Dec. 30, 1958 H. J. CROMWELL 2,866,908

ENGINE STARTING APPARATUS

Filed Oct. 24, 1955 2 Sheets-Sheet 1

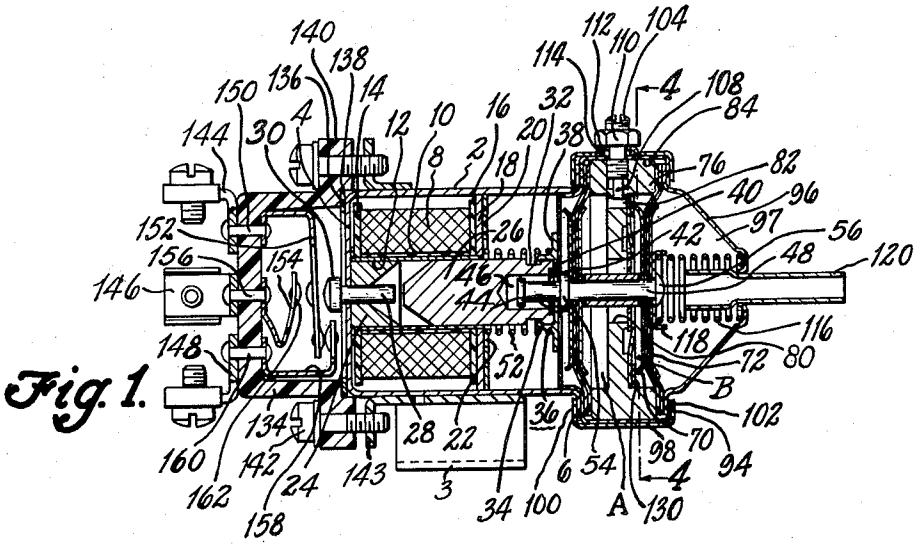


Fig. 1.

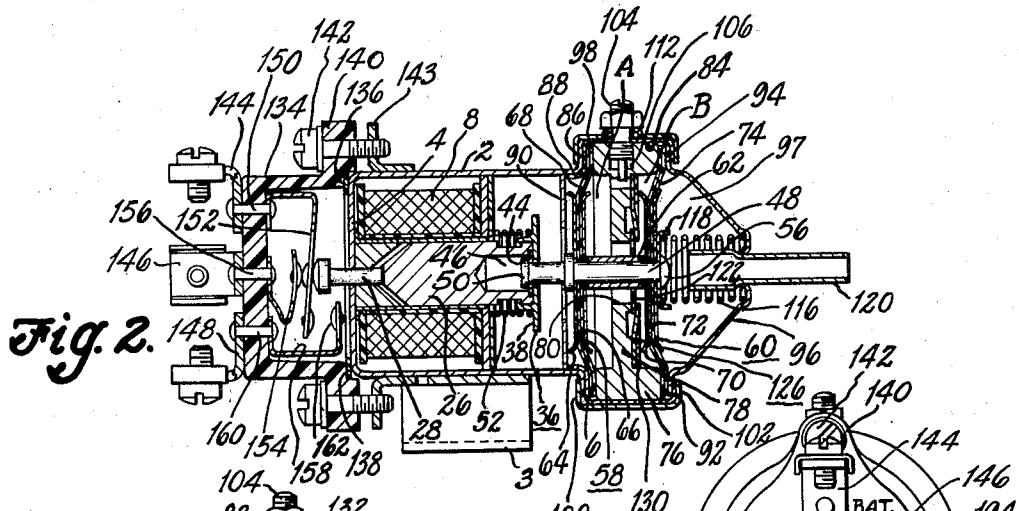


Fig. 2.

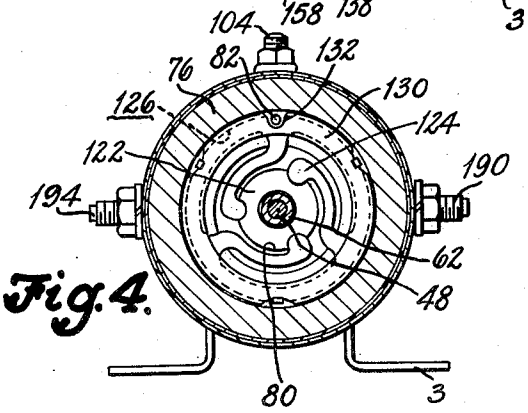


Fig. 4.

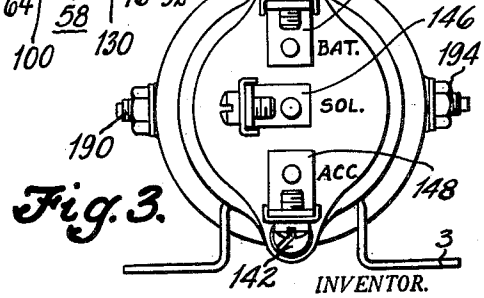


Fig. 3.

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ENGINE STARTING APPARATUS

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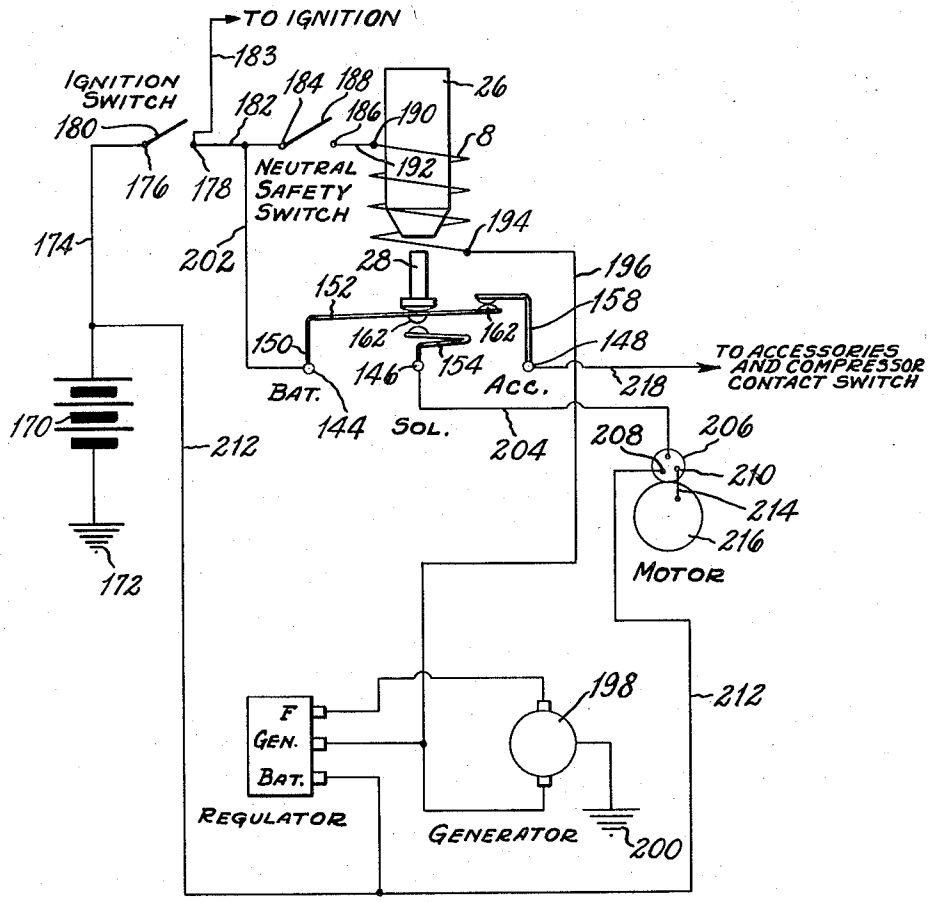


Fig. 5.

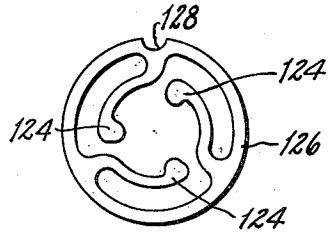


Fig. 6.

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ENGINE STARTING APPARATUS

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Application October 24, 1955, Serial No. 542,365

3 Claims. (Cl. 290—38)

This invention relates primarily to starting apparatus for internal combustion engines, more particularly those of automotive vehicles, in which an electric starting motor is rendered effective by actuation of a manually operated control member and is automatically rendered ineffective when the engine becomes self operative by means operable in response to some force created by operation of the engine, for example, the force of engine suction.

Starting apparatus of this type generally includes a main starter switch in circuit with the starting motor which, when closed, causes the starting motor to become operative to crank the engine, for starting purposes. This main switch is generally operated by an electromagnet which closes the switch when energized and permits opening of the switch when deenergized.

The action of this magnet is generally controlled by a magnetic switch which, in turn, is controlled by certain manually operated switches which are closed to bring about energization of the magnetic switch and a normally closed automatically operated switch which is automatically opened to effect opening of the magnetic control switch when the engine becomes self operative, to cause the starting motor to become inoperative. In one device such as described the magnetic control switch is energized when the ignition switch and a neutral safety switch operated by the transmission control lever are closed and is deenergized when a switch which is normally closed is opened by engine suction when the engine starts to run under its own power. In another device the magnetic control switch is caused to close by closing of the manually operated ignition switch and a switch operated by the carburetor throttle valve or directly by the accelerator pedal which controls the position of the carburetor throttle valve, while a normally closed suction operated switch in circuit with the other switches is opened by engine suction when the engine becomes self operative, to cause the control switch to open.

In some installations the automatically operated switch is normally opened by the generator when the engine is self operative, while in some other installations the automatic switch is opened by the effect of both engine suction and the generator.

In starting apparatus of this kind when the deenergization of the starting motor is effected automatically in response to self operation of the engine, whether by engine suction or by some other means which is operated by the engine, such as the generator, difficulties are encountered under certain conditions as set forth hereinafter. It is not uncommon for engines, in starting, to make what is termed a false start. That is, the engine will be started, will make a few rotations under its own power and stop. When this takes place and a starting apparatus employing a suction operated control switch is used, such switch will be opened as soon as the engine runs, but when the engine stops the suction will become insufficient to hold the switch open before the engine and

starting motor parts stop rotating and the suction operated switch will close while the driving pinion of the starting motor and/or the engine gear with which it engages are still in motion. Closing of the suction operated switch will energize the starting motor and if this takes place while the pinion and/or engine gear are in motion serious damage may obviously result.

It is therefore the primary object of the present invention to provide a starting apparatus of the character previously referred to having a novel form of suction operated control switch which is so designed that it will open immediately upon the engine becoming self operative, but cannot reclose for an appreciable interval after the switch is open, so that if the suction effective on the switch becomes insufficient to maintain the switch in open position, as would occur when the engine stops, the switch cannot close until after the lapse of enough time for the engine and starting motor to come to rest.

The control switch which is disclosed herein was specifically designed for use in starting apparatus and is particularly desirable for such use, but it is a further object of the invention to provide a fluid pressure operated control switch for an electric circuit which is of novel construction and is effective to open said circuit immediately when the fluid pressure effective on said switch reaches a predetermined value and is provided with means to retard the closing of said switch in the event that the fluid pressure becomes ineffective to hold the switch open, so that the switch cannot be immediately closed upon a change in fluid pressure which would permit a closing of said switch.

More specifically, it is an object of the present invention to provide a control switch for an electric circuit which is operable in response to variations in a partial vacuum effective on said switch and is so constructed that the switch is opened when the partial vacuum reaches a predetermined value, may be closed when the vacuum falls below such predetermined value and is provided with means for retarding the closing of said switch in response to decrease in the vacuum effective thereon.

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 the present invention is clearly shown.

In the drawings:

Fig. 1 is a vertical section through the suction operated control switch;

Fig. 2 is a similar view but with the parts in different position;

Fig. 3 is an end elevation of the control switch as seen from the left in Fig. 1;

Fig. 4 is a section on the line 4—4 of Fig. 1;

Fig. 5 is a circuit diagram of a circuit of a starting apparatus in which a control switch constructed in accordance with the present invention is employed;

Fig. 6 is a detail view of a valve controlling member embodied in the control switch.

Since the invention in this instance lies principally in the control switch the switch will be described before the circuit in which it is used. As disclosed, the switch includes a substantially cylindrical housing **2** secured to a supporting bracket **3** which can be mounted in any suitable position. The housing **2** has a closed end **4** at the left as seen in Fig. 1 and is open at the right end, at which an outwardly extending flange **6** is provided for a purpose set forth later. Positioned within the housing **2** is an electro-magnet or solenoid of conventional construction. This magnet has a winding **8**, which surrounds a tube **10** of insulating material and the latter surrounds a brass tube **12**. At opposite ends of the winding **8** are two insulating washers **14** and **16**, washer

14 being positioned between the left end of the winding and the closed end 4 of the housing 2, while washer 16 is positioned between the right end of the winding 8 and a supporting plate 18 which extends across the housing 2, to which it is secured and has a central opening into which the right end of the tube 12 extends. A washer 20 having a central opening 22 is positioned at the right of and immediately adjacent to the plate 18.

Fixed in position within the tube 12 and at the left end thereof is the solenoid core 24 and slidable within the tube 12 is the armature 26 which moves to the left, when the winding 8 is energized, to the Fig. 2 position, but when the magnet is deenergized is moved to the right, by means described later, to the Fig. 1 position. Slidable in a central opening in the core 24 is a pin 28, of Bakelite, which is a well-known phenol condensation product, or any other suitable insulating material, whch has an enlarged head 30. This pin actuates certain switch contacts which will be later described and is moved to the left upon leftward movement of the armature 26 when the winding 8 is energized.

The armature, near the right end thereof, has a circumferential notch 32 into which an inwardly extending flange 34 of a cup-shaped element 36 extends as shown in Figs. 1 and 2. The cup-shaped member 36 has at its right end an outwardly extending flange 38 and inwardly extending flange 40 which engages the right end of the armature 26. Clamped between said inwardly extending flange and a shoulder 42 formed at the right end of the armature is a washer 44 which is provided with a central opening.

Formed at the right end of the armature is a centrally disposed recess of cylindrical form 46 and extending into such recess through the opening in the washer 44 is a short rod or pin 48 having an enlarged head 50 which fits loosely in the recess 46 and is of larger diameter than the opening in the washer 44. Obviously, the armature can move relatively to the pin 48 and when the winding 8 is energized to effect movement of the armature to the Fig. 2 position, the washer 44 is moved to a position where it is substantially in contact with the enlarged head 50 of the pin 48. If the magnet is deenergized by breaking the circuit through the winding 8 a spring 52 which surrounds the armature and lies between the plate 18 and the projecting flange 38 moves the armature back to the Fig. 1 position, and will effect opening of the switch if it is closed when the armature is moved as described.

When the control switch is used to control the operation of an engine starting apparatus it is desirable, as already pointed out, to effect opening of the switch immediately when the engine becomes self operative, and to prevent the reclosing of the switch until an appreciable interval has elapsed, to prevent possible closure of the switch while moving parts of engine or starting motor are still in motion. To accomplish this result suction operated means will open the switch while the winding 8 is still energized if the engine starts to run under its own power and subsequent closing of the switch is prevented until after an appreciable time interval.

To this end the pin or rod 48 is provided with an extending flange 54 and an enlarged head 56 between which are two diaphragm assemblies designated generally by the numerals 58 and 60, that are separated by a short sleeve 62 which surrounds the pin 48 between the diaphragm assemblies.

The diaphragm assembly 58 is positioned adjacent the flange 54 and comprises a metal plate 64 positioned adjacent the flange and having an opening through which the pin 48 extends, while positioned between said plate and a similar plate 66 at the left end of the sleeve 62 are two flexible diaphragms 68. When the device is assembled these diaphragms are clamped tightly between the two plates 64 and 66. At the right end of the sleeve 62 is a similar assembly of two metal plates 70 and 72 with two flexible diaphragms 74 between them. This arrangement of diaphragms and plates, when the device is assembled, is clamped between the right end of sleeve 62 and the enlarged head 56 of the pin 48. The plates 64, 66, 70 and 72 are of lesser diameter than the diaphragms and are provided for reinforcing purposes to prevent breakage of the flexible diaphragms.

Positioned between the diaphragm assemblies is a short cylinder 76 which may be either metal or a suitable plastic material, while extending across this cylinder and integral therewith is a partition plate 78 which divides the space between the diaphragm assemblies into two chambers A, at the left, and B, at the right of said plate. This plate has a central and rather large opening 80 and another opening 82 which is quite small, these openings being provided for a purpose to be more fully described later. The diaphragm assemblies, at their outer peripheries, are clamped between the ends of cylinder 76 and a clamping member with sufficient pressure to form a leak proof joint. The clamping member is a metal sleeve 84 which immediately surrounds the cylinder 76. This clamping member is bent inwardly at 86 so as to engage the diaphragms 68 and has a cylindrical extension 88 which projects into the right end of the housing member 2, the end of such extension engaging a plate 90 which extends across the housing 2 near the right end thereof. The part 86 of the clamping member is positioned between the peripheral edge of diaphragm 68 and the outwardly extending flange 6 of the housing 2.

The clamping member 84 also has an inwardly projecting flange 92 at the right of the diaphragm assembly 60 but such flange does not directly engage the diaphragm assembly. Lying between the flange 92 and the diaphragm assembly is a flange 94 extending outwardly from a cup-shaped member 96 within which is a chamber 97, to which engine suction is communicated, as more fully set forth later.

Immediately surrounding the clamping member 84 is a second clamping member 98 which has two inwardly projecting flanges 100 and 102, the flange 100 engaging the flange 6 of the housing 2 and the flange 102 engaging flange 92 of the member 84. When the parts are in the position shown in the drawings sufficiently heavy pressure is applied to the flanges 100 and 102, so that when the device is assembled the clamping members exert enough pressure on the peripheral edges of the diaphragm assemblies to prevent leakage past the diaphragms and also secure such assemblies and associated mechanism to the solenoid.

The restricted opening 82 in the partition plate 78 can be varied in area by an adjustable pin which functions as a control valve and which determines the rate of flow from one side of the partition plate to the other under certain conditions. The pin is designated by the reference numeral 104 and is threaded in a recess 106 formed in the wall of the cylinder 76, while a reduced portion 108 of such pin extends into the opening 82. The pin can be adjusted with a screw-driver and a lock nut 110 will retain the pin in any adjusted position. The nut 110, when tightened, engages a cup-shaped washer 112 within which is positioned an O-ring seal 114, so that when the nut is tightened, the seal prevents any possible leakage around the pin 104.

Positioned within the chamber 97 is a helical spring 116 which is received between the member 96 and a cup-shaped washer 118 that is clamped between the enlarged head 56 of the pin 48 and the reinforcing plate 72. This spring normally holds the diaphragm assemblies in the position shown in the drawings, but when sufficient suction is communicated to the chamber, as when the engine becomes self-operative to overcome the force of the magnet and spring, the entire assembly will be moved to the right and this will open the starter control switch and cause the starting motor to become inoperative. Suction is communicated to the chamber 97 through a metal conduit 120 which may be brazed, or otherwise suitably secured, to the member 96.

The space between the diaphragm assemblies is filled

with some suitable fluid, the viscosity of which changes relatively little with changes in temperature and which will not damage the material of the diaphragms. By way of example, oleum spirits is a material which has been found to be satisfactory. As the diaphragms move back and forth this fluid moves from one side of the partition plate 78 to the other. The flow of fluid from the left side of such plate to the right thereof when the diaphragms move toward the right is unrestricted so that when the engine becomes self operative and the suction is effective to move the diaphragms to the right the movement is immediate, but when moved in the opposite direction the flow of fluid from right to left of the plate is restricted to delay movement of the diaphragms toward the left.

To bring about the movement described the relatively large opening 80 is controlled by a flat disk valve 122 which surrounds the sleeve 62 and normally is held in position to close the opening 80 by spring fingers 124, which extend inwardly from and are integral with an annular member 126 which fits within the cylinder 76 and is positioned adjacent the partition plate when the parts are in assembled position as shown in the drawings. A notch 128 in the member 126 is adapted to register with the opening 82 when the member 126 is properly positioned. The member 126 is held in position by a retaining washer 130 which fits within the cylinder 76 and is staked or otherwise suitably secured in position. The washer 130 is also provided with a notch 132 which registers with the opening 82 when the parts are properly positioned.

The spring fingers 124 exert a very light pressure in the disk valve 122 to normally hold the valve closed but when the diaphragm assembly moves to the right the pressure of the fluid on the disk valve immediately unseats the valve to permit a substantially unrestricted flow of fluid through opening 80 from left to right. However, when the diaphragms move from right to left pressure of the fluid immediately seats the valve 122 and all fluid passing from the right to left side of the diaphragm must pass through the restricted opening 82, so that movement of the diaphragms to the left is delayed. The rate of fluid flow through opening 82 and the amount of delay in the movement of the diaphragms is determined by adjustment of the pin 104.

The switch contacts which are controlled by operation of the pin 28 are supported by a cup-shaped auxiliary housing 134 of Bakelite, which is a well-known phenol condensation product, or other suitable plastic. At the open end of the housing 134 a shoulder 136 is formed and, when the device is assembled the shoulder engages a suitable gasket 138 which lies between the shoulder and the closed end of the housing 2. To retain the housing 134 in position it is provided with ears 140 through which attaching screws 142 pass, such screws having threaded engagement with lugs 143 provided on the housing 2. These lugs may be welded or otherwise suitably secured to the housing 2.

The specific arrangement of the contacts forms no part of this invention, but as shown herein there are three binding posts 144, 146 and 148, to which conductors may be attached, and which are supported on the end wall of the housing 134. These binding posts are connected with pins which extend through the end wall of the auxiliary housing 134 and the inner ends of such pins engage spring contact members, the pins being riveted over such contact members and lateral extensions of the binding posts, as shown in the drawings, to hold the spring members and the binding posts in fixed position relative to the supporting housing 134.

As shown in the drawings the binding post 144, which is adapted to be connected with a source of current such as a storage battery, is connected by a pin 150 with a spring contact member 152, and in the position of the parts shown in Fig. 2 this contact member is in engagement with a spring contact member 154 which is connected by a pin 156 with the binding post 146, from which a conductor extends to the solenoid which effects closing of the main starting motor switch, as will be more fully described later.

When the parts are in the position shown in Fig. 1 the spring contact member 152 is in a position to establish contact between itself and a spring contact member 158 connected by pin 160 with the binding post 148 to which a conductor leading to a switch or switches controlling one or more accessories, such as the radio, or compressor clutch for an air conditioning system, for example, may be connected. It may be said at this point that the arrangement disclosed with respect to the accessory contact is not a part of this invention and is not claimed herein, but is the subject of another application.

Each of the contact members above described has one or more contacts 162 formed of suitable contact material secured thereto in any desirable way, and it will be apparent that the member 152 has two contacts 162 thereon, one of which is adapted to engage the contact on contact member 154 and the other is adapted to engage the contact on member 158. The spring member 152 is biased to the right so that normally, when the magnet winding 8 is not energized, a contact on member 152 engages the contact on member 158, but when the magnet is energized the spring bias is overcome and the other contact on member 152 engages the contact on member 154, which is electrically connected with the magnet which closes the main starting motor switch.

In Fig. 5, a control circuit is illustrated, in which the above described control switch may be used. As shown, a battery 170 is grounded at 172 and a conductor 174 leads from the battery to fixed contact 176 of the ignition switch which includes a second fixed contact 178 and a movable contact 180 engageable with the contact 178 to close the switch. A wire 182 connects contact 178 with a fixed contact 184 of a neutral safety switch having a second fixed contact 186 and a movable contact 188 movable to bridge the two fixed contacts to close the switch. A wire 183 leads from contact 178 to the ignition system. The specific means for actuating the contact 188 forms no part of the present invention and may be of entirely conventional construction, the contact 188 being moved by the lever which controls the vehicle transmission, into engagement with contact 186 when the transmission control lever is set in its neutral position.

Connecting the contact 186 with the binding post 190 on housing 2 is a wire 192. This binding post 190 is connected with one end of the winding 8 of the operating magnet of the control switch and the other end of such winding is connected with a binding post 194 which is connected to wire 196 which leads to the generator 198 and is grounded through the ground connection 200.

Connecting with the wire 182 between the battery and the neutral safety switch is a wire 202 which connects with the binding post 144 to which the spring contact member 152 is also connected. Connected with binding post 146 which is connected with the spring contact member 154, is a wire 204 which is connected with the winding of a solenoid 206. This solenoid controls the closing of the main starting motor switch and when energized effects closing of such switch and causes the starting motor to operate. Deenergization of such solenoid will cause the starting motor to become inoperative and deenergization of solenoid 206 is effected automatically through the medium of the control switch previously described when the engine becomes self operative.

Solenoid 206 operates a movable contact, not shown, which engages two fixed contacts 208 and 210. Contact 208 is connected by wire 212 with wire 174 between the battery and the ignition switch while contact 210 is connected by wire 214 with the starting motor 216, so that when contacts 208 and 210 are connected current will flow

from the battery through the wires 174 and 212, contacts 208, 210 and wire 214 to the starting motor to effect operation thereof. The specific construction of the solenoid 206 and its connections with the starting motor constitute no part of the present invention, but the solenoid and connections may be of the construction shown in the patent to Dyer 2,287,791, June 30, 1942, if desired.

With the parts in the position shown in Figs. 1 and 5 of the drawings, which is the normal position of the parts, that is the position of the parts when the starting motor is not in operation, the spring contact arm 152 is in position where it is in electrical contact with the spring contact member 158 connected to binding post 148 to which a conductor 218 is connected. This conductor may lead to various accessories or control switches therefor including a switch which controls the operation of the compressor of an automotive air conditioning system and when the contact arms 152 and 158 are in engagement, as shown in Figs. 1 and 5, these accessories are operable, but when such contact arms are separated, as during operation of the starting motor, none of the accessories which are controlled by movement of these arms can be operated. This arrangement is provided to limit the load on the battery and starting motor during engine starting, as much as possible.

The operation of the device and circuit disclosed will now be briefly described. When the ignition switch and neutral safety switch are both closed current will flow from the battery to the ignition system and through wire 174, the switches referred to, wires 182 and 192 to winding 8, then through wire 196, generator 198 and connection 200 to ground and back to the battery. This energizes the magnet of the control switch and the armature 26 thereof moves downwardly as seen in Fig. 5, pushing the plastic pin 28 downwardly and moving spring contact arm 152 downwardly into engagement with the arm 154. With the parts in this position current flows from the battery through wire 174, contacts 176, 180, 178, and wire 202 to binding post 144. From this binding post the path of current is through pin 150, contact arms 152 and 154, pin 156 to binding post 146, from which current flows to the winding of the solenoid 206 and to ground. The solenoid 206 is thus energized, whenever the magnet of the control switch is energized, to move the movable contact of the main starter switch, which is not shown, into engagement with contacts 208 and 210, so that current can flow from the battery through wire 212, the contacts referred to and wire 214 to the starting motor 216, causing it to become operative.

The starting motor will continue to run until the engine starts to run under its own power and when this takes place the engine suction, which is communicated to the chamber 97, will be very greatly increased, becoming sufficient to move the armature 26 to the Fig. 1 position while the winding 8 is still energized and the switches controlling such winding are still closed. In other words the control switch is opened when the engine becomes self operative, entirely automatically and regardless of the condition of the manually operable switches in circuit with the winding of the control switch.

The movement of armature 26 to the right takes place immediately whenever a predetermined suction is communicated to the chamber 97 and this takes place substantially as soon as the engine starts to run under its own power. However, an engine sometimes makes a false start, that is after starting and running for a very brief interval it will stop instead of continuing to run under its own power. In such event the suction in chamber 97 may become great enough to open the control switch as described and the engine stalls immediately. The suction can no longer hold the switch open and if the armature of the control switch could move to the left immediately the control switch might be reclosed and the starting motor re-energized before the engine or starting motor parts become stationary. This might result in serious damage and is prevented in the device disclosed by means which has been fully described. Briefly, movement to the left of the armature 26 and the diaphragm assemblies connected thereto, is retarded because the fluid in chamber B which must be transferred to chamber A has to pass through the restricted opening 32 and an appreciable time interval is necessary for this to take place. This interval is sufficient for all moving parts to come to rest, and the starting motor cannot be energized, even if the manual control switches are closed, until this takes place.

It will be understood that when the control switch disclosed is used with a circuit such as disclosed in Fig. 5, and the engine is operating at speeds above a predetermined speed, the generator sets up a counter voltage in the winding 8 which will prevent any closure of the control switch as long as such engine speed is maintained, even if the suction in chamber 97 falls below that necessary to hold the diaphragm assembly in the position to which it is moved by engine suction when the engine begins to run under its own power. This arrangement, although an additional safety factor, forms no part of the present invention, being disclosed in earlier patents.

It will also be understood that while the control switch disclosed herein was designed primarily for use in an engine starting apparatus in which it accomplishes an important and desirable result, its use is not limited to this particular purpose but can be used in other devices.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, as may come within the scope of the claims which follow.

What is claimed is as follows:

1. In starting apparatus for internal combustion engines having a current source and an electric starting motor operable by current from said source; control mechanism for controlling the operation of said starting motor comprising in combination; a control switch, a magnet for closing said control switch to cause the starting motor to become operative, manually operated means for controlling the energization of said magnet, a suction operated member operable to open said switch, means between the armature of said magnet and the suction operated member including a lost motion connection operative to permit movement of the armature to switch closing position when the suction operated member is in a normal position without movement of said member, but preventing movement of the suction operated member in a direction to open the switch without corresponding movement of the armature, means for communicating the engine suction to said member to move said member to open the switch when a predetermined suction is effective thereon and while the magnet is energized, means enabling immediate movement of said member to open the switch when a predetermined suction is effective thereon and means for delaying a reverse movement of said member to reclose the switch when the suction falls below said predetermined suction.

2. In starting apparatus for internal combustion engines having a current source and an electric starting motor operable by current from said source; control mechanism for controlling the operation of said starting motor comprising in combination; a control switch, a solenoid for closing said control switch to cause the starting motor to become operative when the solenoid is energized, manually operable means for effecting energization of the solenoid, means for automatically opening the control switch when the engine becomes self operative while the solenoid is energized, said means comprising a pair of diaphragms spaced from each other to form a fluid containing chamber therebetween and connected together so as to move simultaneously, means including a lost motion connection for operatively connecting the armature of the solenoid to said diaphragms so that the armature is movable thereby to effect opening of the switch, means for communicating the engine

suction to one of said diaphragms so as to move both of said diaphragms in a direction of the switch when a predetermined suction is effective on said diaphragm, means for moving the diaphragms in the opposite direction when the suction effective thereon falls below the predetermined suction, a stationary partition plate between the diaphragms through which fluid is forced when the diaphragms are moved in either direction, said plate having an opening therein which is unrestricted and through which fluid flows when the diaphragms are moved to open the control switch, whereby the opening of such switch is effected substntially immediately when a predetermined engine suction is reached.

3. In starting apparatus for internal combustion engines having a current source and an electric starting motor operable by current from said source; control mechanism for controlling the operation of said starting motor comprising in combination; a control switch, a solenoid for closing said control switch to cause the starting motor to become operative when the solenoid is energized, manually operable means for effecting energization of the solenoid, means for automatically opening the control switch when the engine becomes self operative while the solenoid is energized, said means comprising a pair of diaphragms spaced from each other to form a fluid containing chamber therebetween and connected together so as to move simultaneously, means including a lost motion connection for operatively connecting the armature of the solenoid to said diaphragms so that the armature is movable thereby to effect opening of the switch, means for communicating the engine suction to one of said diaphragms so as to move both of said diaphragms in a direction of the switch when a predetermined suction is effective on said diaphragm, means for moving the diaphragms in the opposite direction when the suction effective thereon falls below the predetermined suction, a stationary partition plate between the diaphragms through which fluid is forced when the diaphragms are moved in either direction, said plate having a restricted opening therein through which fluid must pass when the diaphragms are moved as the result of a reduction in the suction effective thereon below said predetermined suction, whereby movement of the diaphragms following such a reduction in engine suction is retarded, and means for variably adjusting the area of such restricted opening so as to modify the rate of movement of said diaphragm.

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