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TRANSISTOR IGNITION SYSTEM

Original Filed Aug. 6, 1962

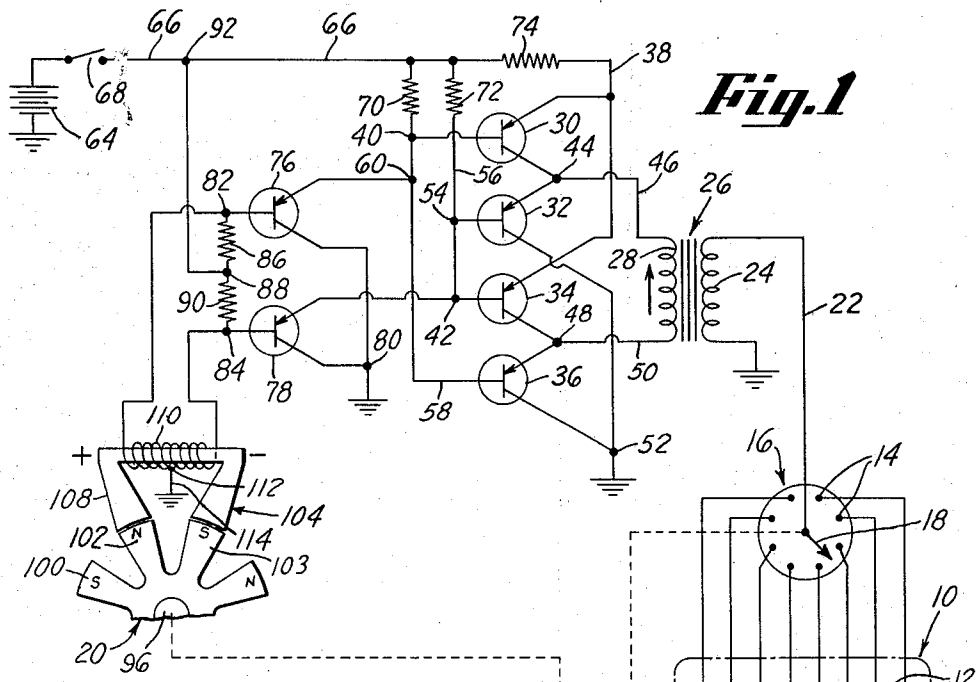


Fig. 1

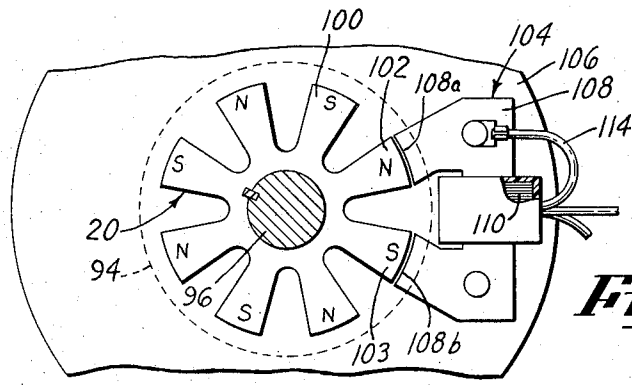


Fig. 2

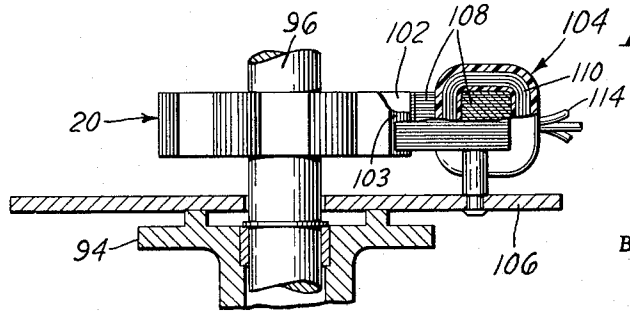


Fig. 3

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TRANSISTOR IGNITION SYSTEM

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3 Claims. (Cl. 310—70)

This invention relates to an ignition system for internal combustion engines and more particular to an ignition system wherein a semiconductor such as a transistor controls the current flow in the primary winding of the ignition coil. This application is a division of application S.N. 215,081, filed on August 6, 1962.

One of the problems encountered in the use of transistor ignition systems is the destructive kick back voltage which comes from the primary winding when the current flow to the primary winding is interrupted and which under certain conditions can destroy the transistor that controls primary current. In some instances, diodes and combinations of diodes and resistors have been used to block the kick back voltage or to provide a current path around the transistor for the energy developed by the kick back voltage.

One of the objects of this invention is to provide an ignition system wherein the kick back voltage is used to build up energy for firing a spark plug. This object is accomplished by continuously reversing the current flow through the primary winding of the ignition coil so that when an inverse kick back voltage occurs, the current flowing through the primary winding from a D.C. source is in the same direction as the current developed by the kick back voltage. In this system, transistors are used to control the current flow through the primary winding and the transistors are connected to provide current flows for the primary winding that are alternating in opposite directions.

Still another object of this invention is to provide a completely breakerless ignition system which is capable of causing a reversal in current through the primary winding of an ignition coil during operation of the ignition system.

A more specific object of this invention is to provide a transistor ignition system wherein the conduction of the transistors is controlled by a magnetic pick up device which has a center tapped pick up coil and a rotor which rotates relative to the pick up coil and which has sectors of alternate opposite magnetic polarities.

Another object of this invention is to provide a voltage pulse generating device which can be used to control a semiconductor ignition system or the like and which has an A.C. output that is substantially a square wave. This type of output voltage is useful since it can instantaneously reverse the bias voltage applied to one or more semiconductors such as transistors to cause them to switch sharply from one condition to the other. This object is carried forward by providing a magnetic rotor which has radially extending pole teeth that cooperate with the pole faces of a core. The rotor pole teeth have the same width and are spaced from each other by this same width. In addition, the pole faces of the core are spaced this same width and the pole faces themselves have the same width. As a result of this, the voltage output is an alternating square wave which is capable of sharply switching semiconductors such as transistors.

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.

In the drawings:

FIGURE 1 is a schematic circuit diagram of an ignition system made in accordance with this invention.

FIGURE 2 is a top view of a magnetic pick up device for controlling the ignition system of FIGURE 1.

FIGURE 3 is a side view of the magnetic pick up device illustrated in FIGURE 2.

Referring now to the drawings and more particularly to FIGURE 1, the reference numeral **10** designates an internal combustion engine which has a plurality of spark plugs **12** for firing the combustible mixture of the engine. In this particular instance, there are eight spark plugs for an eight cylinder engine but it will be apparent to those skilled in the art that the number of spark plugs can vary with the number of cylinders in the engine. The spark plugs **12** are connected with the electrodes **14** on a conventional distributor cap generally designated by reference numeral **16**. A rotor member **18** is driven in synchronism with the engine and is driven in synchronism with a rotor member **20** of a magnetic pick up which is more fully described hereinafter. The rotor contact **18** is electrically connected with a lead wire **22** coming from the secondary winding **24** of an ignition coil **26**.

It is seen that the opposite side of the secondary winding **24** is grounded and that the ignition transformer **26** has a primary winding **28**.

The current flow through the primary winding **28** is controlled by a plurality of semiconductor devices which in this case take the form of PNP transistors **30, 32, 34** and **36**. It can be seen that the emitter electrodes of transistors **30** and **34** are connected with a lead wire **38**. The base electrode of transistor **30** is connected with a junction **40** while the base electrode of transistor **34** is connected with junction **42**. The collector electrode of transistor **30** is connected with junction **44** and it can be seen that this junction is connected to one side of the primary winding **28** by a conductor **46**. The collector electrode of transistor **34** is connected with junction **48** and this junction is connected with the opposite side of primary winding **28** via a conductor **50**.

The emitter electrode of transistor **32** is connected with junction **44** while the collector electrode of this transistor is grounded through junction **52**. The base electrode of transistor **32** is connected with junction **54** on a lead wire **56**. The emitter electrode of transistor **36** is connected to junction **48** whereas the collector electrode of this transistor is grounded at junction **52**. The base electrode of transistor **36** is connected with junction **60** via the lead wire **58**.

Ignition power for the ignition system is supplied by a D.C. voltage source **64** which is illustrated as a battery. It will of course be appreciated that the battery supplies ignition power during cranking of the engine but that ignition power thereafter is supplied by a generator which also charges the battery in a motor vehicle system. In any event, ignition power is supplied to the system either from the battery or from a generator through a conductor **66** and a manually operable ignition switch **68**.

A resistor **70** connects the junction **40** with conductor **66** and another resistor **72** connects the conductor **56** with junction **54**. A resistor **74** is connected between lead wires **66** and **38**.

The conduction of transistors **30** through **36** is controlled by a magnetic pick-up device and a pair of PNP transistors **76** and **78**. The emitter electrode of transistor **76** is connected with junction **60** while the collector electrode of this transistor is connected with grounded junction **80**. The base electrode of transistor **76** is connected with junction **82**.

The emitter electrode of transistor **78** is connected with junction **42** while the collector electrode of this tran-

sistor is grounded at junction **80**. The base electrode of transistor **78** is connected with junction **84**.

A resistor **86** connects the junctions **82** and **88** and another resistor **90** connects the junctions **88** and **84**. It is seen that junction **88** is connected with junction **92** on the power supply conductor **66**.

The magnetic pick up assembly for controlling the ignition system is illustrated in FIGURES 2 and 3. This magnetic pick up assembly includes a base **94** which rotatably supports a shaft **96** that is driven by the engine. The shaft **96** carries the rotor **20** which is formed of a nickel material and which has eight radially directed pole tips or arms which are magnetized with opposite polarities as is depicted in FIGURE 2. In other words, the arm or pole tip **100** has a south polarity whereas the arm or pole tip **102** has a north polarity. This sequence continues for the other six pole tips as is clear from an inspection of FIGURE 2. The nickel rotor is permanently magnetized by a suitable magnetizing fixture so that the pole tips are permanently magnetized in a manner illustrated in FIGURE 2. The rotor thus is a permanent magnet with the pole tips having alternate opposite magnetic polarities. The arcuate ends of the pole tips are the same circumferential length as the gaps between the pole tips. In the embodiment illustrated, each arcuate end of a pole tip and gap is one sixteenth of a circle for an eight cylinder engine but this of course would change to one twelfth for a six cylinder engine, one eighth for a four cylinder engine and so forth.

The pick up coil assembly is generally designated by reference numeral **104** and is supported on a timing plate **106** which can be adjusted relative to the base **94**. This timing plate can be shifted around the axis of the shaft **96** by a suitable vacuum unit which is not illustrated and which would be connected with the intake manifold of the engine **10**. The magnetic pick up assembly includes a laminated core **108** formed of magnetic material such as steel laminations. A coil winding **110** is wound on the core and this coil winding is center tapped at **112** as is apparent from FIGURE 1. This center tap is grounded by lead wire **114** illustrated in FIGURE 1 and in FIGURE 2. It is seen that the ends **108***a* and **108***b* of the core **108** are arcuately shaped.

The pole faces **108***a* and **108***b* have the same arcuate length as the pole tips of rotor **20** and the gap between these pole faces is the same arcuate length of the pole faces **108***a* and **108***b*.

It will be appreciated that as the rotor **20** rotates, the flux passes from one pole tip then through the magnetic core and then back to another pole tip. Thus with the rotor in the position shown in FIGURE 2, the flux can flow from pole tip **102**, through the magnetic core **108** and then back to the pole tip **103**. This, of course, will cause a voltage to be induced in the center tapped coil winding **110**. It can be seen that as the rotor rotates, the magnetic flux is continuously reversed in the magnetic core **108**. In other words, the pole tip **102** is a north pole but when the rotor rotates so that pole tip **100** aligns with core face **108***a*, the flux through the core **108** is reversed in direction from the direction of flux flow with the parts in the position illustrated in FIGURE 2. It will be appreciated that there are only short instants of time wherein during movement of the rotor with respect to the core when the rotor pole tips are not aligned with at least some port of the pole faces **108***a* and **108***b*. During these instants, the field collapses and is instantly built up in the opposite direction. This provides a square wave voltage output which can sharply switch the transistors in a manner to be more fully described.

The operation of the ignition system of this invention will now be described. When ignition switch **68** is closed, the power line **66** is connected with one side of the direct current power source **64**. This biases the transistors **76** and **78** to their nonconductive states since a positive voltage is applied to their base electrodes through junction **92** and resistors **86** and **88**. It can be seen that the base current path for transistors **30** and **36** is through the emitter-collector circuit of transistor **76** and since this transistor is now off, the transistors **30** and **36** are turned off in their emitter-controllor circuits. The base current path for transistors **32** and **34** is through the emitter-collector circuit of transistor **78** and since this transistor is likewise turned off, the transistors **32** and **34** are turned off.

As the rotor **20** rotates, the voltage induced in the pick up coil will at certain positions of rotor **20** have a polarity as indicated in FIGURE 1 but this polarity will then be sharply reversed during continued rotation. This polarity thus continuously sharply reverses as the rotor **20** rotates.

When the voltage induced in the coil winding **110** has the polarity shown in FIGURE 1, the base of transistor **76** is driven positive whereas the base of transistor **78** is driven negative. With the base of transistor **78** negative, a base current flows in transistor **78** to turn it on in its emitter-collector circuit. This completes a base current path for transistors **32** and **34** and they turn on in their emitter-collector circuits. A circuit may now be traced for supplying current to the primary winding **28** which is from junction **92**, through lead wire **66**, through resistor **74**, through lead wire **38**, through the emitter-collector circuit of transistor **34**, through the primary winding **28** through lead wire **46**, through the emitter-collector circuit of transistor **32** and then to ground via junction **52**. This will cause a build up of current in the primary winding **28** with current flowing through this winding in the direction of the arrow indicated in FIGURE 1.

As the rotor **20** now rotates to reverse the flux in the core **108**, the voltage induced in the coil winding **110** is sharply reversed from its polarity shown in FIGURE 1. This drives the base electrode of transistor **78** positive to turn it off and therefore turn off transistors **32** and **34**. At the same time, the base electrode of transistor **76** is driven negative so it now conducts. With transistor **76** conducting, there is a base current path for transistors **30** and **36** and a circuit can now be traced in a reverse direction through primary winding **28**. This circuit is from lead wire **66**, through resistor **74**, through lead wire **38**, through the emitter-collector circuit of transistor **30**, through lead wire **46**, through primary winding **28**, and then through the emitter-collector circuit of transistor **36** to ground. It can be seen from the foregoing that as the rotor rotates, a pair of transistors shut off, for example, transistors **32** and **34**, while the other pair of transistors **30** and **36** turn on. The net effect of this is to break the circuit to the primary winding **28** for one direction of current flow which previously has been building up and then to complete a circuit for the primary winding for current flow in an opposite direction. During reversal of current flow through the primary winding **28**, a high voltage is induced in the secondary winding **24** which causes one of the spark plugs **12** of fire. The kick back voltage of primary winding **28** will be in the same direction as the next built up of current since the circuit for the primary winding is interrupted for one direction of flow but is then completed for another direction of current flow.

The resistors **86** and **88** are bias resistors for the base electrodes of transistors **76** and **78** as are the resistors **70** and **72** for the transistors **30** through **36**. The resistor **74** is a current limiting resistor.

The particular construction of the magnetic pick up of this invention plays an important part in insuring correct operation of the system. Thus, by using a magnetic rotor having equally spaced pole tips and gaps and a complementary core with the same spacing, a sharp switching action is attained with a square wave voltage output.

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. A pulse generator for controlling a semiconductor ignition system comprising, a base, a shaft supported by said base and adapted to be driven by an engine, a rotor driven by said shaft having a plurality of radially extending and circumferentially spaced arms, said rotor being a permanent magnet with its arms having alternate opposite magnetic polarities, a timing plate, and a coil assembly supported by said timing plate including a core member formed of magnetic material and a coil winding wound on said core member, said coil winding being tapped intermediate its ends, the ends of said arms cooperating with the pole faces of said core member and having equal lengths which are substantially equal to the gaps between the arms.

2. A voltage pulse generator for triggering a semiconductor ignition system comprising, a base member, a shaft rotatably supported by said base member and adapted to be driven by an engine, a permanent magnet rotor driven by said shaft having a plurality of radially extending and circumferentially spaced arms magnetized

with alternate opposite magnetic polarities, a timing plate adjustable relative to said rotor, a coil assembly supported by said timing plate including a magnetic core carrying a coil winding, said magnetic core having pole faces cooperating with the pole faces of said arms, the lengths of said pole faces of said arms, the length of the gap between said arms, the length of the gap between the pole faces of said core member and the length of the pole faces of said core member all being substantially equal.

3. The pulse generator according to claim 2 where the coil winding that is wound on the core member is tapped intermediate its ends.

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