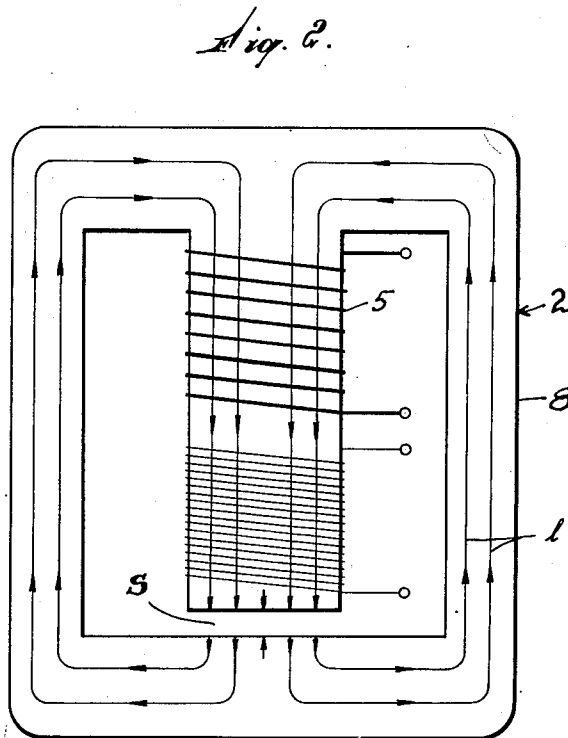
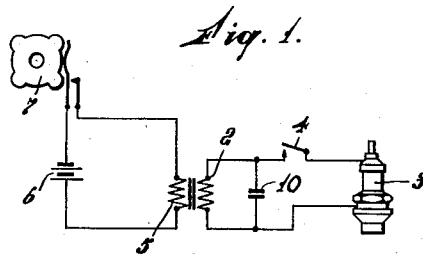


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SYSTEM FOR PERIODICALLY CHARGING
ONE OR A PLURALITY OF CONDENSERS
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SYSTEM FOR PERIODICALLY CHARGING
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The invention relates to a system for periodically charging one or a plurality of condensers at a substantially constant voltage by means of an induction coil, whose iron core is provided with an air gap and whose primary is included in a circuit to be closed and to be broken at a variable number of periods, while its secondary is connected with the condenser or condensers.

Such systems are used for igniting low tension creepage spark plugs in internal combustion engines, for which purpose one or a plurality of condensers are charged by an impulse from an induction coil and are discharged over a creepage spark plug at the moment of sparking. If in a system of this type use were made of an induction coil having the same properties as the conventional high tension induction coils, the condenser would be charged much higher when there are few interruptions per second, which corresponds to a small number of revolutions of the engine, than when there are many interruptions per second, which corresponds to a great number of revolutions of the engine. Measurements have shown that the voltages generated by said high tension induction coils vary from 30,000 volts at a small number of revolutions to 10,000 at a great number of revolutions. In the magneto system of ignition the very opposite is the case.

In the case of high tension spark plugs such large potential differences do not have much influence on the ignition, provided the voltage does not drop to below a minimum value. The upper voltage limit remains confined by the resistance of the ignition circuit. In low tension creepage spark plugs, however, large potential variations are very detrimental. If the condenser is charged to too high a voltage, the spark of such a spark plug will become too strong which will shorten the life of the creepage spark plug. For the proper operation of the system it is necessary to obtain a voltage across the condenser which is substantially constant at any number of interruptions per second and which is always sufficient to produce a good spark on the creepage spark plug.

The object of this invention is to provide an induction coil by means of which at, for example, 1 to 200 and more interruptions per second of the primary circuit, a substantially constant high tension can be obtained at the secondary side of the coil, with which tension the condenser is charged, so that a substantially constant energy discharging over the creepage spark plug, is available which favorably influences the running of the engine.

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The objects and advantages of the invention will be more fully understood from the following description in conjunction with the accompanying drawings in which:

Fig. 1 is a circuit diagram of an ignition system in accordance with the invention; and

Fig. 2 is an enlarged view of the induction coil shown in the circuit of Fig. 1.

In the circuit shown in Fig. 1 of the drawings, a condenser 10 is charged by an impulse from an induction coil 2 and is discharged over a creepage spark plug 3 at the moment of sparking by a switch 4. The primary 5 of the induction coil is connected in a circuit with a source of energy 6 and an interrupter 7. The interrupter 7 and the switch 4 are coupled to the engine so that the number of revolutions of the engine determines the number of interruptions of the coil. As shown in Fig. 2, the induction coil 2 has an iron core 8. The reference character 1 designates the length of the iron path of the magnetic flux while S designates the length of the air path of the magnetic flux in the induction coil.

When the system is calculated for a constant voltage of e. g. at most about 5000 volts, all parts constructed to withstand this voltage will never be overloaded and in consequence will have a long life.

This invention is based on the conception that in order to keep the voltage generated by the induction coil constant, the energy built up in the magnetic field at different numbers of interruptions per second should remain as constant as possible. This energy amounts to $\frac{1}{2} Li^2$ joules, wherein L represents the self-inductance of the primary of the induction coil and i the current through said primary at the moment at which the primary circuit is interrupted.

The current i can be calculated from the equation:

$$i = \frac{E}{R} \left(1 - e^{-\frac{R}{L} t} \right)$$

wherein E is the voltage of, for example, a battery included in the primary circuit and wherein:

R is the resistance of the primary circuit;

e is the base of natural logarithms;

L is the self-inductance of the primary of the induction coil,

t is the period for which the contact-breaker is closed.

If $E=6$ volts, $R=1.2$ ohms and $L=0.005$ H, and the closing periods are $t=00$ (continuously closed contact), $t=0.02$ second and $t=0.01$ second, the

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currents are 5 amperes, 4.95 amperes and 4.45 amperes respectively.

From the above it appears the current lasting 0.01 second reaches a value of 89% of the current lasting indefinitely.

At a closing period of 0.005 second said value is only 70%.

The energy accumulated in the field is proportional to i^2 so that at different numbers of interruptions the percentual variations in energy will be even greater.

The system according to this invention is characterized by an induction coil whose iron core is supersaturated at a small number of periods and is substantially saturated at a high number of periods.

According to the present invention therefore the problem of keeping the energy accumulated in the field constant at different numbers of periods is solved by varying the self-inductance of the ignition coil inversely proportionally to the variations of the squares of the supply current.

The self-inductance of a coil having an iron core is determined by the formula

$$4\pi w^2 \frac{q \cdot \mu}{l + S\mu}$$

wherein:

w represents the number of windings;

q the cross-section of the iron;

μ the permeability;

l the length of the iron path of the magnetic flux;

S the length of the air path of the magnetic flux;

Seeing that in this formula w and q are constants

$$L = K \frac{\mu}{l + S\mu}$$

and when expressing the ratio: length of the iron path (l): length of air path (S) by the term a , then

$$L = \frac{K\mu}{S(a + \mu)}$$

wherein μ is dependent on the number of ampere turns. In order to magnetize the core and the air gap the total number of ampere turns required is:

$$A(\text{mpere}) T(\text{urns})/\text{cm}(\text{core}) + \frac{AT/\text{cm}(\text{core})}{a} \mu$$

At a given magnetization curve it is possible now to draw curves for various values of a , i. e. $a=10,000-5,000-1,000-500-200-100$ and 50, which curves show the course of the value

$$\frac{\mu}{a + \mu}$$

as a function of the total AT/cm , and the self-inductance being proportional to

$$\frac{\mu}{a + \mu}$$

and the total number of ampere turns/cm being proportional to i , the curves also show the course of the self-inductance as a function of the current.

From the foregoing considerations it is known how many per cents the self-inductance must change at a given percentual variation of the current if the energy of the field in the coil is to remain constant. It is now possible to find points on the curves which points meet the above condition. Once said points have been found all the

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further data of the coil are calculable in as much as l and At are known. Furthermore

$$i = \frac{E}{R}$$

by means of which Equation w is computable. From $l:S=a$ follows

$$\frac{l}{a} = S$$

so that a is known from L and S .

I claim:

1. In an ignition device for internal combustion engines employing low tension surface discharge spark plugs, a condenser having a maximum voltage variation of 10%, means for discharging said condenser through said spark plugs, means for periodically charging said condenser comprising an induction coil having an iron core, a primary winding and a secondary winding both on said core and a magnetic circuit including said core, the balance of said magnetic circuit being separated from said core by an air gap, means for supplying electric current, connections between said current supply and said primary winding including an interrupter driven in timed relation with the engine and connections between said secondary winding and said condenser, the iron core of the induction coil being supersaturated at low R. P. M. of the engine and substantially saturated at high R. P. M. and the self-inductance of said coil varying inversely to the square of the supply current.

2. In an ignition device for an internal combustion engine employing low tension surface discharge spark plugs, a condenser, means including a switch operated in timed relation with the engine for periodically connecting a spark plug across the condenser to discharge it through said spark plug, means for periodically charging said condenser comprising an induction coil having an iron core, a primary winding and a secondary winding both on the same said core and a magnetic circuit including said core and a portion separated from said core by an air gap, means for supplying electric current, connections between said current supply and said primary winding including an interrupter operated in timed relation with the engine and means for connecting said secondary winding across said condenser, the iron core of the induction coil being supersaturated at low R. P. M. of the engine and substantially saturated at high R. P. M. and the self-inductance of said coil varying inversely to the square of the supply current.

3. Ignition device for internal combustion engines employing low tension surface discharge spark plugs in which at least one condenser with a voltage variation of not more than 10% is periodically charged in dependence on the number of revolutions of the motor with the aid of an induction coil the iron core of which is provided with an air gap and in which the primary winding is comprised in a circuit which, by means of an interrupter with parallel connected condenser, is closed and interrupted a varying number of times, whereas the secondary winding is connected with the ignition condensers characterized in that the iron core of the induction coil at low R. P. M. of the motor is supersaturated and at high R. P. M. is substantially saturated and in that the primary and the secondary windings are disposed on an iron core which is separated from the remaining magnetic circuit by an air gap.

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4. In an ignition device for an internal combustion engine employing low tension surface discharge spark plugs, a condenser, means including a switch operated in timed relation with the engine for periodically connecting a spark plug across the condenser to discharge it through said spark plug, means for periodically charging said condenser comprising an induction coil having an iron core, a primary winding and a secondary winding both on the same said core and a magnetic circuit including said core and an air gap, means for supplying electric current, connections between said current supply and said primary winding including an interrupter operated in timed relation with the engine and means for connecting said secondary winding across said condenser, the iron core of the induction coil being supersaturated at low R. P. M. of the engine and substantially saturated at high R. P. M. and the self-inductance of said coil varying inversely proportionally to the square of the supply current, the magnetic energy of said coil being equal to

$$\frac{1}{2} \left(\frac{K}{l + S\mu} \right) \left[\frac{E}{R} \left(l - e^{-\frac{R(l + Sw)}{K\mu} t} \right) \right]^2$$

and being substantially constant, R being a constant, μ being the permeability of the core, l being the length of the iron portion of said magnetic circuit, S being the length of said air gap, E being the voltage of said current supply, R being the resistance of said primary winding and connections with said current supply, e being the base of natural logarithms and t being the length of time said primary winding is connected to said supply.

5. In an ignition device for a variable speed internal combustion engine, at least one low ten-

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sion creepage spark plug, a condenser, means including a switch operated in timed relation with the engine for periodically connecting a spark plug across the condenser to discharge it through said spark plug, means for periodically charging said condenser comprising an induction coil having an iron core, a primary winding and a secondary winding both on the same said core and a magnetic circuit including said core and an air gap, means for supplying electric current, connections between said current supply and said primary winding including an interrupter operated in timed relation with the engine and hence at variable time intervals as the engine speed varies and means for connecting said secondary winding across said condenser, the iron core of the induction coil being supersaturated at low engine speed and substantially saturated at high engine speed and the self-inductance of said coil varying inversely proportionally to the square of the supply current, the magnetic energy of said coil being substantially constant regardless of the variation of engine speed and consequent variation of the intervals at which said interrupter is operated.

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