Jan. 9, 1968 E. LINDBERG ET AL 3,362,388

SAFETY IGNITION SYSTEM

Filed March 24, 1966 2 Sheets-Sheet 1

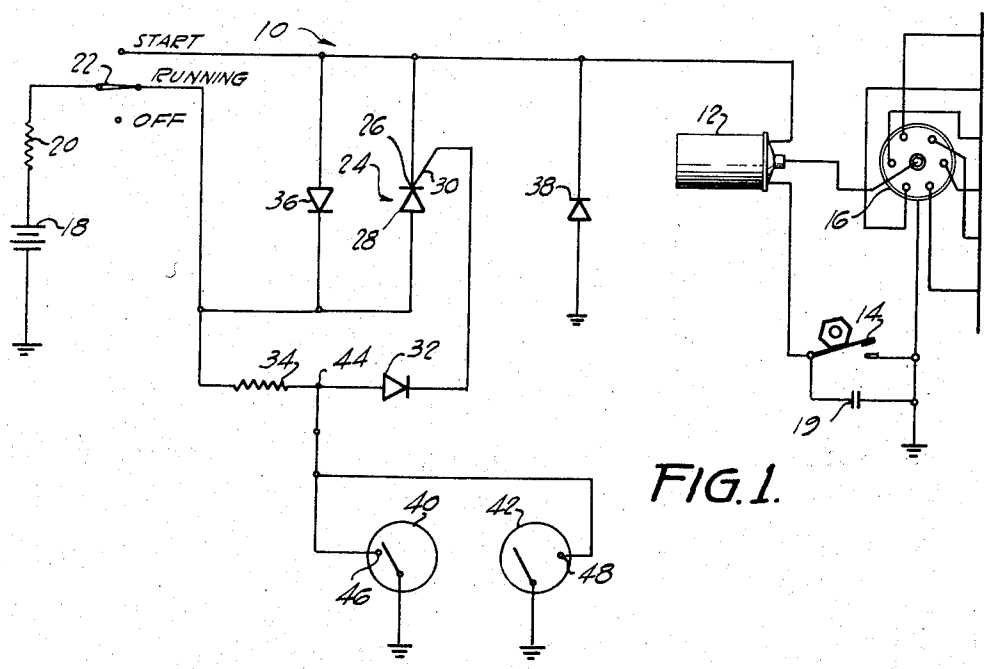


FIG. 1.

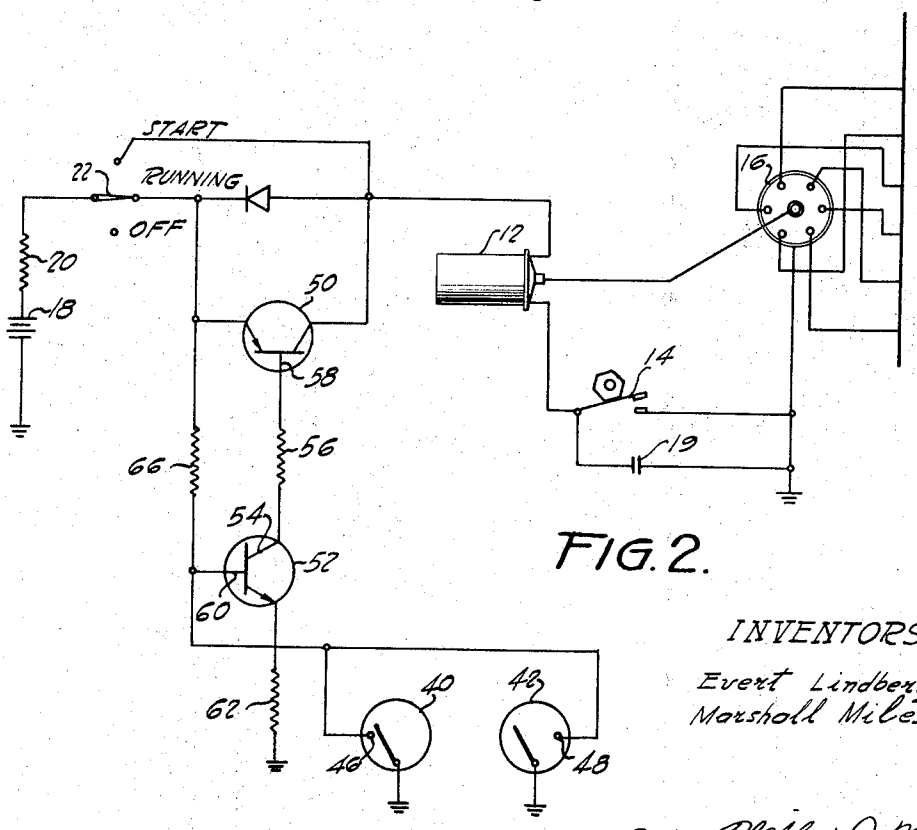


FIG. 2.

INVENTORS.
Evert Lindberg
Marshall Miles

By William J. Newman
Attorney

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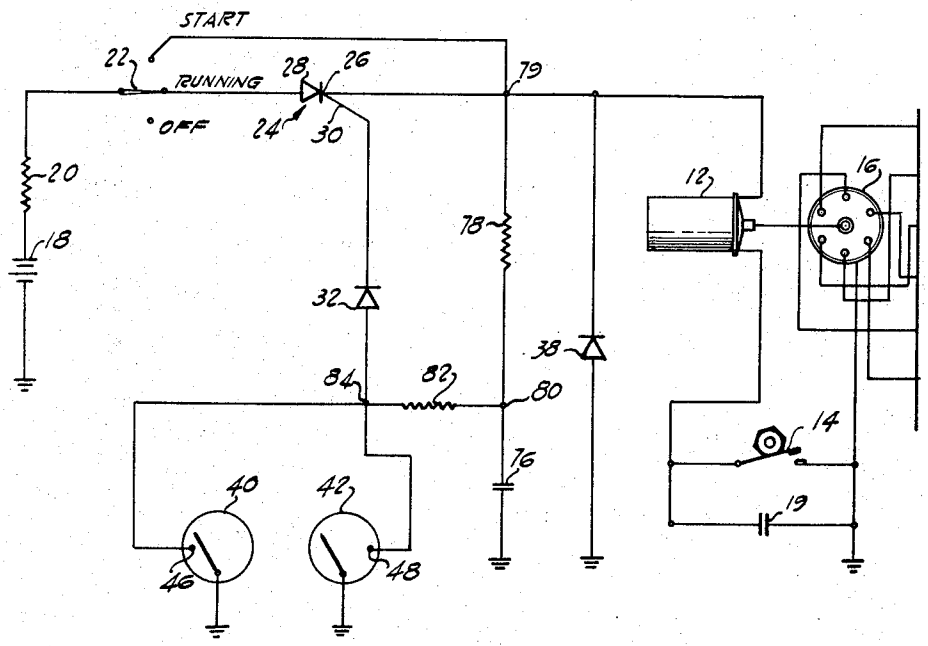


FIG. 3.

INVENTORS.
Evert Lindberg
Marshall Miles.

By William J. Keenan
Attorney

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SAFETY IGNITION SYSTEM

Evert Lindberg, Chicago, and Marshall Miles, Wilmette, Ill., assignors to Stewart-Warner Corporation, Chicago, Ill., a corporation of Virginia

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This invention relates to engine ignition systems and more particularly to improvements in such systems including safety switches for automatically rendering the engines inoperable responsive to the detection of unsafe engine running conditions.

Internal combustion engines are often operated unattended in remote locations. It is therefore desirable that provisions be made for the automatic detection of the engines if a malfunction occurs such as, for example, engine overheating or loss of oil pressure. These systems usually comprise engine condition indicating gauges with electrical contacts included therein which close when an unsafe condition level is reached. The operation of the electrical contact causes the attendant electric circuit to deactivate the engine in some manner.

The fuel feed line safety systems usually have a solenoid valve in the fuel line that closes upon detection of the malfunction. This is not an ideal system, however, because the engine keeps running after the detection of the malfunction until the fuel in the line between the valve and the engine is completely exhausted. During this time, of course, the engine may be seriously damaged. This, therefore, is not the ideal type safety system.

An ignition type safety system such as disclosed and claimed herein is preferred because it is immediate acting upon the detection of the malfunction or unsafe condition. The device operates to open the ignition circuit to stop the detonation sparks which inherently stops the engine immediately. In addition, the currents required to be switched by the detecting gauges are very slow, thus preserving the switch contacts.

It is therefore an object of the present invention to provide safety systems which operate to deactivate the engine ignition system and thus provide immediate shutdown.

It is also an object of this invention to provide engine safety systems which operate to deactivate the ignition system but eliminate the flow of excessive currents through the unsafe condition detectors.

Another object of this invention is to provide engine safety systems which are economical but reliable even in the most adverse of environment conditions.

Other objects and advantages of this invention will become apparent upon a further reading of the specification especially when taken in view of the accompanying drawings in which:

FIG. 1 is a schematic diagram of one embodiment of an improved ignition system with engine safety features included;

FIG. 2 is a schematic diagram of a second embodiment of an improved ignition system including the engine safety features; and

FIG. 3 is a schematic diagram of a third embodiment of an improved ignition system including the engine safety features.

Briefly, the unsafe condition disabling systems of this invention comprise a current carrying electronic switch such as a Silicon Controlled Rectifier or a Transistor,

in series connection with the ignition system of the engine to be protected. An unsafe condition detector such as a temperature and/or pressure gauge having electrical contacts are associated with the control element of the electronic switch (SCR gate or transistor base) for opening the electronic switch and discontinuing current flow in the engine ignition system.

The ignition and engine safety system 10 of FIG. 1 comprises a standard induction coil 12 in series connection with the cam operated breaker points 14 and distributor 16 to the spark plugs (not shown). That circuit is energized from the power supply 18 through ballast resistor 20, switch 22 and a silicon controlled rectifier 24. The cathode 26 of the SCR 24 is conected to the coil 12 while the anode 28 is connected through the switch 22 and ballast resistor 20 to the positive terminal of voltage source 18 so that it is in forward conducting connection when triggered on by its gate 30.

The gate 30 is normally biased in a positive direction with respect to the cathode 26 by means of diode 32 and dropping resistor 34 in connection with the switch 22. Although the gate 30 is normally biased for conduction of the SCR 24, conduction therethrough is intermittent in view of the action of the breaker points 14 and the induction coil 12. The SCR will conduct in a forward direction during the period of closure of the breaker contacts 14. However, when the contacts 14 open a momentary oscillating current is established in the circuit by means of the coil 12 and condenser 19. During the first reverse cycle of this current the SCR is cut off. The diode 36 is provided to limit the reverse voltage across the SCR if the SCR has too low a reverse voltage rating; however, proper selection of an SCR will eliminate the need for diode 36.

Another diode 38 has its cathode connected to the cathode of the SCR and its anode grounded to prevent excessive forward voltages across the SCR during the high voltage pulses generated by the coil 12 at the opening of breaker contacts 14. The diode 32 in the gate circuit of the SCR prevents the gate to cathode voltage from rising above the rated peak reverse voltage of the SCR.

The unsafe engine detecting units 40 and 42 control the operation of the SCR 24 by their connection to the gate circuit at junction 44. The detection units 40 and 42 are preferably gauges for indicating engine running conditions and include contacts 46, 48, respectively, which close when an unsafe running condition is present. The closure of either one of the contacts 46 or 48 places ground at the junction 44, thus preventing the flow of positive current to the SCR gate 30. The SCR is therefore cutoff and remains so until the engine running condition attains a safe level, at which point the respective contacts 46 or 48 in the detection units 40 or 42, respectively, open to restore the positive current to the SCR gate.

The engine condition detecting unit 42 may be an engine temperature gauge with the contact 48 being closed at the upper limit of the safe engine operating temperature range. The unit 40 may be an oil pressure indicating gauge which operates to close its contacts 46 when the oil pressure drops below a required minimum level. With the parallel connection of the two gauges 40 and 42 positive current is shunted to ground if either the temperature or the oil pressure are at unsafe levels.

It is to be observed that in the particular circuit shown the junction 44 is shunted to ground potential through the oil pressure gauge 40 whenever the engine is not

running. This presents a problem in starting the engine because the SCR 26 cannot be made to conduct as long as ground potential remains at junction 44. The switch 22, therefore, has a start contact which serves to shunt the anode-cathode circuit of the SCR 24 during engine startup. After the engine is running and the oil pressure is raised to a sufficient level to open contacts 46, the switch 22 is operated to its normal running position. It is to be noted that other provisions may be made for conditioning the circuit for startup other than the start contacts on switch 22. For example, a switch such as a push button normally closed type may be series connected between the pressure gauge 40 and the junction 44 so that the pressure gauge circuit may be deactivated during startup. However, the start provisions as shown in FIG. 1 are preferred because it may be accomplished with the single switch 22.

It may be seen that the current load required to be passed through the respective gauge contacts 46, 48 is quite small because the gate current required to turn the SCR off is very small. Thus, low current contacts may be used in the gauges 40, 42 with no concern over damage by excessive currents. In addition, no solenoids or relays are used in the system, thus avoiding the well known mechanical problems associated therewith.

FIG. 2 shows another embodiment of the invention utilizing a power transistor 50 in place of the silicon controlled rectifier 24. This circuit also includes an ignition coil 12 and breaker contacts 14 which are normally series connected with the voltage source through ballast resistor 20, switch 22 and the emitter to collector circuit of transistor 50. During normal running conditions the base current for the power transistor 50 is provided by a second transistor 52 which has its collector 54 connected through resistor 56 to the base 58 of power transistor 50. The emitter 60 is grounded through resistor 62 and its base 64 is forward biased by its connection through resistor 66, switch 22 and ballast resistor 20 to the positive terminal of battery 18.

The unsafe engine condition detecting units 40 and 42 are connected to the base of transistor 52. The closure of either of the respective contacts 46, 48 connect ground directly to the transistor base 64, thus cutting it off and stopping the flow of current to the base 58 of the power transistor 50. Failure of base current to the transistor 50 cuts it off and disrupts the ignition current flow for the engine.

The same startup problems are present in this circuit as are present in the circuit of FIG. 1 so that a start contact is provided on switch 22 to initially shunt the power transistor 50. Here too, the start contact may be substituted by a switch in the conductor between the base 64 of transistor 52 and the gauges 40, 42.

In the development work on these circuits a problem was encountered under certain conditions. That is, if the temperature sensor 42 or the pressure sensor 40 were of the normal type in which a small force holds the contacts in engagement upon detection of a malfunction, vibrations of the engine sometimes caused the contacts to open and close intermittently. When the malfunction is detected, it will be recalled that the contacts in one of the detectors 40, 42 close and the ignition circuit opens by virtue of the non-conduction of the electronic switch 24 or 50. If the engine is vibrating the lightly closed contacts in the detector may open and refire the ignition system. This phenomena was actually experienced during development and the engine kept running in a stumbling manner. This problem can be solved by using snap-action type switches for the malfunction detectors 40 or 42 such as are well known in the switch art.

The embodiment shown in FIG. 3, however, is a cheaper means for accomplishing this same purpose. The circuit in FIG. 3 is essentially the same as that shown in FIG. 1 except for the gate circuit for the silicon controlled rectifier. Hence, similar elements in the circuit will be given the same reference numerals and only the changes in the gate circuit will be described.

A capacitor 76 is series connected with a resistor 78 between ground and the junction 79 between the induction coil 12 and the cathode 26 of the silicon controlled rectifier 24. The gate 30 of the silicon controlled rectifier 24 is connected to the junction 80 between the resistor 78 and capacitor 76 through the diode 32 and a resistor 82. The low pressure detector 40 and high temperature detector 42 are parallel connected between ground and the junction 84 between the diode 32 and resistor 82.

This circuit operates in the following manner to protect the ignition system of an engine. To initiate operation of the engine the manually operable switch 22 is switched to its start position to connect the battery 18 directly to the induction coil 12 through the ballast resistor 20. The engine may be turned over and started in the conventional manner. When it is running switch 22 is turned to its running position.

During normal operation the breaker points 14 intermittently open to cause the magnetic field in the ignition coil 12 to collapse and generate a high voltage in the secondary of that coil. The potential between the junction 79 and ground rises abruptly to about 200 volts at each breaking of the point 14 charging the capacitor 76 so that the junction 80 between resistor 78 and capacitor 76 is positive with respect to ground. In a conventional ignition system the voltage across the coil 12 oscillates rapidly positive and negative finally decaying to approximately 12 volts, if that is the voltage of the battery 18. In this circuit, however, the diode 38 prevents the negative swing and hence prevents the discharge of the capacitor 76.

The subsequent closure of breaker points 14 reestablishes the path for the current from the power source through silicon controlled rectifier 24, the ignition coil 12 and breaker points 14 to ground. The silicon controlled rectifier is able to conduct during this period by virtue of the positive current flow from the capacitor 76 through resistor 82 and diode 32 to the gate 30 of the silicon controlled rectifier. The silicon controlled rectifier continues to conduct until the next opening of the breaker points 14 and this cycle repeats itself indefinitely.

If, however, one of the malfunction detectors 40 or 42 senses an unsafe condition, the respective contacts 46 or 48 closes resulting in the discharge of capacitor 76 through resistor 82 and the particular malfunction detector 40 or 42. Discharge current is then prevented from flowing to the gate 30 of the silicon controlled rectifier 24 and it is therefore prevented from conducting to fire the ignition system.

The capacitor 76 and resistor 82 are selected to have a very short time constant to ensure the rapid discharge of the capacitor 76 even if the contacts 46 or 48 are only momentarily engaged. In addition, the time constant must be small enough so that the capacitor 76 is discharged before the next closure of breaker points 14 regardless of the speed of the engine. It has been found that a time constant of approximately 33 microseconds is sufficient as would be represented by a .1 microfarad capacitor 76 and a 330 ohm resistor 32. It may be seen that once the capacitor 76 is discharged, the silicon controlled rectifier 24 can no longer conduct and the capacitor 76 cannot be recharged. The engine is therefore latched off and cannot restart itself.

While this invention has been described in terms of specific embodiments, it is to be understood that many modifications and additions may be made thereto without deviating from the basic teachings. For example, the systems illustrated and described herein are for use with engine ignition systems in which the negative terminal of power source is grounded. Obviously minor modifications may be made to these circuits to adapt them to grounded positive terminal systems. In view of these and other modifications it is intended to be bound only by the scope of the appended claims.

What is claimed is:

1. In an ignition system including a D.C. current source in series connection with an ignition coil and breaker points for periodically interrupting current flow through the ignition coil; an unsafe condition disabling system comprising a current carrying electronic switch in series connection with said breaker points having a control electrode, and means including an unsafe condition detector connected to said control electrode for opening said switch responsive to an unsafe condition.

2. In the system of claim 1 wherein said electronic switch is a silicon controlled rectifier having its anode and cathode forward polarized in said series connection, and said control electrode is the gate of said silicon controlled rectifier.

3. In the system of claim 2 wherein said detector means comprises a set of contacts operable upon detection of an unsafe engine condition to prevent the flow of positive current to said gate.

4. In the system of claim 3 wherein there are provided means for connecting the gate of said silicon controlled rectifier to the positive terminal of said D.C. current source to normally provide positive current to said gate and means connecting said set of contacts between said gate and the negative terminal of said battery, said set of contacts being normally open and operable to close responsive to an engine malfunction.

5. In the system of claim 4 wherein said set of contacts are temperature sensitive to close and shunt the flow of positive current away from said gate responsive to excessive engine temperatures.

6. In the system of claim 4 wherein said set of contacts are pressure sensitive to close and shunt positive current away from said gate responsive to engine pressures below a desired level.

7. In the system of claim 6 wherein means are provided for overriding said detector means during engine start-up.

8. In the system of claim 7 wherein said overriding means comprises a switchable shunt across the anode and cathode of said silicon controlled rectifier.

9. In the system of claim 1 wherein said electronic switch is a transistor having its emitter and collector forward polarized in said series connection and wherein said control electrode is the base of said transistor.

10. In the system of claim 9 wherein said detector means comprises a switch operable upon detection of an unsafe condition to prevent the flow of conduction current to said base.

11. In the system of claim 9 wherein said detector means comprises a second transistor having its emitter and collector in series forward connection with the base of the first transistor and its base normally biased for forward conduction and wherein said detector means further comprises a set of contacts in connection with the base of said second transistor, said set of contacts operable responsive to an unsafe engine condition to shut-off said second transistor responsive to an unsafe engine operating condition.

12. In the system of claim 11 wherein said set of contacts are operable to close and shunt conduction current away from the base of said second transistor responsive to excessive engine temperature.

13. In the ignition system of claim 11 wherein said set of contacts are operable to close and shunt conduction current away from the base of said second transistor responsive to engine pressure level below a desired level.

14. In the system of claim 13 wherein means are provided for overriding said detector means during engine start-up.

15. In the system of claim 14 wherein said overriding means comprises a switchable shunt across the emitter and collector of said first transistor.

16. In the system of claim 3 wherein there are provided means including a capacitor chargeable responsive to current flow through the engine ignition system for supplying positive current flow to the gate of said silicon controlled rectifier and means connecting said set of contacts across said capacitor, said set of contacts being normally open and operable to close responsive to an engine malfunction to discharge said capacitor and prevent positive current flow to said silicon controlled rectifier gate.

17. In the system of claim 16 wherein said set of contacts are temperature sensitive to close responsive to excessive engine temperatures.

18. In the system of claim 16 wherein said set of contacts are pressure sensitive to close responsive to engine pressures below a desired level.

19. In an ignition system for an engine having a D.C. current source with a grounded negative terminal, an ignition coil and breaker points, the improvement comprising a silicon controlled rectifier, means series connecting said coil and said points between the cathode of said SCR and ground, means including a manually operable switch with a first contact connecting the anode of said SCR to the positive terminal of said source, a first diode having its cathode connected to the SCR cathode and its anode connected to ground, a resistor and a second diode in series connection between said first contact and the gate of said SCR with the cathode of said second diode connected directly to said gate, an engine temperature responsive switch between the anode of said second diode and ground operable to close at temperatures above a desired level, an engine oil pressure responsive switch between the anode of said diode and ground operable to close at pressures below a desired level, and means including a second contact on said manually operable switch for connecting the positive terminal of said source to the cathode of said SCR.

20. In an ignition system for an engine including a D.C. current source having a grounded negative terminal, an ignition coil and breaker points, the improvement comprising a PNP transistor, means series connecting the coil and breaker points between the collector of said transistor and ground, means including a manually operable switch with a first contact connecting the emitter of said transistor to the positive terminal of said source, an NPN transistor, a first resistance connecting the collector of said NPN transistor to the base of said PNP transistor, a second resistance connecting the emitter of said NPN transistor to ground, means including a third resistance and said first contact connecting the base of said NPN transistor to the positive terminal of said source, an engine temperature responsive switch between the emitter of said NPN transistor and ground operable to close at temperatures above a desired level, an engine oil pressure responsive switch between the emitter of said NPN transistor and ground operable to close at pressures below a desired level, and means including a second contact on said manually operable switch connecting the positive terminal of said source to the collector of said PNP transistor.

21. In an ignition system for an engine having a D.C. current source with a grounded negative terminal, an ignition coil and breaker points, the improvement comprising a silicon controlled rectifier, means series connecting said coil and said points between the cathode of said silicon controlled rectifier and ground, means including a manually operable switch with a first contact connecting the anode of said silicon controlled rectifier to the positive terminal of said source, a first diode having its cathode connected to the silicon controlled rectifier cathode and its anode connected to ground, a first resistor having one terminal connected to the cathode of said silicon controlled rectifier, a capacitor having one plate connected to the other terminal of said first resistor and the other plate connected to ground, a second resistor having one terminal connected to the other terminal of said first resistor, a second diode having its cathode connected to the gate of said silicon controlled rectifier and its anode connected to the other terminal of said second resistor, an engine temperature responsive switch between the anode

of said second diode and ground operable to close at temperatures above a desired level, an engine oil pressure responsive switch between the anode of said second diode and ground operable to close at temperatures below a desired level, and means including said second contact on said manually operable switch for connecting the positive terminal of said source to the cathode of said silicon controlled rectifier.

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LAURENCE M. GOODRIDGE, *Primary Examiner.*