ABSTRACT: A solid-state electronic device which senses stator voltage during normal restart of an internal combustion engine following intentional shutdown of during attempted restart of an engine following shutdown thereof by a system detecting abnormal engine operating conditions, and which overrides the shutdown system to permit at least temporary engine operation during a predetermined interval in which abnormal operating conditions may persist. The override device includes a reactive charging and discharging timing stage which determines the override period by a controlled discharge commencing when starter operation ends, as well as amplification and switching stages which actuate an engine-controlling component to both initiate and end the override period in response to the operation of the reactive timing stage.
AUTOMATIC OVERRIDE FOR ENGINE SAFETY SHUTDOWN SYSTEMS

BACKGROUND

In the past, automated engine shutdown systems or motor vehicles and the like, and particularly for trucks, have been devised which automatically shut down the operation of the engine whenever an abnormal operating condition is detected, such as dangerously low engine oil pressure or dangerously high engine or engine coolant temperature. Such systems are steadily finding increased usage, since they can prevent serious damage to or even total loss of an expensive engine which would otherwise surely occur if the driver failed to note the presence of the abnormal condition from his instruments, or if the instruments were defective or gave inaccurate readings.

Such shutdown systems are not a complete answer to the problem in and of themselves, however, since they may cause shutdown at any time, with or without advance warning, and many such times it may be quite important or even essential to allow at least limited additional engine operation, as for example to provide for the safety of the vehicle or its driver. This is particularly so if, for example, the vehicle is equipped with power-operated steering or brakes and shutdown occurs at highway speeds, or while descending hills, while traveling a sharply curving roadway, or when movement to a safe parking place is required. Consequently, all successful shutdown systems of this general character must have some type of override system which will permit restarting of the engine and at least brief subsequent operation.

In the past, override systems for this purpose have been provided in the form of manually operated switches or the like which the driver must operate prior to or at the same time as restarting is attempted. Because any such system of this type has limitations which are clearly apparent from the standpoint of operator inconvenience and the other types of overrides have been proposed which will operate in a more automated manner, and which will permit restarting in more customarily manner, following which shutdown is once again allowed to occur after a predetermined interval of operation. Override systems such as these are eminently more desirable and, considered from a purely functional point of view, are satisfactory. However, actual override devices of this type which have heretofore been provided have generally been characterized by the presence of numerous purely mechanical components, timer motors, heavy moving-contact switches, and/or electrical circuits which produce a significant current drain on the engine ignition or generating circuits, as well as by the presence of heating elements and temperature-responsive switches operated in conjunction therewith. Therefore, such override systems have been expensive to manufacture and purchase, difficult to mount or operate due to their relative size, weight and position requirements, and have required considerable repair and maintenance. Also, in many instances, the reliability has not been of a desirably high level.

SUMMARY OF THE INVENTION

The present invention has as a major objective the provision of a new form of override system which is of a purely electronic nature, which is comprised substantially entirely of solid-state components, and which is therefore extremely reliable, not subject to maintenance or upkeep problems, of a small and compact physical nature, and which has novel operational characteristics.

Briefly stated, the override system of the invention comprises an input terminal which is connected to the starter energizing circuit of the vehicle and which couples voltage from the starter circuit to a reactive timing circuit to charge the latter. The timing circuit commences a timed discharge when starter operation is terminated, and a multistage voltage amplification and switching circuit coupled to the timing circuit receives the charging and discharging voltage present at the latter. The charging voltage immediately triggers the multistage circuit such that the shutdown system is immediately overridden, and the multistage circuit is again triggered after a predetermined interval at a particular discharge level of the timing circuit. At this point, the shutdown system is no longer overridden, and thus will cause secondary shutdown a predetermined interval after restart has occurred. The override device of the invention is therefore completely automatic in operation, and requires no specific actuation by the vehicle operator; furthermore, successive restarts can be initiated at will, and each will be allowed to continue for a similar time interval, following which automatic shutdown once again occurs.

IN THE DRAWINGS

FIG. 1 is a schematic circuit diagram of the override system; and

FIG. 2 is a pictorial schematic representation in circuit form showing the override system connected into a preferred shutdown system.

PREFERRED EMBODIMENT

The automatic override system 10 of the invention, illustrated in detail in the schematic of FIG. 1, is shown connected into an exemplary preferred shutdown system 20 in FIG. 2. Referring first to the latter figure for a general understanding of the complete shutdown system, it will be seen that the storage battery 22 of the vehicle has its positive terminal (for the particular polarity arrangement of both FIGS. 1 and 2) connected to a terminal B of a typical automotive ignition switch 24, from which electrical power from the battery is supplied to other vehicle circuits, including the ignition circuit (from a terminal I), an accessory circuit (from a terminal A) and the starter circuit (from a terminal S). As will be understood, the ignition switch 24 is typical of many such components presently in use, in which the starter circuit is automatically energized by movement to a particular position of the ignition key, as is the ignition circuit. There are, of course, other similar ignition switcher which are presently known and in use, with the electrical connections which are directly analogous to those illustrated. These include, for example, switches of the same basic type, but in which the starter circuit is manually energized through a push button "start" switch.

The shutdown system 20 of FIG. 2 illustrates the use of one particular exemplary engine-controlling component 26 and comprising a solenoid-operated fuel valve, another such example of component comprising, for example, a solenoid air valve. As will be understood, engine control components of the type illustrated at 26 permit engine operation or provide engine shutdown by controlling the fuel supply; in the case of the fuel valve 26, there is a direct shutoff of fuel upon actuation of the valve, whereas in the case of air valve of the type mentioned above, the fuel supply is controlled by a pneumatic power cylinder (not shown) whose actuating air is controlled by a valve. While engine control is thus shown to be accomplished through controlling the fuel supply, it should of course be understood that engine control can also be accomplished in a directly analogous manner by opening or closing the ignition circuit through an appropriate switch.

In the overall system 20, power from the battery is supplied through the ignition switch 24, from both the ignition circuit terminal I and the starter circuit terminal S, along conductors 30 and 32, respectively. Conductor 30 is connected to terminal 1 of the override system 10 of the invention, as well as to a common contact of a temperature-sensing component 34 which monitors the operating temperature of the vehicle engine (or the coolant used therein) and which may be mounted, for example, in the cylinder head to communicate with the water or coolant jackets therein. Conductor 32, from the starter circuit terminal, is coupled to terminal 2 of the override device. The negative terminal of the vehicle battery is supplied to a system ground conductor 36 having connections to the engine control component 26, to terminal 4 of the auto-
matic override 10, and to one side of a warning light 38 and alarm bell 40, or other such warning device.

In addition to the temperature sensor 34 noted previously, the system 20 also include a pressure sensor device 42, which is connected to the engine oil pressure to monitor the same; if desired, this element may be coupled to the oil pressure sense line from the engine leading to the conventional indicator element at the dashboard of the vehicle. Both the temperature sensor 34 and the pressure sensor 42 are conventionally known as feedback and each have their electrical connection terminals, including a common terminal (designated C), a normally closed switch terminal (designated NC), and a normally open terminal (NO). The sensors operate by switching their normally open contacts to a closed condition and their normally closed contacts to an open condition relative to their common contact when they detect engine oil pressure which is lower than what is considered a minimum pressure for normal operation or engine temperature which is higher than a maximum for normal operation. Thus, the word "normal" is used herein relative to such standards of continuous engine operation, which may differ from conditions during normal starting operation as well as from conditions during abnormal operation. The normally closed contact of the pressure sensor 42 is coupled by a lead 44 to the terminal 3 of the override device 10, and by a lead 45 to that side of the fuel valve 26 which is energized to actuate the latter. The normally closed contact terminal of the temperature sensor 34 is coupled by a lead 46 to the common contact terminal C of the pressure sensor 42, while the normally open contact terminals of both the temperature sensor 34 and the pressure sensor 42 are interconnected by a lead 48 which connects both to the ungrounded side of the warning light 38 and/or alarm bell 40, either or both of which may be used.

The override system 10 shown in FIG. 1 comprises basically an input terminal 2 (counpled to the vehicle starter circuit through the ignition switch terminal S), a reactive timing circuit 12, and a four stage solid state level-detecting, amplifying and switching network 14. More particularly, input terminal 2 leads to a series diode CR1 which allows positive potential from the starter circuit to charge a capacitor C1 in the reactive timing circuit 12. As illustrated, there is no series resistance between the capacitor and the starter circuit, and the capacitor thus charges to the full potential of the starter circuit in a very rapid time. The diode CR1 prevents subsequent discharge of capacitor C1 through terminal 2 and into the starter circuit, to assure discharge of the capacitor through a pair of resistors R11 and R12. The latter is connected to a ground conductor 16 leading to terminal 4 of the override device and, in the overall shutdown system 20, to the negative side of the battery 22. The junction of resistors R11 and R12 is connected to the base of the transistor Q4, such that resistor R11 serves to control the current flow thereto.

Transistor Q4 comprises a first voltage amplifier and, in effect, a level-detector as well, since it is biased into conduction by a positive charge on capacitor C1 and driven out of conduction at a particular point in the discharge of this capacitor through resistors R11 and R12. The emitter and collector of transistor Q4 are both connected between conductors 15 and 16, which interconnect with terminals 1 and 4, respectively, of the override device and which are thus at the positive and negative potentials of the terminals of the battery 22. That is, the emitter connects to the common junction of "voltage-dividing" resistors R11 and R12 which are connected between conductors 15 and 16, and the collector is similarly connected through resistors R7 and R8. Also, the collector of transistor Q4 is connected to the base of a transistor Q3, whose emitter is similarly connected between conductors 15 and 16 by a pair of voltage-divider resistors R5 and R6. Transistor Q3 is a second voltage amplifier, and its collector is coupled through a resistor R4 to that side of the positive potential source represented by conductor 15, through a resistor R3. Resistor R4 serves a current-liming function, whereas the function of resistor R3 is mentioned in more detail subsequently.

Transistor Q3, mentioned just above, has its emitter connected directly to power conductor 15, whereas its collector is connected to the junction of a pair of resistors R1 and R2, respectively connected to conductors 15 and ground conductor 16. Also, the collector of transistor Q2 drives the base terminal of a main switching transistor Q1, whose emitter is connected directly to power conductor 15, and whose collector is connected directly to terminal 3 of the override device. As stated, transistor Q1 provides a primary power-switching stage, whereas transistor Q2 provides a third stage of voltage amplification. As illustrated in FIG. 1, the polarity arrangement of the particular preferred embodiment under discussion, transistors Q4 and Q3 are NPN devices, whereas transistors Q2 and Q1 are both PNP devices. Consequently, the basic operation of the override system 10 is as follows.

Whenever the starter circuit of the vehicle is energized, as in an attempted restart after shutdown resulting from the presence of abnormally low engine oil pressure or abnormally high engine temperatures, the instantaneous charging of capacitor C1 and its subsequent controlled discharging drive transistor Q4 into conduction. This drives the base of transistor Q3 toward a decreased potential, causing transistor Q4 (which is normally in conduction) into cutoff. When transistor Q3 is driven out of conduction in this manner, the positive potential of transistor 15 applied to the base of transistor Q2 through resistor R3 holds this transistor (which also is normally in conduction) in a state of cutoff or nonconduction, inasmuch as transistor Q2 is a PNP device. With transistor Q2 at cutoff, the potential at the base of transistor Q1 provided by resistors R3 and R2 is sufficiently low to cause this main power transistor to be switched on, thereby providing a switched output of substantially the full potential present at terminal 1 to be present at terminal 3.

This occurs whenever the first stage transistor Q4 is driven into conduction by the charging of capacitor C1. Because of the voltage amplification circuit design for the other stages leading to transistor Q1, the switching operation of this transistor is rapid or sharp, and this transistor thus functions as an on-off switch for power at terminal 3 of the override device. That is, at the point when transistor Q4 goes out of conduction due to a predetermined extent of discharge of capacitor C1, transistors Q3 and Q2 are driven into conduction to apply a high positive voltage to the base of transistor Q1, driving it immediately to cutoff.

In view of the foregoing discussion of the operation of the override device 10, the operation of the overall shutdown system 20 will be readily appreciated. Basically, the engine-control component 26 will normally be maintained in an energized condition during normal operation of the vehicle, since when the engine is running normally there is a completed or closed circuit from the ignition contact I through conductor 30 to the common contact of the temperature sensor 34, through the normally closed contact of the latter to a conductor 46 leading to the common contact of the pressure sensor 42, and through the normally closed contact of the latter to conductors 44 and 45 leading to the particular engine-control component involved. The energizing circuit is opened by an abnormal engine operating condition detected by either the temperature sensor 34 or the pressure sensor 42, which would then reverse the condition of its normally open and normally closed contacts and apply power from the ignition circuit terminal and conductor 30 to conductor 48, actuating the warning light 38 or alarm bell 40, approximately the same time that power is removed from the engine-control component 26 and engine shutdown initiated. In this connection, it is to be noted that in accordance with the invention, a time-delay may readily be incorporated in this system by which engine shutdown occurs a predetermined time after the warning lamp or alarm bell is actuated, so that the operator has at least a brief warning that shutdown is about to occur.

In the presence of such an engine shutdown, the driver may immediately actuate his ignition switch or starter switch to crank the engine in the normal starting manner, whereupon the override system 10 will operate in the manner set forth.
above to produce an immediate switched output at terminal 3 of the override device, thereby energizing the engine-control component and permitting starting of the engine. The same is true during all normal starting since at such time there will be little or no engine oil pressure (none until the engine is at least cranked by the starter, and then very little until it actually starts) and the pressure sensor 42 will therefore not pass current from the ignition circuit to the engine control component to energize the latter. Furthermore, engine temperatures may rise drastically during a brief shutdown after hard running, and at such a time the temperature sensor 34 may also open the circuit to the engine-control component. Thus, even normal starting is accomplished through the operation of the present override device, which overcomes the shutdown condition maintained by the remainder of the system.

In either event, as soon as the engine starts, the operator will naturally release his starter switch, and at this point the RC timing circuit 12 will commence its discharge. It is at this point that the allowable interval of restart operation commences, since at a predetermined point in the discharge of capacitor C1 the steadily diminishing voltage applied to the base of transistor Q3 will reach the threshold value at which the transistor is biased, whereby transistor Q4 ceases to conduct. At this point in time, the main switching transistor Q1 is also immediately and sharply shut off, thereby removing the excitation voltage from conductor 45 and from the engine-control component 26 to cause engine shutdown if either of the sensors 34 or 42 continues to detect an abnormal engine operating condition. Of course, in the event that during this brief timing interval of allowable restart operation (which may be on the order of thirty seconds), an abnormal engine operating condition previously detected is no longer present, or in the event of a normal start following a normal or intentional shutdown, the sensors 34 and 42 will operate in a normal manner and will maintain the excitation of the engine control component, through conductors 30, 46, 44 and 45; consequently, under these circumstances the cutoff of transistor Q1 will have no effect, and the engine will maintain operation. The operator of the vehicle will be aware of a return of normal engine operating conditions, however, since the warning light or alarm bell 38, 40 will cease operation.

It is to be noted that with the present invention the allowable period of restart engine operation is independent of the length of time it may actually take to restart the engine, since the timing interval does not commence until starter operation ends, i.e., at the instant the engine starts and the starting circuit is deenergized. Any desired number of similar restart operations may be initiated at the discretion of the operator, simply by attempting to start the engine in the normal manner each time it is automatically shut down by the system. Also, there is no significant current drain on the vehicle power system caused by the present override, and thus normal engine ignition and normal starter excitation will both be present. Many other advantages are also provided, including the fact that the override circuit or system forms an extremely compact package which can be mounted in a vehicle in any position, which is an advantage not provided by prior systems of a predominantly mechanical nature. Also, the override requires no resetting actuation and requires no delay between successive restart operations.

It is entirely conceivable that upon examining the foregoing disclosure, those skilled in the art may devise particular embodiments of the concepts forming the basis of the invention which differ somewhat from the preferred embodiment shown and described herein, or may make various changes in structural details to the present embodiment. In this connection, it is to be noted that other parts of the vehicle may if desired by mounted by appropriate sensors connected into the overall shutdown system; for example, engine coolant pressure may be so monitored, as may transmission or engine lubricant temperature. Similarly, other specific types of sensors or other components may be utilized. Consequently, it is to be recog-

ized that the preferred embodiment shown and described is for purposes of general illustration only and is not to be regarded as limiting the scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows.

1. An electronic override device for engine safety shutdown systems, comprising: means for monitoring engine operation and providing an electrical input signal condition in response to the restarting of a shutdown vehicle engine; a timer means for receiving said input signal and providing an electrical control signal having a progressive time-dependent variation after receipt of said input signal; and an electrical driver and switching circuit means for initially providing a first electrical output switching function and for receiving said control signal and providing a second electrical output switching function following the occurrence of a predetermined level condition of said control signal; said driver and switching circuit means being connectable to an engine-control component to override control of the engine by such shutdown system by coupling said first and second output switching functions to said component to thereby control the same.

2. The override device of claim 1, wherein said means for monitoring provides a first electrical input signal condition during attempted engine restart and a second such signal condition upon termination of such attempt, and wherein said timer means provides said control signal variation only after receiving said second signal condition.

3. The override device of claim 1, wherein said timer means comprises a reactive charging and discharging circuit.

4. The override device of claim 1, wherein said driver and switching means comprises at least a level-detecting stage and a switching stage coupled thereto and controlled thereby.

5. The override device of claim 4, wherein said driver and switching means comprises at least one amplification stage.

6. The override device of claim 4, wherein said timer means comprises a reactive charging and discharging circuit.

7. The override device of claim 2, wherein said first input signal condition comprises the presence of an electrical voltage and said second such condition comprises the absence of such voltage, and wherein said timer means comprises a reactive circuit which is charged by said voltage and which discharges upon the absence thereof.

8. The override device of claim 7, wherein said driver and switching means comprises a multistage solid-state circuit having at least a level-detecting stage and a switching stage coupled thereto and controlled thereby.

9. A safety shutdown system for motor vehicle engines and the like, comprising in combination: a control component connected to a part of the engine to shut down operation of the engine upon receiving a predetermined shutdown signal condition and to permit engine operation upon receiving a different signal condition; at least one sensor means connected to the engine and coupled to said control component, for detecting a predetermined abnormal condition of engine operation and initiating such shutdown signal condition; an override means coupled to said control component for providing said different signal condition thereto for a predetermined time interval to permit engine operation during such interval despite such abnormal condition of operation; said override means including means for monitoring engine operation and providing an electrical input signal condition in response to the restarting of a shutdown engine, a timer means for receiving said input signal and providing an electrical control output signal having a progressive time-dependent variation after receipt of said input signal, and an electrical driver and switching circuit means for receiving said control signal and providing an electrical output switching function prior to the occurrence of a predetermined level condition of said control signal, said driver and switching circuit means being connectable to an engine-control component to effect override thereof by coupling said output switching function thereto, such switching condition comprising said different signal condition.