July 30, 1968 L. W. BELL 3,394,690

IGNITION SYSTEM

Filed Aug. 28, 1967 4 Sheets-Sheet 1

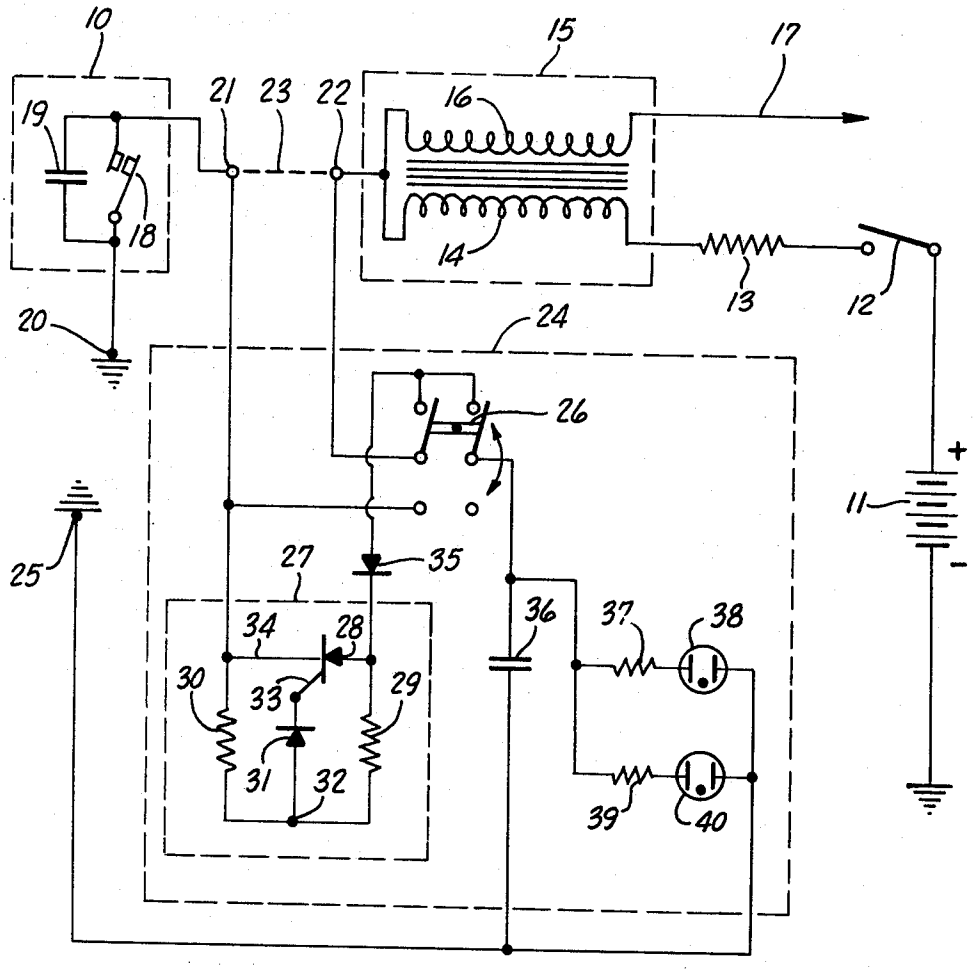


FIG. 1

LAURENCE W. BELL
INVENTOR.

BY Jack M. Wiseman

ATTORNEY

July 30, 1968 L. W. BELL 3,394,690

IGNITION SYSTEM

Filed Aug. 28, 1967 4 Sheets-Sheet 2

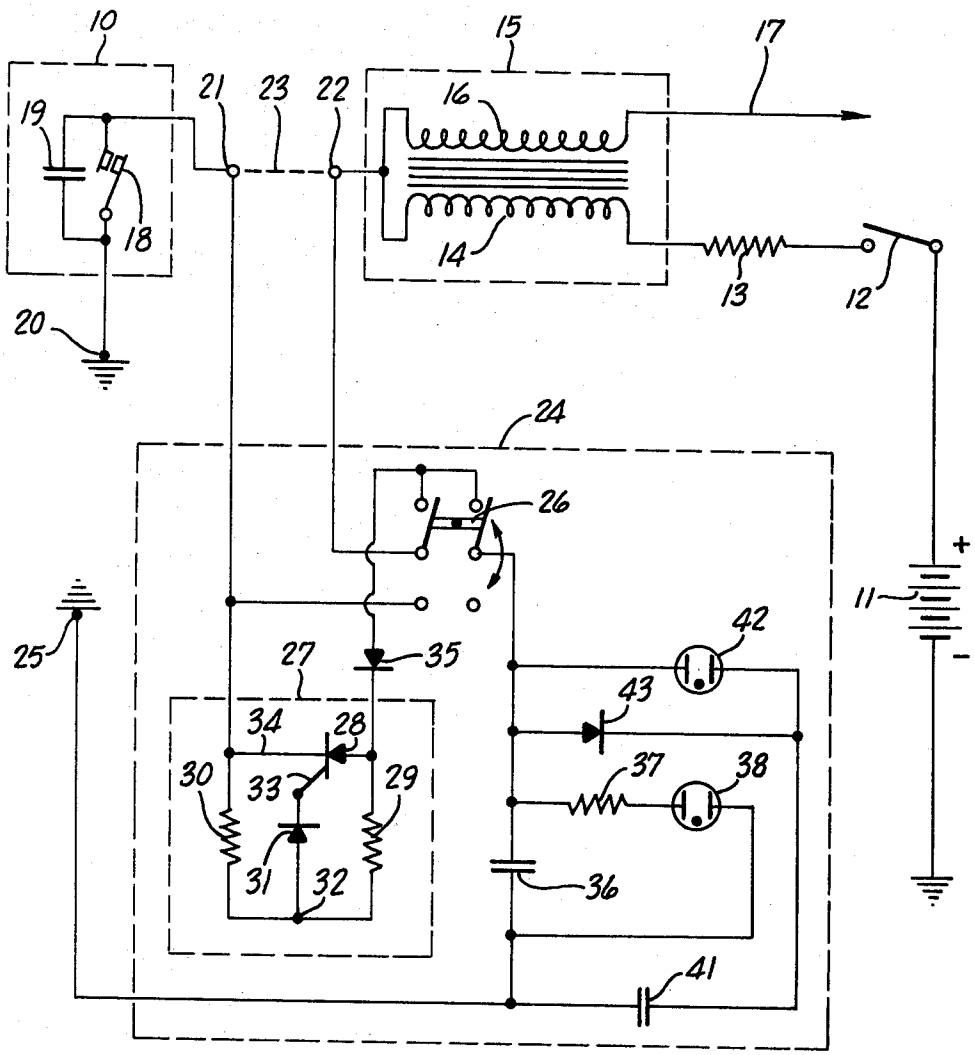


FIG. 2

LAURENCE W. BELL
INVENTOR.

BY Jack M. Wiseman

ATTORNEY

July 30, 1968 L. W. BELL 3,394,690

IGNITION SYSTEM

Filed Aug. 28, 1967 4 Sheets-Sheet 3

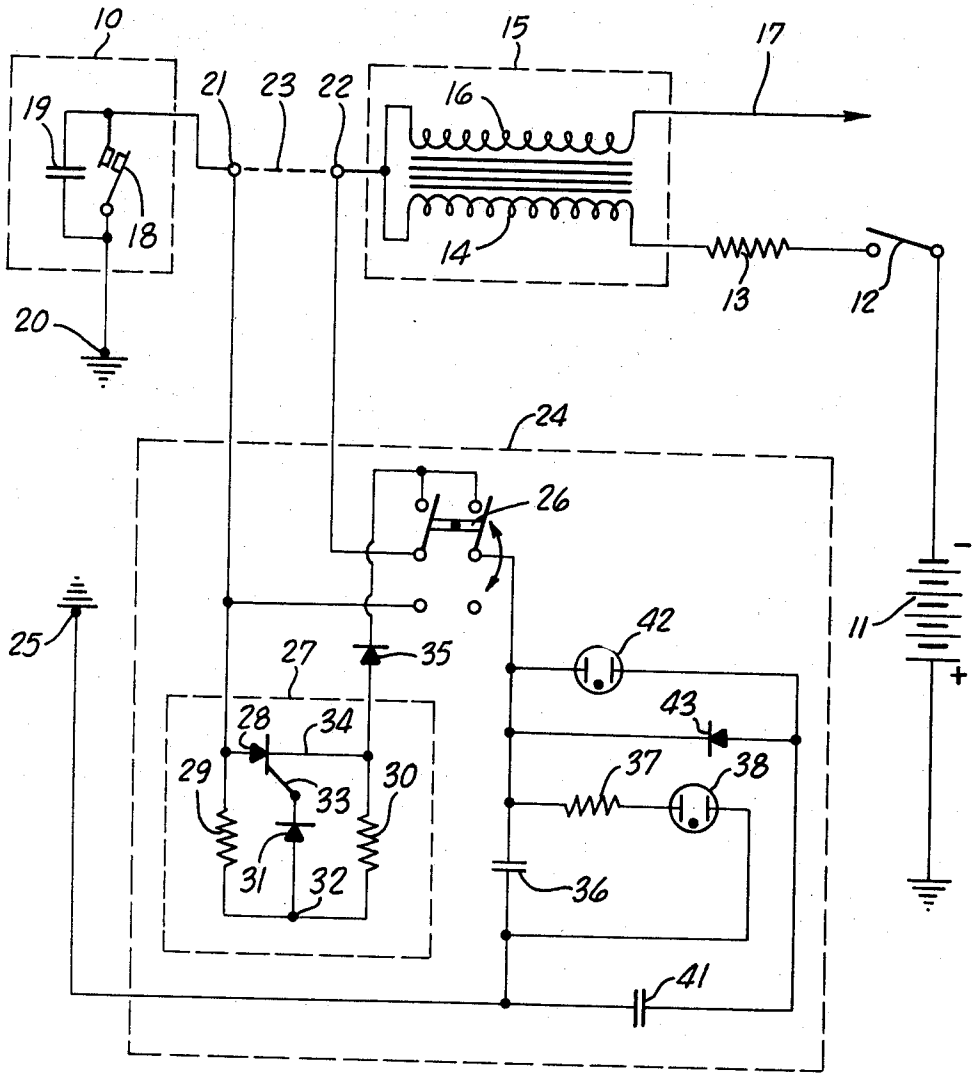


FIG. 3

LAURENCE W. BELL
INVENTOR.

BY Jack M. Wiseman

ATTORNEY

July 30, 1968 L. W. BELL 3,394,690

IGNITION SYSTEM

Filed Aug. 28, 1967 4 Sheets-Sheet 4

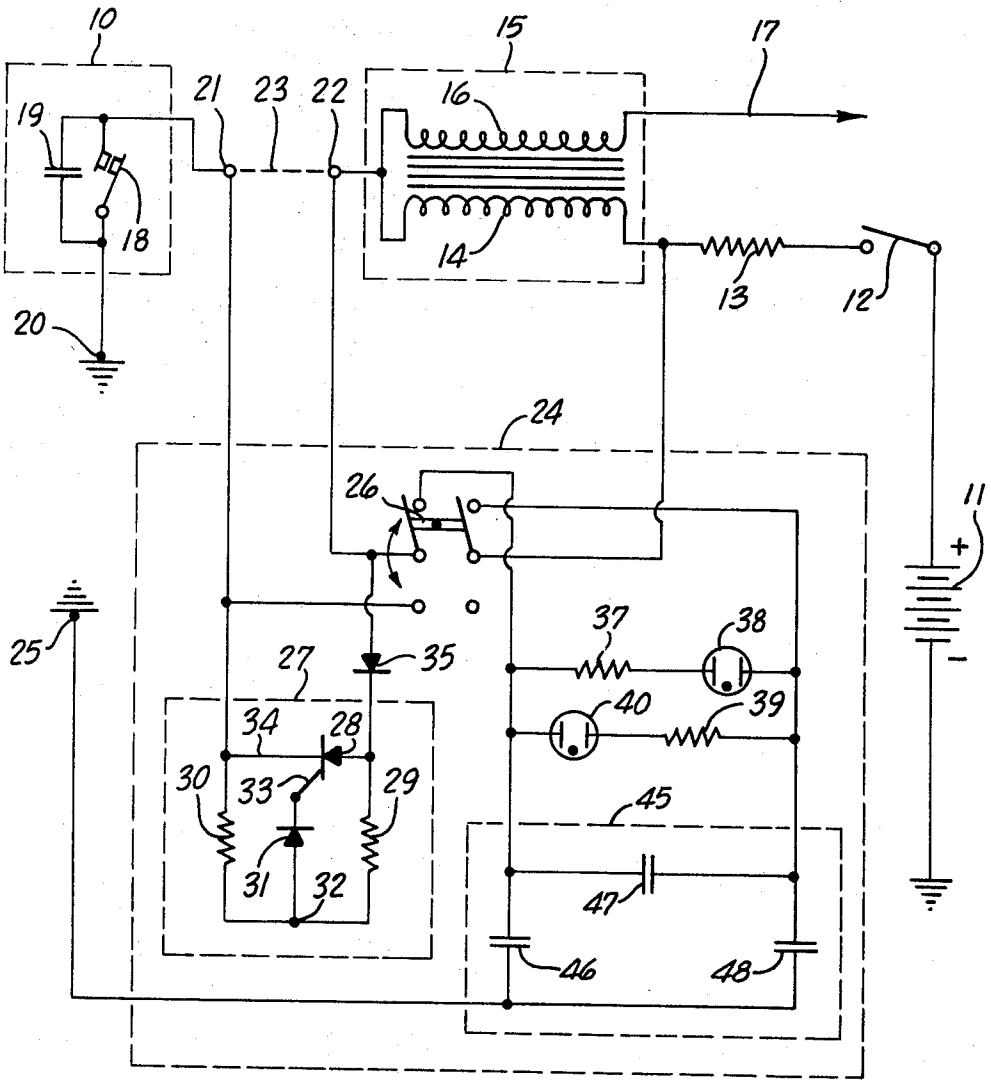


FIG. 4

LAURENCE W. BELL
INVENTOR.

BY Jack M. Wiseman

ATTORNEY

United States Patent Office

3,394,690

Patented July 30, 1968

3,394,690

IGNITION SYSTEM

Laurence W. Bell, 717 Benicia Road, Vallejo, Calif. 94590

Filed Aug. 28, 1967, Ser. No. 663,720
13 Claims. (Cl. 123—148)

ABSTRACT OF THE DISCLOSURE

A circuit for use in an ignition system for an internal combustion engine, which circuit includes an electronic switch connected between the distributor breaker points and the ignition coil of a conventional ignition system. More particularly, a silicon controlled rectifier is connected in the current path between the ignition coil and the breaker points so that the closing and opening of the breaker points triggers the rectifier into a conducting and nonconducting mode respectively. To accomplish this, a voltage dividing resistance is connected in parallel with the rectifier and the voltage across a portion of the voltage divider is applied to the gate electrode of the rectifier. The voltage dividing resistance is of such a value as to limit the flow of current through the breaker points on the closing thereof to a safe value and yet provide a gate electrode voltage sufficient to trigger the rectifier into the conducting mode after the closing of the breaker points, whereupon the rectifier shunts current from the voltage divider and reduces the trigger voltage to a safe level. A capacitor and a gas discharge tube are each connected in parallel with the switch to permit the ringing down of the ignition coil at its natural resonant frequency without damage to the switch. Provision is made for connecting the breaker points directly to the ignition coil to permit the performance of a normal engine tune-up. In modifications of the circuit, capacitive networks are provided for storing the energy of the ignition coil during the time the breaker ponts are open in order to provide multiple firing of the spark plugs for more efficient utilization of fuel.

SPECIFICATION

The present invention relates in general to ignition systems for internal combustion engines, and more particularly to a novel circuit adapted to be connected between the ignition coil and breaker points of a conventional ignition system.

The lifetime for effective performance of a conventional ignition system is severely limited by the arcing caused by the interruption of large currents through the breaker points. Special ignition systems which are presently available for reducing such arcing introduce other significant problems. For example, in one system where current is transferred to a transistor which is controlled by the breaker points, there exists insufficient current and voltage to burn off, and overcome the resistance of, oil film on the points and, moreover, the transistor control circuits have been found unreliable on a mass production basis. In another system involving a capacitor discharge, an undesirably complicated D–C to D–C converter is required and, moreover, this system requires the making and breaking of a circuit carrying sufficiently large amounts of current that substantial radio and television interference is generated.

One object of the present invention is to provide an improved ignition system.

Another object of the present invention is the provision of a circuit which can be easily installed between the distributor breaker points and the ignition coil of a conventional ignition system.

Another object of the present invention is the provision of an ignition system which permits multiple firing of the spark plugs while the breaker points are open for more efficient utilization of fuel.

Still another object of the present invention is the provision of an ignition system which permits the performance of a normal engine tune-up.

These and other objects of the invention are attained by a circuit comprising an electronic switch and means responsive to the closing and opening of the breaker points for operating said electronic switch so that sufficient current passes through said points for fully energizing the ignition coil only after the points have been securely closed.

The various features and advantages of the present invention will become more apparent upon a consideration of the following description taken in connection with the accompanying drawings, wherein:

FIGURE 1 is a schematic circuit diagram of an ignition system embodying the present invention;

FIGURE 2 is a schematic circuit diagram of a modification of the ignition system shown in FIG. 1;

FIGURE 3 is a schematic circuit diagram of the ignition system of FIGURE 2 in which the positive terminal of the battery is grounded; and

FIGURE 4 is a schematic circuit diagram of a further modification of the ignition system shown in FIGURE 1.

Illustrated in FIGURE 1, is an internal combustion ignition system embodying the present invention in which a standard distributor circuit **10** is used to make and break the primary circuit from a standard automobile battery **11** through an ignition switch **12**, a current-limiting or ballast resistor **13**, and a primary winding **14** of a standard ignition coil **15**, thereby inducing a voltage in a secondary winding **16** which is applied via a conductor **17** to the distributor cap and spark plugs in the usual manner.

The standard distributor circuit **10** comprises breaker points **18** and capacitor **19** connected in shunt between a ground terminal **20** and output terminal **21**. In the standard ignition systems, the distributor output terminal **21** is connected directly with an input terminal **22** in series with the primary winding **14**, as indicated by the broken line **23**. In accordance with the present invention, an electronic switching circuit **24** is connected between said terminals **21** and **22**. The circuit **24** is grounded at a terminal **25** which may conveniently be located on the motor block near the mounting bracket of the ignition coil **15**. The circuit **24** is preferably packaged as a unit in accordance with standard commercial mounting techniques, with the components of the circuit maintained in a proper thermal environment as, for example, by a heat sink.

The circuit **24** includes a double pole double throw switch **26** which in its lower position connects the distributor breaker terminal **21** directly to the ignition coil terminal **22** as in the conventional configuration, so that a normal engine tune-up can be performed in accordance with the automobile manufacturer's specifications. In operation, the switch **26** is placed in the upper position

to disconnect the terminal **22** from the terminal **21** and connect the circuit **24** between said terminals.

The principal current control function of the circuit **24** is performed by the circuit **27** connected in D-C series between the primary winding terminal **22** and the breaker terminal **21**. The circuit **27** comprises a silicon-controlled rectifier **28** connected in parallel with two voltage-dividing resistors **29** and **30**. A gate diode **31** is connected between a point **32**, at the junction between the voltage-dividing resistors **29** and **30**, and a gate electrode **33** of the silicon controlled rectifier **28**.

As is well-known, the silicon controlled rectifier **28** is a fully on or fully off device which will conduct current in either direction once it has been triggered to the conducting mode by a positive voltage pulse applied to the gate electrode **33** with respect to the negative electrode **34** of the rectifier. In the circuit **27**, this positive voltage is developed across the resistor **30** and is applied to the gate electrode **33** via the gate diode **31**. The turn-on pulse should be of high enough voltage and current to insure reliable operation over the entire range of expected ambient temperatures, for example from —40° F. to 150° F. A gate signal of this amplitude would damage the rectifier **28** if left on for the full time of operation in the conducting mode; thus the gate signal must be quickly reduced to a safe value as soon as the rectifier **28** is turned on. In order to turn the rectifier **28** off, it is necessary to reduce the current therethrough below a small value, typically less than one milliampere, and to hold it below this value for a finite time of typically a few nanoseconds. The rectifier **28** is then in its nonconducting mode and presents a high resistance, typically several megohms, to the flow of current in either direction, and it remains in this nonconducting mode until again turned on by a gating pulse.

In operation, when the ignition switch **12** is first turned on and the starter motor is energized, current flows from the battery **11** through the switch **12**, the ballast resistor **13**, the primary winding **14**, a blocking diode **35**, and the voltage dividing resistors **29** and **30**, and begins to charge up the capacitor **19** connected across the breaker points **18** which are then open. This flow of charging current would generally be too small to develop sufficient voltage drop across the resistor **30** for turning on the silicon controlled rectifier **28**. However any tendency of the rectifier **28** to turn on during this time is quickly nullified, typically within a few nanoseconds, when the capacitor **19** is substantially fully charged.

When the turning of the engine causes the breaker points **18** to close, the capacitor **19** is discharged and at the same time a closed D-C circuit is provided from the battery **11** through the ignition switch **12**, the ballast resistor **13**, the primary winding **14**, the blocking diode **35**, the voltage divider resistors **29** and **30**, and the distributor points **18** to ground. At the instant of closing, the resistors **29** and **30** present such resistance to the battery **11** that the total D-C current so passing through the breaker points **18** is limited to a value which is sufficiently low that the points are not detrimentally effected while the voltage developed by this current across the resistor **30** is sufficient to initiate the triggering of rectifier **28** into the conducting mode. For example, if silicon controlled rectifier **28** is of a type rated 200 P.I.V. at 5 amps., a minimum gate voltage of 6 volts across resistor **30** is required to trigger operation in the conducting mode. If battery **11** has an E.M.F. of 12 volts, resistor **29** has a resistance of 60 ohms, and resistor **30** has a resistance of 180 ohms, then the total resistance of 240 ohms for the two resistors limits the current through the breaker points **18** upon the closing thereof to a safe value of 50 milliamps, and the voltage drop caused by this current flowing through resistor **30** is 9 volts which is sufficient to trigger the rectifier **35** into the conducting mode. The gate diode **31**, which may be of a type rated 50 P.I.V. at 1 amp., is of the correct polarity for insuring that only positive voltage pulses are transmitted to the gate electrode **33**.

After the breaker points **18** have closed and the rectifier **28** has been triggered into the conducting mode, as described above, the D-C current entering the circuit **27** through the blocking diode **35** is shunted by the rectifier **28** from the voltage dividing resistors **29** and **30** so as to reduce the signal applied to the gate electrode **33** sufficiently fast and to a sufficiently low level that no damage is done to the rectifier **28**. The resistance of the rectifier **28** in this turned-on or conducting mode is low enough to establish the D-C current passing through the primary winding **14** at a high level, approximately 3 amperes for the component value example previously given. This large current permits the build-up of a large magnetic field in the primary winding **14**, as is required for the subsequent sparking action, and yet does not damage the points **18** since by this time they have been securely closed.

When the engine turns to such position that the breaker points **18** are again opened, the field in the primary winding **14** collapses, thereby inducing a voltage which is stepped up by transformer action in the secondary winding **15** to provide the sparking voltage to the spark plug conductor **17**. At the instant of the opening of the points **18**, the capacitor **19** provides a parallel path which removes all current from the breaker point **18** until the capacitor **19** is again fully charged. As the capaictor **19** charges, the current through the rectifier **28** is reduced to the turn-off level and the rectifier **28** is again placed into the nonconducting mode until the engine turns to the next closing of the breaker points **18** and the above sequence of events is repeated.

It is to be noted that in the novel circuit just described, the breaker points **18** operate with the silicon controlled rectifier **28** in a master-slave configuration. The closing and opening of the breaker points **18** does not make and break a circuit carrying the current required to produce a sparking voltage by the ignition coil **15**, as in a conventional ignition system. Instead, the closing and opening of the breaker points **18** causes the rectifier **28** to make and break such a circuit. Thus, damage to the breaker points **18** as a result of arcing upon the interruption of a large current therethrough is prevented. Moreover, since the distributor capacitor **19** remains fully charged during the time the breaker points **18** are opened and discharges through the points when they close, sufficient current and voltage is provided to burn off, and overcome the resistance of, oil films and like contamination on the surface of the points, thus assuring adequate contact to carry the required current through voltage divider **29**, **30**, for triggering the rectifier **28** into the conducting mode and energizing the winding **14** to maximum magnetic field value for optimum sparking action upon collapse of the field.

In order to provide protection against the transient generation of excessive back E.M.F., induced by the collapse of the magnetic field in the primary winding **14** upon the opening of the breaker points **18**, an auxiliary capacitor **36** is provided in addition to the blocking diode **35**. The diode **35** is of proper polarity for blocking the large initial surge of induced alternating current from feeding back through the rectifier **28**. In the absence of the capacitor **36**, current would oscillate, at the natural resonant frequency of the ignition coil **15**, between the winding **14** and the breaker capacitor **19** at a typical average level of 125 volts during a decay or ringing down period following the opening of the contacts **18**, thus creating the possibility of voltages on alternate half cycles of proper polarity and sufficient magnitude for spurious triggering of the rectifier **28** and, also, creating the possibility of high-voltage damage to components of the circuit **24**. The auxiliary capacitor **36** presents a low capacitive impedance path to the flow of A.C. decay current, at the natural resonant frequency of the ignition

coil **15**, from the winding **14**, which path is in parallel with the high resistive impedance path presented by the circuit **27**. Accordingly, the initial flow of current is into the capacitor **36**, which current leads the build-up of voltage by 90 electrical degrees. This protects the circuit against high-voltage damage and, also, insures that the current level through resistor **30** is sufficiently low that the rectifier **28** will remain in the turned-off or nonconducting mode until another triggering signal is produced by the closing of the breaker points **18**.

Two additional current paths are connected in parallel with the auxiliary capacitor **36**. One path consists of a current-limiting resistor **37** in series with a gas discharge lamp **38**; and the other path consists of a current-limiting resistor **39** in series with a gas discharge lamp **40**. The lamps **38** and **40** have a three-fold function. First they serve to regulate the voltage across the ignition coil **15**. For example, considering a typical minimum requirement for adequate spark plug firing of .03 watt-seconds of power at a voltage of 65 volts across the primary winding **14**, resistor **37** may be 1800 ohms, lamp **38** may be a type NE–51 neon lamp having a firing voltage of 76 volts and an extinction voltage of 55 volts with a .058 watt power rating, resistor **39** may be 820 ohms, and lamp **40** may be type NE–51H high brightness neon lamp having a firing voltage of between 95 and 105 volts with a 0.25 watt power rating. Under operating conditions, one or both of the lamps is in a glow discharge of fired state which protects the primary circuit against transient voltage peaks. Moreover, this glow enables the lamps to serve as a visible indicator of the proper functioning of the circuit.

The third function of the lamps **38** and **40** is as a free-running multivibrator or relaxation oscillator at or near the natural resonance frequency of the coil **15**. The amount of sparking voltage available at conductor **17** is proportional to the rate of collapse of current in primary winding **14** upon the opening of the breaker points **18**. This rate is, in turn, proportional to the effective capacitance of the primary circuit. In conventional ignition systems, this capacitance is that of the breaker capacitor **18**, which is fixed at a rather small value in order to be near resonance at the typical natural resonant frequencies of the coil **15** in the range of 800 to 2500 cycles per second. In the novel circuit of FIGURE 1, however, at the instant the current stops flowing in the primary circuit upon opening of the points **18**, the low capacitive impedance presented by the auxiliary capacitor **36** causes this capacitor to charge rapidly to a voltage of more than the firing voltage of the lamp **38** whereupon said lamp becomes fully ionized and conducts current at its rated voltage around the capacitor **36** to ground and continues to so conduct until the voltage across the capacitor **36** is reduced to the extinction voltage of the lamp **38**, thereby providing a longer time for the decay current to flow on each cycle of the oscillation and thus simulating a larger effective capacitance in the primary circuit. This causes wider and fewer voltage excursions on the ringing down action of the coil **15** and results in a higher secondary sparking voltage on the conductor **17**.

The natural frequency at which the coil **15** resonates during the ringing down or decay period following opening of the breaker points **18** is much greater than the frequency at which these points open and close over the normal range of engine speeds. Thus, if sufficient voltage and power can be supplied to the secondary circuit conductor **17** upon the collapse of the field of the primary winding **14** during each cycle of the natural resonance frequency oscillations, a multiple firing of the spark plug will occur in the period between the opening of the points **18** for one cylinder and the closing of the points **18** for the next cylinder. Such multiple sparking results in more efficient utilization of fuel and, therefore, both improves the economy of engine operation and reduces the concentration of unburned contaminants discharged into the atmosphere. FIGURES 2, 3 and 4 show modifications of the present invention which permit such multiple sparking.

In FIGURE 2, elements **10** through **38** correspond to the like-numbered elements in FIGURE 1, and the function of these elements is essentially the same as that already described with reference to FIGURE 1. However, the path **39**, **40**, in parallel with the auxiliary capacitor **36** has been replaced by a parallel path consisting of a capacitor **41** connected in series with a gate circuit composed of the parallel combination of a gas discharge tube **42** and a blocking diode **43**. The capacitance of capacitor **41** is sufficiently large to accept a charge of approximately 67% of the energy stored in the coil **15** during the period that the breaker points **18** are opened at the lowest engine speed.

In the operation of the circuit of FIGURE 2, upon the opening of the breaker points **18**, the auxiliary capacitor **36** constitutes a parallel branch of low capacitive impedance and, hence, the initial flow of current is into this capacitor. After the capacitor **36** is charged, current flows through the parallel resistive impedance presented by the gate circuit **42**, **43** and charges the large capacitor **41**. The polarity of the diode **43** is such that current passes through this element in the forward direction upon charging of the capacitor **41**, but is blocked from flowing through this element in the reverse direction. Accordingly, the capacitor **41** can discharge only through the lamp **42** which introduces a long time constant for the discharge in order to maintain the multiple sparking action for a substantial period after the opening of the breaker points **18**. This multiple sparking occurs in synchronism with the relaxation oscillations of the lamp **38** at the natural resonant frequency of the coil **15**. As the associated oscillating voltage across the primary winding **14** begins to fall a sufficient voltage drop is impressed across the lamp **42** that the capacitor **41** discharges current into the primary winding **14** and thus replenishes the losses in the circuit of the oscillating lamp **38** so as to maintain the multiple sparking action.

The circuits as shown in FIGURES 1 and 2 are energized by battery **11** with the negative terminal grounded. As will be understood by those skilled in the art, the circuits of the present invention may be used equally well when the positive terminal of the battery is grounded, provided that connections of polarity sensitive elements are reversed. To illustrate this, FIGURE 3 shows the same circuit as that shown in FIGURE 4, except for such reversal of polarity, and the same numerals are used for corresponding elements of the two circuits. It is to be noted that, since the polarity of the battery **11** is reversed, it is necessary to also reverse the polarity of the rectifier **28** and the diodes **35** and **43**. Also, since the flow of current is reversed, the polarity of the resistive voltage divider **29**, **30**, is reversed and therefore, the position of the resistors **29** and **30** is reversed in order to develop a positive gating voltage across the resistor **30** which is applied to the gate electrode **33** (via the gate diode **31**) with respect to the negative terminal **34** of the rectifier **28**.

Referring now to FIGURE 4, elements **10** through **40** correspond to the like-numbered elements in FIGURE 1, and the function of these elements is essentially the same as that already described with reference to FIGURE 1. However, the auxiliary capacitor **36** is replaced by a capacitive network **45** of the type described and claimed in my copending U.S. patent application, Ser. No. 575,075, filed Aug. 25, 1966, which is resonant with the effective primary circuit inductance of the coil **15** at the frequency of the opening and closing of the breaker points **18** over the entire range of engine speeds. This network comprises a first capacitor **46** which has a value selected to cause a series resonance with the coil **15** at a first engine speed, for example, 4800 r.p.m., a second capacitor **47** which has a value selected to casue a parallel resonance with the coil **15** at a second engine speed, for example, 3000 r.p.m., and a third capacitor **48** which has a value selected to

cause a series resonance at a third engine speed, for example, 1200 r.p.m. This network provides a wideband response such that the opening of the points **18** at any engine speed results in the collapse of the current of the primary winding **14** through a low resistive impedance resonant path. This permits a rapid rise and collapse of the field in the coil **15** and, hence, induces a high secondary voltage on the spark plug conductor **17**. This is done without the making or breaking of a current carrying circuit and this avoids radio and television interference which is characteristic of conventional capacitor discharge systems used for enhancing sparking voltage, and yet removes the necessity for a critical setting of the spacing of the breaker points **18**.

In the operation of the circuit of FIGURE 4, the opening of the breaker points **18** causes resonance current at the frequency of the opening and closing of the breaker points to flow from the primary winding **14** into the capacitive network **45** and then back to the primary winding to permit the magnetic field therein to build-up to full strength just prior to the next opening of the points. This establishes a circulating current flow in the primary circuit which is dissipated only by the resistance of the wires in the circuit. These losses are compensated for by the D–C current flow from the battery **11** during the time the breaker points **18** are closed. Since these losses are small, the breaker points **18** carry a small current both during the engine cranking or start-up and during normal engine operation, thereby minimizing the risk of breaker point burn out.

The circulating resonant current at the point closing frequency supplies sufficient power to maintain multiple sparking action which is triggered by the oscillations of the lamps **38** and **40** at the natural resonant frequency of the coil **15**. If, for example, lamp **38** is type NE–51 neon lamp and lamp **40** is type NE–51H neon lamp, at the instant the voltage across the primary winding **14** reaches 76 volts, lamp **38** fires and conducts its full wattage of .058 watt and at the instant this voltage has risen to 105 volts the lamp **40** fires and conducts its full wattage of 0.25 watt. At this point, the voltage begins to drop until the 55 volt extinction voltage of lamp **38** is reached whereupon the current through both lamps **38** and **39** is sharply reduced and the voltage across the winding **14** again builds-up to repeat the foregoing process at the natural resonant frequency of the coil **15**. The voltage of the winding **14** varies about 70 volts from a maximum voltage of about 125 volts to the extinction voltage of 55 volts, with the wattage varying between 0.25 watt and .058 watt, all during each cycle of the natural resonant frequency of the coil **15**. This is more than sufficient to generate a typical firing value of .03 watt-seconds of secondary circuit power during each cycle, and thus produce prolonged multiple sparking for more efficient fuel utilization. Moreover, it should be noted that due to the wideband properties of the capacitive network **45**, this multiple sparking action continues even at high engine speeds where conventional ignition systems, whose response is governed solely by the inductance of the coil **15**, begin to experience a severe loss of sparking voltage in the secondary circuit. In the circuit of FIGURE 4, it has been found that more reliable operation of the lamp **40** is achieved when the relative positions of the lamp **40** and the resistor **39** are reversed as compared with the circuit of FIGURE 1, it being noted that the relationship of these elements to the primary winding **14** is different for these two circuits.

It is to be understood that modifications and variations of the embodiments of the invention disclosed herein may be resorted to without departing from the spirit of the invention and scope of the appended claims.

Having thus described my invention, what I claim as new and desire to protect by Letters Patent is:

1. A circuit for use in an ignition system for an internal combustion engine having distributor breaker points and an ignition coil for generating a sparking voltage upon the closing and opening of said points with a source of potential connected to said coil for supplying electrical energy therefor, said circuit comprising an electronic switch connected in series with said distributor breaker points and said ignition coil and, said electronic switch comprising means connected in the current path between said ignition coil and said breaker points and responsive to the closing and opening of said breaker points for operating said electronic switch so that sufficient current passes through said points for fully energizing said coil after said points are securely closed.

2. A circuit according to claim **1** wherein said means comprises a silicon controlled rectifier adapted to be connected in the current path between said ignition coil and said breaker points so that the closing and opening of said breaker points triggers said rectifier into a conducting and nonconducting mode, respectively.

3. A circuit according to claim **2** wherein a voltage dividing resistance is connected in parallel with said rectifier, and means are provided for applying the voltage across a portion of said resistance to a gate electrode of said rectifier, said resistance being of such value as to limit the flow of current through said breaker points on the closing thereof to a safe value and as to provide a voltage across said resistance portion sufficient to trigger said rectifier into the conducting mode after the closing of said points whereupon said rectifier shunts current from said voltage divider to thereby reduce said trigger voltage.

4. A circuit according to claim **1** further comprising means for connecting said breaker points directly to said ignition coil so as to permit the performance of a normal engine tune-up.

5. A circuit according to claim **1** further comprising means for presenting a low capacitive impedance path in parallel with said electronic switch with respect to the current in said ignition coil upon the opening of said breaker points.

6. A circuit according to claim **5** further comprising a gas discharge tube connected in a current branch in parallel with said low capacitive impedance path.

7. A circuit according to claim **6** further comprising an additional gas discharge tube connected in an additional current branch in parallel with said low capacitive impedance branch, said additional gas discharge tube having a firing voltage which is higher than the firing voltage of said first-named gas discharge tube.

8. A circuit according to claim **6** further comprising an additional current branch connected in parallel with said low capacitive impedance branch, said additional branch comprising a capacitor sufficiently large to receive a substantial portion of the energy stored in said ignition coil upon the opening of said breaker points, said capacitor being connected in series with the parallel combination of a diode of proper polarity for conducting current to said capacitor and a gas discharge tube, whereby said capacitor provides sufficient discharge current for maintaining a multiple sparking action at the natural resonant frequency of said ignition coil.

9. A circuit according to claim **1** further comprising a capacitive network adapted to be connected in the primary circuit of said ignition coil over the frequency range of the closing and opening of said breaker point corresponding to the entire range of engine speeds of said internal combustion engine, thereby maintaining a multiple sparking action of said ignition coil.

10. A circuit according to claim **9** further comprising a gas discharge tube connected in the primary circuit of said ignition coil so as to undergo relaxation oscillations at the natural resonant frequency of said coil.

11. A circuit as claimed in claim **1** wherein said means controls the operation of said electronic switch so that sufficient current passes through said points for fully energizing said coil only after said points are securely closed.

12. A circuit as claimed in claim 1 wherein said means is connected in series with said distributor breaker points and said ignition coil.

13. A circuit as claimed in claim 1 and comprising impedance means connected in parallel with said means, said impedance means being of such value as to limit the flow of current through said breaker points to a safe value on the closing thereof and to cause said electronic switch to operate after the closing of said points so that sufficient current passes through said points for fully energizing said coil only after said points are securely closed.

References Cited

UNITED STATES PATENTS

3,016,476	1/1962	Bataille	123—148 XR
3,168,891	2/1965	Cook	123—148
3,347,218	10/1967	Leftwich	123—148

LAURENCE M. GOODRIDGE, *Primary Examiner.*