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Katsumata

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[54] **BREAKERLESS IGNITION SYSTEM**

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

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

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

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[57] **ABSTRACT**

A breakerless ignition system for an internal combustion engine, which is of capacitor discharging type comprising a controlled rectifier to control the discharging current of a capacitor to supply firing current through the controlled electrode and cathode of said controlled rectifier for conduction thereof, characterized in that control means is provided which comprises at least two ignition signal sources one of which has a different characteristic of ignition in advanced phase relative to revolution of the engine from that of the other source and transformer means to compound the signal outputs from said ignition signal sources whereby proper advanced ignition phase can be provided to the engine.

16 Claims, 8 Drawing Figures

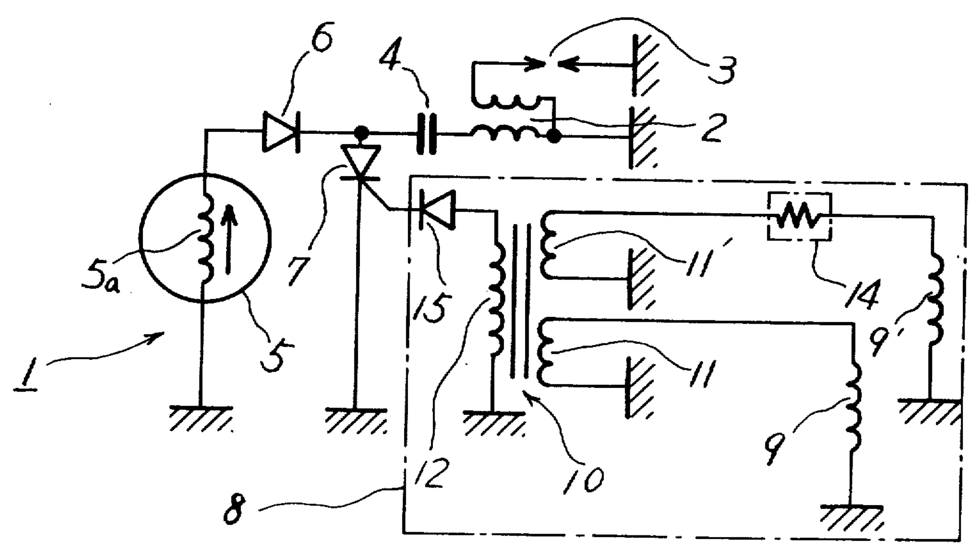


FIG.1

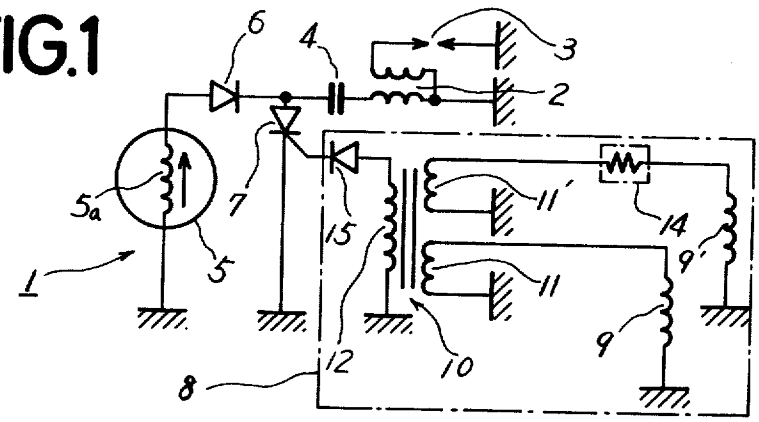


FIG.2

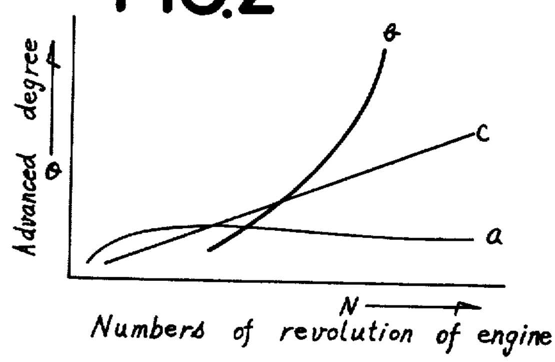


FIG.3A

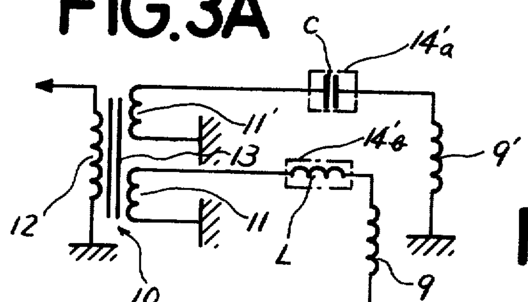


FIG.3B

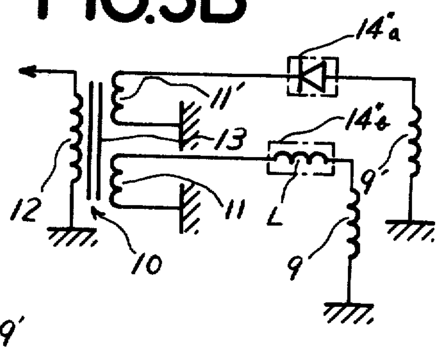


FIG.3C

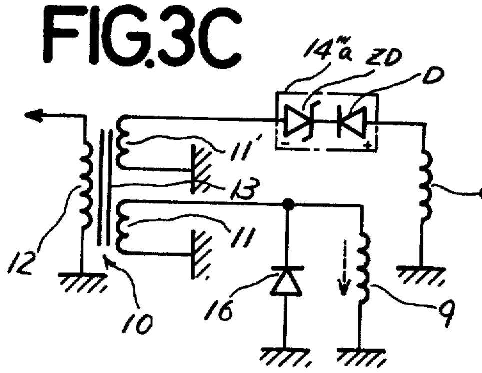


FIG.4

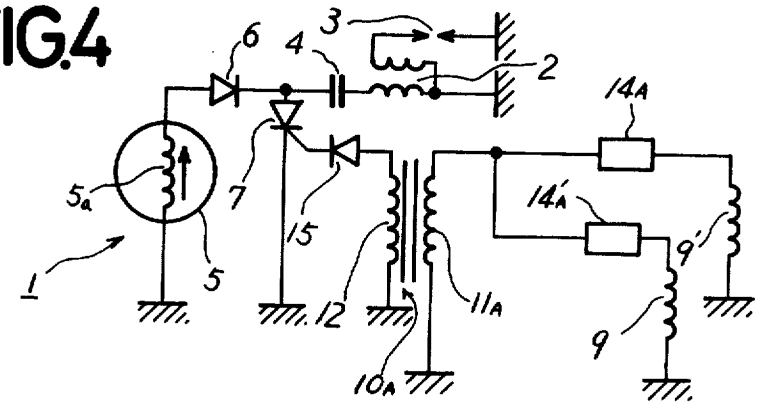


FIG.5

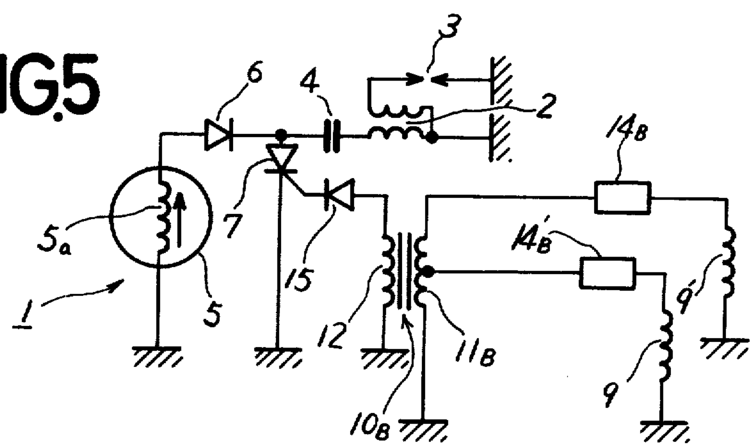
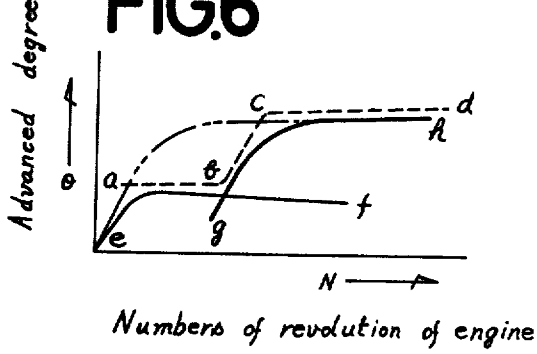


FIG.6



BREAKERLESS IGNITION SYSTEM

FIELD OF THE INVENTION

This invention relates generally to a breakerless ignition system for an internal combustion engine and more particularly to control means for a breakerless ignition system for an internal combustion engine.

BACKGROUND OF THE INVENTION

In an internal combustion engine, the ignition position of a piston in the engine is preferred to be generally 5° to 10° before the upper dead point of the piston for continuation of stable revolution of the engine during lower speed of operation thereof and on the other hand to be generally 20° to 35° during higher speed of operation thereof.

As shown in FIG. **6** of the accompanying drawings, preferred advanced ignition degree of the piston has been plotted against revolution of the engine as in the dotted line *a-b-c-d*, which is ideal curve for proper operation of the engine.

As known in the art, the breakerless ignition system comprises a semiconductor controlled rectifier to control the conduction of a primary ignition current through an ignition coil. Conventionally, the controlled rectifier has been controlled in its controlled electrode by a single ignition signal source which in turn produces an ignition signal in timing relation to the position of the piston in the engine for conduction of the controlled rectifier. As understood by those skilled in the art, the single ignition signal source, which may be a generator coil, can produce a predetermined signal having a characteristic of ignition in the form of a simplified curve as shown in the dot and dash line of FIG. **6.** Therefore, if the generator coil would be designed to have an output saturated at the low level corresponding to that of ideal curve required for stable revolution during lower speed of operation of the engine, it then produces an unsuitable output for stable revolution during higher speed of operation of the engine, and vice versa. Thus, the conventional breakerless ignition system does not provide a proper ignition spark in the cylinder of the engine entirely during wider speed of operation thereof.

A SUMMARY OF THE INVENTION

Accordingly, it is a principal object of the present invention to provide a breakerless ignition system for an internal combustion engine in which provision is made of ignition spark properly advanced in phase during both lower and higher speeds of operation of the engine.

In accordance with the present invention, there is provided a breakerless ignition system for an internal combustion engine, which comprises an ignition coil, an ignition plug connected to a secondary side of said ignition coil and received in the cylinder of the engine for ignition of a fuel gas therein, a capacitor connected to a primary side of said ignition coil, a power source to charge said capacitor, a controlled rectifier to control the discharge of said capacitor through the primary side of said ignition coil for energization thereof, and control means to supply firing current through the controlled electrode and cathode of said controlled rectifier for conduction thereof, characterized in said control means comprising at least two ignition signal sources, one of which has a different characteristic of ignition in advanced phase relative to revolution of the engine from that of the other source, and transformer means to compound signal outputs from said ignition signal sources whereby proper advanced ignition phase can be provided to the engine.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and advantages of the present invention will become apparent to those skilled in the art from the teachings of the following description of preferred embodiments with reference to the accompanying drawings;

FIG. **1** is a schematic diagram of one preferred embodiment of a breakerless ignition system for an internal combustion engine in accordance with the present invention;

FIG. **2** shows characteristic curves of ignition degrees plotted against revolution of the engine when an output of an ignition signal generator is adjusted by modulators for use in the present invention;

FIG. **3A** shows a modification of a modulator for use in the present invention;

FIG. **3B** shows further modification of a modulator in use for the present invention;

FIG. **3C** shows another modification of a modulator in use for the present invention;

FIG. **4** is a schematic diagram of a modification of the present invention;

FIG. **5** is a schematic diagram of another modification of the present invention;

and FIG. **6** shows characteristic curves of ignition degree against revolution of the engine in accordance with the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to FIG. **1**, there is shown a breakerless ignition system for an internal combustion engine, indicated generally at numeral **1.** While the embodiment is described which is applied to a single-cylindered engine, it will be understood by those skilled in the art that it will be able to be applied to multiple-cylindered engine. The ignition system **1** comprises an ignition coil **2** with a primary side thereof grounded at one end to earth and with a secondary side of the ignition coil **2** connected to one end of an ignition plug **3** received in a combustion chamber in the cylinder of the engine for ignition of compressed fuel gas therein and grounded at the other end thereof to earth.

This ignition system is shown to be of capacitor discharge type including a capacitor **4** connected at one end to the other end of the primary side of the ignition coil **2.** A power source, such as a magneto generator **5,** is provided which comprises an armature coil **5***a* grounded at one end thereof to earth and connected at the other end thereof to anode of a diode **6,** the cathode of which is connected to the other end of the capacitor **4.** The generator **5** is driven by the engine and produces electric power in timing relation to revolution of the engine, which has an alternative wave form. Thus, when the output is of positive half wave as indicated by an arrow is generated from the magneto generator **5,** the current flows through the diode **6** to the capacitor **4** and then through the primary side of the ignition coil **2** back to the generator **5** to charge the capacitor **4** to gradually increase the voltage across the capacitor **4.**

In order to discharge the capacitor **4** through the primary side of the ignition coil **2** there is provided a semiconductor controlled rectifier such as thyristor **7** which has the anode thereof connected to the said other end of the capacitor **4** and its cathode grounded to earth. When the thyristor **7** is in the conductive state as the capacitor **4** remains at high level in voltage, the latter is discharged through the thyristor **7** and then through the primary side of the ignition coil **2** to establish higher voltage across both ends of the secondary side of the ignition coil **2** and therefore, to spark in the ignition plug **3** to ignite the compressed fuel gas in the cylinder.

Ignition control means **8**, which serves to fire the controlled rectifier in timing relation to the position of the piston in the cylinder, comprises two ignition signal sources which are formed of two signal coils **9** and **9'** of a magneto type signal generator driven by the engine, with respective one ends of the signal coils grounded to earth. The signal coils **9** and **9'** are associated with the thyristor **7** as described hereinafter, and are so designed that the signal output of the signal coil **9** is raised more rapidly than that of the signal coil **9'** and saturated at a lower level than the latter. This can be accomplished by a modulator described just hereinbelow, or alternatively by the signal coil **9** having more numbers of turn than the signal coil **9'** has. Thus, it will be noted that the characteristic of ignition in advanced phase during lower speed of operation of the engine is provided by the signal coil **9** to the ignition system while that during higher speed is provided by the signal coil **9'**. As well known, the signal generator may be provided in the magneto generator **5** or alternatively separately from the latter.

Ignition control means **8** also comprises a signal transformer **10** which includes two primary windings **11** and **11'**, a secondary winding **12** and a magnetic core **13** serving to magnetically couple the primary windings **11** and **11'** with the secondary winding **12**. The signal coil **9** is shown to be connected at the other end thereof to one end of the transformer primary winding **11** and the signal coil **9'** to be connected at the other end thereof to one end of the transformer primary winding **11** through a modulator or adjustor **14** which may be in the form of a single resistance, with the other ends of the primary windings grounded to earth. The modulator **14** will be described in more detail hereinafter. The secondary winding **12** has one end connected to an anode of a diode **15** the cathode of which is connected to the gate of the thyristor **7** and has the other end grounded to earth.

As understood, the transformer **10** serves to compound the signals from the signal coils **9** and **9'** of the magneto generator to supply turn-on current to the gate and cathode of the thyristor **7** to turn it on. Another function of the transformer **10** is to make the ignition signal from control means **8** narrower in its width. The ignition signal occurs while power from the magneto generator **5** is of positive half wave and in the charging condition of the capacitor **4**, but if the ignition signal continues to occur after power in the next positive half wave is produced from the magneto generator **5**, then the current which must flow through the capacitor **4** to charge it in the next charging cycle would flow through the thyristor **7** without charging the capacitor to override the ignition system. Therefore, the magnetic core **13** is preferably of saturable type in which when it is energized to a predetermined degree it is saturated and as a result even though energized furthermore the magnetic flux through the core has no variation in amplitude. Thus, its variation in amplitude occurs only before saturation of the magnetic core to limit in width the ignition signal from control means **8** that is derived from the secondary winding of the transformer **10**.

In operation, before the piston of the cylinder in the engine reaches the explosion cycle, the capacitor **4** has been charged by current flowing from the magneto generator **5** therethrough. On taking consideration into a characteristic of ignition in advanced phase only from the signal coil **9** of the ignition signal generator, the output from the signal coil **9** flows through the primary winding **11** of the signal transformer **10** and the output from the secondary winding **12** thereof flows through the forward diode **15** and then through the gate and cathode of the thyristor **7**. When the current through the gate and cathode of the thyristor **7** reaches the turn-on level, the thyristor is turned on to instantly discharge the now-charged capacitor **4** through the anode and cathode of the thyristor **7** and then through the primary side of the ignition coil **2**. Thus, as aforementioned, high voltage is established across the secondary side of the ignition coil **2** to permit the ignition plug **3** to spark for ignition of the now-compressed fuel gas in the cylinder.

On taking into consideration a characteristic of ignition in advanced phase only from the other signal coil **9'** of the ignition signal generator, during lower speed of operation of the engine the output from the signal coil **9'** has been substantially controlled or blocked by the modulator **14** to have no effect of the turn-on of the thyristor **7**. As the engine operates or rotates at higher numbers of revolution, the output from the signal coil **9'** of the ignition signal generator becomes higher to positively energize the primary winding **11'** of the transformer **10**, the secondary winding **12** of which permits the current to flow through the forward diode **15** and then through the gate and cathode of the thyristor **7** in the same manner as described in connection with the signal coil **9** of the ignition signal generator. Now, the thyristor **7** is fired so that the discharging current flows from the capacitor **4** through the primary side of the ignition coil **2** for sparking of the ignition plug **3**. Thus, when the engine operates at lower speed, the signal output from the signal coil **9** of the generator permits the thyristor **7** to become conductive to control the discharge or primary ignition current through the primary side of the ignition coil **2**. The characteristic of ignition in advanced phase through the signal coil **9** is shown in solid curve *e-f* of FIG. **6**. On the other hand, when the engine operates at higher speed, the signal output from the signal coil **9'** of the signal generator permits the thyristor **7** to become conductive to control the primary ignition current through the primary side of the ignition coil **2**. The characteristic of ignition in advanced phase through the signal coil **9'** is shown in solid curve *g-h* of FIG. **6**. Since the signal transformer **10** may be energized by either of the signal outputs from the signal coils **9** and **9'** of the signal generator depending upon the numbers of revolution of the engine, the ignition system in accordance with the present invention provides the characteristic of ignition in advanced phase as shown in composite curve *e-g-h*, which is substantially close to the ideal curve *a-b-c-d* in FIG. **6**.

The modulator **14**, which comprises the resistor in a system of FIG. **1**, serves to modulate the signal output from signal coil **9'** of the signal generator so that the characteristic of ignition through the signal coil **9'** differs from that through the signal coil **9.** A separate modulator may be associated with the signal coil **9** of the signal generator as described hereinafter. In the alternative form, the modulator may comprise inductance L, capacitor C or composite elements selected from the group consisting of inductance, capacitor and resistance. FIG. **2** shows the characteristics of ignition in advanced phase in case of application of the above modulator element to the ignition system, in which the abscissa shows numbers of revolution of the engine N while the ordinate shows the advanced degree of ignition. When the modulator comprises inductance L in series with the signal coil of the signal generator it tends to restrain the system from advancing in ignition as shown in curve a of FIG. **2.** On the contrary, when capacitor C is employed, the system tends to have no advancing effect during lower speed of operation of the engine and to have considerable advancing effect during higher speed as shown in curve b of FIG. **2.** When resistance is employed as shown in FIG. **1**, the system presents the linear characteristic of ignition in advanced phase as shown in curve c of FIG. **2.** The resistance may be replaced by non-linear resistance, an example of which will be described hereinafter.

The ignition control means **8** of FIG. **3**A includes a modulator **14'***a* comprising a capacitor C in series with the signal coil **9'** of the signal generator and a second modulator **14'***b* comprising an inductance L in series with the signal coil **9** of the signal generator. In FIG. **3**B the modulator **14''***a* is shown to comprise a diode in series with the signal coil **9'**, which is of non-linear resistance while the modulator **14''***b* comprises an inductance L in series with the signal coil **9**, which is identical to the modulator **14'***h* of FIG. **3**A. Ignition control means **8** of FIG. **3***c* includes a modulator **14''***a* comprising a combination of series-connected diode D and Zener diode ZD in series with the signal coil **9'** with the Zener diode connected in reverse direction relative to the signal coil **9'**. In order to by-pass the negative half wave of output from the signal coil **9** (shown in dotted arrow), there is provided a diode **16** in parallel with the signal coil **9** of the signal generator. In this embodiment, when the engine operates at lower speed, the signal from the signal coil **9'** is blocked by the Zener diode ZD.

FIG. **4** shows a modification of the ignition system in accordance with the present invention in which the signal transformer **10A** comprises a single primary winding **11A** to which are connected in parallel the signal coils **9** and **9'** of the signal generator and in which the signal coils have respective modulators **14A** and **14'A** connected in series thereto. The modulators **14A** and **14'A** may be preferably in the form of inductance and capacitor, respectively as shown in FIG. **3A**. Alternatively, those modulators may be of such type as shown in FIG. **3B**. It will be understood that the operation of the ignition system shown in FIG. **4** is substantially identical to that shown in FIG. **1.**

FIG. **5** shows another modification of the present invention in which the signal transformer **10B** comprises a tapped primary winding **11B** the non-grounded end of which is connected the signal coil **9'** and the tap of which is connected the signal coil **9** of the signal generator. In this embodiment, the modulators **14B** and **14'B** may be provided in association with the signal coils **9** and **9'**, which may be of such type as shown in FIG. **3A** or **3.** With this arrangement, when the engine operates at lower speed, the signal output from the signal coil **9** is transformed in high ratio of transformation through the signal transformer **10B**, as understood by those skilled in the art.

While some preferred embodiments have been described with reference to the accompanying drawings, it is intended not to limit the invention thereto, but various modifications and variations may be made within the spirit and scope of the present invention, which should be defined by the appended claims.

What is claimed is:

1. A breakerless ignition system for an internal combustion engine, comprising an ignition coil, an ignition plug connected to the secondary side of said ignition coil and received in the cylinder of the engine for igniting a fuel gas therein, a capacitor connected to a primary side of said ignition coil, a power source to charge said capacitor, a controlled rectifier to control the discharge of said capacitor through the primary side of said ignition coil for energization thereof, and ignition control means to supply firing current through the controlled electrode and cathode of said controlled rectifier for conduction thereof, characterized in that said ignition control means comprises at least two ignition signal sources one of which has a different characteristic of ignition in advanced phase against revolution of the engine from that of the other signal source and transformer means for compounding the signal outputs of said ignition signal sources and coupling said signal outputs to said controlled electrode, said transformer means having saturable core means for limiting the time width of signals coupled through said transformer means, whereby proper advanced ignition phase can be provided to the engine.

2. A breakerless ignition system as set forth in claim **1**, characterized in that said ignition control means further comprises a modulator connected in series circuit with one of said ignition signal sources.

3. A breakerless ignition system as set forth in claim **2**, wherein the other of said ignition signal sources controls firing of said controlled rectifier during lower speed of operation of the engine.

4. A breakerless ignition system as set forth in claim **3**, wherein said modulator comprises an inductance.

5. A breakerless ignition system as set forth in claim **2**, wherein one of said ignition signal sources controls firing of said controlled rectifier during higher speed of operation of the engine.

6. A breakerless ignition system as set forth in claim **5**, wherein said modulator comprises a linear resistance.

7. A breakerless ignition system as set forth in claim **5**, wherein said modulator comprises a diode.

8. A breakerless ignition system as set forth in claim **5**, wherein said modulator comprises a capacitance.

9. A breakerless ignition system as set forth in claim **5**, wherein said modulator comprises a diode in series circuit with a Zener diode.

10. A breakerless ignition system as set forth in claim **1**, characterized in that said ignition control means further comprises modulators respectively connected in series circuit with said ignition signal sources.

11. A breakerless ignition system as set forth in claim **10**, wherein one of said modulators comprises a linear resistance.

12. A breakerless ignition system as set forth in claim **10**, wherein one of said modulators comprises a diode.

13. A breakerless ignition system as set forth in claim **10**, wherein one of said modulators comprises a capacitance.

14. A breakerless ignition system as set forth in claim **13**, wherein the other modulator comprises an inductance.

15. A breakerless ignition system as set forth in claim

11, wherein one of said modulators comprises a diode in series circuit with a Zener diode.

16. A breakerless ignition system as set forth in claim **1**, wherein said transformer means comprises primary winding means and secondary winding means, said primary winding means comprising a tapped winding one end of which is grounded to earth, and one of said signal sources being connected to the non-grounded end of said tapped winding and the other signal source being connected to the tap of said tapped winding.

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