June 30, 1959 R. A. CHEETHAM 2,892,454

ENGINE STARTING APPARATUS

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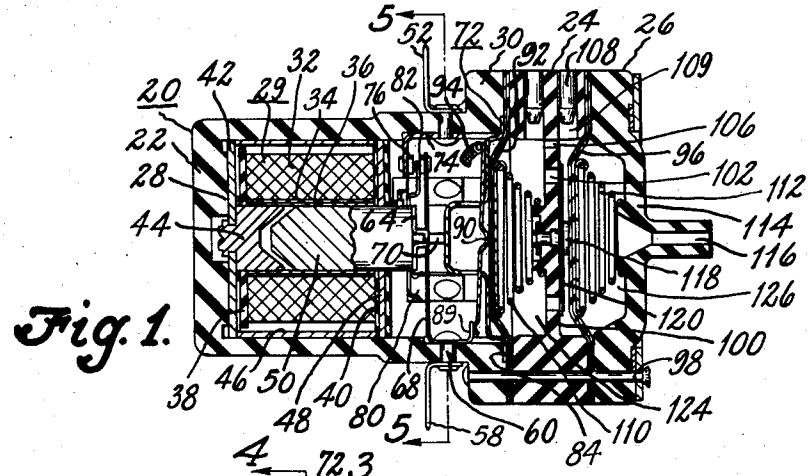


Fig. 1.

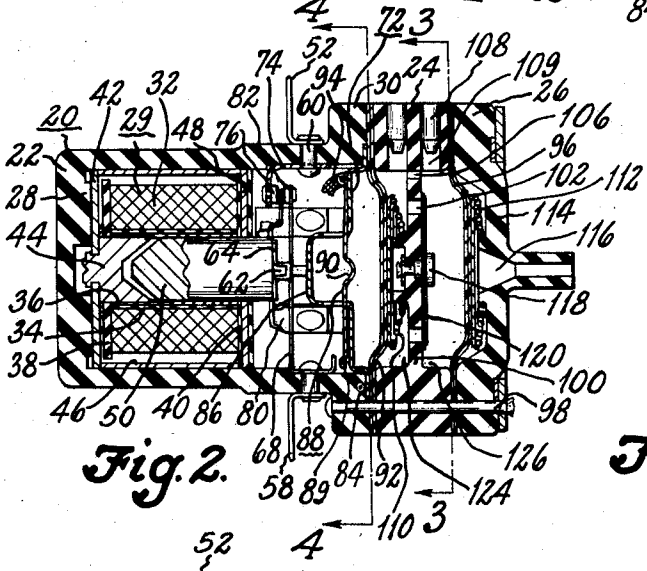


Fig. 2.

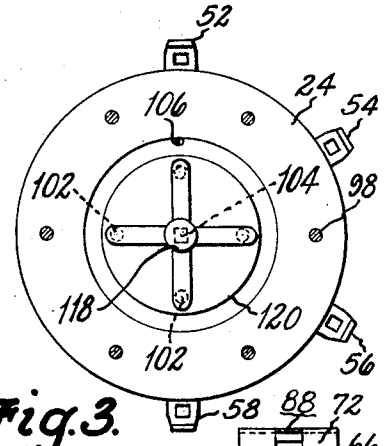


Fig. 3.

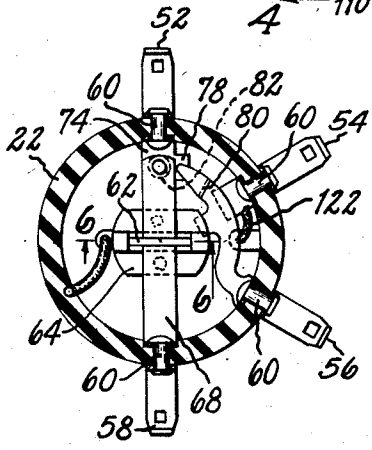


Fig. 5.

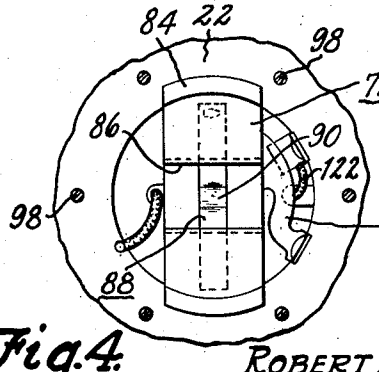


Fig. 4.

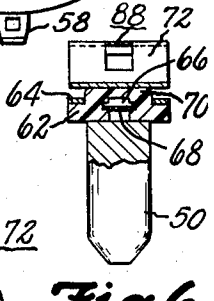


Fig. 6.

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ENGINE STARTING APPARATUS

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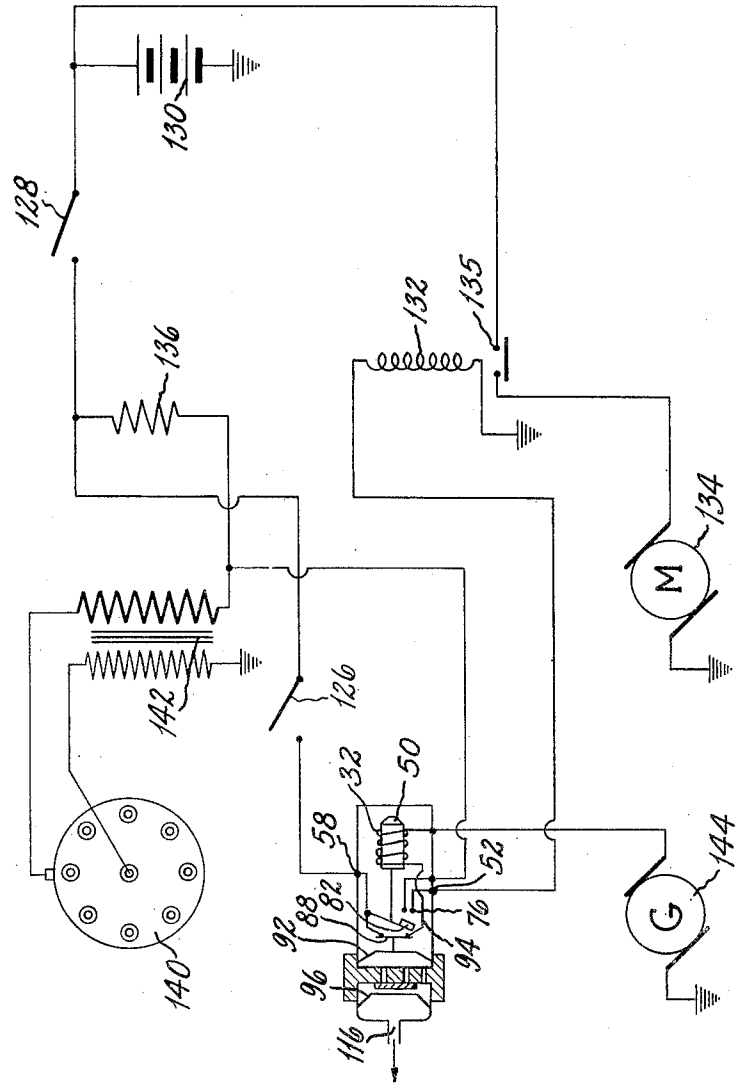


Fig. 7.

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ENGINE STARTING APPARATUS

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8 Claims. (Cl. 123—179)

This invention relates to starting apparatus for internal combustion engines, and more particularly to the automotive type starting apparatus 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 means operable in response to engine operation, for example, the force of engine suction.

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

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 will not reclose for an appreciable interval after the switch is opened, so that if the suction effective on the switch becomes insufficient to maintain the switch in an open position, as will occur when the engine stops, the switch cannot close until a lapse of enough time for the engine and starting motor to come to rest.

While the control switch which is disclosed herein was specifically designed for use in starting apparatus and is particularly desirable for such use, it is a further object of the present invention to provide a fluid pressure operated control switch for an electric circuit which is of such novel construction to open a circuit immediately when the fluid pressure effective on the 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 the 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 a predetermined value and is provided with means for retarding the closing of said switch in response to a decrease in the vacuum effective thereon.

It is another object of the present invention to provide a delay mechanism for use with a starting motor circuit for use with an internal combustion engine which delay mechanism includes a movable armature of an electromagnet, a pair of spaced independently movable diaphragms one of which is directly responsive to engine suction and the other of which is delayed of its movement in one direction only and to provide a stop for limiting the movement of the armature of the electromagnet and the diaphragm which is retarded in its movement.

A still further object of the present invention is to include a pair of independently movable diaphragms in a control device wherein one of the diaphragms is arranged to be freely movable by an external force and the other to be responsive to the movement of the first diaphragm with a retarded movement in one direction only so that the second diaphragm which is limited in its movement by a stop means may close a switch which is also carried by the stop means to close the circuit to an electromagnet which has an armature independently movable relative to said diaphragms and which is limited in its movement by said stop.

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:

Figure 1 is a sectional view through the suction operated device according to the present invention, with the parts of the suction operated device in an at rest position.

Figure 2 is a view of the device in Figure 1 with the suction operated parts of the device in an actuated position.

Figure 3 is a view along line 3—3 of Figure 2 showing the valve means between the diaphragms.

Figure 4 is a view along line 4—4 of Figure 2 particularly showing the stop means for one of the diaphragms and the armature of the electromagnet.

Figure 5 is a view along line 5—5 in Figure 1 showing the arrangement of the contacts for the device.

Figure 6 is a view, partly in section, along line 6—6 in Figure 5 showing an arrangement for carrying one of the contact arms on the plunger and the location of the stop for the plunger.

Figure 7 is a diagrammatic view of an electric circuit in which the device according to the present invention is employed.

Since the invention in this application is concerned principally with the control switch, the switch will be described prior to the circuit in which it is used, as disclosed. The switch according to the present invention incorporates certain improvements which will become hereinafter apparent over the device as set forth in application, Serial No. 542,365, which was filed October 24, 1955, and has been assigned to the assignee of the present invention.

The switch device **20** as shown in the drawings includes a housing which is formed of three parts, **22**, **24**, and **26** which are preferably formed of a suitable molded plastic material such as a molded thermoplastic or a phenylformaldehyde resin, and is provided with a bracket, not shown, suitably attached to the device **20** to permit the device to be secured in any suitable position on a vehicle.

The housing part **22** has a closed end **28** at the left as seen in Figure 1 and is open at the right end at which end an outwardly extending flange **30** is provided. Positioned within the housing **22** is an electromagnet or solenoid **29** of conventional construction. This solenoid has a winding **32** which surrounds a tube **34** of insulating material and the latter surrounds a brass tube **36**. At the opposite ends of winding **32** are two insulating washers **38** and **40**. The washer **38** is positioned between the winding **32** and a washer **42** which is used to secure in position the pole piece **44**. Surrounding the winding **32** is a suitable metal tube **46** which, together with a metal washer **48** and a metal washer **42**, provides a path for the magnetic flux which is set up by the winding **32** when the winding is energized. The solenoid core or pole

piece 44 is secured within the tube 36. Slidable within the tube 36 is an armature 50 which is moved to the left when the winding 32 is energized to the position shown in Figure 2. When the magnet winding 32 is de-energized, the armature 50 is moved to the right, as shown in Figure 1, by means which will be later described.

Secured to the outer wall of the housing part 22 are terminals 52, 54, 56 and 58. The terminal 52 is connected with the starting motor solenoid, the terminal 54 to the vehicle engine generator, the terminal 56 is connected to a resistance in the ignition system, and the terminal 58 is connected to the battery through circuits which will be hereinafter described. The terminals 52—58 are each secured to the housing part 22 by means of rivets 60 which extend through the wall of the housing and serve to anchor and connect the parts which will be hereinafter described to the respective terminals so that an electrical circuit will be complete therebetween.

Suitably secured to the right end of the armature is a stop means and contact actuator most clearly seen in Figure 6. This means includes a part 62 which is preferably formed of insulating material which is held in position by a metal part 64 which is suitably secured to the armature as by welding. The part 62 is provided with a central T-shaped opening 66 which receives and holds in position the contact actuator or arm 68 which is connected by a suitable rivet to terminal 58. The member 62 also has a projecting portion 70 which extends outwardly from the armature 50 and beyond the portions of member 64 which secure the member 62 to the armature. This projecting portion 70 serves as a limit stop when it engages the portion of member 72 as shown in Figure 1. The member 72 will be hereinafter described. The contact actuator arm 68 is normally stressed to the right as in Figure 1 and thus constantly urges the armature 50 to the right.

Also positioned within the housing part 22 is a stationary contact support 74 which has one end secured to a rivet 60 which is connected with terminal 52 and the other end formed to support the stationary contact 76. The member 74 has an extending portion 78 which is adapted to be engaged by the bent contact arm 80 which, in turn, is connected through a rivet 60 to the terminal 56. The bent contact arm is located to be engaged by the metallic member 64 so that the contact arm 80 will engage the extending portion 78 when the contact arm 68 is moved by member 62 to cause the contact 82 which is supported by arm 68 into engagement with the stationary contact 76. When contact 82 is in engagement with contact 76, and arm 80 is in engagement with extending portion 78, it is clearly apparent that the circuits will be complete from the battery terminal 58 to both the starter solenoid terminal 52 and the ignition resistance terminal 56.

As has been heretofore stated, the member 72 is also disposed within the housing part 22. This member is formed as shown in the drawings to have an extending flange portion 84 which permits the member to be secured in position relative to housing part 22. The member is also provided with an extending intermediate portion 86 which has suitable openings therein to permit the passage of the contact arm 88 therethrough. The extending portion 86 serves to limit the movement of the projecting portion 70 of member 62. The openings in the intermediate portions in member 72 permit a relatively free movement of the contact arm 88. The contact arm 88 has one end secured to member 72 as by welding and has its other end projecting to engage the bent-up portion 89 of arm 68. The intermediate portion 90 of member 88 is curved as shown to engage the material of the diaphragm 92, the function of which will be hereinafter described. From the above, it is apparent that when the diaphragm 92 is in the position shown in Figure 1, then a portion of the member 88 will be in contact with portion 89 of member 68. When the parts of this device are in this position, the circuit will be complete from the battery terminal 58 through portion 89, member 88 to a lead 94 which is connected to the winding 32 of the solenoid so that the solenoid will be energized as long as member 88 is in contact with portion 89. From the drawings, it is apparent that the diaphragm 92 is secured between the parts 22 and 24 of the housing and the diaphragm 96 is positioned and secured between the parts 24 and 26 of the housing when the rivets 98 secure the parts of the housing together.

The housing part 24 is provided with a wall 100. This wall has suitably located radial openings 102 and a central opening 104 therein. A small diameter opening 106 is also provided in the wall 100. The purpose of all of these openings will become hereinafter apparent. Outwardly extending in the walls of the housing part 24 on opposite sides of wall 100 are bores 109 which are suitably closed by plugs 108. These plugs 108 and bores 109 are used to completely fill the space between diaphragms 92 and 96 with a fluid. The diaphragm 92 is constantly urged to the left by a spring 110 which has one end seated on the diaphragm and its other end on the wall 100. The diaphragm 96 is likewise constantly urged to the left by a spring 112 which has one of its ends seated on the diaphragm and the other resting on a wall 114, which forms a portion of the housing part 26. Extending through the wall 114 is a suitable bore 116 which preferably terminates as a nipple to permit a suction hose or other suitable conduit to be connected thereto.

The opening 104 has a rivet 118 extending therethrough. This rivet is used to secure a valving disc 120 which is sized to cover the openings 102 and permit the opening 106 to be exposed. As heretofore stated, the terminal lead 94 is connected to the windings of the solenoid. The other end of the solenoid windings 32 are connected through a lead 122 with the terminal 54 for the purpose which will become hereinafter apparent.

With the above parts of the switch in mind, the function of the device will now be described. When the engine is inoperative, so that the parts of the switch are in the position shown in Figure 1 and the neutral safety switch 126 and the ignition switch 128, shown in Figure 7, are in the closed position, it is apparent that current will flow from the battery 130 to the terminal 58 through member 88 to lead 94 of the solenoid windings 32 so as to energize the solenoid and cause the armature 50 to move from the position shown in Figure 1 to the left to the position shown in Figure 2 of the drawings. The leftward movement of the armature 50 will cause the contacts 82 and 76 to close and the contact arm 80 to engage portion 78 to complete circuits to the starter solenoid winding 132 and the ignition resistance 136 by-pass circuit. The completion of the circuit to the starter solenoid winding 132 will cause switch contacts 135 to close and cause the actuation of the starting motor 134 which, in turn, will crank the engine until the engine becomes self-operative. After the engine becomes self-operative, a manifold suction will be created, and will be imposed through bore 116 upon the diaphragm 96 to cause the diaphragm to move to the right against the force of spring 112. When diaphragm 96 moves to the right, the fluid which is contained between the two diaphragms 92 and 96, will flow from the chamber 124 which is located between the diaphragm 92 and wall 100, through the large openings 102 and pass valve means which include valve disc 120 into chamber 126 which is located between the wall 100 and the diaphragm 96. This flow of fluid will occur rapidly because of the large sized openings 102 which are provided so that diaphragm 92 will move rapidly to the right and permit the member 88 which is normally biased to the right and held in the circuit closing position shown in Figure 1 by the force of spring 110 to move to the right and break its engagement with the portion 89 of member 68. This will cause

the circuit to lead 94 to be broken so that the solenoid 29 will become deenergized and likewise the armature 50 will move to the right to cause the engagement between contacts 76 and 82 and the portion 78 and contact 80 to be broken so that the circuit to the starting motor 134 and the ignition by-pass resistance 136 terminal is likewise broken. At this point, it is to be noted that the movement of the armature 50 to the right is caused by the stress of member 68 and is limited by member 72 and that the member 72 also limits the movement of the diaphragm 92 to the left while it serves to carry the contact arm 88. The ignition system shown in Figure 7 is conventional and includes the distributor 140 in ignition coil 142 which functions in the well known manner to provide igniting sparks at the proper instant at the spark plugs, not shown.

When the engine becomes inoperative, so that the suction through bores 116 is no longer imposed on diaphragm 96, both of the diaphragms 92 and 96 will tend to move to the left. The movement of these diaphragms, however, will be restricted for at that time the valve means 120 will close the openings 102 so that the flow of fluid from chamber 126 to chamber 124 will be severely retarded as all of the flow will have to pass through opening 106 which has been calibrated to cause a retarded movement of the diaphragm 92.

The space between the diaphragms 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 and it is to be noted that silicone fluids may be used. These form no portion of the present invention. As the diaphragms move back and forth, this fluid moves from one side of the wall 100 to the other. The flow of fluid from the left side of the wall to the right side thereof when the diaphragms move to the right is unrestricted so that when the engine becomes self-operative and the suction is effected to move the diaphragms to the right, the movement is immediate, but when the movement is in the opposite direction, the flow of fluid from right to the left of the wall is restricted to delay the movement of the individually movable diaphragms to the left.

To bring about this control movement, the relatively large openings 102 are controlled by the flat disc valve 120 which is held in position by the rivet 118 and is formed of flexible material so that fluid pressure will react thereon to cause the openings 102 to be exposed when the fluid moves to the right and which will be forced into sealing engagement with the material of the wall which surrounds the opening 102 when the flow of fluid is to the left. This type of flap valve is well known.

It is clearly apparent that the device according to the present invention may be suitably installed in the electrical systems of an automotive vehicle as shown in Figure 7 when the terminal 58 is connected with the battery and the terminal 52 is connected with the proper circuit to the engine starting solenoid. Further, the terminal 54 is grounded through the generator 144 so that as the engine is operating at speeds above a predetermined speed, the generator 144 will set up a counter voltage in the winding 32 which will prevent any closure of the switch as long as the engine speed is maintained even if the suction on diaphragm 96 falls below that necessary to hold the diaphragm 96 in a position to which it is moved by engine suction when the engine runs on its own power. This arrangement, although an additional safety factor, forms no part of the present invention.

It will also be understood that while the control switch as 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 that particular purpose but can be used in other devices.

While the embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. In a starting apparatus for internal combustion engines having a current source and an electric starting motor operable by current from said source, a control mechanism for controlling the operation of said starting motor comprising; a normally open control switch, a magnet for closing said switch, an armature movable by a second switch for controlling the energization of said magnet, means including a pair of diaphragms both independently movable relative to the armature and to each other for opening and closing said second switch, and a means providing a common limit stop for one of the diaphragms and the armature.

2. In a starting apparatus for internal combustion engines having a source of current, an electric starting motor operable by current from said source, a control mechanism for controlling the operation of said starting motor, comprising; an electromagnet, a pair of normally open contacts adapted to control the operation of said motor, said contacts being adapted to be closed by said electromagnet when said magnet is energized from said source, a means for controlling the energization of said magnet including; a second pair of normally closed switch contacts and a pair of spaced independently movable diaphragms both of which are adapted to be moved when said engine becomes self-operative and only one of which is adapted to move with a delayed action when the self-operation of said engine ceases for closing said second mentioned switch contacts, and a member providing a limit stop for the armature and a support for one of said second pair of switch contacts.

3. In a starting apparatus for internal combustion engines having a source of current, an electric starting motor operable by current from said source, a control mechanisms for controlling the operation of said starting motor including; an electromagnet, a pair of normally open contacts adapted to control the operation of said motor, said contacts being adapted to be closed by said electromagnet when said magnet is energized from said source, a means for controlling the energization of said electromagnet comprising; in combination; a pair of normally closed switch contacts, a pair of spaced independently movable diaphragms both of which are adapted to move rapidly in one direction when the engine becomes self-operative and one of which controls movement of one of said second pair of switch contacts, and a means for delaying the movement of said one diaphragm when the self-operative condition of said engine ceases and a means providing a limit stop for the armature and a support for one of said second pair of switch contacts.

4. In starting apparatus for internal combustion engines having a source of current and an electric starting motor operable by current from said source; a mechanism for controlling the operation of said starting motor, comprising; a control switch, an electromagnet for closing said control switch to cause the starting motor to become self-operative, a second switch having a movable member arranged for controlling the energization of said electromagnet, means connected with engine suction to open said second switch when the engine becomes self-operative to cause said starting engine to become inoperative, said means comprising; a pair of independently movable spaced diaphragms one of which is in direct communication with the engine suction and the other of which is adapted to engage and open said second switch when the engine suction exceeds a predetermined value and a member providing a common limit stop for the armature and the other diaphragm and a support for the movable member of the switch.

5. In starting apparatus for internal combustion engines having a current source and an electric starting

motor operable by current from said source, a control mechanism for controlling the operation of said starting motor comprising; a control switch, an electromagnet having a movable armature for closing said switch when said electromagnet is energized, a second switch having a movable member for controlling the energization of said electromagnet, a means including a pair of spaced independently movable diaphragms both independently movable relative to the armature and to each other for delaying the closing of said second switch after the engine has become self-operative, and a common limit for the electromagnet armature and the movable member of the second switch.

6. In starting apparatus for internal combustion engines having a current source and an electric starting motor operable by current from said source, a unitary housing enclosing a control mechanism for controlling the operation of said starting motor comprising; a control switch, an electromagnet having a movable armature for closing said switch when said electromagnet is energized, a second switch for controlling the energization of said electromagnet, a pair of diaphragms both movable independently of the armature and each other and spaced to provide a fluid chamber therebetween, a wall within said chamber having openings therein, valve means for closing certain of said openings arranged to restrict fluid flow through said openings in one direction of fluid flow only, means for connecting one of said diaphragms only with a source of engine suction, and means for actuating said second switch with the movement of the other diaphragm.

7. In starting apparatus for an internal combustion engine having a source of current and an electric starting motor operable by current from said source, a unitary housing enclosing a control mechanisms for controlling the operation of said starting motor comprising an electromagnet having a movable armature arranged to close an electric switch and a pair of spaced diaphragms both independently movable relative to the diaphragm and independently movable relative to each other one of which is movable in response to a predetermined engine suction and the other is freely movable in response to the movement of said first diaphragm when said suction increases as the engine becomes self-operative and has a restricted movement when said suction decreases when the self-operation of said engine ceases.

8. In a device of the character described, the combination comprising; an armature adapted to be moved when an electromagnet is energized, a switch having a movable member engageable with a stationary member for controlling the energization of said electromagnet, a diaphragm independently movable relative to the armature and adapted to move said movable member, and a member adapted to provide a limit stop for said armature and said diaphragm and a support for the movable member of said switch.

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