ABSTRACT: In an engine-starting system there is a starter circuit for starting the engine in the usual way, but in the starting circuit is provided means for breaking the transistor circuit when the engine speed is above a predetermined value. Conveniently this means is a transistor in series with a relay controlling the starter, and this transistor is turned off when the engine speed is above a predetermined value. However, delay means is provided for keeping the starter circuit broken for a predetermined period of time after the engine speed falls below the predetermined value.
ENGINE-STARTING SYSTEMS

This invention relates to engine-starting systems, particularly, although not exclusively, for diesel-engine vehicles. A system according to the invention comprises a starter circuit for starting an engine, means for breaking the starter circuit when the engine speed is above a predetermined value, and delay means operable when the engine speed falls below said predetermined value for keeping the starter circuit broken for a predetermined period of time.

The invention is designed to minimize the possibility of damaging the starter by trying to start the engine when it is running. Thus, the starter circuit is automatically cutout at a predetermined engine speed, so that a second attempt cannot be made to start an engine once it has already started. There is still a danger that an attempt can be made to start an engine when the speed of the engine is falling but the engine has not stopped, and the delay means is incorporated to prevent this possibility.

An example of the invention is illustrated in the accompanying circuit diagram.

Referring to the drawings, the vehicle with which the system is associated has a battery 5 with positive and negative terminals 11, 12 the battery being charged through a full-wave rectifier 7 by an alternator 6 driven by the engine. The output from the alternator is also fed through three further diodes 8 to a terminal 9 which is connected to a voltage regulator (not shown) controlling the alternator output by varying the current flow in its field winding. The terminals 9, 11 are interconnected through a warning lamp 30 in series with a switch 25 which will, on a diesel engine vehicle, be the auxiliary switch of the vehicle, but in a spark ignition system will be the ignition switch. The alternator also has one phase point connected to a terminal 10 at which an AC output is obtained at a frequency dependent on the speed of rotation of the alternator, which in turn is dependent on engine speed.

The terminal 11 is connected through the switch 25, a starter switch 13 and a winding 14 in series to the collector of an NPN transistor 15 the emitter of which is connected to the terminal 12. The winding 14 is bridged by a diode 16, and the junction of the winding 14 and switch 13 is connected through a normally open pair of contacts 17 and the starter solenoid 18 in series to the terminal 12. The contacts 17 are closed by the winding 14 when the winding 14 is energized.

The collector and base of the transistor 15 are bridged by a diode 19, and the base of the transistor is connected through a Zener diode 21 to the collector of an NPN transistor 22 having its emitter connected through a resistor 23 to the line 12. The collector of the transistor 22 is connected through a resistor 24 to the junction of the lamp 30 and switch 25, and the emitter of the transistor 22 is connected through a resistor 26 to the same junction.

The circuit further includes a resistor 27 and a diode 28 connected in series between the collector of the transistor 15 and the base of the transistor 22 to provide a feedback path. Moreover, the base of the transistor 22 is connected to the terminal 10 through a diode pump circuit which includes a capacitor 29 and a diode 31 in series between the terminal 10 and the base of the transistor 22, together with a diode 32 connecting the junction of the capacitor 29 and diode 31 to the terminal 12, and a capacitor 33 and a variable resistor 34 in parallel between the base of the transistor 22 and the terminal 12.

The terminal 10 is further connected to the terminal 12 through a diode 35 and a capacitor 36 in series, the junction of the diode 35 and capacitor 36 being connected through a variable resistor 37 and a diode 38 to the collector of the transistor 15.

When it is desired to start the engine, the switch 25 must first be closed, the lamp 30 is illuminated, the voltage regulator is energized through the lamp 30, and sufficient voltage is developed across the Zener diode 21 to render it conductive, so that current flows through the resistor 24 and Zener diode to turn on the transistor 15. At this stage there is no base current supplied to the transistor 22, which is therefore off. When the switch 13 is closed, current flows through the winding 14 and the transistor 15 so that the contacts 17 close and the sole- noid 18 is energized. The alternator immediately produces an output, and thereafter the lamp 30 is extinguished and the supply to the terminal 9 is by way of the diodes 8. As soon as the alternator produces an output, the circuit is maintained in an in known manner to produce across the resistor 34 a voltage which rises with engine speed. The emitter voltage of the transistor 22 is set by the resistors 26 and 23 and as the base voltage rises a condition is reached, at a predetermined engine speed, at which the transistor 22 starts to conduct so that current flowing through the resistor 24 is diverted through the transistor 22. As the transistor 15 starts to turn off, the current flowing through the diode 38 and the transistor 15 is diverted through the base emitter of the transistor 22 to assist turn on of the transistor 22, this feedback increasing the switching speed of the circuit. The Zener diode 21 enables the transistor 15 to be turned off even though the emitter of transistor 22 is at a higher voltage than that required to turn on the transistor 15. Thus, the circuit switches rapidly to a condition in which the transistor 22 is on and the transistor 15 is off, so that the winding 14 is deenergized and the contacts 17 open to break the starter circuit. The starter circuit remains broken as long as the engine speed is above the predetermined value. However, when the engine speed falls below the predetermined value, the voltage produced across the resistor 34 by the diode pump circuit will fall below the level at which the transistor 22 conducts, and so the circuit would be capable of reverting to its condition with the transistor 15 on. The return to this condition is, however, delayed by the delay network. This delay network includes the capacitor 36 which charges by way of the diode 35, and then discharges through the resistor 37 and diode 38, and thence through the resistor 27 and diode 28 to hold the transistor 22 on for a predetermined period of time which will be chosen so that the engine speed will fall to zero.

Having thus described my invention I claim as new and desire to secure by Letters Patent:

1. An engine-starting system for a road vehicle having a battery and an alternator driven by the engine for charging said battery, said system comprising in combination a starter circuit for starting the engine, a diode pump circuit operated by a said alternator for producing an output dependent on engine speed, a switching circuit operated by the output from said diode pump circuit for breaking the starter circuit when the engine speed is above a predetermined value, said switching circuit incorporating a first transistor which is turned on by the diode pump circuit at said predetermined engine speed, a second transistor in the starter circuit which is turned off when the first transistor conducts, a Zener diode through which the base of said second transistor is supplied with current, and a feedback circuit between the first and second transistors for increasing the base drive to the first transistor as the second transistor starts to turn off, said system further including delay means operable when the engine speed falls below said predetermined value for keeping the starter circuit broken for a predetermined period of time.

2. A system as claimed in claim 1 in which the delay means includes a capacitor which is charged by the alternator phase output and holds the first transistor on for said predetermined period of time after the output of the diode pump circuit has fallen to a value at which the first transistor could have turned off.

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