Feb. 28, 1967 A. G. HUFTON 3,306,275

ELECTRONIC APPARATUS

Filed Nov. 9, 1964

FIG. 1

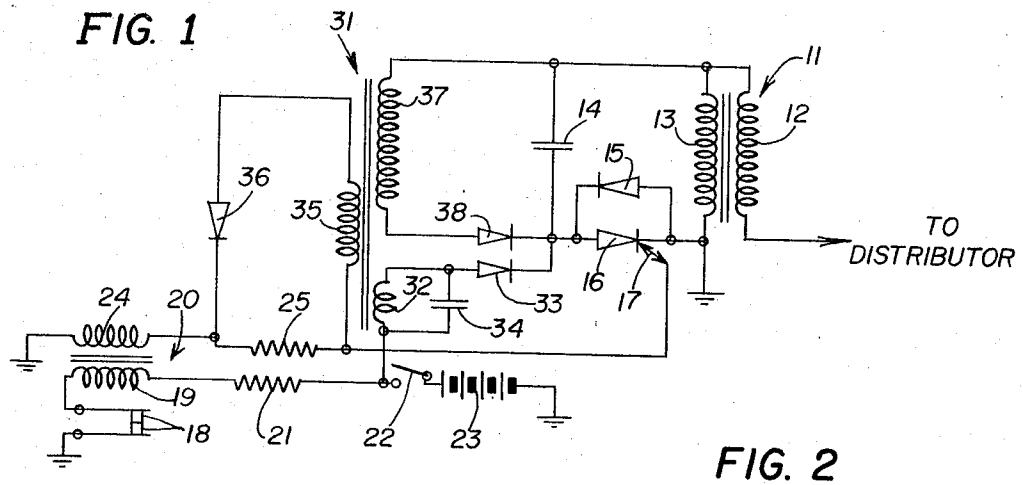
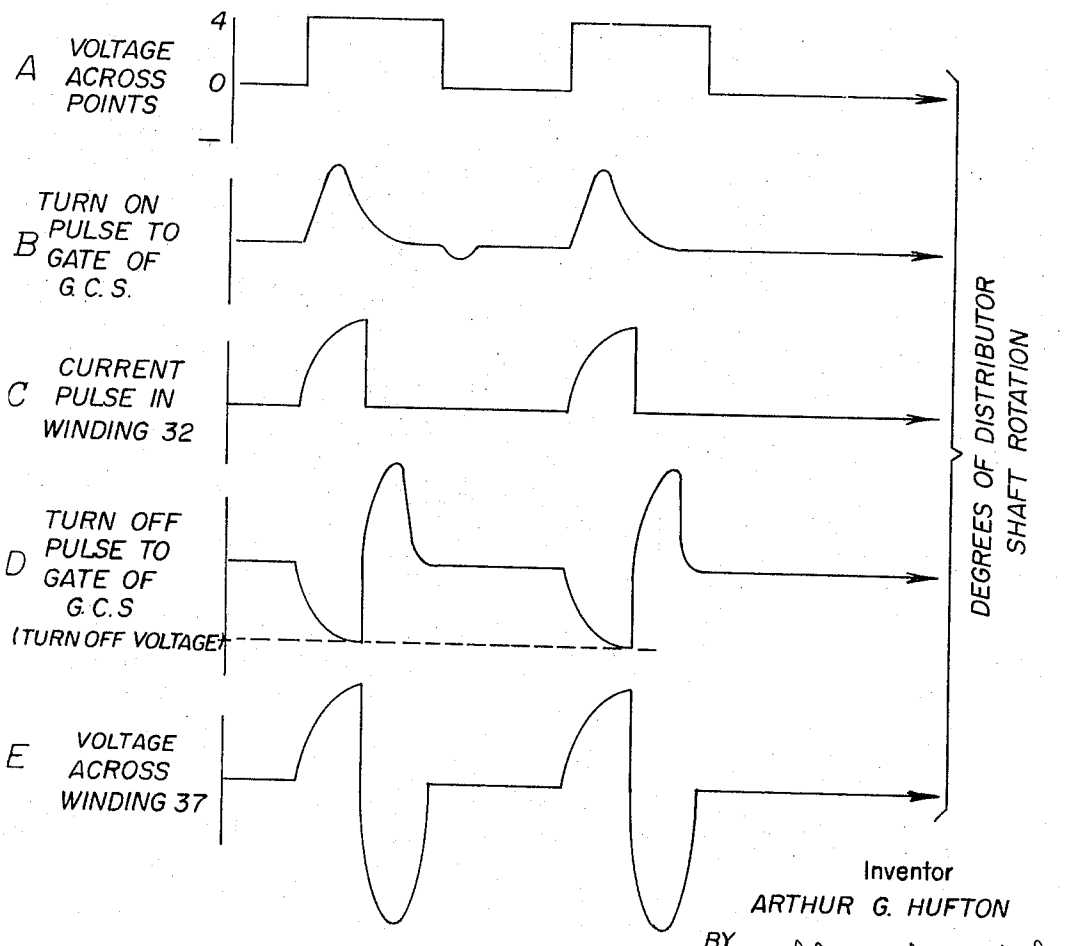


FIG. 2



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United States Patent Office 3,306,275 Patented Feb. 28, 1967

3,306,275

ELECTRONIC APPARATUS

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Filed Nov. 9, 1964, Ser. No. 409,793
5 Claims. (Cl. 123—148)

This invention relates to ignition systems for internal combustion engines, and more particularly to an improved ignition system utilizing the capacitor discharge principle.

Capacitor discharge ignition systems, that is, those systems which utilize a capacitor for intermittently discharging and causing current flow through an ignition coil, have been proposed over a long period of time. Such ignition systems have been recognized as theoretically superior to other types of ignition systems, but as a practical matter, capacitor discharge systems have not been satisfactory. Many of the capacitor discharge systems proposed to date have been complex and have required a large number of components. Often such systems failed to produce adequate voltage under certain conditions, and were unstable over variations in ambient temperature.

Accordingly, it is an object of this invention to provide an improved, low cost, ignition system for an internal combustion engine.

Another object of the invention is to provide a capacitor discharge system which provides adequate firing voltage for all conditions, and affords stability at high ambient temperature.

Still another object of the invention is to provide an improved ignition system utilizing the capacitor discharge principle and which is simple of operation and requires few components.

A feature of the invention is the provision of a firing circuit for an ignition coil, which circuit includes a capacitor connected to the ignition coil, a circuit for charging the capacitor, and a gate controlled semiconductor switch for discharging the capacitor in timed relation with the internal combustion engine.

Another feature of the invention is the provision, in a capacitive discharge ignition system, of a transformer having a primary winding connected in series between a source of potential and a gate controlled semiconductor switch and having a secondary winding connected to the gate of the semiconductor switch and responsive to current flow in the primary winding subsequent to discharge of an ignition capacitor to apply a turn off pulse to the gate.

Still another feature of the invention is the provision of a capacitor discharge ignition system having a transformer as above described and which includes a further secondary winding connected to the ignition capacitor for charging the same by a reverse transient pulse upon turn off of the semiconductor switch.

In the drawing:

FIG. 1 is a schematic diagram of an igntion system constructed in accordance with the invention; and

FIG. 2 is a set of curves illustrating the operation of the system wtih respect to time in degrees of crank shaft revolution.

In accordance with the invention, an ignition system for an internal combustion engine includes an ignition coil for supplying high voltage firing pulses to the internal combustion engine and further includes pulse means operable in synchronism wtih the internal combustion engine. The ignition system also includes a capacitor and a gate controlled semiconductor switch connected in series with the ignition coil. The gate controlled switch is turned on and off at predetermined times to permit

the capacitor, which has been charged to a high voltage, to discharge through the ignition coil and produce firing pulses therein.

A transformer having a primary and two secondary windings is utilized to control the operation of the firing circuit. The primary winding of the transformer is connected in series between the semiconductor switch and the source of potential. One of the secondary windings is connected to the gate region of the semiconductor switch and is responsive to current flow in the primary winding subsequent to discharge of the capacitor to apply a pluse to the gate region to turn the semiconductor switch off. The other secondary winding is connected to the capacitor and charges the capacitor by a reverse transient pulse upon turn off of the semiconductor switch.

Referring now to FIG. 1, an ignition transformer **11** has a secondary winding **12** coupled to the center post of a distributor for an internal combustion engine, not shown, as is well known in the art. Secondary winding **12** is connected to one end of primary winding **13** which, in turn, is connected to one side of an ignition capacitor **14**. The other end of primary winding **13** is grounded. Capacitor **14** is connected to the anode of a gate controlled semiconductor switch **16**. Gate controlled semiconductor switch **16** is of the four layer type and has a gate region **17** responsive to pulses of opposite polarity applied thereto to render the semiconductor switch **16** conductive and non-conductive respectively. When semiconductor switch **16** is conductive, a circuit path is completed through the series combination of the primary winding **13** of transformer **11**, capacitor **14** and semiconductor switch **16**. A protective diode **15** is connected across semiconductor switch **16** to protect the switch from backswing voltages in winding **13**.

Positive pulses are applied to the control region or gate **17** of semiconductor switch **16** by means of a pulse circuit. This pulse circuit is comprised of a pair of breaker points **18** connected in series with the primary winding **19** of a transformer **20**, and through resistor **21** and ignition switch **22** to a source of direct current potential, storage battery **23**. Breaker points **18** open and close in synchronism with the operation of the internal combustion engine, as is well known in the art. Transformer **20** includes a secondary winding **24** which is connected through a resistor **25** to gate region **17** of semiconductor switch **16**.

Assuming for the present that a charge is placed on ignition capacitor **14** at the proper times, with breaker points **18** closed, current flow limited by resistor **21** occurs in primary winding **19** of transformer **20**. Transformer **20** is wound such that this current produces a negative potential at the resistor end of secondary winding **24**, which has no effect on semiconductor switch **16**. When the points **18** open, however, the collapsing field in primary winding **19** produces a positive pulse in secondary winding **24**, which is applied through resistor **25** to gate **17** of semiconductor switch **16**. This positive pulse causes semiconductor switch **16** to turn on so that capacitor **14** is connected across winding **13**.

Almost the full voltage across the ignition capacitor **14** is thus applied across primary winding **13** of ignition coil **11** in a very short time, causing a rapid build-up of current. This action induces high voltage in the secondary winding **12** of ignition coil **11** according to the turns ratio of the ignition coil. This high voltage pulse is then applied to the center post of the distributor for firing the fuel mixture in the respective cylinders of the internal combustion engine. The breaker points **18** shown in the pulsing circuit are merely an example of one pulsing device. Other systems for producing a positive pulse for application to transformer **20** for developing a timely

output voltage in secondary winding 24 might also be utilized within the scope of this invention.

Semiconductor switch 16 is turned off by the application of a negative pulse to gate 17. This pulse is developed by means of transformer 31, which has a primary winding 32 connected in series between the storage battery 23 and the semiconductor switch 16 through diode 33. A capacitor 34 is connected across primary winding 32 of transformer 31. Transformer 31 further includes a secondary winding 35 which is connected in series with a diode 36 across resistor 25. When capacitor 14 has discharged through semiconductor switch 16, this switch will remain conductive resulting in a rising current pulse in primary winding 32, as illustrated in FIG. 2, curve C. This rising current pulse induces a voltage in secondary winding 35 such that the juncture between winding 35 and resistor 25 goes negative. This voltage, illustrated in curve D of FIG. 2, is applied to the gate electrode 17 of semiconductor switch 16. As may be seen from curve D, when this negative going pulse exceeds the turn off voltage level for the semiconductor switch 16, the switch will be turned off, reducing primary current and hence the secondary voltage, quickly to zero.

The energy stored in transformer 31 is also utilized to charge the capacitor 14. Transformer 31 is provided with a further secondary winding 37, which is connected in series with a diode 38 across ignition capacitor 14. As may be seen from curve E of FIG. 2, when semiconductor switch 16 is turned off causing the primary current of transformer 31 to go quickly to zero, a voltage backswing will occur in secondary winding 37. This backswing voltage is utilized to charge capacitor 14 through diode 38. The backswing voltage appearing in winding 35 is prevented from triggering the semiconductor switch 16 by the diode 36. It should be noted that the entire sequence of the operation of the circuit is triggered by a single pulse. This permits a wide choice in triggering methods utilized. The system is capable of giving a satisfactory high voltage output to the spark plugs of an internal combustion engine with all the advantages of capacitor discharge ignition systems, but with fewer components than prior systems. This enables simplicity of design and compactness with greater stability at higher temperatures.

It may therefore be seen that the invention provides an improved low cost ignition system for an internal combustion engine, which system utilizes the capacitor discharge principle. The system provides adequate firing voltages while utilizing a minimum of power and few components.

I claim:

1. In an ignition system for an internal combustion engine, which system has an ignition coil for supplying high voltage firing pulses to the internal combustion engine and pulse means operable in synchronism with the internal combustion engine, a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, capacitor means, charging means coupled to said capacitor means for applying a voltage thereto for charging said capacitor means, a gate controlled semiconductor switch connected in series with said capacitor means and the ignition coil, said semiconductor switch having a gate region responsive to a pulse of a given polarity to turn said semiconductor switch on and responsive to a pulse of opposite polarity to turn said semiconductor switch off, means coupled to the pulse means to apply pulses of the given polarity to said gate region to turn said semiconductor switch on and discharge said capacitor means through said ignition coil for producing a firing pulse therein, a transformer having primary and secondary windings, said primary winding being connected in series between said semiconductor switch and a source of potential, said secondary winding being connected to said gate region and being responsive to current flow in said primary winding subsequent to discharge of said capacitor means to apply a pulse opposite said given polarity to said gate region to turn said semiconductor switch off.

2. In an ignition system for an internal combustion engine which system has an ignition coil for supplying high voltage firing pulses to the internal combustion engine and pulse means operable in synchronism with the internal combustion engine, a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, capacitor means, a gate controlled semiconductor switch connected in series with said capacitor means and the ignition coil, said semiconductor switch having a gate region responsive to a pulse of a given polarity to turn said semiconductor switch on and responsive to a pulse opposite the given polarity to turn said semiconductor switch off, means coupled to said gate region and responsive to said pulse means to apply pulses of the given polarity thereto in synchronism with the pulse means, a transformer having a primary winding and first and second secondary windings, said primary winding being connected in series between said semiconductor switch and a source of potential, said first secondary winding being connected to said gate region and being responsive to current flow in said primary winding subsequent to discharge of said capacitor means to apply a pulse opposite said given polarity to said gate region to turn said semiconductor switch off, and means including said second secondary winding being connected to said capacitor means for charging the same by a reverse transient pulse induced in said second secondary winding upon turn off of said semiconductor switch.

3. In an ignition system for an internal combustion engine, which system has an ignition coil for supplying high voltage firing pulses to the internal combustion engine and a source of direct current potential, a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, capacitor means, a gate controlled semiconductor switch connected in series with said capacitor means and the ignition coil, said semiconductor switch having a gate region responsive to a pulse of a given polarity to turn said semiconductor switch on and responsive to a pulse of polarity opposite to the given polarity to turn said semiconductor switch off, means coupled to said gate region to apply pulses of the given polarity thereto in synchronism with operation of the internal combustion engine, a transformer having a primary winding and a secondary winding, said primary winding being connected in series with said semiconductor switch across the source of potential, said secondary winding being connected to said gate region and being responsive to current flow in said primary winding subsequent to discharge of said capacitor means to apply a pulse of said opposite polarity to said gate region to turn said semiconductor switch off, and means coupled to said transformer and to said capacitor for charging said capacitor by a voltage developed in said transformer in response to turn off of said semiconductor switch.

4. In an ignition system for an internal combustion engine, which system has an ignition coil for supplying high voltage firing pulses to the internal combustion engine and a source of direct current potential, a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, capacitor means, a gate controlled semiconductor switch connected in series with said capacitor means and the ignition coil, said semiconductor switch having a gate region responsive to a pulse of a given polarity to turn said semiconductor switch on and responsive to a pulse of polarity opposite to said given polarity to turn said semiconductor switch off, means coupled to said gate region for applying pulses of the given polarity thereto in synchronism with the internal combustion engine, a transformer having a primary winding and first and sec-

ond secondary windings, first rectifier means connecting said primary winding in series with said semiconductor switch across a source of potential, said first secondary winding being connected to said gate region and being responsive to current flow in said primary winding subsequent to discharge of said capacitor means to apply a pulse of the opposite polarity to said gate region to turn said semiconductor switch off, and second rectifier means connected in series with said second secondary winding across said capacitor means for charging the same by a reverse transient pulse induced in said second secondary winding upon turn off of said semiconductor switch.

5. In an ignition system for an internal combustion engine, which system has an ignition coil for supplying high voltage firing pulses to the internal combustion engine and a source of direct current potential, a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, capacitor means, charging means coupled to said capacitor means for applying a voltage thereto for charging said capacitor means, discharging means coupled to said capacitor means for discharging said capacitor means through the ignition coil, a single gate controlled semiconductor switch included in both said charging and discharging means, said semiconductor switch having a gate region responsive to a pulse of a given polarity to turn said semiconductor switch on and responsive to a pulse of polarity opposite to the given polarity to turn said semiconductor switch off, and means coupled to said

gate region to apply pulses of a given polarity thereto in synchronism with operation of the internal combustion engine for turning said semiconductor switch on to actuate said discharging means, said charging means including a transformer having a primary winding and a secondary winding, said primary winding being connected in series with said semiconductor switch across the source of direct current potential to apply energy to said transformer, said secondary winding being connected to said gate region and applying a pulse thereto to turn off said semiconductor switch so that energy in said transformer provides a voltage for charging said capacitor.

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