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AUTOMATIC STARTING SYSTEM AND APPARATUS

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This invention relates to automatic electrical starting systems for hydrocarbon engines for automatically connecting in the starting motor when the ignition switch is turned on and for automatically cutting out the starting motor as soon as the engine has been started, with re-connection of the starting motor in circuit should the engine accidentally stall or stop.

An important object of the invention is to provide an arrangement in which a governor switch controls the energizing circuit for an electromagnetic switch which in turn controls the starting motor circuit, with the operation of the governor switch controlled by suction effect produced by the operation of the engine. I employ a governor switch structure comprising a suction chamber or cylinder in which is a piston which, when inert or retracted, holds the governor switch closed, the suction chamber being connected with the intake manifold of the engine, but provision being made to prevent response of the piston to the comparative low suction effect while the engine is being started but to permit response of the piston to the increased suction when the engine has been started so that the switch will then be opened and the starting motor cut out of circuit.

It frequently happens that, when the engine is accelerating or operating at high speed, or is laboring under other conditions, the suction in the intake becomes very low and under such conditions the suction may be insufficient to hold the governor piston against retraction and closure of the governor switch and reclosure of the starting motor circuit at a time when the engine is running. An important object of the invention is therefore to guard against such undesirable and untimely operation of the starting motor and this I preferably accomplish by the provision of a suction or vacuum pump driven by the engine, with the arrangement and operation such, that when the intake manifold suction is normal and sufficient during running of the engine, the governor switch structure will be properly controlled, but, under abnormal or low suction or vacuum during running of the engine, the pump will produce the necessary vacuum or suction for the proper and safe operation of the governor structure.

The various features of my invention are shown incorporated in the structure disclosed on the drawing, in which drawing:

Figure 1 is a vertical sectional view of a preferred form of pumping mechanism;

Figure 2 is a vertical section of the governor structure; and

Figure 3 is a vertical section of an electromagnetic switch for controlling the starting motor circuit, the electrical circuits connecting the various elements being diagrammatically shown.

The apparatus of my improved system comprises an electromagnetic switch E for controlling the starting motor circuit, a governor switch structure G for controlling the energizing circuit of the electromagnetic switch, and a vacuum pump structure V for balancing the vacuum condition in the governor switch structure.

Any suitable form of electromagnetic switch may be used. The switch shown comprises a cylindrical casing 10 having a detachable cover 11. In the bottom of the casing is a spool 12 of insulating material for receiving an energizing winding 13 whose ends are connected with terminal posts 14 and 15 mounted on the wall of the casing 10 but insulated therefrom. At the lower end of the spool bore is the stationary core part 16 of magnetic material, and the armature or movable core member 17 is operable in the upper end of the spool bore, this armature terminating at its upper end in a switch head 18 for engagement with terminal brackets 19 and 20 supported by terminal posts 21 and 22 mounted on but insulated from the casing 10. A spring 23 interposed between the spool 12 and the switch head tends to hold the head above the terminal brackets 19 and 20 and out of contact therewith. Upon current flow through the winding 13 the armature will be drawn downwardly to engage the switch head 18 with the terminal brackets 19 and 20 for closure of the circuit for the engine starting motor indicated diagrammatically at 24. A button 25 projects upwardly thru the casing cover 11 by means of which the switch head 18 may be manually depressed for closure of the starting motor circuit, the button being preferably of insulating material.

The governor switch structure comprises a cylinder 26 having a detachable cover 27. A piston 28 within the cylinder has a piston rod 29 extending therefrom upwardly through the guide hub 30 of the cover 27, a spring between the piston and cover tending to hold the piston retracted within the cylinder.

Mounted on the cover 27 is a casing 32 for the circuit controlling switch mechanism comprising a switch lever 33 and a contact bracket 34. The switch lever is pivoted intermediate its ends as indicated at 35, its inner end being forked to provide abutment fingers 36 and 37 for engagement by a collar 38 secured on the piston rod 29. The contact bracket 34 is secured to the cas-

ing 32 but insulated therefrom and a terminal post 39 extends therefrom. When the piston is retracted in the cylinder the collar 38 is in engagement with the finger 36 of the switch lever 5 to hold the outer end of the lever in contact with the contact bracket 34 and when the piston is raised the collar engages with the finger 37 to swing the switch lever away from the contact bracket. To give a snap action to the switch lever 10 a spring 40 is secured at one end above the lever and its other end is connected with the end of an arm 41 extending downwardly from the lever, the operation being such that when the spring axis passes through the lever fulcrum axis after starting movement of the lever in one direction the spring will thereafter rapidly continue the movement of the lever in such direction for quick opening or closing of the circuit controlled by the switch. 15

At its upper end the cylinder 26 has the outlet 42 which is connected by piping 43 with the inlet 44 of the vacuum pump V whose outlet 45 is connected by piping 46 with the engine intake manifold so that the cylinder 26 may be subjected to the engine intake manifold suction or to the suction produced by the vacuum pump V. 25

Describing now the electrical connection, a battery 47, which is usually the battery on the vehicle on which the starting circuit is applied, has one terminal grounded, the other terminal being connected with a switch 48 which is usually the ignition switch on the vehicle, the switch lever being shown connected with the battery and the ignition coil 49 being connected with the switch contact button 50 so that when the switch is closed the ignition system will be in operation. 30 35

The ungrounded side of the battery is connected by conductor 51 with the terminal post 21 of the electromagnet switch E whose other terminal post 22 is connected by a conductor 52 with one terminal of the engine starting motor 24 whose other terminal is grounded. A second switch 53 is provided for connecting the automatic starting system for service. The lever of the switch is shown connected with the ignition switch contact 50, and the contact 54 of the switch 53 is connected by conductor 55 with the terminal post 14 of the energizing winding for the electromagnet switch E, the other terminal post 15 of the winding being connected by conductor 56 with the terminal post 39 of the governor switch G, the frame of this governor switch and consequently the switch lever 33 being grounded. 40 45 50

If the driver does not desire to use the automatic starting he closes only the switch 48 for connecting the ignition system for service and the electromagnetic switch E is manually closed by pressing the button 25, the starting motor being then connected in circuit for starting the engine. If the driver desires to use the automatic starting he first closes the switch 53 and then closes the ignition switch 48. The ignition will then be in service and the energizing circuit for the electromagnet switch E will be closed and this switch 55 will be electromagnetically operated to close the starting motor circuit. The energizing circuit for the electromagnet switch will be from the battery, through the switches 48 and 53, through conductor 55, the switch winding 13, conductor 56, 60 and through the closed governor switch to ground and back to the battery, and the governor switch will then control the energizing circuit. 65 70

When the engine is at rest or is being started by the starting motor, the governor switch G should remain closed. To assure closure of the

governor switch during starting of the engine the air passageway 57 is formed in the piston rod 29 which at its inner end communicates with the cylinder 26 and its upper end is open to the atmosphere when the piston 28 is at the inner end of the cylinder. This channel 57 is restricted but is calibrated to admit sufficient air into the cylinder to prevent response of the piston 28 to the comparatively low suction in the engine intake manifold while the engine is being slowly turned over by the starting motor. However, as soon as the engine has been started and is running the suction is greatly increased and the suction in the cylinder overcomes the air bleed and the piston is moved upwardly to swing the switch lever 33 to open the switch. As soon as the lower end of the air bleed channel enters the guide hub 30 in the top of the cylinder, the air channel will be closed to the cylinder and the entire suction effect in the cylinder is then effective in powerfully moving the piston for opening of the switch, and with such opening the energizing circuit for the electromagnet switch E will be interrupted and the starting motor circuit will be opened. Should the engine accidentally stop at any time the suction will cease and the spring 31 will retract the piston into the cylinder and the governor switch will be reclosed and the electromagnet switch E will be actuated to reclose the engine starting motor circuit so that the engine is thus immediately automatically restarted after accidental stopping thereof. 80 85 90 95 100 105

It is very important that the engine, after failure to operate, should come to a complete stop before the governor switch is reclosed in order to avoid connection of the starting motor with the engine while running. I therefore provide a vent plug 58 having the vent outlet 59 communicating with the cylinder below the piston and this vent outlet may be more or less restricted by an adjustable valve 60 so that when the suction fails in the cylinder the retraction of the valve 28 is retarded by the resistance to the outflow of air from the cylinder below the piston through the restricted vent passage 59, the closure of the governor switch being thus delayed until the engine has come to a full stop. 110 115 120

Under certain conditions of operation of an engine the vacuum or suction in the intake manifold becomes very low, as for example when the engine is accelerating or operating at high speed or under other conditions when the carbureter throttle opening is wide. Provision must be made for preventing retraction of the governor piston and closing of the governor switch when such conditions of engine operation occur. To meet these conditions I have provided the vacuum pump V which is operable while the engine is running to generate sufficient suction in the governor cylinder in case the intake suction becomes insufficient to assure holding of the governor switch in open position while the engine is running. The pump shown comprises a body frame 61 and a valve chamber frame 62 secured to the frame 61 with a diaphragm 63 interposed between the frames. The frame 61 is secured to a suitable support 64 which may be the engine frame, or the frame of any apparatus associated with the engine, and in this frame is journaled a cam shaft 65 having a cam 66 thereon, the cam shaft 65 being connected to be driven either directly or indirectly from the engine shaft so that when the engine shaft turns the cam shaft will also turn. Within the frame 61 a rocker arm 67 is pivoted at its lower end on a shaft 68 supported by the frame 61, the upper 125 130 135 140 145 150

end of the rocker arm being in the path of a push rod 69 which is engaged by the cam 66. A spring 70 is interposed between the rocker arm and a wall of the frame 61, the spring keeping the rocker arm in contact with the push rod 69 and the push rod in contact with the cam 66 so that when the cam shaft 65 rotates the rocker arm will be rocked back and forth.

Pivoted at its outer end on the shaft 68 is a lever 71 which has the abutment 72 engageable by the rocker arm 67, the other end of the lever receiving the upper end of a pin 73 extending from the diaphragm 63. The frame 62 forms a cylindrical pocket 74 below the central part of the diaphragm 63 and the pin 73 and this spring tends to move the diaphragm upwardly to hold the lever 71 with its abutment 72 against the rocker arm 67. With this arrangement, when the rocker arm is rocked, the diaphragm will be vertically vibrated.

A check valve 75 is interposed between the pump inlet 44 and the space below the diaphragm to check flow from this space to the inlet 44, the valve spring 76 tending to close the valve against flow from the inlet to the space below the diaphragm. Another check valve 77 is interposed between the space below the diaphragm and the pump outlet 45 to check flow from the outlet to said space the spring 78 tending to hold the valve to prevent flow to the outlet from the space below the diaphragm. As before explained the pump inlet 44 is connected with the cylinder 26 and pump outlet 45 is connected with the engine intake manifold. When the engine is at rest the pump valves are closed. While the engine is being rotated by the starting motor the valves may open to the suction, but if they do, the suction will have no effect on the piston and the governor cylinder on account of the air bleed channel 57. When the engine has been started by the motor and the suction in the intake manifold comes to normal, both pump valves will be opened and this increased suction will be transmitted to the governor cylinder and the piston will be moved to open the governor switch. Under normal conditions of running of the engine the intake suction will be sufficient to hold the diaphragm 63 down against the force of the spring 74 and when the diaphragm is thus held down the lever 71 will be swung down and its abutment 72 displaced from the path of the rocker arm 67. Should there be an occurrence of the abnormal running conditions of the engine above referred to, with resultant drop in the suction force in the manifold, the diaphragm 63 will be released and the lever 71 will be swung back into the operating range of the rocker arm 67 and the lever 71 will be swung down by the rocker arm to move the diaphragm downwardly, the spring 74 returning the diaphragm and the lever, the result being a vibration or pumping action of the diaphragm. During the upstroke of the diaphragm the check valve 77 is closed and the check valve 75 opened and air is withdrawn from the cylinder 26 into the space below the diaphragm, and during downward stroke of the diaphragm valve 75 closes and valve 77 opens and the air which has been drawn into the space below the diaphragm is expelled through the pump outlet 45 into the engine manifold, any suction effort present in the intake manifold assisting the vacuum pump in drawing air out of the cylinder 26 so that the piston is held in switch opening position. Thus, while the engine is running, the vacuum pump keeps up the

suction in the governor cylinder should the available suction in the manifold be insufficient. Proper and safe operation of the governor is therefore assured and the starting motor will not be connected with the engine at any time while it is running, and the restricted air vent 59 will prevent connection of the starting motor with the engine until the engine has come to a full stop.

The rocker arm 67 may also be utilized for operating a diaphragm pump for pumping combustion fluid from the supply tank to the carburetor for the engine. Such pump may comprise the diaphragm 79 connected by the stem 80 with the end of the lever 81 pivoted on the shaft 68 and having the abutment 82 for engagement by the rocker arm, the diaphragm being moved downwardly when the rocker arm moves inwardly and being returned by the pressure of a spring 83. The fuel tank is connected with the space above the diaphragm through a check valve 84 and the outlet from this space to the carburetor is controlled by a check valve 85. The fuel may first be run through a filter 86. When the carburetor reservoir is filled, and its inlet valve closes, the pressure in the space above the diaphragm 79 will hold the diaphragm down and the lever 81 will be held out of range of the rocker arm, but as soon as the pressure is relieved the diaphragm is again vibrated to pump fuel to the carburetor reservoir.

I do not desire to be limited to the exact construction, arrangement and operation shown and described as changes and modifications may be made without departing from the scope of the invention as defined in the appended claims.

I claim as follows:

1. In combination, a hydrocarbon engine, a starting motor therefor, an electric circuit for said motor, a governor switch for controlling the opening and closing of the starting motor circuit, means whereby said switch is closed when the engine is below minimum running speed, vacuum responsive means for operating said switch to cause opening of said motor circuit, a connection between said vacuum responsive means and the engine intake path, said vacuum responsive means being adapted to hold said switch in circuit opening position when sufficient vacuum exists in the engine during running thereof, a vacuum pump interposed in said connection, a driving connection between the engine and said pump, means for rendering said pump ineffective when the engine vacuum is sufficient for operation of the vacuum responsive means to hold said switch in circuit opening position, and means for rendering said pump effective to supply sufficient vacuum for holding said switch in circuit opening position when the engine vacuum fails during running of the engine.

2. In combination, a hydrocarbon engine, a starting motor therefor, an electric circuit for said motor, a governor switch for controlling the opening and closing of the starting motor circuit, means whereby said switch is closed when the engine is below minimum running speed, vacuum responsive means for operating said switch to cause opening of said motor circuit, a connection between said vacuum responsive means and the engine intake manifold, said vacuum responsive means being adapted to hold said switch in circuit opening position when sufficient vacuum exists in the engine during running thereof, a vacuum pump interposed in said connection, a driving connection between said engine and said pump, means controlled by the engine

vacuum for rendering said pump ineffective when the engine vacuum is sufficient for operation of the vacuum responsive means to hold said switch in circuit opening position and for rendering said pump effective to supply sufficient vacuum for holding said switch in circuit opening position when the engine vacuum fails during running of the engine.

3. In combination a hydrocarbon engine, a starting motor therefor, an electric circuit for said motor, a governor switch for controlling the opening and closing of the starting motor circuit, means whereby said switch is closed when the engine is below minimum running speed, vacuum responsive means for operating said switch to cause opening of said motor circuit, a con-

nection between said vacuum responsive means and the engine intake manifold, said vacuum responsive means being adapted to hold said switch in circuit opening position when sufficient vacuum exists in the engine during running thereof, a vacuum pump interposed in said connection, a driving connection between said engine and said pump, and valve means controlled by the engine vacuum for rendering said pump ineffective when the engine vacuum is sufficient for operation of the vacuum responsive means and for rendering said pump effective to supply sufficient vacuum for holding said switch in circuit opening position when the engine vacuum fails during running of the engine.

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