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ELECTRICAL APPARATUS

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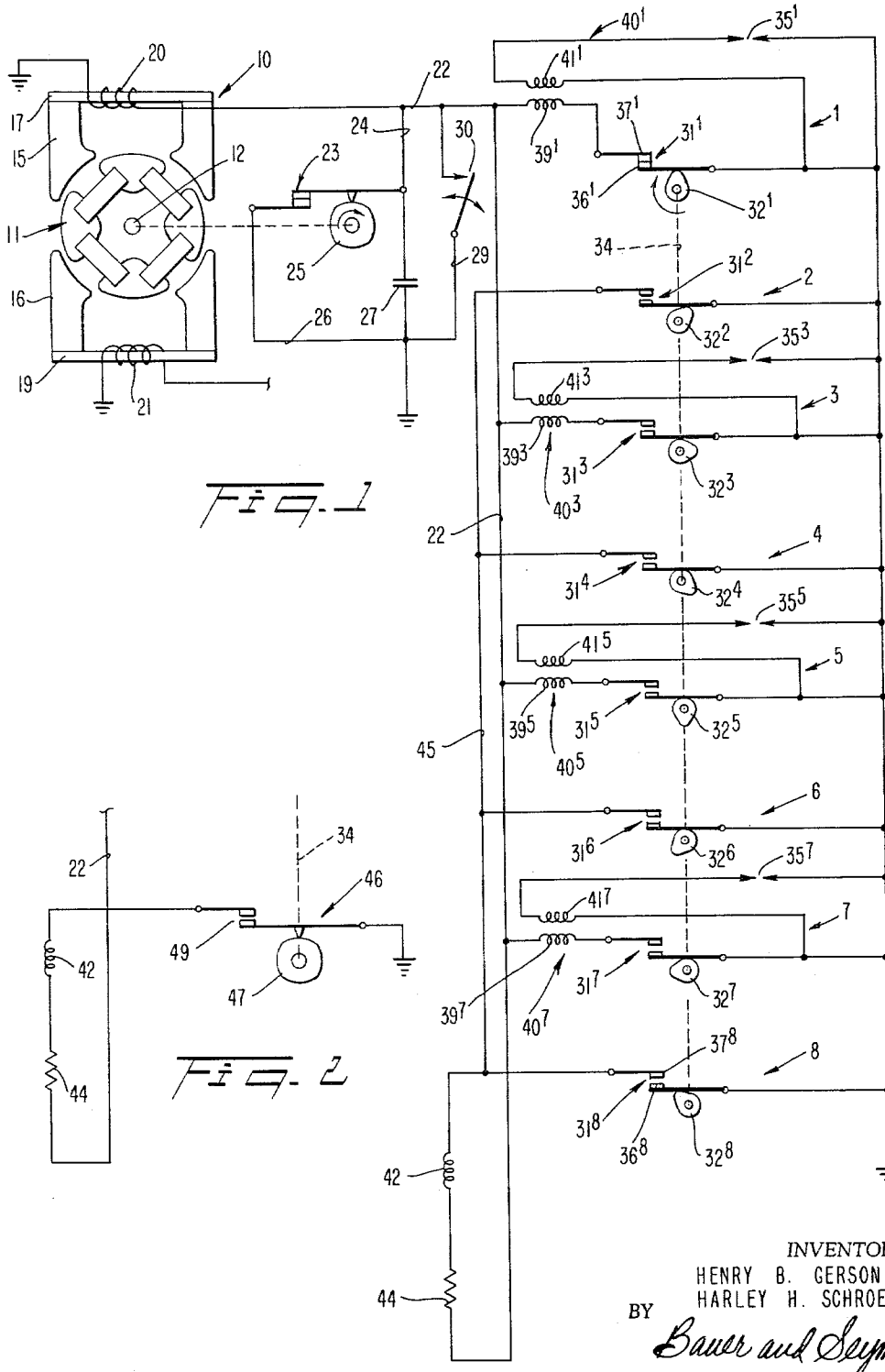



Fig. 1




Fig. 2

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# ELECTRICAL APPARATUS

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This invention relates to electrical apparatus, and more particularly to a system, such as an ignition system for spark ignited internal combustion engines, for generating electrical energy and cyclically distributing such energy to a plurality of circuits in sequence.

The invention has among its objects the provision of novel apparatus for supplying electrical energy to a plurality of circuit means, such as the sparking plug circuits of a multi-cylinder combustion engine or the like, in sequence and in timed relation to the rotation of a shaft such as the crankshaft of such engine.

Another object of the invention is to provide novel apparatus of the above character which is so constructed as to facilitate adaptation of the same to engines having different numbers of cylinders, or to permit the energy supplying apparatus to be driven at different speeds with respect to the crankshaft, with but a minimum of modification or adjustment.

A further object of the invention is to provide novelly constructed distributing apparatus for an electrical current-generating and distributing system, such distributing apparatus being so constructed as to be readily adapted to the ignition systems of a variety of different types of internal combustion engines.

Still another object is to provide a novel magneto supplied ignition system for engines in which the sparks or pulses are required at uneven intervals of crankshaft rotation or at equal intervals which exceed or differ from the successive magneto rotor intervals at which spark energy may be effectively supplied.

A still further object is to provide an engine ignition system of the above type which is novelly constructed to enhance the operating life of the magneto circuit breaker in such engines and hence, the trouble-free operating life of the engine.

It is also an object of the invention to provide a novel engine ignition system whereby greater energy may be made available from a given magneto for engine starting and low engine speed operation.

Yet another object of the invention resides in the provision of novel apparatus of the type described which permits the use of the apparatus with an engine having a lesser number of cylinders than the maximum number which the current-generating and distributing apparatus can supply when driven at a given speed, such apparatus functioning with no decrease in efficiency when thus employed with an engine having such lesser number of cylinders.

A still further object is to provide novel ignition apparatus which may be applied to engines having different numbers of cylinders without reducing the service life of any of the parts of the system.

The above and further objects and novel features of the invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawing. It is to be expressly understood, however, that the drawing is for the purpose of illustration only and is not intended as a definition of the limits of the invention.

It the drawing, wherein like reference characters refer to like parts throughout the several views,

FIG. 1 is a circuit diagram showing an ignition circuit in accordance with the invention, such circuit being served by one coil of the schematically illustrated magneto; and



FIG. 2 is a fragmentary diagram of a modified circuit in accordance with the invention.

The embodiment of the invention illustrated in FIG. 1 of the drawing, by way of example, is in the form of a magneto generator-distributor combination adapted for use in a low-voltage distribution type of ignition system for a multi-cylinder internal combustion engine. One such system is shown, for example, in the patent to R. B. Clark et al., No. 2,847,590. The ignition system of the present invention represents an improvement over that disclosed in such Clark et al. patent, the system of the present invention being such that the magneto generator-distributor combination may be readily adapted for use with a variety of engines having different numbers of cylinders, ranging from the maximum number of cylinders for which the combination is designed when the generator is driven at a given speed with respect to the engine crankshaft to substantially any smaller number of cylinders. Thus, for example, the illustrative 4-pole magneto generator-distributor combination may be employed to supply the ignition needs of an 8-cylinder 4-cycle engine when the generator shaft is driven at the speed of the crankshaft of the engine and the distributor cam shaft is driven at one-half crankshaft speed. When such magneto generator is connected to a distributing system such as shown in the drawing, however, the combination can supply the ignition needs of a 4-cylinder 4-cycle engine when the magneto generator is still driven at crankshaft speed. The system of the invention may be further adapted, as will be obvious to those skilled in the art, to serve the ignition needs of other engines, such as those having an uneven number of cylinders and those requiring sparks at uneven intervals of crankshaft rotation, by changing the speed ratio between the crankshaft of the engine and the generator shaft or by changing the number of operative distributing units connected to sparking plugs of the engine, or both. The system also lends itself admirably to adaptation to engines wherein it is desired to increase the spark energy of the ignition system by increasing the speed of the magneto generator relative to the speed of the engine crankshaft. The system as illustrated in the drawing may, for example, supply the needs of an 8-cylinder 4-cycle engine with increased energy when the generator is driven at twice the crankshaft speed. The system of the invention is similarly adapted for two-stroke cycle engines by doubling the generator and crankshaft speeds.

In the drawing there is shown a magneto generator generaly designated 10, said magneto generator having a rotor 11 carrying four equally angularly spaced poles. Rotor 11 is fixedly mounted on a driven rotor shaft 12. By way of example, shaft 12 is adapted to be connected, by means not shown, to the crankshaft of a 4-cylinder 4-cycle engine, such connecting means being such as to drive the magneto shaft 12 at crankshaft speed, or to the crankshaft of an 8-cylinder 4-cycle engine to be driven at twice crankshaft speed. Rotor 11 rotates within a housing (not shown), the housing carrying two pairs of stator pole shoes 15 and 16 with which the poles on the rotor sequentially cooperate. The magnetic circuits between the poles of pole shoes 15 and 16 are completed by coil cores 17 and 19, about which coils 20 and 21 are disposed, respectively. In the illustrative system, only coil 20 is shown as being used; coil 21 may, for example, be connected to an output and distributing system identical with that shown for an engine provided with dual ignition, or it may be removed when a dual ignition system is not required. Core 19 and poles 16 may also be eliminated or they may be retained as a magnetic keeper.

One end of coil 20 is connected to ground. The other end of such coil is connected to a wire 22 which is branched so as to be connected to four operative dis-

tributing circuits or units 1, 3, 5, and 7 of the system. Such operative distributing units are sequentially energized in the proper sequence by the operation of normally closed breaker points 23 of the magneto generator. Breaker points 23 are repeatedly opened by a four-lobe cam 25 connected to shaft 12 of the magneto generator so as to rotate therewith. The cams $32^1$, $32^3$, $32^5$, and $32^7$ of the distributing units are fixedly connected to a cam shaft 34 so as to rotate therewith. Shaft 34 may be connected to the rotor shaft 12 so as to rotate at one-half the speed of such shaft and thus in suitable ratio with the four-lobe cam 25. As stated, breaker points 23 are normally closed, being spring pressed toward the closed position shown. A wire 24, which is connected to the movable contact of breaker points 23, is connected to wire 22 and hence to one end of coil 20. A wire 26 extends from the fixed contact of the breaker points to ground, and thus to the grounded end of coil 20. Connected in shunt with the breaker points 23 is a condenser 27 which minimizes arcing between the breaker points when the points are opened by cam 25.

During rotation of magneto rotor 11, a relatively low alternating voltage is generated in coil 20 when breaker points 23 are closed, thus providing a closed circuit through the coil 20. At the proper time in the rotation of the rotor 11 relative to the stator pole shoes, the breaker points 23 are opened by cam 25, thereby producing a surge of current in wire or bus bar 22. Such operation is repeated four times during each revolution of the 4-pole rotor 11 and cam 25. The system shown is provided with a wire 29 and an interposed manually operated switch 30 which are connected in shunt with breaker points 23, whereby to render the electrical system ineffective, when the switch is closed, to supply energy to the sparking plugs which are operatively connected to the output end of wire 22 in a manner to be described.

As above noted, the illustrative system has four operative distributing units 1, 3, 5, and 7 which are associated with the respective sparking plugs of a 4-cylinder 4-cycle engine. Since such units 1, 3, 5, and 7 are identical, a detailed description of unit 1 will suffice. Parts in units 3, 5, and 7 which are similar to those in unit 1 are designated by the same reference character with an appropriate different exponent. Unit 1 has a normally open contactor $31^1$ which is intermittently closed by a single lobed cam $32^1$ fixedly mounted on shaft 34. The lower movable contact $36^1$ is connected to ground. The upper fixed contact $37^1$ is connected to wire 22 through the primary winding $39^1$ of a voltage step-up transformer $40^1$. The secondary winding $41^1$ has one end thereof connected to ground as shown, and the other end connected to a first electrode of a sparking gap or plug $35^1$. The other electrode of such sparking gap is connected to ground. Cam $32^1$ is so oriented on shaft 34 that contactor $31^1$ is closed shortly before gap $35^1$ is to be fired and permitted to open shortly after a discharge has occurred across gap $35^1$.

With contactor $31^1$ closed, a surge of current is delivered by the magneto generator through wire 22 into primary winding $39^1$ and thence to ground through the closed contactor $31^1$. Such surge of current through primary winding $39^1$ induces a high voltage in secondary winding $41^1$ of the transformer, such voltage being high enough to cause a spark discharge to occur at gap $35^1$. Such energization of the distributing unit and the discharge of its respective spark gap is repeated in the proper timed sequence in each of distributing units 1, 3, 5, and 7.

The magneto generator 10 is designed to normally supply the ignition needs of an 8-cylinder 4-cycle engine when its rotor is driven at engine speed in combination with eight separate distributor units like unit 1 described above. However, when the rotor speed is doubled to increase the available energy for starting and slow speed operation or when the generator is connected to a 4-cylinder 4-cycle engine and is driven at crankshaft speed, it produces twice the number of energy surges in wire 22 as are required in the operation of the engine and alternate surges are unused. In the 4-cylinder system, the unused surges occur intermediate the surges which successively energize units 1, 3, 5, and 7. The system of the present invention provides novel means whereby such unused surges are dissipated without deleteriously affecting the energization of units 1, 3, 5, and 7 or appreciably shortening the useful life of any of the components of the system.

The energy dissipating means shown in FIG. 1 includes four cam and contactor units 2, 4, 6, and 8 which may be parts of a magneto generator-distributor such as that shown in the Clark et al. patent, No. 2,847,590, as conventionally made for use with an 8-cylinder 4-cycle engine wherein the generator is driven at the speed of the engine crankshaft. Units 2, 4, 6, and 8 are similar and hence only unit 2 is described. It includes a normally open contactor $31^2$ and a cam $32^2$ affixed to shaft 34 for closing its contactor shortly before the occurrence of the surge of energy generated by the magneto after contactor $31^1$ is opened.

One contact of contactor $31^2$ is connected to ground and the other contact of such contactor is connected to a wire 45. Wire 45 is connected to wire 22 through a series connected inductance 42 and resistor 44, the inductance being preferably wound on a core of magnetic metal. Inductance 42 and resistor 44 are so chosen that together they produce an impedance which, when subjected to a current pulse from the generator through wire 22, will result in a voltage wave shape across points 23 and hence a flow of current between said points as the same are separated which similates the same voltages and currents which occur when units 1, 3, 5, and 7 are energized. The cams of units 2, 4, 6, and 8 are so oriented with respect to shaft 34 that such units successively receive and dissipate the energy of surges generated by the magneto intermediate those which energizes units 1, 3, 5, and 7 for firing the spark plugs. Because of the impedance match mentioned above, conditions within the system, including those at breaker points 23, are substantially the same whether the system is delivering an energy surge to one of the distributing units 1, 3, 5, and 7 or is delivering a surge to one of the cam and contactor units 2, 4, 6, and 8 thence to the energy dissipating impedance 42, 44. It will be seen that without the matching energy dissipating units and with distributor units 1, 3, 5, and 7 all receiving alternate surges of like polarity, the transfer of metal from one contact of magneto breaker 23 to the other, due to arcing, would occur in one direction only or unevenly in one direction. This would result in a substantial reduction in the operating life of the breaker contacts, a result which is avoided by the present invention.

An alternative system in accordance with the invention is fragmentarily shown in FIG. 2. In such alternative system the cam and contactor units 2, 4, 6, and 8 and wire 45 are omitted from the system of FIG. 1 and one of such units is replaced by the cam and contactor unit 46 shown in FIG. 2. Unit 46 includes a four-lobe cam 47 affixed to shaft 34, cam 47 closing a normally open contactor 49 four times during each revolution of shaft 34. The cam 47 is so oriented with respect to the cams of distributing units 1, 3, 5, and 7 that contactor 49 is closed to receive each of the unused energy pulses generated by the magneto. The movable contact of contactor 49 is connected to ground; the other is connected to wire 22 of the modified system of FIG. 1 through series connected inductance 42 and resistor 44. As will be apparent from the above, the system of FIG. 2 functions electrically in the same manner as that of FIG. 1, the essential difference between the two systems being the use of a single cam and contactor unit in FIG. 2 to direct unwanted surges to the energy dissipating unit 42, 44 rather than the four cam and contactor units employed in FIG. 1.

It has been found that the use of an energy dissipating unit 42, 44, having an effective impedance substantially

equalling the effective impedance of each of the transformer circuits of units 1, 3, 5, and 7, does not decrease the effectiveness of the system in delivering energy to the operative distributing units but does result in an increase in the service life of the magneto circuit breaker. When unwanted energy pulses of a similar system are dissipated in the generator circuit, with or without an added resistance, it has been found that the voltage wave form of the positive and negative pulses appearing across the points of breaker 23 are markedly dissimilar. This results in undue arcing at the breaker points of the magneto and in the transfer of a greater amount of metal in one direction between such points than in the other direction. When it is attempted to minimize such arcing by an increase in the capacity of the condenser 27 of FIG. 1 which is connected in shunt with the breaker points, a noticeable decrease in the output voltage of the magneto and thus a decrease in the efficiency of the system occur.

As above set forth, the effective impedance of the energy dissipating unit 42, 44 is made at least substantially to equal and preferably equals the effective impedance presented by a circuit comprising transformer $40^1$. In one satisfactory commercial system made in accordance with the invention, the inductance 42 employs an open magnetic core inductor having a coil composed of 279 turns of #22 wire and the resistor 44 is a 2 ohm 10 watt resistor. The breaker point shunting condenser 27 in such embodiment has a capacity of 0.95 $\mu$f. when both coils 20 and 21 of the magneto are operatively employed. When coil 21 is not used and a magnetic keeper is substituted for core 19, the condenser 27 in such embodiment preferably has a capacity of 1.2 $\mu$f.

As above indicated, the system of the present invention may also be used advantageously when the speed at which the magneto is driven is increased to secure a higher magneto output voltage. Such increase of magneo speed results in the production of a number of unused energy surges or pulses during each rotation of the rotor of the magneto. Such unwanted pulses are conveniently dissipated by use of a system in accordance with the present invention. Since magnetos are conveniently constructed to generate an even number of evenly spaced surges during each revolution of the rotor, the adaptation thereof to engines having an uneven number of cylinders or a firing order of the spark plugs wherein the successive intervals between sparks are not the same in crankshaft degrees necessitates the generation of some unused, unwanted surges which may be satisfactorily dissipated in accordance with the present invention.

Although only a limited number of embodiments of the invention are illustrated in the accompanying drawing and described in detail in the foregoing specification, it is to be expressly understood that the invention is not limited to the details of construction thus illustrated and described. For example, the system of FIG. 1 may be modified by connecting wires 22 and 45 directly together and by using a separate energy dissipating unit 42, 44 with each of units 2, 4, 6, and 8, each such energy dissipating unit being connected in series with the contactor of its respective unit, 2, 4, 6, and 8. Likewise, although the inductance 42 and the resistor 44 have been shown and described as being separate and connected in series, a satisfactory energy dissipating unit may be made wherein the winding of the inductance is composed either wholly or partially of resistance wire, such inductance having an impedance which is the same as that yielded by the described unit 42, 44. Various other modifications, including changes in the design and arrangement of the parts illustrated, will now be apparent to those skilled in the art and may be made without departing from the spirit and scope of the invention.

What is claimed it:

1. In an ignition system a source of successive pulses of electrical energy comprising an induction coil and a normally closed circuit breaker connected across said coil and adapted to be periodically opened to initiate said



pulses, first and second parallel connected branch circuits connected to said coil in parallel with said circuit breaker, said first branch circuit comprising the primary winding of a transformer. the secondary winding of which is operatively connected to the terminals of a spark gap, and said second branch circuit comprising impedance means consisting of a combination of inductance and resistance, a normally open contactor in each of said branch circuits, and means for selectively closing and opening said contactors sequentially in timed relation to the opening of said circuit breaker, said impedance means having such relation to the effective impedance of said first branch circuit that the voltage wave form across the circuit breaker as it opens will be generally the same irrespective of which branch circuit has its contactor closed.

2. An ignition system as defined in claim 1 wherein said voltage wave form is of one polarity when the contactor in the first branch circuit is closed and of the opposite polarity when the contactor in said second branch circuit is closed.

3. In an ignition system for combustion engines, an ignition coil comprising a primary winding and a secondary winding, a spark gap connected across said secondary winding, a first normally open contactor connected in series with said primary winding, a second normally open contactor and impedance means connected in series with each other and in parallel with said series connected primary winding and first contactor, said impedance means comprising a combination of inductance and resistance, means for successively closing and opening said contactors in sequence, and means including a normally closed circuit breaker for supplying a surge of current through each of said contactors upon the opening of said circuit breaker whereby a spark is created at said spark gap by the surge occurring while said first contactor is closed and the energy of the surge occurring while said second contactor is closed is effectively dissipated by said impedance means, the latter being such as to effectively match the corresponding impedance of the circuit including said first contactor and primary winding, whereby the wave form of the voltage across the contacts of the circuit breaker when it opens is generally the same except for polarity in both instances.

4. In the combination of a spark ignition internal combustion engine having a crankshaft and a plurality of cylinders, a spark gap associated with each cylinder, a magneto having a stator and a rotor and means driving the magneto rotor in synchronism with the engine crankshaft, the magneto producing a number of surges of electrical energy during each complete cycle of the engine which is in excess of the number of cylinders of the engine, the improved ignition system which comprises current distributing means connected to the output of the magneto, means to operate the distributing means at predetermined times in the engine cycle to fire the spark gaps in sequence, first circuit means having substantial impedance connecting the distributing means to the spark gaps, and means to dissipate the excess surges of electrical energy which are not employed to energize the spark gaps, said last-named means comprising second circuit means connected to the output of the magneto, said second circuit means being normally open, means to close said second circuit means shortly before each excess surge is generated by the magneto and means connected to the second circuit means and having an impedance which closely approximates the impedance of the first circuit means to dissipate the energy of said excess surges of electrical energy.

5. A timed ignition system comprising a magneto having a stator and a rotor, the rotor being adapted to be connected to an engine to rotate in synchronism therewith, an output circuit connected to the magneto, the magneto producing a predetermined number of surges of electrical energy during each revolution of the rotor,

current distributing means connected to the output of the magneto, means to operate the distributing means at predetermined times in the engine cycle, a spark gap for each cylinder of the engine, first circuit means having substantial impedance operatively connected the distributing means to the spark gaps, the magneto producing a number of surges of electrical energy during each complete engine cycle which is in excess of the number of spark gaps, and means to dissipate the excess surges of electrical energy which are not employed to energize the spark gaps, said last-named means comprising second circuit means connected to the output of the magneto, said second circuit means being normally open, means to close said second circuit means shortly before each excess surge is generated by the magneto and means associated with the second circuit means to dissipate the energy of said excess surges of electrical energy, said last-named means having an impedance which closely approximates the impedance of the first circuit means.

6. In ignition apparatus, a magneto generator comprising an induction coil, a normally closed circuit breaker connected across said coil, means for inducing current flow in said coil and means to intermittently open said circuit breaker to initiate surges of electrical energy in said coil, first circuit means for dissipating the energy of some of said surges comprising a first normally open contactor and impedance means connected in parallel with said circuit breaker across said induction coil, means for intermittently closing said first contactor shortly before the opening of said circuit breaker to thereby direct surges of electrical energy through said impedance means, second circuit means including the primary winding of a transformer and a second normally open contactor connected in parallel with said circuit breaker across said coil, the secondary winding of the transformer being connected across the electrodes of a spark gap, and means for closing and opening said last-named contactor in sequence with the closing and opening of said first contactor shortly before the opening of said circuit breaker, the impedance of said circuits being such that the wave form of the voltage across the circuit breaker and the magnitude of the current flow between the circuit breaker contacts as the latter are being separated is substantially the same independently of which contactor is closed.

7. Ignition apparatus as defined in claim 6 wherein said impedance means consists of a combination of an inductive winding with substantial resistance.

8. In an ignition system for a multi-cylinder combustion engine having a spark plug in each cylinder adapted to be fired by pulses of electrical energy, a magneto driven by the engine to generate electrical energy pulses in excess of the number of pulses required to fire said spark plugs, said magneto comprising an induction coil, means for inducing current flow in said coil and a periodically operated circuit breaker connected across said coil, whereby a said energy pulse is generated upon each opening of said circuit breaker, and circuit means connected to the output of said coil in parallel with said circuit breaker for dissipating the energy of said excess pulses, said circuit means consisting of impedance means and normally open contactor means for intermittently connecting said impedance means to said output of the magneto coil whenever a said excess pulse is generated upon the opening of said circuit breaker.

9. An ignition system as defined in claim 8 wherein said impedance means comprises an inductive winding having substantial resistance in the turns thereof.

10. An ignition system as defined in claim 8 wherein said impedance means comprises a resistance connected in series with an inductance winding.

11. An ignition system as defined in claim 10 wherein said inductance winding is wound on a metallic core.

12. In the combination of a spark ignition internal combustion engine having a driven shaft and at least one cylinder, a spark gap associated with each cylinder, a magneto having a stator, a rotor, an induction coil and normally closed breaker points connected in shunt with the induction coil, means for driving the rotor in synchronism with the engine shaft, and means to open the breaker points at predetermined times in the rotation of the rotor to initiate surges of electrical energy, the magneto producing a number of surges of electrical energy during each complete cycle of the engine which is in excess of the number of cylinders of the engine, the improved ignition system which comprises current distributing means connected to the magneto coil, first circuit means having substantial impedance connecting the distributing means to the spark gaps, and means to dissipate the excess surges of electrical energy generated by the magneto, said last-named means comprising a second circuit means connected to the magneto coil, means to close said second circuit means shortly before each excess surge is generated by the magneto and means associated with the second circuit means and having an impedance which closely approximates the impedance of the first circuit means to dissipate the energy of said excess surges of electrical energy.

13. An ignition system as defined in claim 12 wherein the first circuit means comprises a transformer having substantial inductance and resistance.

14. An ignition system as defined in claim 13 wherein the energy dissipating means comprises a combination of inductance and resistance which substantially matches the impedance of said first circuit.

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