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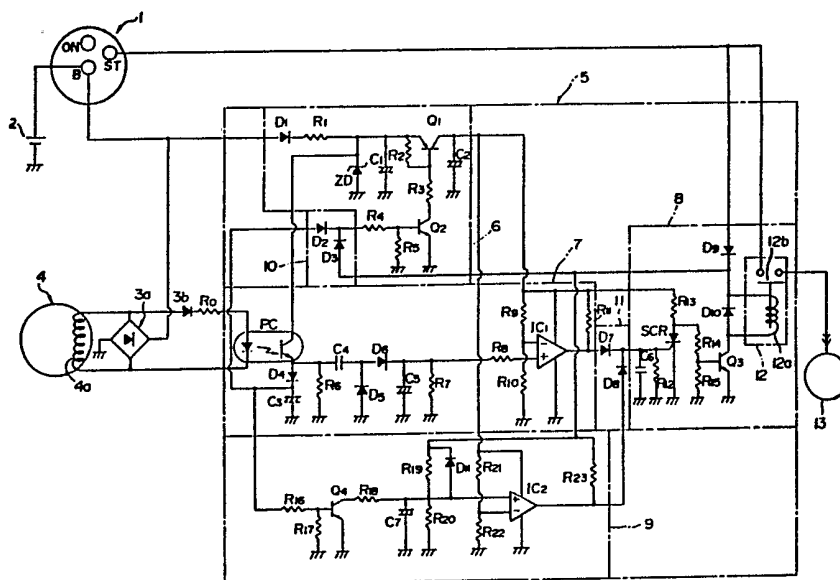
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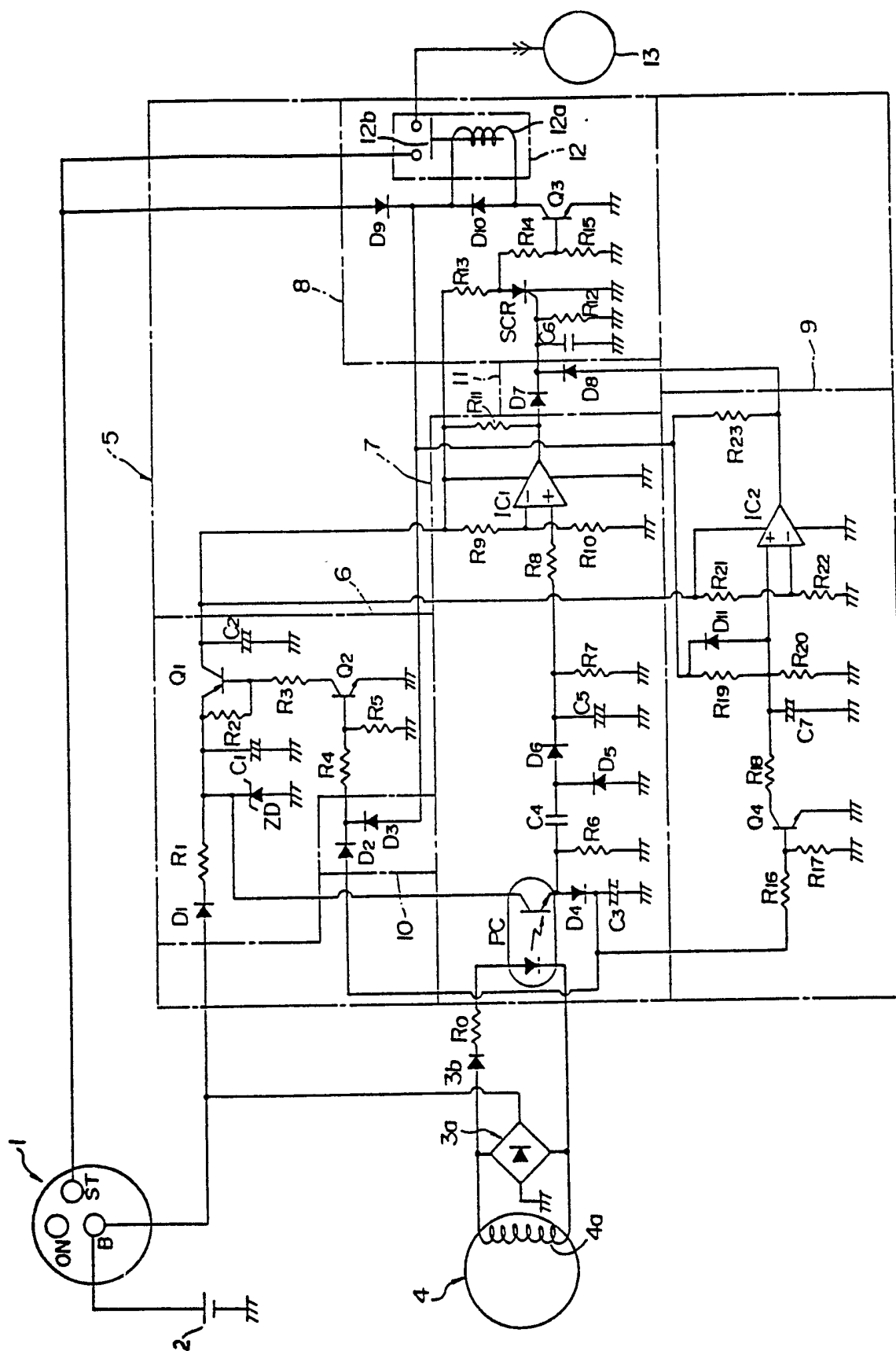
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(54) Engine starting device

(57) When an ignition switch 1 is closed to its engine starting contact ST, a signal passes via an OR gate 10 causing a circuit 6 to provide an ON signal to a driver circuit 8, whereby a starter motor 13 is energised. Rotation of the engine is detected from the output of a generator 4 which is caused to charge a capacitor C5 to a voltage dependent on the engine speed. When the engine speed exceeds a reference, an overrun prevention circuit 7 sends an OFF signal via OR gate 11 to circuit 8 to deenergise motor 13. OR gate 10 also has an input which goes high when circuit 7 senses engine rotation. Restarting of the motor 13 is therefore inhibited until both switch contact ST is opened and the engine has stopped. If engine rotation cannot be detected by circuit 7, a transistor Q4 in a backup timer 9 is held OFF so that a capacitor C7 in an RC timing circuit R19, C7 begins charging, whereby after a certain time a comparator IC2 sends an alternative OFF signal via OR gate 11 to circuit 8 to deenergise motor 13.





DESCRIPTIONENGINE STARTING DEVICE

The present invention relates to a starter for an automotive engine, and more particularly to an engine starting device which prevents the overrun of a selsyn motor.

In the prior art, a starter for an engine is connected to a safety relay circuit, which supplies a selsyn motor with electric power through a relay adapted to be excited by a key switch, thereby to prevent the burn-out of the armature coil of the selsyn motor, the overrun of the motor itself, etc. resulting from power supply for a long time.

A technique concerning the safety relay circuit is disclosed in, for example, the official gazette of Japanese Utility Model Registration Application Publication No. 6307/1986. In the prior-art example, the safety relay circuit is constructed of a transistor whose base and collector are respectively connected to both the ends of the coil of a relay and whose emitter is grounded, a capacitor which begins to be charged simultaneously with the energization of the relay, a Zener diode which is connected to the capacitor, and a transistor by which the base of the first-mentioned transistor is electrically shut off

simultaneously with the turn-on of the Zener diode, whereby the energizing time period of the relay, namely, the operating time period of the starter is controlled by a so-called CR timer circuit which is based on the charging time constant of the capacitor.

With the safety relay circuit in the prior-art example, however, the operating points of the circuit are influenced by the constants of circuit elements such as resistors, the capacitor and the Zener diode, a supply voltage, the capacity of the selsyn motor, etc., so that the operating time periods of such starters become discrepant. This leads to the problem that, in a case where the key switch is held at its start position for a long time without noticing the start of the engine, the prevention of the overrun of the selsyn motor is not always ensured.

Moreover, in a case where the key switch is turned "off" and is subsequently set at the start position again before the complete stop of the engine, the CR timer circuit undergoes the delay of the circuit operation thereof in correspondence with the time constant, and the selsyn motor is driven though for a short time. Thus, the damage of gears, etc. might be incurred.

The present invention has been made in view of the above circumstances, and has for its object to provide an engine starting device which can reliably prevent the overrun of a selsyn motor through the detection of the rotation of an engine and which can protect the selsyn motor from erroneous manipulations, thereby to enhance safety.

In order to accomplish the object, an engine starting device according to the present invention for an engine of a motor vehicle having a key switch and a selsyn motor, comprises a power source circuit section, an overrun prevention circuit section, and a driver circuit section; said power source circuit section being provided with an OR gate through which a signal from the key switch and a signal based on a rotation of the engine are received as inputs, and delivering an "on" signal to said driver circuit section as an output and also supplying a circuit voltage to said overrun prevention circuit section and said driver circuit section; said overrun prevention circuit section comparing a smoothed voltage obtained by smoothing a frequency output based on the rotation of the engine, with a set reference voltage based on the circuit voltage from said power source circuit section, and delivering an "off" signal

to said driver circuit section as an output when the smoothed voltage has become, at least, equal to the set reference voltage; said driver circuit section supplying electric power to the selsyn motor in response to the "on" signal from said power source circuit section, cutting off the power supply to the selsyn motor in response to the "off" signal from said overrun prevention circuit section, and holding the power cutoff state by virtue of the circuit voltage from said power source circuit section.

With the engine starting device thus constructed, when the key switch is set at its start position in order to start the engine, the "on" signal is output from the power source circuit section to the driver circuit section through the OR gate, and the selsyn motor is supplied with the electric power, so that the engine is cranked.

In addition, the signal based on the rotation of the engine is input to the power source circuit section through the OR gate, and the circuit voltage is supplied to the respective circuit sections.

Simultaneously, in the overrun prevention circuit section, the frequency output based on the rotation of the engine is smoothed, and the smoothed voltage is compared with the set reference voltage which is

based on the circuit voltage from the power source circuit section.

Besides, when the smoothed voltage has become, at least, equal to the set reference voltage, the "off" signal is output from the overrun prevention circuit section to the driver circuit section, the power supply to the selsyn motor is cut off, whereupon the power cutoff state is held by the circuit voltage from the power source circuit section.

By way of example only, a specific embodiment of the present invention will now be described, with reference to the accompanying drawing which is a circuit diagram of an embodiment of starting device in accordance with the present invention.

In the drawing, numeral 1 designates a key switch, the B terminal of which has a movable contact capable of selective connection with the ON terminal of ST (start) terminal thereof, and which is connected to a battery 2 and is also connected to the charge coil

4a of a magneto 4 through a rectifier 3a (a full-wave rectifier formed of a diode bridge).

In addition, the charge coil 4a has its output terminal connected to a rectifier 3b. (a half-wave rectifier formed of a diode), which is connected to an engine starting circuit 5 through a resistor R_0 .

The engine starting circuit 5 is constructed of a power source circuit section 6, an overrun prevention circuit section 7, a driver circuit section 8, a time-limit start circuit section 9, and OR gates 10, 11. This engine starting circuit is so arranged that the output of the charge coil 4a is isolatedly input thereto through a photocoupler PC, whereby noise is prevented from mixing from the charge coil 4a into the engine starting circuit 5.

The power source circuit section 6 is such that the anode of a diode D_1 is connected to the B terminal of the key switch 1, that the emitter of a PNP-type transistor Q_1 is connected to the cathode of the diode D_1 through a resistor R_1 , and that a Zener diode ZD and a capacitor C_1 are connected in parallel between the emitter of the transistor Q_1 and the ground of the circuitry.

Besides, one end of a capacitor C_2 is connected to the collector of the transistor Q_1 , while the other

end thereof is grounded. Further, the transistor Q_1 has a bias resistor R_2 connected between its emitter and base and has its base connected to the collector of a grounded-emitter NPN-type transistor Q_2 through a resistor R_3 .

In addition, the output side of the OR gate 10 is connected to the base of the transistor Q_2 through a resistor R_4 , and one end of a bias resistor R_5 is also connected thereto, while the other end thereof is grounded.

The OR gate 10 is constructed by interconnecting the cathodes of diodes D_2 , D_3 . It is a 2-input OR circuit whose output side is formed of the cathodes of the respective diodes and whose input sides are formed of the anodes thereof.

The overrun prevention circuit section 7 is such that the phototransistor of the photocoupler PC has its collector connected to the cathode of the Zener diode ZD of the power source circuit section 6 and has its emitter connected to the anode of a diode D_4 .

Besides, one end of a capacitor C_3 and the anode of the diode D_2 of the OR gate 10 are connected to the cathode of the diode D_4 , and the other end of the capacitor C_3 is grounded.

Further, one end of a resistor R_6 grounded at

the other end is connected to the emitter of the phototransistor, and the cathode of a diode D_5 and the anode of a diode D_6 are also connected thereto through a capacitor C_4 .

The diode D_5 has its anode grounded, and the diode D_6 has its cathode connected to the non-inverting input terminal of a comparator IC_1 through a resistor R_8 . Further, a capacitor C_5 and a resistor R_7 are connected in parallel between the cathode of the diode D_6 and the ground, and the resistor R_7 and the capacitor C_4 constitute a differentiation circuit.

The comparator IC_1 has its power source terminal connected to the collector of the transistor Q_1 of the power source circuit section 6, voltage dividing resistors R_9 , R_{10} connected in series with the collector of the transistor Q_1 are connected to the inverting input terminal of the comparator IC_1 in a manner to divide a voltage, and a resistor R_{11} connected to the output terminal of the comparator IC_1 is connected to the collector of the transistor Q_1 .

The driver circuit section 8 is such that the output terminal of the comparator IC_1 of the overrun prevention circuit section 7 is connected to the gate of a thyristor SCR through the OR gate 11, and that a resistor R_{12} and a capacitor C_6 are respectively

connected between the gate of the thyristor SCR and the ground in order to prevent commutation ascribable to the influence of noise or the rise rate of a critical "off" voltage.

The thyristor SCR has its cathode grounded, and has its anode connected to the collector of the transistor Q_1 of the power source circuit section 6 through a resistor R_{13} . Further, voltage dividing resistors R_{14} , R_{15} are connected between the anode of the thyristor SCR and the ground, and the base of a grounded-emitter NPN-type transistor Q_3 is connected to the node between the voltage dividing resistors R_{14} , R_{15} .

One end of the excitation coil 12a of a relay 12, a surge absorbing diode D_{10} being connected in parallel with this excitation coil, is connected to the collector of the transistor Q_3 , and the cathode of a diode D_9 is connected to the other end of the excitation coil 12a of the relay 12.

The relay 12 has the ST terminal of the key switch 1 connected to one terminal of its relay contact 12b, and has a selsyn motor 13 connected to the other terminal thereof.

In addition, the diode D_9 has its anode connected to the ST terminal of the key switch 1 and has its

cathode connected to the anode of the diode D_3 of the OR gate 10.

The time-limit start circuit section 9 is such that one end of a resistor R_{16} is connected to the cathode of the diode D_4 of the overrun prevention circuit section 7, that the base of a grounded-emitter NPN-type transistor Q_4 and one end of a bias resistor R_{17} are connected to the other end of the resistor R_{16} , and that the other end of the bias resistor R_{17} is grounded.

In addition, the collector of the transistor Q_4 is connected to the non-inverting input terminal of a comparator IC_2 through a resistor R_{18} , and a capacitor C_7 and a resistor R_{20} are respectively connected between the non-inverting input terminal of the comparator IC_2 and the ground. Further, one end of a resistor R_{19} and the anode of a diode D_{11} are connected to the non-inverting input terminal of the comparator IC_2 .

The other end of the resistor R_{19} and the cathode of the diode D_{11} are interconnected, and are connected to the cathode of the diode D_9 of the driver circuit section 8.

Further, voltage dividing resistors R_{21} , R_{22} connected to the collector of the transistor Q_1 in

the power source circuit section 6 are connected to the inverting input terminal of the comparator IC_2 in a manner to divide a voltage.

Besides, the output terminal of the comparator IC_2 is connected to the gate of the thyristor SCR of the driver circuit section 8 through the OR circuit 11 and is also connected to the cathode of the diode D_9 of the driver circuit section 8 through a resistor R_{23} .

Likewise to the OR gate 10, the OR gate 11 is constructed by interconnecting the cathodes of diodes D_7 , D_8 . The anode of the diode D_7 is connected to the output terminal of the comparator IC_1 of the overrun prevention circuit section 7, while the anode of the diode D_8 is connected to the output terminal of the comparator IC_2 of the time-limit start circuit section 9.

(Operation)

Next, the operation of the embodiment constructed as described above will be described.

Engine Starting:

First, when the movable contact of the B terminal of the key switch 1 is connected to the ST terminal, the engine starting circuit 5 is so actuated that current flows from the battery 2 to the bias resistor R_5 and the base of the transistor Q_2 through the diode

D_9 of the driver circuit section 8, the diode D_3 of the OR gate 10 and the resistor R_4 of the power source circuit section 6. Then, the transistor Q_2 is turned "on", followed by the turn-on of the transistor Q_1 .

On this occasion, the thyristor SCR of the driver circuit section 8 is "off". Therefore, current flows from the transistor Q_1 of the power source circuit section 6 to the bias resistor R_{15} and the base of the transistor Q_3 via the resistors R_{13} , R_{14} of the driver circuit section 8, and this transistor Q_3 is turned "on".

That is, on the basis of the current signal from the key switch 1, the "on" signal is output from the power source circuit section 6 to the driver circuit section 8. Then, the relay 12 is turned "on" to close the relay contact 12a. As a result, the starter motor 13 is driven, and the engine is cranked.

Subsequently, when the engine is cranked, an A.C. voltage is generated across the charge coil 4a of the magneto 4 and is subjected to half-wave rectification by the rectifier 3b. Then, current flows to the light-emitting diode of the photocoupler PC of the overrun prevention circuit section 7, and the phototransistor is turned "on" by the light output of the diode.

When the phototransistor of the photocoupler PC is turned "on", the capacitor C_3 is charged through the diode D_4 . Also, current flows to the base of the transistor Q_2 of the power source circuit section 6 via the diode D_2 of the OR gate 10, the transistor Q_2 is turned "on" to turn "on" the transistor Q_1 , the capacitor C_2 is charged by the transistor Q_1 , and a stabilized circuit voltage V_{CC} is supplied from the power source circuit section 6 to the respective circuit sections 7, 8, 9.

Simultaneously, current flows from the diode D_4 to the bias resistor R_{17} and the base of the transistor Q_4 through the resistor R_{16} of the time-limit start circuit section 9, the transistor Q_4 is turned "on" to have a low level as its collector potential, and the non-inverting input terminal of the comparator IC_2 is held at the low level.

Besides, a comparison voltage V_{REF2} , which is obtained by dividing the circuit voltage V_{CC} from the power source circuit section 6 by means of the voltage dividing resistors R_{21} , R_{22} , is applied to the inverting input terminal of the comparator IC_2 . Herein, the output of the comparator IC_2 is held at the low level.

Thus, in the time-limit start circuit section

9, the output of the comparator IC_2 is normally held at the low level while the output from the charge coil 4a is input to the overrun prevention circuit section 7 owing to the rotation of the engine.

Meanwhile, a half-wave A.C. voltage is delivered from the phototransistor of the photocoupler PC of the overrun prevention circuit section 7, and it is converted into a frequency output corresponding to the revolution number of the engine by the differentiation circuit configured of the capacitor C_4 and the resistor R_7 . The frequency output has its minus polarity side cut by the diode D_5 and is smoothed by the capacitor C_5 .

The smoothed voltage V_F from the capacitor C_5 is applied to the non-inverting input terminal of the comparator IC_1 , and is compared with a set reference voltage V_{REF1} applied to the inverting terminal thereof. The set reference voltage V_{REF1} is obtained by dividing the circuit voltage V_{CC} from the power source circuit section 6 by means of the voltage dividing resistors R_9 , R_{10} , and it is set as a voltage corresponding to the allowable safe revolution number N_{SET} of the selsyn motor 13.

Herein, when the cranking revolution number N of the engine is less than the allowable safe revolu-

tion number N_{SET} , $V_F < V_{REF1}$ holds on the input side of the comparator IC_1 . On this occasion, the output of the comparator IC_1 is at the low level.

Accordingly, the outputs of the overrun prevention circuit section 7 and the time-limit start circuit section 9 to be applied to the driver circuit section 8 through the OR gate 11 are both at the low level. Therefore, the gate voltage of the thyristor SCR of the driver circuit section 8 is at the low level, and this thyristor SCR is held in its "off" state.

On the other hand, when the cranking revolution number N of the engine has become, at least, equal to the allowable safe revolution number N_{SET} , $V_F \geq V_{REF1}$ holds, and the output of the comparator IC_1 is inverted from the low level to a high level.

Then, the gate voltage of the thyristor SCR of the driver circuit section 8 becomes the high level to turn "on" this thyristor SCR, and the base voltage of the transistor Q_3 becomes the low level.

Consequently, the transistor Q_3 is turned "off", and the relay 12 is turned "off" to open the relay contact 12b, so that the power supply to the selsyn motor 13 is cut off.

In this way, even in a case where the key switch 1 has been kept connected to the ST position for a

long time without noticing the start of the engine, the supply of the electric power to the selsyn motor 13 is forcibly cut off when the revolution number of the engine has become, at least, equal to the allowable safe revolution number of the selsyn motor 13, whereby the overrun of the selsyn motor 13 can be avoided to prevent gears etc., not shown, from damage.

Normal Running Mode:

Next, when the B terminal of the key switch 1 is connected from the ST terminal back to the ON terminal after the start of the engine, the thyristor SCR of the driver circuit section 8 triggered and turned "on" by the high level output of the overrun prevention circuit section 7 holds its "on" state while the circuit supply voltage V_{CC} is fed from the power source circuit section 6 in accordance with the output from the charge coil 4a of the magneto 4.

Accordingly, even in case of such an erroneous manipulation that the key switch 1 in the ON-terminal connection is turned "off" in order to stop the engine and that the B terminal of the key switch 1 is connected to the ST terminal again before the complete stop of the engine, the transistor Q_3 and relay 12 of the driver circuit section 8 are held in their

"off" states till the stop of the engine, whereby the selsyn motor 13 is not fed with the electric power, and the safety is kept.

Time-limit Starting:

Here, even in case of the breaking of any connection lead to the engine starting circuit 5, for example, a connection lead from the B terminal of the key switch 1 to the engine starting circuit 5 or a connection lead from the ST terminal to the engine starting circuit 5, the selsyn motor 13 is not fed with the electric power, and the safety is secured. However, in a case where a connection lead laid from the charge coil 4a of the magneto 4, or the like has broken and where the rotation of the engine cannot be detected, the selsyn motor can be driven for only a predetermined time period by the time-limit start circuit section 9 in preparation for emergency.

Now, the time-limit operation of the time-limit start circuit section 9 will be described.

When the B terminal of the key switch 1 is connected to the ST terminal thereof, the transistor Q_3 of the driver circuit section 8 is turned "on", the relay 12 is turned "on", and the selsyn motor 13 is supplied with the electric power and is driven,

as stated before.

On this occasion, in the case of the breaking of the connection lead from the charge coil 4a, or the like, even when the engine is cranked, the phototransistor of the photocoupler PC is not turned "on" in the overrun prevention circuit section 7, and the output of the comparator IC_1 remains unchanged at the low level. Moreover, since the capacitor C_3 is not charged, the terminal voltage thereof remains unchanged at the low level.

Accordingly, the transistor Q_4 of the time-limit start circuit section 9 is held "off", and the capacitor C_7 is charged in accordance with a time constant of $R_{19} \cdot C_7$ by a path which extends from the diode D_9 of the driver circuit section 8 to this capacitor through the resistor R_{19} of the time-limit start circuit section 9.

The terminal voltage of the capacitor C_7 is applied to the non-inverting input terminal of the comparator IC_2 . Thus, when a set time T_{SET} which is determined by the above time constant has lapsed, the terminal voltage V_{C7} of the capacitor C_7 becomes, at least, equal to the comparison voltage V_{REF2} applied to the inverting input terminal of the comparator IC_2 , that is, the voltage obtained by dividing the

circuit voltage V_{CC} from the power source circuit section 6 by means of the voltage dividing resistors R_{21} , R_{22} , and the output of the comparator IC_2 is inverted from the low level to the high level.

Then, the gate voltage of the thyristor SCR of the driver circuit section 8 is brought to the high level through the OR gate 11, and this thyristor SCR is triggered and turned "on".

In this way, when any signal input from the charge coil 4a as based on the engine rotation is not received in correspondence with the signal input from the key switch 1, the "off" signal is delivered from the time-limit start circuit section 9 to the driver circuit section 8 after the lapse of the set time T_{SET} based on the time constant of the resistor R_{19} and capacitor C_7 of the time-limit start circuit section 9. Thus, the transistor Q_3 of the driver circuit section 8 is turned "off", the relay 12 is turned "off", and the power supply to the selsyn motor 13 is cut off.

Accordingly, even in the case where the connection lead laid from the charge coil 4a has broken and where the output of the charge coil 4a is not applied to the engine starting circuit 5, not only the start of the engine is possible, but also the safety is secured owing to the operation that the power supply

to the selsyn motor 13 is automatically cut off after the lapse of the predetermined time period since the beginning of the power supply.

As described above, according to the present invention, when in starting an engine, a key switch is set at its start position to supply a selsyn motor with electric power and to crank the engine, an overrun prevention circuit section operates to smooth a frequency output based on the rotation of the engine and to compare the smoothed voltage with a set reference based on a circuit voltage supplied from a power source circuit section.

Subsequently, when the smoothed voltage has become, at least, equal to the set reference voltage, an "off" signal is delivered from the overrun prevention circuit section to a driver circuit section, and the power supply to the selsyn motor is cut off. This brings forth the effect that the overrrun of the selesyn motor can be reliably prevented through the detection of the rotation of the engine.

Besides, even in case of such an erroneous manipulation of setting the key switch at the start position again before the engine stops completely, the power cutoff state of the selsyn motor is held by the circuit voltage supplied from the power source

circuit section. This results in the excellent effect that the selsyn motor is not supplied with the power, thereby further enhancing the safety.

CLAIMS

1. An engine starting device for an engine of a motor vehicle having a key switch and a selsyn motor, comprising a power source circuit section, an overrun prevention circuit section, and a driver circuit section; said power source circuit section being provided with an OR gate through which a signal from the key switch and a signal based on a rotation of the engine are received as inputs, and delivering an "on" signal to said driver circuit section as an output and also supplying a circuit voltage to said overrun prevention circuit section and said driver circuit section; said overrun prevention circuit section comparing a smoothed voltage obtained by smoothing a frequency output based on the rotation of the engine, with a set reference voltage based on the circuit voltage from said power source circuit section, and delivering an "off" signal to said driver circuit section as an output when the smoothed voltage has become, at least, equal to the set reference voltage; said driver circuit section supplying electric power to the selsyn motor in response to the "on" signal from said power source circuit section, cutting off the power supply to the selsyn motor in response to the "off" signal from said overrun prevention circuit

section, and holding the power cutoff state by virtue of the circuit voltage from said power source circuit section.

2. An engine starting device as claimed in claim 1, further comprising a time-limit start circuit section which includes CR time constant means, which is also supplied with the circuit voltage from said power source circuit section, and which delivers an "off" signal to said driver circuit section as an output when a preset time of said CR time constant means has lapsed, so that said driver circuit section cuts off the power supply to the selsyn motor in response to the "off" signal from said time-limit start circuit section.

3. An engine starting device, substantially as herein described, with reference to, and as illustrated in, the accompanying drawing.
