

[54] TRANSISTORIZED IGNITION SYSTEM

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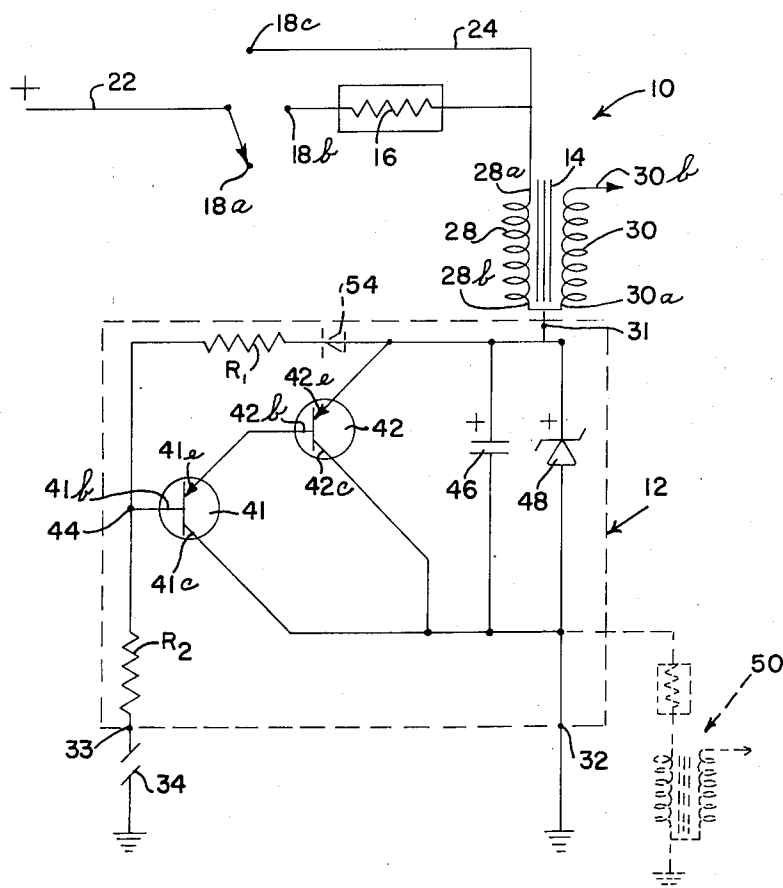
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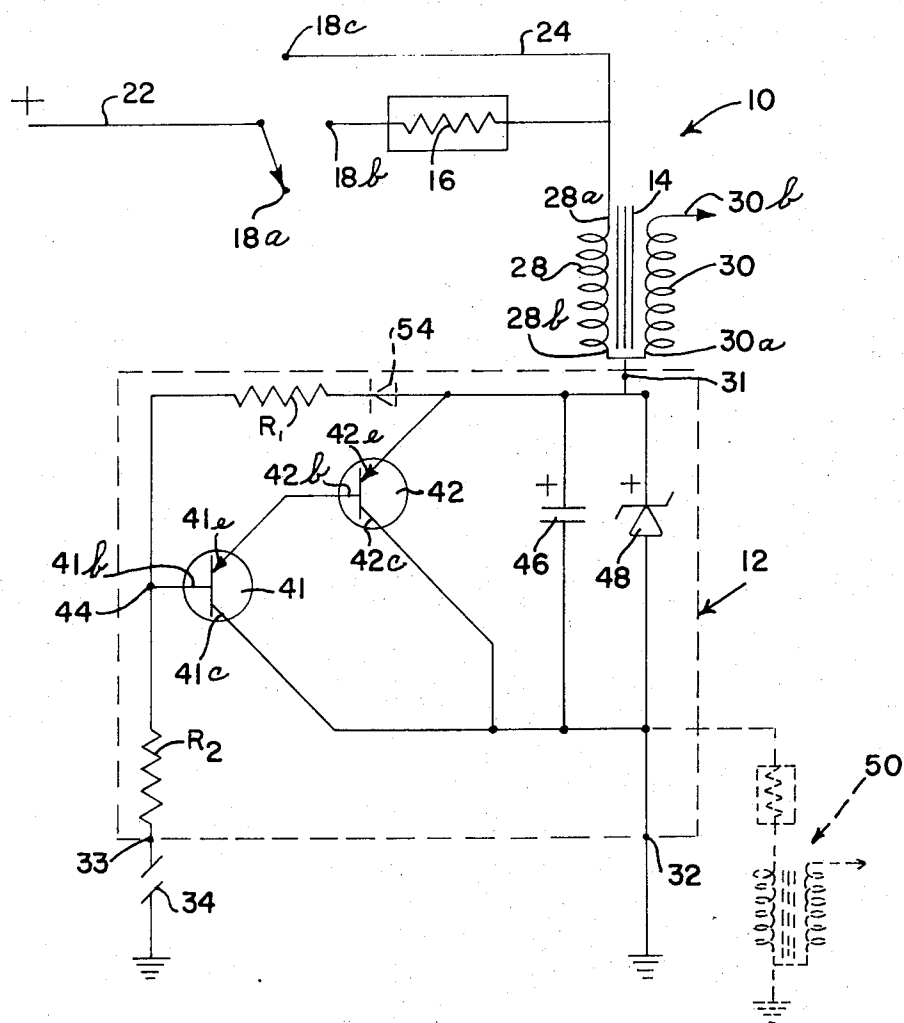
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[57] ABSTRACT

An electrical system for use with an ignition system of the type including an ignition coil and breaker points. The electrical system provides for low current through the breaker points to minimize wear and corrosion of the breaker points, provides a high primary winding current at saturation of the primary winding and of the transistors of the electrical system to provide a strong spark, and has a minimum of components. The system includes first and second compound-connected transistors with the base of the second transistor being connected to the emitter of the first transistor and the collectors of said transistors being connected to ground potential. A voltage dividing circuit is adapted to be connected in series with the breaker points of a distributor between the emitter of the second transistor and the breaker points. The base of the first transistor is connected to a predetermined point in the voltage dividing circuit; and the emitter and collector of the second transistor are adapted to be connected in series with the primary winding of an ignition coil and a source of electric potential.

8 Claims, 1 Drawing Figure





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TRANSISTORIZED IGNITION SYSTEM

This invention relates to improvements and innovations in transistor circuits for use in transistorized ignition systems. More particularly, the present invention relates to an electrical system including two compound-connected transistors for use in an ignition system.

Heretofore, a variety of transistorized ignition systems have been proposed for use with an internal combustion engine such as the internal combustion engine used in an automobile. In this respect, it has been known for some time that with a transistorized ignition system: a hotter spark across the electrodes of a spark plug can be obtained; a reduction in arcing across the breaker points in a distributor can be obtained, thereby reducing the maintenance normally required on the electrical ignition system of the automobile; and a relatively constant output voltage across the secondary winding of the ignition coil at varying engine speeds (RPM), and particularly at relatively high engine speeds, can be obtained.

A number of such known transistorized ignition systems are disclosed in the *Transistor Ignition Systems Handbook* by Brice Ward, first printing Jan. 19, 1966 by Howard W. Sams & C., Inc. Each of the known transistorized ignition systems typically includes a power transistor having the emitter and collector thereof connected in series with the primary winding of an ignition coil and a source of electric potential and having the base thereof connected to a point in a voltage dividing circuit which is connected in series with the breaker points in the distributor and with the source of electric potential. In the known transistorized ignition systems however, there is some drop-off in the output voltage of the secondary winding of the ignition coil at high engine speeds, some arcing across breaker points, and some fall off in the maximum current through the primary winding of the coil and a resultant drop in spark energy at high engine speeds. It is desirable therefore, to provide an improved transistorized ignition system which operates more efficiently with respect to output voltage, breaker point arcing, and spark energy. Accordingly, it is a primary object of the present invention to provide such an improved transistorized ignition system.

Another object of the present invention is to provide an electrical system which is adapted for use in an electrical ignition system and in which a minimum of components are used providing a very reliable circuit.

Another object of the present invention is to provide an electrical system which is adapted for use in an electrical ignition system which utilizes a transistor circuit including two compound-connected transistors.

Another object of the present invention is to provide an improved transistorized ignition system which provides a relatively constant output voltage at the secondary winding of an ignition coil through a wide range of engine speeds.

Another object of the present invention is to provide a transistorized ignition system which greatly minimizes, if not altogether eliminates, arcing across the breaker points in a distributor of an electrical ignition system used with an internal combustion engine.

Another object of the present invention is to provide an improved transistorized ignition system which maintains a hot spark across the electrodes of a spark plug

by maintaining high current flow through the primary winding of an ignition coil at high engine speeds.

Another object of the present invention is to provide a transistorized ignition system including two compound-connected transistors which act together as one transistor requiring a very small "trigger" or "turn on" signal and having a very small drop off of collector current from emitter current at saturation of the "one transistor."

Another object of the present invention is to provide a transistor circuit for use in an electrical ignition system, with the circuit providing for very stable operation of the ignition system and providing a relatively constant output voltage and current to the spark plugs through a wide range of engine speeds.

Another object of the present invention is to provide an electrical system for use in an electrical ignition system for an internal combustion engine and which electrical system is of simple and compact design so that the electrical system can be simply installed without the need for special skills and with a minimum of tools.

Still another object of the present invention is to provide an electrical system which includes a transistor circuit and which can be simply connected into the electrical ignition system for an internal combustion engine by merely connecting two leads into the ignition system circuit and by connecting a heat sink chassis mounting the electrical system to ground potential.

In accordance with one preferred embodiment of the invention, there is provided an electrical system for use in an ignition system of the type including an ignition coil and distributor breaker points, the electrical system including first and second compound-connected transistor each having a base and first and second output terminals, and means for applying a signal to the base of the first transistor. The base of the second transistor is connected to the first output terminal of the first transistor, the second output terminal of the first transistor is connected to the second output terminal of the second transistor, and the first and second output terminals of the second transistor are adapted to be connected in series with the ignition coil and a source of electric potential.

For a more complete understanding of the nature and scope of the present invention reference will now be had to the accompanying schematic drawing of the electrical system of the present invention.

Referring now to the drawing, an electrical ignition system is generally indicated at 10 and the electrical system of the present invention, which is adapted for use in and forms a part of the system 10, is generally indicated at 12.

The ignition system 10 also includes an ignition coil 14, a ballast resistor 16 and a single pole triple throw switch 18 having three stationary contacts 18a, 18b and 18c and one movable contact 20. The switch 18 is typically a key operated ignition switch of the type normally found in an automobile. As shown in the drawing, a line 22 from a suitable source of electric potential, such as a 12 volt battery, is connected to the movable contact 20 of the switch 18. When the movable contact 20 is in a first position engaging the contact 18a, the switch 18 is in the off position. When it engages the contact 18b, the switch 18 is in the running position with a circuit established between the line 22 and the ballast resistor 16 through the switch 18; and when the contact 20 engages the contact 18c, the switch 18 is in

the start position with a circuit established between the line 22 and a lead 24 which by-passes the ballast resistor 16 and is connected to the ignition coil 14.

The ignition coil 14 is of known construction and includes a primary winding 28 and a secondary winding 30. As shown, the lead 24 and the ballast resistor 16 are connected to one end 28a of the primary winding 28. The other end 28b is connected to one end 30a of the secondary winding 30. The other end 30b of the secondary winding 30 is adapted to be connected to one electrode of a conventional spark plug (not shown).

As shown in the drawing, the electrical system 12 of the present invention has three terminals or leads generally indicated at 31, 32 and 33. Preferably, the electrical system 12 is mounted on a heat sink chassis which, being metal, can take the place of, or constitute, lead 32. In this way, the electrical system can be assembled and sold as a complete package with two leads extending from the chassis for connection into a conventional ignition system to form the ignition system 10. In this respect, the lead 31 is adapted for connection to one end, end 28b of the primary winding 28, the lead "chassis"-32 is adapted for connection to a common or ground conductor which is connected to the source of electrical potential, i.e., to one side of the battery, and the lead 33 is adapted for connection to one side of a set of breaker points 34 in a distributor (not shown) forming part of the ignition system 10.

The system 12 includes first and second compound-connected transistors 41 and 42. The transistor 41 has a base 41b and first and second output terminals-emitter and collector-41e and 41c. Likewise, the transistor 42 has a base 42b and first and second output terminals-emitter and collector-42e and 42c. As shown, the base 42b of the second transistor 42 is connected to the emitter 41e of the first transistor 41 and the collector 41c of the first transistor 41 is connected to the collector 42c of the second transistor 42. The emitter 42e of the second transistor 42 is connected to the lead 31 and the collector 42c of the second transistor 42 is connected to the lead 32. In this way, when the electrical system 12 is connected into and forms part of the ignition system 10, the emitter and collector 42e and 42c of the second transistor 42 will be connected in series with the primary winding 28 of the ignition coil 14.

The electrical system 12 also includes a voltage dividing circuit formed by resistors R_1 and R_2 which are connected between leads 31 and 33. As shown the base 41b of the transistor 41 is connected to a junction 44 between the resistors R_1 and R_2 . In other words, the resistor R_1 is connected between the emitter 42e of the second transistor 42 and the base 41b of the first transistor 41, and the second resistor R_2 is connected between the base 41b of the first transistor 41 and the lead 33 adapted to be connected to breaker points 34.

The compound connecting of transistors has been known for some time and in this respect reference may be had to paragraph 138 in Section VII of Chapter 7 in *Technical Manual No. 11-690, Basic Theory and Application of Transistors*, published by the Headquarters, Department of the Army on Mar. 17, 1959. The utilization however, of compound-connected transistors in an electrical circuit or system adapted for use in an electrical ignition system has not heretofore been proposed. More specifically, the combination of compound-connected transistors with an ignition coil, ballast resistor and breaker points in an electrical ignition system

has not been heretofore proposed. The electrical system 12 of the present invention, by utilizing compound-connected transistors provides several advantages over known transistorized ignition systems. In this respect, the drop off of collector current at high emitter currents through the second transistor 42 is very small. As a result, the coil 14 can be connected between the source and the system 12 or between the system 12 and ground with the current flowing through the primary winding 28 being essentially the same for either connection. Also, by using a primary winding having a small current rise time and by using compound-connected transistors which are quickly saturated, the operating characteristics of the system 10 are maintained relatively constant even at high engine speeds resulting in the obtainment of a "hot spark" (spark energy) through a wide range of engine speeds. Additionally, the compound-connected transistors 41 and 42 act as a single transistor with very high gain. As a result, only a very small signal need be applied to the base 41b of the first transistor 41 in order to "trigger" or "turn on" the transistor 41 to turn on the transistor 42.

Moreover, by including two compound-connected transistors and a voltage dividing circuit consisting in the resistors R_1 and R_2 , the electrical system 12 operates with a very small electrical current through the breaker points 34 and there is very little, if any, arcing across the breaker points 34 when they are opened or closed. In this way, pitting or corrosion of the breaker points 34 is avoided.

In one preferred embodiment of the electrical system 12 and as shown in the drawing, a capacitor 46 is connected across the emitter 42e and collector 42c of the second transistor 42. The capacitor 46 functions mainly as an AC shunt for transient signals or currents which may be picked up by the ignition system 10. In particular, upon collapse of the magnetic field induced in the ignition coil 14, the capacitor 46 will absorb any current generated in the primary winding 28. As a result, it is very likely that a charge will be placed on the capacitor 46 after the breaker points 34 are opened and the induced magnetic field collapses.

Although the actual operation of the system 12 is not known with complete certainty, it is believed that any charge accumulated or placed on the capacitor 46 will assist and enhance the operation of the circuit 12 particularly at high engine speeds. In this respect, it will be understood that the ignition coil 14 is initially in a steady state (zero field) condition and will resist a change in its state. Therefore, when the breaker points 34 are closed the inherent tendency of the coil 14 to resist a change in the state of the magnetic field therein will momentarily impede the flow of current through the primary winding 28 and through the resistors R_1 and R_2 . Thus, a very slight time lag in the flow of current through resistors R_1 and R_2 may be incurred if the capacitor 46 is not connected in the circuit. It is believed that by having the capacitor 46 in the system 12 when the breaker points 34 are closed, a current path is immediately established through resistors R_1 and R_2 for the discharge of any current charge stored in the capacitor 46, and it is believed that this current will be sufficient to establish a signal of sufficient magnitude at the base 41b of the first transistor 41 for immediately "turning on" the first transistor 41 to "turn on" the second transistor 42. Accordingly, it is believed that the charging of the capacitor 46 upon each collapse of the

field in the coil 14, and the dissipation of this charge through the resistors R_1 and R_2 ensures and provides for immediate "turn on" of the transistors 41 and 42 to ensure saturation of the coil 14 to maintain a "hot spark" (high spark energy) through a wide range of engine speeds.

Also, in one preferred embodiment of the electrical system 12 of the present invention and as shown in the drawing, a zener diode 48 is connected across the emitter 42e and collector 42c of the second transistor 42. The zener diode 48 has a break down voltage which is less than the maximum permissible collector-emitter voltage for the transistor 42, and its primary purpose is to protect the second transistor 42 from over-voltages in a well known manner.

Since, as described above, there is very little drop off between the emitter and collector currents through the transistor 42, the ballast resistor 16 and the ignition coil 14 can be connected between ground potential and the lead 32, as generally indicated by phantom lines at 50. However, the circuit connections described above are preferred since they simplify the assembly of the electrical system 12 and the connection thereof into an ignition system to form the system 10. In this respect the collectors 41c and 42c can be simply connected to the heat sink (metal) chassis on which the transistors 41 and 42 are preferably mounted. Then the ground connection, indicated by the lead 32 in the drawing, is effected through the chassis which can be easily secured to the metal frame supporting the internal combustion engine. In this way, there are only two leads, the leads 31 and 33, from the electrical system 12 which need to be connected as shown. If the collectors were not connected to ground, they would have to be insulated from ground and the third lead 32 would then be connected to the collectors 41c and 42c.

By reason of the compact circuit connections in the electrical system 12 and by having only two output leads 31 and 33, the preferred embodiment of the electrical system 12 of the present invention can be readily and simply installed with a minimum of tools and without requiring special skills. In this respect, a simple instruction sheet for installing the electrical system 12 in an automobile will instruct one (a) to securely mount the heat sink to the chassis of the automobile, (b) to break the conventional connection between the coil and the breaker points, (c) to connect the lead 31 to one side of the primary winding of the ignition coil and (d) to connect the lead 33 to the breaker points.

In one working example of the ignition system 10 utilizing the electrical system 12 of the present invention, the values of the circuit elements of the ignition system 10 were as follows:

Ballast resistor 16 — 0.5 ohms (150 watts)

Resistor R_1 — 10 ohms (1 watt)

Resistor R_2 — 10 ohms (11 watts)

Capacitor 46 — 2 microfarads (150 WVDC — Electrolytic)

Zener diode 48 — Motorola IN3004 (91 Volts Breakdown Voltage)

Transistors 41 and 42 — Motorola 2N2834 (20 Amp, V 100 Volts)

Ignition coil 14 — 400:1 Turns^{CE} ratio (Low Primary Winding Inductance — 40 KV Output Voltage)

The ignition system 10 is cyclically operated with each cycle being initiated by the closing of the breaker points 34. As soon as the breaker points 34 are closed,

current flows through the resistors R_1 and R_2 from either the capacitor 46 and/or the voltage source. When a signal of sufficient magnitude is established at the base 41b of the transistor 41, the transistor 41 is "turned on" to "turn on" the transistor 42, i.e., to allow current to flow through the emitter base junction of the transistor 42 and the emitter collector of the transistor 41 to "turn on" the transistor 42. When the transistor 42 is rendered conducting, current flows through the primary winding 28 of the coil 14 until the breaker points 34 are opened at which time the field in the coil 14 collapses and produces a spark across the electrodes connected to the ends of the secondary winding 30 of the coil 14.

Although one preferred embodiment of the electrical system 12 of the present invention has been described it is to be understood that obvious modifications or variations can be made to the electrical system 12 of the present invention without departing from the scope of the invention. In this respect it is to be understood that the electrical system 12 can operate without the capacitor 46 and the diode 48 bearing in mind, of course, that the possibility of damage to the transistors 42 and 41 is appreciably increased by the removal of these protective circuit elements. Additionally, a diode can be connected between the emitter 42e and the resistor R_1 as shown in phantom lines at 54 for preventing inverse current flow through the resistors R_1 and R_2 and for limiting power losses in the transistors 41 and 42. Another variation would be to eliminate the connection between the ends 28b and 30a of the windings 28 and 30 of the coil 14, connect the end 30a to ground, and then connect a relatively large resistor between the end 28b of the primary winding 28 and ground, to permit a small amount of current to flow through the primary winding at all times. Accordingly, the scope of the present invention is only to be limited as necessitated by the accompanying claims.

I claim:

1. A transistorized ignition system including, in combination, a transformer coil having a primary winding and a secondary winding, first and second compound-connected transistors each having a base and first and second output terminals, said first output terminal of said first transistor being connected to said base of said second transistor, said second output terminal of said first transistor being connected to said second output terminal of said second transistor, and said output terminals of said second transistor being connected in series with the primary winding of said transformer, a voltage dividing circuit connected between said first output terminal of said second transistor and one terminal of a set of breaker points in a distributor, the base of said first transistor being connected to a point in said voltage dividing circuit, and a capacitor connected across said output terminals of said second transistor in such a manner that, when the breaker points are closed and before the transistors conduct, a closed loop series circuit is formed for discharging any charge on said capacitor, said loop consisting of said capacitor, said voltage dividing circuit and the common conductor for said system.

2. The system of claim 1 including a zener diode connected across said output terminals of said second transistor.

3. The system of claim 1 wherein said coil is connected to said first output terminal of said second transistor.

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sistor and is adapted to be connected to a source of electric potential.

4. The system of claim 1 wherein said voltage dividing circuit includes a first resistor connected between said first output terminal of said second transistor and the base of said first transistor and a second resistor connected between the base of said first transistor and said breaker points.

5. The system of claim 1 including a ballast resistor connected in series with said primary winding of said coil.

6. An electrical system for use with an ignition system of the type including an ignition coil, said electrical system including first and second compound-connected transistors each having a base and first and second output terminals, means adapted to be connected between the ignition coil and a cyclical switching device and connected to said base of said first transistor for cyclically applying a signal to said base of said first transistor, said base of said second transistor being connected to said first output terminal of said first transistor, said second output terminal of said first transistor being connected to said second output terminal of said second transistor, said first and second output terminals of said second transistor being adapted to be connected in series with the ignition coil and a source of electric potential said signal applying means consisting of a first impedance connected between said first output terminal of said second transistor and the base of said first transistor and a second impedance connected to said base of said first transistor and adapted to be connected to a cyclical switching device, and a capacitor connected across said output terminals of said second transistor in

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such a manner that, when the switching device is closed and before the transistors conduct, a closed loop series circuit is formed for discharging any charge on said capacitor, said loop consisting of said capacitor, said first impedance, said second impedance and the common conductor for said system.

7. The electrical system of claim 6 including a zener diode connected across said output terminals of said second transistor.

8. An electrical system for use with an ignition system of the type including an ignition coil, said system including first and second compound-connected transistors, the emitter and collector of said second transistor being adapted to be connected in series with the ignition coil and a source of electric potential, the emitter of said first transistor being connected to the base of said second transistor, the collector of said first transistor being connected to the collector of said second transistor, a resistor connected between the emitter of said second transistor and the base of said first transistor, a resistor connected to said base of said first transistor and adapted to be connected to a cyclical switching device, a capacitor connected across said emitter and collector of said second transistor in such a manner that, when the switching device is closed and before the transistors conduct, a closed loop series circuit is formed for discharging any charge on said capacitor, said loop consisting of said capacitor, said resistors and the common conductor for said system, and a zener diode connected across said emitter and collector of said second transistor.

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