United States Patent

Campbell et al.

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[45] **Feb. 29, 1972**

[54] **INTERNAL COMBUSTION ENGINE IGNITION SYSTEM HAVING INCREASED IGNITION SPARK ENERGY**

[72] Inventors: **Robert E. Campbell; Gerald O. Huntzinger**, both of Anderson, Ind.

[73] Assignee: **General Motors Corporation**, Detroit, Mich.

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[52] **U.S. Cl.** .....**123/148 E**, 315/209 T, 315/220

[51] **Int. Cl.**.....**F02p 3/06**

[58] **Field of Search**.....123/148 E; 315/220, 209 T

[56] **References Cited**

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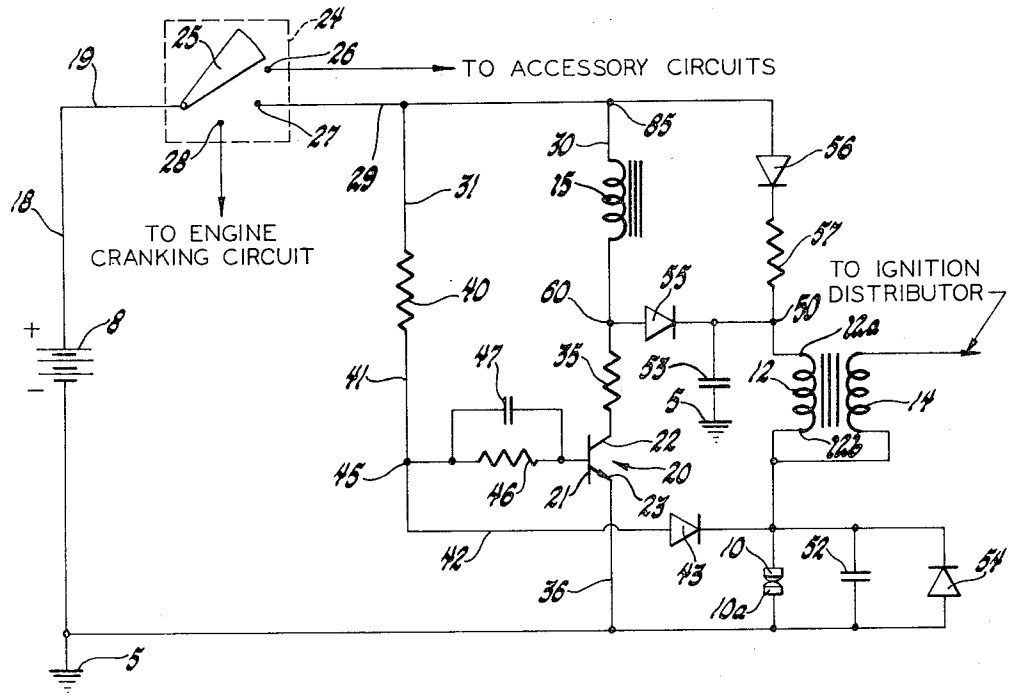
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Primary Examiner—Laurence M. Goodridge
Assistant Examiner—Cort Flint
Attorney—Eugene W. Christen, Creighton R. Meland and Richard G. Stahr

[57] **ABSTRACT**

An improved internal combustion engine ignition system having increased ignition spark energy. The series combination of an inductor and the current carrying electrodes of a transistor is connected in parallel with the series combination of the ignition coil primary winding and the ignition coil primary winding switch across the battery. The transistor conducts through the current carrying electrodes with each opening of the ignition coil primary winding switch to complete an energizing circuit for the inductor and extinguishes with each closing of the ignition coil primary winding switch to interrupt the energizing circuit for the inductor. The potential induced in the inductor by the collapsing magnetic field thereof is applied across the ignition coil primary winding in series aiding relationship with the potential of the battery to increase the rate of rise of the ignition coil primary winding current.

4 Claims, 2 Drawing Figures



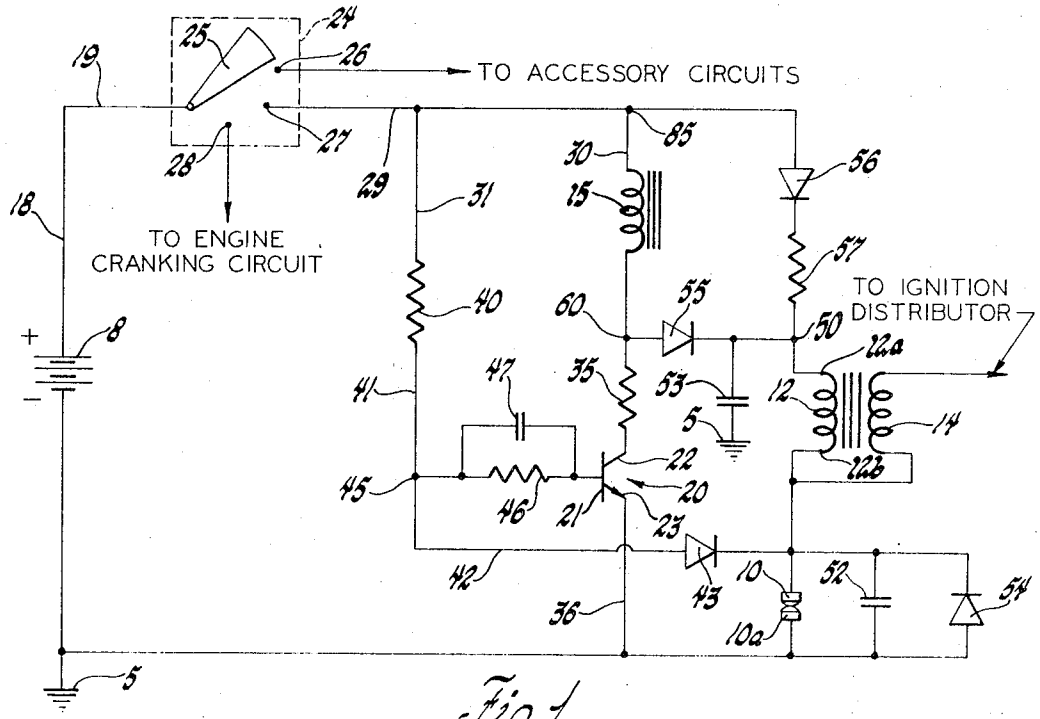


Fig. 1

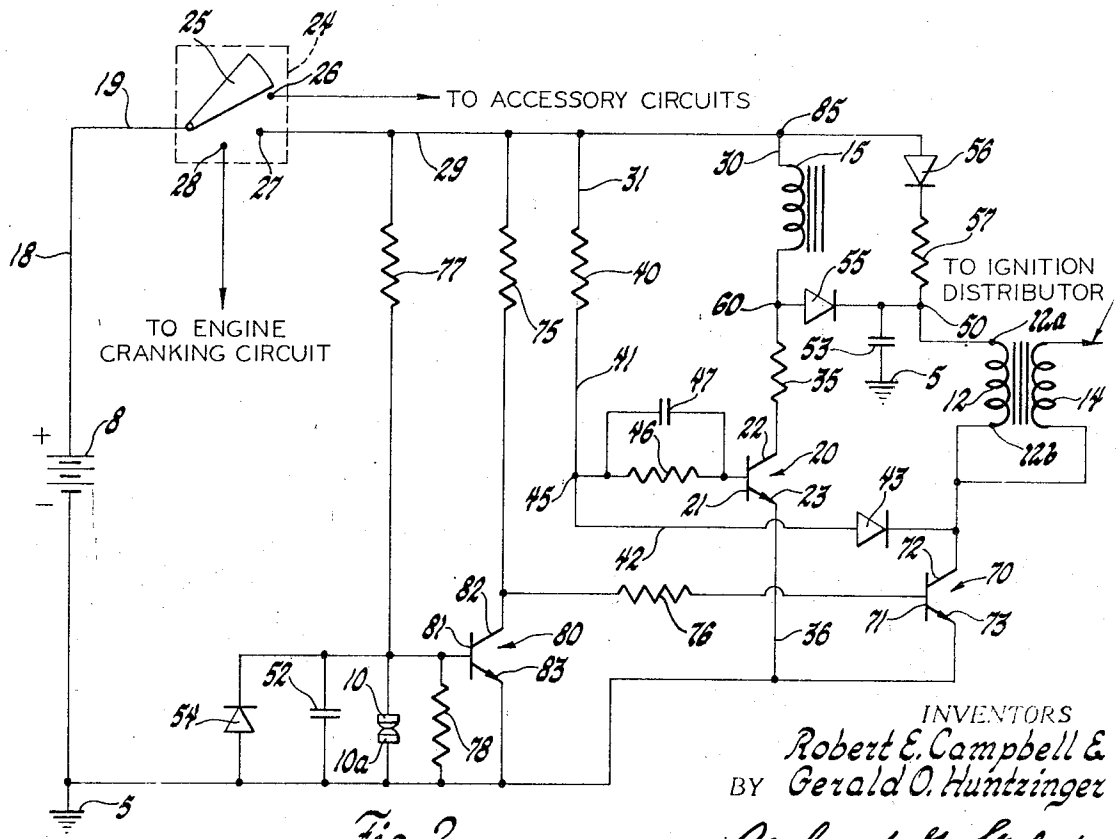


Fig. 2

INVENTORS
Robert E. Campbell &
BY Gerald O. Huntzinger
Richard G. Stahl
ATTORNEY

INTERNAL COMBUSTION ENGINE IGNITION SYSTEM HAVING INCREASED IGNITION SPARK ENERGY

This invention is directed to internal combustion engine ignition systems and, more particularly, to an internal combustion engine ignition system having increased ignition spark energy.

One objectionable characteristic of internal combustion engine ignition systems of the type which depends upon the collapse of the magnetic field of the ignition coil primary winding to produce the ignition spark energy is the inability of the system to provide sufficient energizing current through the ignition coil primary winding at high engine speeds.

It is, therefore, an object of this invention to provide an improved internal combustion engine ignition system.

It is another object of this invention to provide an improved internal combustion engine ignition system having increased ignition spark energy.

In accordance with this invention, an improved internal combustion engine ignition system having increased ignition spark energy is provided wherein the potential induced in an inductor element, upon the collapse of the magnetic field thereof when the energizing circuit therefor is interrupted by an electrical switch with each closing of the ignition coil primary winding switch, is applied across the ignition coil primary winding in series aiding relationship with the source of direct current operating potential.

For a better understanding of the present invention, together with additional objects, advantages, and features thereof, reference is made to the following description and accompanying drawings in which:

FIG. 1 illustrates one embodiment of the ignition system of this invention in schematic form, and

FIG. 2 is another embodiment of the ignition system of this invention in schematic form.

In FIGS. 1 and 2 of the drawings, like elements have been assigned like numerals of reference and the point of reference or ground potential has been shown by the accepted schematic symbol and referenced by the numeral 5.

Referring to the figures, the internal combustion engine ignition system having increased ignition spark energy of this invention is set forth in schematic form in combination with a source of direct current potential, which may be a storage battery 8, and includes an ignition coil primary winding 12; an ignition coil primary winding switch, ignition distributor breaker contacts 10 and 10*a* of FIG. 1 or transistor 70 of FIG. 2, having current carrying elements which are operated to electrical circuit open and closed conditions in timed relationship with the engine; an inductor element 15; an electrical switching device, transistor 20, having current carrying elements connected in series with the inductor element 15 across the source of direct current potential and responsive to the electrical circuit open and closed conditions of the current carrying elements of the ignition coil primary winding switch for completing and interrupting the energizing circuit for the inductor element 15, respectively, and circuitry for applying the potential induced in the inductor element 15 upon the collapse of the magnetic field thereof with each operation of the current carrying elements of the ignition coil primary winding switch to the electrical circuit closed condition across the ignition coil primary winding 12 in series aiding relationship with the potential of the source of direct current potential.

The ignition coil primary winding switch may be any electrical switching device which may be operated to electrical circuit open and closed conditions and which has an electrical current rating which will adequately switch the ignition coil primary winding energizing current. In FIG. 1, the ignition coil primary winding switch is illustrated as a pair of conventional ignition distributor breaker contacts 10 and 10*a* which are operated open and closed in timed relationship with the engine. In FIG. 2, the ignition coil primary winding switch is illustrated as an ignition distributor breaker contact triggered type NPN transistor 70 which is triggered not conductive and conductive through the collector-emitter electrodes in timed relationship with the engine.

In the interest of reducing drawing complexity and since the methods and arrangements for operating the ignition distributor breaker contacts open and closed in timed relationship with the engine are well known in the internal combustion engine art and, per se, form no part of this invention, only the ignition distributor breaker contacts have been schematically set forth in the figures.

The ignition coil primary winding 12 and the current carrying elements of the ignition coil primary winding switch are connected in series across the source of direct current potential. In FIG. 1, this circuit may be traced from the positive polarity terminal of battery 8, through leads 18 and 19, movable contact 25 and stationary contact 27 of electrical switch 24, lead 29, diode 56, current limiting resistor 57, ignition coil primary winding 12, ignition distributor breaker contacts 10 and 10*a* and point of reference or ground potential 5 to the negative polarity terminal of battery 8. In FIG. 2, the current carrying elements of transistor 70, collector electrode 72 and emitter electrode 73, replace ignition distributor breaker contacts 10 and 10*a* in this circuit.

Electrical switch 24 may be a conventional automotive type ignition switch having a manually rotatable movable contact 25, shown in the "O" position in the figures, which bridges stationary contacts 27 and 28 in the "Crank" position and bridges stationary contacts 26 and 27 in the "Run" position to which the movable contact is spring biased to return upon the release of torque when the engine starts.

Any electrical switching device of the type having current carrying elements which may be operated to an electrical circuit closed condition upon the application thereto of an electrical signal may be used as the electrical switching device in the ignition system of this invention. In the figures, and without intention or inference of a limitation thereto, the electrical switching device is shown to be a type NPN transistor 20 having the usual base or control electrode 21 and two current carrying elements, collector electrode 22 and emitter electrode 23, which may be operated to an electrical circuit closed condition, that is, conductive through the collector-emitter electrodes thereof, upon the application of the electrical signal across the base electrode 21 and a selected one of the current carrying elements thereof.

Inductor element 15 and the current carrying elements of the electrical switching device, the collector-emitter electrodes of type NPN transistor 20, are connected in series across the source of direct current potential, battery 8, through a circuit which may be traced from the positive polarity terminal of battery 8 through leads 18 and 19, movable contact 25 and stationary contact 27 of electrical switch 24, leads 29 and 30, inductor element 15, current limiting resistor 35, the collector-emitter electrodes of type NPN transistor 20, lead 36 and point of reference or ground potential 5 to the negative polarity terminal of battery 8. As the collector electrode 22 of type NPN transistor 20 is connected to the positive polarity terminal of battery 8 upon the closure of movable contact 25 of electrical switch 24 to stationary contact 27 and the emitter electrode 23 thereof is connected to the negative polarity terminal of battery 8 through lead 36 and point of reference or ground potential 5, type NPN transistor 20 is correctly poled for forward conduction through the collector-emitter electrodes thereof with movable contact 25 of switch 24 closed to stationary contact 27.

Circuit means is provided for applying an electrical signal to the electrical switching device each time the ignition coil primary winding switch is operated to the electrical circuit open condition for operating the current carrying elements thereof to the electrical circuit closed condition.

Referring to the figures, the electrical signal is applied across the control electrode, base electrode 21, and a selected one of the current carrying elements, emitter electrode 23, of type NPN transistor 20 upon each operation of the current carrying elements of the ignition coil primary winding switch to the electrical circuit open condition for triggering transistor 20 conductive through the current carrying electrodes

thereof, the collector-emitter electrodes, through resistor 40 lead 41 and the parallel combination of resistor 46 and filter capacitor 47 and through lead 36 and point of reference or ground potential 5, respectively, in a manner to be later explained.

Resistor 40 of this circuitry is connected in series with the current carrying elements of the ignition coil primary winding switch, ignition distributor breaker contacts 10 and 10*a* of FIG. 1 or the collector-emitter electrodes of transistor 70 of FIG. 2, across the source of direct current potential, battery 8, through a circuit which may be traced from the positive polarity terminal of battery 8, through leads 18 and 19, movable contact 25 and stationary contact 27 of switch 24, leads 29 and 31, resistor 40, leads 41 and 42, diode 43, the ignition distributor breaker contacts 10 and 10*a* of FIG. 1 or the collector-emitter electrodes of transistor 70 in FIG. 2, and point of reference or ground potential 5 to the negative polarity terminal of battery 8. The control electrode, base electrode 21 of transistor 20, is connected to the junction 45 between resistor 40 and the ignition coil primary winding switch through the parallel combination of resistor 46 and filter capacitor 47, in both figures.

The junction 60 between inductor element 15 and the current carrying elements of the electrical switching device, the collector-emitter electrodes of transistor 20, is electrically connected to the terminal end 12*a* of the ignition coil primary winding 12 opposite the terminal end 12*b* thereof connected to the current carrying elements of the ignition coil primary winding switch, ignition distributor breaker contacts 10 and 10*a* of FIG. 1 or the collector-emitter electrodes of transistor 70 of FIG. 2, through diode 55 poled to conduct current from junction 60 toward junction 50.

Upon each interruption of the energizing circuit of inductor element 15 in a manner to be later explained, the resulting collapsing magnetic field induces a potential in inductor element 15. While the energizing circuit of inductor element 15 is established, the potential of the terminal end thereof connected to junction 85 is of a positive polarity with respect to the terminal end connected to junction 60. It is well known that the potential induced in an inductor by the collapsing magnetic field thereof, upon the interruption of the energizing circuit, is of a polarity which tends to maintain the flow of current which produced the magnetic field. Consequently, the potential induced in inductor element 15 upon the collapse of the magnetic field thereof upon each interruption of the energizing circuit with each operation of the current carrying elements of ignition coil primary winding switch, breaker contacts 10 and 10*a* of FIG. 1 or the collector-emitter electrodes of transistor 70 of FIG. 2, to the electrical circuit closed condition is of a positive polarity at the terminal end thereof connected to junction 60 with respect to the opposite terminal end connected to junction 85. This induced potential reverse biases diode 56, a condition which is tantamount to interrupting the circuit between junctions 85 and 50, and is applied across the ignition coil primary winding 12 in series aiding relationship with the potential of battery 8 negative-to-positive a circuit which may be traced from junction 60; through forward poled diode 55; ignition coil primary winding 12; the current carrying elements of the ignition coil primary winding switch, ignition distributor breaker contacts 10 and 10*a* of the circuit of FIG. 1 or the collector-emitter electrodes of transistor 70 of the circuit of FIG. 2; point of reference or ground potential 5; battery 8 in a negative- direction; leads 18 and 19; movable contact 25 and stationary contact 27 of switch 24 and leads 29 and 30 to the opposite terminal end of inductor 15. As this induced potential is applied across ignition coil primary winding 12 in series aiding relationship with the potential of battery 8 while the current carrying elements of the ignition coil primary winding switch are in a circuit closed condition, the energizing current through ignition coil primary winding 12 is increased over that which would be produced by only battery 8 by an amount determined by the magnitude of this induced potential.

Referring to FIG. 1, upon the closure of movable contact 25 of switch 24 to stationary contacts 27 and 28, battery potential appears across lead 29 and point of reference or ground potential 5 of a positive polarity upon lead 29 with respect to point of reference or ground potential 5 and the cranking circuitry, not shown, of the associated engine is energized to crank the engine which operates ignition distributor breaker contacts 10 and 10*a* open and closed in timed relationship therewith in a manner well known in the internal combustion engine art.

With each operation of the distributor breaker contacts 10 and 10*a* to the electrical circuit closed condition, an energizing circuit for the ignition coil primary winding 12 is completed through a circuit which may be traced from the positive polarity terminal of battery 8 through leads 18 and 19, movable contact 25 and stationary contact 27 of switch 24, lead 29, diode 56, current limiting resistor 57, primary winding 12, ignition distributor breaker contacts 10 and 10*a* and point of reference or ground potential 5 to the negative polarity terminal of battery 8. As the closed ignition distributor breaker contacts 10 and 10*a* provide a substantially short circuit across the base-emitter electrodes of type NPN transistor 20, this device does not conduct with the ignition distributor breaker contacts 10 and 10*a* closed.

With each operation of the ignition distributor breaker contacts 10 and 10*a* to the circuit open condition, the energizing circuit for the ignition coil primary winding 12 is interrupted, the short circuit is removed from across the base-emitter electrodes of transistor 20, and an electrical signal appears across junction 45 and point of reference or ground potential 5 which is of a positive polarity upon junction 45 with respect to point of reference or ground potential 5. The resulting collapsing magnetic field of ignition coil primary winding 12 induces an ignition potential in the ignition coil secondary winding 14 which is directed to the proper spark plug of the associated engine through the ignition distributor, not shown, in a manner well known in the internal combustion engine art. The electrical signal appearing across junction 45 and point of reference or group potential 5 is applied across the base-emitter electrodes of type NPN transistor 20 through resistor 46 and point of reference or ground potential 5, respectively.

This electrical signal, which is of a positive polarity upon junction 45 with respect to point of reference or ground potential 5, is of the correct polarity relationship to produce base-emitter current flow through a type NPN transistor, consequently, forward poled type NPN transistor 20 conducts through the current carrying electrodes thereof, collector-emitter electrodes 21 and 22, to complete the energizing circuit for inductor 15 which may be traced from the positive polarity terminal of battery 8 through leads 18 and 19, movable contact 25 and stationary contact 27 of switch 24, leads 29 and 30, inductor element 15, current limiting resistor 35, the collector-emitter electrodes of transistor 20, lead 36 and point of reference or ground potential 5 to the negative polarity terminal of battery 8. The resulting flow of energizing current through inductor element 15 produces a magnetic field in a manner well known in the art.

Consequently, each time the ignition distributor breaker contacts 10 and 10*a* are operated to the circuit closed condition after a circuit open condition, the energizing circuit for the ignition coil primary winding 12 is completed through a circuit previously described and the base-emitter electrodes of transistor 20 are substantially short-circuited thereby. As this short circuit drains base current from transistor 20, this device extinguishes to interrupt the energizing circuit for inductor 15.

The potential induced in inductor element 15 upon the collapse of the magnetic field thereof upon each interruption of the energizing circuit with each operation of the ignition distributor breaker contacts 10 and 10*a* to the electrical circuit closed condition is applied across the ignition coil primary winding 12 in a series aiding relationship with the potential of battery 8 through a circuit previously described.

Referring to FIG. 2, upon the closure of movable contact 25 of switch 24 to stationary contacts 27 and 28, battery potential appears across lead 29 and point of reference or ground potential 5 of a positive polarity upon lead 29 with respect to point of reference or ground potential 5 and the cranking circuitry, not shown, of the associated engine is energized to crank the engine which operates ignition distributor breaker contacts 10 and 10*a* open and closed in timed relationship therewith in a manner well known in the internal combustion engine art.

With each closing of the ignition breaker contacts 10 and 10*a*, the base-emitter electrodes 81 and 83 of type NPN transistor 80 are substantially short-circuited, consequently, this device is not conductive through the collector-emitter electrodes 82 and 83 thereof. With transistor 80 not conducting, base-emitter current flows through type NPN transistor 70 through resistors 75 and 76. As the collector-emitter electrodes of type NPN transistor 70 are correctly poled for forward conduction therethrough, this device is operated to the electrical circuit closed condition, i.e., conductive through the collector-emitter electrodes, to complete the energizing circuit for ignition coil primary winding 12 and substantially short circuit the base-emitter electrodes of type NPN transistor 20.

With each opening of the ignition breaker contacts 10 and 10*a*, battery potential appears across resistors 77 and 78, consequently, base-emitter current flows through type NPN transistor 80 through resistor 77. As the collector-emitter electrodes of transistor 80 are correctly poled for forward conduction therethrough, this device conducts through the collector-emitter electrodes to operate transistor 70 to the electrical circuit open condition by substantially short-circuiting the base-emitter electrodes of transistor 70 to extinguish transistor 70. With transistor 70 extinguished, the energizing circuit for ignition coil primary winding 12 is interrupted, the short circuit is removed from across the base-emitter electrodes of transistor 20 and the electrical signal appears across junction 45 and point of reference or ground potential 5. This electrical signal produces base-emitter and, consequently, collector-emitter current flow through transistor 20 to complete the energizing circuit for inductor element 15.

Upon the next closing of ignition distributor breaker contacts 10 and 10*a*, the base-emitter electrodes of transistor 80 are substantially short circuited. Consequently, transistor 80 extinguishes to operate transistor 70 to the circuit closed condition by removing the short circuit from across the base-emitter electrodes of transistor 70 which permits the flow of base-emitter current for transistor 70 through resistors 75 and 76. Consequently, transistor 70 again conducts through the collector-emitter electrodes to complete the energizing circuit for the ignition coil primary winding 12 and to short circuit the base-emitter electrodes of transistor 20 to extinguish transistor 20. As the transistor 20 extinguishes, the energizing circuit for inductor element 15 is interrupted and the potential induced therein by the collapsing magnetic field is applied across the ignition coil primary winding 12 in series aiding relationship with the potential of battery 8 through the circuit previously described.

Diode 43 prevents the flow of current through ignition coil primary winding 12 and the base-emitter electrodes of transistor 20 when the current carrying elements of the ignition coil primary switch are open; diode 55 prevents the flow of transistor 20 collector-emitter current flow through current limiting resistor 57, capacitor 52 is the conventional ignition capacitor, capacitor 53 is a filter capacitor and diode 54 is a negative voltage clamp.

In a practical application of the circuit of this invention, inductor element 15 was an iron core electrical coil of 2.5 millihenries and transistor 20 was a type 2N4915.

From this description of two embodiments of the novel improved ignition system of this invention, it is apparent that the electrical switching device, transistor 20, is responsive to the electrical circuit open and closed conditions of the current carrying elements of the ignition coil primary winding switch for completing and interrupting the energizing circuit for the inductor element 15, respectively, and that the potential induced in inductor element 15 upon the collapse of the magnetic field thereof with each operation of the current carrying elements of the ignition coil primary winding switch to the electrical circuit closed condition is applied across the ignition coil primary winding in series aiding relationship with the potential of the source of direct current potential, battery 8.

As these two potentials are in series aiding relationship, the total potential applied across the ignition coil primary winding is the algebraic sum thereof. Consequently, the energizing current through the ignition coil primary winding is increased over that which is produced by the source of direct current potential by an amount determined by the magnitude of the potential induced in inductor element 15. This increased energizing current, of course, produces an increased ignition coil primary winding magnetic field. As the magnitude of the ignition spark energy potential induced in the ignition coil secondary winding is directly proportional to the intensity of the ignition coil primary winding magnetic field, the increased ignition coil primary winding magnetic field produced by the ignition system of this invention provides an increased ignition spark energy.

While specific switching devices, transistor types and electrical polarities have been set forth in this specification, it is to be specifically understood that alternate electrical switching devices and transistor types having similar electrical characteristics and compatible electrical polarities may be used without departing from the spirit of the invention.

While a preferred embodiment of the present invention has been shown and described, it would be obvious to those skilled in the art that various modifications and substitutions may be made without departing from the spirit of the invention which is to be limited only within the scope of the appended claims.

What is claimed is:

1. An internal combustion engine ignition system having increased ignition spark energy comprising in combination with a source of direct current potential,

an ignition coil primary winding,

an ignition coil primary winding switch having current carrying elements which are operated to electrical circuit open and closed conditions in timed relationship with the engine,

means for connecting said ignition coil primary winding and said current carrying elements of said ignition coil primary winding switch in series across said source of direct current potential,

an inductor element,

an electrical switching device having current carrying elements connected in series with said inductor element across said source of direct current potential and responsive to the electrical circuit open and closed conditions of said current carrying elements of said ignition coil primary winding switch for completing and interrupting the energizing circuit for said inductor element, respectively, and

means for applying the potential induced in said inductor element upon the collapse of the magnetic field thereof with each operation of said current carrying elements of said ignition coil primary winding switch to said electrical circuit closed condition across said ignition coil primary winding in series aiding relationship with the potential of said source of direct current potential.

2. An internal combustion engine ignition system having increased ignition spark energy comprising in combination with a source of direct current potential,

an ignition coil primary winding,

an ignition coil primary winding switch having current carrying elements which are operated to electrical circuit open and closed conditions in timed relationship with the engine,

means for connecting said ignition coil primary winding and said current carrying elements of said ignition coil primary winding switch in series across said source of direct current potential,

an inductor element,

an electrical switching device of the type having current carrying elements which may be operated to an electrical circuit closed condition upon the application thereto of an electrical signal,

means for connecting said inductor element and said current carrying elements of said electrical switching device in series across said source of direct current potential,

circuit means for applying an electrical signal to said electrical switching device each time said ignition coil primary winding switch is operated to the electrical circuit open condition for operating said current carrying elements thereof to the electrical circuit closed condition, and

means for electrically connecting the junction between said inductor element and said current carrying elements of said electrical switching device to the terminal end of said ignition coil primary winding opposite the terminal end thereof connected to said current carrying elements of said ignition coil primary winding switch.

3. An internal combustion engine ignition system having increased ignition spark energy comprising in combination with a source of direct current potential,

an ignition coil primary winding,

an ignition coil primary winding switch having current carrying elements which are operated to electrical circuit open and closed conditions in timed relationship with the engine,

means for connecting said ignition coil primary winding and said current carrying elements of said ignition coil primary winding switch in series across said source of direct current potential,

an inductor element,

a transistor having a control electrode and two current carrying electrodes,

means for connecting said inductor element and said current carrying electrodes of said transistor in series across said source of direct current potential,

a resistor,

means for connecting said resistor in series with said current carrying elements of said ignition coil primary winding switch across said source of direct current potential,

means for connecting said control electrode of said transistor to the junction between said resistor and said current carrying elements of said ignition coil primary winding switch, and

means for electrically connecting the junction between said inductor element and said current carrying electrodes of said transistor to the terminal end of said ignition coil primary winding opposite the terminal end thereof connected to said current carrying elements of said ignition coil primary winding switch.

4. An internal combustion engine ignition system having increased ignition spark energy comprising in combination with a source of direct current potential,

an ignition coil primary winding,

a set of ignition distributor breaker contacts operated open and closed in timed relationship with the engine,

means for connecting said ignition coil primary winding and said ignition distributor breaker contacts in series across said source of direct current potential,

an inductor element,

a transistor having current carrying electrodes connected in series with said inductor element across said source of direct current potential and responsive to the opening and closing of said ignition distributor breaker contacts for completing and interrupting the energizing circuit for said inductor element, respectively, and

means for applying the potential induced in said inductor element upon the collapse of the magnetic field thereof upon each operation of said ignition distributor breaker contacts to the closed condition across said ignition coil primary winding in series aiding relationship with the potential of said source of direct current potential.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,645,246 Dated February 29, 1972

Inventor(s) Robert E. Campbell and Gerald O. Huntzinger

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 23, "O" should read -- Off --; line 39, after "of", "the" should read -- an --. Column 3, line 56, after "8" delete "negative-to-posi-"; line 57, delete "tive" and insert -- through --; line 63, after "negative" delete the hyphen and insert -- to positive --. Column 4, line 39, "group" should read -- ground --.

Signed and sealed this 27th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents