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Canup

[11] **3,853,106**

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[54] **HIGH FREQUENCY CONTINUOUS-WAVE IGNITION ENERGY FOR AN INTERNAL COMBUSTION ENGINE**

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[52] **U.S. Cl.** .... **123/148 E,** 315/209

[51] **Int. Cl.** **F02p 1/00**

[58] **Field of Search** .... 123/148 E, 149 A, 149 D; 315/209

[56] **References Cited**

UNITED STATES PATENTS

3,356,896	12/1967	Shano	123/148 E
3,407,795	10/1968	Aiken et al.	123/148 E
3,575,153	4/1971	Hardin	123/148 E
3,593,696	7/1971	Guido	123/148 E

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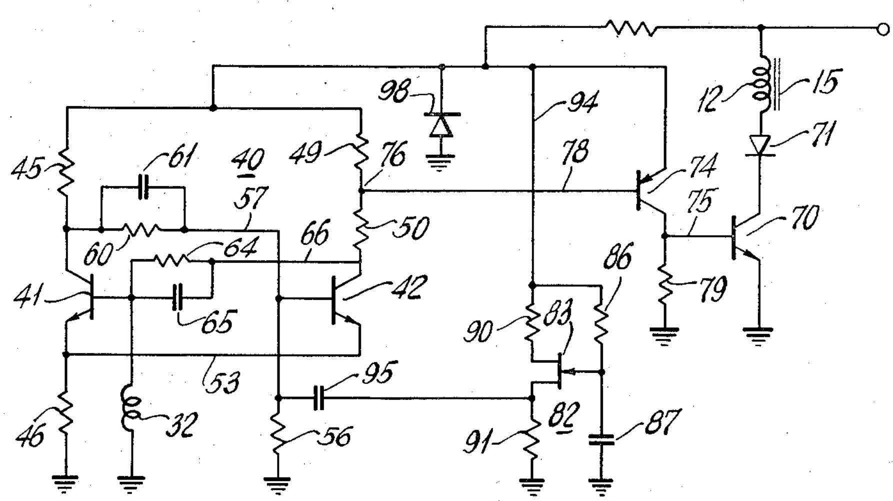
[57] **ABSTRACT**

An ignition system useful with a high frequency continuous-wave source of spark energy, where a saturation winding controls the turning on and off of an oscillator which feeds the high frequency output. The system controls current flow to the saturation winding during a timed interval for each spark. The interval is under control of a timing shaft that has magnetic flux density change for inducing a signal in a control coil. The control coil acts to switch a flip-flop circuit which, in turn, controls the gating of current flow to the oscillator control winding.

9 Claims, 4 Drawing Figures



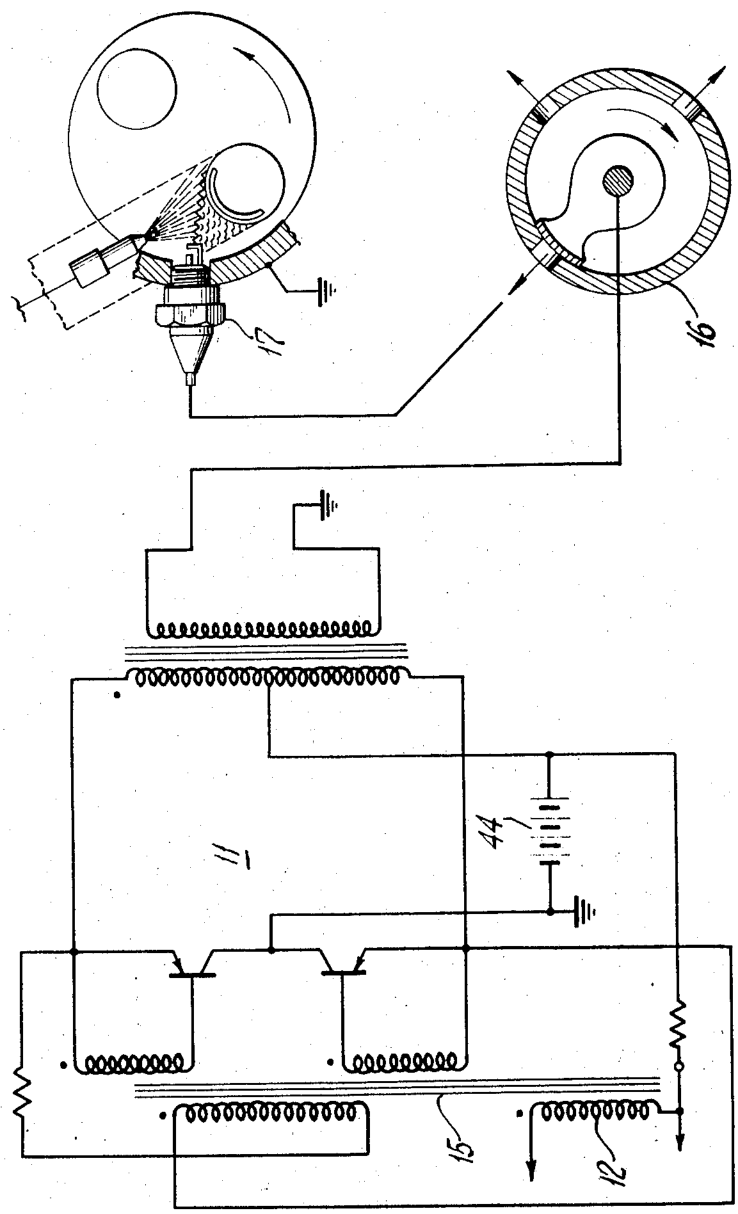


Fig. 1.

Fig. 2.

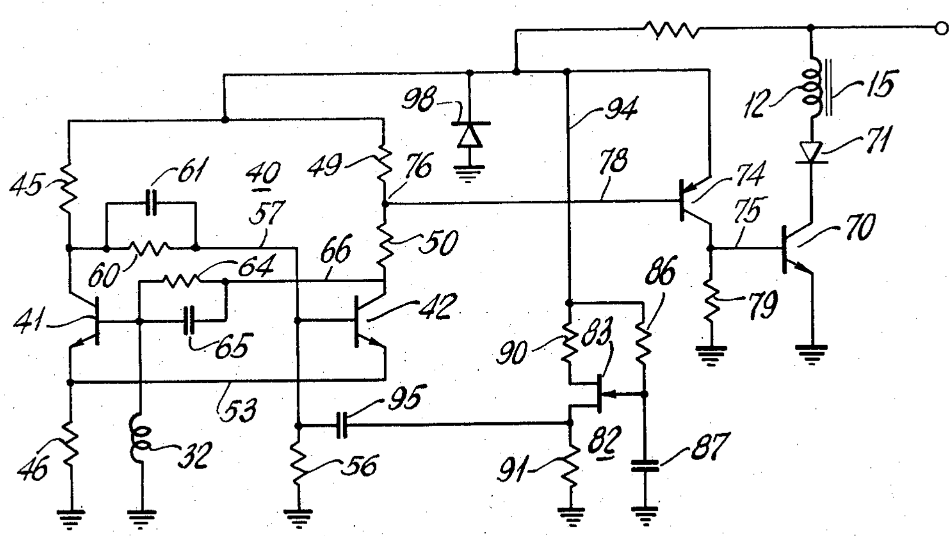


Fig. 3.

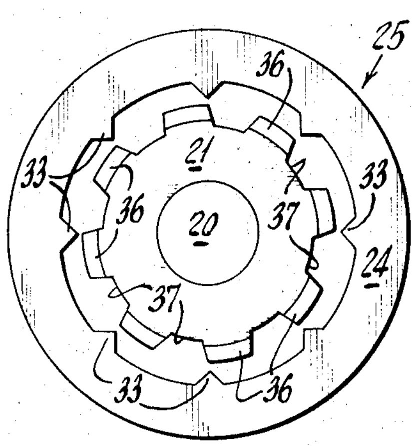
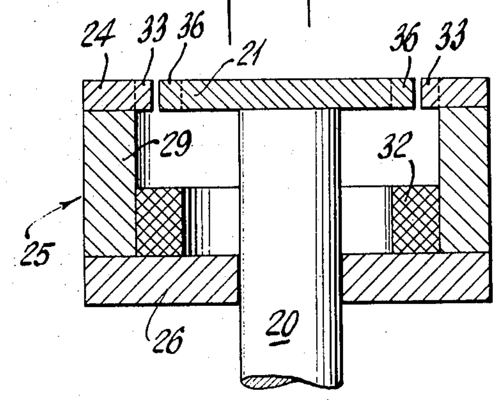


Fig. 4.



HIGH FREQUENCY CONTINUOUS-WAVE IGNITION ENERGY FOR AN INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to internal combustion engine ignition systems in general, and particularly concerns such an ignition system that is applicable to the type of ignition spark that is created by continuous-wave energy during the entire sparking interval.

2. Description of the Prior Art

While there are various known arrangements for providing high frequency sparking energy to be used with internal combustion engine systems, there is in particular, an ignition system that employs an oscillator to generate high frequency signals and which includes a saturation winding for controlling the oscillator. Such an ignition system is shown and described in a prior U.S. Pat. No. 3,407,795, issued Oct. 29, 1968, inventors R. W. Aiken, et al. However, that system employed conventional breaker points to control current flow in the control winding. Such conventional breaker point contacts are subject to point bounce, erosion and wear-off of the cam rubbing block. While such difficulties per se are, of course, not unique in regard to the particular type of ignition system mentioned above; the conventional ignition systems are not such that the present invention may be employed. And furthermore, while there have been different arrangements proposed for eliminating the use of conventional breaker points, none of them are applicable to the type of ignition system that employs a saturation winding for timing the spark and its duration.

SUMMARY OF THE INVENTION

Briefly, the invention relates to a combination for use in a high frequency continuous-energy ignition system that is for an internal combustion engine. Such system employs a control winding for starting and stopping said high frequency continuous-wave energy, and it has a shaft for timing said energy relative to said engine. The invention concerns improved means for controlling current flow through said winding in accordance with a pre-determined amount of shaft angle rotation. It comprises in combination electromagnetic means associated with said shaft for providing an initial pulse of one polarity and a terminal pulse of the opposite polarity, separated by a pre-determined degree of shaft angle rotation, both pulses for each cylinder of said engine. It also comprises electronic means actuated by both said pulses for cutting off said current flow when said initial pulse appears and for restoring said current flow when said terminal pulse appears.

Again briefly, the invention relates to a system for use in a high frequency continuous-wave ignition system for an internal combustion engine. The said system employs: (a) a control winding for starting and stopping said high frequency continuous-wave energy; and it has (b) a shaft for timing said energy relative to said engine. The invention comprises improved means for controlling current flow through said winding (a) in accordance with a predetermined amount of shaft (b) angle rotation, and it comprises in combination (c) a rotor of magnetically permeable material carried by said shaft. The rotor has a plurality of radial projections with concentric arcuate extremities extending concentrically over an arc equal to said predetermined rotation angle. It also comprises (d) a stator of magnetically permeable material including a permanent magnet and a closed path for the magnetic flux which includes said rotor (c), and (e) a plurality of pointed projections on said stator (d) matching in number the projections on said rotor (c) and forming a minimum air gap when in radial registration with said rotor projections throughout said arc. It also comprises (f) a coil located in inductive relation with said magnetic flux, and (g) a flip-flop circuit comprising a pair of transistors and having said coil (f) connected therein for switching same. In addition, it comprises (h) a diode and (i) transistor connected in series with said control winding (a) for controlling current flow therethrough, and (j) a PNP transistor connected to the base of said transistor (i). Finally, it also comprises (k) a circuit for connecting said PNP transistor to one branch of said flip-flop circuit (g) for making said transistor (i) become non-conducting when said flip-flop (g) is in one state and return to being conducting when it (g) is in the other state, and (i) a unijunction transistor oscillator connected to one side of said flip-flop (g) for switching it (g) back to said other state after a predetermined time delay in case said engine stops with it (g) having been switched to one state.

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** illustrates a high frequency continuouswave ignition system according to the prior art, e.g. the above mentioned U.S. Pat. No. 3,407,795;

FIG. **2** is a circuit diagram illustrating an electronic control system according to the inventions;

FIG. **3** is a top plan view illustrating schematically a timing shaft and related rotor and stator elements, according to the invention; and

FIG. **4** is a longitudinal cross-sectional view of the shaft and related elements that are illustrated in FIG. **3.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

It is to be noted that this invention is particularly applicable to the controlling of an ignition system like that shown in the above mentioned U.S. Pat. No. 3,407,795, although it could equally well be employed with any ignition system that makes use of a corresponding type of control winding for starting and stopping the generation of spark energy during a spark interval. It will be observed that the FIG. **1** system is substantially the same as the system of the foregoing U.S. patent, insofar as the elements illustrated there are concerned. Consequently, no detailed explanation is necessary here and it is sufficient to observe that the system employs a Jensen type oscillator **11.** This oscillator has a control winding **12** which acts to saturate a magnetic core **15** of the oscillator **11** when the winding has current flowing therein.

When spark energy is desired, the current flow through winding **12** is cut off and this creates instantaneous starting of the oscillator **11** in the manner that is explained in the aforementioned U.S. Pat. No. 3,407,795. The oscillator **11** provides high frequency continuous-wave energy in the output circuit shown that leads to a distributor **16** and a spark plug **17,** all as illustrated.

Referring to FIG. **2,** it is to be noted that the winding **12** and the magnetic core **15** are shown here in an electronic control circuit that is in accordance with the invention. This circuit determines the timing of intervals during which current flow through the control winding **12** is cut off, so that the oscillator **11** (FIG. **1**) will oscillate and supply spark energy.

Control of the foregoing intervals is timed to be in proper synchronization with the internal combustion engine, by having the control circuit (illustrated in FIG. **2**) acted upon by a spark timing element. Such timing element includes a shaft **20** (FIGS. **3** and **4**) that is mechanically rotated by direct connection with the engine (not shown) in a conventional manner. This shaft is illustrated in FIGS. **3** and **4** along with a rotor **21** that is constructed of magnetically permeable material. It is attached to the shaft **20** for rotation therewith at all times, and it is in alignment with a top annular portion **24** of a stator **25.** The stator includes a lower disc-like portion **26** for completing a magnetic flux path through the stator and rotor of the combined elements.

Stator **25** includes a cylindrical magnet section **29** that provides a source of magnetic flux for the aforementioned flux path. It will be appreciated by one skilled in the art that, while it may not be as mechanically feasible, the magnetic flux might be provided by other means, e.g. by having an electromagnetic coil (not shown) with current flow therein. However, in any event, there is an induction coil **32** that is situated in inductive relation to the magnetic field created by the flux through the foregoing flux path. Consequently, changes in flux density will generate an EMF in the coil **32.**

It will be observed that on the inner periphery of the annular portion **24** of the stator **25,** there are a plurality of pointed projections **33.** These are equal in number to the number of cylinders of the internal combustion engine for a four cycle engine, in order to provide the proper timing. The projections **33** extend radially inward into close clearance from the radially outermost surfaces of a corresponding plurality of projections **36** that are located on the periphery of the rotor **21.** With the foregoing structure, when the rotor projections **36** are in correspondence radially with the stator projections **33,** there will be a minimum size air gap that is distributed around among all of the pairs of projections.

It will be noted that the structure of rotor **21** includes a corresponding number of recessed portions **37** between the projections **36.** These are provided so that during the rotation of shaft **20,** when projections **36** are out of correspondence radially with the projections **33** (on the stator), there will be a very substantial air gap created in the flux path.

It is to be noted also, that while the circumferential widths of the rotor projections **36** are illustrated as being a relatively large angle, this is an exaggeration merely for the purposes of illustration of the principles involved. Actually, the angle will be smaller in accordance with conventional practice.

Referring to FIG. **2** again, it will be noted that induction coil **32** is located in a flip-flop circuit **40** which includes a pair of transistors **41** and **42** that are connected in a known manner for creating a bi-stable oscillator that can be switched from one state to the other and will remain in either state until switched to the other. Each stable state has one of the transistors **41** or **42** conducting while the other is cut off. The foregoing flip-flop circuit **40** includes one branch circuit with a resistor **45** that is connected between a source of B+ voltage **44,** i.e. the battery indicated in FIG. **1** and the collector electrode of the transistor **41.** Also, the emitter of transistor **41** is part of the circuit. It is connected to one end of another resistor **46** that has the other end thereof connected to ground, as illustrated.

The other transistor **42** is connected in another branch circuit that leads from the B+ voltage source **44** through a pair of resistors **49** and **50** that are connected in series. This circuit leads to the collector electrode of the transistor **42.** The circuit continues from the emitter element of transistor **42** and then it is connected over via a circuit connection **53** to the same end of the resistor **46** as was the emitter of the other transistor **41.**

The base electrode of transistor **42** is connected to one end of a resistor **56** that has the other end thereof connected to ground, as illustrated. The base of transistor **42** is also connected via a circuit wire **57** to one end of a resistor **60** that has a shunting capacitor **61** connected there across. The other end of resistor **60** is connected over to the collector electrode of transistor **41** in the other branch. Similarly, with respect to transistor **41,** there is a connection from the base electrode thereof to one end of a resistor **64** that has a shunting capacitor **65** connected there across. The other end of resistor **64** is connected via a wire **66** back over to the collector electrode of the transistor **42.**

It will be noted that the elements of the flip-flop circuit **40** which have been described, provide for a cross action from one transistor to the other such that the bistable state mentioned above, is created. This type of circuit is now well known to those skilled in this art.

Continuing to refer to FIG. **2,** it will be observed that current flow through the winding **12** (control of oscillator **11** — FIG. **1**) is under control of a transistor **70.** This transistor is connected in series with a diode **71** so that both together are in series with the winding **12,** while the transistor controls current flow therethrough. The state of conduction or non-conduction of transistor **70** is controlled by a PNP transistor **74** that has the collector electrode thereof connected directly to the base of transistor **70** by a circuit wire **75.** The PNP transistor **74** is in turn controlled for determining current flow therethrough by having a circuit connection **78** that goes from the base electrode of transistor **74** to a connection point **76** that is between resistors **49** and **50** of the flip-flop circuit **40.** Consequently, when the transistor **42** is conducting, there will be sufficient voltage drop across resistor **49** to apply enough potential between the emitter and the base of PNP transistor **74** to cause it to conduct. The resulting current flow through a resistor **79** will provide a voltage drop that causes a potential to be applied over the wire **75** to the base of the transistor **70** such that it will conduct.

On the other hand, when the flip-flop circuit **40** has been switched to the opposite state from that just described above, the transistor **42** will be no longer conducting. Them, the transistor **41** will conduct and transistor **42** will be cut off. Therefore, the current flow through PNP transistor **74** will cease and in turn, the transistor **70** will no longer conduct. Consequently, the current flow through control winding **12** will be cut off.

It may be noted that as an additional feature, there is included an arrangement for making sure that the high frequency spark voltage is not continuously supplied in case the engine should stop with the shaft **20** so positioned that the rotor and stator elements are in correspondence with the matching projections **33** and **36** in radial alignment. Such conditions would leave the flip-flop circuit **40** switched over so as to cut off the current flow in control winding **12** and thus cause the oscillator **11** to continue to produce spark voltage output to the engine. Since these conditions would be dangerous to personnel handling the engine, provision is made for switching the flip-flop circuit **40** back to the other state so as to cause current to flow in control winding **12** and therefore cut off oscillator **11** and the generation of spark energy.

In order to accomplish the foregoing, there is a timing circuit that includes a unijunction transistor oscillator **82** (see FIG. **2**). This oscillator is made up of a unijunction transistor **83** that has its control electrode connected between a resistor **86** and a capacitor **87** which are connected in series. These provide a time constant effect so that a pulse will be obtained after a predetermined time delay in case the engine has stopped as indicated above. Such pulse will cause the flip-flop circuit to be switched back so as to cut off the oscillator **11.**

The other two electrodes of the unijunction transistor **83** are connected respectively to one end of each of two resistors **90** and **91.** Resistor **90** has the other end thereof connected via a circuit wire **94** to the B+ voltage source. The other end of resistor **91** is connected to ground, as illustrated. In addition, there is a capacitor **95** that is connected between one end of the resistor **56** of the transistor **42** branch of the flip-flop circuit, and one end of resistor **91** in the unijunction transistor **83** circuit.

OPERATION

As indicated above, the oscillator **11** (FIG. **1**) is controlled, turned on and off, by the flow of direct current through winding **12** of the timing transformer (core **15**). As long as no current flows, the oscillator will run and a spark is available. When current flows, the timing transformer is saturated and insufficient feedback is present for the oscillator to oscillate. However, for the oscillator to start, the flow of current through the start-stop winding **12** of the timing transformer (core **15**) must be interrupted abruptly. Such interruption was accomplished with mechanical switching at the breaker points, in prior arrangements.

With this invention, the foregoing interruption is accomplished using the electronic circuit and related elements that are illustrated in FIG. **2.** Its operation may be described as follows:

The transistors **41** and **42** and allied components compose a conventional flip-flop circuit with the exception of winding **32** which has replaced the conventional base to ground resistor of transistor **41.** The coil **32** is the pickup coil on the stator **25** that is associated with the timing shaft **20.**

Assuming that transistor **42** is "on", the current flow through resistor **49** will cause a sufficient voltage differential between the base and emitter of the PNP transistor **74** so that it will be conducting. This will cause a sufficient voltage to be developed across resistor **79** so that transistor **70** will be conducting. The timing, or control, winding **12** of the oscillator **11** is connected through the diode **71** to the collector of transistor **70.** Sufficient current flows so that no oscillation of the basic oscillator **11** of the internal combustion engine ignition system can occur.

When the leading edges of the projections **36** on the rotor **21,** pass the stationary points of the stator projections **33,** a positive voltage pulse is developed across the coil **32.** This voltage pulse applied to the base of the "off " transistor **41** will cause this transistor to start to conduct. The positive pulse applied to the base coil will appear as a negative pulse at the collector. This negative pulse is coupled through capacitor **61** and resistor **60** to the base of the "on" transistor **42.** This negative pulse on the base appears as a positive pulse on the collector (amplified by the gain of the transistor) of transistor **42.** This positive pulse is coupled to the base of transistor **41** by resistor **64** and capacitor **65.** This cascading action causes the system to "flip" and transistor **41** now becomes conducting and transistor **42** nonconducting. When transistor **42** becomes nonconducting, PNP transistor **74** no longer conducts, hence there will be no forward bias on the transistor **70** and it will cease to conduct. When the flow of current through the timing transformer (core **15**) ceases, the oscillation starts and a spark occurs. As long as transistor **42** is off, the oscillation will continue and a spark will be available for ignition.

When the trailing edges of the projections **36** on the rotor **21** pass the points of projections **33** on the stator **25,** a change of flux will occur and a negative voltage pulse will be induced in the coil **32.** This negative pulse will be applied to the base of transistor **41** which is now the "on" transistor. This pulse will cause the flip-flop **40** to flip so that transistor **42** will be conducting and transistor **41** off. This, in turn, will cause transistor **70** to conduct which will stop the oscillation of the ignition system.

ADDITIONAL ELEMENTS

It may be noted that there is a Zener diode **98** (FIG. **2**) that is connected between the B+ voltage supply and ground. This is employed to regulate the amplitude of the B+ voltage and consequently a single electronic system may be used with different values of battery voltage.

It may be noted also that the diode **71** is provided for preventing voltage induced in the control winding **12** (FIGS. **1** and **2**) from damaging the transistor **70** (FIG. **2**) during the time that the Jensen type oscillator **11** (FIG. **1**) is running.

While a particular embodiment of the invention haS been described in considerable detail above, 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.

I claim:

1. In a high frequency continuous-wave ignition system for an internal combustion engine, said system employing a control winding for starting and stopping said high frequency continuous-wave energy, and having a shaft for timing said energy relative to said engine,

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

electromagnetic means associated with said shaft for providing an initial pulse of one polarity and a terminal pulse of the opposite polarity separated by a predetermined degree of shaft angle rotation and both pulses for each cylinder of said engine, and

bistable oscillator means actuated by both said pulses for cutting off said current flow when said initial pulse appears and for restoring said current flow when said terminal pulse appears.

2. The invention according to claim **1**, wherein

said electromagnetic means comprises a coil,

a rotor carried by said shaft, and

a stator,

said rotor and said stator providing a permeable magnetic flux path having a gap therein and said coil being located in inductive relationship to said flux, and wherein

said electronic means comprises a flip-flop circuit having said coil connected therein.

3. The invention according to claim **2**, wherein

said gap varies depending upon the angular position of said shaft from maximum to a predetermined minimum at the generation of one of said pulses and from said minimum back to maximum at the generation of the other of said pulses, and wherein

said electronic means further comprises current flow control means in series with said control winding, and

circuit means for connecting said current flow control means to one branch of said flip-flop circuit.

4. The invention according to claim **3**, wherein

said minimum gap produces said initial pulse at the beginning and said terminal pulse at the ending thereof, and wherein

said current flow means comprises a diode, and

a transistor, and wherein

said circuit means comprises a PNP transistor connected to the base of said transistor.

5. The invention according to claim **4**, wherein

said flip-flop circuit comprises a pair of transistors.

6. The invention according to claim **2**, further including

timing means connected to one side of said flip-flop circuit for restoring said current flow after a predetermined delay in case said engine stops with said shaft between said initial and terminal pulses.

7. The invention according to claim **6**, wherein

said timing means comprises a unijunction transistor oscillator.

8. In a high frequency continuous-wave ignition system for an internal combustion engine, said system employing

a. a control winding for starting and stopping said high frequency continuous-wave energy, and having

b. a shaft for timing said energy relative to said engine,

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

c. a rotor of magnetically permeable material carried by said shaft (b) and having a plurality of radial projections with concentric arcuate extremities extending concentrically over an arc equal to said predetermined rotation angle,

d. a stator of magnetically permeable material including a permanent magnet and a closed path for the magnetic flux which includes said rotor (c),

e. a plurality of pointed projections on said stator (d) matching in number of projections on said rotor (c) and forming a minimum air gap when in radial registration with said rotor projections throughout said arc,

f. a coil located in inductive relation with said magnetic flux,

g. a flip-flop circuit comprising a pair of transistors and having said coil (f) connected therein for switching same,

h. a diode and

i. transistor connected in series with said control winding (a) for controlling current flow therethrough,

j. a PNP transistor connected to the base of said transistor (i),

k. a circuit for connecting said PNP transistor to one branch of said flip-flop circuit (g) for making said transistor (i) become non-conducting when said flip-flop (g) is in one state and return to being conducting when it (g) is in the other state, and

l. a unijunction transistor oscillator connected to one side of said flip-flop (g) for switching it (g) back to said other state after a predetermined time delay in case said engine stops with it (g) having been switched to said one state.

9. In a high frequency continuous-wave ignition system for an internal combustion engine, said system employing a control winding for starting and stopping said high frequency continuous-wave energy, and having a shaft for timing said energy relative to said engine,

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

means associated with said shaft for providing an initial pulse of one polarity and a terminal pulse of the opposite polarity separated by a predetermined degree of shaft angle rotation and both pulses for each cylinder of said engine, and

bistable oscillator means actuated by both said pulses for cutting off said current flow when said initial pulse appears, and for restoring said current flow when said terminal pulse appears.

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