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IGNITION SYSTEM WITHOUT CONTACTS

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FIG. 1

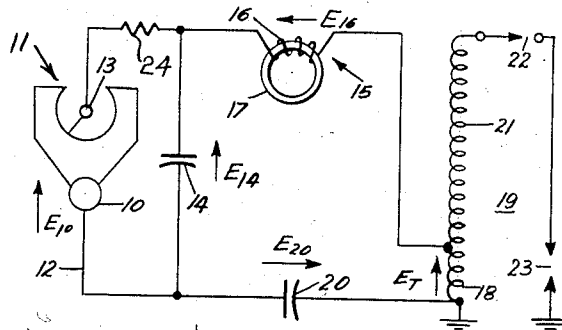


FIG. 2

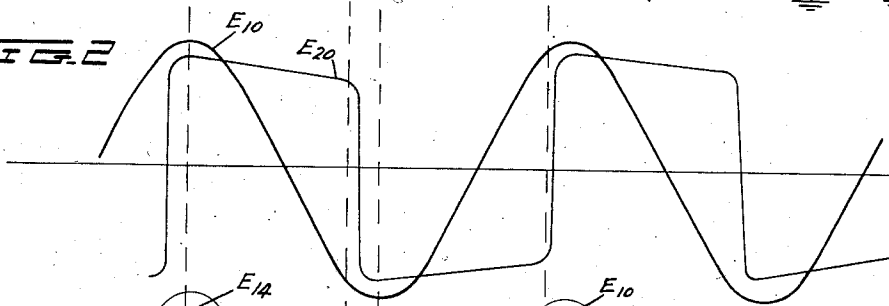


FIG. 3

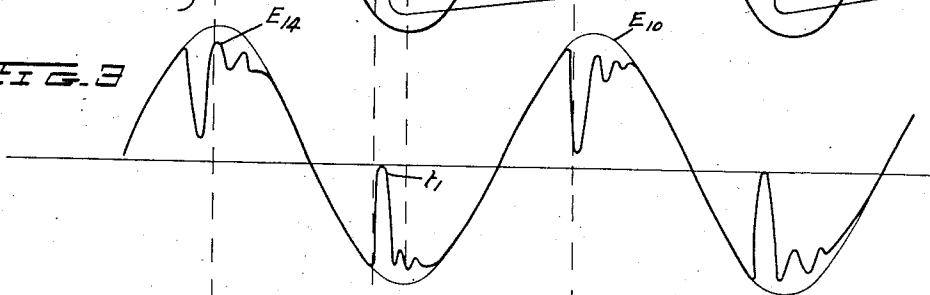


FIG. 4

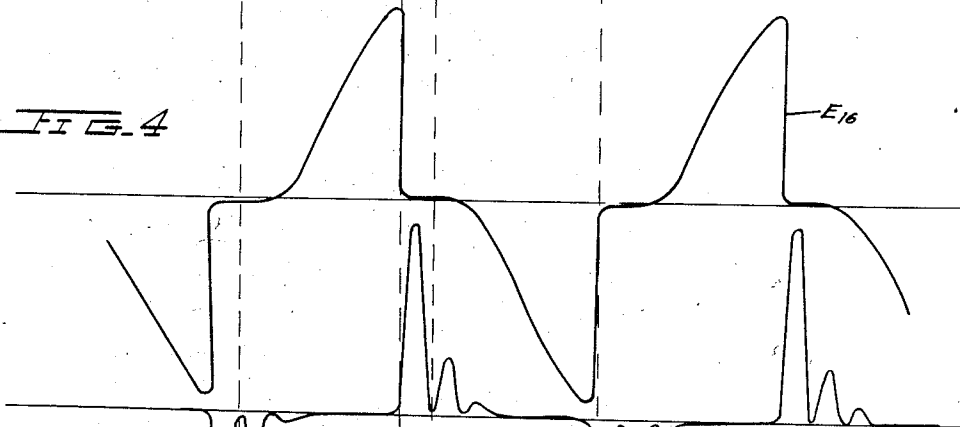


FIG. 5



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IGNITION SYSTEM WITHOUT CONTACTS

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5 Claims. (Cl. 307—108)

My invention relates to an ignition system without contacts and more specifically to an ignition system for an internal combustion engine wherein a saturable reactor controls the energization of a spark transformer.

Ignition systems for internal combustion engines are well known devices for generating a high-voltage, low-current arc in a spark plug so as to ignite a combustible mixture in the cylinders of an engine.

In the past, the spark was initiated by interrupting a contact carrying an appreciable current in series with a coil having a high inductance. When the contact opens, the energy stored in the high inductance coil will generate a high voltage across its terminals. This high voltage is then transformed into a secondary winding which may be an extension of the primary winding so as to provide autotransformer action in generating an extremely high voltage across the secondary winding which is connected across the spark gap.

This classical system is subjected to many disadvantages. The first disadvantage is that the contact is subject to extreme wear since it carries an appreciable current which must be interrupted at its highest value followed by a high recovery voltage across the contact. Hence the contact must perform a substantial interrupting task which is harmful to the contact surfaces and leads to damage thereof which is especially harmful in that contact timing is altered.

Furthermore, the above described system shows poor performance at high speeds since at high speeds, the frequency of contact operation is increased, thereby allowing an insufficient time for the current to increase to a sufficient value to obtain an efficient spark condition on the next operation. Hence, the engine which is running very fast will lose a great amount of power and expel a great amount of unburnt gasoline vapor since the ignition system creates a weaker arc as the engine speed increases.

Attempts have been made to overcome this last described disadvantage wherein power is obtained not from a battery but from a small permanent magnet generator. In this type of system, as the speed of the engine increases, the voltage of the generator will also increase to thereby provide a greater rate of increase of current in the coil so that the current interrupted by the contact is substantially constant at any speed. This system, however, introduces the disadvantage of requiring a relatively powerful generator having a low impedance, thus leading to a device which is relatively large and expensive while still maintaining the disadvantage of requiring a contact means for initiating sparking.

A further disadvantage which is common to both of the above mentioned systems is that the induction coil or spark transformer is used as an energy storing device. That is to say, the induction coil must continuously carry the required sparking energy so as to demand a relatively high power drain on the power supply battery or generator.

The principle of my invention is to eliminate the con-

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tact required in each of the above mentioned systems while utilizing an A.-C. generator which may be of the permanent magnet type as a power source which has a low power rating and may have a relatively high impedance. More specifically, my invention contemplates the storing of energy from a voltage source by means of capacitors and to thereafter allow this stored energy to be transmitted to an energy transforming device such as a spark transformer responsive to saturation of the saturable reactor. Conversely, when the saturable reactor is in the unsaturated state, it will prevent energy from being transferred between the energy storing means and the energy transferring means.

In my novel invention, it may be seen that as well as providing an ignition system which does not utilize a contact device and which allows the use of a relatively small permanent magnet generator, that it also allows the size of the spark transformer to be appreciably decreased. For in my novel construction, the spark transformer or induction coil is no longer an energy storing device but is an energy transferring device. Hence, the power requirements of the induction coil are now relatively small and the size of the power source may be decreased since it may transfer energy to the energy storing means over a relatively long period of time, thereby reducing its power drain.

In a specific embodiment of my novel circuit, the energy may be stored in two capacitors charged to opposite polarities. The discharge will occur in series with the induction coil when the two oppositely charged capacitors are short-circuited by means of saturating a saturable reactor connected in series with the capacitors.

The energy stored in the two capacitors at opposite potentials may be provided by a small permanent magnet A.-C. generator. This generator could be a three-phase generator having two phases thereof bridged by a potentiometer. Thus by taking the output voltage of the generator from a point on the potentiometer and the third phase, an A.-C. voltage of variable phase angle may be obtained so as to allow adjustment of the subsequent firing point of the spark plugs.

Clearly this generator may be driven by the engine in which the spark plugs are to be fired.

The saturable reactor which is connected in series with the capacitors will prevent discharge of the capacitors into one another and when unsaturated will block the voltage appearing between the two capacitors, thus effecting a flux change in the reactor. When the flux in the reactor can no longer change, the reactor saturates suddenly and passes current freely. Capacitor voltage will therefore appear on a spark transformer which is connected in the circuit so as to immediately cause an arc on the spark plug associated with the spark transformer. When the arc occurs, the discharge current and frequency is given by the leakage reactance of the saturable reactor and the spark transformer and substantially all of the energy stored in the capacitors is transmitted to the arc.

Thus it may be seen that the spark transformer may be made much smaller than was previously the case, since it is now merely an energy transforming device. Similarly, a clear separation is now available between the switching component which is the saturable reactor and the phase shifting component which could be the potentiometer, while the prior type of ignition systems were forced to accomplish both functions in the single contact.

Furthermore, it is seen that as the engine speed increases, the firing energy of the arc increases so as to provide efficient ignition over the complete range of speed of the engine.

Accordingly, a primary object of my invention is to

provide an ignition system for internal combustion engines.

Another object of my invention is to provide an ignition system wherein a saturable reactor is utilized as a switching element.

Still another object of my invention is to provide an ignition system utilizing an energy storing means which is connected and disconnected to an energy transferring means by a saturable reactor.

A further object of my invention is to provide an ignition system utilizing a power source which is an A.-C. generator driven by an engine to charge a capacitor means which may be subsequently discharged through an induction coil responsive to the saturation of a saturable reactor.

Yet a further object of my invention is to provide an ignition system wherein switching is obtained by a saturable reactor means and timing is obtained by phase shifting the input A.-C. power of an A.-C. generator.

A still further object of my invention is to provide an A.-C. generator for the power source of an ignition system wherein the generator is comprised of a three-phase generator having a potentiometer connected across two phases, so that the input voltage to the ignition system is taken from a point on the potentiometer and the remaining phase, this input voltage being phase shiftable so as to control firing time.

These and other objects of my invention will become apparent from the following description when taken in conjunction with the drawings in which:

Figure 1 shows a circuit diagram of an embodiment of my novel invention.

Figure 2 shows the voltage time characteristics of the generator voltage and a capacitor voltage of Figure 1 when plotted on the same time scale.

Figure 3 shows the voltage time characteristics of the generator voltage and the second capacitor voltage of the circuit of Figure 1.

Figure 4 shows the voltage time characteristic of the saturable reactor of Figure 1.

Figure 5 shows the voltage time characteristic of the spark transformer of Figure 1.

Referring now to Figure 1, my novel ignition system may be seen as comprising the three-phase A.-C. generator 10 which could be of the permanent magnet type. Although it is not shown in Figure 1, it is to be understood that the generator 10 could be driven by the internal combustion engine with which it is associated.

A potentiometer 11 is shown as being connected across two phases of the three-phase generator 10 and an output voltage is then taken from the remaining phase 12 and a terminal 13 of the potentiometer which is connected to any variable point along this element. The output of the potentiometer is then seen as being connected across a capacitor 14 which is in turn connected in series relationship with a saturable reactor 15 having a winding 16 and a core 17, the primary winding 18 of the spark transformer 19 and capacitor 20. The secondary winding 21 of the spark transformer or induction coil is then seen as being connected through a distributor contact 22 to a spark gap 23.

The operation of the circuit of Figure 1 may be more fully understood in conjunction with Figures 2, 3, 4 and 5 which show, on a common time base, the manner in which the voltages vary to effect the desired firing of spark gap 23.

Figure 2 shows the generator voltage E_{10} as being plotted on the same axis as the voltage E_{20} of capacitor 20 while Figure 3 shows the voltage E_{10} as being plotted on the same axis with the voltage E_{14} of the capacitor 14. It is to be understood that the particular phase of the voltage E_{10} of Figure 2 and Figure 3 could be varied by varying the potentiometer 11 of Figure 1 so as to subsequently advance or decrease the firing point of the spark gap 23.

As may be seen in Figure 2, the voltage E_{20} across the capacitor 20 stays at an approximately constant level over each half-cycle while the voltage E_{14} of Figure 3 which is the voltage of capacitor 14 is in phase with the voltage E_{10} of the voltage source 10. The difference between these two capacitor voltages E_{20} and E_{14} appears on the saturable reactor winding 16 as E_{16} of Figure 4.

At the time t_1 , the voltage across these two capacitors is, as may be seen in Figures 2 and 3, substantially identical with the exception of a small remaining oscillation which is still existent in the transformer 19. After time t_1 , the generator voltage decreases at a relatively great rate and carries the voltage E_{14} with it. The generator voltage would similarly decrease the voltage E_{20} on the capacitor 20 but this is prevented by the unsaturated condition of the saturable reactor 15.

However, the flux of saturable reactor core 17 will be changed in view of the flow of magnetizing current due to the unbalanced voltage between E_{14} and E_{20} so as to reverse the flux of the core 17. Because saturable reactor 15 was saturated in the opposite direction, however, this flux change takes a relatively long time during which the only current flow is that of the magnetizing current of the saturable reactor winding 16 which is extremely low.

Due to this relatively low magnetizing current, the voltage E_{20} on capacitor 20 decreases only very slightly and at the time t_2 the capacitors 20 and 14 are charged in opposite directions. That is to say, capacitor 20 is still charged in the same direction at the time t_2 , and has substantially the same magnitude, while the voltage E_{14} of the capacitor 14 has been completely reversed by the generator 10 and at time t_2 is in an opposite direction and of practically the same magnitude as the voltage E_{20} of capacitor 20.

At this time t_2 , the flux of the saturable reactor core 17 will have been completely reversed so as to allow saturation of this component to thereby allow capacitors 14 and 20 to be connected directly across winding 18 of the spark transformer 19. These capacitors will then discharge and the voltage across coil 18 will assume the shape seen in Figure 5.

The voltage E_{19} of Figure 5 is seen as having a very steep wave front which corresponds to a relatively high frequency at a voltage which is determined by the turns ratio between windings 18 and 21 which voltage will then appear across the spark gap 23 so as to fire the spark plug associated with spark gap 23. After firing of the spark plug, the voltage of the two capacitors 14 and 20 is seen in Figures 2 and 3 to equalize in a series of short, rapidly diminishing oscillations with the energy mainly being dissipated in the spark gap due to the low resistance of winding 16 and windings 18 and 21.

At the time t_3 , the complete cycle of operation starts once again but in an opposite direction. That is, the voltage on the saturable reactor winding 16 is now negative as may be seen in Figure 4 while the capacitors 14 and 20 are charged to the opposite polarity as may be seen in Figures 2 and 3. At the time t_4 , the saturable reactor saturates once again, thus causing another arc to appear on the spark gap 23.

Clearly, the distributor 22, as is well known, operates to connect the various spark gaps of the system to the ignition system per se when they are to be fired.

Several points are to be noted in the description of operation set forth above. First, it is clear that the firing angle of the spark gap 23 may be adjusted by an adjustment of the potentiometer 11, this adjustment being independent of the switching means represented by the saturable reactor 15.

Furthermore, a resistor 24 could be inserted in series with the potentiometer 11 in case the drain on the generator 10 should be excessive during the discharge interval. In a practical case, however, this will not be necessary because the generator, in order to be simple and

cheap, can be made with a high leakage reactance so as to be self-protecting.

It is important to note that generator 10 does not have to provide the instantaneous high energy for the spark gap 23, but merely supplies this energy over a relatively long period of time to the energy storing means for capacitors 14 and 20.

Furthermore, the transformer 19 is no longer an energy storing means as it was in the past, but is now merely an energy transferring means so as to allow a substantial decrease in its size.

As the engine speed varies so as to require a variation in the firing speed which would be seen in Figure 5 as a variation in the time between the peak of a half-wave to the peak of a subsequent half-wave, then the output voltage E_{10} of the generator 10 will similarly vary. This variation in output voltage would therefore vary the point of saturation of the saturable reactor 15 since this device can support only a given voltage for a given time.

Hence, since the time between cycles and the generator voltage is proportional, and the voltage and the voltage time area stored by the saturable reactor is constant, the angular displacement between the firing times of the device is always the same regardless of the motor speed and the only change is in the firing voltage.

Although I have here described preferred embodiments of my invention, many modifications and variations will now be evident to those skilled in the art. I prefer, therefore, to be limited, not by the specific disclosure herein, but only by the appended claims.

I claim:

1. An ignition system; said ignition system comprising a voltage source, a saturable reactor, capacitor means, and a transformer; said transformer having a primary and secondary winding; said saturable reactor means, capacitor means and transformer primary winding being connected in series relationship; said voltage source being connected to charge said capacitor means; said capacitor means being discharged through said transformer primary winding when said saturable reactor is saturated to cause sparking voltage to appear across said secondary windings; said capacitor means including a first and second capacitor; said first capacitor being connected across said voltage source; said second capacitor, said saturable reactor, and said transformer primary winding being connected in series across said voltage source.

2. An ignition system; said ignition system comprising an alternating voltage source, a saturable reactor, capacitor means, and a transformer; said saturable reactor means, capacitor means, and transformer being connected in series relationship; said voltage source being connected to charge said capacitor means, said capacitor means being discharged through said transformer when said saturable reactor is saturated; and means to phase shift the voltage of said voltage source; said capacitor means including a first and second capacitor; said first capacitor being connected across said voltage source; said second capacitor,

said saturable reactor and said transformer being connected in series across said voltage source.

3. An ignition system; said ignition system comprising an alternating voltage source, a saturable reactor, capacitor means, and a transformer; said transformer having a primary and secondary winding; said saturable reactor means, capacitor means and transformer primary winding being connected in series relationship; said voltage source being connected to charge said capacitor means, said capacitor means being discharged through said transformer primary winding when said saturable reactor is saturated to cause sparking voltage to appear across said secondary winding; and means to phase shift the voltage of said voltage source; said alternating source comprising a permanent magnet generator driven by an external motor; said capacitor means including a first and second capacitor; said first capacitor being connected across said voltage source; said second capacitor, said saturable reactor, and said transformer primary winding being connected in series across said voltage source.

4. An ignition system comprising an A.-C. voltage source, a saturable reactor, a first and second capacitor and a transformer; said transformer being a tapped coil forming a primary and secondary winding; said first and second capacitors, said saturable reactor and said transformer primary winding being connected in series; said voltage source being connected across said first capacitor; said first and second capacitors being discharged in series with said transformer primary winding responsive to saturation of said saturable reactor; said capacitor means including a first and second capacitor; said first capacitor being connected across said voltage source; said second capacitor, said saturable reactor, and said transformer primary winding being connected in series across said voltage source.

5. An ignition system comprising an A.-C. voltage source, a saturable reactor, a first and second capacitor and a transformer; said transformer being a tapped coil forming a primary and secondary winding; said first and second capacitors, said saturable reactor and said transformer primary winding being connected in series in a closed loop; said voltage source being connected across said first capacitor; said first and second capacitors being discharged in series with said transformer primary winding responsive to saturation of said saturable reactor; said voltage source comprising a three-phase generator having a first and second phase connected to the ends of a potentiometer and the voltage output taken from the remaining phase and an adjustable point on said potentiometer.

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