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3,374,778

ELECTRONIC IGNITION SYSTEM

Filed Oct. 22, 1965

2 Sheets-Sheet 1

FIG. 1

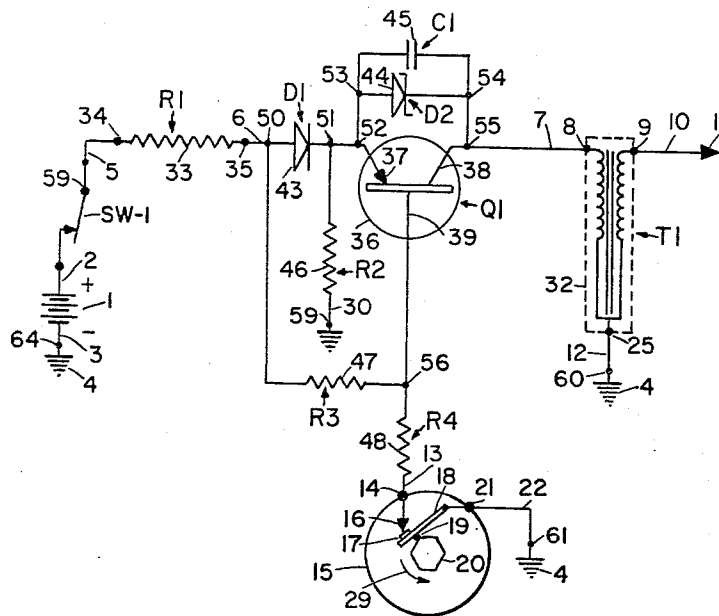
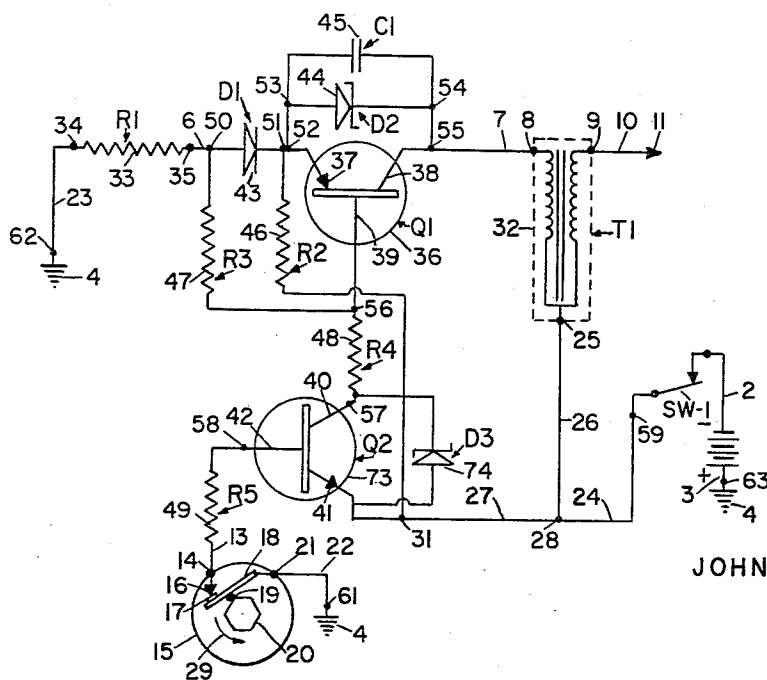


FIG. 2



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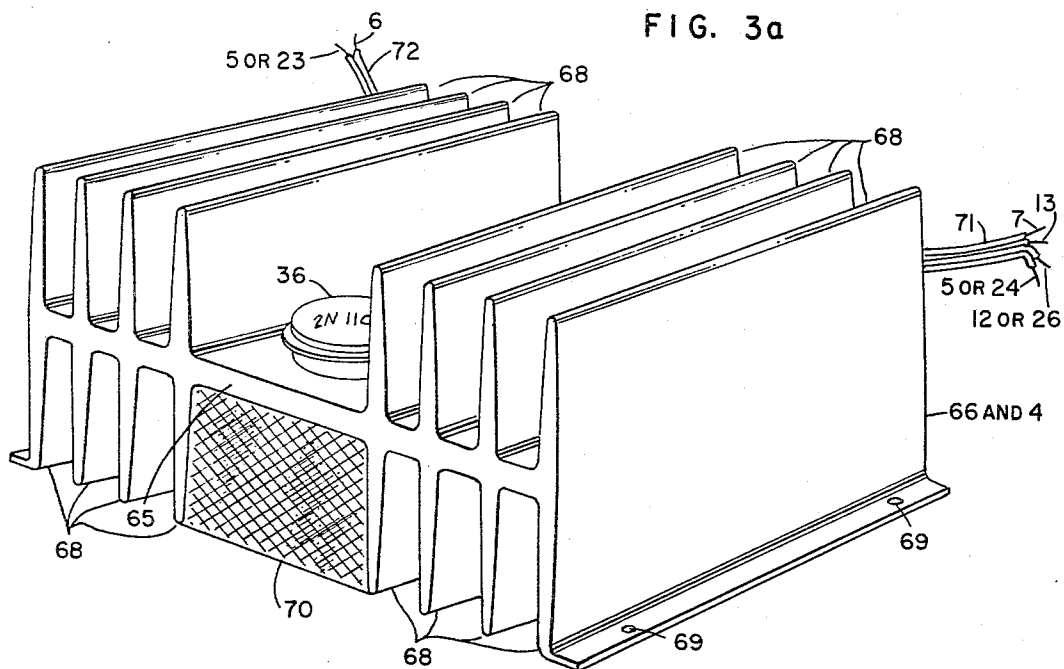
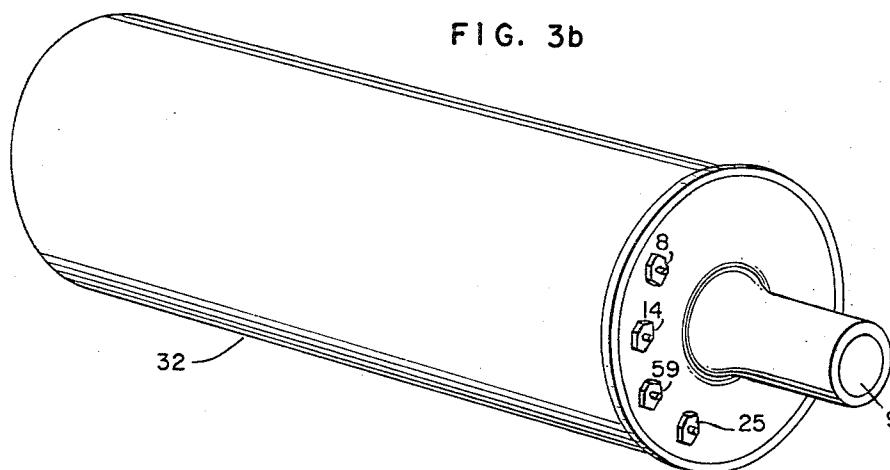
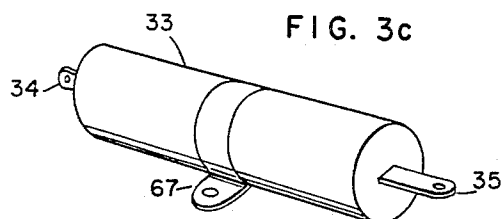
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2 Sheets-Sheet 2



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ELECTRONIC IGNITION SYSTEM
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ABSTRACT OF THE DISCLOSURE

Electronic ignition systems for internal combustion engines, one using a transistorized positive ground system and another a transistorized negative ground system, the negative ground system having an ignition coil directly connected to the collector of the transistor and a circuit arrangement preventing a direct voltage path between the coil and the base of the transistor, and the positive ground system having a second transistor for turning on the first transistor and protected by a zener diode and by a circuit arrangement preventing a direct voltage path between the ignition coil and the collector of the second transistor to protect the second transistor from transient voltages and to permit the use of a lower power zener diode.

This invention relates to improvements in electronic ignition systems for internal combustion engines, and particularly with reference to ignition systems for automotive and marine use.

Conventional transistorized ignition systems have limitations with respect to efficiency and reliability. Particularly with respect to the protection of circuit elements from voltages in excess of their maximum ratings, conventional transistorized ignition systems have no means of protecting transistors against excessive voltages to insure against failure or burning out. Conventional transistorized ignition systems have insufficient voltage protection of transistors, thereby resulting in burning out or other failure of the circuit elements.

With respect to wear on components such as spark plugs and points, conventional non-transistorized ignition systems cause excessive wear on these components. Overheating of the transistor element in conventional transistorized ignition systems is very common due to the lack of proper heat dissipating ability.

Another defect in conventional non-transistorized ignition systems is that they supply inconstant high voltage for the spark plugs, especially at high engine speeds, which results in incomplete combustion bringing about carbon deposits, poor gas mileage, burned valves, and fouled spark plugs, among other disadvantages. A need exists for an ignition system which will provide constant high voltage for the spark plugs regardless of the speed of the engine or the conditions under which it is operating.

To overcome these disadvantages, my invention employs a heat sink with much greater heat dissipating ability due to increased surface area which eliminates overheating of the transistor which frequently occurs in conventional transistorized systems.

My invention also uses a transistor of a capacity able to supply all of the power required by the coil in the ignition system.

Further, my invention incorporates an emitter biasing diode which provides greater protection for the transistor than existing systems which omit such an emitter biasing diode.

My invention incorporates a zener diode with a power rating sufficient to insure against failure or burning out whereas those conventional transistorized systems using zener diodes invariably fail to provide a zener diode with adequate power ratings and accordingly such diodes fre-

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quently fail or burn out or fail to provide proper protection against excessive voltage for the transistor.

It is, therefore, an object of this invention to improve the efficiency of ignition systems for internal combustion engines.

Another object of this invention is to increase reliability of ignition systems for internal combustion engines by reducing wear on components such as spark plugs and points.

A further object of this invention is to provide an ignition system which completely eliminates condensers.

A still further object of this invention is to provide a transistorized ignition system which will reduce maintenance as well as the necessity of replacing parts such as spark plugs and points.

These and other objects which will be more readily understood by reference to the following specification, taken in conjunction with the accompanying drawings in which:

FIGURE 1 is an embodiment of my invention which illustrates a schematic circuit diagram thereof using a negative ground system.

FIGURE 2 is an embodiment of my invention which illustrates a schematic circuit diagram thereof using a positive ground system.

FIGURES 3a, 3b and 3c is a perspective view of the components used in the schematic circuit diagrams of FIGURES 1 and 2.

In the embodiment of my invention shown in FIGURE 1, the circuit begins with a battery 1 which is connected by wire 3 to point 64 which is a common point 4 or ground. This may be either the positive or negative terminal of the battery 1. As shown in FIGURE 1, ground is the negative terminal.

The ignition system switch SW-1 is connected to the positive terminal of the battery 1 as shown in FIGURE 1.

The circuit shown in FIGURE 1 uses a transistor Q1, 36, which is a PNP type, high current, high voltage, germanium transistor. This transistor 36 is used to switch high power on and off to the ignition coil 32. Because of the inductive characteristics of ignition coil 32, the transistor 36 requires protection from the high voltages induced in the primary winding of ignition coil 32 which are sent back to the collector 38 of transistor 36 through conductor 7.

Without suppression of such high voltages, the emitter 37 collector 38 junction of the transistor may be permanently damaged. To provide such suppression and to protect the transistor 36, a special diode known as a zener diode D-2, 44, is connected across the emitter 37-collector 38 junction of the transistor 36.

The zener diode 44 conducts a positive transient voltage from the collector 38 to the emitter 37 of transistor 36, with great rapidity.

The voltage developed across the collector 38 emitter 37 junction in this respect is kept at a very low level which is approximately $\frac{1}{2}$ to $1\frac{1}{2}$ volts. All negative transient voltage are conducted in the reverse direction which is sometimes called the zener direction of diode 44 at a higher voltage but a voltage that is relatively lower, about 50 to 80 volts.

In either direction, diode 44 has a limited conduction time so that diode 44 may not become operative, i.e. "turn on" fast enough to suppress the extremely fast rising voltages coming from the primary winding of coil 32. Therefore, a capacitor 45 is used to bridge the diode 44 to suppress rapid voltage transients or changes across diode 44 by slowly absorbing and slowly releasing electrical charges.

Nevertheless, my invention provides even more protection for transistor 36 by a second network consisting of

diode 43, a resistor 46, and resistor 47. When transistor 36 is in a non-conducting state, most of the transient voltages are received from the primary winding of coil 32, and no current is flowing from collector 38 to emitter 37.

Resistor 46 causes diode 43 to conduct current which is returned to ground 4. When diode 43 is so conducting current, there is a voltage drop of approximately $\frac{1}{2}$ volt across the diode.

Diode 43 is connected to the base 39 of transistor 36 through resistor 47. At this time, the transistor 36 is in a non-conducting state, so that the base 39 draws a negligible voltage drop across resistor 47.

Under these circumstances, the emitter 37-base 36 junction of transistor 36 is placed in the reverse bias condition such that the break down or arc-over voltage between all of the internal elements resistor 36 in either direction is greatly increased.

Resistor 33 limits the amount of current in amperes flowing through the emitter 37-collector 38 junction of transistor 36 when the latter is in an "ON" or conducting state. Without resistor 33, currents over 50 amperes would occur in the emitter 37-collector 39 junction of transistor 36. Since the transistor 36 is rated at only 15 amperes of current, the transistor 36 would be rapidly destroyed.

The above described two protection circuits have proved to be adequate to protect transistor 36. Resistor 48 in the base circuit 39 of transistor 36 limits the amount of current in amperes flowing from the emitter 37 to the base 39. Without resistor 48, the emitter 36-base 39 junction would be destroyed.

With respect to FIGURE 2, the circuit illustrated therein is essentially the same as that illustrated in FIGURE 1, except for the addition of three components, which are respectively transistor 73, resistor 49, and diode 74. These three components have been added because the points on a positive ground system would provide only a positive pulse, and transistor 36 requires a negative pulse on its base 39 to "turn it on."

The collector 49 of transistor 73 is connected to resistor 48. The emitter 41 of transistor 73 is connected to the terminal of the battery 1 through ignition switch SW-1. Transistor 73 is an NPN type device and requires a positive pulse on its base 42 to put it in an "ON" or conducting state. When transistor 73 is in a conducting state, a negative pulse from the battery 1 is carried from the emitter 41 to the collector 40 and delivered through resistor 48 to base 39 of transistor 36. In this way, transistor 36 is put into a conducting state and the primary objective of the additional transistor 73 is accomplished.

Resistor 49 in the base 42 circuit of transistor 73 serves the same purpose as resistor 48 in the base 39 circuit of transistor 36. Diode 74 is connected across the emitter 41 collector 40 junction of transistor 73 and serves the same purpose as diode 44 across emitter 37-collector 38 junction of transistor 36.

With reference to FIGURE 3, the heat sink 66 illustrated there, previously referred to as ground 4 in FIGURES 1 and 2, is made of a special aluminum alloy having a great capacity for absorbing and conducting heat. Transistor 36, diode 44, diode 43, and transistor 73, each generates heat, and large amounts of heat at times. Accordingly, transistor 36 is mounted directly on heat sink 66 so that the heat generated in transistor 36 is carried into the entire heat sink 66 and primarily to the sixteen vertical fins 68 which dissipate the heat into the air. The amount of heat that can be dissipated from fins 68 depends solely on the surface area exposed to the air.

In other transistorized systems, the surface area of heat sinks therein varies from 10 or 12 square inches to 100 square inches. In comparison, heat sink 66 incorporates fins 68 which provide a total surface area exceeding 400 square inches, thereby providing more than four times the protection from high surrounding temperatures than

any other transistorized ignition system presently available.

All of the components used in this invention, except transistor 36 and resistor 33 are encapsulated at the bottom of the heat sink at 70 by an epoxy resin type compound. Such encapsulation protects each of the components so covered from moisture, dirt, dust, vibration, and other adverse effects from exposure to the environment. In relation to the components so covered, the encapsulation also acts in the same way as a heat sink. Most of the conventional transistorized ignition systems do not incorporate any such encapsulation and leave all of their components exposed to free air, subject to moisture, dust, dirt, vibration and other adverse effects. Further, the lack of such encapsulation in conventional systems deprives them of additional heat dissipation provided by such encapsulation over and above the heat sink itself.

The encapsulation does not contain resistor 33 because the latter must dissipate extreme amounts of heat. The resistor 33 is designed to dissipate heat into free air in quantities sufficient to raise the temperature of air to the boiling point of water. Resistor 33 is connected to the remainder of the circuit by cable 72 which carries conductors 5 and 6, or 6 and 23.

Because resistor 33 and the components located in or about heat sink 66 may require location some distance away from ignition coil 32, cable 71 is incorporated and contains conductors 5, 7, 12, and 13, or 7, 13, 24, and 26. These conductors connect to their respective ignition coil 32, at respective terminal 8, 14, 25, and 59.

Terminal 14 is a tie point for conductor 13 and cable 71 and a wire running to the distributor, which is normally at that point in conventional ignition systems. Tie point 59 can be used as a tie-down support for existing wires coming from ignition switch SW-1, which wires are referred to in FIGURE 1 as conductor 5 or conductor 24. Nevertheless, any existing standard ballast resistor in conventional ignition systems must be removed or bypassed for proper performance.

My invention has been field tested upon installation in various automobiles. The results of such tests were that the automobiles had an increase in power, started much easier, had less engine noise and vibration, with much less maintenance required, and improvement in gasoline mileage.

Test No. 1

A negative ground system embodying my invention was installed in a 1962 Pontiac Tempest automobile. After 40,000 miles of operation with my invention installed, an increase in mileage of about 20% or about 4 miles per gallon was noted along with an appreciable increase in power. The engine also started very quickly in all kinds of weather, hot, cold wet or dry. Another result was less engine noise and vibration. During the 40,000 mile period of operation, the automobile had no spark plug or ignition point replacement.

Test No. 2

A duplicate of the negative ground system in Test No. 1 was installed in a 1960 Lincoln Continental automobile. After about 18,000 miles of operation with my invention installed, an increase in mileage of about 20% or about 4 miles per gallon was noted along with more power and quicker starts.

Similar results were noted after installation of my invention in a 1960 Buick Le Sabre automobile, after 9,000 miles of operation.

Although I have described my invention in detail with reference to the accompanying drawings illustrating preferred embodiments of my invention, it is understood that numerous changes in the details of construction and arrangement of parts may be made without departing from the spirit and scope of the invention as hereinafter claimed.

I claim:

1. In an electronic ignition circuit of the type using a positive ground system for internal combustion engines comprising
 circuit means for providing a unidirectional source of electric current with a positive ground;
 a transistor having a base, emitter and collector electrodes;
 circuit means for delivering a negative electrical impulse to turn on said transistor;
 an ignition coil connected to said transistor and switched on and off by said transistor;
 a zener diode connected across the emitter-collector junction of said transistor and bridged by a capacitor;
 circuit means protecting said transistor from high transient voltages comprising a diode connected on one side to said base through a resistor and on the other side to ground through a second resistor;
 and a resistor placed in series with electric current flowing through the emitter-collector junction to limit said current when the transistor is conducting, the improvement comprising means directly connecting said ignition coil to the collector of said transistor, and circuit means arranged to prevent a direct voltage path between said ignition coil and the base of said transistor to protect said transistor from transient voltages and a second zener diode arranged to

protect said circuit means delivering a negative electrical impulse.

2. An electronic ignition circuit according to claim 1 in which the circuit means supplying a negative pulse to the transistor therein comprises,
 a transistor having a base, emitter, and collector electrodes; said emitter electrode being connected through an ignition switch to the negative side of said source of unidirectional electric current, a second zener diode connected across the emitter-collector junction of said transistor, circuit means arranged to prevent a direct voltage path between said ignition coil and the collector of said transistor to protect said transistor from transient voltages and to permit the use of a lower powered zener diode; and
 a resistor connected to said collector electrode.

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LAURENCE M. GOODRIDGE, *Primary Examiner.*