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[54] **AIR METER SWITCHING ARRANGEMENT FOR AN ELECTRIC FUEL INJECTION SYSTEM**

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[51] **Int. Cl.** **F02m 51/00**

[58] **Field of Search** ..... 123/32 AE, 32 EA, 123/119 R, 119 F, 139 E, 179 L

[56] **References Cited**

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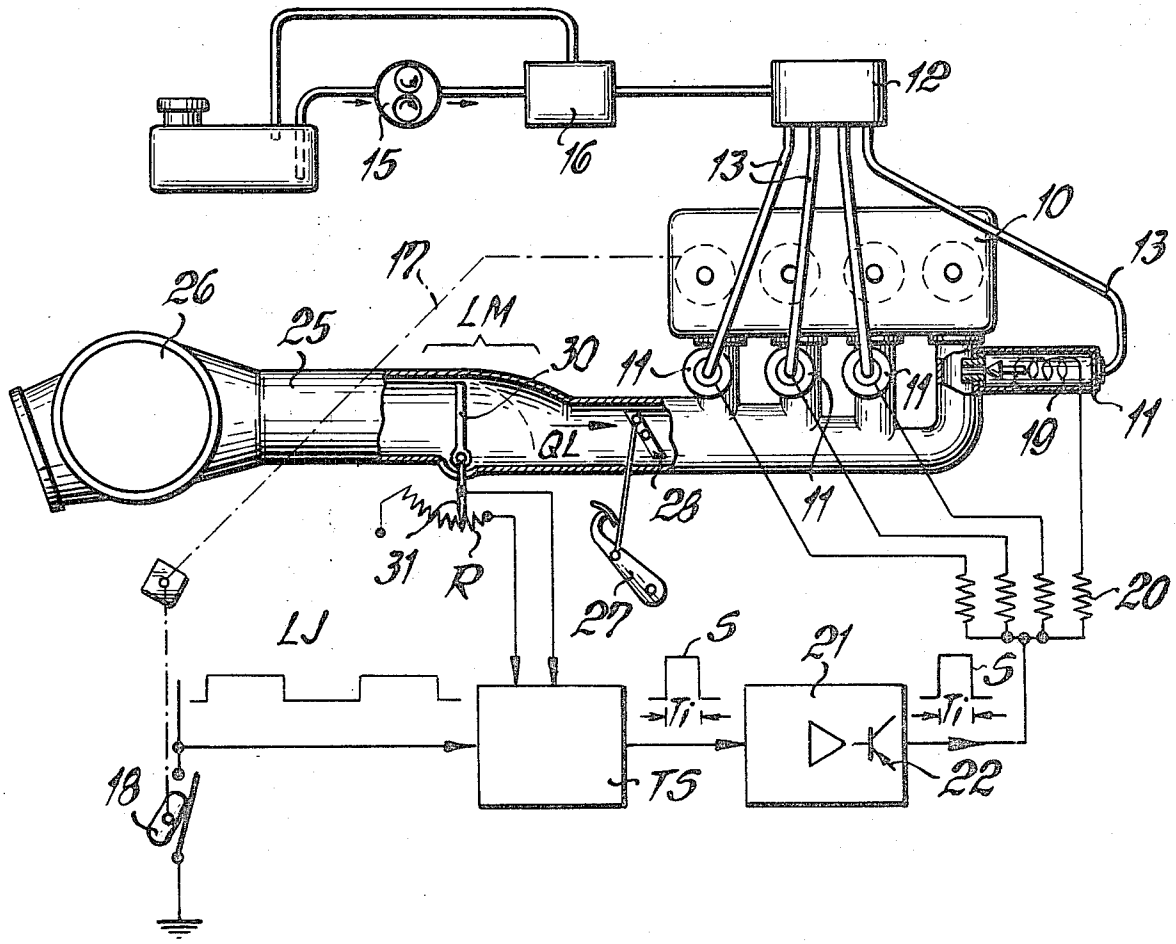
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[57] **ABSTRACT**

An electromagnet, energized only when the engine operates at full load and high r.p.m., attracts the static plate of the air meter out of the air path of the engine intake manifold. A switch, operated by the static plate only when the latter is pivoted to at least the idling position, is associated with a circuit that insures that the fuel pump operates only when the engine is turning over.

14 Claims, 5 Drawing Figures



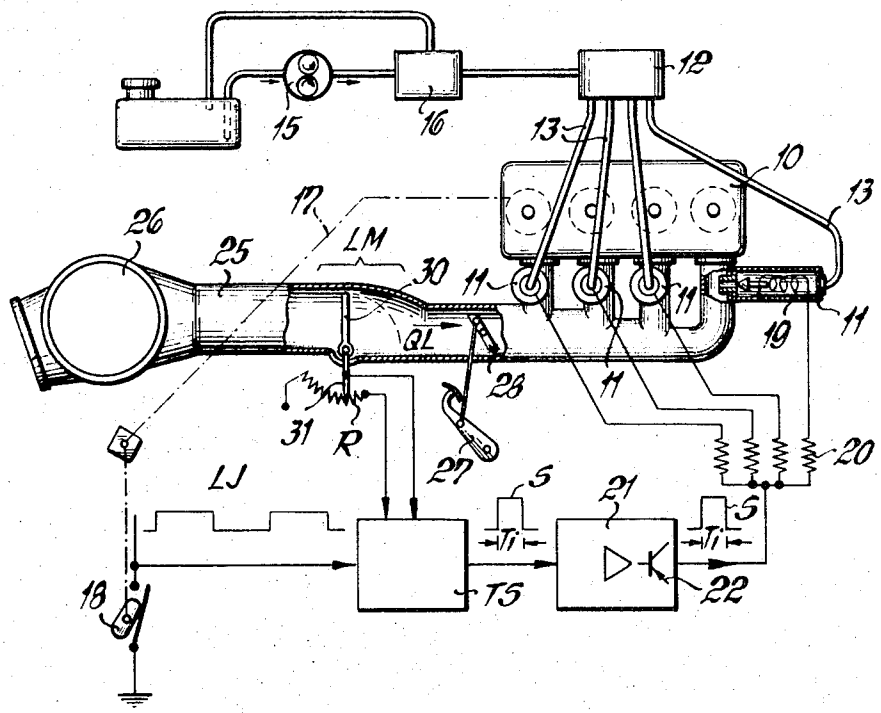


Fig. 1

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Fig. 2

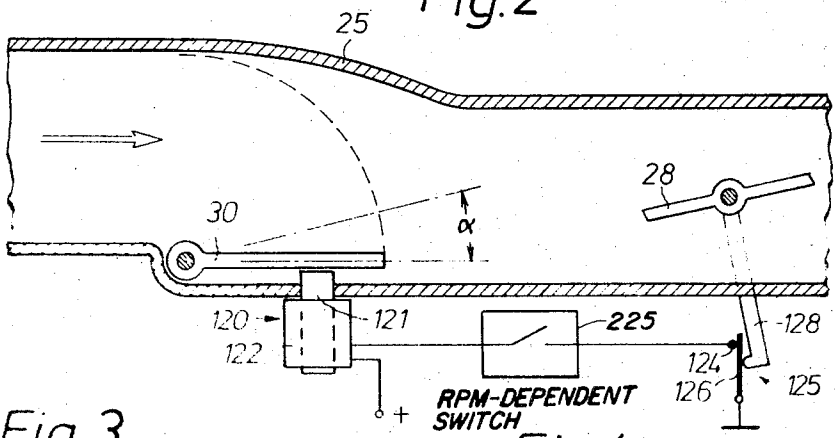


Fig. 3

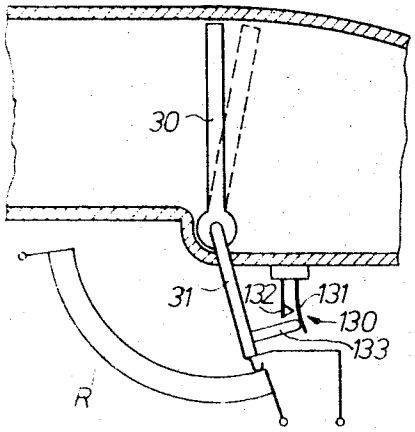


Fig. 4

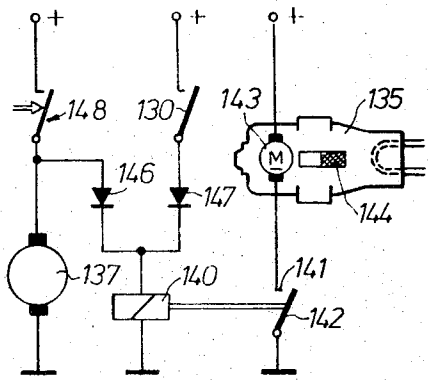
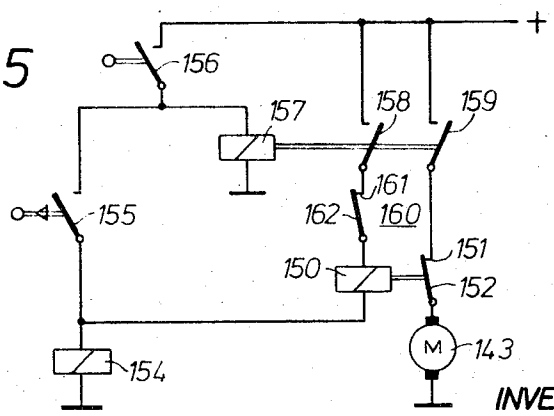


Fig. 5



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AIR METER SWITCHING ARRANGEMENT FOR AN ELECTRIC FUEL INJECTION SYSTEM

BACKGROUND OF THE INVENTION

The invention relates to an arrangement to be used in conjunction with the air meter of the electronic fuel injection system of an internal combustion engine.

SUMMARY OF THE INVENTION

An object of the invention is an arrangement for moving the static plate out of the path of the air in the intake manifold so as to avoid the 1 or 2 percent reduction in the maximum power output of the engine.

A further object of the invention is an arrangement in conjunction with the static plate of the air meter that insures that the fuel pump does not operate unless the engine is turning over.

Briefly, the invention consists of air meter means for providing the time average of the amount of air sucked through the engine intake manifold, the air meter means including a movable static plate located within the intake manifold and mounted to pivot about an axis in response to the flow of air through the intake manifold, electromagnet means for pivoting, when energized, the static plate out of the air path in the intake manifold, and switch means for causing energizationof the electromagnet means at full load in the upper speed range of the engine.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiment when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic, longitudinal, view, partly in cross-section of an electronic fuel injection system with an air meter;

FIG. 2 is a longitudinal view, partly in cross-section of an arrangement for moving the static plate completely out of the path of the air in the intake manifold;

FIG. 3 is a longitudinal view, partly in cross-section, of a static plate switch; and

FIGS. 4 and 5 are wiring diagrams of circuits that can be used with static plate switches of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIG. 1, the illustrated fuel injection arrangement is intended for a four cylinder, four stroke, internal combustion engine 10. The arrangement essentially comprises four electromagnetic fuel injection spray valves 11 that are connected by respective fuel conveying pipes 13 to a distributor 12, and an electric motor driven fuel pump 15, a pressure regulator 16 that keeps the fuel at a constant pressure, and an electronic control (to be described) that a signel generator 18, which is coupled to the engine cam shaft rotating synchronously with the crank shaft, operates twice during each complete rotation of the crank shaft to produce one rectangular valve opening pulse S. These pulses cause the valves 11 to open. The period T_i of the pulse S determines the open time of the valve 11 and therefore the amount of fuel that is forced out of a valve at a nearly constant pressure of 2 atmospheres. The magnet coils 19 of the fuel injection spray valves 11 are connected in series with respective decoupling resistors 20, which latter are connected in common to the output of an amplification and power output stage 21. The stage 21 contains at least one power transistor 22, the emitter collector path of this transistor being connected in series with the decoupling resistors 20 and the magnet coils 19, which latter are connected at one end to ground.

With external auto ignition gasoline engines of the kind illustrated, the amount of air sucked into a cylinder during a single suction stroke determines the amount of fuel that can be completely burned during the following power stroke. If the engine is to be used efficiently, little air should remain after the power stroke. In order to obtain the desired stoichiometric ratio between air and fuel, there is provided in the intake manifold, between the filter 26 and the throttle valve 28, an air meter LM, which essentially comprises a static plate 30 and an adjustable resistor R of which the movable tap 31 is coupled to the static plate. The position of the throttle valve is controlled by an accelerator 27. The air meter LM operates in conjunction with a transistor switch TS, the output of which delivers the control pulse S for the output stage 21.

With reference to FIG. 2, all of those parts that perform similar functions in FIGS. 1 and 2 are denoted by the same reference numerals. When the engine is operated at full load, the static plate 30, which serves to measure the time average of the amount of air sucked through the engine intake manifold, is pivoted by the air stream until the force of the return spring (not shown) of the static plate and the force of the air are in equilibrium. This fact results in reduction of from 1 to 2 percent of the maximum output of the engine, a loss that is undesirable in many applications. To avoid this power loss, there is provided in the embodiment illustrated in FIG. 2 an electromagnet 120 of which the core 121, composed of soft iron, projects into the interior of the light metal intake manifold 25 and is positioned opposite the static plate 30, which is made of a magnetizable metal. One end of the electromagnet winding 122 can be connected to an engine speed dependent switch (not shown) which is closed when the engine speed exceeds a predetermined r.p.m. This switch, in turn, is connected to the starter battery (not shown). The other end of the winding 122 is connected to the stationary contact 124 of a throttle valve switch 125 of which the movable arm 126 is connected to ground. The throttle valve switch is closed, as shown in FIG. 2, as soon as the throttle valve 28 is moved to near the open position shown in FIG. 2. The throttle valve 28 is connected to a lever 128 that bears against the contact arm 126 and pushes the latter against the stationary contact 124 when the throttle valve approaches its maximum open position. The contact arm 126 is normally biased open by a spring, not shown. The attractive force of the electromagnet 120, when the latter is energized, pivots the static plate 30 through an angle α of from 10° to 15° so as to move it completely out of the air path in the intake manifold,opening up the entire cross-section of the latter for air and in so doing eliminating the loss of power that otherwise would occur. As soon as the throttle valve returns to a less open position, the movable contact arm 126 is free to move clockwise under the influence of its spring and to open

the throttle valve switch **125.** Consequently, the energizing current for the electromagnet **120** is broken, and the static plate **30** is pivoted by its return spring (not shown) to a position in which the return force of the spring and the dynamic pressure in the intake manifold are in euilibrium.

Although the engine speed dependent switch **225** is not essential to the invention, the combination of the switch **225** and the throttle valve switch **125** has the advantage that the winding **122** is energized only when the throttle valve is in the full load position and the engine speed exceeds a predetermined r.p.m. In the present embodiment components **124–126, 128, 225, 226, 120, 121** and **122** together constitute overriding means.

In accordance with the invention, the static plate **30** need not be made entirely of a magnetizable metal, it being sufficient if that face of the static plate opposite the soft iron core **121** is covered with magnetizable metal, such as one or more small plates. Further in accordance with the invention the core **121** can be positioned nearer to the pivot axis of the static plate **30** then is shown in FIG. **2.** In this case, the air gap between the static plate **30** and the core **121** can be made sufficiently small, so that the attractive force is sufficient even when the static plate **30** must still be pivoted through a fairly large angle when the electromagnet **120** is energized.

Fuel injection systems of the kind contemplated to be used in conjunction with the invention, operate with a constant fuel pressure or with a constant pressure difference of the fuel. These systems require a fuel pump for providing the pressure, the pump as a rule having a drive that is independent of the engine, the drive being, for example, an electric motor powered by the starter battery of the internal combustion engine. The electromagnetic fuel injection spray valve **11** (see FIG. **1**) can be held open continuously under certain conditions, such as foreign particles on the sealing seat or continuous energization of the electromagnet of the valve, so that fuel is continuously fed to the engine. The danger then exists that fuel delivered by the fuel pump, which still operates, to a cylinder of the stopped engine will cause appreciable damage during the compression stroke when the engine is again started up. To avoid such damage, it is essential that the fuel pump also be shut off when the engine is shut off. To this end, as shown in FIG. **3,** the static plate **30** cooperates with a static plate switch **130** which incorporates the two contact tongues **131** and **132.** These two tongues are held apart by a finger **133,** connected to the static plate **30,** when the static plate is in its rest position, drawn in solid line in FIG. **3,** this position being taken by the static plate only when the engine is stopped. The finger **133** is fixed to the arm **31,** which serves as the slider, or movable tap, of the resistor R and which is fixed to the rotatable shaft of the static plate **30.** The arrangement is so designed that the tongues **131** and **132** are in contact as soon as the engine is running under its own power and sufficient air is sucked through the intake manifold during idling so that the static plate is moved to the position shown in dot-dash line in FIG. **3.**

The static plate switch **130** can be advantageously connected to the circuit shown in FIG. **4.** This circuit ensures that the fuel pump **135** is turned on only when either the starter motor **137** of the internal combustion engine is operated or the internal combustion engine is turning over at some speed, such as at least idling speed, that is higher than the starting r.p.m. The static plate switch **130** cooperates with a pump relay **140,** the contacts **141** and **142** of which are closed when the relay winding is energized and therefore are denoted as make contacts. These make contacts are connected in series with the electric motor **143** of the fuel pump **135,** the field excitation of the motor **133** being provided by the field magnet **144.**

The winding of the pump relay **140** is connected to the cathodes of two diodes **146** and **147,** the anode of the diode **147** being connected to the static plate switch **130.** The anode of the other diode **146** is connected in series with the starter switch **148** of the starter motor **137,** the diode being conductive when the starter switch is closed to start the engine. The current flowing through the diode **146** closes the two make contacts **141** and **142** of the pump relay **140,** thereby turning on the electric motor **143** of the fuel pump **135,** even though the static plate **30** is still in its rest position and, consequently, the two contact tongues **131** and **132** of the static plate switch **130** are still open.

In a variation of the embodiment shown in FIG. **3,** the static plate switch can be so constructed that its contacts are closed only when the static plate is in its rest position. A static plate switch **160** of this kind is shown in the circuit illustrated in FIG. **5.** The static plate switch **160** is connected in series with a fuel pump relay **150** of which the contacts **151** and **152** are closed when the winding of the relay **150** is deenergized, these contacts therefore being denoted as normally closed contacts. These contacts are connected in series with the electric drive motor **143** of the fuel pump **135,** which is shown in FIG. **4,** but not in FIG. **5.** One end of the pump relay **150** is connected to the static plate switch **160,** and the other end is connected to a starting relay **154,** which is used to turn on the starter motor, not shown. The starting relay **154** is energized by closing a hand operated starting switch **155** and a hand operated ignition switch **156,** which latter must be closed to start up the engine. Connected to the ignition switch **156** is a master relay **157** of which the normally open contacts **158** and **159,** when closed, provide a current path through the static plate switch **160** for the pump relay **150** and, when the contacts **151** and **152** are closed, provide a current path for the motor **143** of the fuel pump. Since the pump relay **150** is connected to the starter switch **155,** it necessarily is deenergized — its contacts **151** and **152** closing — as soon as the starter switch **155** is closed. If the engine starts up immediately and idles, the static plate **30** is pivoted to the dot-dash position shown in FIG. **3;** and the contacts **161** and **162** are opened. The pump relay **150** is consequently deenergized, and the contacts **151** and **152** close, turning on the drive motor **143** for the fuel pump. It must be emphasized that the static plate switch **160** is so designed that the contacts **161** and **162** are held closed by the finger **133** only when the static plate **30** is in the rest position; as soon as the static plate is moved by even a small amount of air, the static plate switch **160** is opened.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions and circuits, differing from the types described above.

While the invention has been illustrated and described as embodied in air meter switching arrangements for an electronic fuel injection system it is not

intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

We claim:

1. In combination with an internal combustion engine having an air intake passage and a throttle valve in said intake passage, an arrangement comprising an air flow sensing member located in said air intake passage in the path of inflowing air and mounted for displacement by the inflowing air to an extent indicative of the air inflow rate; transducer means cooperating with said sensing member and operative for generating an electrical signal indicative of the displacement of said member and thereby indicative of the air inflow rate; fuel-injection means comprising fuel-quantity selecting means connected to said transducer means and responsive to said electrical signal and operative for injecting into a cylinder of said internal combustion engine an amount of fuel dependent upon said electrical signal; and overriding means for automatically moving said sensing member out of the path of inflowing air independently of the prevailing air inflow rate when said throttle valve is opened to a predetermined extent, so as to maximize the flow cross-section of the air intake passage and maximize the quantity of injected fuel for purposes of quick acceleration.

2. In combination with an internal combustion engine having an air intake passage and a throttle valve in said intake passage, an arrangement comprising an air flow sensing member located in said air intake passage in the path of inflowing air and mounted for displacement by the inflowing air to an extent indicative of the air inflow rate; transducer means cooperating with said sensing member and operative for generating an electrical signal indicative of the displacement of said member and thereby indicative of the air inflow rate; and overriding means for automatically moving said sensing member out of the path of inflowing air independently of the prevailing air inflow rate when said throttle valve is opened to a predetermined extent to maximize the flow cross-section of the air intake passage for purposes of quick acceleration, said overriding means comprising an electromagnet generating a magnetic force effective for moving said sensing member out of the path of inflowing air.

3. The arrangement defined in claim **2**, wherein said sensing member is at least in part of magnetizable material.

4. The arrangement defined in claim **3**, wherein said electromagnet is located in said air intake passage in proximity to said sensing member when the latter is in the displaced position thereof corresponding to maximum air inflow.

5. The arrangement defined in claim **3**, wherein said overriding means is operative for moving said sensing member out of the path of inflowing air independently of the prevailing air inflow rate when said throttle valve is opened to a predetermined extent providing the engine speed exceeds a predetermined value.

6. The arrangement defined in claim **5**, wherein said overriding means comprises an electromagnet generating a magnetic force effective for moving said sensing member out of the path of inflowing air, said electromagnet having a current path including a first switch and a second switch and being energized only when both said switches are closed, means for closing said first switch when said throttle valve is opened to said predetermined extent and means for closing said second switch when the engine speed exceeds said predetermined value.

7. In combination with an internal combustion engine having an air intake passage and a throttle valve in said intake passage, an arrangement comprising an air flow sensing member located in said air intake passage in the path of inflowing air and mounted for displacement by the inflowing air to an extent indicative of the air inflow rate; transducer means cooperating with said sensing member and operative for generating an electrical signal indicative of the displacement of said member and thereby indicative of the air inflow rate; and overriding means for moving said sensing member out of the path of inflowing air independently of the prevailing air inflow rate when said throttle valve is opened to a predetermined extent, so as to maximize the flow cross-section of the air intake passage for purposes of quick acceleration; a fuel pump; and means for initiating operation of said fuel pump when said sensing member assumes a position indicating that the air inflow rate has reached at least a predetermined minimum value.

8. The arrangement defined in claim **7**, and further comprising a starter motor; and means for automatically initiating operation of said fuel pump in response to operation of said starter motor.

9. The arrangement defined in claim **8**, wherein said fuel pump is provided with an electric drive motor having a current path and an electromagnetic relay comprising a motor switch in said current path; and a further switch connected in series with the winding of said relay to carry energizing current for the same and operated by said sensing member when the latter assumes a predetermined position.

10. The arrangement defined in claim **9**, and further including a starting switch connected to said starter motor for carrying energizing current for the latter.

11. The arrangement defined in claim **10**; and further including a diode connected between one end of said winding and said starting switch and another diode connected between said one end of said winding and said further switch.

12. The arrangement defined in claim **10**, wherein said further switch is automatically closed when said sensing member assumes a position indicative of the absence of air inflow, and wherein said electromagnetic relay when energized is operative for opening said motor switch.

13. The arrangement defined in claim **12**, wherein one end of the winding of said electromagnetic relay is connected to said further switch and wherein the other end of said winding is connected to said starting switch.

14. The arrangement defined in claim **13**; further including an ignition switch connected to a source of current and to the ignition system of the engine; a master relay having at least first and second make contacts, the first make contact being connected in series with said drive motor and the second make contact being connected in series with said winding of said electromagnetic relay and with said further switch.

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