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Hobo et al.

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[54] **ELECTRIC CONTROL CIRCUIT SYSTEM FOR INTERNAL COMBUSTION ENGINES**

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[52] **U.S. Cl.** ..... **123/102**; 123/148 E; 123/103 R

[51] **Int. Cl.**[2] **F02N 17/00**

[58] **Field of Search** 123/102

[56] **References Cited**

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Assistant Examiner—James W. Cranson, Jr.
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[57] **ABSTRACT**

There is provided an electric control circuit system for internal combustion engines comprising an electric motor for controlling the number of revolutions of an internal combustion engine, a control resistor in the energizing circuit for the electric motor, a control resistor on-off cutout circuit, an AC generator for generating a speed voltage proportional to the number of revolutions of the engine, a relay control circuit for generating pulses having an on-off ratio corrsponding to the speed voltage, and an electric motor control relay, whereby when the diesel engine rotates at an excessive speed, the fuel injection quantity of a fuel injection system in the engine is reduced by the resistor on-off cutout circuit and the relay control circuit.

4 Claims, 4 Drawing Figures

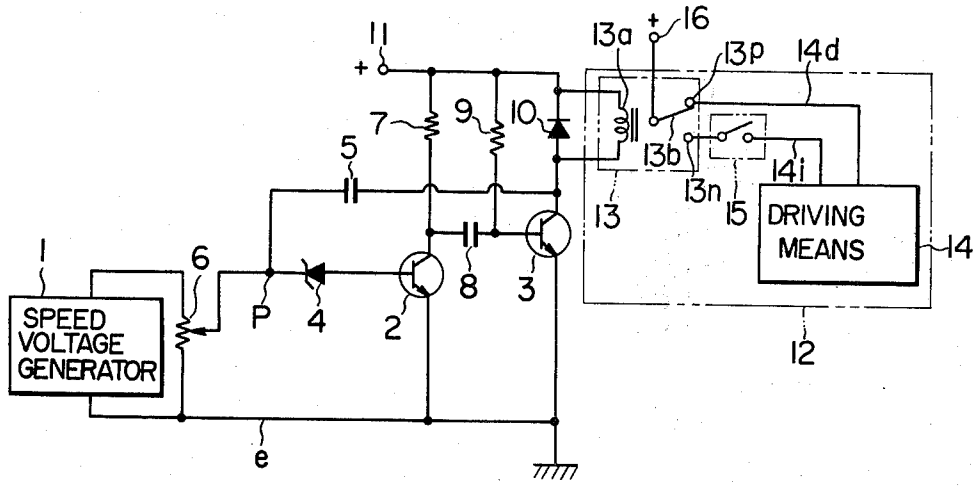


FIG. 1

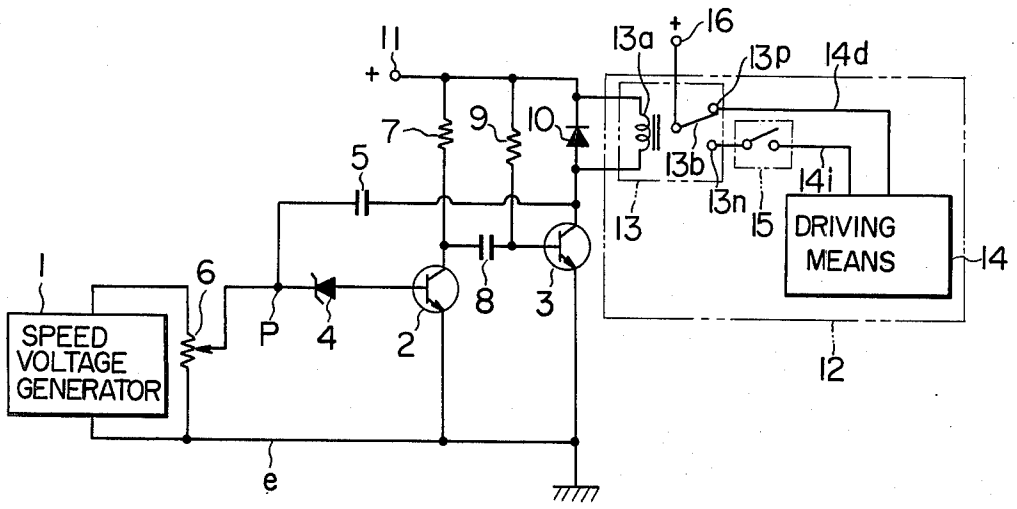


FIG. 2

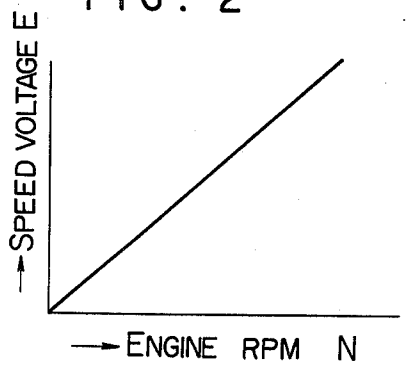


FIG. 4

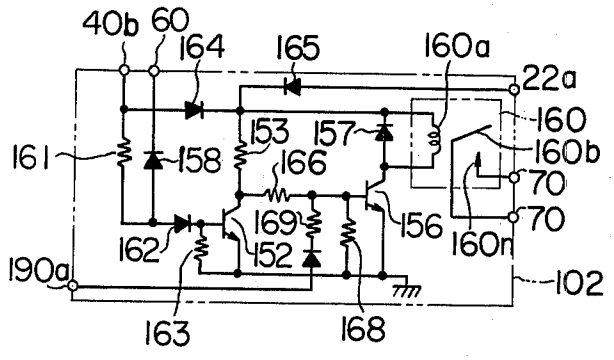
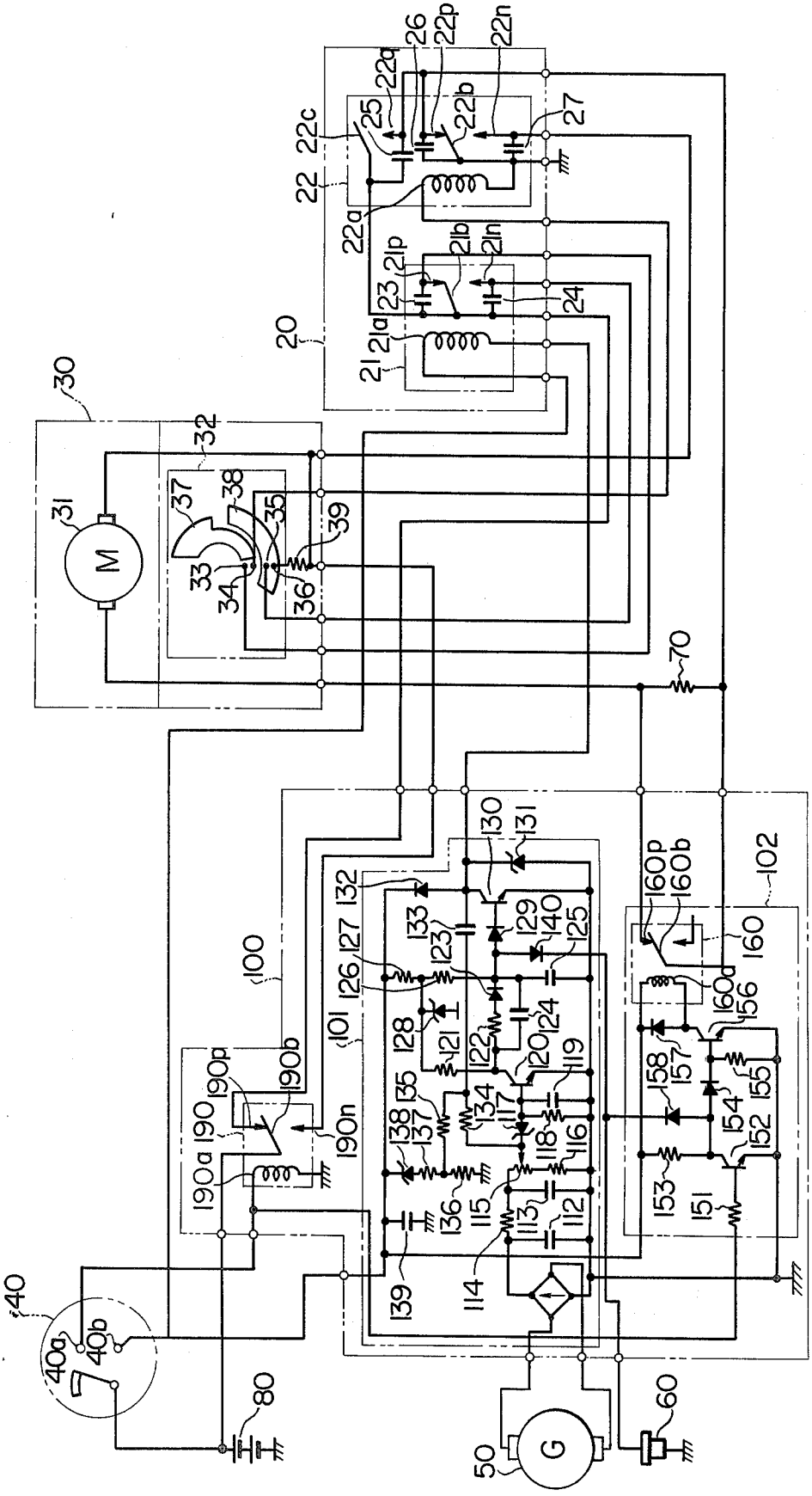


FIG. 3


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22a
22b
22c
22n
22p
22q
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34
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36
37
38
39
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40a
40b
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151
152
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157
158
160
160a
160b
160d
160p
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190a
190b
190n
190p

ELECTRIC CONTROL CIRCUIT SYSTEM FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an electric control circuit for an internal combustion engine, particularly a diesel engine, wherein when the speed of the diesel engine exceeds the normal maximum revolutions, a control element, such as, the control rack of a fuel injection pump controlled by a pneumatic governor or the throttle valve for regulating the pressure in the inlet manifold, is forcibly actuated to reduce the quantity of fuel delivered by a fuel injection pump with a pneumatic governor and thereby to prevent the overspeeding of the diesel engine.

2. Description of the Prior Art

Known diesel engines of this type equipped with a fuel injection pump having a pneumatic governor have a disadvantage in that when the control characteristic of the pneumatic governor varies with a change in the atmospheric pressure, for example, there is the danger of the diesel engine being caused to overspeed and eventually damaged.

SUMMARY OF THE INVENTION

With a view to overcoming the foregoing difficulty, it is the object of the present invention to provide electric control circuit system for internal combustion engines wherein the number of revolutions of an engine is electrically detected, whereby when the engine revolutions exceed the normal maximum revolutions, a control element is actuated by an electric motor or the like to reduce the quantity of fuel delivered by a fuel injection pump and thereby to prevent the engine from overspeeding.

A great advantage of the present invention is hunting phenomenon of an internal combustion engine due to the use of an on-off control circuit and the breaking down of the engine due to its overspeeding can be prevented, thereby improving the efficiency of control of an engine by an engine controlling electric motor and ensuring a longer life for a control relay.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an electric circuit diagram showing the basic circuit construction of an electric control circuit system for internal combustion engines according to the present invention.

FIG. 2 is an engine rpm versus speed voltage characteristic diagram of the speed voltage generator used in the basic circuit of this invention shown in FIG. 1.

FIG. 3 is an electric circuit diagram showing an embodiment of the system according to the present invention.

FIG. 4 is an electric circuit diagram showing a second embodiment of the system according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described in greater detail with reference to the illustrated embodiments. The basic circuit construction of the system of this invention will be described first with reference to FIG. 1 in which numeral 1 designates a speed voltage generator for generating a speed voltage E corresponding to the

number of revolutions N of a diesel engine as illustrated in FIG. 2, numeral 2 an error detecting transistor, numeral 3 a relay actuating transistor. Numeral 4 designates a comparator Zener diode, numeral 5 a feedback capacitor, numeral 6 a revolution setting potentiometer, numerals 7 and 9 resistors, numeral 8 a capacitor, numeral 10 a surge voltage absorbing diode. Numeral 12 designates a control unit, numeral 13 a reversing transfer relay, numeral 13*a* a relay coil, number 13*b* a movable contact which is shifted from one fixed contact to the other by the electromagnetic attraction of the relay coil numerals 13*a*, 13*p* and 13*n* fixed contacts. Numeral 14 designates a driving means whose one terminal 14*d* is connected to the fixed contact 13*p* so that when the movable contact 13*b* comes into contact with the fixed contact 13*p*, the driving means 14 forcibly moves a control rack controlled by a pneumatic governor to reduce the quantity of fuel delivered by a fuel injection pump which is not shown. The other terminal 14*i* is connected to the fixed contact 13*n* of the relay 13 through a cam switch 15 which is open when the number of revolutions of the diesel engine is at the normal speed and therefore the driving means 14 increases the quantity of fuel delivered by the fuel injection pump when the movable contact 13*b* comes into contact with the fixed contact 13*n*. Terminals 11 and 16 are connected to the positive side of a DC power source.

With the construction described above, the operation of the basic circuit of this invention will now be described. The speed voltage generator 1 generates the DC speed voltage E corresponding to the revolutions N of the diesel engine as shown in FIG. 2. With the voltage driving ratio of the revolution setting potentiometer 6 preliminarily adjusted so that the voltage applied to the comparator zener diode 4 when the revolutions of the diesel engine are greater than the maximum revolutions at the normal engine speed is higher than the breakdown voltage of the zener diode 4, if the revolutions of the diesel engine are lower than the maximum revolutions at the normal engine speed, the error detecting transistor 2 is rendered nonconductive and the relay actuating transistor 3 is rendered conductive. As a result, the collector current of the relay actuating transistor 3 flows into the relay coil 13*a* of the reversing transfer relay 13, causing the movable contact 13*b* to engage the fixed contact 13*n*. In this case, if the cam switch 15 is in the closed position, current flows to the driving means 14 through the terminal 14*i* so that the control element or the control rack of the fuel injection pump is operated in a direction that increases the quantity of fuel delivered by the fuel injection pump until the control element reaches its normal operating position. When the control element is eventually moved to the normal operating position thereof, the cam switch 15 is opened with the result that the operation of the driving means 14 is stopped to cause the pneumatic governor to control the quantity of fuel delivered by the fuel injection pump. This pneumatic governor is of conventional type and therefore its construction and operation will not be described in detail.

When the number of revolutions of the diesel engine exceeds the maximum revolutions at the normal speed, the speed voltage generated by the speed voltage generator 1 becomes higher than the breakdown voltage of the comparator zener diode 4 so that the base current flows in the error detecting transistor 2 to cause con-

duction between the collector and the emitter thereof. At this instant, the charge that has been stored in the capacitor **8** through the terminal **11**, the resistor **7**, the capacitor **8**, the base and the emitter of the relay actuating transistor **3** and the ground, applies a reverse bias to the relay actuating transistor **3** to render the relay actuating transistor **3** nonconductive. This cuts off the supply of the exciting current to the relay coil **13***a* of the reversing transfer relay **13** and thus the movable contact **13***b* comes into contact with the fixed contact **13***p*. Consequently, current flows to the driving means **14** through the terminal **14**d to operate the control element in the direction which decreases the quantity of fuel delivered by the fuel injection pump. During this time interval, the capacitor **8** is charged in the reverse direction by the current flowing through the terminal **11**, the resistor **9**, the capacitor **8**, the collector and the emitter of the error detecting transistor **2** and the ground. As a result, the reverse bias voltage applied to the base of the relay actuating transistor **3** is gradually reduced so that the base of the relay actuating transistor **3** is eventually biased in the forward direction. At this instant, conduction is caused between the collector and the emitter of the relay actuating transistor **3** and thus current flows into the relay coil **13***a* of the reversing transfer relay **13** causing the movable contact **13***b* to come into contact with the fixed contact **13***n*. Consequently, the potential at the collector of the relay actuating transistor **3** decreases and thus the voltage between points P and *e* is decreased by the charge previously stored in the feedback capacitor **5** through the terminal **11**, the relay coil **13***a*, the capacitor **5**, the revolution setting potentiometer **6** and the ground. This stops the base current of the error detecting transistor **2** supplied through the comparator Zener diode **4** and therefore the error detecting transistor **2** is rendered nonconductive. When this happens, the feedback capacitor **5** is charged in the reverse direction by the current caused by the speed voltage generated by the speed voltage generator **1** and flowing through the collector and the emitter of the relay actuating transistor **3**. Consequently, the voltage between the points P and *e* begins to gradually rise and it again becomes higher than the breakdown voltage of the comparator Zener diode **4**, whereupon the error detecting transistor **2** is again rendered conductive and thus the relay actuating transistor **3** is rendered nonconductive. Thereafter, this process of the conduction and nonconduction of the error detecting transistor **2** and the relay actuating transistor **3** is repeated in this manner to thereby cause and sustain oscillations in this system. In this case, the ratio of the conduction time to the nonconduction time of the relay actuating transistor **3** varies in accordance with the time interval during which the feedback capacitor **5** is charged by the speed voltage generator **1** and this capacitor voltage becomes higher than the breakdown voltage of the comparator zener diode **4**, that is, the difference between the revolutions of the diesel engine and its maximum normal revolutions. Accordingly, the conduction time of the relay actuating transistor **3** is decreased in proportion to the extent by which the revolutions of the diesel engine are greater than its maximum normal revolutions, so that the movable contact **13***b* of the reversing transfer relay **13** remains in contact with the fixed contact **13***p* longer than the time interval which it remains in contact with the fixed contact **13***n* and therefore the effective value of the current that flows through the terminal **14***d* becomes greater than the effective value of the current that flows through the terminal **14***i*. In this manner, the control element or the control rack of the fuel injection pump is forcibly operated by the driving means **14** to reduce the quantity of fuel delivered, thereby controlling the number of revolutions of the diesel engine to always operate the engine at a speed lower than the maximum normal revolutions and thus to prevent the overspeeding of the engine.

Next, the basic electric circuit of this invention shown in FIG. **1** will be described in greater detail with reference to an exemplary electric circuit of FIG. **3** showing a first embodiment of this invention. In FIG. **3**, numeral **40** designates a key switch including an starting terminal **40***a* which is closed when the engine is started and an operating terminal **40***b* which is closed when the engine is in operation. Numeral **50** designates a speed detector consisting of a generator which generates an AC voltage corresponding to the engine speed, numeral **60** a reversal detector which is energized when the direction of rotation of the running engine is reversed. Numeral **70** designates a control resistor, numeral **80** a battery, numeral **30** a driving control unit comprising an internal combustion engine controlling electric motor **31** and a switch mechanism **32** comprising four contacts **33, 34, 35** and **36** and two cam switches **37** and **38** actuated by the controlling electric motor **31** to selectively close the contacts **33, 34, 35** and **36.** Numeral **20** designates a control relay unit comprising two relays **21** and **22.** The relay **21** comprises a relay coil **21***a*, a movable contact **21***b* which is shifted from one fixed contact to the other by the electromagnetic attraction of the coil **21***a*, fixed contacts **21***p* and **21***n* and arc extinguishing capacitors **23** and **24**, while the relay **22** comprises a relay coil **22***a*, movable contacts **22***b* and **22***c* which are actuated in associated relation by the electromagnetic attraction of the relay coil **22***a*, fixed contacts **22***p*, 22*n* and **22***q*, and arc extinguishing capacitors **25, 26** and **27.** Numeral **100** designates a comparator control circuit comprising a starting relay **190**, a relay control circuit **101** and a resistor cutout circuit **102.** The relay **190** comprises a relay coil **190***a*, a movable contact which is shifted from one fixed contact to the other by the electromagnetic attraction of the relay coil **190***a*, and fixed contacts **190***p* and **190***n*. The relay control circuit **101** comprises a full-wave rectifier **111** for converting the AC voltage generated by the speed detector **50** into a DC voltage, smoothing capacitors **112** and **113**, a smoothing resistor **114**, an engine controlling revolution setting potentiometer **115**, a resistor **116**, a zener diode **117**, transistors **120** and **130**, resistors **118, 121,** 122, 126 and **127**, capacitors **119, 124, 125** and **139**, diodes **123, 129** and **140**, an arc extinguishing zener diode **131**, an arc extinguishing diode **132**, a feedback capacitor **133**, voltage compensating Zener diodes **128** and **138**, and resistors **135, 136** and **137.** The resistor cutout circuit **102** comprises resistors **151, 153** and **155**, transistors **152** and **156**, diodes **154** and **158**, an arc extinguishing diode **157**, and a resistor cutout relay **160** including a relay coil **160***a*, a movable contact **160***b* actuated by the electromagnetic attraction of the relay coil **160***a* and a fixed contact **160***p*.

With the construction described above, the operation of this embodiment is as follows. Firstly, to start the engine, the key switch **40** is thrown to the starting termi-

nal **40***a* with the result that current flows into the relay coil **190***a* of the starting relay **190** and thus the movable contact **190***b* comes into contact with the fixed contact **190***n* to energize the electric motor **31.** Consequently, the cam switch **37** closes the contacts **33** and **34** and the cam switch **38** closes the contacts **35** and **36.** In this case, the transistor **152** in the resistor cutout circuit **102** is turned on by the base current supplied by the starting signal of the key switch **40** and thus the transistor **156** is turned off. Consequently, the movable contact **160***b* of the resistor cutout relay **160** is in contact with the fixed contact **160***p* and thus the resistor cutout relay **160** short-circuits the control **70.** Thereafter, when the key switch **40** is thrown to the operating terminal **40***b*, no base current is supplied to the transistor **152** of the resistor cutout circuit **102** with the result that the transistor **152** is turned off and the transistor **156** is turned on. Consequently, current flows into the relay coil **160***a* of the resistor cutout relay **160** to cause the movable contact **160***b* to separate from the fixed contact **160***p* and thereby to insert the control resistor **70** in the energizing circuit for the electric motor **31.** In this operating condition, only the contacts **33** and **34** are closed by the cam switch **37.** When, in this operating condition, the engine overspeeds, the cam switch **37** closes the contacts **33, 34** and **35** and the base current flows into the transistor **120.** Consequently, the relay control circuit **101** is caused to oscillate by the transistors **120** and **130,** the capacitors **124** and **133** and the resistor **126** which constitute the essential elements of an astable multivibrator. Thus, the current flow to the electric motor **31** of the driving control unit **30** is controlled in accordance with the on-off ratio of the movable contacts **22**b and **22***c* of the relay **22** in the electric motor control relay unit **20** and it is also limited by the control resistor **70.** In this way, the rotational speed of the electric motor **31** is controlled. Then, when the key switch **40** is opened to stop the engine, the resistor cutout circuit **102** is also disconnected from the power source so that the movable contact **160***b* of the resistor cutout relay **160** comes into contact with the fixed contact **160***p* to short-circuit the control resistor **70.** On the other hand, with the key switch **40** in the operating condition, if the direction of rotation of the diesel engine is reversed, the reversal detector **60** connects the base of the transistor **156** in the resistor cutout circuit **102** to the ground through the diode **158** to turn off the transistor **156** and thereby to shoft-circuit the control resistor **70.** Accordingly, when the engine is operating, the control resistor **70** is inserted in the energizing circuit of the electric motor **31** to reduce the current flow thereto, whereas when the engine is started, stopped or reversed, the control resistor **70** is short-circuited to permit the flow of sufficient current to the electric motor **31.** In this way, the control efficiency of the engine by the electric motor **31** is improved and any damage to the engine which may be caused by the overspeeding of the engine in operation is prevented by the operation of the resistor cutout relay **160.**

The second embodiment of the present invention shown in FIG. **4** will now be described. In FIG. **4,** the same reference numerals as used in FIG. **3** designate the identical or equivalent parts. In other words, the second embodiment is identical with the first embodiment excepting that the resistor cutoff circuit **102** has a different circuit construction. The resistor cutout circuit **102** comprises resistors **153, 161, 163, 166, 168** and **169,** diodes **157, 158, 162, 164, 165** and **167,** transistors **152** and **156,** resistor cutout relay **160.** During the starting period of the engine, the base current of the transistor **156** is forcibly supplied through the diode **167** and the resistor **169** to turn the transistor **156** on. Consequently, current flows into the relay coil **160***a* of the resistor cutout relay **160** and thus the movable contact **160***b* comes into contact with the fixed contact **160***n* to short-circuit the control resistor **70.** On the other hand, when the engine is operating, the base current flows into the transistor **152** through the resistor **161** so that the transistor **152** is turned on and the transistor **156** is turned off. This stops the current flow into the relay coil **160***a* of the resistor cutout relay **160** and the movable contact **160***b* separates from the fixed contact **160***n* to insert the control resistor **4** in the energizing circuit for the electric motor **31.** Further, when the direction of rotation of the running diesel engine is reversed, the base of the transistor **152** is grounded through the diode **158** so that the transistor **152** is turned off and the transistor **156** is turned on to permit the current flow into the relay coil **160***a* of the resistor cutout relay **160.** Consequently, the movable contact **160***b* comes into contact with the fixed contact **160***n* to short-circuit the control resistor **70.** Furthermore, with the engine operating, if the key switch **40** is opened to stop the engine, the connection between the contacts **33** and **34** of the switch mechanism **32** in the driving control unit **30** is maintained by the cam switch **37** for a while and the power is supplied to the resistor cutout circuit **102** through the diode **165.** In this case, no base current flows into the transistor **152** so that the transistor **152** is turned off and the transistor **156** is turned on. Consequently, the movable contact **160***b* comes into contact with the fixed contact **160***n* and the control resistor **70** is short-circuited. When the driving control unit **30** rotates the switch mechanism **32** to the normal stop position, the contacts **33** and **34** are opened to stop the supply of power to the resistor cutout control **102.**

It will thus be seen that in the first embodiment of this invention shown in FIG. **1,** the speed voltage corresponding to the number of revolutions of an engine is applied to the comparator zener diode **4** connected to the base of the error detecting transistor **2,** the collector signal of the error detecting transistor **2** is supplied to the base of the relay actuating transistor **3** through the charging and discharging circuits comprising the capacitor **8** and the resistors **7** and **8,** and a portion of the collector signal of the relay actuating transistor **3** is applied to the base of the error detecting transistor **2** through the feedback capacitor **5** and the comparator zener diode **4.** Thus, there is the remarkable advantage in that when the number of revolutions of the engine exceeds the maximum normal revolutions, the error detecting transistor **2** and the relay actuating transistor **3** are caused to oscillate with the result that the ratio between the time intervals during which the movable contact **13***b* of the reversing transfer relay **13** engages the fixed contacts **13***p* and **13***n*, respectively, is varried in accordance with the difference between the engine revolutions and the manximum normal revolutions to vary the speed at which the control element is actuated and thereby to reliably prevent the overspeeding of the engine, and that it is possible to prevent the occurrence of hunting phenomenon of the engine and the like

which may take place with the simple on-off control circuit in which the movable contact **13***b* of the reversing transfer relay **13** simply comes into contact with the fixed contact **13***p* to move the control element in a direction that reduces the fuel injection quantity of the fuel injection pump when the number of revolutions of the engine exceeds the maximum revolutions at the normal engine speed.

Further, since the system of this invention comprises the electric motor for controlling an internal combustion engine, the control relay unit for interrupting the supply of current to the electric motor when the engine overspeeds, the control resistor inserted in the energizing circuit for the electric motor, and the resistor cut-out circuit whereby the control resistor is retained in the energizing circuit for the electric motor when the engine is in operation, while the control resistor is short-circuited when the engine is started, stopped or reversed, there is the remarkable advantage in that during the operation of the engine involving the danger of the overspeeding of the engine, the current flow to the electric motor is reduced to prevent any damage to the engine due to the overspeeding of the engine and that during the starting, stopping or reversing of the engine, the supply of sufficient current to the electric motor is ensured to improve the control efficiency of the engine by the electric motor.

There is a further remarkable advantage in that by the insertion of the control resistor in the energization circuit for the electric motor, the number of operations of the control relay unit which interrupts the current supply upon occurrence of the overspeeding engine can be reduced to thereby ensure a longer life for the control relay unit.

We claim:

1. In combination, an electric control circuit and an internal combustion engine having a fuel injection quantity control member and a rotatable member driven by said engine, said combination comprising:

means connected to said rotatable member for generating a speed voltage corresponding to the number of revolutions of said internal combustion engine,

pulse generating means connected to said speed voltage generating means to start oscillating when said speed voltage exceeds a predetermined value and generate pulses having an on-off ratio which varies in accordance with said speed voltage,

switch means connected to said pulse generating means to alternately open and close a power supply circuit in accordance with said pulses,

driving means connected to said switch means for controlling said fuel injection quantity control member, to thereby increase or decrease the quantity of fuel injected in response to said opening and closing operations of said switch means.

2. An electric control circuit according to claim **1**, wherein said driving means comprises an electric motor.

3. An electric control circuit according to claim **1**, wherein said switching means comprises relay means.

4. An electric control circuit according to claim **1**, which further comprises

a key switch having a first contact actuated during the starting period of said engine and a second contact actuated during the operating period of said engine,

a resistor connected in said power supply circuit for controlling the input to said driving means, and

means connected to said first and second contacts to short-circuit said resistor during said starting period and to release said short-circuiting of said resistor during said operating period.

* * * * *