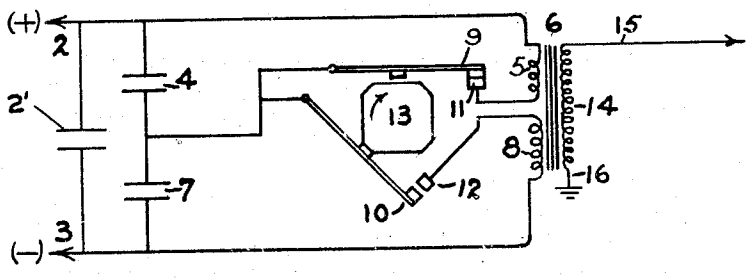
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IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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This invention relates generally to ignition systems for internal combustion engines, and particularly to ignition systems suitable for multi-cylinder internal combustion engines operating at high speeds.

An object of this invention is to provide an improved ignition system for internal combustion engines that is capable of supplying a spark of undiminished voltage to multi-cylinder engines operating at high speeds.

Another object of this invention is to provide an improved ignition system for internal combustion engines that utilizes a substantially uninterrupted flow of current from the supply generator and a unidirectional current flow in the primary circuits of the induction coil or transformer.

Another object of this invention is to provide an improved ignition system for internal combustion engines in which the generator is at no time short circuited except by a capacitor, making the use of a current limiting resistor unnecessary.

Another object of this invention is to provide an improved ignition system for internal combustion engines in which the primary circuit breaker points are not subject to contact deteriorating arcs when the primary circuit is broken.

A further object of this invention is to provide an improved ignition system for internal combustion engines which employs the substantially simultaneous charge of one capacitor and discharge of andther capacitor in the production of the high voltage secondary voltage.

Our invention will be explained in connection with the accompanying drawing, which is a diagrammatic sketch of an ignition system incorporating our invention in its preferred form.

Referring to the drawing, the positive supply line 2 from a conventional engine driven generator or other direct current source of electrical energy (not shown) connects to one terminal of capacitor 4 and also to one terminal of one primary or low voltage winding 5 of iron core step-up transformer or induction coil 6. The negative supply line 3 from the generator connects to one terminal of capacitor 7 and also to one terminal of the other primary winding 8 of transformer 6. A storage capacitor 2' is preferably connected across the positive terminal 2 and the negative terminal 3 of the source, but if the source have a sufficiently low internal resistance this capacitor will not be required for satisfactory operation of our invention. The remaining terminals of capacitors 4 and 7 are interconnected and these interconnected terminals also connect to both movable breaker point contacts 9 and 10. The remaining terminal of primary or low voltage winding 5 connects to fixed breaker point contact 11 and the remaining terminal of primary winding 8 connects to fixed breaker point contact 12. The circuit at breaker point contacts 9 and 11, as well as the circuit at breaker point contacts 10 and 12, are normally closed by spring action. A rotatable engine-driven cam 13 operates to break the circuit at these contacts in accordance with the timing of the engine. Secondary or high voltage winding 14 of transformer 6 is inductively coupled to both primary windings 5 and 8, one terminal 15 of winding 14 being connected to the engine distributor (not shown), the other terminal 16 being connected to ground. The distributor is of conventional type and selectively energizes a number of conventional spark plugs (not shown) in a manner well known to the art. Either the positive or the negative terminal of the generator may be connected to ground without affecting the operation of the system. Capacitors 4 and 7 are preferably, though not necessarily, of equal capacity. Secondary winding 14 is wound with many times the number of turns of either primary winding 5 or 8, such that the voltage induced in the secondary winding will be sufficient to jump the spark plug gap within the cylinders of the engine. Preferably, though not necessarily, primary windings 5 and 8 are so disposed in inductive relationship with secondary winding 14 and are wound with such a number of turns as to induce substantially equal voltages in winding 14.

In operation, assuming both capacitors initially discharged, with the breaker point contacts in the position shown in the figure, capacitor 7 is charged through primary winding 5 and breaker point contacts 9 and 11 substantially to the terminal voltage of the generator or other charging source. As cam 13 rotates in the direction indicated, the circuit at breaker point contacts 9 and 11 is broken and immediately thereafter the circuit at breaker point contacts 10 and 12 closes, permitting capacitor 7 to discharge through primary winding 8. Substantially simultaneously with this discharge, capacitor 4 is charged through breaker point contacts 10 and 12 and winding 8 substantially to the terminal voltage of the generator. As cam 13 rotates further in the same direction the circuit at breaker point contacts 10 and 12 opens and immediately thereafter the circuit at breaker point contacts 9 and 11 closes. Capacitor 4 then dis-

charges through primary winding 5 accompanied by a substantially simultaneous charge of capacitor 7 through this same winding. Storage capacitor 2', when employed, is charged by the charging source and supplies the curent, or at least part thereof, to charge capacitors 4 and 7.

As cam 13 continues to rotate, the above cycle is repeated.

As in prior ignition systems employing capacitor discharge for the production of the high voltage for the spark plugs, when a previously charged capacitor is discharged through the primary winding of a transformer, a sudden and rapid current surge occurs in such winding immediately after the discharge circuit is closed. This current surge causes a rapid change of flux in the primary winding of the transformer and, through the iron core, this rapidly changing flux links the secondary winding, inducing a sufficient voltage therein to jump the gap at the spark plugs. But after the initial surge the current flow rapidly decreases as the capacitor is discharged and, when the discharge circuit is opened, the current flow has reached a very low value or has ceased entirely, and little or no arcing or sparking occurs at the breaker point contacts.

Similarly, when a partially or completely discharged capacitor is charged through the primary winding of a transformer, a charging current surge occurs immediately after the charging circuit is closed, producing a rapidly changing flux which links the secondary winding and induces a high voltage therein. As the capacitor becomes charged its terminal voltage increases, the charging current rapidly decreases and ceases entirely when the terminal voltage of the capacitor reaches that of the generator. When the charging circuit is opened, the charging current has either reached a very low value or has ceased flowing entirely, resulting in no appreciable arcing or sparking at the breaker point contacts when the circuit is opened.

In our invention, the discharge current surge of capacitor 4 and the charging current surge of capacitor 7 occur practically simultaneously through primary winding 5 with the result that their effects are cumulative in producing an increased induced voltage in the secondary winding. Similarly, the charging current surge of capacitor 4 and the discharge current surge of capacitor 7 occur practically simultaneously through primary winding 8, with a similar effect. In addition, the flow of current in each primary coil, i. e., the charging current of one capacitor and the discharge current of the other, is always in the same direction.

When the storage capacitor 2' is employed, at no time is the current flow from the generator or other charging source completely interrupted. For a very brief interval occurring twice each cycle, when both sets of breaker point contacts are open, the only current path from the charging source is through capacitor 2'. But for the very great portion of each cycle, the charging source is charging either capacitor 4 or capacitor 7 in addition to supplying current to capacitor 2'. The above results in an uninterrupted and more nearly steady flow of current from the generator.

When the internal resistance of the charging source is such that storage capacitor 2' need not be employed, the current flow from the charging source is interrupted for a very brief instant twice each cycle, but such periods of interruption are small compared with the length of the cycle. Thus, with capacitor 2' omitted from the circuit, the charging source, while not supplying current for the entire cycle, does supply current for the very great portion thereof, as compared with prior ignition systems employing capacitor discharge in which the charging source supplies current for only approximately half the cycle.

Comparing our invention with a system employing a single large capacitor the alternate charge and discharge of which each produces a secondary high voltage sufficient to jump a spark plug gap, it is apparent that our invention, while using capacitors each of which has less capacity than the capacitor employed in the system above referred to, is able to produce a secondary high voltage substantially the same as that produced by the single capacitor system. A resulting consequence is that the peak charging current capacity required from the charging source is less with our invention and that a charging source of lower cost, smaller dimension and less weight can be successfully employed, frequently a not inconsiderable factor especially in aircraft.

As previously mentioned, capacitors 4 and 7 are charged or discharged immediately after the breaker point contacts are closed, and, at the time the circuit at the breaker point contacts is broken, the current flow through them has reached either zero or a very low value. Thus, little or no arcing occurs at the breaker point contacts when they are opened, resulting in greatly extended useful life of the breaker point contacts as compared with systems in which these breaker point contacts break an appreciable current.

Since, with capacitors 4 and 7 of substantially the same capacity, substantially equal voltages are induced in the secondary winding each time the breaker point contacts close, there is no necessity for introducing a current limiting resistor in any portion of the primary circuit in order to equalize the induced secondary voltages. Further, since, in our invention, the generator circuit includes one or more capacitors for any position of the breaker point contacts, a conductive circuit is never completed across the generator and a current limiting resistor is not necessary for the protection of the generator.

One desirable result from the use of low resistance transformer primary circuits, i. e., with no current limiting resistor in the circuit, is a small time constant. Such is especially desirable with high speed engines requiring a large number of sparks per minute. With a small time constant the rate of charge and discharge of the capacitors is sufficiently rapid to produce a spark of substantially undiminished intensity even at high engine speeds. Our invention has successfully produced up to 20,000 sparks per minute with undiminished voltage.

Other modifications and changes in the proportions and arrangement of the parts may be made by those skilled in the art without departing from the nature and scope of this invention, within the scope of what is hereinafter claimed.

The invention described herein may be manufactured and/or used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

We claim:

1. In combination, a source of electrical energy of substantially constant potential, a first capac-

itor and a second capacitor electrically connected in series across said source, a step-up transformer having a first primary winding, a second primary winding and a secondary winding, a common circuit for charging said first capacitor and for discharging said second capacitor including said first primary winding and a cam actuated contact means, a common circuit for discharging said first capacitor and for charging said second capacitor including said second primary winding and another cam actuated contact means, whereby cyclically said first capacitor is charged and said second capacitor is substantially simultaneously discharged through said first primary winding, and alternately said first capacitor is discharged and said second capacitor is substantially simultaneously discharged through said second primary winding, both said capacitors being charged from said source.

2. In combination, a source of electrical energy of substantially constant potential, a first capacitor and a second capacitor electrically connected in series across said source, a step-up transformer having a first primary winding, a second primary winding and a secondary winding, a common circuit for charging said first capacitor and for discharging said second capacitor including said first primary winding and a cam actuated contact means, a common circuit for discharging said first capacitor and for charging said second capacitor including said second primary winding and another cam actuated contact means, whereby cyclically said first capacitor is charged and said second capacitor is substantially simultaneously discharged through said first primary winding, and alternately said first capacitor is discharged and said second capacitor is substantially simultaneously discharged through said second primary winding, both said capacitors being charged from said source, the flow of current in both said primary windings being unidirectional, both said primary windings inducing substantially equal voltages in said secondary winding.

3. In combination, a source of electrical energy of substantially constant potential, two capacitors electrically connected in series across said source, a step-up transformer having two primary windings and a secondary winding, a cam actuated contact means cyclically operable to charge one said capacitor and to simultaneously discharge the other said capacitor through one of said primary windings, and alternately to discharge the previously charged capacitor and to simultaneously charge the previously discharged capacitor through the other said primary winding, said primary windings being alternately energized, both said capacitors being charged from said source.

4. In combination, a source of electrical energy of substantially constant potential, a first capacitor and a second capacitor electrically connected in series across said source, a step-up transformer having a first primary winding, a second primary winding and a secondary winding, a common circuit for charging said first capacitor and for discharging said second capacitor including said first primary winding and a cam actuated contact means, a common circuit for discharging said first capacitor and for charging said second capacitor including said second primary winding and another cam actuated contact means, whereby cyclically said first capacitor is charged and said second capacitor is substantially simultaneously discharged through said first primary winding, and alternately said first capacitor is discharged and said second capacitor is substantially simultaneously discharged through said second primary winding, and a storage capacitor connected across said source.

5. In combination, a source of electrical energy of substantially constant potential, a first capacitor and a second capacitor electrically connected in series across said source, a step-up transformer having a first primary winding, a second primary winding and a secondary winding, a common circuit for charging said first capacitor and for discharging said second capacitor including said first primary winding and a cam actuated contact means, a common circuit for discharging said first capacitor and for charging said second capacitor including said second primary winding and another cam actuated contact means, whereby cyclically said first capacitor is charged and said second capacitor is substantially simultaneously discharged through said first primary winding, and alternately said first capacitor is discharged and said second capacitor is substantially simultaneously discharged through said second primary winding, and a storage capacity connected across said source, the flow of charging current from said source being substantially uninterrupted.

6. In combination, a source of electrical energy of substantially constant potential, a first capacitor and a second capacitor electrically connected in series across said source, a step-up transformer having a first primary winding, a second primary winding and a secondary winding, a common circuit for charging said first capacitor and for discharging said second capacitor including said first primary winding and a cam actuated contact means, a common circuit for discharging said first capacitor and for charging said second capacitor including said second primary winding and another cam actuated contact means, whereby cyclically said first capacitor is charged and said second capacitor is substantially simultaneously discharged through said first primary winding, and alternately said first capacitor is discharged and said second capacitor is substantially simultaneously discharged through said second primary winding, and a storage capacitor connected across said source, the flow of current in both said primary windings being unidirectional, both said primary windings inducing substantially equal voltages in said secondary winding.

7. In combination, a source of electrical energy of substantially constant potential, a first capacitor and a second capacitor electrically connected in series across said source, a step-up transformer having a first primary winding, a second primary winding and a secondary winding, a common circuit for charging said first capacitor and for discharging said second capacitor including said first primary winding and a cam actuated contact means, a common circuit for discharging said first capacitor and for charging said second capacitor including said second primary winding and another cam actuated contact means, whereby cyclically said first capacitor is charged and said second capacitor is substantially simultaneously discharged through said first primary winding, and alternately said first capacitor is discharged and said second capacitor is substantially simultaneously discharged through said second primary winding, and a storage capacitor connected across said source, the flow of current in both said primary windings being unidirectional, both said primary windings inducing substan-

tially equal voltages in said secondary winding, the flow of charging current from said source being substantially uninterrupted.

8. In combination; a source of electrical energy of substantially constant potential, two capacitors electrically connected in series across said source, a step-up transformer having two primary windings and a secondary winding, a cam actuated contact means cyclically operable to charge one said capacitor and to simultaneously discharge the other said capacitor through one of said primary windings, and alternately to discharge the previously charged capacitor and to simultaneously charge the previously discharged capacitor through the other said primary winding, said primary windings being alternately energized, and a storage capacitor connected across said source.

9. In combination, a source of electrical energy of substantially constant potential, two capacitors electrically connected in series across said source, a step-up transformer having two primary windings and a secondary winding, a cam actuated contact means cyclically operable to charge one said capacitor and to simultaneously discharge the other said capacitor through one of said primary windings, and alternately to discharge the previously charged capacitor and to simultaneously charge the previously discharged capacitor through the other said primary winding, said primary windings being alternately energized, and a storage capacitor connected across said source, the flow of charging current from said source being substantially uninterrupted.

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