engaged with the gear 205.

The operation of the auxiliary motor is controlled by a manually operable switch in this embodiment of the invention. The auxiliary motor is grounded at 222 and connected by the wire 223 with one fixed contact 224 of a manually operable switch which includes another fixed contact 225 connected by wire 226 to the battery, and a movable contact member 227 adapted to be manually operated and normally held in its open position by a compression spring 228. Whenever the contact 227 is moved to engage the contacts 224 and 225 current flows from the battery through the connection 224 to the ground, from the battery through the wire 226 to contact 225, contact member 227, contact 224, and wire 223 to the auxiliary motor and through the ground connection 222 to ground, completing the circuit of the auxiliary motor and rendering said motor effective to perform its functions of closing the starting motor circuit and engaging the pinion 204 with the engine gear 205. It will be understood that in this embodiment of the invention the auxiliary motor circuit is not automatically broken as in the previously described forms of the invention but remains closed until the contact member 227 is permitted to be moved to its disengaged position by action of the operator.

The auxiliary motor for shifting the driving pinion and controlling the starting motor, in a manually controlled circuit has several advantages, one of which is apparent because it constitutes means for performing these functions which in the pedal shift type of starter have been effected by manual effort. The motor also, aids the main starting motor in cranking the engine and when the engine begins to run under its own power the gear 211 acting as a brake on the gear 212 effects demeshing of the pinion and flywheel gear without the use of any additional means to perform this function.

While the form of embodiment of the present invention as herein disclosed, constitutes a pre-

ferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. Control apparatus for internal combustion engines, comprising in combination, a starting motor normally disconnected from the engine, a current source for supplying current to said starting motor, a switch for connecting said starting motor with said current source, an auxiliary rotary motor for establishing driving connection between said starting motor and the engine and for closing said switch to connect the starting motor with the current source, and means whereby the auxiliary motor is effective to aid the starting motor in driving the engine when driving relation is established between the starting motor and the engine, said auxiliary motor being adapted to receive current from said current source.

2. Control apparatus for internal combustion engines, comprising in combination, a current source, a starting motor normally disconnected from the engine, a shiftable member for establishing driving connection between the starting motor and the engine, and an auxiliary motor operable to move the shiftable member into position to complete the driving connection between the starting motor and engine, and to interrupt the driving connection between said starting motor and engine when the latter begins to operate under its own power.

3. Control apparatus for internal combustion engines, comprising in combination, a starting motor, a current source supplying current to said starting motor, a switch for connecting the starting motor with the current source, a sleeve slidable on the starting motor shaft, means operated by said sleeve to close said switch, an auxiliary rotary motor and means operated thereby for operating said sleeve.

4. Control apparatus for internal combustion engines, comprising in combination, a starting motor, a current source supplying current to said starting motor, a switch for connecting the starting motor with the current source, a sleeve slidable on the starting motor shaft and movable to simultaneously close said switch and effect driving relation between the starting motor and the engine, an auxiliary rotary motor and means operated by the auxiliary motor to move said sleeve.

5. Control apparatus for internal combustion engines, comprising in combination, a starting motor, a current source supplying current to said starting motor, a switch for connecting the starting motor with the current source, a threaded sleeve slidable on the starting motor shaft and adapted to operate the starting motor switch and render said motor effective to drive the engine, a gear for sliding said sleeve when rotated, an auxiliary motor having an armature shaft, and a gear mounted thereon and directly engaging said first mentioned gear to effect movement of the sleeve on operation of the auxiliary motor.

6. Control apparatus for internal combustion engines, comprising in combination, a starting motor, a current source supplying current to said starting motor, a generator, an auxiliary rotary motor adapted to render the starting motor effective to drive the engine, and an automatic relay adapted to control the circuit of said auxiliary motor, said relay comprising switch contacts, an electromagnet adapted to close said contacts when the generator is inoperative, and a suction operated diaphragm adapted to open said contacts when the engine suction exceeds a predetermined amount.

7. Control apparatus for internal combustion engines, comprising in combination, a starting motor, a current source supplying current to said starting motor, a generator, an auxiliary motor adapted to render the starting motor effective to drive the engine, and an automatic relay adapted to control the circuit of said auxiliary motor, said relay comprising switch contacts, a housing containing an electromagnet adapted to close said switch contacts and having a diaphragm chamber formed therein, a diaphragm in said chamber adapted to be operated by engine suction to open said contacts, a disc carried by said diaphragm and forming an armature, said disc adapted to be moved into engagement with said housing on high engine suction to form a magnetic seal therewith and aid the engine suction in preventing closing of the switch contacts, and means for communicating the engine suction to the diaphragm chamber.

8. Control apparatus for internal combustion engines, comprising in combination, a current source, a starting motor adapted to receive current from said source and normally disconnected from the engine and having an armature shaft extending therefrom, a shiftable member slidable on said shaft for establishing driving connection between the starting motor and the engine, a switch controlling the circuit between the current source and said starting motor and adapted to be operated by said slidable member, an auxiliary motor having a rotary armature shaft, means whereby rotation of the armature shaft of the auxiliary motor moves the slidable member on the shaft of the starting motor to establish driving connection between said starting motor and the engine, and to close the starting motor switch, and means for controlling the operation of the auxiliary motor.

9. Control apparatus for internal combustion engines, comprising in combination, a current source, a starting motor adapted to receive current from said source and normally disconnected from the engine and having an armature shaft extending therefrom, a shiftable member slidable on said shaft for establishing driving connection between the starting motor and the engine, an auxiliary motor having a rotary armature shaft, operating mechanism between the armature shaft of the auxiliary motor and the slidable member so constructed that rotation of said armature shaft causes sliding movement of said member along the shaft of the starting motor to establish driving connection between the starting motor and engine, said operating mechanism being also so constructed as to cause a movement of said slidable member in the reverse direction when the engine starts to run under its own power to disable the driving connection between the starting motor and the engine.

10. Control apparatus for internal combustion engines, comprising in combination, a current source, a starting motor adapted to receive current from said source and normally disconnected from the engine and having an armature shaft extending therefrom, a shiftable member slidable on said shaft for establishing driving connection between the starting motor and the engine, an auxiliary motor having a rotary armature shaft, operating mechanism between the armature shaft of the auxiliary motor and the slidable member so constructed that rotation of said armature shaft causes sliding movement of said

member along the shaft of the starting motor to establish driving connection between the starting motor and engine, means for causing the auxiliary motor to stop when the engine is running at a predetermined speed, said operating mechanism being so constructed as to cause a movement of said slidable member in the reverse direction when the motor starts to run under its own power independently of the stopping of the auxiliary motor.

11. Control apparatus for internal combustion engines, comprising in combination, a starting motor, a current source for supplying current to said starting motor, a circuit between said starting motor and current source having a main starter switch therein, an auxiliary rotary motor for operating said switch and also in circuit with the current source, a generator, a manually operable switch for rendering said auxiliary motor effective, and an automatic switch controlled jointly by suction of the engine and the generator for rendering the auxiliary motor ineffective.

12. Control apparatus for internal combustion engines, comprising in combination, a starting motor, a current source for supplying current to said starting motor, a circuit between said starting motor and current source, an auxiliary rotary motor also in circuit with said current source and adapted when operative to cause the starting motor to become effective to drive the engine, an ignition switch, means whereby closing of the ignition switch causes the auxiliary motor to become operative, and an automatic switch operated by engine suction to cause said auxiliary motor to become inoperative when the engine is running under its own power.

13. Control apparatus for internal combustion engines, comprising in combination, a starting motor normally disconnected from the engine, a shiftable member operative to establish driving connection between the starting motor and the engine, a current source, a circuit between said current source and said starting motor, a starter switch in said circuit adapted to be closed by movement of said shiftable member, an auxiliary rotary motor also in circuit with said current source and adapted when operative to move said shiftable member into position to establish driving connection between the starting motor and the engine and to close said starter switch, a manually operable switch for causing the auxiliary motor to become operative and an automatic switch operable by engine suction to cause said auxiliary motor to become inoperative when the engine is operating under its own power.

14. Control apparatus for internal combustion engines, comprising in combination, a starting motor normally disconnected from the engine, a shiftable member operative to establish driving connection between the starting motor and the engine, a current source, a circuit between said current source and said starting motor, a starter switch in said circuit adapted to be closed by movement of said shiftable member, an auxiliary rotary motor also in circuit with said current source and adapted when operative to move said shiftable member into position to establish driving connection between the starting motor and the engine and to close said starter switch, a manually operable switch for causing the auxiliary motor to become operative, a generator, and an automatic switch operable by engine suction and the generator to cause said auxiliary motor to become inoperative when the engine is operating under its own power.

15. Control apparatus for internal combustion engines, comprising in combination, a current source, a starting motor adapted to receive current from said source and normally disconnected from the engine, a drive shaft operable by said motor, a member adapted to be moved laterally to establish driving connection between the starting motor and the engine and in driving relation with said drive shaft in either normal or shifted position, an auxiliary rotary motor, means operated by rotation of said auxiliary motor to move said member laterally to connect the starting motor in driving relation with the engine, said means being so constructed that subsequent to the connection of the starting motor in driving relation with the engine the auxiliary motor is operative to assist the starting motor in driving said engine, and means for controlling the operation of said auxiliary motor.

16. Control apparatus for internal combustion engines, comprising in combination, a current source, a starting motor adapted to receive current from said source and normally disconnected from the engine, a drive shaft operable by said motor, a sleeve having a helical thread slidable on said drive shaft and rotatable therewith, a driving member carried by and rotatable with said sleeve during the starting of the engine, a rotatable member engaging said thread and held against lateral displacement whereby rotation of said rotatable member causes a sliding movement of said sleeve to effect engagement of the driving member with the driven part of the engine, an auxiliary motor for operating said rotatable member, and means for controlling the operation of said auxiliary motor.

17. Control apparatus for internal combustion engines, comprising in combination, a current source, a starting motor adapted to receive current from said source and normally disconnected from the engine, a drive shaft operable by said motor, a sleeve having a helical thread slidable on said drive shaft and rotatable therewith, a driving member carried by and rotatable with said sleeve during the starting of the engine, a rotatable member engaging said thread and held against lateral displacement whereby rotation of said rotatable member causes a sliding movement of said sleeve to effect engagement of the driving member with the driven part of the engine, a switch for connecting the starting motor with the current source, means for effecting rotation of said rotatable member, and means carried by said sleeve to effect closing of said switch during the sliding movement of said sleeve.

18. Control apparatus for internal combustion engines, comprising in combination, a current source, a starting motor, an ignition switch, means operable on closing of the ignition switch to render the starting motor effective to drive the engine, said means comprising a sleeve slidable on the armature shaft of the starting motor, an auxiliary motor, a rotatable member rotated by the auxiliary motor to effect sliding movement of said sleeve, and means constructed to delay the operation of the starting motor relative to the closing of the ignition switch, said means comprising a reduction gearing between the auxiliary motor and the rotatable member.

19. Control apparatus for internal combustion engines, comprising in combination, a current source, a starting motor, an ignition switch, a starting motor switch, means operable on closing of the ignition switch to close the starting motor switch and establish driving relation between

the starting motor and the engine, said means comprising a sleeve slidable on the armature shaft of the starting motor, an auxiliary motor, a rotatable member rotated by the auxiliary motor to effect sliding movement of said sleeve, and means constructed to delay the closing of the starter switch and establishment of driving connection between the starting motor and the engine, said means comprising a reduction gearing between the auxiliary motor and the rotatable member.

20. Control apparatus for internal combustion engines, comprising in combination, a starting motor normally disconnected from the engine, a current source for supplying current to said starting motor, a switch for connecting said starting motor with the current source, an auxiliary rotary motor operated by current from said current source, a member shiftable in a rectilinear path for establishing driving connection between the starting motor and the engine and for closing said switch and so constructed that the rotary movement of said motor effects rectilinear movement of said member.

21. Control apparatus for internal combustion engines, comprising in combination, a starting motor normally disconnected from the engine, a current source for supplying current to said starting motor, a switch for connecting said starting motor with the current source, an auxiliary rotary motor operated by current from said current source, a member shiftable in a rectilinear path for establishing driving connection between the starting motor and the engine and for closing said switch and so constructed that the rotary movement of said auxiliary motor effects rectilinear movement of said member, said operating mechanism including a reducing gearing between the auxiliary motor and said member whereby the movement of said member to position to close the switch is delayed with respect to the operation of said auxiliary motor.

22. Control apparatus for internal combustion engines, comprising in combination, a starting motor normally disconnected from the engine, a current source for supplying current to said starting motor, a switch for connecting said starting motor with the current source, an auxiliary rotary motor operated by current from said current source, means operable by said auxiliary motor for establishing driving connection between the starting motor and the engine and for closing said starter switch, and reducing gearing between said last named means and the auxiliary motor whereby the operation of said last named means is delayed with respect to the operation of the auxiliary motor.

JOHN B. DYER.