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[54] ELECTRONIC RELAY AND IGNITION SYSTEM UTILIZING SAME

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[51] **Int. Cl.**.....**F02p 3/06**

[58] **Field of Search** .....123/148 AC, 148 DC, 148 E; 307/239, 246–255

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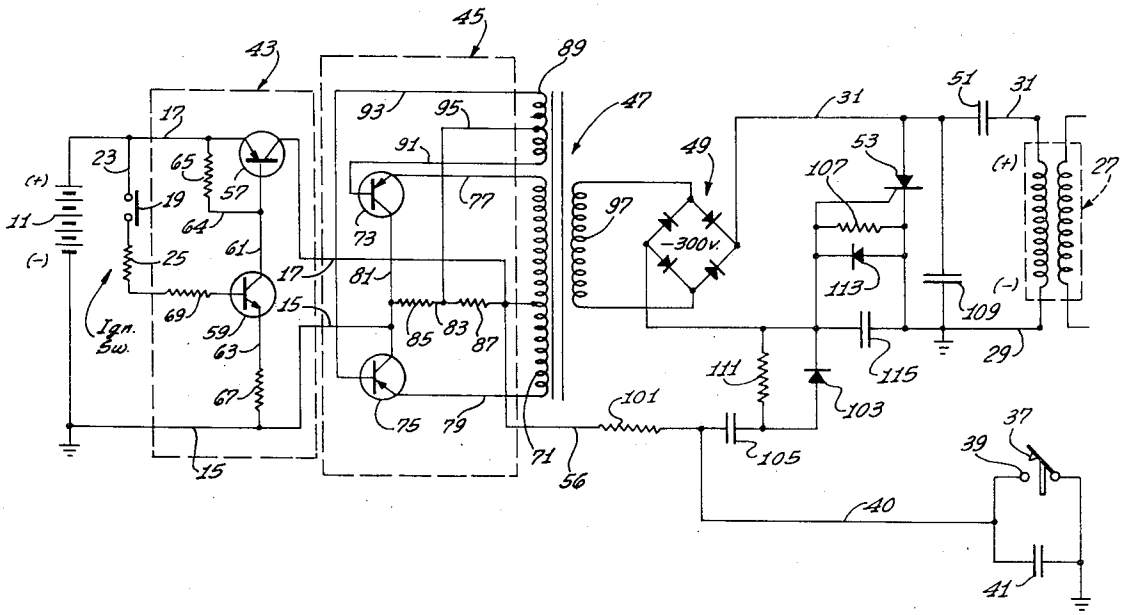
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[57] **ABSTRACT**

This disclosure describes an electronic relay which is particularly adapted for use with a capacitor discharge ignition system to control the supply of current from the battery to the capacitor discharge ignition system. The electronic relay may include first means for at least substantially preventing the flow of electrical energy from the battery to the capacitor discharge ignition means and second means electrically connectible to the ignition switch and responsive to receiving electrical energy therefrom when the ignition switch is closed to permit the flow of the electrical energy from the source of electrical energy to the capacitor discharge means.

11 Claims, 2 Drawing Figures



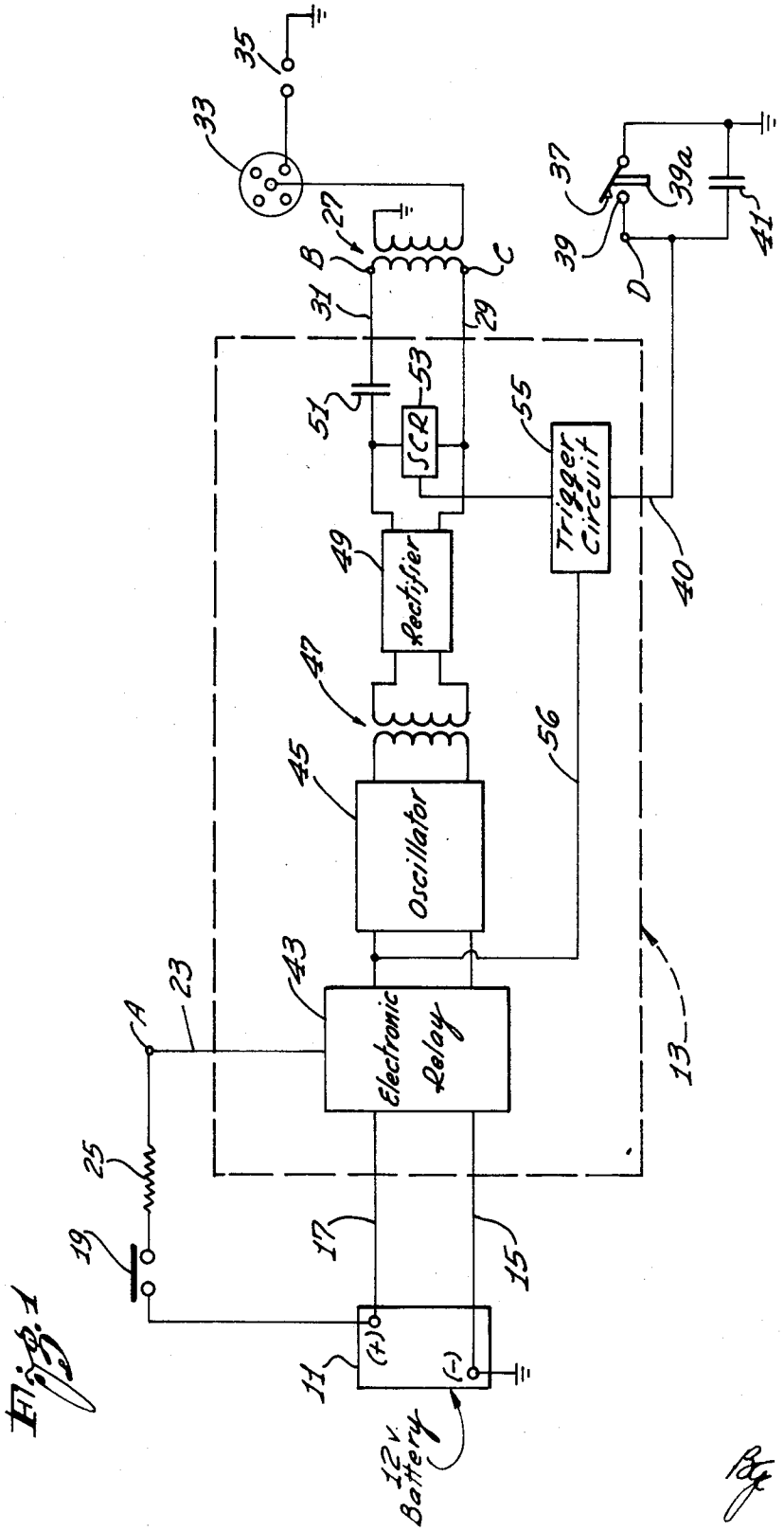


Fig. 1

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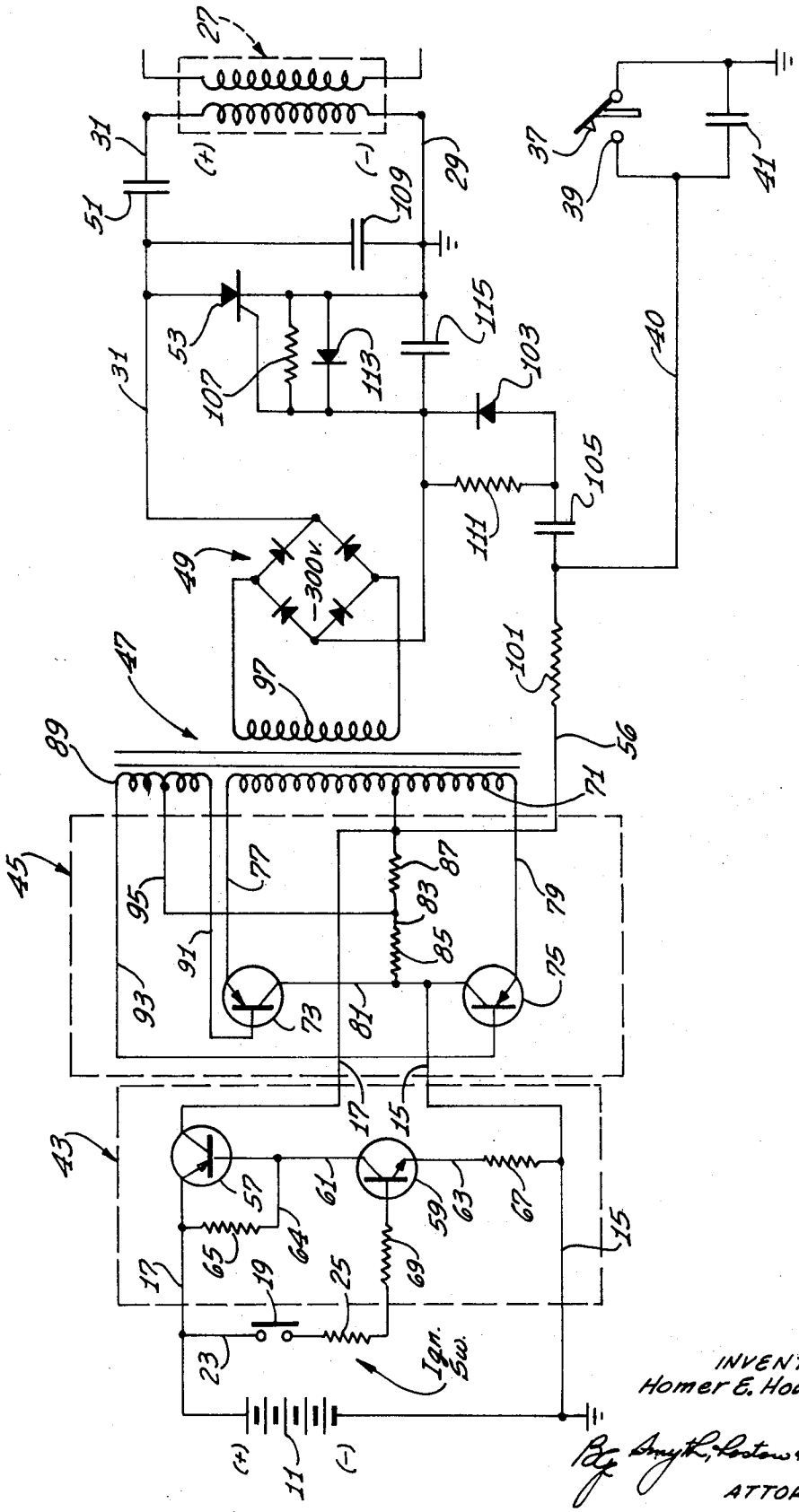


Fig. 2

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ELECTRONIC RELAY AND IGNITION SYSTEM UTILIZING SAME

BACKGROUND OF THE INVENTION

Automotive vehicles have for many years employed ignition systems which utilize the build-up and collapse of a magnetic field in a saturable reactor. The conventional saturable reactor ignition system includes a coil or transformer which is supplied with electrical energy from the battery when the ignition switch is closed and cam driven breaker points for controlling the discharge of the coil. Electrical energy from the coil is directed to the appropriate spark plug by the distributor.

This type of system performed satisfactorily many years ago when the typical engine had only four or six cylinders and was of the slow speed and low compression type. However, with the advent of the modern eight cylinder high-speed and high-compression engine, the saturable reactor ignition system is quite inadequate.

As speed of the internal combustion engine increases, the ignition system requires an increase in electrical power. The ignition system power demand is proportional to engine rpm. This creates a serious problem because as engine rpm increases, the time available for energization of the coil decreases so that the current or power actually received for the production of the spark is reduced as engine rpm increases. Stated differently, the current or power available for spark production varies inversely with the demand of the system.

Numerous attempts have been made to obviate this problem. One of the most common is the use of a 12 volt battery, a 6 volt coil and a resistor in series with the ignition switch to reduce the voltage applied to the coil to approximately 7 volts at low rpm. The voltage drop in this resistor is also an inverse function of engine speed so a higher voltage is applied to the coil as engine speed increases. This series resistor is now utilized in most automobiles, and although it has alleviated the problem to some degree, it has not solved it.

An improved form of ignition system is the capacitor discharge ignition system. Such systems typically include a transformer for increasing battery voltage, a capacitor for storing the high voltage current, and a suitable means for discharging the energy stored in the capacitor across the primary of the coil. A primary advantage of a capacitor discharge ignition system is that the energy content of each capacitor storage discharge is constant, and thus such a system draws power from the primary source at a rate which varies directly with the demand. Thus, a capacitor discharge system draws twice the power at 4,000 rpm that it does at 2,000 rpm.

There are numerous capacitor discharge ignition systems available; however, the installation of such systems on existing vehicles is most difficult. For proper operation, the capacitor discharge system must draw full battery power, and accordingly, the series resistor described hereinabove must be bypassed. This presents a most serious installation problem in that this series resistance is in the form of an elongated conductor intermediate the ignition switch and the coil. In order to bypass this resistance and still utilize the ignition switch to turn the engine on, a direct electrical connection must be made at the ignition switch itself. Because of the location of the ignition switch, this connection is difficult or impossible to make.

SUMMARY OF THE INVENTION

The present invention makes it possible to gain full effectiveness from a capacitor discharge ignition system by utilizing an electronic relay which is responsive to the application of current thereto when the ignition switch closes to permit full battery power to be supplied to the capacitor ignition discharge system. With the present invention, the presence or absence of the resistor in series with the ignition switch has no effect on the capacitor ignition discharge system even though the system is not connected directly at the ignition switch. This materially facilitates installation or retrofit of the capacitor ignition discharge system on existing vehicle as it can be electrically connected to the ignition switch at a location physically substantially remote from the ignition switch.

Although other electronic relays may be used, results are optimized with the electronic relay of this invention. According to the present invention, the electronic relay preferably includes a power transistor and a control transistor. The control transistor operates as a switch which is turned on by the application of a small current thereto. When the control transistor conducts, it renders the power transistor conductive.

The control transistor can be electrically connected to the ignition switch so that the ignition switch controls the flow of current to the control transistor from the battery. The control transistor is of the type which is operated by the application of a very small current and the presence of the conventional series resistor has no effect on its operation.

When the control transistor conducts, the current flowing therethrough renders the power transistor conductive so that full battery power less minor losses in the power transistor is applied to the capacitor ignition discharge system. With the transistors arranged in this fashion, the power gain equals the product of the individual power gains of the transistors. This means that the current flowing through the control lead to the control transistor draws minimum current in relation to the current supplied to the capacitor ignition discharge system through the power transistor and there is a minimum power loss through the resistor in series with the ignition switch. With this construction, the electronic relay and the capacitor ignition discharge system can be physically located next to the battery and connected thereto with short heavy cables, and the control lead from the control transistor, which must be of substantial length can be a small wire.

The power transistor and the control transistor should be of opposite polarity and with the conventional automobile ignition system, they should be of the PNP and NPN types, respectively. Preferably the control transistor is operated as an emitter follower in cascade with the power transistor which operates as a collector follower. With this arrangement, the power transistor is rendered conductive or nonconductive in response to the application and removal, respectively, of a small signal voltage to the base of the control transistor.

Although the electronic relay of this invention can be used in other environments, it is particularly adapted for use with a capacitor ignition discharge system. When so used, the resulting ignition system can be very easily installed on existing vehicles. The capacitor ignition discharge system of this invention can be installed

on an existing vehicle by simply attaching six different leads to very accessible portions of the existing ignition system, and there is no need to cut or remove any of the existing wiring.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view of an ignition system constructed in accordance with the teachings of this invention.

FIG. 2 is a schematic wiring diagram of a preferred form of the capacitor ignition discharge system and the electronic relay.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a dc power source in the form of a battery 11 supplies electrical energy to a capacitor discharge ignition system 13 through a pair of leads 15 and 17. The capacitor discharge ignition system 13 is turned on and off by an ignition switch 19 which is connected between the positive terminal of the battery 11 and a control lead 23 from the capacitor discharge ignition system 13. A resistor 25 is provided in series with the ignition switch 19 for the purpose of improving the spark when the capacitor discharge ignition system 13 is not utilized. The resistor 25 is typically in the form of an elongated cable extending away from the ignition switch 19 and is found on substantially all of the existing automotive vehicles.

When the ignition switch 19 is closed, the capacitor discharge ignition system periodically supplies electrical energy to a coil 27 through leads 29 and 31. The coil 27 steps up the voltage supplied thereto and supplies it to a distributor cap 33 of a distributor which supplies the energy to a spark gap 35. Although only one spark gap 35 is shown in FIG. 1, there will, of course, be one of such spark gaps for each cylinder of the engine with which the ignition system is being utilized.

The distributor also has the usual breaker points 37 and 39 which are driven by the cam shaft 39*a* of the engine with which the ignition system is utilized. The breaker points 37 and 39 are connected to the capacitor discharge ignition system by a lead 40. When the points 37 and 39 are closed, the capacitor discharge ignition system 13 is building up its charge, and when the points are opened, the system 13 discharges the energy stored therein to the primary winding of the coil 27. In this manner, the breaker points 37 and 39 control the rate at which pulses of energy are supplied to the coil 27.

A condenser 41 is connected in parallel with the breaker points 37 and 39. This is the standard condenser which is provided for most, if not all, conventional ignition systems.

All of the components of the ignition shown in FIG. 1 except for the capacitor discharge ignition system 13 may be conventional. In addition, the typical conventional system would include a conductor (not shown) joining a point A adjacent the resistor 25 to a point B adjacent the primary winding of the coil 27 and a second conductor joining a point C on the coil with a point D near the breaker points 37 and 39. To install the capacitor discharge ignition system, it is only necessary to disconnect the points A and B and the points C and D and to connect the leads 15, 17, 23, 29, 31 and 40, as shown.

With further reference to FIG. 1, the capacitor discharge ignition system 13 includes an electronic relay 43 to which dc current is supplied by the leads 15 and 17. The electronic relay 43 receives a small signal current from the battery 11 through the lead 23 when the ignition switch 19 is closed. The electronic relay 43 normally blocks the flow of current from the battery to the remainder of the capacitor discharge ignition system 13, but is responsive to receiving the signal current through the ignition switch 19 and the lead 23 to permit conduction of the battery current therethrough to an oscillator or inverter 45 which converts dc to ac. This permits stepping up of the voltage in a transformer 47. By way of example, if the battery 11 is a 12 volt battery, the transformer 47 may increase the voltage to about 300 volts.

The alternating current from the transformer 47 is converted back to dc in a rectifier 49. The current from the rectifier 49 charges a capacitor 51 with the discharge of the capacitor being prevented by a silicon control rectifier 53 which is nonconductive when the breaker points 37 and 39 are closed. A trigger circuit 55 which receives direct current from a lead 56 is responsive to opening of the points 37 and 39 to make the SCR 53 conductive to permit the capacitor 51 to discharge the energy stored therein across the primary winding of the coil 27. This energy in the coil 27 is then utilized to produce a spark across the spark gap 35 to initiate combustion of the fuel-air mixture within the cylinder of the engine.

Referring to FIG. 2, the electronic relay 43 includes a power transistor 57 and a complementary control transistor 59. In the embodiment illustrated, the transistor 57 and 59 are of the PNP and NPN types, respectively. The power transistor 57 and the control transistor 59 are cascaded with the power transistor 57 operating as a collector-follower and the control transistor operating as an emitter-follower.

As shown in FIG. 2, the lead 17 is connected to the emitter of the transistor 57 and extends through the relay 43 while the grounded lead 15 also extends through the relay 43. A conductor 61 electrically connects the base of the transistor 57 to the collector of the control transistor 59 while a second conductor 63 connects the emitter of the transistor 59 to the grounded lead 15. A conductor 64 is connected between the conductor 61 and the lead 17 around the emitter of the power transistor 57 and a biasing resistor 65 is provided in the conductor 64 to control the voltage in the conductor 61. A load resistor 67 is connected between the emitter of the transistor 59 and the grounded lead 15. Control current is applied to the base of the transistor 59 when the ignition switch 19 is closed through the resistor 25 and a resistor 69.

The transistor 59 may be very small and draws only a very small current which may be of the order of 0.005 amp. Thus, when the ignition switch 19 is closed, a very small amount of current acts on the base of control transistor 59 to render it conductive. The resistor 69 is preferably large in comparison with typical values of the resistor 25 and may be of the order of 100 ohms so that variations of the resistance of the resistor 25 from one vehicle to the next will have little effect. The re-

sistor 69 serves to assist in establishing the desired current which is applied to the base of the transistor 59.

With the ignition switch 19 open, a positive 12 volts is supplied through the conductor 64 to the base of the power transistor 57; however, because the transistor 59 is nonconductive with the ignition switch 19 open, there is no current flow in the conductors 61 and 64, and accordingly, the power transistor 57 is turned off and prevents supply of current to the remainder of the capacitor discharge ignition system. With the closing of the ignition switch 19, the control transistor 59 becomes conductive so that there is a small current flow in the conductors 61 and 63 and through the transistor 59 to the grounded lead 15. The power transistor 57 is responsive to this current flow to become conductive to thereby permit the supply of current therethrough to the remainder of the system 13.

The resistor 67 limits current flow to ground and therefore prevents burnout of the small control transistor 59. Although the particular resistance of the resistor 67 must be selected depending upon the current capacity of the transistor 59, in the embodiment illustrated, it is of the order of 50 ohms.

When the ignition switch 19 is opened, the current bias on the base of the transistor 59 is removed and this transistor shuts off to thereby open the circuit from the base of the transistor 57 to the grounded lead 15. Although the resistance of the resistor 65 is dependent upon the design parameters for the relay 43, in the embodiment illustrated, it is of the order of 100 ohms.

With the transistors 57 and 59 cascaded as shown, the total gain across the relay is the product of the gains of both of the transistors. Thus, assuming gains of 40 and 50 for the transistors 57 and 59, respectively, a control current of 0.005 amp applied to the base of the transistor 59 can control a current of 10 amps in the lead 17. As the lead 23 conducts only minimal current, the power loss there is negligible. Physically the lead 23 can be very small, and only the leads 15 and 17 between the relay 43 and the battery should be heavy in order to handle full battery current.

It can be seen, therefore, that the relay 43 is responsive to the application of a small control current to permit substantially full battery current to be supplied to the load. Although the electronic relay 43 may be utilized in various environments to control the supply of the current to many different kinds of loads, in the embodiment illustrated, it is utilized as a portion of a capacitor discharge ignition system to control the supply of current thereto.

In FIG. 2, the oscillator 45, the transformer 47 and the rectifier 49 are in the form of a dc to dc converter. The lead 17 supplies a positive voltage to a center tap of a primary winding 71 of the transformer 47 and the direction of current flow from the center tap through the primary winding 71 will depend upon which of two transistors 73 and 75 are in a conductive state. As shown, the emitters of the transistors 73 and 75 are connected to the opposite ends of the primary winding 71 by conductors 77 and 79, respectively, with the collectors of the transistors being connected by a conductor 81. The lead 17 and the conductor 81 are interconnected by a conductor 83 having resistors 85 and 87 therein. The transistors 73 and 75 are controlled by a control winding 89, the opposite ends of which are connected by conductors 91 and 93 to the bases of the transistors 73 and 75, respectively, and the center of which is connected to the conductor 83 intermediate the resistors 85 and 87 by a conductor 95.

The transformer 47 also includes a secondary winding 97 in which a high voltage current is induced by the primary winding 71. The efficiency of the transformer is enhanced by the use of ferrite cores for the windings 71, 89 and 97, and this also permits a high conversion frequency in order to obtain high power from relatively small components. In the embodiment illustrated, the frequency of the alternating current may be approximately 6,000 cycles per second. In operation of the dc to dc converter, a positive current is supplied to the center of the coil 71 and the oscillator functions as a feedback oscillator to induce a high frequency voltage in the secondary winding 97 with the secondary voltage alternating between positive and negative values.

In the embodiment illustrated, the rectifier 49 is a full wave diode bridge rectifier. The rectifier 49 supplies direct current through the lead 29, the primary of the coil 27 and the lead 31 to charge a capacitor 51. The capacitor 51 cannot discharge electrical energy stored therein because the SCR 53 is in a non-conductive state.

A positive voltage is supplied through the lead 56 and a resistor 101 to the lead 40. With the breaker points 37 and 39 closed, the positive voltage flows therethrough to ground; however, when the breaker points open, current flows through a diode 103 charging a capacitor 105. The voltage appearing at the gate of the SCR across a resistor 107 triggers the SCR 53 into full conduction which connects the capacitor 51 directly across the primary of the coil 27 causing the capacitor 51 to discharge its energy into the primary winding of the coil. This sudden discharge of energy into the primary of the coil 27 induces a high voltage in the secondary winding of the coil 27. Because the capacitor 51 and the inductance of the primary winding of the coil 27 form a high-frequency oscillatory circuit, the capacitor 51 overswings in voltage and charges in the opposite direction thereby applying a momentary reverse voltage to the anode of the SCR 53 turning the latter off. A capacitor 109 which is connected between the leads 29 and 31 functions as a safety device in delaying application of the recharge cycle to within the safe limits of the SCR 53 dv/dt rating.

When the breaker points 37 and 39 close, the capacitor 105 is discharged through a resistor 111. A capacitor 115 filters the high-frequency components of the oscillator from appearing at the gate of the SCR. As a precaution against the false triggering of the SCR 53 due to any breaker point bounce which might occur, a diode 113 is provided to clamp the SCR gate negative for the period during which the capacitor 51 is being charged. Although in the illustrated embodiment, the cam driven distributor points act as a timing mechanism to control discharge of the capacitor discharge system, other timing means can be used.

Although exemplary embodiments of the invention have been shown and described, many changes, modifications and substitutions may be made by one having ordinary skill in the art without necessarily departing from the spirit and scope of this invention.

I claim:

1. In an ignition system electrically connectible to a source of electrical energy and including an ignition switch electrically connectible to the source of electrical energy, a coil having primary and secondary windings, a resistor connected between the ignition switch and the primary winding of the coil, a capacitor discharge ignition circuit for supplying electrical energy from the source of electrical energy to the primary winding, the improvement comprising:

conductor means electrically connectible to the source of electrical energy and to the capacitor discharge ignition circuit to supply electrical energy from the source of electrical energy to the capacitor discharge ignition circuit; and

semiconductor means in said conductor means for at least substantially preventing the flow of current from the source through said conductor means to said capacitor discharge ignition circuit when the ignition switch is open; and second means coupled to the ignition switch to receive current from the electrical energy source through the ignition switch when the ignition switch is closed and responsive to receiving electrical current from the ignition switch when the latter is closed to render said semiconductor means conductive to permit flow of current from the electrical energy source through said conductor means to the capacitor discharge ignition circuit.

2. An improvement as defined in claim 1 wherein said semiconductor means includes a first transistor in said conductor means for normally blocking the flow of current from said electrical energy source through said conductor means to said capacitor discharge ignition circuit and said second means includes a second transistor having the base thereof electrically connectible to the ignition switch, said transistors being of different polarities, said improvement also including circuit means for electrically connecting the transistors whereby the current from said ignition switch renders said second transistor conductive and the current then flowing in said circuit means renders the first transistor conductive to thereby permit supply of electrical energy from the source of electrical energy through said conductor means to said capacitor discharge ignition circuit.

3. An improvement as defined in claim 2 including means for causing the second transistor for drawing significantly less current than said first transistor.

4. A vehicle ignition system of the type having an ignition switch electrically connectible to a source of electrical energy, said vehicle ignition system comprising:

capacitor discharge ignition means electrically connectible to the source of electrical energy for supplying pulses of electrical energy for use in producing ignition sparks;

semiconductor means for at least substantially preventing the flow of electrical energy from the source of electrical energy to said capacitor discharge ignition means; and

control means electrically connectible to the ignition switch and responsive to receiving electrical energy therefrom when the ignition switch is closed to render said semiconductor means conductive to permit the flow of electrical energy from the source of electrical energy to the capacitor discharge ignition means.

5. An ignition system as defined in claim 4 wherein said control means is also responsive to the failure of said control means to receive electrical energy from the ignition switch as a result of the opening of the ignition switch to cause said semiconductor means to return to its substantially nonconductive state in which the semiconductor means substantially prevents flow of electrical energy from the source of electrical energy to the capacitor ignition discharge system.

6. A vehicle ignition system as defined in claim 4 wherein said control means includes semiconductor means responsive to receiving electrical energy from the ignition switch when the latter is closed to render the first mentioned semiconductor means conductive.

7. A vehicle ignition system as defined in claim 4 wherein said semiconductor means includes a PNP transistor and said second means includes an NPN transistor and circuit means for interconnecting the collector of the NPN transistor to the base of the PNP transistor, the base of the NPN transistor being electrically connectible to the ignition switch whereby closing of the ignition switch supplies current to the base of the NPN transistor to render the latter conductive to permit current to flow in said circuit means to thereby render the PNP transistor conductive to permit the supply of electrical energy therethrough to the capacitor discharge ignition means.

8. A vehicle ignition system as defined in claim 4 wherein said capacitor discharge ignition means includes means for increasing the voltage of the electrical energy supplied thereto by the source of electrical energy, a capacitor for receiving the electrical energy of increased voltage and chargeable in response thereto, and means for causing said capacitor to discharge the electrical energy stored therein to supply electrical energy for the production of an ignition spark.

9. An ignition system as defined in claim 4 including a first conductor for electrically interconnecting the semiconductor means and the source of electrical energy and second conductor means for electrically connecting the control means and the ignition switch, said first conductor being of greater cross sectional area than said second conductor.

10. A vehicle ignition system having an ignition switch electrically connectible to a source of electrical energy, said vehicle ignition system comprising:

ignition means for supplying pulses of electrical energy for use in producing ignition sparks;

first and second conductor means of different potentials, said first conductor means being connected to said ignition means;

a first transistor connected in series with said first conductor means to selectively permit and prevent the flow of electrical energy therethrough to said ignition means; and

a second transistor connected across said conductor means to operate said first transistor, said second transistor being operable in response to the electrical energy received from the source of electrical energy through the ignition switch when the ignition switch is closed whereby the first transistor is controlled by the ignition switch.

11. An ignition system for retrofit on a vehicle having a source of electrical energy, an ignition switch coupled to the source of electrical energy, a resistor in series

with the ignition switch, and a coil, said ignition system comprising:

a capacitor discharge ignition system coupled to the coil for supplying electrical energy thereto;

conductor means for coupling the capacitor discharge ignition system to said source along a conductive path which excludes said resistor;

a semiconductor having conductive and nonconductive states;

means for connecting said semiconductor in series with said ignition switch and said resistor whereby upon the closing of the ignition switch the semiconductor receives electrical energy from said source which causes said semiconductor to assume the conductive state, said semiconductor becoming nonconductive upon the opening of the ignition switch; and

said conductor means including means responsive to said semiconductor being in said conductive and nonconductive states to close and open said conductive path, respectively, whereby the capacitor discharge ignition system is supplied with full power from said source when the ignition switch is closed.

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