IGNITION SYSTEM WITH MAGNETIC PULSE GENERATING MEANS

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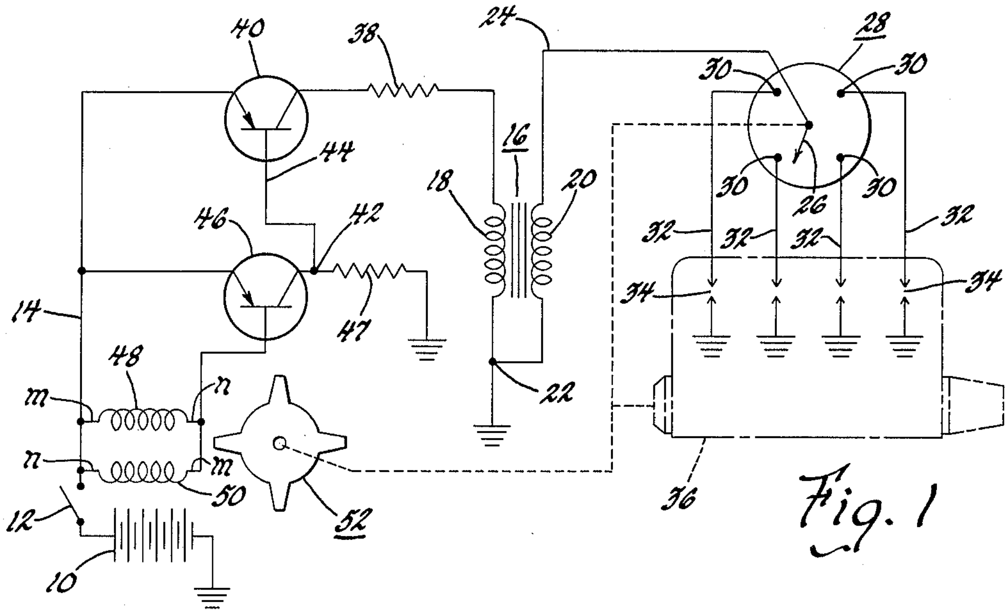

Fig. 1

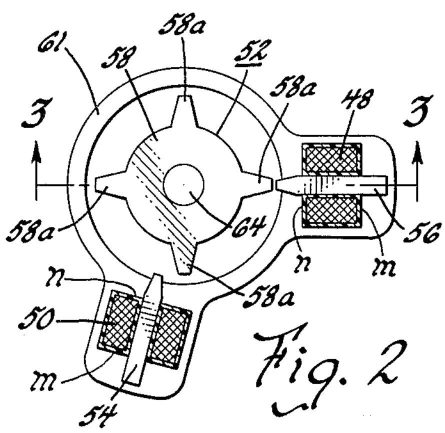

Fig. 2

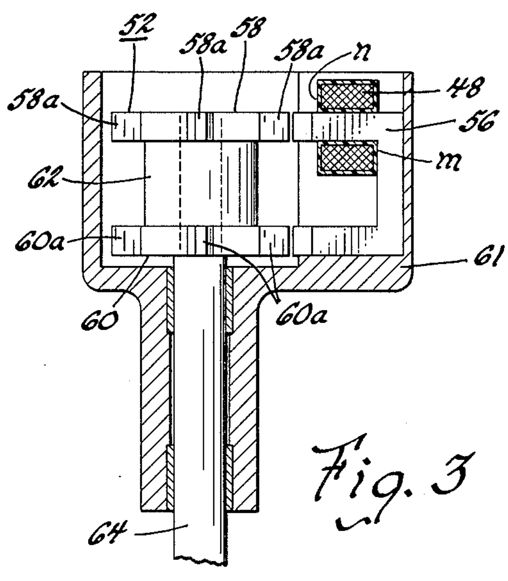

Fig. 3

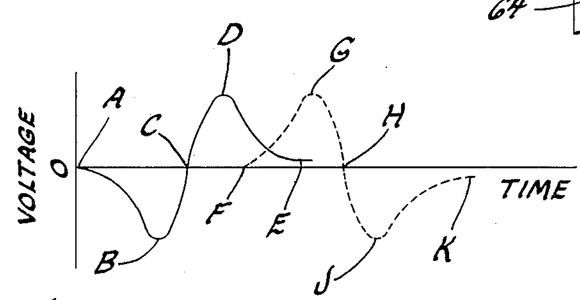

Fig. 4

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IGNITION SYSTEM WITH MAGNETIC PULSE GENERATING MEANS

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This invention relates to ignition systems for internal combustion engines and more particularly to a breakerless ignition system wherein a semiconductor such as a transistor controls the current flow through the primary winding of an ignition coil.

The present invention is directed to an ignition system for an internal combustion engine wherein a semiconductor such as a transistor controls the current flow through the primary winding of an ignition coil and wherein the semiconductor is turned on and off by a pulse generating means driven by the engine. In this type of system, the pulse generating means develops pulses of voltage which control the on and off time of the transistor to therefore periodically interrupt the current flow through the primary winding of the ignition coil. One of the problems encountered in this type of system is to maintain the transistor switched off for a sufficient period of time to permit a large voltage to be induced in the secondary winding. It accordingly is one of the objects of this invention to provide a breakerless transistor ignition wherein the time that the transistor is turned off is increased as compared to heretofore known breakerless transistor ignition systems.

A more specific object of this invention is to provide a breakerless transistor ignition system wherein the turning on and turning off of the transistor that controls primary winding current is controlled by a pair of pick-up coils which have overlapping voltage output wave forms that maintain the transistor off for a period of time corresponding to the period where the voltage pulses overlap.

Another object of this invention is to provide a breakerless transistor ignition system wherein a semiconductor such as a transistor controls current flow through the primary winding of an ignition coil and wherein this transistor has its conductivity controlled by a pulse generating means that includes a plurality of pick-up coils.

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 voltage pulse generating means that controls the conductivity of the transistors shown in FIGURE 1.

FIGURE 3 is a sectional view of the voltage pulse generating unit taken along line 3—3 of FIGURE 2.

FIGURE 4 are curves of voltages generated in the pick-up coils of the magnetic voltage pulse generating means shown in FIGURES 2 and 3.

Referring now to the drawings and more particularly to FIGURE 1, the reference number **10** designates a source of direct current power for an ignition system which on a motor vehicle may be a storage battery. In motor vehicle installations, a generator charges the storage battery and supplies ignition power when the engine is running. One side of the battery **10** is grounded and the opposite side thereof is connected with an ignition switch **12**. The opposite side of ignition switch **12** is connected with a lead wire **14**.

The ignition system includes an ignition coil **16** having

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a primary winding **18** and a secondary winding **20**. The primary and secondary windings are connected together at junction **22** and this junction is grounded as shown. One side of the secondary winding **20** is connected with lead wire **24** which in turn is electrically connected with a rotor contact **26** of a spark distributing device **28**. The spark distributing device **28** includes the fixed contacts or electrodes **30** which are electrically connected with the lead wires **32**. The lead wires **32** are connected respectively with the spark plugs **34** on the internal combustion engine **36**. The opposite side of the spark plugs **34** are grounded as shown. The engine is shown as a four cylinder engine having four spark plugs, but it will be apparent to those skilled in the art that the system of this invention will have equal application to engines having a number of cylinders other than four.

The primary winding **18** of the ignition coil **16** is connected in series with a resistor **38** and this resistor is connected in series with a circuit element or three terminal semiconductor switch means which in this case takes the form of a PNP transistor **40** having emitter, collector and base electrodes. The current carrying terminals of the semiconductor switch means **40** are the emitter and collector electrodes while the control terminal is the base electrode. It is seen that the collector electrode of transistor **40** is connected with the resistor **38** whereas the emitter electrode of transistor **40** is connected with lead wire **14**. The base electrode of transistor **40** is connected with a junction **42** via the lead wire **44**.

The junction **42** is connected with the collector electrode of a PNP transistor **46**. The emitter electrode of transistor **46** is connected with lead wire **14**. Connected between the junction **42** and ground is a resistor **47**.

The emitter and base electrodes of transistor **46** are connected by pick-up coils **48** and **50**. These pick-up coils **48** and **50** have voltages induced therein as a magnetic rotor **52** rotates. The rotor **52** is driven by the engine **36** as is the rotor contact **26** of the spark distributor **28** as is depicted by the dotted lines of FIGURE 1.

Referring now more particularly to FIGURES 2 and 3, it is seen that the pick-up coil **50** is wound on one leg of U-shaped member **54** which is formed of magnetic material. In a similar fashion, the coil winding or pick-up coil **48** is wound on a U-shaped member **56** which is likewise formed of magnetic material. The rotor **52** as seen in FIGURES 2 and 3 comprises a pair of pole pieces **58** and **60** which are secured to a permanent magnet **62** and to a shaft **64** which drives the rotor **52**. The pole pieces **58** and **60** are formed of magnetic material. The shaft **64** may be formed of stainless steel or may be fitted with a non-magnetic insert to magnetically isolate it from the permanent magnet and pole pieces. The pole piece **58** has four projecting teeth **58*a*** which swing past one end of the U-shaped members **54** and **56** when the rotor **52** is rotating. The pole piece **60** is formed with teeth **60*a*** which are exactly aligned with the teeth **58*a***. It is seen from FIGURE 3, that as the rotor **52** rotates, the projecting teeth **58*a*** and **60*a*** pass by the ends or tips of the U-shaped members **54** and **56**.

The permanent magnet **62** may be of the ferrite type or any other type and is axially magnetized so that the pole pieces **58** and **60** have different magnetic polarities. The U-shaped magnetic members **54** and **56** and the coils that they carry are fixed relative to the rotor **52** and can be secured to a suitable housing **61** formed of a nonmagnetic material such as die cast aluminum. It is also possible to secure the U-shaped members **54** and **56** to a rotatable breaker plate that will be adjusted by vacuum apparatus. In any event, the U-shaped members **54** and **56** and their attached coils are fixed a predetermined circumferential distance from each other regardless of what they are fastened to.

It is to be pointed out that the circumferential spacing between U-shaped members **54** and **56** is greater than the circumferential spacing of the teeth on the pole pieces **58** and **60**. It thus is seen from FIGURE 2 that the radially extending teeth **58a** are spaced 90° from each other whereas the ends of the U-shaped members **54** and **56** are circumferentially spaced a distance somewhat greater than 90°. Where the rotor **52** rotates clockwise in FIGURE 2, it can be seen that one pair of teeth **58a** and **60a** will become aligned with the U-shaped member **56** before another pair of teeth **58a** and **60a** become aligned with the U-shaped member **54**.

The voltage output of the pick-up coils **48** and **50** is depicted in FIGURE 4 which illustrates the voltage output as a function of time or rotor position. When a pair of teeth **58a** and **60a** approach the U-shaped member **56**, a voltage *m–n* is induced in coil winding **48** which begins at point A. As the teeth **58a** and **60a** approach and then become aligned with the U-shaped member **56**, a voltage wave form is developed which goes to a maximum in the negative direction at point B and then returns to point C when the teeth **58a** and **60a** are exactly aligned with the U-shaped member **56**. As the teeth **58a** and **60a** now move out of alignment with the U-shaped member **56**, a voltage of induction is developed which is in a reverse direction and which goes from point C through point D and then decays to point E on the solid line curve shown in FIGURE 4.

As soon as a pair of teeth **58a** and **60a** move out of alignment with the U-shaped member **56**, a second pair of teeth **58a** and **60a** will be approaching the U-shaped member **54** and a voltage *n–m* will be induced in the pick-up coil **50** which is depicted in the dotted lines of FIGURE 4. This voltage is the same as voltage *m–n* but has a reverse polarity because of a reversal in connection of its output leads. This voltage *n–m* starts at point F, moves to a maximum in a positive direction at point G, then moves to zero at point H, to a maximum in a negative direction at point J and then decays substantially to zero at point K. It is noted that the curves of voltages developed in pick-up coils **48** and **50** overlap so that as the voltage in coil winding **58** is decaying from D to E a voltage is being developed at the same time in the coil winding **50** from points F to G. When the teeth **58a** and **60a** are out of alignment with both U-shaped members **54** and **56**, there is no voltage developed in either coil winding **48** or **50**.

When it is desired to set the ignition system of this invention into operation, the ignition switch **12** is closed. With the engine **36** either being cranked or in a running condition, the rotor **52** and the rotor contact **26** are driven by the engine. This causes pulses of voltage to be induced in the coil windings **48** and **50** having the wave forms illustrated in FIGURE 4.

When the ignition switch **12** is closed and no voltage is induced in either coil winding **48** or **50**, the transistor **40** will be conductive in its emitter-collector circuit so that current flows from lead wire **14**, through the emitter-collector circuit of transistor **40**, through resistor **38** and through the primary winding **18** to ground. Transistor **40** is now conductive in its emitter-collector circuit because it has a path for base current which is through lead wire **44**, junction **42** and the resistor **47** to ground.

With the rotor **52** rotating, a pulse of voltage shown between points A and B in the curve of FIGURE 4 will be induced in the coil winding **48**. The coil winding **48** is so connected with the emitter and base electrodes of transistor **46** that this pulse of voltage will drive the base electrode of transistor **46** more positive than the emitter electrode so that the transistor **46** remains nonconductive. The junction **42** now has a potential which is essentially ground potential and the transistor **40** therefore remains conductive in its emitter-collector circuit. As the teeth **58a** and **60a** pass by the U-shaped member **56**, the voltage curve moves from point C to point E as seen in FIGURE 4. This will cause the base electrode of transistor **46** to become negative with respect to the emitter electrode and the transistor **46** now will begin to conduct current between its emitter and collector electrodes. With transistor **46** conductive between its emitter and collector electrodes, the junction **42** takes a potential which is substantially equal to the potential of lead wire **14**. This then means that there is substantially no difference in potential between the emitter and base electrodes of transistor **40** so that it turns off in its emitter-collector circuit. This interrupts the current flow to the primary winding **18** and as a result of this, a large voltage is induced in the secondary winding **20** which is applied to one of the spark plugs through the rotor contact **26** and one of the lead wires **32**.

The transistor **46** remains conductive after a pair of teeth **58a** and **60a** leave the U-shaped member **56** since another pair of teeth **58a** and **60a** swing past the U-shaped member **54**. A voltage *n–m* then is induced in the coil winding **50** which is shown in dotted lines in FIGURE 4. The output leads of coil winding **50** are connected in a reverse manner with the emitter and base electrodes of transistor **46** as compared to the connection of coil winding **48** with these electrodes. In other words, point *n* of coil winding **48** is connected with the base electrode of transistor **46** whereas point *m* of coil winding **50** is connected to the same base electrode. Points *n* on the two coil windings are identical physical points on the coil windings, that is, they are at the same point on a coil winding relative to the magnetic circuit for the coil winding. The same is true of corresponding point *m*. Thus, as the voltage developed in pick-up coil **50** goes from points F to G, it drives the emitter electrode of transistor **46** positive with respect to the base electrode of this transistor so that the transistor remains turned on and thus keeps the transistor **40** turned off in its emitter to collector circuit. The voltage developed in the coil winding or pick-up coil **50** thus prolongs the time that the transistor **40** is turned off so that the circuit for the primary winding **18** is interrupted for a sufficient length of time to cause a high voltage to be induced in the secondary winding **20** and a firing of one of the spark plugs **34**.

When point H is reached on the curves of FIGURE 4, the transistor **46** is turned off and the transistor **40** once more resumes conduction in its emitter-collector circuit. When no voltage is induced in either coil winding **48** or **50**, it is seen that the emitter and base electrodes of transistor **46** are connected to substantially the same potential so that the transistor **46** is turned off and the transistor **40** remains on. The transistor **40** is thus turned on in its emitter-collector circuit for a greater time than it is turned off during one revolution of the rotor **52** and will be turned on at four separate time intervals separated by four shorter time intervals where it is turned off. The time of turn-off is prolonged with the system of this invention since the voltage wave forms developed by the pick-up coils **48** and **50** overlap as is clearly apparent from FIGURE 4. This insures that the current flow through the primary winding **18** of ignition coil **16** will be interrupted for a sufficient length of time to cause a high voltage to be induced in the secondary winding **20** and a good firing of the spark plugs **34**.

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

What is claimed is as follows:

1. An ignition system for an internal combustion engine comprising, a source of direct current voltage, an ignition coil having a primary winding and a secondary winding, a circuit element having a pair of current carrying terminals and a control terminal, means connecting the current carrying terminals of said circuit element in series with said primary winding and across said source of direct current voltage, voltage pulse generating means including a pair of oppositely poled coils connected in electrical parallel relationship with each other and a magnetic means adapted to be driven in synchronism with said engine positioned in cooperative relationship with said coils for producing spaced, discrete pairs of alternating current pulses, the pulses of each pair being shifted to partially overlap in only one polarity and means for connecting said coils across said control terminal and one of said current carrying terminals of said circuit element.

2. An ignition system for an internal combustion engine comprising, a source of direct current voltage, an ignition coil having a primary winding and a secondary winding, a three terminal semiconductor switch means having a pair of current carrying terminals and a control terminal, an energizing circuit for said primary winding including the current carrying terminals of said semiconductor switch means connected in series therewith, voltage pulse generating means including a pair of oppositely poled coils connected in electrical parallel relationship with each other and a magnetic means adapted to be driven in synchronism with said engine positioned in cooperative relationship with said coils for producing spaced, discrete pairs of alternating current pulses, the pulses of each pair being shifted to partially overlap in only one polarity and means for connecting said coils across said control terminal and one of said current carrying terminals of said semiconductor switch means.

3. The system according to claim **2** where the three terminal semiconductor switch means is a transistor.

4. An ignition system for an internal combustion engine comprising, a source of direct current voltage, an ignition coil having a primary winding and a secondary winding, a three terminal semiconductor switch means having a pair of current carrying terminals and a control terminal, an energizing circuit for said primary winding including the current carrying terminals of said semiconductor switch means connected in series therewith, voltage pulse generating means including first and second circumferentially spaced oppositely poled coil windings and a rotor member adapted to be driven in timed relation with said engine having circumferentially spaced teeth of magnetic material, the spacing of said teeth on said rotor member being less than the circumferential spacing of said coil windings, and means connecting said coil windings in parallel and in controlling relationship with the control terminal and one of said current carrying terminals of said semiconductor switch means.

5. An ignition system for an internal combustion engine comprising, a source of direct current voltage, an ignition coil having a primary winding and a secondary winding, a first transistor having emitter, collector and base electrodes, an energizing circuit for the primary winding of said ignition coil connected with said voltage source and including the emitter-collector circuit of said first transistor in series, a second transistor having emitter, collector and base electrodes, means connecting the emitter-collector circuit of said second transistor across said voltage source, means connecting the base electrode of said first transistor with the collector electrode of said second transistor, voltage pulse generating means including a pair of oppositely poled coils connected in electrical parallel relationship with each other and a magnetic means adapted to be driven in synchronism with said engine positioned in cooperative relationship with said coils for producing spaced, discrete pairs of alternating current pulses, the pulses of each pair being shifted to partially overlap in only one polarity and means for connecting said coils across the emitter and base electrodes of said second transistor.

6. An ignition system for an internal combustion engine comprising, an ignition coil having a primary winding and a secondary winding, a source of direct current voltage, a first normally conducting transistor having emitter, collector and base electrodes, means connecting the emitter-collector circuit of said first transistor in series with said voltage source and the primary winding of said ignition coil, a second normally not conducting transistor having emitter, collector and base electrodes, means connecting the emitter-collector circuit of said second transistor across said voltage source in such a manner as to be forward poled, means connecting the base electrode of said first transistor whereby said first transistor is rendered not conducting while said second transistor is conducting, with the collector electrode of said second transistor, voltage pulse generating means comprising a pair of oppositely poled coils connected in electrical parallel relationship with each other and a rotor member having equiangularly spaced teeth of magnetic material about its circumference adapted to be rotated about an axis in timed relation with said engine, said coils being asymmetrically circumferentially disposed about said axis adjacent said teeth and having an angular displacement between adjacent coils greater than the angular displacement between adjacent teeth and means for connecting said coils across said emitter and base electrodes of said second transistor for controlling the period during which said second transistor is conducting.

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