

[54] **INTERNAL COMBUSTION ENGINE SPEED LIMIT CIRCUIT**

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 [58] Field of Search **123/102, 148 E**

[56] **References Cited**

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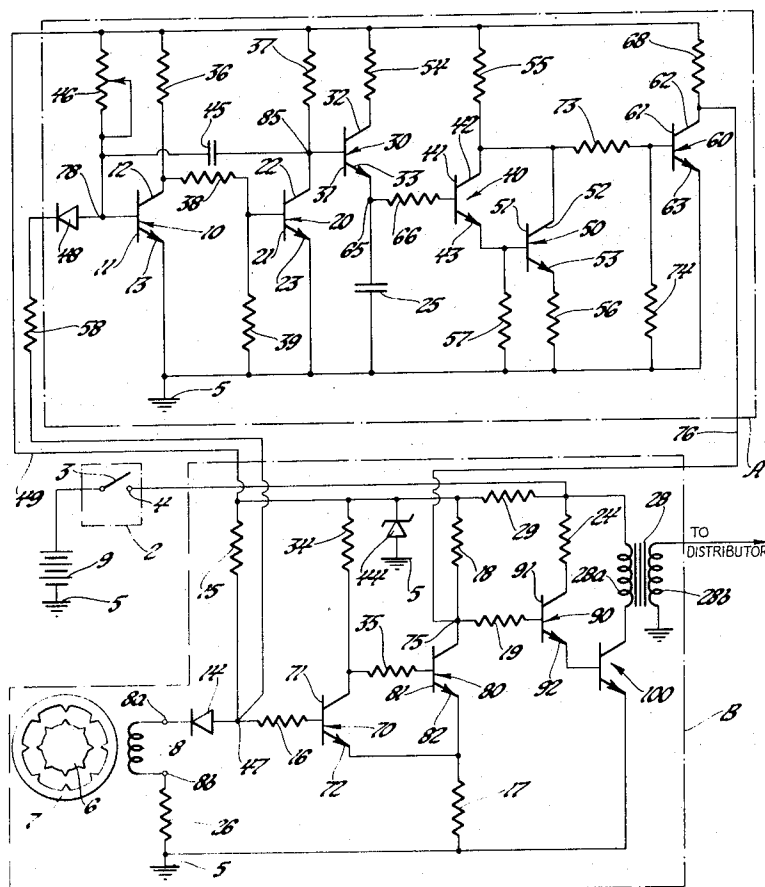
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[57] **ABSTRACT**

An internal combustion engine speed limit circuit for preventing the engine speed from exceeding a predetermined maximum. A monostable multivibrator circuit, responsive to the engine ignition signals, produces

a series of equally spaced electrical pulses at a repetition rate proportional to engine speed. These signals base bias a charge circuit transistor conductive to periodically establish a charge circuit for a capacitor and a base drive circuit for two transistors connected in Darlington pair which, while conducting, divert base drive current from a control transistor through the current carrying electrodes thereof, thereby maintaining the control transistor not conductive. While the charge circuit transistor is not conducting during the spaces between the electrical pulses, the discharge of the capacitor supplies the base drive current for the transistors of the Darlington pair to maintain these devices conductive and, consequently, the control transistor not conductive. As the speed of the motor increases, the duration of each one of the series of electrical pulses decreases until, at the predetermined engine speed, the electrical pulses are no longer produced, consequently, the charging circuit for the capacitor is no longer periodically established. The charge upon the capacitor dissipates through the base-emitter electrodes of the transistors of the Darlington pair until it has reduced to a predetermined minimum at which insufficient base drive current is supplied thereby to maintain the Darlington pair conductive. Base drive current is then supplied to the control transistor which conducts through the collector-emitter electrodes thereof to disenable the ignition system of the engine.

1 Claim, 2 Drawing Figures



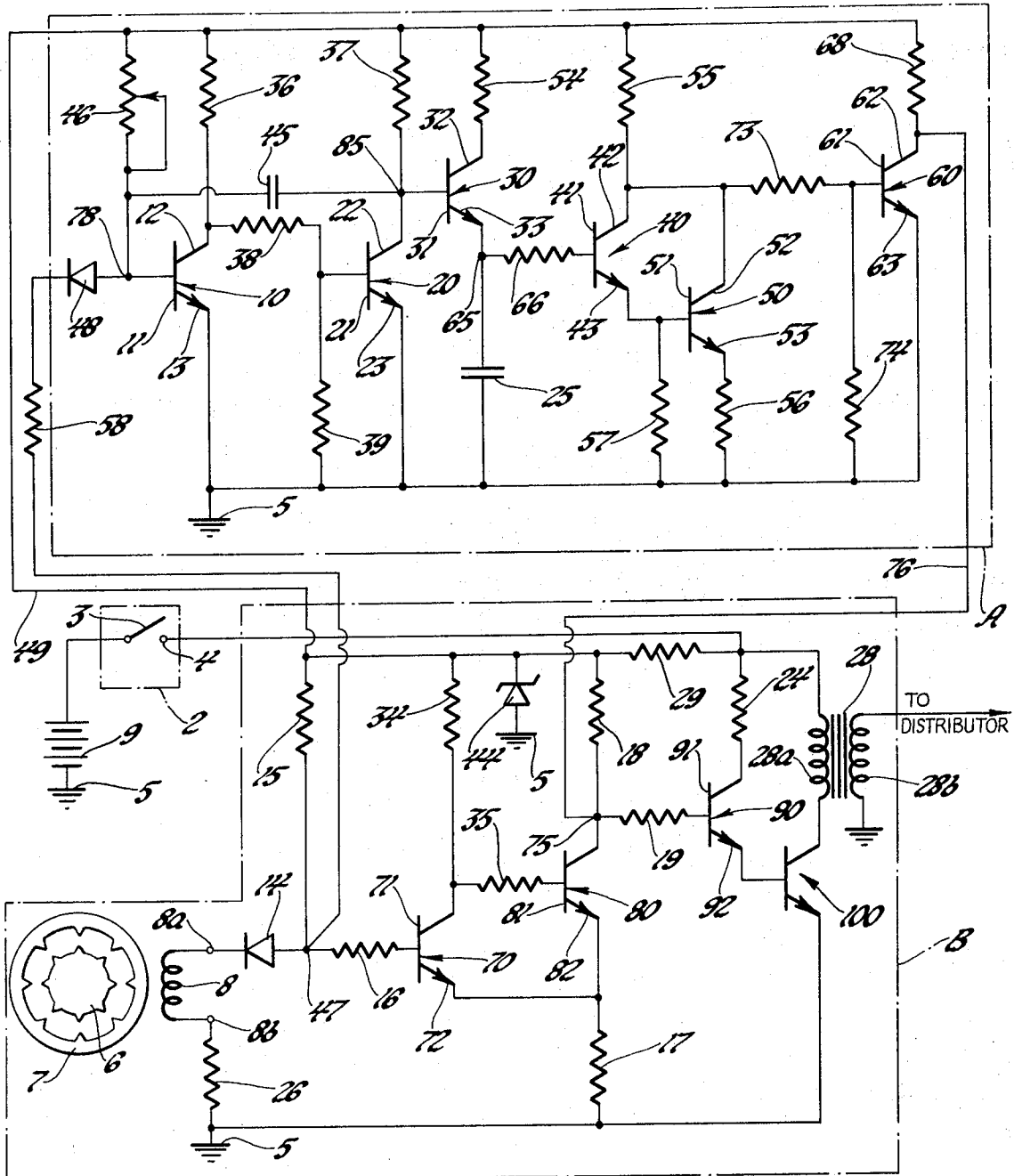


Fig. 1

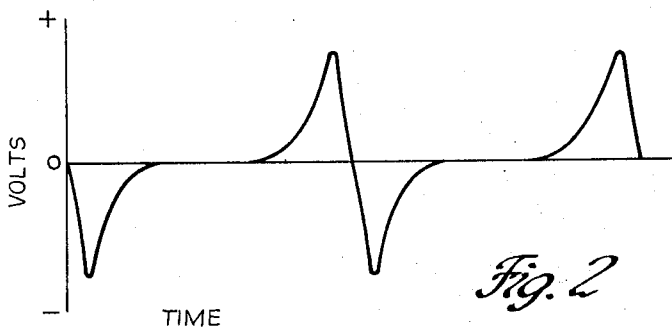


Fig. 2

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INTERNAL COMBUSTION ENGINE SPEED LIMIT CIRCUIT

This invention is directed to an internal combustion engine speed limit circuit and, more particularly, to an internal combustion engine speed limit circuit which is responsive to the charge upon a capacitor reducing to a predetermined minimum for disabling the ignition system of the engine when the engine speed reaches a predetermined maximum.

With certain types of internal combustion engines, for example, high performance automobile engines, the engine may be driven at a rate of speed high enough to destroy the engine. Therefore, a circuit which will limit the engine speed to a predetermined maximum by disabling the ignition system when the engine speed has reached the predetermined maximum is desirable.

It is, therefore, an object of this invention to provide an improved internal combustion engine speed limit circuit.

It is another object of this invention to provide an improved internal combustion engine speed limit circuit which is responsive to the charge upon a capacitor reducing to a predetermined minimum for disabling the ignition system of the engine when the engine speed reaches a predetermined maximum.

In accordance with this invention, an internal combustion engine speed limit circuit for preventing the engine speed from exceeding a predetermined maximum is provided wherein a charge circuit transistor responsive to each one of a series of equally spaced electrical pulses of a repetition rate proportional to engine speed periodically establishes a charging circuit for a capacitor and circuitry responsive to the charge upon the capacitor reducing to a predetermined minimum disables the ignition system of the engine when the engine speed reaches a predetermined maximum.

For a better understanding of the present invention, together with additional objects, advantages and features thereof, reference is made to the following description and accompanying drawing in which:

FIG. 1 sets forth in schematic form, within dashed rectangle A, the internal combustion engine speed limit circuit of this invention in combination with a compatible ignition system, set forth schematically within dashed rectangle B; and

FIG. 2 illustrates the wave form of the ignition signals produced by the ignition system of FIG. 1.

Referring to FIG. 1 of the drawing, the novel internal combustion engine speed limit circuit of this invention for preventing the engine speed from exceeding a predetermined maximum is set forth in schematic form, within dashed rectangle A, in combination with the engine ignition system which produces ignition signals in timed relationship with the engine, set forth in schematic form within dashed rectangle B, and a source of direct current supply potential, which may be associated battery 9, and includes circuitry for producing a series of equally spaced electrical pulses at a repetition rate proportional to engine speed, may be a conventional monostable multivibrator circuit comprising transistors 10 and 20 and the associated circuitry; a control capacitor 25; an electrically operated charge circuit switching device, which may be type NPN transistor 30, having current carrying elements connected in series in the charge circuit of capacitor 25 responsive to each one of the series of electrical pulses for estab-

lishing the charge circuit for the duration of each of the electrical pulses and circuitry, which may be transistors 40 and 50 connected in Darlington pair and control transistor 60, responsive to the charge upon capacitor 25 reducing to a predetermined minimum for disabling the ignition system of the engine when the engine speed reaches a predetermined maximum.

As the point of reference or ground potential is the same point electrically throughout the system, it has been illustrated by the accepted schematic symbol and referenced by the numeral 5 in the drawing.

An electrical switch 2 having a movable contact 3 and a stationary contact 4 is set forth in FIG. 1. Movable contact 3 and stationary contact 4 may be the pair of normally open "run" contacts of a conventional automotive type ignition switch. In the following description of the novel engine speed limit circuit of this invention, it will be assumed that movable contact 3 is closed to stationary contact 4.

Without intention or inference of a limitation thereto, one example of an internal combustion engine ignition system with which the speed limit circuit of this invention may be used is schematically set forth within dashed rectangle B of FIG. 1. The ignition signals may be produced in timed relationship with the engine by any one of the several conventional magnetic type distributors which are well known in the automotive art. One example of a magnetic distributor well known in the automotive art with which the engine speed limit circuit of this invention may be used is of the variable reluctance type such as that disclosed and described in detail in U.S. Pat. No. 3,254,247, Falge, which issued May 31, 1966 and is assigned to the same assignee as that of the present application. In the interest of reducing drawing complexity, the variable reluctance type ignition distributor has been set forth in schematic form in the drawing. A rotor 6 is rotated in timed relationship with the engine by the engine in a manner well known in the automotive art within the bore of pole piece 7. Equally spaced about the outer periphery of rotor 6 and about the bore of pole piece 7 are a series of projections equal in number to the number of cylinders of the engine with which the distributor and ignition system is being used. Pole piece 7 may be made up of a stack of a number of laminations of magnetic material secured in stacked relationship by rivets or bolts or other fastening methods and the magnetic flux may be provided by a permanent magnet, not shown, which may be secured to the lower face surface thereof. As each projection on rotor 6 approaches a projection on pole piece 7, the reluctance of the magnetic path between rotor 6 and pole piece 7 decreases and as each projection on rotor 6 moves away from a projection on pole piece 7, the reluctance of the magnetic circuit between rotor 6 and pole piece 7 increases. Consequently, the magnetic field produced by the permanent magnet increases and decreases as each projection on rotor 6 approaches and passes a projection on pole piece 7, a condition which induces an alternating current potential in pickup coil 8, magnetically coupled to pole piece 7, of a wave form as shown in FIG. 2.

With each positive polarity excursion of the ignition signal, terminal end 8a of pickup coil 8 of a positive polarity with respect to terminal end 8b, diode 14 is reverse biased, consequently, base drive current is supplied to type NPN transistor 70 through resistors 15 and 16, through which the base electrode 71 of transis-

tor 70 is connected to the positive polarity terminal of battery 9, and through resistor 17 and point of reference or ground potential 5, through which the emitter electrode 72 of transistor 70 is connected to the negative polarity terminal of battery 9, consequently, transistor 70 conducts through the collector-emitter electrodes. With transistor 70 conducting through the collector-emitter electrodes, base drive current is diverted from type NPN transistor 80 to extinguish this device. With transistor 80 extinguished, base drive current is supplied to type NPN transistor 90 through resistors 29, 18 and 19, through which the base electrode 91 of transistor 90 is connected to the positive polarity terminal of battery 9, and through the base-emitter electrodes of switching transistor 100 and point of reference or ground potential 5, through which the emitter electrode 92 of transistor 90 is connected to the negative polarity terminal of battery 9. Base current is supplied to switching transistor 100 through resistor 24 and the collector-emitter electrodes of transistor 90, consequently, this device conducts through the collector-emitter electrodes thereof to complete an energizing circuit for the primary winding 28a of ignition coil 28. With each negative polarity excursion of the ignition signal, terminal end 8a of pickup coil 8 of a negative polarity with respect to terminal end 8b, diode 14 is forward biased to divert base drive current from transistor 70 through pickup coil 8 and resistor 26 to point of reference or ground potential 5, consequently, transistor 70 extinguishes. While transistor 70 is not conductive, base drive current is supplied to transistor 80 through resistors 29, 34 and 35, through which the base electrode 81 of transistor 80 is connected to the positive polarity terminal of battery 9, and through resistor 17 and point of reference or ground potential 5, through which the emitter electrode 82 is connected to the negative polarity terminal of battery 9, consequently, transistor 80 conducts through the collector-emitter electrodes. While transistor 80 is conductive through the collector-emitter electrodes, base current is diverted from transistor 90, consequently, this device extinguishes. With transistor 90 not conductive, base drive current is not supplied to switching transistor 100, consequently, transistor 100 extinguishes to interrupt the energizing circuit for the primary winding 28a of ignition coil 28. The resulting collapsing magnetic field induces a high potential ignition pulse in the secondary winding 28b of ignition coil 28 which is conducted to the ignition distributor, not shown. To regulate the ignition system operating potential, a Zener diode 44 may be connected as shown.

To produce a series of equally spaced electrical pulses at a repetition rate proportional to engine speed, a conventional monostable multivibrator circuit responsive to the ignition signals produced by the engine ignition system may be employed. Within dashed rectangle A of the drawing, a conventional monostable multivibrator circuit comprising type NPN transistors 10 and 20 and the interconnecting circuitry is set forth in schematic form. The collector electrode 12 and the emitter electrode 13 of type NPN transistor 90 and the collector electrode 22 and the emitter electrode 23 of type NPN transistor 20 are connected across the positive and negative polarity terminals, respectively, of battery 9, through respective collector resistors 36 and 37 and point of reference or ground potential 5. Therefore, these type NPN transistors are properly poled for

forward collector-emitter conduction therethrough. The base electrode 21 of transistor 20 is connected to the junction between resistors 38 and 39 and the base electrode 11 of transistor 10 is connected to the collector electrode 22 of transistor 20 through timing capacitor 45, to the positive polarity terminal of the source of direct current supply potential 9 through a variable resistor 46 and to junction 47 of the ignition circuit within dashed rectangle B between diode 14 and resistor 16 through an isolating diode 48 and resistor 58. Consequently, the monostable multivibrator circuit is responsive to the ignition signals produced by the engine ignition system in a manner which will be explained in detail later in this specification.

Control capacitor 25 is charged through a charging circuit which includes the current carrying elements of an electrically operated switching device in series which is responsive to each one of a series of electrical pulses produced by the monostable multivibrator circuit for establishing the charging circuit for the duration of each of the electrical pulses. The electrically operated switching device may be any switching device which is operable by an electrical signal and is illustrated in the FIGURE as a type NPN transistor 30 having the usual base 31, collector 32 and emitter 33 electrodes. The charging circuit for control capacitor 25 may be traced from the positive polarity terminal of battery 9, through switch 2, lead 49, collector resistor 54, the collector-emitter electrodes of type NPN transistor 30, control capacitor 25 and point of reference or ground potential 5 to the negative polarity terminal of battery 9. The base electrode 31 of type NPN transistor 30 is connected to the junction 85 between collector resistor 37 and collector electrode 22 of output transistor 20 of the monostable multivibrator circuit. As the collector-emitter electrodes of type NPN transistor 30 are connected to the positive and negative polarity terminals of battery 9, respectively, this type NPN transistor is properly poled for forward collector-emitter conduction therethrough.

The circuitry responsive to the charge upon control capacitor 25 reducing to a predetermined minimum for disenabling the ignition system of the engine when the engine speed reaches a predetermined maximum includes a high impedance discharge circuit for capacitor 25, the base-emitter junction of each of two type NPN transistors 40 and 50 connected in Darlington pair, and control transistor 60. The collector electrode 42 of transistor 40 and the collector electrode 52 of transistor 50 are connected to the positive polarity terminal of battery 9 through collector resistor 55 and the emitter electrode 43 of transistor 40 is connected to the base electrode 51 of transistor 50. The emitter electrode 53 of transistor 50 is connected to point of reference or ground potential 5 through emitter resistor 56. A resistor 57 may be connected between the base electrode 51 of transistor 50 and point of reference or ground potential 5 for the purpose of temperature stability. The base electrode 41 of transistor 40 is connected to junction 65 between the emitter electrode 33 of transistor 30 and control capacitor 25 through a coupling resistor 66. The collector electrode 62 of control transistor 60 is connected to the positive polarity terminal of source of direct current potential 9 through collector resistor 68 and the emitter electrode 63 thereof is connected to the negative polarity terminal of source of direct current supply potential 9 through point of

reference or ground potential 5. Consequently, type NPN control transistor 60 is properly poled for forward collector-emitter conduction therethrough. The base electrode 61 of transistor 60 is connected to the collector electrodes 42 and 52 of respective transistors 40 and 50 through a coupling resistor 73. Resistor 74 may be connected between base electrode 61 of transistor 60 and point of reference or ground potential 5 for the purpose of establishing the proper base-emitter bias across control transistor 60. The collector electrode 62 of transistor 60 is connected to junction 75 of the engine ignition system within dashed rectangle B through lead 76, consequently, the operation of transistor 60 disables the engine ignition system in a manner to be explained in detail later in this specification. If desirable, collector resistor 68 may be eliminated from the circuit set forth in FIG. 1, in which event, collector resistor 18 of the ignition system circuit functions as the collector resistor for control transistor 60.

With the associated engine in the running mode, each positive polarity excursion of the ignition signal reverse biases diodes 14 and 48, consequently, a potential appears across junction 78 and point of reference or ground potential 5 of a positive polarity upon junction 78 with respect to point of reference or ground potential 5. As this potential is applied across the base-emitter electrodes of type NPN transistor 10 of the monostable multivibrator circuit in the proper polarity relationship to produce base-emitter current flow through a type NPN transistor, base drive current is supplied transistor 10 to trigger this device conductive through the collector-emitter electrodes thereof. With transistor 10 conducting through the collector-emitter electrodes, base drive current is diverted from transistor 20, consequently, transistor 20 is not conductive. With transistor 20 not conducting, an electrical signal appears across junction 85 and point of reference or ground potential 5 of a positive polarity upon junction 85 with respect to point of reference or ground potential 5. Each negative polarity excursion of the ignition signals forward biases diodes 14 and 48, consequently, the base drive current for transistor 10 of the monostable multivibrator circuit is diverted therethrough to extinguish this device. With transistor 10 extinguished, base drive current is supplied to type NPN transistor 20 through resistors 29, 36 and 38 to trigger this device conductive through the collector-emitter electrodes. While transistor 20 is conducting, the potential upon junction 85 goes to ground and a charge circuit is established for timing capacitor 45 through variable resistor 46 and point of reference or ground potential 5 through which base drive current is diverted from transistor 10 to maintain this device not conductive until timing capacitor 45 has become charged. By the time timing capacitor 45 has become charged, the positive polarity excursion of the next ignition signal has reached a sufficient magnitude to reverse bias diodes 14 and 48. Therefore, base drive current is again supplied to transistor 10 through variable resistor 46 to trigger this device conductive through the collector-emitter electrodes. Conducting transistor 10 diverts base drive current from transistor 20 to extinguish this device. While transistor 20 is extinguished, the electrical signal again appears across junction 85 and point of reference or ground potential 5 of a positive polarity upon junction 85. The space between the electrical signals appearing across junction 85 and point of refer-

ence or ground potential 5 is constant as determined by the time constant of the charging circuit of timing capacitor 45 for any setting of variable resistor 46. To change the space between these signals, variable resistor 46 may be adjusted. From the foregoing description, it is apparent that the monostable multivibrator circuit is responsive to the engine ignition system ignition signals for producing a series of equally spaced electrical pulses at a repetition rate proportioned to engine speed.

The series of equally spaced electrical signals produced by the monostable multivibrator circuit which appear across junction 85 and point of reference or ground potential 5 are applied across the base-emitter electrodes of transistor 30 in the proper polarity relationship to produce base-emitter current flow through a type NPN transistor, consequently, transistor 30 is triggered conductive through the collector-emitter electrodes thereof by each one of these signals to establish the charging circuit for control capacitor 25. Consequently, transistor 30 is responsive to each one of the series of electrical pulses produced by the monostable multivibrator circuit for establishing the charging circuit for control capacitor 25 for the duration of each one of the electrical pulses.

As the collector-emitter electrodes of transistors 40 and 50 are connected across the base-emitter electrodes of control transistor 60, while transistors 40 and 50 are conductive through the collector-emitter electrodes, base drive current for control transistor 60 is diverted therethrough. Control transistor 60, therefore, is maintained not conductive while transistors 40 and 50 are conductive.

Conducting transistor 30 also supplies base drive current for transistor 40 through resistor 66 and to transistor 50 through resistor 66 and the base-emitter electrodes of transistor 40. Consequently, transistors 40 and 50 are conductive through the collector-emitter electrodes thereof to maintain control transistor 60 not conductive while transistor 30 conducts for the duration of each of the series of electrical signals produced by the monostable multivibrator circuit.

While transistor 20 of the multivibrator circuit conducts during the space or interval between the series of electrical pulses produced by the monostable multivibrator circuit, transistor 30 is extinguished as the base drive current therefor is diverted through conducting transistor 20. With transistor 30 extinguished, the charging circuit for capacitor 25 is interrupted. The base-emitter junction of transistor 30 prevents capacitor 25 from discharging through conducting transistor 20, however, the charge upon capacitor 25 supplies base drive current for transistors 40 and 50 to maintain these devices conductive to divert base drive current from transistor 60 and maintain transistor 60 not conductive.

At lower engine speeds, by the time timing capacitor 45 has become charged, the ignition signals have become enough positive to reverse bias diodes 14 and 48, consequently, base drive current is again supplied to type NPN transistor 10 when timing capacitor has become charged to trigger this device conductive through the collector-emitter electrodes which extinguishes transistor 20. With transistor 20 extinguished, the electrical signal again appears across junction 85 and point of reference or ground potential 5 to again trigger transistor 30 conductive to establish the charging circuit for

control capacitor 25 before the charge thereon has reduced to the minimum at which it no longer supplies sufficient base drive current for transistors 40 and 50. That is, the time required for timing capacitor to charge is less than the time required for capacitor 25 to discharge to the predetermined minimum. So long as the engine speed remains below the predetermined maximum, control transistor 60 is maintained not conductive.

When the speed of the engine reaches the predetermined maximum, each positive polarity excursion of the ignition signals to reverse bias diodes 14 and 48 occurs before timing capacitor 45 becomes charged. Consequently, during these positive polarity excursions of the ignition signals, base current is diverted from transistor 10 through charging timing capacitor 45 and conducting transistor 20 to maintain transistor 10 not conductive and transistor 20 conductive. During each negative polarity excursion of the ignition signals to forward bias diodes 14 and 48, timing capacitor 45 discharges therethrough and base drive current for transistor 10 is diverted therethrough, a condition which maintains transistor 10 not conductive and transistor 20 conductive. Consequently, the series of electrical pulses no longer appear across junction 85 and point of reference or ground potential 5 to trigger transistor 30 conductive. When the charge upon control capacitor 25 has reduced to a predetermined minimum at which insufficient base drive current is supplied thereby to maintain transistors 40 and 50 of the Darlington pair conductive, these devices extinguish. With transistors 40 and 50 extinguished, base drive current is supplied to type NPN control transistor 60 through resistors 55 and 73 to trigger this device conductive through the collector-emitter electrodes. With control transistor 60 conducting through the collector-emitter electrodes, base drive current is diverted therethrough from drive transistor 90 of the ignition system, thereby disabling the ignition system.

As the space between the series of electrical pulses appearing across junction 85 and point of reference or ground potential 5 is determined by the time constant of the charging circuit of timing capacitor 45, the predetermined speed of the engine at which the circuit of this invention is selected to become operable to disable the ignition system may be selected by adjusting variable resistor 46 in the charge circuit of timing capacitor 45, the shorter the spacing between the series of electrical pulses, the lower the speed of the engine at which the circuit of this invention operates to disable the ignition system.

The predetermined minimum charge upon capacitor 25 is determined by the impedance of the discharge circuit including resistor 66, the base-emitter junctions of

each of transistors 4 and 50 of the Darlington pair and resistor 56. This minimum charge may be adjusted by providing a variable resistor for resistor 56.

Although specific transistor types, switching devices and electrical polarities have been set forth in this specification, it is to be specifically understood that alternate transistor types, switching devices and compatible electrical polarities may be employed without departing from the spirit of the invention.

The engine speed limit circuit of this invention has been described in combination with an electronic ignition system and a magnetic type distributor. It is to be specifically understood that this novel circuit may be used with other type ignition systems and distributors. For example, conventional ignition distributor breaker contact points may provide the ignition signals to which the monostable multivibrator circuit is responsive and the collector-emitter electrodes of control transistor 60 may be connected in shunt around the breaker contact points to provide a short circuit thereacross when the engine speed reaches the predetermined maximum.

While a preferred embodiment of the present invention has been shown and described, it will be obvious to those skilled in the art that various modifications and substitutions may be made without departing from the spirit of the invention which is to be limited only within the scope of the appended claims.

We claim:

1. An internal combustion engine speed limit circuit for preventing the engine speed from exceeding a predetermined maximum comprising in combination with the engine ignition system which produces ignition signals in timed relationship with the engine and a source of direct current supply potential, a monostable multivibrator circuit responsive to said ignition signals for producing a series of equally spaced electrical pulses at a repetition rate proportional to engine speed, a capacitor, a charge circuit through which said capacitor is charged across said source of direct current supply potential, a first transistor having two current carrying electrodes connected in series in said charge circuit responsive to each one of said series of electrical pulses for establishing said charge circuit for the duration of each of said electrical pulses, a high impedance discharge circuit for said capacitor, and a second transistor having two current carrying electrodes which is maintained not conductive while said capacitor is discharging and is rendered conductive through said current carrying electrodes when the charge upon said capacitor has reduced to a predetermined minimum for disabling the ignition system of the engine when the engine speed reaches a predetermined maximum.

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