United States Patent

Wesemeyer

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[54] **IGNITION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES HAVING AN ALTERNATING CURRENT GENERATOR**

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[51] **Int. Cl.**..**F02p 3/06**

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

[56] **References Cited**

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[57] **ABSTRACT**

Shunted across the charging winding of the alternating current generator is an impedance and a spark discharge capacitor connected in series. A thyristor is connected to permit discharge of the capacitor through the primary winding of the spark core when the thyristor is conductive, the control electrode of the latter being connected to the impedance so that the triggering voltage is the voltage drop across the impedance.

16 Claims, 3 Drawing Figures

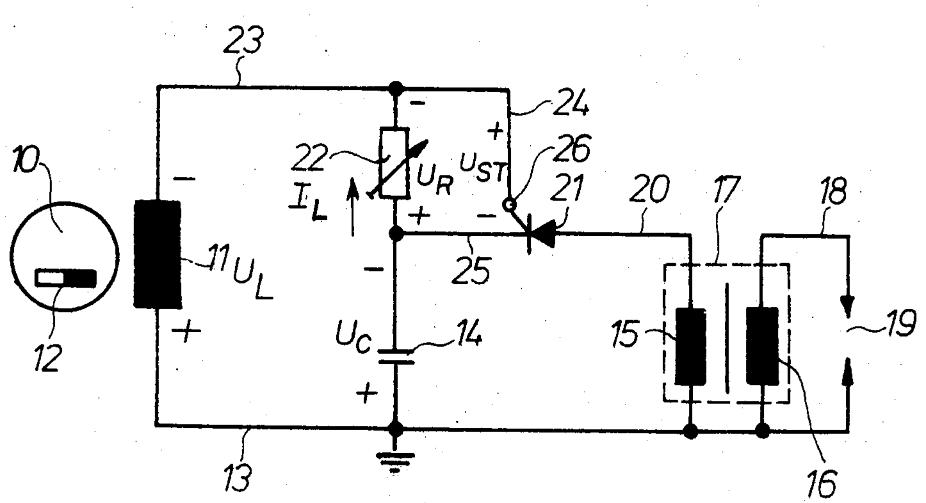

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Fig.1

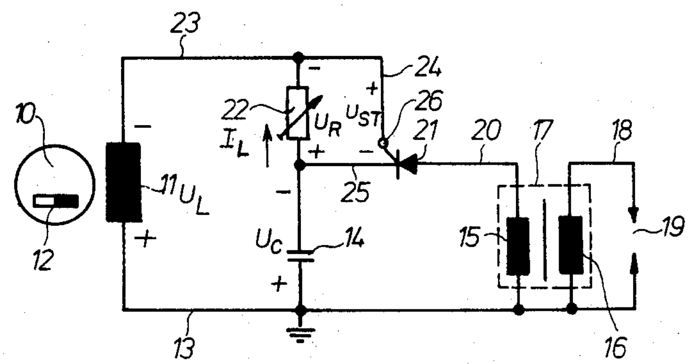


Fig.2

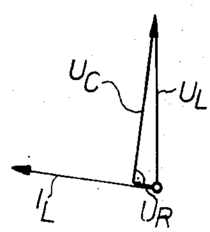
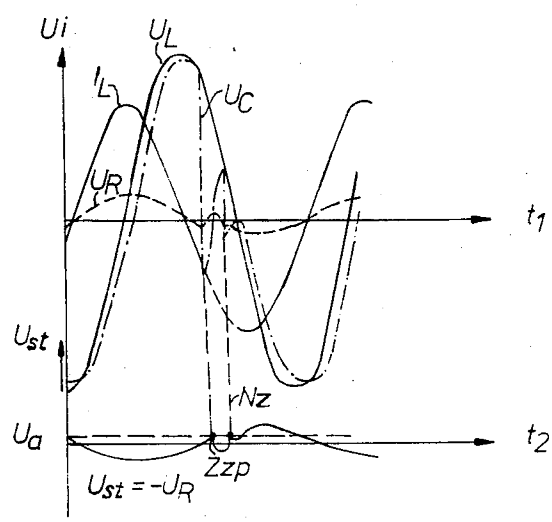


Fig.3



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IGNITION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES HAVING AN ALTERNATING CURRENT GENERATOR

BACKGROUND OF THE INVENTION

The invention relates to an ignition arrangement for internal combustion engines, the arrangement having a spark discharge capacitor that is charged by the alternating current generator and discharged, at the ignition point, through the primary of the spark plug, by an electronic switch.

With these known arrangements it is essential to trigger the electronic switch—usually a transistor, a thyristor, or a triac—by a control voltage conducted to the switch at the ignition time. The required control voltage is obtained from a battery or a generator, and is conducted by a mechanical or an electronic control switch at the correct time to the control electrode of the transistor or thyristor. The prior art also discloses circuits for connecting the control electrode of a thyristor to a pulse generator having magnets, the pulse generator delivering a voltage pulse at the ignition point to trigger the thyristor.

These solutions have the disadvantage that special and sometimes trouble prone, arrangements are necessary to generate the triggering voltage and/or to switch this triggering voltage to the control electrode of the electronic switch.

SUMMARY OF THE INVENTION

An object of the invention is an ignition arrangement that solves, in a very simple manner, the problem of obtaining the triggering voltage from the charging circuit and conducting this voltage to the control electrode of the electronic switch at the desired time.

The invention consists essentially of an alternating current generator, a capacitor connected to the alternating current generator to be charged thereby, a spark coil having a primary winding and a secondary winding, the latter winding being connected to at least one spark plug, electronic switch means triggered into conductivity by a control voltage, the electronic switch means being connected between the capacitor and the primary winding so that when the electronic switch means is conductive the capacitor is free to discharge through the primary winding to induce in the secondary winding a voltage pulse sufficient to spark the plug, and impedance means connected in series with the capacitor for causing a voltage gap, that is, the control voltage, the resistive or the reactive component of the impedance means having any value including zero.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims.

The invention itself, however, both as to its construction and its method of operation, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram of the ignition arrangement of the invention;

FIG. 2 is a vector diagram showing the phase relationships between the charging current and the voltages across the capacitor, the impedance, and the charging winding; and

FIG. 3 shows the time relationships of the current and of the voltages of the vector diagram of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1, the ignition arrangement of the invention is energized by an alternating current generator **10**, in the charging winding **11** of which there is induced an alternating voltage by the rotation of a bar having permanent magnets, the bar **12** being driven by the internal combustion engine, not shown. A lead **13** connects one end of the charging winding **11** to one plate of a spark discharge capacitor **14** and to respective ends of the primary winding **15** and the secondary winding **16** of a spark coil **17**. A spark plug wire **18** connects the other end of the secondary winding to a spark plug **19**. A lead **20** connects the other end of the primary winding **15** to the anode of a thyristor **21**, which latter acts as an electronic switch. The cathode of the thyristor is connected by a lead **25** to the junction between the capacitor **14** and an impedance **22**, the impedance and the capacitor being connected in series. Components **20**, **21** and **25** constitute discharge current path means connecting capacitor **14** with primary winding **15**. A lead **23** connects the series connected impedance and capacitor to the other end of the charging winding **11**. The triggering voltage for the control electrode **26** of the thyristor is conducted by a lead **24**, connected between the control electrode and the end of the impedance remote from the capacitor.

When the internal combustion engine operates, there is induced in the charging winding **11** of the generator **10** an alternating current voltage, which, so long as the thyristor **21** is non-conductive, causes a current to flow in the capacitor charging circuit, the magnitude and phase of this current depending on the total impedance of the charging circuit. FIG. 2 is a vector diagram of the current and voltages in the charging circuit. It will be assumed that the instantangeous positive value of the voltage U_L induced in the winding **11** is 150 volts, that the resistance of the impedance **22** is approximately 50 ohms, and that the capacitor **14** is 1 microfarad. With these assumptions, the charging current I_L of approximately 200 milliamperes leads the voltage U_R by approximately **82°**. The voltage drop U_R across the impedance **22** is approximately **10** volts and is in phase with the current I_L. The voltage U_C across the capacitor **14** is approximately 148 volts, and it lags the voltage U_R by 90° and the voltage U_L by 8°.

The spark discharge capacitor i4 is charged and discharged at the frequency of the alternating voltage U_L induced in the charging winding **11**. In order to assure a maximum voltage at the sparkplug **19** it is essential that the capacitor is discharged as nearly as possible when the capacitor voltage U_C is at its maximum positive value. This condition is ensured by using, for the thyristor triggering voltage, the negative part of the voltage U_R across the impedance **22**. In FIG. 3, the current and voltages in the charging circuit are plotted along the upper time axis t_1, and the thyristor triggering voltage U_{st} is plotted along the lower time axis t_2. Since the triggering voltage U_{st} is measured from the cathode of the thyristor, it is the negative of the voltage U_R

across the resistor 22, which latter voltage is shown in dash lines in FIG. 3. The triggering voltage U_{st} becomes positive shortly after the capacitor voltage U_c is maximum (shown in dot-dash lines). At the moment Zzp that the plug 19 is to fire, the voltage U_{st} is 1.5 voltage positive, and it instantaneously triggers the thyristor. As FIG. 3 shows, at this moment the voltage U_c across the capacitor 14 has fallen very little from its peak value, so that very nearly the maximum possible amount of stored electrical energy is discharged through the thyristor 21 and the primary winding 15 of the spark plug 17. The high voltage induced in the secondary 16 causes a first spark at the spark plug 19. Since a positive voltage U_L is induced in the charging winding 11 at the moment capacitor 14 begins to discharge, the latter is immediately recharged after being discharged and then again discharged during a secondary firing Nz thereby producing one or more sparks of rapidly decreasing energy, at the plug 19. This charging and discharging of the capacitor 14 is repeated during each period of the voltage induced in the charging winding 11; the ignition occurs at the frequency of the generator, which frequency is dependent on the motor rpm.

The impedance 22 is a voltage dependent component, in order to avoid exceeding the maximum permissible triggering voltage at high speeds of the internal combustion engine. As shown in FIG. 1, the impedance 22 can be made adjustable to enable shifting of the ignition point in dependence on the motor rpm or the motor load. The resistive or reactive component of the impedance can have any value including zero. The reactive component can be inductive and/or capacitive. By changing the value of the impedance 22, the magnitude and phase of U_R are changed, and the ignition point Zzp is shifted, at which point the triggering voltage U_{st} is equal to the triggering voltage U_a of the thyristor 21.

In accordance with the invention, a semiconductor, such as a Zener diode, can be used as the impedance 22.

It is advantageous to construct the capacitor 14, thyristor 21, and the impedance 22 as a replaceable subunit. With this in view, the lead 13 can be omitted, and the respective terminals of the charging winding 11, capacitor 14, primary 15, and secondary 16 connected to ground.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of circuits differing from the types described above.

While the invention has been illustrated and described as embodied in ignition arrangement for internal combustion engines having an alternating current generator, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

I claim:

1. An ignition arrangement adapted to activate at least one spark plug of an internal combustion engine, comprising, in combination ignition capacitor means; A.C. generator means; capacitor current path means connecting said generator means with said capacitor means for supplying alternating current thereto; transformer means having a primary winding and a secondary winding; discharge current path means connecting said capacitor means with said primary winding and including electronic switch means having control electrode means and controlling current flow from said capacitor means through said path means as a function of the voltages at said control electrode means; and impedance means arranged in said capacitor current path means connected in series with said capacitor means and connected with said control electrode means, the voltage across said impedance means determining the voltages at said control electrode means, and thereby determining the current flow from said capacitor means through said discharge current path means.

2. An arrangement as defined in claim 1, wherein said A.C. generator means produces current flow through said capacitor means in one direction and alternately in opposite direction, thereby alternately increasing and decreasing the voltage across said capacitor means.

3. An arrangement as defined in claim 1, wherein said A.C. generator means produces current flow through said capacitor means and impedance means in one direction, producing across said impedance means a voltage drop preventing current flow through said switch means, and alternately produces current flow through said capacitor means and impedance means in opposite direction, producing across said impedance means a voltage drop permitting current flow through said switch means.

4. An arrangement as defined in claim 1, said switch means comprising thyristor means.

5. An arrangement as defined in claim 3, said switch means comprising thyristor means having a gate and a cathode together constituting said control electrode means.

6. An arrangement as defined in claim 1, wherein said generator means produces during each voltage-cycle out-of-phase first and second voltage drops across said capacitor means and said impedance means, respectively, and wherein said first voltage drop varies between minimum and maximum values, and wherein said second voltage drop varies between values respectively permitting and preventing current flow through said switch means, and further wherein said second voltage drop reaches a value permitting current flow through said switch means a fraction of a voltage-cycle after said first voltage drop reaches said maximum value.

7. An arrangement as defined in claim 1, said capacitor means, impedance means, primary winding, secondary winding and generator means each having two terminals, and wherein said switch means comprises a thyristor having an anode, a cathode and a gate, and

wherein said impedance means has one terminal connected with one terminal of said generator means and with said gate and another terminal connected with one terminal of said capacitor means and with said cathode, and wherein said primary winding has one terminal connected to said anode.

8. An arrangement as defined in claim **7**, wherein the other terminal of said capacitor means is connected to the other terminal of said generator means, to the other terminal of said primary winding, to one terminal of said secondary winding, and to ground.

9. An arrangement as defined in claim **1**, wherein said impedance means has a voltage-dependent resistive component.

10. An ignition arrangement as defined in claim **1**, wherein said generator means includes a charging winding, said series connected capacitor and impedance means being connected in parallel with said generator means.

11. An ignition arrangement as defined in claim **1**, wherein said capacitor, means electronic switch means and impedance means compose a replaceable subunit of the ignition arrangement.

12. An ignition arrangement as defined in claim **1**, wherein said impedance means is adjustable.

13. An ignition arrangement as defined in claim **1**, wherein said impedance means includes inductively and capacitively reactive components.

14. An ignition arrangement as defined in claim **1**, wherein said impedance means includes an inductively reactive component.

15. An ignition arrangement as defined in claim **1**, wherein said impedance means includes a capacitively reactive component.

16. An ignition arrangement as defined in claim **1**, wherein said impedance means is at least predominantly resistive.

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