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IGNITION SYSTEM

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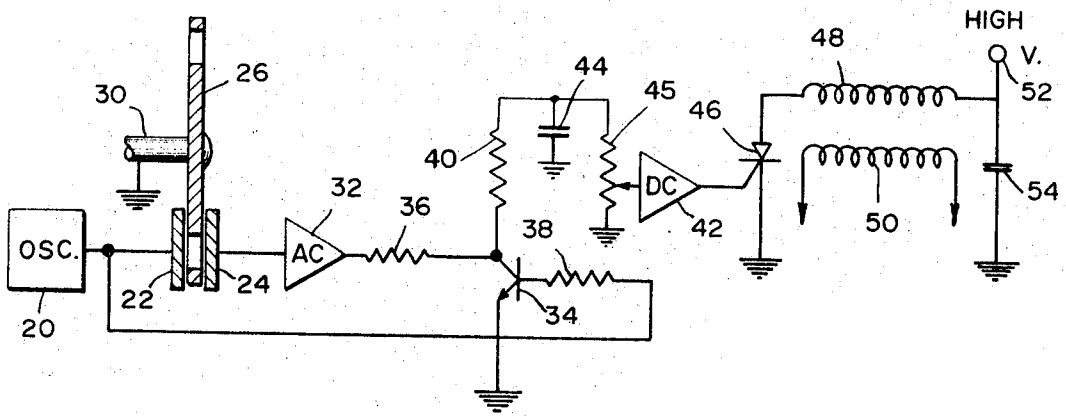


FIG. 1

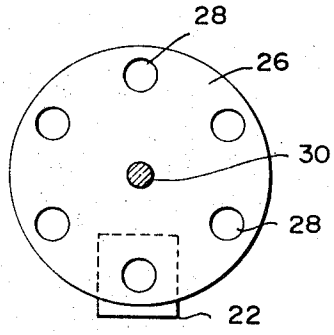


FIG. 2

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IGNITION SYSTEM

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ABSTRACT OF THE DISCLOSURE

An ignition system for internal combustion engine, in which system current flow through an ignition coil is controlled by a silicon controlled rectifier. The rectifier is triggered by pulses derived by a circuit including an oscillator connected to one electrode of a capacitor, the other capacitor electrode being coupled to the rectifier. A perforated electrostatic shield, rotatable in synchronism with the engine, is disposed between the capacitor electrodes to couple and decouple the output of the oscillator across the electrodes depending on sequential movement of the solid and perforate portions of the shield between the electrodes. To enhance operation, a synchronous detector matches the signals directly from the oscillator with the signals coupled across the capacitor electrodes, and the matched signals are then rectified to provide corresponding DC pulses for triggering the controlled rectifier.

This invention relates to ignition systems for internal combustion engines, and more particularly to timing apparatus which varies a capacitive coupling adapted to control operation of a semiconductor device which, in turn, controls current flow through the primary winding of an ignition coil.

Ignition systems usually comprise an engine-driven timing device, for example, the usual cam-operated points, which controls actuation of an ignition coil primary winding, the ignition coil secondary winding being coupled to an engine driven distributor which determines which spark plug will be fired.

Ordinarily, the ignition points act as a switch which periodically permits a current to pass through the ignition coil primary winding. And as in the case of other mechanical switches, points are subject to many of the usual switching problems. For example, closure and breakage of the circuit must be accomplished quickly to reduce arcing. Closure must be positive to insure an uninterrupted signal, hence the points are usually spring-biased. Yet, at high speeds, because of mechanical inertia, the spring forces may not be sufficient to effect proper contact before the cam forces the points apart. A primary problem of course is wear occasioned in part by arcing and in part by mechanical contact, requiring disassembly and replacement of the points. Wear also tends to cause timing changes due to variation of cam surfaces.

It has been suggested, for example, in U.S. Patent No. 3,280,810 that the current flow of the primary winding of the ignition coil be controlled by a device such as a semiconductor controlled rectifier, the conduction timing of the latter in turn being controlled by the variation of an inductive coupling.

While this is one approach which seeks to overcome the above-noted problems, there are nevertheless several disadvantages to the system shown. For example, the ratio of coupled to decoupled signals should be as large as possible, for in effect, this is the measure of the figure of merit used to determine when firing of an induction coil should occur. With inductive coupling it is very difficult to reduce the decoupled signal to a very low value relative to the strength of the coupled signal hence

this ratio can be poor. Inductive coupling uses coils which require substantial shielding to avoid inductive pick-up of noise, otherwise may tend to exhibit poor signal-to-noise ratios with attendant timing problems. In addition, many inductive systems depend on the rate of change of flux through a pickup coil, hence at low engine speeds tend to provide signals of reduced amplitude. Lastly, but quite importantly, the use of inductive coupling calls for transformer windings, core materials and the like and can be expensive to manufacture.

A principal object of the present invention is to provide an ignition system for internal combustion engines wherein the current flow through an ignition coil is controlled by an engine driven timing device which provides a timing signal in accordance with the capacitive coupling of a signal across a pair of capacitive electrodes.

Other objects of the invention will in part be obvious and will in part appear hereinafter. The invention accordingly comprises the apparatus possessing the construction, combination of elements, and arrangement of parts which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the present invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIG. 1 is a schematic drawing partly in block form, partly in elevational fragmentary cross section, and partly in circuit diagram showing an embodiment of the principles of the present invention; and

FIG. 2 is a front view showing details of a shielding plate of the embodiment of FIG. 1.

Generally, the present invention is an improvement on ignition systems for an internal combustion engine which system includes the usual source of direct current, an ignition coil having primary and secondary windings, a distributor operated synchronously by the engine for switching the output of the ignition coil to the engine spark plugs, and a semiconductor switch for controlling current flow through the coil primary winding from the current source. Only as many of these elements as are required for delineating the invention are shown in the drawing inasmuch as they, as well as their interconnections, are all so well-known in the art. The improvement comprises generally means for providing timed control signals for operation of the semiconductor switch and includes a source of a train of oscillating electrical signals, capacitive means having spaced-apart first and second capacitive electrodes one of which is connected to the source of oscillating signals, electrical shielding means mounted for movement between the capacitive electrodes so as to periodically permit the train of signals to be coupled and decoupled with the second capacitive electrode, and means responsive only to the signals coupled to the second electrode for operating the semiconductor switch. In the preferred embodiment, the last-named means comprises a circuit which provides a switching signal to the switch in response to signals which originated in the source of the train, thereby discriminating against spurious signals or noise originating elsewhere.

Turning now to FIG. 1, there is shown an ignition system including a high frequency oscillator **20** which may be a typical electronic oscillator with its own power source, a DC to AC inverter powered by the engine generator or battery, an AC to AC converter powered by an engine operated alternator, or the like. Preferably oscillator **20** provides a single-phase AC, typically at potentials such as 6 or 12 volts, and at frequencies about 1 mHz.

Also included are capacitive means shown simply as two capacitive electrodes or plates **22** and **24** spaced apart from one another by a volume filled with a dielec-

tric such as air. Plate **22** is connected to the output of oscillator **20** so that the AC signal from the latter is applied to the plate.

Electrically shielding means, in the form of a plate or flat, thin disk **26** of electrically conductive material such as copper or the like, is mounted for rotation in the plane of the disk between plates **22** and **24**. Disk **26**, shown in front view in FIG. 2, has a plurality of separated dielectric portions therein, typically formed simply as apertures or holes **28**. The latter preferably are equidistantly spaced from one another along an annular line around the center of rotation of the disk. Holes **28** are dimensioned and spaced from one another, and disk **26** is so positioned that when the latter is rotated, each hole in sequence is moved between plates **22** and **24**, only one hole at a time. Thus, when one of hole **28** is between the plates, the AC signal on plate **22** is capacitively coupled through the dielectric in the hole to plate **24**. When, on the other hand, the solid portion of the disk between two holes lies between the plates, the disk serves effectively to prevent coupling of the signal to plate **24**. To insure that shielding is optimized, disk **26** is typically mounted on, and electrically connected to, electrically conductive shaft **30** which is grounded, for example, through slip rings. Shaft **30** is, of course, driven by the internal combustion engine typically synchronously with the distributor rotor.

Plate **24** is preferably connected to the input of AC amplifier **32**. The output of the latter is connected to a synchronous phase detector which preferably comprises a two input-terminal circuit which provides a substantially DC output signal only when signals of given frequencies are present at both input terminals, and the signals are properly phased with respect to one another. Such a detector typically comprises transistor **34**, typically a silicon NPN type, having its emitter connected through load resistor **36** to the output of amplifier **32**, its emitter connected to system ground, and its base coupled to the output of oscillator **20** through resistor **38**. Because it is desirable to have the signals applied respectively to the transistor base and collector, 180° out of phase with one another, amplifier **32** can be an inverting type, or alternatively the coupling of the transistor base can be to an appropriately wound transformer winding in the oscillator and amplifier **32** can then be non-inverting.

The collector of transistor **34** is also connected through resistor **40** to the input of second amplifier **42** which is preferably a DC, noninverting amplifier. An integrating capacitor **44** is connected between the input of amplifier **42** and system ground.

Preferably the connection of resistor **40** to amplifier **42** is through potentiometer **45** which can be manually adjusted and can be located advantageously with the other engine controls available to the operator of a motor vehicle. The output of amplifier **42** is connected to the gate lead of controlled rectifier **46**, typically a solid state silicon controlled rectifier, which has its anode-cathode circuit connected in series between ground and one end of primary winding **48** of an induction coil. A switching transistor or other similar device may also be used in the same manner.

Typically the latter also includes secondary winding **50**, which is connected to the engine distributor (not shown). The other end of primary winding **48** is typically connected as at terminal **52** to a high voltage source and also through capacitor **54** to ground.

In operation a high DC voltage is applied at terminal **52** but no current will flow unless controlled rectifier **46** is in its conductive state, and no current is induced in secondary winding **50**. With oscillator **20** producing typically its 1 mHz. output signal, as disk **26** rotates about shaft **30** is synchronism with the engine, holes **28** and disk **26** sequentially cause the 1 mHz. signal to be coupled and decoupled with plate **24**. This provides at plate **24** a series of pulses, each containing a wave train at 1 mHz., the pulses having a repetition rate dependent upon the rate of rotation of disk **26** and the number of holes **28**. The number of holes in the disk depends on the number of spark plugs to be fired in the engine, typically on a 1:1 basis.

The wave train content of the pulses, amplified by amplifier **32** provides an alternating current through resistor to the collector of transistor **34**, i.e., bursts of 1 mHz. frequency content at the repetition rate established as above noted. Simultaneously, the output of oscillator **20** provides a current through resistor **38** at the same 1 mHz. frequency to the base of transistor **34** but in opposite phase to the current applied at the collector of the transistor. This base current then periodically opens and closes the collector-emitter circuit of the transistor. When the collector-emitter circuit is conductive, the transistor acts to shunt the collector current to ground and when the collector-emitter circuit is open, the current at the collector flows through resistor **40**. Thus, only the positive half-cycles of the current through resistor **36** are applied to resistor **40** inasmuch as transistor **34** is nonconducting when the negative half-cycles of the base current are applied thereto.

Capacitor **44**, being connected to ground, serves to integrate or smooth out the half-wave ripple of the signal from amplifier **32** allowed to pass by transistor **34**, the essentially DC resultant being applied to amplifier **42**. It will be seen that noise originating or picked up in the current between the oscillator and the collector of the transistor will then be passed in random fashion by the chopping action of the transistor and will tend to be averaged out or suppressed upon integration by capacitor **44**. Hence, the circuit acts as a synchronous rectifier and a fairly high Q filter, providing reasonably high noise rejection. The connection between oscillator **20** and the transistor base can be readily shielded to insure that the signals applied to the base are reasonably free of noise.

Amplifier **42** raises, if necessary, the levels of the DC signals applied thereto, to the necessary magnitudes required to trigger controlled rectifier **46**. The latter preferably is a solid-state silicon device but other devices such as thyratrons and power transistors are also useful.

Thus, as plate **26** is rotated, bursts of AC are produced at a repetition rate dependent on the rotation of the engine. Each burst is then synchronously filtered, to provide corresponding pulses of essentially DC at the same repetition rate. These latter pulses, applied to controlled rectifier **46** insures that the circuit of primary winding **48** is opened and closed synchronously to provide corresponding pulses to secondary winding **50**, which can be fed to control the spark plugs of an internal combustion engine. The timing can be adjusted electrically by changing the electrical threshold level of the DC signals firing rectifier **46**, and in the form shown this is accomplished by adjusting potentiometer **45**. Alternatively, amplifier **42** can be a thresholding amplifier if desired.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. In combination with an ignition system for an internal combustion engine, which system includes a source of direct current, an ignition coil having primary and secondary windings, and a semiconductor control means connected between said source and said primary winding for controlling current flow through the latter, the improvement comprising an oscillator;

capacitive means having spaced apart first and second capacitive electrodes one of which is connected to the output of said oscillator;

electrical shield means mounted for movement relative to said capacitive means between said electrodes for

periodically interrupting capacitive coupling of the output of said oscillator to said second electrode; and

means responsive to signals capacitively coupled to said second electrode for switching the semiconductor means on and off in accordance with the periodic interruption of said coupling.

2. In combination as defined in claim 1 wherein said semiconductive means is a controlled rectifier having its gate lead connected to said second electrode and its anode-cathode circuit connected in series with said primary winding.

3. In combination as defined in claim 2 including means for adjusting the electrical threshold level of said rectifier so as to accordingly vary the timing of said system.

4. In combination as defined in claim 1 wherein said shield means comprises an electrically conductive plate having a plurality of apertures therethrough and mounted for movement so that said apertures are sequentially disposed between said electrodes, said plate being electrically connected to system ground.

5. In combination as defined in claim 4 wherein said plate is mounted for rotation and said apertures are distributed along an annular line about the center of said rotation.

6. In combination as defined in claim 1 wherein said means connecting said second electrode includes phase detection means having a pair of input terminals and an input terminal for providing a repetitive substantially DC signal at said output terminal of magnitude according to the relative phase of separate signals applied at said input terminals, and of repetition rate according to the periodic interruption of said coupling;

said input terminals being respectively connected to said first and second electrodes, and said output terminal being connected for controlling said semiconductor means.

7. In combination as defined in claim 6 wherein said phase detections means comprises a comparator for producing an oscillatory rectified signal of maximum amplitude only when the frequency of said separate signals are substantially identical and means for integrating said oscillatory signal.

References Cited

UNITED STATES PATENTS

3,217,216	11/1965	Dotto	317—250
3,361,123	1/1968	Kasama et al.	

LAURENCE M. GOODRIDGE, *Primary Examiner.*

U.S. Cl. X.R.

123—146.5; 315—209, 223