

[54] **HIGH FREQUENCY TYPE IGNITION SYSTEM**

[75] Inventor: **Robert E. Canup**, Richmond, Va.

[73] Assignee: **Texaco Inc.**, New York, N.Y.

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 87,549, Nov. 6, 1970, abandoned, and a continuation-in-part of Ser. No. 193,909, Oct. 29, 1971.

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

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

[58] Field of Search..... 123/148 E; 315/212, 209

References Cited

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Primary Examiner—Laurence M. Goodridge

Assistant Examiner—Cort Flint

Attorney, Agent, or Firm—T. H. Whaley; C. G. Reis

[57]

ABSTRACT

A high-frequency ignition system which employs electromagnetic feedback with a control winding applying at least partial saturation to stop and start oscillations. It employs an improved combination to apply magnetic bias to part of the magnetic feedback circuit in order to overcome the possibility of a failure to start the oscillator upon de-energization of the control winding. It may also include a semiconductor in the control winding circuit for insuring a desired polarity of the last half-cycle of AC current.

15 Claims, 4 Drawing Figures

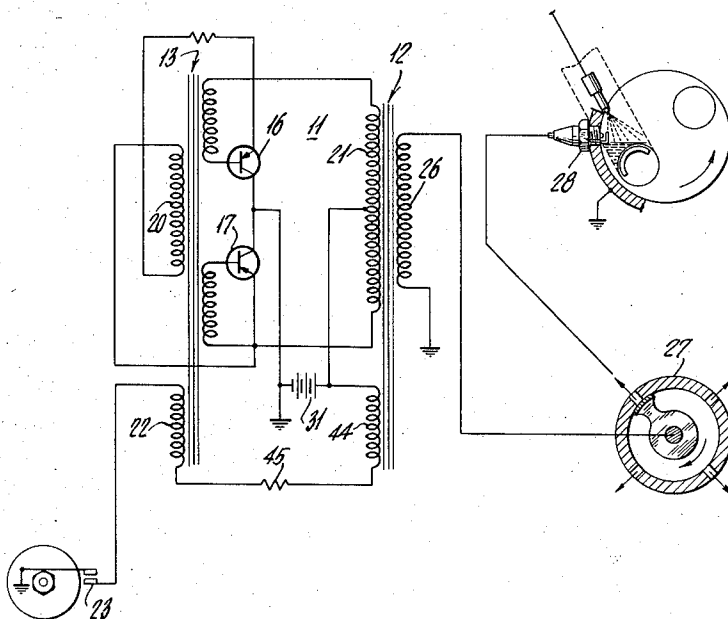


FIG. 1.

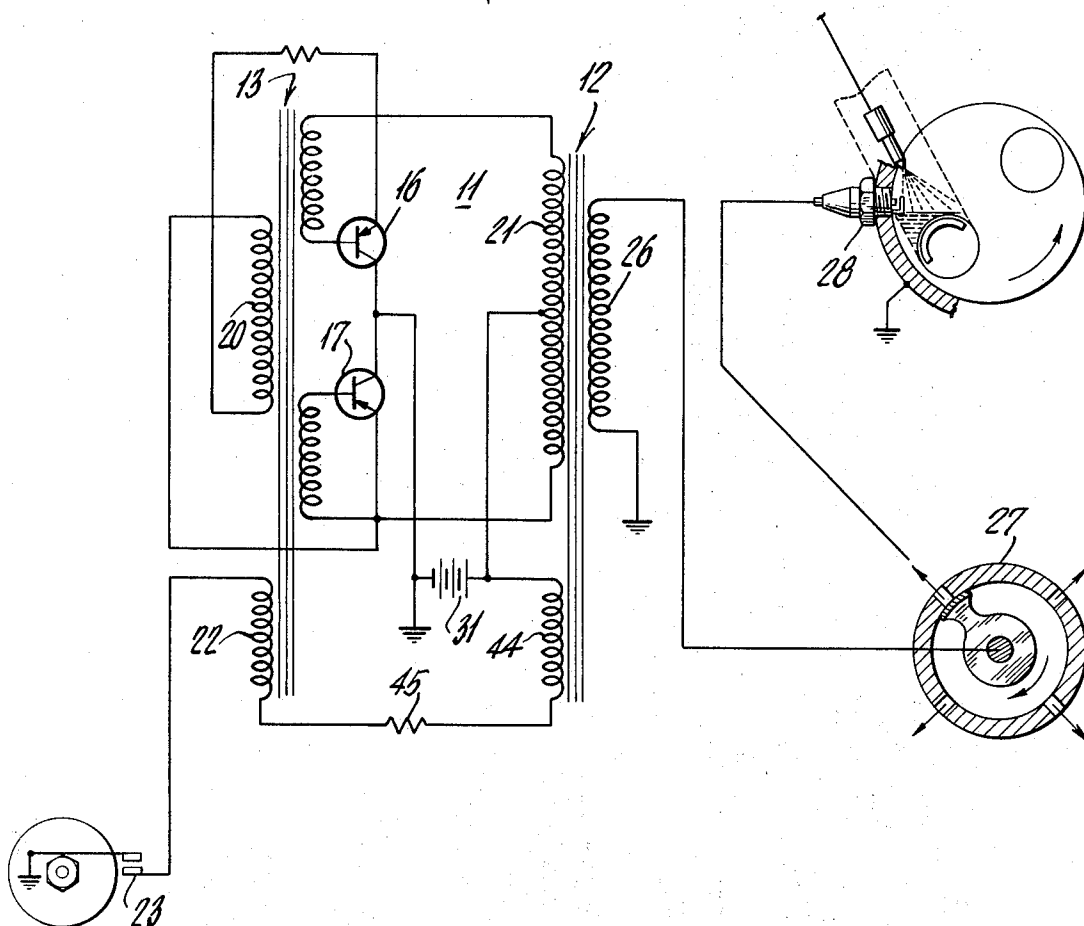


FIG. 2.

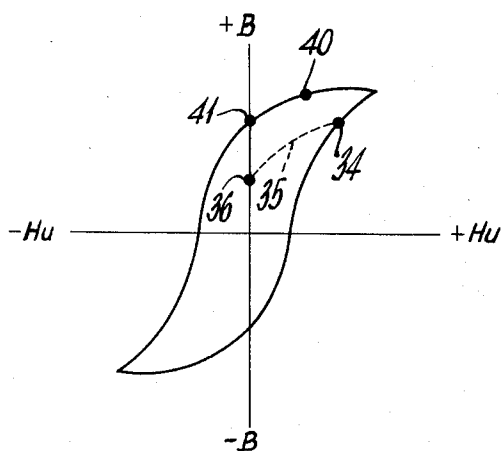
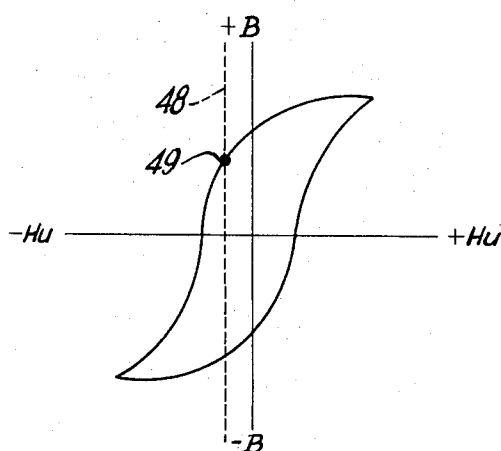
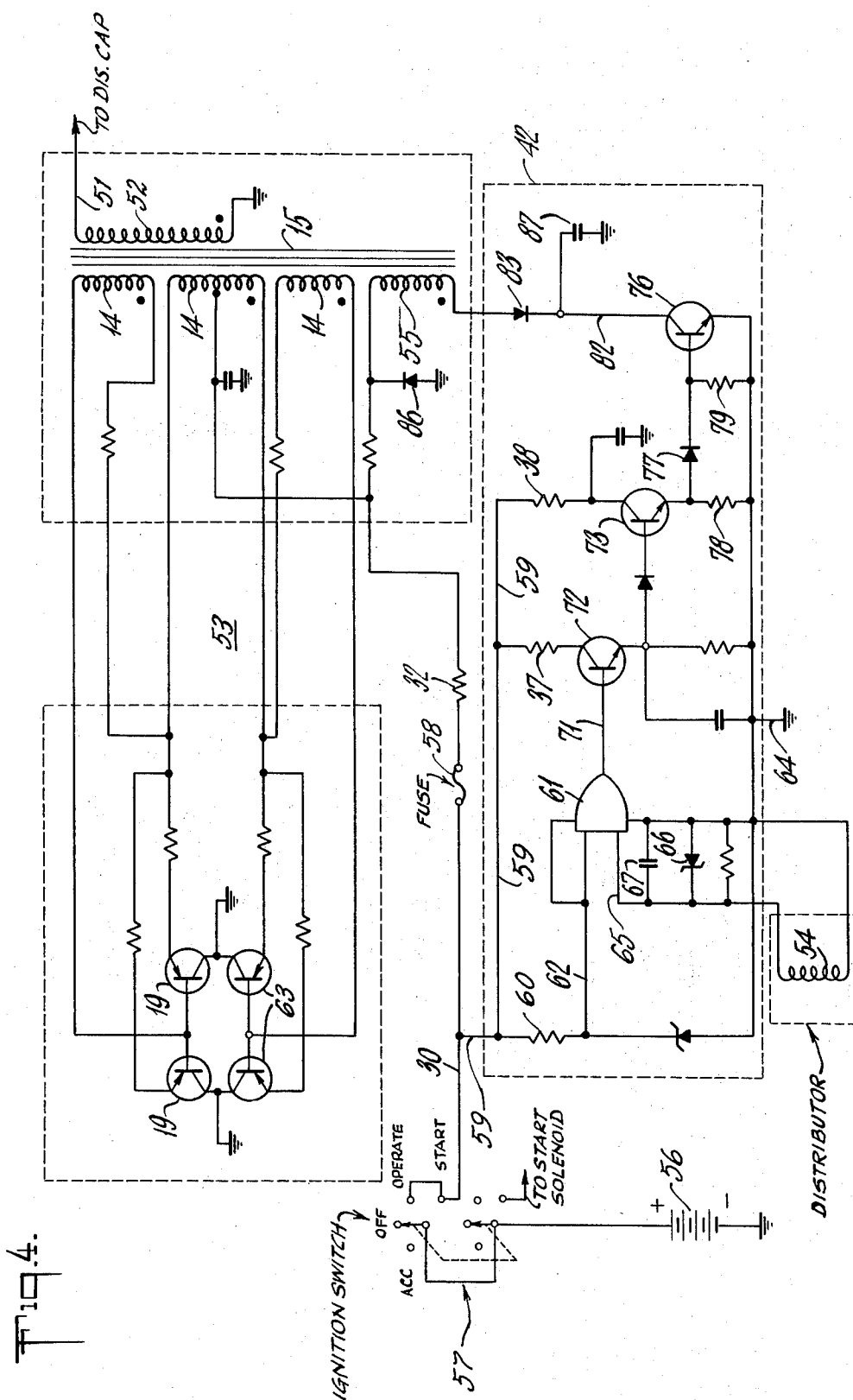


FIG. 3.





HIGH FREQUENCY TYPE IGNITION SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part of two copending applications of the same inventor as follows:

Ser. No. 87,549

Filed: Nov. 6, 1970

Title: HIGH FREQUENCY TYPE IGNITION SYSTEM (to be abandoned in favor of this application), and

Serial No. 193,909

Filed: Oct. 29, 1971

Title: CONTINUOUS-WAVE IGNITION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention concerns ignition systems in general. More specifically, it relates to a high-frequency system of the type that employs saturable core or overloading of electromagnetic feedback, with at least partial magnetic saturation to control starting and stopping of oscillation. It particularly concerns improvements for such systems.

2. Description of the Prior Art

A known type of high-frequency ignition system is disclosed in U.S. Pat. No. 3,407,795. However, it has been found that this system occasionally fails to start oscillating when the breaker points are open. Also, there have been heretofore proposed other types of high-frequency oscillators employed in ignition systems but these too may have the magnetic circuit come to rest in such state that the oscillation will not start at the instant desired. This invention provides for a means to overcome such difficulties so that the oscillator will always start whenever the control winding is de-energized, i.e., when the breaker points are opened or an engine-timed spark-control unit is actuated.

SUMMARY OF THE INVENTION

Briefly, this invention relates to an ignition system for use with an internal combustion engine having breaker points associated therewith for initiating a high-frequency spark signal created by an oscillator employing electromagnetic feedback coupling, and wherein said breaker points control application of means for saturating said feedback coupling to stop said oscillator. In such system, the invention concerns the improvement which comprises means for applying a magnetic bias to at least part of said electromagnetic coupling in a direction for setting the magnetic state so that said oscillator will start when said breaker points open, irrespective of the at-rest magnetic state following the stopping of said oscillator.

Again briefly, the invention concerns an ignition system for use with an internal combustion engine having engine-timed current-flow control means associated therewith for initiating a high-frequency spark signal that is created by an oscillator employing electromagnetic feedback coupling therein. The said current-flow control means controls application of means for at least partially saturating said feedback coupling to stop said oscillator, and the invention particularly concerns the improvement that comprises means for applying a magnetic bias to at least part of said electromagnetic mag-

netic coupling in a direction for setting the magnetic state so that said oscillator will start when said current-flow control means stops current flow irrespective of the at-rest magnetic state following the stopping of said oscillator.

Once more, briefly, the invention concerns improved elements in combination with an ignition system for use with an internal combustion engine having engine-timed current-flow control means associated therewith for initiating a continuous-wave high-frequency spark signal. Said signal is created by a continuous-wave oscillator employing electromagnetic feedback coupling therein. The current-flow control means controls application of means for at least partially saturating said feedback coupling to stop said oscillator. The invention particularly concerns the improvement that comprises means for removably applying a magnetic bias to at least part of said electromagnetic coupling, and semiconductor means associated with the saturating means.

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 an application of the invention to a two-transformer ignition system;

FIG. 2 is a showing of a typical hysteresis loop for illustrating conditions in one of the magnetic cores of the FIG. 1 system;

FIG. 3 is another illustration of the same hysteresis loop as shown in FIG. 2 with the addition of a dashed-line indication of shifted axis for the magnetic intensity; and

FIG. 4 is a circuit diagram illustrating another application of the invention, this to a single-transformer ignition system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIG. 1, it may be noted that the ignition system illustrated is basically like that shown in the above-noted U.S. Pat. No. 3,407,795. Such system has a relatively high-frequency continuous-wave oscillator 11 that employs electromagnetic feedback coupling and includes two transformers 12 and 13, all as explained in the foregoing patent. This basic circuit is well-known and it employs a pair of transistors 16 and 17. These have the base electrodes connected to windings on the saturable core of transformer 13. There is also a feedback winding 20 that together with a center-tapped winding 21 on output transformer 12, are part of the oscillator circuit which is like that described in the foregoing patent.

In addition, there is a control winding 22 that is located on the saturable core transformer 13. It is a saturating winding and it is connected in series with a pair of breaker points 23 for controlling flow of DC current through the winding 22. The arrangement is such that when the oscillator 11 is oscillating, an output high-frequency spark signal is generated in an output winding 26 on the transformer 12. This spark energy is delivered via a distributor 27 to a spark plug 28. Energy

to drive the oscillator 11 is supplied by a DC source, such as a battery 31 that is illustrated.

The foregoing system was found to occasionally fail to start oscillating upon opening of the breaker points 23. It was discovered that a cause for this difficulty related to the electromagnetic flux conditions in the output transformer 12. Thus, with reference to FIG. 2, it may be noted that during oscillation the core of this transformer is driven repeatedly through a complete hysteresis loop such as the one illustrated. Now of course, the oscillation will be stopped when the breaker points 23 close and this may be at any point along the hysteresis loop at random. Thereafter, the magnetic state will become one of "zero" magnetic current or magnetizing force as the magnetic flux decays back to a steady-state condition. Following that, when the breaker points 23 open again the first current flow will drive the core through the hysteresis loop to the right-hand side, and the flux change will tend to induce the feedback voltage in the center-tapped winding 21 which in turn will induce a voltage in the feedback winding 20 that will further turn on that one of the transformers 16 or 17 that starts the oscillation.

Thus, for example (still with reference to FIG. 2), if the oscillation stops when the magnetic state of the core is at a point 34 on the hysteresis loop, the magnetic flux will decay along a minor hysteresis loop 35 which is indicated by a dashed line. Such decay continues to a point 36 on the zero magnetic intensity line or axis. Thereafter, when the breaker points are again opened and the feedback action starts, there will be a sufficient flux change in the core of transformer 12 to induce an adequate voltage in the primary winding 21 thereof to start the oscillation.

However, should it happen that the oscillation was stopped with the magnetic state of the core at a point 40 on the hysteresis loop, then the flux will decay back to a point 41 on the zero magnetic intensity axis. Thereafter, when the breaker points 23 are opened and the control winding 22 is de-energized, its collapsing field will tend to start the oscillation. But, in this case will not be sufficient flux change in the core of transformer 12 to induce enough voltage in the primary winding 21 (and therefore the feedback winding 20 of the saturable core transformer 13) to cause adequate feedback for starting the oscillation.

While the probability is small that the oscillator will stop with the core magnetic state at some point along the upper right-hand portion of the hysteresis loop, it is a random occurrence and the probabilities are sufficient that over any substantial period of time the failure to start is predictable.

In order to overcome the foregoing possible misfire, there is added to the basic circuit of the type described in the above-noted patent (U.S. Pat. No. 3,407,795), an additional winding 44 (see FIG. 1) on the transformer 12. This winding is connected in series with a resistor 45 and the control winding 22 as well as the breaker points 23. By properly choosing the polarities, this winding 44 provides a desired magnetic bias on the core of transformer 12 during the time when the breaker points 23 are closed. This, in effect, causes flux in the core to be always on the negative side of the B-H curve. This is indicated in FIG. 3 by a dashed line 48. The result is that even though the magnetic flux conditions are such as described above with respect to the points 40 and 41 on the FIG. 2 curve, there will be a

steady-state flux condition at a point 49 on the hysteresis curve (see FIG. 3) to which the flux will decay. Therefore, when the initial oscillator startup conditions are obtained thereafter, a large enough flux change will always take place to start the oscillator. Consequently, under no conditions can there be a failure of starting of the oscillator when the breaker points 23 are opened. In other words, regardless of where on the hysteresis curve of the magnetic core of transformer 12 the oscillation may have ceased, there will always be an initial flux change sufficient to cause the oscillator to start.

It will be appreciated that the various values for components such as the resistor 45 and the voltage of the DC supply 31, as well as the dimensions of the cores and the number of turns of the windings for the transformers 12 and 13, plus the windings 44 and 22, will all be selected so as to provide the desired conditions of magnetic bias while still providing for the desired oscillator action with its start-stop control by the saturation winding 22.

It will also be appreciated that the invention may be applied to other types of continuous-wave oscillators and ignition systems. For example, the oscillator circuit might be of the Uchirin-Royer type that is illustrated in FIG. 4 and my above-noted co-pending application Ser. No. 193,909, instead of the Jensen type which is illustrated above in connection with FIG. 1.

Referring to FIG. 4, 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 51 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 51 leads out from a secondary winding 52 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 53, which is basically like the circuit disclosed in a copending application Ser. No. 100,642, filed December 22, 1970 now U.S. Pat. No. 3,749,973 issued July 31, 1973. Consequently, no detailed explanation of the oscillator operation is needed. However, it may be pointed out that the oscillator 53 employs two pairs of transistors 19 and 63 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 53 is not new, per se, but, as employed in this case, it makes use of a control winding 55 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 55 acts to control the starting and stopping of the oscillator 53. This involves the application of DC-current flow through the winding 55, along with a low-impedance path, so that when the DC current is flowing and the low-impedance path is effective, the winding 55 will load down the oscillator sufficiently to stop its oscillation. Then, when it is desired to supply spark energy over the output connection 51, the oscillator 53 will be started by removing the DC-current flow through winding 55. The decaying flux thus created will act in the proper direction to cause instantaneous starting of the oscillator 53. The oscillator will, of course, then supply the desired high-voltage

high-frequency spark signal over the circuit including output connection 51.

It is important to note that there is a semiconductor element, which may be the diode 86 illustrated, that is connected in the above-mentioned low-impedance path. This diode 86 will ensure a desired polarity of the magnetic flux in the core of the transformer 15 so that the magnetic bias created by the DC current mentioned above will not be counteracted.

The ignition system is energized whenever a power source, e.g. a 12-volt battery 56, is connected to supply the DC power to the system. This is accomplished in a conventional manner with the circuit from battery 56 being carried via an ignition switch 57 which connects the positive side of battery 56 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 53 via a fuse 58 and a resistor 32.

At the same time, the positive voltage from battery 56 is connected via a circuit connection 59 to one side of each of three resistors 60, 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 a co-pending application Ser. No. 67,450, filed Aug. 27, 1970.

Thus, as is explained in more detail in my above-noted application Ser. No. 193,909, filed Oct. 29, 1971, there is a breakerpointless arrangement that includes structure for electromagnetic coupling with a coil 54 (FIG. 4).

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 60 from that which is connected to the common connector 59. There is another input connection 65 that connects the 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 input 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 3 in a Darlington configuration to amplify and feed the output of the NAND gate 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 55 via a circuit connection 82 and a diode 83. Part of the winding 55 (oscillator control) circuit also includes another diode 86 (mentioned above) and a capacitor 87. The latter two have one side of each grounded, as shown.

OPERATION OF FIG. 4

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 53 is cut off because of the low-impedance path across the control winding 55 that includes the diode 86 and the power transistor 76. Also, a DC current in the winding 55 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 57 is on.

When the distributor rotor projections (not shown) reach alignment with the stator projections (not shown), 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 55 which starts the oscillator 53, while the low-impedance path is also removed.

The sparking interval with the oscillator 53 oscillating continues until the trailing edges of the rotor projections (not shown) pass out of alignment with the stator projections (not shown). 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 53 that applies a positive voltage to the collector of transistor 76, will load the oscillator and stop it while, at the same time, DC-current flow is re-established in the winding 55.

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 53 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.

I claim:

1. In combination with an ignition system for use with an internal combustion engine having breaker points associated therewith for initiating a high-frequency continuous-wave spark signal, said system including an oscillator for generating said spark signal, said oscillator having an output transformer for supplying said spark signal to said engine, said oscillator employing electromagnetic feedback including at least part of the magnetic circuit of said output transformer, and wherein said breaker points control application of means for at least partially saturating said feedback coupling to stop said oscillator, the improvement comprising

means for removably applying a magnetic bias to at least part of said electromagnetic feedback coupling including said output transformer and in a direction for setting the magnetic state thereof so that said oscillator will start when said breaker points open irrespective of the at-rest magnetic state in said feedback coupling following the stopping of said oscillator.

2. The invention according to claim 1 wherein said magnetic bias means comprises a winding magnetically coupled to said electromagnetic coupling, and

circuit means for passing DC current through said winding when said breaker points are closed.

3. The invention according to claim 1 wherein said electromagnetic feedback coupling comprises a transformer having a saturable core and an output transformer.

4. The invention according to claim 3 wherein said magnetic bias applying means comprises a winding on said output transformer, and

circuit means for passing DC current through said output transformer winding when said breaker points are closed.

5. The invention according to claim 4 wherein said saturable core transformer has a saturation control winding connected in series with said magnetic bias winding on the output transformer.

6. In an ignition system for use with an internal combustion engine having breaker points associated therewith for initiating a high-frequency spark signal created by an oscillator employing electromagnetic feedback coupling,

said coupling comprising a saturable core transformer having a saturating (control) winding thereon, and

an output transformer,

the improvement comprising a magnetic bias winding on said output transformer, and

circuit means for connecting said bias winding in series with said control winding and said breaker points and including impedance means for determining the amount of current flow when said breaker points are closed.

7. In combination with an ignition system for use with an internal combustion engine having engine-timed current flow control means associated therewith for controlling initiation and termination of a high-frequency continuous-wave spark signal, said system including an oscillator for generating said spark signal, said oscillator having an output transformer for supplying said spark signal to said engine, said oscillator employing electromagnetic feedback including at least part of the magnetic circuit of said output transformer, and wherein said current flow control means controls application of means for at least partially saturating said oscillator feedback coupling to stop said oscillator, the improvement comprising

means for removably applying a magnetic bias to at least part of said oscillator electromagnetic feedback coupling including said output transformer and in a direction for setting the magnetic state thereof so that said oscillator will always start when said engine-timed current flow control means stops said current flow irrespective of the at-rest magnetic state following the stopping of said oscillator.

8. The invention according to claim 7 wherein said magnetic bias means comprises

a winding magnetically coupled to said electromagnetic feedback coupling, and

circuit means for passing and cutting off DC current through said winding under control of said current flow control means.

9. The invention according to claim 7 wherein said electromagnetic feedback coupling comprises

a transformer having a saturable core and an output transformer.

10. The invention according to claim 9 wherein said magnetic bias applying means comprises

a winding on said output transformer, and

circuit means for passing DC current through said output transformer winding when said current flow control means is passing current.

11. The invention according to claim 10 wherein said saturable core transformer has a saturation control winding connected in series with said magnetic bias winding on the output transformer.

12. In an ignition system for use with an internal combustion engine having engine-timed current flow control means associated therewith for initiating a high-frequency spark signal created by an oscillator employing electromagnetic feedback coupling,

said coupling comprising a saturable core transformer having a saturating control winding thereon, and

an output transformer,

the improvement comprising a magnetic bias winding on said output transformer, and

circuit means for connecting said bias winding in series with said control winding and said engine-timed current flow control means and including impedance means for determining the amount of current flow when said current flow control means is passing current.

13. In combination with an ignition system for use with an internal combustion engine having engine-timed current flow control means associated therewith for controlling initiation and termination of a continuous-wave high-frequency spark signal, said signal including an oscillator for generating said spark signal, said oscillator having an output transformer for supplying said spark signal to said engine, said oscillator employing electromagnetic feedback including at least part of the magnetic circuit of said output transformer, and wherein said current flow control means controls application of means for at least partially saturating said oscillator feedback coupling to stop said oscillator, the improvement comprising

means for removably applying a magnetic bias to at least part of said oscillator electromagnetic feedback coupling, and

semiconductor means associated with said saturating means for ensuring a predetermined polarity of saturation when said oscillator is stopped.

14. The invention according to claim 13, wherein said semiconductor means comprises a diode, and circuit means for connecting said diode in series with said feedback coupling saturating means.

15. In an ignition system including a source of DC current and an inverter-type oscillator, said system being adapted for use with an internal combustion engine having engine-timed current flow control means associated therewith for controlling initiation and ter-

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mination of a continuous-wave high-frequency spark signal created by said oscillator, said oscillator employing electromagnetic feedback coupling,

said coupling comprising an output transformer for applying said spark signal to said engine, said output transformer having a magnetic core and a control winding in addition to at least one feedback winding for said oscillator,

the improvement comprising first circuit means for connecting said source of DC current to said con-

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trol winding when said oscillator is not oscillating in order to apply a magnetic bias to said core, a diode, and

second circuit means for connecting said diode in series with said current flow control means and said control winding whereby said oscillator will always stop with the polarity of the magnetic flux aiding the magnetic bias created by said DC current.

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