April 25, 1967 J. T. HARDIN ETAL 3,316,448

CONTACTLESS IGNITION SYSTEM

Filed Oct. 15, 1965 2 Sheets-Sheet 1

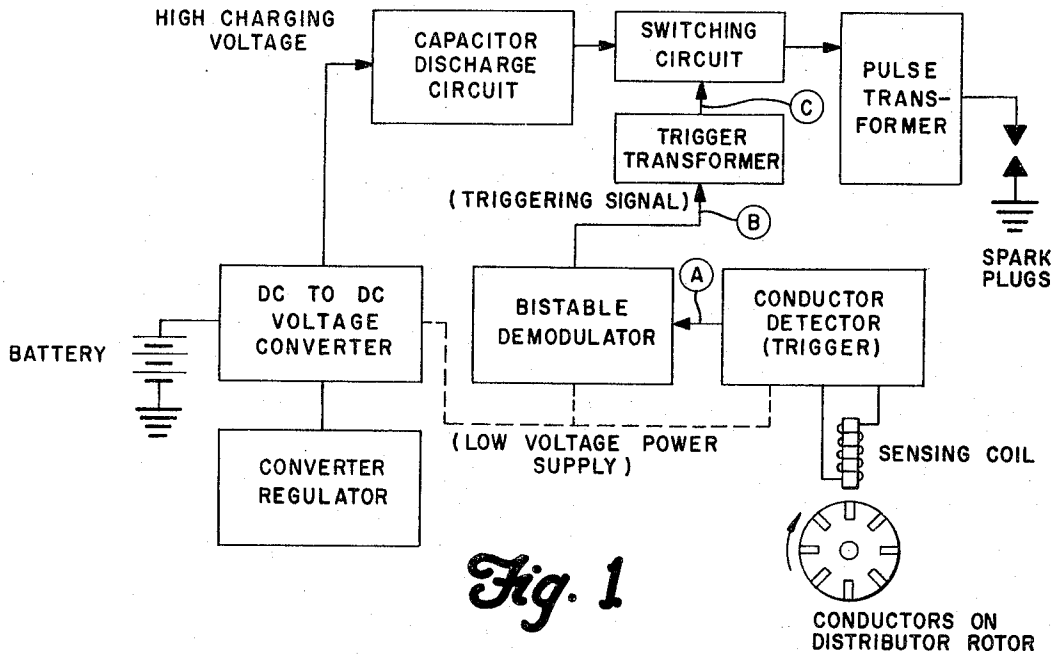
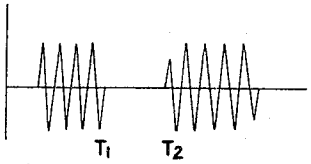
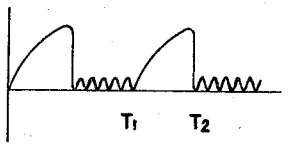


Fig. 1



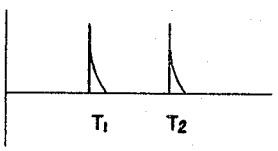
(TRIGGER SIGNAL AT POINT A)

Fig. 2



(DEMODULATED SIGNAL AT POINT B)

Fig. 3



(TRIGGER TRANSFORMER OUTPUT)

Fig. 4

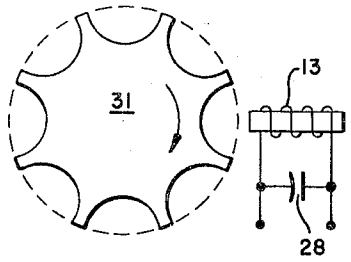


Fig. 5

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April 25, 1967 J. T. HARDIN ETAL 3,316,448

CONTACTLESS IGNITION SYSTEM

Filed Oct. 15, 1965 2 Sheets-Sheet 2

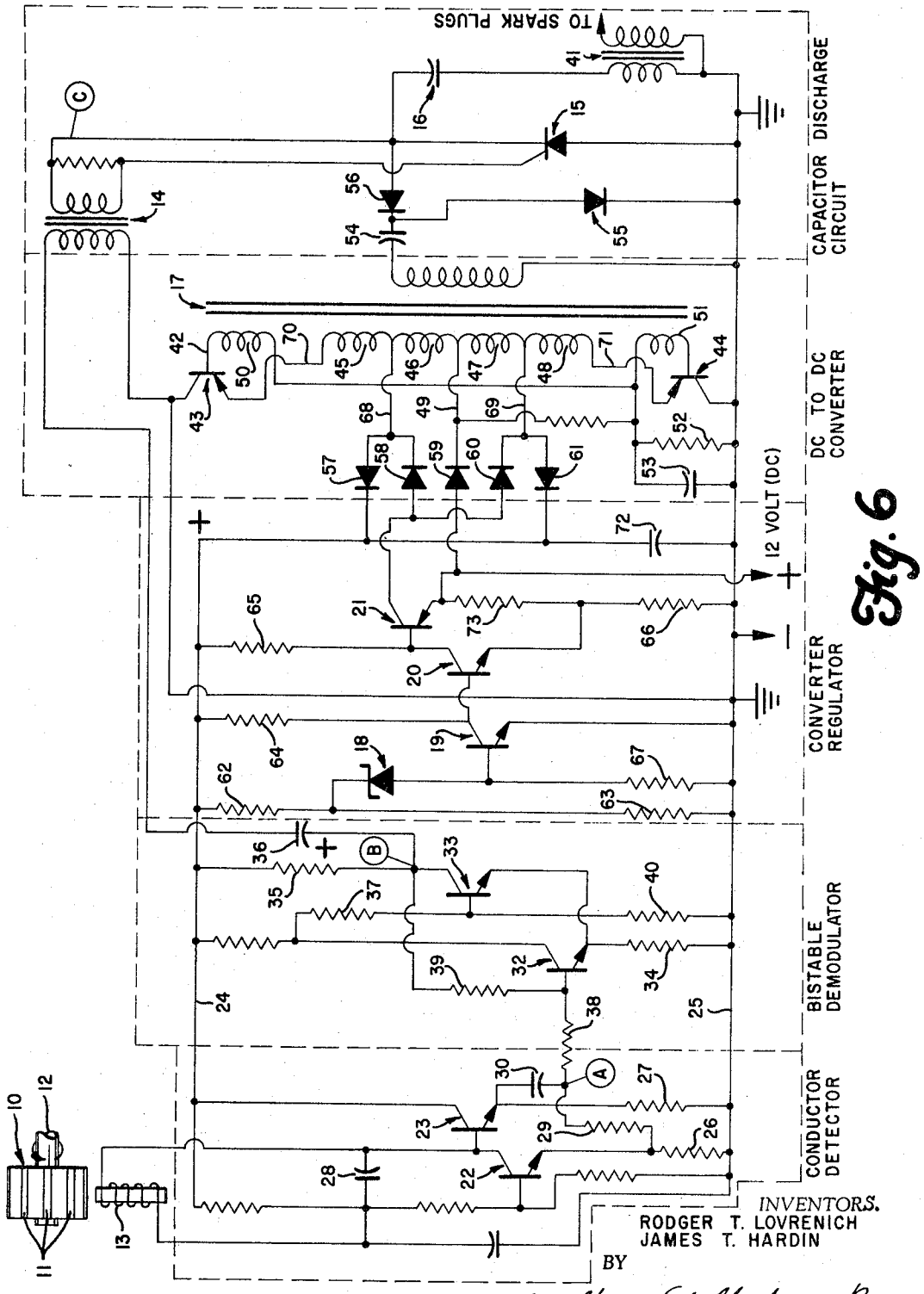


Fig. 6

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CONTACTLESS IGNITION SYSTEM

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This invention relates to an ignition system for internal combustion engines in which no mechanical breaker contacts or points are required and which is capable of supplying a uniformly high voltage spark to the spark plugs regardless of voltage variations in the D.C. power supply, regardless of engine speed and which is not subject to mechanical and electrical erosion.

More specifically this invention relates to a contactless ignition system for an internal combustion engine which includes a power supply voltage regulator and a transistorized triggering circuit which controls the flow of current from a capacitor discharge type ignition system, which triggering circuit is controlled by the proximity of moving conductors, driven by the internal combustion engine, to an inductive pick-up or sensing coil in the triggering circuit.

Conventional automotive ignition systems include a pair of mechanical breaker contacts or points which control the current flow to a primary winding of an ignition coil where energy is stored, which, upon release, induces a high voltage current in the coil secondary which is then directed to the spark plugs. Inherent disadvantages in a mechanical breaker system are the mechanical and electrical erosive forces which cause the points to wear out or to pit due to the inductive "kick back" voltage from the primary of the spark coil. Also, the points may become fouled or coated by films which interfere with their function of making and breaking the electrical circuit.

Another inherent problem present in mechanical breaker point systems is the presence of contact bounce due to mechanical resonance of the moving parts at high engine speeds. In recent years, a number of "contactless" ignition systems have been proposed in which the mechanical breaker points have been replaced by various electrical components such as photoelectric cells or magnets operatively connected to a triggering mechanism to regulate the periodic discharge of energy from the spark coil or pulse transformer to the spark plugs. Such systems, while satisfactory in many respects, usually suffer from certain deficiencies such as the inability to switch high voltage electrical pulses without a large series of amplification stages, or sensitivity to severe environmental variations in temperature, humidity, etc. inherent in an automotive installation.

Another problem inherent in conventional ignition systems, and present in some of the recently developed contactless systems is the drop in available output voltage at very low speeds, such as during cranking of the engine. The switching action of conventional breaker points is inefficient at very low speeds and contactless systems which depend upon the speed of a moving conductor through a magnetic field become inefficient or inoperable at low speeds due to the fact that they are incapable of sensing or being triggered by the very small rate of change of flux in the slowly moving conductor.

Accordingly, it is an object of this invention to provide a contactless ignition system which, in addition to eliminating the maintenance problems inherent in conventional mechanical breaker-point systems, is not subject to variations in the power supply voltage and thus will operate through a wide range of operating conditions.

It is another object of this invention to provide a contactless ignition system including a voltage converter for converting a low voltage power supply to a high voltage level necessary to charge a capacitor discharge type system and for supplying a constant voltage supply to a transistorized triggering system which controls the discharge of the high voltage from a storage capacitor to a pulse transformer which supplies a high energy spark to the spark plugs.

It is a further object of this invention to provide a contactless ignition system which is capable of operating at a constant maximum output and high efficiency at any speed above zero to at least 6000 r.p.m.

It is yet another object of this invention to provide a contactless ignition system which includes a transistorized triggering circuit in which a triggering signal, which controls the discharge of high voltage energy to the spark plugs, is in turn controlled by the proximity of moving conductors to an inductive sensing coil in the triggering circuit, which system is capable of being installed in a standard automotive distributor bowl and in which the movement of the conductors are mechanically driven by the automotive engine.

Other objects and advantages of this invention will be apparent from the following detailed description of the preferred embodiment thereof, reference being made to the accompanying drawings in which:

FIGURE 1 is a block diagram showing the essential components of the contactless ignition system of this invention, and schematically indicating the functional relationships therein;

FIGURES 2–4 schematically illustrate the shape of the electrical signal from the conductor-detector component, the bistable-demodulator component and the trigger transformer, respectively, of the ignition system of FIGURE 1;

FIGURE 5 illustrates another configuration of the distributor rotor which may be used in place of that illustrated in FIGURE 1; and

FIGURE 6 is a circuit diagram of a preferred embodiment of the complete contactless ignition system of this invention, showing the mechanically driven conductors which are moved relative to a pickup coil in the triggering circuit, and showing circuit diagrams of the various components of the contactless ignition system. These components which are separated by dotted lines in FIG. 1, include a conductor detector circuit, a bistable demodulating circuit, which circuits together with a trigger transformer comprise the triggering circuit, a D.C. to D.C. voltage converter, a voltage converter regulator and a capacitor discharge circuit including a low impedance pulse transformer.

Summary of the invention

As previously explained, the contactless ignition system of this invention may be used with a conventional distributor for an internal combustion engine. FIG. 6 schematically shows a rotor **10** having a number of conductors **11** spaced about its periphery. The rotor **10** is fabricated from a nonconductive material such as nylon with the conductors **11** embedded throughout the periphery. The rotor **10** is driven proportionally to engine speed and may be directly attached to the distributor shaft **12** of the automobile in place of the conventional distributor cam. The conductor detector circuit includes a two-transistor oscillator controlled by the proximity of the conductors **11** to an inductive pickup coil **13** which is part of a parallel resonant L.C. circuit in the forward loop of the oscillator. The output of the oscillator of the conductor detector circuit is detected by a two transistor bistable demodulator circuit, the output of which is operatively connected to the primary of trigger transformer **14**.

Periodically timed signals from the bistable demodulator to the primary of the trigger transformer **14** induce a timed signal of increased voltage in the secondary of the transformer **14** which is used to control the conductive state of a solid state controlled rectifier **15** which controls the discharge of energy from a storage capacitor **16** in the capacitor discharge circuit. High voltage energy is supplied to the storage capacitor **16** from the secondary of a power transformer **17**, the primary of which is supplied with a relatively low voltage signal from two transistor push-pull type oscillator. A D.C. to D.C. converter regulator is effective first to regulate the voltage across the primary of the power transformer **17**, regardless of variations of the battery input voltage, and further to maintain a constant voltage supply to the transistors in the conductor detector and bistable demodulator circuits for proper operation thereof. The converter regulator includes a breakdown of Zener diode **18** and three transistors **19**, **20**, and **21** operably connected to rectifying diodes in the D.C. to D.C. converter in a manner such that a constant voltage across the primary of the power transformer **17** will be maintained, by auto-transformer principle, and a constant D.C. bias voltage across the transistors in the conductor detector and bistable demodulator circuits will be maintained. The operation of the various circuits and their interrelationships will be explained in detail below.

The conductor-detector circuit

A pair of NPN type transistors **22** and **23** are connected across lines **24** and **25** with resistors **26** and **27** between their emitters and line **25** to provide proper D.C. bias. The line **25** is directly connected to the negative terminal of a D.C. power source, such as a 12 volt battery. The line **24** is supplied with a positive voltage from the converter regulator circuit as will be subsequently explained. The collector to base circuit of transistor **22** includes a parallel resonant L.C. circuit including the capacitor **28** and the inductive pickup coil **13**. The base of transistor **23** is connected to the collector of transistor **22** and the emitter of transistor **23** is connected to the emitter of transistor **22** to form a positive feedback circuit where transistor **23** is an emitter follower and transistor **22** is employed in the common base configuration.

The oscillator, including transistors **22** and **23**, can oscillate only at the resonant frequency of the parallel L.C. circuit including the capacitor **28** and the sensing coil **13** when the ratio of energy stored in the resonant circuit to the energy dissipated for a given time, is above a predetermined value. This ratio, Q, must be of a value high enough such that the gain of the oscillator closed loop is equal to or larger than unity.

As previously explained, the pickup coil **13** is positioned adjacent the rotor **10** on the distributor shaft **12** whereby rotation of the shaft **12** and rotor **10** will vary the distance from the pickup coil **13** to the conductor **11** on the rotor **10**. This will periodically vary the amount of coupling between the pickup coil **13** and nearest conductor **11**, thus changing the Q of the sensing coil **13** and the capacitor **28** and thus the effective impedance of the parallel L.C. circuit. As a conductor **11** approaches the sensing coil **13**, the effective impedance of the L.C. circuit decreases and the forward loop gain of the oscillator decreases. When the total loop gain drops below unity, the oscillations cease until the nearest conductor **11** has again moved away from the sensing coil **13** far enough to raise the oscillator loop gain above unity, at which time oscillations again start.

In order for the oscillator to oscillate, the total gain of the oscillator circuit must be unity or larger, thus the total impedance of the collector circuit of the transistor **22** must equal or exceed the effective resistance of resistor **29** plus the reflected resistance at the emitter of transistor **22** through a capacitor **30**. The resistor **29** is selected such that variations in the Q of the parallel

resonant circuit comprised of the sensing coil **13** and capacitor **28** due to movement of the conductors **11** on the rotor **10**, will vary the tuned effective resistance of the L.C. circuit relative to the fixed value of the resistor **29** and effective emitter resistance of transistor **22** so that the oscillator will alternately oscillate and stop since the total oscillator gain is varying above and below unity.

The length of the periods of oscillation and the off interval between periods of oscillation, will, of course, be proportional to engine speed. The output of the oscillator circuit at the emitter of the transistor **23** is schematically shown in FIGURE 2 as it would appear at point A in FIG. 6.

Various modifications in the shape of the conductor **11** and rotor **10** will affect the output of the oscillator circuit. A rotor having integrally formed, radially projecting teeth may be used, such as the rotor **31** shown in FIGURE 5. Other variations will be apparent to those skilled in the art.

The demodulator circuit

The output signal from the conductor detector circuit hereinbefore described is used as the input signal to a "bistable demodulator" circuit which includes a pair of NPN transistors **32** and **33** having their emitter-collector circuits connected across lines **24** and **25** through a common emitter resistor **34**. The transistors **32** and **33** form a "Schmitt trigger" circuit with the addition of an RC time delay circuit including a resistor **35** and the capacitor **36** connected to the collector of the transistor **33**. The collector of transistor **32** is connected to the base of transistor **33** through a resistor **37** and the base of transistor **32** is connected to the conductor-detector circuit through a resistor **38**. The collector of the transistor **33** is coupled to the base of the transistor **32** through a resistor **39** and the base of the transistor **33** is connected to the line **25** through a resistor **40**.

One side of the capacitor **36** is connected to the primary of the trigger transformer **14**, the secondary of which is connected to the gate of the controlled rectifier **15** which controls the discharge of energy from the storage capacitor **16** to a pulse transformer **41**, the secondary of which is operably connected, through a conventional type distributor rotor, to the various engine spark plugs. Operation of the capacitor discharge system will be described in detail below.

The transistor **32** of the modified Schmitt trigger circuit is selected and biased such that it is in a stable state of conduction when no input signal is being applied at its base through resistor **38** from the conductor-detector circuit. The output from the transistor **32** is applied to the base of the transistor **33** and holds it in a nonconducting or off condition. While the transistor **33** is off, the capacitor **36** is charged, through the resistor **35**, to an initial energy level with the polarity as indicated. When the conductor-detector circuit starts to oscillate, as controlled by the position of the conductors **11** relative to the sensing coil **13** as previously described, the output of the oscillator is impressed upon the base of transistor **32** and the transistor **32** is turned off; thence the transistor **33** starts to conduct and the energy stored in the capacitor **36** is discharged at once through the primary of the triggering transformer **14**.

While the Schmitt trigger circuit of transistors **32** and **33** would normally be expected to follow the oscillatory output of the conductor-detector circuit impressed upon the base of transistor **32**, it is prevented from doing so due to the time constant of the RC circuit of the resistor **35** and the capacitor **36** which prevents the complete recovery of the collector voltage of the transistor **33**. Due to the relative high frequency of oscillations of the input signal at base of transistor **32**, there is insufficient time available to charge the capacitor **36** to its initial energy level. Therefore, the energy discharged from this capacitor **36**, through the secondary of the trigger-

ing coil 14, after the intial discharge when the transistor 33 first conducts, is very low during the continuing oscillatory cycle of the conductor detector circuit. Thus, the signal at the collector of the transistor 33 appears as periodic sharp voltage variations reaching a maximum once during each period of oscillation of the conductor detector circuit. This signal is schematically shown in FIGURE 3 as it would appear at point B in FIG. 6.

When the distributor rotor 10 reaches a position where the Q of the parallel resonant circuit including the sensing coil 13 and the capacitor 28 is such that oscillations cease, then the transistor 32 remains on, the transistor 33 remains off, and the capacitor 36 is again charged to its initial high level of energy. Further movement of rotor 10 and conductors 11 again causes oscillation to start in the conductor-detector circuit and the cycle is repeated.

It will be apparent that the modified Schmitt trigger circuit comprising transistors 32 and 33 and the RC time delay circuit in the collector circuit of transistor 33 effectively comprise a "bistable demodulator" which generates a large pulse at the beginning of each cycle of oscillation from the conductor-detector circuit. It will be apparent that such a demodulation circuit may be used as a triggering circuit in other environment in addition to that illustrated in this application.

The power convertor

In the preferred embodiment described, a D.C. to D.C. convertor comprising a two transistor, push-pull type oscillator is operably connected to the primary 42 of a power transformer 17. The transistors 43 and 44 are PNP type transistors with their emitters connected through transformer primary windings 45, 46, 47 and 48 to the positive battery terminal at the center tap 49 of the transformer primary 42. The transistors 43 and 44 are base connected through regenerative feedback coils 50 and 51 which are biased positively with respect to the collectors of transistors 43 and 44 by means of a resistor 52 connected in parallel with a capacitor 53. Alternate conduction by the transistors 43 and 44 induces a high voltage alternating current in the secondary of the power transformer 17. The ratio of the windings in the primary 42 and secondary of the transformer 17, in the described embodiment, is such that the 12 volts supplied by the battery is increased to 150 volts in the transformer secondary. This voltage is effectively doubled in the capacitor discharge system described below so that the voltage available to the pulse transformer 41 is about 300 volts.

The capacitor discharge system

The secondary winding of the transformer 17 has one side directly connected to ground (line 25) and the other side connected through a first capacitor 54 and a reverse biased diode 55 to ground. The capacitor 54 is connected in series with a second diode 56, the storage capacitor 16 and the primary of the pulse transformer 41. The secondary of the pulse transformer 41 is connected, through the conventional distributor rotor (not shown) to the spark plugs. When the push-pull oscillator including transistors 43 and 44 oscillates so that the top of the secondary of the power transformer 17 is positive, the capacitor 44 is negatively charged, on the right as shown in FIGURE 1, through the diode 55. On the reverse cycle, this charge and that of the secondary of the transformer 17 charge the storage capacitor 16 to an effective value of twice the secondary voltage. Discharge of capacitor 54 to ground is blocked by diode 55 while current leakage from the storage capacitor 16 is blocked by a diode 56. Thus, the storage capacitor 16 is charged in stepwise increments by the induced A.C. voltage in the secondary of the power transformer 17, and, as previously explained, will approach a charge of 300 volts due to the voltage doubling action of the capacitor 54 and diodes 55 and 56.

The discharge of stored energy from the storage capacitor 16 is controlled by the solid state controlled rectifier 15, such as a silicon controlled rectifier (SCR), whose firing is controlled by a sharp pulse or spike from the trigger transformer 14 which is directly connected to the control electrode or gate of the controlled rectifier 15. The signal from the trigger transformer 14 is schematically shown in FIG. 4 as it would appear at point C in FIG. 6. A sharp pulse from the secondary of the trigger transformer 14 will turn on the controlled rectifier 15 to complete the circuit from the storage capacitor 16 through the primary of the pulse transformer 41. As soon as the controlled rectifier 15 stops conducting, the charge in the storage capacitor 16 will again resume its stepwise accumulation. The circuit arrangement of diodes 55 and 56 eliminates the need for using a controlled rectifier 15 having a high reverse bias characteristic.

In the preferred embodiment described, the turns ratio in the pulse transformer 41 is such that an induced voltage of 25,000 volts is available to the spark plugs.

The converter regulator

A voltage regulator including the transistors 19, 20, and 21, the Zener diode 18 and diode rectifiers 57–61 is operably connected with the primary of the power transformer 17 so that voltage available across the primary windings 45–48, and therefore across the secondary winding, will remain a constant value, regardless of the actual available battery voltage, unless the battery voltage exceeds or drops below certain limits, for instance, 10 and 4 volts, respectively. The Zener diode 18 is connected across lines 24 and 25 between two voltage dividing resistors 62 and 63. The Zener diode is selected so that it will break down and conduct when the voltage between lines 24 and 25 exceeds that desired to properly bias the transistors 22, 23, 32 and 33 in the conductor-detector and bi-stable demodulator circuits previously described. NPN type transistors 19 and 20 are connected across lines 24 and 25 through voltage dropping resistors 64, 65 and 66 in their emitter-collector circuits to provide desired D.C. bias. The base of the transistor 19 is directly connected to the Zener diode 18 and to the line 25 through another voltage dropping resistor 67. The collector of transistor 19 is connected to the base of the transistor 20 and the collector of the transistor 20 is connected to the base of the transistor 21, a PNP type, and to the line 24 through the resistor 65.

In addition to the center tap 49, in the primary winding of the power transformer 17, two intermediate taps 68 and 69 are positioned on the primary winding whereby the voltage drop between the center tap 49 and each intermediate tap 68 and 69 is twice the voltage drop between the intermediate taps 68 and 69 and the ends of the primary winding, designated by reference numerals 70 and 71. For example, if the voltage at the center tap, with respect to ground (line 25), is +12 volts, and, assuming no voltage drop across the emitter-collector circuits of transistors 43 and 44, when the transistor 43 conducts, the voltage at the intermediate tap 68 will be +4 volts, with respect to ground: the voltage at intermediate tap 69 will be +20 volts with respect to ground, due to autotransformer action of the common core winding. Following this example, the number of primary turns between the center tap 49 and taps 68 and 69 is twice the number of turns between taps 68 and 69 and the ends of the winding 70 and 71. When the transistor 44 conducts, the voltages at the intermediate taps 68 and 69 remain the same but reverse polarity.

The diode rectifiers 58, 59 and 60 are directly connected to the intermediate tap 68, the center tap 49 and the intermediate tap 69, respectively. The other side of the diodes 58 and 60 are connected to the collector

of the transistor **21** while the other side of the diode **59** connects directly to the emitter of the transistor **21** and to the positive battery terminal. The diodes **57** and **61** biased oppositely to the diode **58–60**, have one side connected to the intermediate taps **68** and **69**, respectively, and the other side to line **24** which is separated from line **25** by a capacitor **72**.

Assuming that the battery is fully charged at 12 volts and that the push-pull oscillator, including the transistors **43** and **44**, is in the state when the transistor **43** is conducting, then current will flow in the circuit from the battery, the collector-emitter of the transistor **43**, the primary windings **45** and **46** of the power transformer **17** to the center tap **49**, the diode **59** and to the battery. Using the previous example, the voltages, with respect to ground, (line **25**) appearing at taps **68**, center tap **49**, and tap **69** are +4, +12 and +20.

The diodes **57**, **58**, **60** and **61** constitute a bridge rectifier and the voltage at the anode of the diode **61** (or at the top of capacitor **72**) is the algebraic sum of these voltage drops or +20 v. When the push-pull oscillator reverses, the polarities reverse and +20 volts now appears at the anode of the diode **57**. Thus a constant +20 volts of D.C. is maintained in line **24** to bias the transistors in the conductor-detector and bi-stable demodulator circuits and to provide a uniform high voltage in the secondary of the power transformer **17**. During this operation, the transistors **20** and **21** remain off while the transistor **19** is held on by the signal applied to its base from the Zener diode **18**, which conducts as long as the voltage across lines **24** and **25** exceeds its breakdown voltage, for instance, 20 volts.

The voltage regulator described will compensate for low voltage, due to a weak battery condition, low temperature or during cranking, by effectively "shifting" the center tap on the transformer primary windings **45–48** so that the D.C. output of the bridge rectifier including diodes **57**, **58**, **60** and **61** will remain at a uniform selected value, such as 20 volts in the illustrative example. When the voltage output from the bridge rectifier (and thus the voltage across the Zener diode **18**) falls below the predetermined desired value, the Zener diode **18** will stop conducting and will consequently turn off the transistor **19**. The transistor **20** is so biased that it will turn on when transistor **19** turns off; likewise transistor **21**, a PNP type, will turn on when the output from transistor **20** is applied to its base. Thus, a low battery voltage will cause the transistor **21** to turn on. With this transistor **21** conducting, battery current will flow through the emitter-collector of the transistor **21** and diode **58** or **60**, depending upon which transistor **43** or **44** of the push-pull oscillator is conducting. During the conducting period of the transistor **43**, the voltage between the diode **58** or intermediate tap **68** and the top end of the primary **70** will be 4 volts and the voltage drop across the other taps will be the same as before; thus, the voltage at the anode of diode **61** is again +20 volts, the same as it was in the previous example when the battery voltage was a full 12 volts. When the transistor **21** conducts, with transistor **43** conducting, it shifts the effective center tap on the transformer primary from its previous position at **49** to the position of the intermediate tap **68**. In a similar manner, when the transistor **44** is conducting, the effective center tap position is shifted from the previous position of the intermediate tap **68** to intermediate tap **69** and a voltage of +20 volts appears at the anode of the diode rectifier **61**. Because the effective voltage through the primary of the power transformer remains unchanged, due to the action of the Zener diode **18** and transistors **19–21** in shifting the effective position of the center tap on the primary of the power transformer **17**, the induced voltage in the secondary and thus the energy available to the capacitor discharge circuit remains constant, regardless of variations in battery voltage. The voltage applied between lines **24** and **25** is monitored by the Zener diode **18** which, through its control of transistors **19**, **20** and **21**, will keep the voltage across lines **24** and **25** from falling below a predetermined value, such as 20 volts. The Zener diode **18** is not effective to regulate the output voltage if the battery voltage is above a certain value, say 12 volts; however, this problem is not considered significant since selection of different turns ratios between taps on the power transformer primaries **45**, **46**, **47**, **48**, would permit regulation at any desired battery voltage should some different voltage level be desired.

It will be apparent that various modifications may be made to the preferred embodiment described within the theory of operation of the various component systems. Specifically, the power supply and voltage regulator may be modified to provide various voltage levels to regulate the conductor detector and bi-stable demodulator systems and to provide other induced voltage levels in the power transformer secondary. Many of the transistors herein may be replaced by equivalent NPN or PNP types, the substitution of which is with the scope of persons skilled in this art.

Various other modifications will be apparent to those skilled in the art and it is to be understood that such modifications can be made without departing from the scope of the invention, if within the spirit and tenor of the accompanying claims.

What we claim is:

1. An ignition system for an internal combustion engine including at least one spark discharge device, comprising, in combination, a power converter for supplying a source of high voltage charging current to an energy storage device and a source of intermediate direct current voltage from a low voltage supply, said power convertor including a power transformer having primary and secondary windings, a solid state oscillator operatively connected to said low voltage power supply and to said primary windings whereby alternating current through said primary winding will induce said high voltage charging current in said secondary winding and a diode rectifier operatively connected to said primary winding through intermediate taps to rectify voltage induced in said primary by autotransformer action to provide said intermediate direct current voltage, a triggering means for periodically discharging the energy from said energy storage device to said spark discharge device at a rate proportional to engine speed, said triggering means comprising (1) a transistor oscillator circuit operatively connected to said intermediate direct current voltage source and having a parallel resonant circuit whereby variations timed in proportion to engine speed of the total effective impedance of the parallel resonant circuit will cause said oscillator to periodically oscillate, (2) a demodulator circuit operably connected to said oscillator whereby said periodic oscillations are demodulated to a signal having periodic sharp voltage variations timed in proportion to engine speed, and (3) control means operatively connected to said demodulator and responsive to said sharp voltage variations for periodically causing said energy storage device to discharge to said spark discharge device.

2. An ignition system for an internal combustion engine including at least one spark discharge device, comprising, in combination, a power supply including a low to high voltage converter for supplying a high voltage charging current to an energy storage device; periodic oscillator means including at least two transistors and circuit means operably connecting said transistors to said power supply in a feedback amplifier configuration such that the closed loop gain of said amplifier is essentially established by a fixed resistor within said loop and a parallel resonant circuit operatively connected in said loop, whereby said amplifier will oscillate only when the resonant resistance of said parallel resonant circuit is essentially equal to or more than the value of said fixed resistance, said parallel resonant circuit including a ca-

pacitor and an inductive pickup coil positioned in proximity to at least one moving conductor which is driven into and out of proximity with said pickup coil at a speed proportional to engine speed thereby producing timed variations in the resonant resistance of said parallel resonant circuit causing said amplifier to periodically oscillate in timed relation to engine speed; demodulator circuit means operably connected to said periodic oscillator means whereby said timed periodic oscillations are converted to a trigger signal having intermittent sharp voltage variations in timed relation to engine speed; and a solid state controlled rectifier operatively connected to said demodulator means and to said energy storage device and spark discharge device whereby said controlled rectifier is rendered conductive by said sharp voltage variations from said demodulator and whereby conduction of said controlled rectifier causes said storage device to discharge energy stored therein to said spark discharge device.

3. The ignition system of claim 2 in which said oscillator includes a pair of NPN type transistors each having emitter, collector and base electrodes, with the base electrode of the first transistor connected to its collector electrode through said parallel resonant circuit and the base electrode of the second transistor connected to the collector of said first transistor and the emitter electrode of said second transistor connected to the emitter electrode of said first transistor, means to bias said oscillator so that it will oscillate only when the gain of the oscillator loop is larger than unity, and the value of the capacitor and pickup coil are such that the total effective impedance of the parallel resonant circuit is at a minimum when a conductor is in closest proximity to said pickup coil.

4. The ignition system of claim 2 in which said demodulator circuit includes a first transistor having a control electrode operably connected to said oscillator and having an emitter-collector circuit biased across the low voltage side of said power supply, whereby said first transistor will conduct when said oscillator is not oscillating, a second transistor having a control electrode operably connected to the collector of said first transistor and with its emitter-collector biased across the low voltage side of said power supply whereby said second transistor will conduct only when said first transistor is nonconducting and an RC time delay demodulator circuit operably connected to the collector of said second transistor, said RC circuit selected to have a time constant larger than the reciprocal of the frequency of the oscillatory signal applied to the control electrode of said first transistor whereby the capacitor of said RC circuit becomes substantially charged only between periods of oscillation by said oscillator and whereby said charge is discharged from said capacitor of said RC circuit to said controlled rectifier upon the start of a period of oscillation of said oscillator.

5. An ignition system for an internal combustion engine, comprising, in combination, a power supply including a power transformer having primary and secondary windings, said primary winding operably connected to a low voltage power source and the secondary winding operably connected through a voltage doubling means to an energy storage device, at least one spark discharge device connected through a pulse transformer to said energy storage device through a controlled rectifier, which rectifier, when in a state of nonconduction, prevents the discharge of energy from said energy storage device to said spark discharge device via said transformer, said voltage doubling means comprising at least two diodes and a first capacitor operably connected to said energy storage device to charge said energy storage device with double the effective voltage from said secondary winding, said controlled rectifier operably connected in parallel with said diodes and poled oppositely thereto to permit energy from said energy storage device to pass to said spark discharge device via said pulse transformer with said diodes providing a return path from said transformer to said energy storage device, periodic oscillator means including at least two transistors and circuit means operably connecting said transistors to said power supply in a feedback amplifier configuration such that the closed loop gain of said amplifier is essentially established by a fixed resistor within said loop and a parallel resonant circuit operatively connected in said loop, whereby said amplifier will oscillate only when the resonant resistance of said parallel resonant circuit is essentially equal to, or more than the value of said fixed resistance, said parallel resonant circuit including an inductive pickup coil positioned in proximity to at least one moving conductor which is driven into and out of proximity with said pickup coil at a speed proportional to engine speed thereby producing timed variations in the resonant resistance of said parallel resonant circuit causing said amplifier to periodically oscillate in timed relation to engine speed; means for detecting the periodic output of said oscillator means and for applying an intermittent signal to the control electrode of said controlled rectifier, whereby said controlled rectifier is rendered conductive at periodic intervals in proportion to engine speed and whereby said energy from said energy storage device is periodically discharged to said spark discharge device via said pulse transformer.

6. The ignition system of claim 5 wherein said power supply comprises a solid state push-pull oscillator having transistors operably connected to each end of the primary of said power transformer and to said low voltage power supply whereby oscillations in said primary will induce a high voltage alternating current in the secondary of said power transformer and further including a voltage regulator which has a center tap and two intermediate taps on the primary of said power transformer, diode rectifiers operably connected to said center tap and to each of said intermediate taps, a control transistor having its emitter-collector circuit connected to said diode rectifiers, means responsive to voltage variations from said low voltage power source for rendering said control transistor conductive when said voltage from said power source is below a predetermined value, whereby when said control transistor is conductive, the apparent center tap of said power transformer is shifted at each half cycle of operation of said primary connected transistor to one or the other of said intermediate taps through said diode rectifiers.

7. The ignition system of claim 6 in which said means responsive to voltage variations comprises a Zener diode operably connected across said low voltage source and to the control electrode of said control transistor.

8. An ignition system for an internal combustion engine, comprising, in combination, a power supply including a power transformer having primary and secondary windings, a solid state oscillator having alternately conductive transistors operably connected to each end of said primary winding and across a low voltage power source and the secondary winding operably connected through a voltage doubling means to an energy storage device, at least one spark discharge device operably connected to said energy storage device through a controlled rectifier, which, when in a state of nonconduction, prevents the discharge of energy from said energy storage device to said spark discharge device, triggering means having a periodic output signal timed in proportion to engine speed, means for detecting said periodic output signal and for applying an intermittent signal to the control electrode of said controlled rectifier whereby said controlled rectifier is rendered conductive at periodic intervals timed in proportion to engine speed and whereby said energy from said energy storage device is periodically discharged to said spark discharge device, and a voltage regulator which has a center tap and two intermediate taps on the primary of said power transformer, diode rectifiers operably connected to said center tap and to each of said intermediate

taps, a control transistor having its emitter-collector circuit connected to said diode rectifiers and means responsive to voltage variations from said low voltage power source for rendering said control transistor conductive when said voltage from said power source is below a predetermined value, whereby, when said control transistor is conductive, the apparent center tap of said power transformer is shifted at each half cycle of operation of said primary connected transistor to one or the other of said intermediate taps through said diode rectifiers.

9. The ignition system of claim **8** wherein said means responsive to voltage variations from said low voltage power source includes a Zener diode operably connected across said low voltage power supply and to said control transistor whereby said control transistor will conduct when said Zener diode is nonconducting due to low voltage.

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