

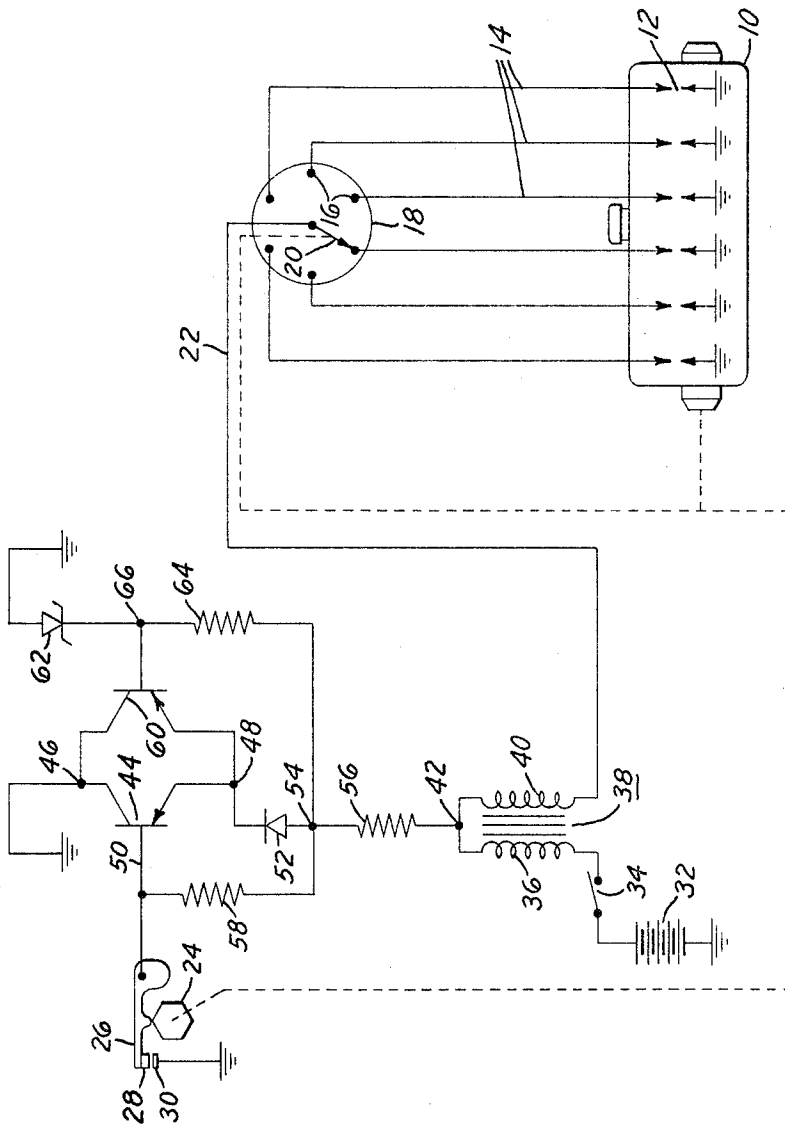
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TRANSISTOR IGNITION SYSTEM HAVING A PROTECTIVE CIRCUIT

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TRANSISTOR IGNITION SYSTEM HAVING A PROTECTIVE CIRCUIT

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This invention relates to a transistor ignition system where a transistor controls the current flow through the primary winding of an ignition coil and more particularly to a transistor ignition system which is provided with a circuit for protecting the power transistor from excessive voltages.

The present invention is concerned with a transistor ignition system of a type where a transistor is connected in series with the primary winding of an ignition coil and is turned on and off by a timing device such as breaker points. This type of ignition system is well known to those skilled in the art and the present invention is concerned with protecting the transistor that controls primary winding current during high voltage conditions.

It has been found that in transistor ignition systems of the type just described, the primary voltage may at times rise to such a value as to damage the transistor that is controlling primary winding current. In order to protect the transistor, a Zener diode can be connected across the emitter and collector electrodes of the transistor. The Zener diode is selected to have a break down voltage which is less than a voltage which would damage the transistor and the Zener diode therefore protects the transistor by not permitting the voltage to rise to a point where the transistor is damaged.

The system that uses the Zener diode has been acceptable but the Zener diode in such a system is a relatively expensive component because of the voltage and current it must handle in protecting the power transistor.

In contrast to the system where a Zener diode is connected directly across the emitter and collector electrodes of the transistor in order to protect the transistor, it is proposed by this invention to use a system that includes a small Zener diode and a low cost type of transistor for protecting the power transistor that controls primary winding current. It therefore is one of the objects of this invention to provide a protective circuit for the power transistor that includes a small Zener diode of lower cost and a low cost type of trigger transistor.

Another object of this invention is to provide a transistor ignition system where the power transistor is shunted by a low cost trigger transistor and where the conduction of the trigger transistor is controlled by a small low cost Zener diode. In carrying this object forward, the Zener diode is connected in the base circuit of the trigger transistor and provides a path for base current for the trigger transistor when an excessively high voltage is applied across the Zener diode.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein preferred embodiments of the present invention are clearly shown.

The single figure drawing is a schematic circuit diagram of a transistor ignition system made in accordance with this invention.

Referring now to the drawing, the reference numeral 10 designates an internal combustion engine which has a plurality of spark plugs 12. The spark plugs 12 are connected respectively with spark plug wires 14 which are connected with the electrodes or inserts 16 of a

distributor cap 18. A rotor contact 20 is rotatably driven by the engine 10 as is depicted by the dotted lines and this rotor contact is capable of transferring spark firing energy from a high voltage lead 22 to one of the inserts or electrodes 16. The rotor contact 20 is synchronized with rotation of the cam shaft of the engine 10 as is well known to those skilled in the art.

The engine 10 in addition to driving the rotor contact 20 drives a cam 24 which moves a breaker arm 26. The breaker arm 26 carries a breaker contact 28 which cooperates with a grounded breaker contact 30. The breaker arm 26 is normally urged to a position where the contacts 28 and 30 are engaged by a spring (not shown) and is moved to an open position by the lobes of the cam 24 as the cam rotates.

The rotation of rotor contact 20 and the breaker cam 24 are synchronized with operation of the engine 10. This can be accomplished by the use of a conventional distributor which has a breaker contact apparatus, the rotor contact and the distributor cap.

The reference numeral 32 designates a source of direct current which is illustrated as a battery. It will be appreciated that the source of direct current may be a generator as in a motor vehicle system where the generator charges the battery.

The negative side of the source of direct current 32 is grounded and the positive side is connected with a manually operable ignition switch 34. The ignition switch is connected with the primary winding 36 of an ignition transformer generally designated by reference numeral 38. This ignition transformer has a secondary winding 40 one side of which is connected with the high voltage conductor 22. The primary and secondary windings 36 and 40 are connected together at junction 42.

The transistor ignition system has a PNP power transistor 44. The collector of transistor 44 is connected with a grounded junction 46. The emitter of transistor 44 is connected with a junction 48. The base of transistor 44 is connected with conductor 50 and this conductor is connected with breaker contact 28 through the conductive breaker arm 26.

A PN junction semiconductor diode 52 has its cathode connected with junction 48 and its anode connected with junction 54. A ballast resistor 56 is connected between the junctions 42 and 54. A resistor 58 connects the junction 54 and the conductor 50.

The ignition system as thus far described is conventional and the improvement in this ignition system is the provision of a protective circuit. This protective circuit includes a low cost PNP trigger transistor 60, a low cost low power Zener diode 62 and a resistor 64. The base of the trigger transistor 60 is connected with junction 66. The Zener diode 62 is connected between junction 66 and ground. The resistor 64 is connected between junctions 54 and 66.

The collector of transistor 60 is connected with the grounded junction 46 while the emitter of transistor 60 is connected with junction 48.

When the ignition switch 34 is closed and the breaker cam 24 is being driven as when the engine 10 is being cranked or when it is running, the breaker contacts 28 and 30 will be opened and closed and the rotor contact 20 will sweep past the fixed contacts or inserts 16 of the distributor cap. When the breaker contacts 28 and 30 are closed, current will flow from the positive side of the battery 32, through the closed ignition switch 34, through primary winding 36, through resistor 56, through the diode 52, through the emitter-base circuit of transistor 44, through conductor 50, through breaker lever 26 and through the closed contacts 28 and 30 to ground. Current will also flow through resistor 58 when the

breaker contacts 28 and 30 are closed and the voltage drop across resistor 58 applies a forward bias to transistor 44 so that this transistor now becomes conductive in its emitter-collector circuit. Since transistor 44 is now switched on in its emitter-collector circuit, current can flow from the positive side of battery 32, through the closed ignition switch 34, through primary winding 36, through resistor 56, through diode 52, and then through the emitter-collector circuit of transistor 44 to ground.

With current flowing through the primary winding 36, the ignition coil 38 begins to store inductive energy. When the breaker contacts 28 and 30 open, the transistor 44 is biased to a nonconductive state which substantially opens the circuit for primary winding current. When the primary circuit is opened, a large voltage is induced in the secondary winding 40 which is applied to one of the spark plugs via conductor 22, rotor contact 20, one of the fixed contacts 16 of the distributor cap and then through one of the spark plug wires 14. It is seen that one of the spark plugs 12 is fired when the breaker contacts 28 and 30 open.

The trigger transistor 60 has its emitter-collector circuit connected in parallel with the emitter-collector circuit of the main power transistor 44. The transistor 60 will not be conductive in its emitter-collector circuit unless the Zener diode 62 breaks down in a reverse direction. If a high voltage is developed in the system which might damage the transistor 44, the Zener diode 62 will break down causing current to flow through resistor 64 toward ground. The voltage drop across resistor 64 will bias the transistor 60 to a conductive condition in its emitter-collector circuit since the emitter will be driven positive with respect to its base. When transistor 60 turns on in its emitter-collector circuit, it shunts the main power transistor 44 to protect it against the high voltage condition that may occur in the ignition system.

The break down voltage of the Zener diode 62 is selected such that it will break down at a voltage that is less than would be capable of damaging the transistor 44 when it is nonconductive. By way of example and not by way of limitation, if it is desired to limit the maximum voltage across the emitter and collector of transistor 44 to 80 volts which is the maximum voltage that can be applied without damage to the transistor, the circuit components including the Zener diode 62 can be selected such that when the voltage across the emitter and collector of transistor 44 reaches 60 volts, the Zener diode breaks down. It will, of course, be appreciated that the Zener diode 62 need not be a 60 volt Zener diode since it is connected in series with the resistor 64 and only a portion of the total voltage is applied across the zener diode.

From the foregoing, it can be seen that a protective circuit has been provided which includes a small Zener diode and a low cost transistor for protecting the main power transistor. This protection will take place during high voltage conditions as may occur when the transistor 44 is driven nonconductive or during an open secondary of the ignition coil.

In the system that has been described, the switching of the transistor 44 is controlled by the opening and closing of breaker contacts 28 and 30. The protective circuit of this invention is applicable to systems where ignition timing can be controlled by devices other than breaker contacts. Thus the conduction of transistor 44 could be controlled by a transistor switch operated by an engine driven magnetic pick-up or other arrangements and it is contemplated that the protective circuit of this invention can be used with a transistor ignition system regardless of the type of device that is used for triggering the system.

While the embodiments of the present invention as herein disclosed constitute a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. In combination, an internal combustion engine, a

plurality of spark plugs for said engine, a source of direct current, an ignition coil having a primary winding and a secondary winding, spark distributing means driven by said engine connected with said spark plugs, means connecting said secondary winding with said spark distributing means, a timing device driven by said engine, a first transistor having emitter, collector and base electrodes, means connecting said primary winding and the emitter and collector electrodes of said first transistor across said source of direct current, means connecting the base electrode of said transistor with said timing device, a second transistor, means connecting the emitter of said second transistor with the emitter of said first transistor, means connecting the collector of said second transistor with the collector of said first transistor, a voltage responsive network connected across the emitter and collector electrodes of said transistors, and means connecting a point on said voltage responsive network with said base electrode of said second transistor, said voltage responsive network including means for biasing said second transistor conductive when a voltage is developed across said emitter and collector electrodes of said first transistor and across said network of a predetermined magnitude and of a polarity to cause current to flow through said first transistor in a forward direction.

2. The combination according to claim 1 where the timing device comprises breaker contacts opened and closed in synchronism with operation of the engine.

3. The combination according to claim 1 where the timing device includes a switching means connected between the base electrode of the first transistor and one side of the source of direct current, said first transistor being biased conductive when said switching means is closed.

4. A transistor ignition system for an internal combustion engine comprising, a first, second and third terminal means, said first terminal means being adapted to be connected with the primary winding of an ignition coil, said second terminal means being adapted to be connected to one side of a source of direct current, said third terminal means being adapted to be connected with an engine operated timing device, a power transistor having emitter, collector and base electrodes, the emitter and collector electrodes of said power transistor being connected across said first and second terminal means, the base electrode of said power transistor being connected with said third terminal means, a trigger transistor having emitter, base and collector electrodes, the emitter and collector electrodes of said trigger transistor being connected respectively with the emitter and collector electrodes of said power transistor, a voltage responsive circuit connected across said first and second terminal means including in a series connection a resistor and a Zener diode connected together at a junction, and means connecting the base electrode of said trigger transistor with said junction, said resistor being connected across the emitter and base electrodes of said trigger transistor, said Zener diode being connected across the base and collector electrodes of said trigger transistor, said resistor developing a voltage to bias said trigger transistor conductive between its emitter and collector electrodes when the voltage appearing across said first and second terminal means reaches a value sufficient to break down said Zener diode.

5. A transistor ignition system comprising, a source of direct current, an ignition coil having a primary winding and a secondary winding, first and second transistors each having emitter, collector and base electrodes, means connecting the emitter electrodes of said transistors together, means connecting the collector electrodes of said transistors together, a circuit connected across said source of direct current including said primary winding and the emitter and collector electrodes of said first and second transistors, a switching means connected between the base electrode of said first transistor and one side of said source of direct current for varying the potential applied

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to said base electrode of said first transistor, said switching means being operated in synchronism with said engine, and a voltage responsive circuit connected across the emitter and collector electrodes of said first and second transistors, said voltage responsive circuit including in a series connection a resistor and a Zener diode connected together at a junction, and means connecting said junction with the base electrode of said second transistor, said resistor being connected across the emitter and base electrodes of said second transistor, said Zener diode being connected across the collector and base electrodes of said second transistor, said resistor developing a bias voltage for biasing said second transistor conductive

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between its emitter and collector electrodes when the voltage appearing across the emitter and collector electrodes of said transistors reaches a value sufficient to cause said Zener diode to break down.

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