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Canup

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[54] **CONTINUOUS-WAVE IGNITION SYSTEM**

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[21] Appl. No.: **193,909**

[52] **U.S. Cl.** .... **123/148 E**

[51] **Int. Cl.** **F02p 3/02**

[58] **Field of Search** .... 123/148 E

[56] **References Cited**

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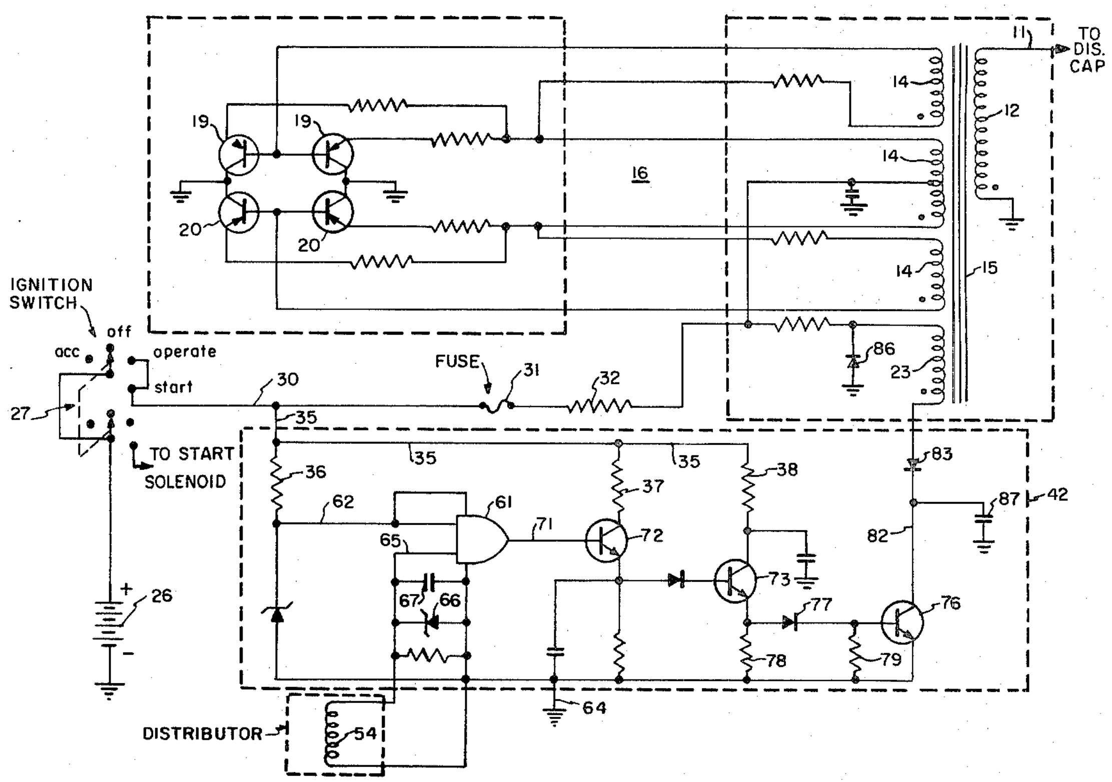
Attorney, Agent, or Firm—Thomas H. Whaley; Carl G. Ries

[57] **ABSTRACT**

A high-frequency continuous-wave ignition system. It employs a control winding with DC bias, to start and stop an oscillator. The start time and duration of oscillator operation takes place as timed by a breaker-pointless means under control of engine crank-shaft angle.

4 Claims, 3 Drawing Figures



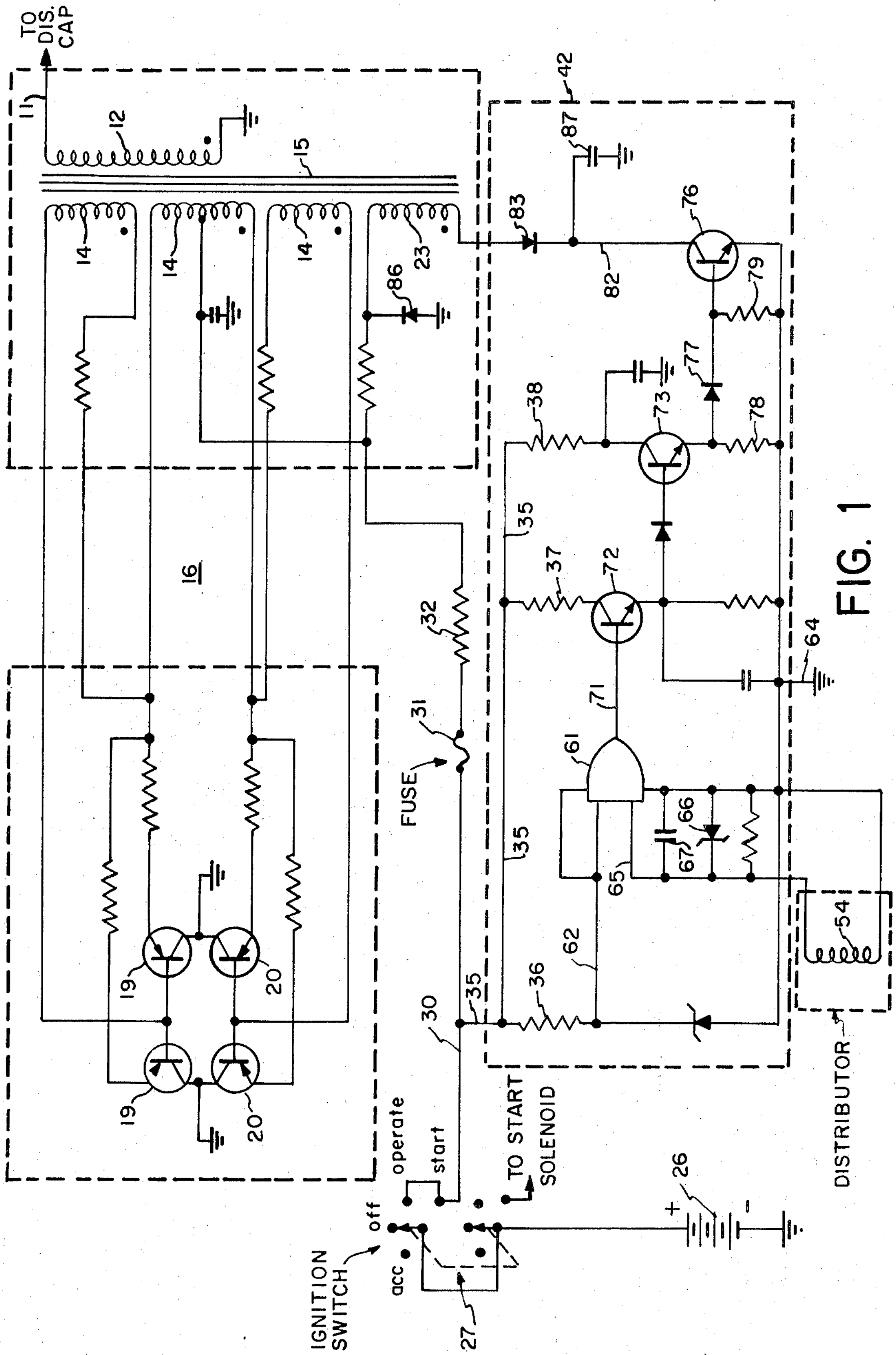

TO DIS. CAP
FUSE
IGNITION SWITCH
off
acc
operate
start
TO START SOLENOID
DISTRIBUTOR

FIG. 1

FIG. 2

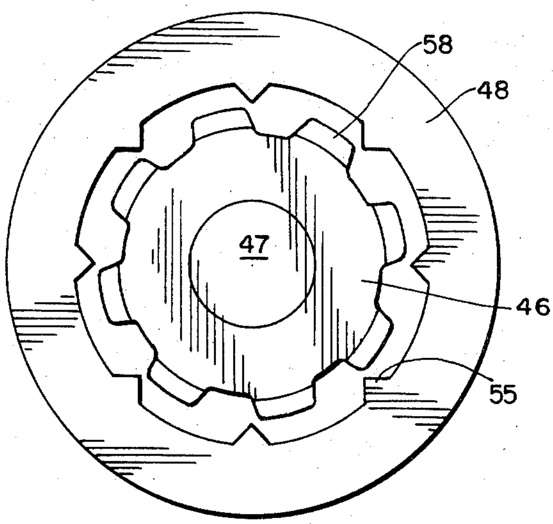
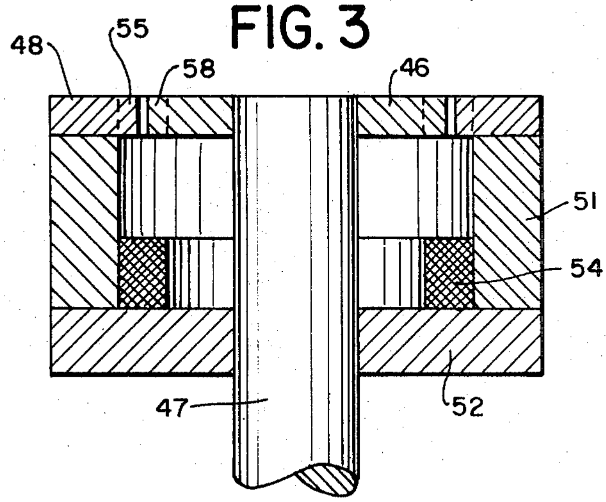


FIG. 3



CONTINUOUS-WAVE IGNITION SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

Subject matter of this application relates to co-pending U.S. Pat. applications of the same inventor as follows:

Ser. No. 67,450
Filed: Aug. 27, 1970
Title: HIGH FREQUENCY CONTINUOUS-WAVE IGNITION ENERGY FOR AN INTERNAL COMBUSTION ENGINE (D71,646), and
Ser. No. 100,642
Filed: Dec. 22, 1970
Title: CONTINUOUS-WAVE HIGH FREQUENCY IGNITION SYSTEM (D71,898).

BACKGROUND OF THE INVENTION

This invention concerns ignition systems for an internal combustion engine in general. More specifically, it relates to an improved ignition system applicable to a high-frequency continuous-wave system. And, even more particularly, it relates to such a system that employs a control winding for starting and stopping the high-frequency continuous-wave energy.

DESCRIPTION OF THE PRIOR ART

While various ignition systems have been proposed making use of high-frequency continuous-wave energy such systems have been found unsatisfactory. A major reason has been a lack of reliability. Apparently, a major factor in such unreliability has been the erratic starting time for the oscillator that is employed. The applicant has previously disclosed a high-frequency system that employs a control winding for the oscillator in such a manner as to insure instant starting of the oscillator when iginition energy is called for. Such systems have been disclosed and claimed in the above-noted co-pending applications, and it is an object of this invention to provide an improved system of the same type that is particularly applicable to a breakerpointless arrangement.

SUMMARY OF THE INVENTION

Briefly, the invention concerns a high-frequency continuous-wave ignition system for an internal combustion engine. The said system employs a control winding for starting and stopping such high-frequency continuous-wave energy, and it has means for timing said energy relative to said engine. In such system, the invention concerns improved means for controlling current flow through said winding in accordance with a predetermined amount of engine shaft angle rotation. It comprises in combination, breakerpointless means controlled by said engine shaft angle for providing a signal pulse having a duration according to said predetermined amount of rotation for each cylinder of said engine. It also comprises electronic means for cutting off said current flow during each said signal pulse.

Again briefly, the invention concerns a high-frequency continuous-wave ignition system for an internal combustion engine, the said system having a unitary magnetic-circuit type of oscillator that employs a control winding for starting and stopping said oscillator. The system also has means for timing the on-cycles of said oscillator relative to said engine. In connection with a system as set forth, the invention concerns an improvement that comprises means for controlling DC-current flow through said control winding in accordance with a predetermined amount of engine shaft angle rotation, and electromagnetic means including a coil for providing a signal pulse having a duration according to said predetermined amount of rotation for each cylinder of said engine. It also comprises means for inducing said signal pulse in said coil, which means comprises a magnetic flux path coupled with said coil, and permanent magnet means for generating magnetic flux in said path. The signal-pulse inducing means also comprises a rotor, a stator and a variable air gap therebetween for inducing said signal pulse. The improvement also comprises electronic means for cutting off said DC-current flow during each of said signal pulses, which electronic means comprises a NAND gate having two inputs and an output circuit. The improvement also comprises first circuit means for connecting said coil to one of said inputs including a Zener diode for limiting the amplitude of said signal pulse. In addition, it comprises means for applying a constant amplitude to the other input of said gate whenever said ignition system is energized, and first transistor means in said output circuit for amplifying the output of said gate, as well as a second transistor means controlled by said first transistor means for controlling said DC-current flow in said control winding.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and benefits of the invention will be more fully set forth below in connection with the best mode contemplated by the inventor of carrying out the invention, and in connection with which there are illustrations provided in the drawings wherein:

FIG. **1** is a circuit diagram illustrating a system according to the invention;

FIG. **2** is a plan view showing a preferred rotor structure for generating an electromagnetic timing pulse, and

FIG. **3** is a transverse cross-sectional view of the structure shown in FIG. **2.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1,** it is to be noted that the circuit diagram illustrates a system to be used for providing high-frequency continuous-wave ignition energy to an internal combustion engine. Thus, there is a circuit connection **11** that goes to the common circuit element of a distributor of an internal combustion engine, as indicated by the caption "TO DIS. CAP." This connection **11** leads out from a secondary winding **12** that is on a transformer **15** which provides the high-voltage, spark-creating energy. The transformer **15** has a plurality of primary or input windings **14,** as illustrated. These are part of an oscillator circuit **16,** which is basically like the circuit disclosed in the above-mentioned co-pending U.S. Pat. application Ser. No. 100,642. Consequently, no detailed explanation of the oscillator operation is needed, However, it may be pointed out that the oscillator **16** employs two pairs of transistors **19** and **20** instead of a single transistor in each case. It will be understood that this does not change the manner in which the oscillator operates.

The basic oscillator circuit **16** is not new, per se, but, as employed in this case, it makes use of a control winding **23** that is magnetically coupled with the oscillator windings **14** on the core of the transformer **15.** As was the case in the afore-mentioned co-pending application, this control winding **23** acts to control the starting and stopping of the oscillator **16.** This involves the application of DC-current flow through the winding **23,** along with a low-impedence path, so that when the DC current is flowing and the low-impedence path is effective, the winding **23** will load down the oscillator sufficiently to stop its oscillation. Then, when it is desired to supply spark energy over the output connection **11,** the oscillator **16** will be started by removing the DC-current flow through winding **23.** The decaying flux thus created will act in the proper direction to cause instantaneous starting of the oscillator **16.** The oscillator will, of course, then supply the desired high-voltage high-frequency spark signal over the circuit including output connection **11.**

The ignition system is energized whenever a power source, e.g., a 12-volt battery **26,** is connected to supply the DC power to the system. This is accomplished in a conventional manner with the circuit from battery **26** being carried via an ignition switch **27** which connects the positive side of battery **26** to a power input circuit connection **30** whenever the ignition switch is either in its "start" or "operate" positions. The circuit connection **30** supplies DC power voltage to the oscillator **16** via a fuse **31** and a resistor **32.**

At the same time, the positive voltage from battery **26** is connected via a circuit connection **35** to one side of each of three resistors **36, 37** and **38.** This provides the power input for an electronic means **42** that is shown enclosed in a dashed-line rectangle. This "means" acts as part of a breakerpointless ignition control unit, which unit acts in a similar manner and the electromagnetic-pulse generating part of which is substantially like that illustrated and described in the above-noted co-pending U.S. Pat. application Ser. No. 67,450.

Thus, with reference to FIGS. **2** and **3,** the breakerpointless arrangement includes a rotor **46** that is carried by a shaft **47.** Rotor **46** is surrounded by a magnetic-material stator **48.** It will be appreciated that the shaft **47** is mechanically connected (not shown) to the crank shaft of the engine. Thus, the ignition system is arranged in a conventional manner so that the rotation of the shaft **47** and attached rotor **46** will be directly related to the engine shaft angle at all times. The breakerpointless pulse-generating structure, described above, includes a magnetic flux path with the rotor **46,** stator **48** and cylindrical permanent magnet ring **51** (FIG. **3**) joining a lower plate **52** of magnetic material. This makes a complete flux path while providing electromagnetic coupling therewith by a coil **54** (FIG. **3** and FIG. **1**).

There are a plurality of inwardly directed radial projections **55** on the stator **48.** These are equal in number to the number of cylinders of the engine, and they extend so as to leave only a small air gap when a corresponding plurality of outwardly directed radial projections **58** on the rotor **46** are in alignment with the projections **55.** It will be clear that when these two sets of projections are not in alignment, the air gap is large, and the result is a substantial change in the flux density through the magnetic path. Such change, of course, generates a signal voltage in the coil **54.**

The arrangement of the electromagnetic rotor elements is, as already indicated, substantially like that of the co-pending U.S. Pat. application Ser. No. 67,450. But, in this case the output signals which are generated are treated in such manner as to clip the amplitude of the leading one of the pair of pulses generated as the projections **58** move into and out of alignment with the sharp-pointed projections **55.** This limits the amplitude of the pulses generated so that they remain at the same height regardless of engine speed. Also, because of the clipping of the pulse, there is an output voltage during the full time the rotor projections **58** are in alignment with the stator projections **55.** Consequently, as will appear more fully below, the system according to this invention gives simplified results and eliminates the need of a special arrangement to shut down the oscillator as was the case in the co-pending application system.

Referring to the electronic means **42,** it is pointed out that there is a NAND gate **61** that has an input connection **62** leading from the other end of the resistor **36** from that which is connected to the common connector **35.** There is another input connection **65** that connects to one end of the winding **54,** in which control pulses are generated. The other end of the winding **54** is connected to ground as shown by a grounded connector **64.** And there is a Zener diode **66** connected across the winding **54** along with a capacitor **67** that is in parallel with the diode **66.** Thus, both the diode **66** and the capacitor **67** have one side of each connected to the input connection **65** of the NAND gate **61.**

There is an output circuit connection **71** that goes from the NAND gate **61** to the base electrode of a transistor **72.** The transistor **72** is coupled with another transistor **73** in a Darlington configuration to amplify and feed the output of the NAND circuit **61** via the circuit connection **71** to the input of a power transistor **76.**

The output from the transistor **73** goes via a diode **77** that is connected between a pair of resistors **78** and **79.** This network goes to the base-emitter circuit of transistor **76.** Transistor **76** is connected with its collector-emitter in series with the oscillator control winding **23** via a circuit connection **82** and a diode **83.** Part of the winding **23** (oscillator control) circuit also includes another diode **86** and a capacitor **87.** The latter two have one side of each grounded, as shown.

OPERATION

Briefly, the operation during a single continuous-wave high-frequency sparking interval may be reviewed as follows. With the engine running and between sparking intervals, the oscillator **16** is cut off because of the low-impedence path across the control winding **23** that includes the diode **86** and the power transistor **76.** Also, a DC current in the winding **23** will apply a magnetic bias to the core of the transformer **15.**

Power transistor **76** will be conducting because the NAND gate **61** has a lack of coincidence at its inputs, i.e., there is a continuous positive voltage applied over connection **62** so long as the ignition switch **27** is on.

When the distributor rotor projections **58** reach alignment with the stator projections **55,** a positive voltage signal is generated in the winding **54.** It is clipped and applied to the other input of the NAND gate **61** over the connection **65.** This coincidence of signals causes the output of the NAND gate to go to zero which cuts off the conduction of the transistor **76.** That, in turn, cuts off the DC current in the winding **23** which starts the oscillator **16,** while the low-impedence path is also removed.

The sparking interval with the oscillator **16** oscillating continues until the trailing edges of the rotor projections **58** pass out of alignment with the stator projections **55.** That causes a negative voltage signal to be generated in the winding **54** which throws the NAND gate **61** on again (positive output voltage). This, in turn, turns the power transistor **76** fully on. Then, the next half cycle of the oscillator **16** that applies a positive voltage to the collector of the transistor **76,** will load the oscillator and stop it while, at the same time, DC-current flow is re-established in the winding **23.**

It will be observed that the system according to this invention does not need any extra elements in the circuit to stop the oscillator if the distributor should stop while the rotor and stator projections are in alignment, because the lack of any generated signal in winding **54** of the distributor (after the clipped voltage falls to zero) causes an anticoincidence at the NAND gate **61** which then stops the oscillator **16** in the manner just described.

While a particular embodiment of the invention has been described above in considerable detail in accordance with the applicable Statutes, this is not to be taken as in any way limiting the invention but merely as being descriptive thereof.

What I claim is:

1. In combination with a high-frequency continuous-wave ignition system for an internal combustion engine, said system including a square wave oscillator employing a unitary magnetic circuit and including a control winding for starting and stopping said high-frequency continuous-wave energy, said system also including means for applying a low-impedance path to said control winding concurrently with a DC current therethrough between each spark duration interval, and said system including means for timing said spark duration intervals relative to said engine,

improved means for controlling current flow through said winding in accordance with a predetermined amount of engine shaft angle rotation, comprising in combination

electromagnetic means including a coil,

means controlled by said engine shaft angle for inducing a signal pulse in said coil having a duration according to said predetermined amount of rotation,

a NAND gate for controlling said current flow through said winding and having two input circuits and an output circuit,

first circuit means including clipping means for applying said signal pulse to one of said input circuits, said clipping means limiting the amplitude of said signal pulse,

second circuit means for applying a constant signal to the other of said two input circuits,

transistor means for controlling current flow in said control winding, and

third circuit means for connecting said NAND gate output circuit to said transistor means, all whereby said low impedance path and said DC current flow are concurrently applied between each spark duration interval.

2. The invention according to claim **1,** wherein said signal-inducing means comprises

a magnetic flux path coupled with said coil,

means for generating magnetix flux in said path, and

means for varying the reluctance of said flux path.

3. The invention according to claim **2,** wherein said reluctance-varying means comprises

a rotor,

a stator, and

a variable air gap therebetween for generating said signal pulse.

4. In combination with a high-frequency continuous-wave ignition system for an internal combustion engine, said system having a unitary-magnetic-circuit type oscillator employing a control winding for starting and stopping said oscillator, and having means for timing the on-cycles of said oscillator relative to said engine, the improvement comprising

means for controlling DC-current flow through said control winding in accordance with a predetermined amount of engine shaft angle rotation,

electromagnetic means including a coil for providing a signal pulse having a duration according to said predetermined amount of rotation for each cylinder of said engine, and

means for inducing said signal pulse in said coil comprising

permanent magnet means for generating magnetic flux in said path,

a rotor,

a stator, and

a variable air gap therebetween for inducing said signal pulse, and

electronic means for cutting off said DC-current flow during each of said signal pulses, comprising

a NAND gate for controlling said DC cut off interval having two inputs and an output circuit, first circuit means for connecting said coil to one of said inputs including a Zener diode for limiting the amplitude of said signal pulse,

means for applying a constant amplitude signal to the other input of said gate whenever said ignition system is energized,

first transistor means in said output circuit for amplifying the output of said gate, and

second transistor means controlled by said first transistor means for controlling said DC-current flow in said control winding.

* * * * *