

Dec. 27, 1966

L. F. MIERAS

3,294,076

IGNITION SYSTEM

Filed Aug. 3, 1964

2 Sheets-Sheet 1

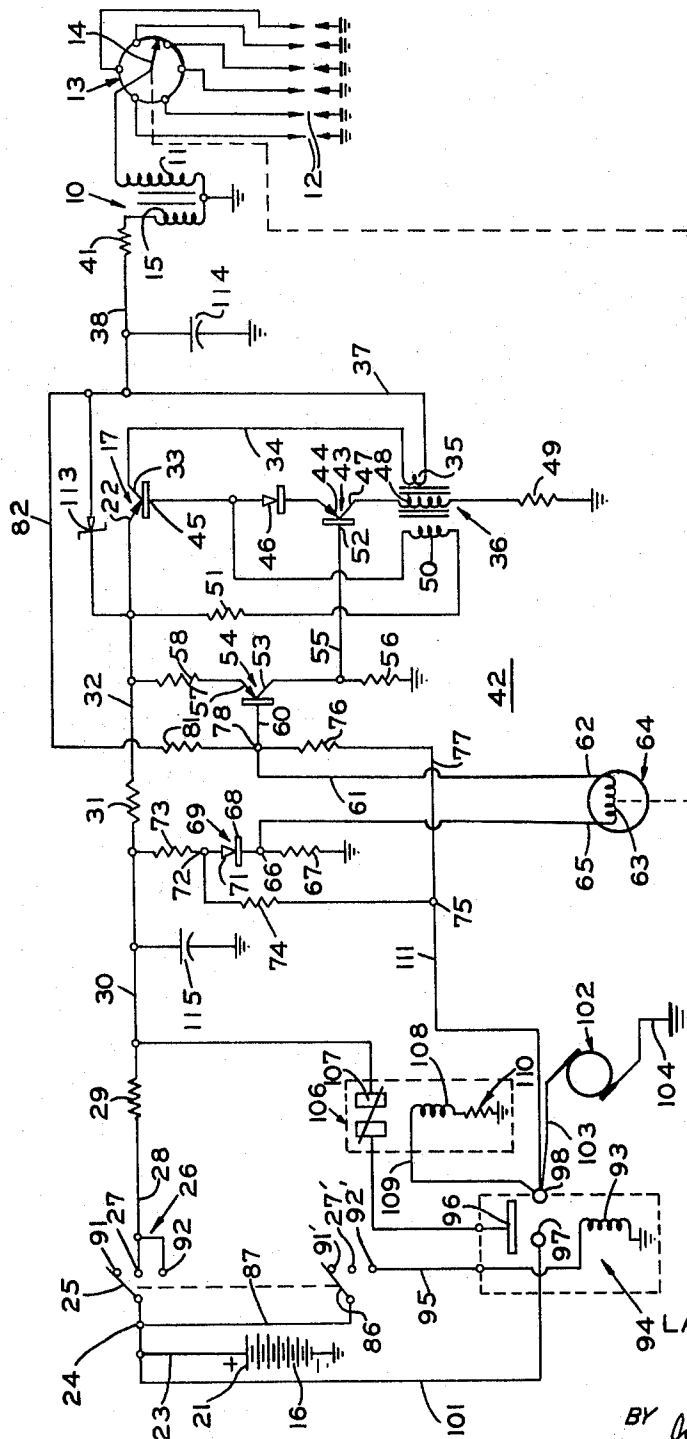


FIG. 1

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2 Sheets-Sheet 2

FIG. 2

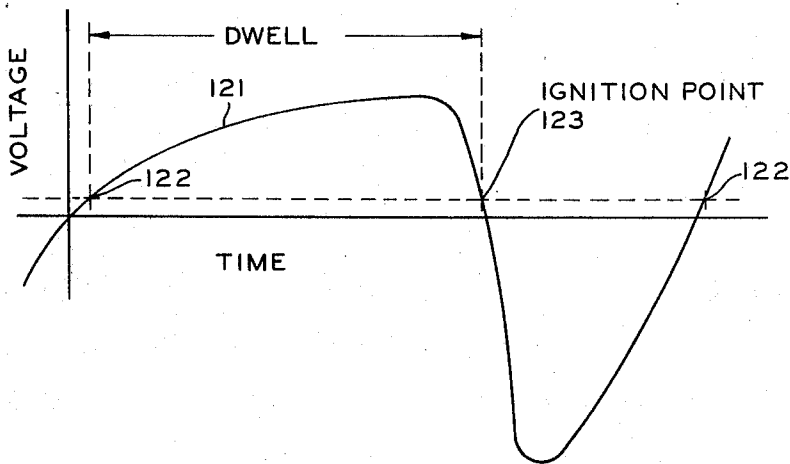
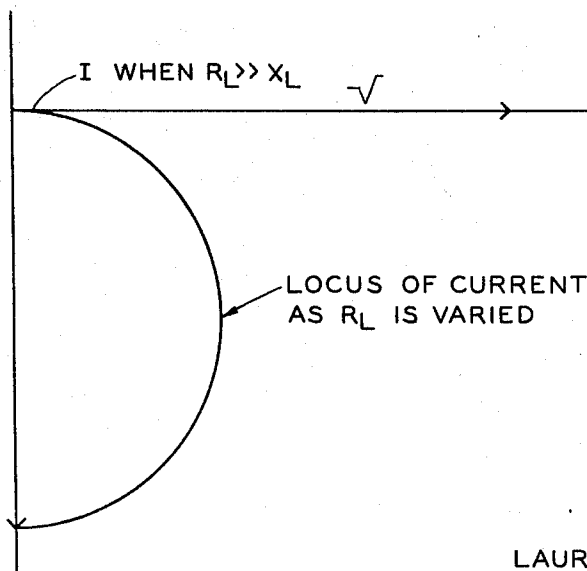


FIG. 3



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3,294,076

IGNITION SYSTEM

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12 Claims. (Cl. 123-148)

This invention relates to an ignition system for an internal combustion engine and more particularly to such an ignition system that employs a solid state switching device coupled to an electromechanical generator that controls both the dwell time and the ignition firing timing of the system.

In the preferred embodiment of the invention, an electromechanical generator is employed that is coupled to a transistorized control circuit. This transistorized control circuit controls the energization of the primary winding of an ignition coil from the source of electrical energy or battery mounted in the vehicle. The electromechanical generator produces an alternating voltage output wave form that is applied to this transistorized circuit for controlling both the period of time that the primary winding of the ignition coil is energized, or the dwell of the ignition system, and the exact firing time of the spark plugs coupled to the ignition system.

It is well known that transistors are current sensitive devices and that the mechanical rotation of an electromechanical generator and the phase of the electrical energy produced thereby are related. It is essential in the ignition system of the invention that the mechanical rotation of the electromechanical generator be substantial in phase with the generated voltage and that the current be substantially in phase with the voltage.

In transistorized circuits it is necessary to use low resistance biasing circuits to properly bias the transistors with small voltage drops. The electromechanical generator and these biasing circuits must of necessity be coupled to the transistors and to one another.

In order to prevent phase shifts of the mechanical rotation with respect to the electrical voltage wave form and to prevent a phase shift or phase difference between the electrical voltage wave form and the current in the electromechanical generator, it is necessary to isolate the low resistance values of these biasing circuits so that the generator is not loaded down and so that the generator sees a highly resistive circuit with respect to the inductive reactance of its output winding. This is accomplished in the invention by use of isolating rectifiers that essentially isolate the low value resistances of the resistors in the transistorized control circuit from the output winding of the generator. The generator is loaded only with highly resistive loads to thus keep both the mechanical rotation in phase with the voltage output and to keep the voltage output in phase with the current. This provides accurate control of both the dwell time and the firing time of the ignition system.

An object of the invention is the provision of an ignition system that employs a solid state switching device under the control of an electromechanical generator in which both the dwell time and the ignition firing time are accurately controlled.

A further object of the invention is the provision of an ignition system employing a solid state switching device and an electromechanical generator in which the voltage output from the generator is maintained in phase with the current output.

Another object of the invention is the provision of an ignition system for an internal combustion engine that employs a solid state switching device and an electromechanical generator in which the voltage and current wave forms produced are synchronized in phase with re-

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spect to the mechanical rotation of the electromechanical generator.

Other objects and attendant advantages of the present invention will be more readily apparent as the specification is considered in connection with the attached drawings, in which:

FIGURE 1 is a circuit diagram of a transistorized ignition system using the present invention;

FIGURE 2 shows a voltage wave form produced by the electromechanical generator of the invention, and

FIGURE 3 is a circle vector diagram of the current and voltage relationships in the electromechanical generator.

Referring now to the drawings in which like reference numerals designate like parts throughout the several views thereof, there is shown in FIGURE 1 the transistorized ignition system of the invention that includes an ignition coil 10 having a secondary winding 11. The secondary winding 11 is sequentially connected to spark plugs 12 through a distributor 13. The distributor 13 includes a rotating arm 14 for sequentially connecting the spark plugs 12 to the secondary winding 11 in synchronism with the operation of the engine in which the ignition system is mounted.

The primary winding 15 of the ignition coil 10 is energized from the source of electrical energy or storage battery 16 under the control of a solid state switching device preferably in the form of a transistor 17 that is connected in series with the primary winding 15 and the source of electrical energy 16. This is accomplished by connecting the positive terminal 21 of the source of electrical energy 16 to the emitter 22 of transistor 17 by means of lead 23, lead 24, movable arm 25 of ignition switch 26, contact 27 of this switch, lead 28, ballast resistor 29, lead 30, resistor 31 and lead 32. The collector 33 of the transistor 17 is connected to the primary winding 15 of ignition coil 10 through lead 34, winding 35 of a bistable electromagnetic switch 36, lead 37, lead 38 and resistor 41.

The control of transistor 17 is accomplished by means of a biasing circuit means 42 that includes a second transistor 43 having an emitter 44 connected to the base 45 of transistor 17 through diode 46. The collector 47 of transistor 43 is connected to ground through winding 48 of bistable electromagnetic switch 36 and a base current limiting resistor 49. The emitter 22 and the base 45 of transistor 17 are interconnected through output winding 50 of bistable electromagnetic switch 36 and a resistor 51.

The base 52 of transistor 43 is connected to collector 53 of transistor 54 by means of lead 55. The lead 55 and the collector 53 of transistor 54 are connected to ground through a resistor 56. The emitter 57 of transistor 54 is connected to lead 32 through resistor 58.

The base 60 of transistor 54 is connected through lead 61 to one terminal 62 of the output winding 63 of an electromechanical generator 64. The other terminal 65 of the output winding 63 is connected to a junction 66 between resistor 67 and the cathode 68 of rectifier or diode 69 that may take the form of a semiconductor p-n junction. The anode 71 of the diode 69 is connected to junction 72 and this junction in turn is connected to one terminal of resistor 73. The other terminal of the resistor 73 is connected to lead 30. A resistor 74 has one terminal connected to junction 72 and the other terminal connected to junction 75, while a resistor 76 has one terminal connected to junction 75 through lead 77 and the other terminal connected to the base 60 of transistor 54 by means of junction 78. The junction 78 is connected to lead 38 through a feedback resistor 81 and lead 82.

The ignition switch 26, in addition to having the movable arm 25, has a second movable arm 86 that moves in unison with the arm 25 and is connected to the positive terminal 21 of the source of electrical energy 16 through the lead 87 and the leads 24 and 23. As shown in the drawing, both movable arms 25 and 86 are in contact with off terminals 91 and 91' respectively. The ignition switch 26 is also provided with start terminals 92 and 92'.

The start terminal 92' is connected to relay winding 93 of starting relay 94 through lead 95. The starting relay 94 has a movable armature 96 normally biased to the open position but which will move into engagement with contacts 97 and 98 when relay winding 93 is energized. The contact 97 is directly connected to the positive terminal 21 of source of electrical energy 16 through lead 101 and lead 23. The other contact 98 of the starting relay 94 is connected to one terminal of the armature of starting motor 102 through a lead 103. The other terminal of the starting motor 192 is connected to ground through a lead 104.

A cold start relay 106 is provided that has a set of normally closed contacts 107 connected to armature 96 of the starting relay 94 and to lead 30. The winding 108 of the cold start relay 106 is connected to contact 98 of the starting relay 94 through lead 109. The other terminal of the winding 198 is connected to ground through a resistor 110.

As more fully described and claimed in my copending application S.N. 387,002 the purpose of this cold start relay is to short out the ballast resistor 29 when the voltage output of the battery 16 is low as it is during cold weather. When the voltage of the battery 16 is high as it is during warm weather, the ballast resistor 29 is retained in the circuit to limit the current in the solid state switching device, shown here in the form of transistor 17.

The junction 75 of the biasing circuit 42 is connected to the contact 98 of the starter relay 94 through a lead 111 thereby grounding the junction point 75 during normal running operations through the armature of starter motor 102, by means of lead 111, contact 98 and lead 103.

Referring back to FIGURE 1, there is shown a zener diode 113 connected across the transistor 17 as a protective device. The capacitor 114 connected between lead 38 and ground is also a protective device to prevent the instantaneous wattage appearing across the transistor 17 from rising to undesirable levels. A capacitor 115 is connected between the lead 30 and ground to absorb high frequency transients that might come through the system to inadvertently trigger the transistorized ignition system.

The transistorized ignition system of this invention may employ the following components that are given by way of example only:

Resistor 73, ohms	15
Resistor 74, ohms	330
Resistor 67, ohms	5,600
Resistor 81, ohms	12,000
Resistor 76, ohms	8,000
Resistor 56, ohms	150
Resistor 31, ohms	.015
Resistor 58, ohms	1.5
Diode 69-1N91-150 milliwatts at 1 to 2 milliamps.	
Transistor 54	RCA2N2953
Transistor 43	RCA2N301

The remaining components are given in my copending application S.N. 170,055. This includes the transistor 17 and the values of the windings and other components that form the bistable electromagnet switch 36.

In normal operation, when the internal combustion engine is running, the movable arms 25 and 86 of the ignition switch 26 are in engagement with the ignition contacts 27 and 27' of ignition switch 26 respectively. This connects the source of electrical energy 16 in series

with the emitter 22 and collector 33 of transistor 17 and the primary winding 15 of ignition coil 10.

At this time, and if it is assumed that the output winding 63 is not producing any output voltage, the transistor 54 is biased to a steady state conducting state. This is done by the connection of the emitter 57 of transistor 54 to the positive terminal 21 of the source of electrical energy 16 through the resistor 58, lead 30, and the circuit previously described. The base 60 of this transistor is connected to ground or the negative terminal of the source of electrical energy 16 through resistor 76, lead 77, junction 75, lead 111, contact 98 of starting relay 94, lead 103, the armature of the starting motor 102, and lead 104. This provides the proper negative bias on the base 60 with respect to the emitter 57 to bias the transistor 54 into its conducting state. The current flow through the base circuit of this transistor, including the resistor 76 and the circuit previously described, will provide approximately a 0.4 volt negative voltage bias on the base 60 with respect to emitter 57.

With transistor 54 conducting, the transistor 43 will be in a nonconducting state, since the voltage drop across the transistor 54 is so small that the base current of transistor 43, flowing out of base 52, is essentially zero. It can be appreciated that when transistor 43 is in a nonconducting state, transistor 17 will also be in a nonconducting state since no current can flow out of the base 45 of transistor 17.

In order to turn transistor 54 off and to turn transistors 43 and 17 on, it is necessary to overcome the negative bias on the base 60 of transistor 54, and this is done by means of the output voltage from the output winding 63 of the electromechanical generator 64. The electromechanical generator employed with this invention is more fully described in my copending application S.N. 387,003, filed August 3, 1964, and is described and claimed in copending application S.N. 403,264, filed October 12, 1964, filed in the name of Frank Skay and assigned to the assignee of this invention.

The output voltage wave form 121 appearing at the terminal 62 that is connected to the base 60 through lead 61 is shown in FIGURE 2. The bias on the transistor 54 that must be overcome by this voltage wave form in order to turn the transistor 54 on is shown in the dotted line. The voltage wave form 121 is the normal output voltage that occurs when the electromechanical generator 64 is driven at normal operating speeds.

When the voltage rises to the cross 122 where the wave form 121 intersects the dotted line, the bias on base 60 of transistor 54 is overcome and the positive potential applied to the base 60 from the output winding 63 blocks current flow from the base 60 thereby turning off transistor 54. This action permits current flow from the base 52 of transistor 43 thereby turning on both transistor 52 and transistor 17.

When the voltage appearing at the terminal 62 and shown in FIGURE 2 falls to the point of the cross 123, the base current from transistor 54 is no longer blocked and, therefore, this transistor will turn on and transistors 43 and 17 will turn off. During the dwell period that transistor 17 is conducting, the time between the two crosses, designated by the numerals 122 and 123, current flows from the source of electrical energy 16 through the emitter 22-collector 33 circuit of the transistor 17 and the primary winding 15 of the ignition coil 10. This current also flows through lead 34, winding 35 of bistable electro-magnetic switch 36 and lead 37. When the point of the cross 123 is reached, the transistor 54 turns on and transistors 43 and 17 turn off. This interrupts current flow in the primary winding 15 of ignition coil 10 and ignition voltages are generated in the secondary winding 11.

The output voltage of the winding 63 appearing at the terminal 62 then goes negative and after a time reverses and comes back to the same level that it was at

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the cross 122. At this time, the transistor 54 will again be turned off and transistors 43 and 17 will be turned on to initiate another ignition cycle.

The electromagnetic switch 36 and its action is identical to that described in my copending application S.N. 170,055 and it furnishes a means for rapidly switching the transistor 17 from a conducting to a nonconducting state at the time the voltage wave form 121 falls to the cross 123.

It can be appreciated from an inspection of the values given of resistors 73 and 67 and the fact that the voltage drop across diode 69 is very small, that the voltage appearing at the junction 66 is only slightly below battery voltage as is the voltage appearing at the junction 78 during steady state conditions that prevail when electro-mechanical generator 64 is not producing an output voltage. Thus, for all practical purposes, the voltage wave form shown in FIGURE 2 that appears at terminal 62 may be considered to be positive and negative with respect to the steady state voltage appearing at the junction 78.

It can be appreciated from an inspection of FIGURE 2 that the electrical energy output from the output winding 63 of electromechanical generator 64 controls not only the timing of the firing of the spark plugs (cross 123) but also controls the dwell time, or the time during the ignition cycle that the primary winding 15 is energized. This time is represented by the time between the crosses 122 and 123. Transistors are current responsive devices and the voltage output of the output winding 63, as shown in FIGURE 2, should bear a fixed relationship to the mechanical rotation of the rotor of the electro-mechanical generator 64. It is essential in the ignition system of the invention that the voltage wave form 121 be in phase with the mechanical rotation of the rotor and that the current in the output winding 63 that is supplied to the base 60 of transistor 53 be in phase with the voltage represented by wave form 121.

It is well known that if a generator sees a low resistive load so that there is a heavy current flow through the generator that a shift in the flux lines will take place and a phase shift will occur between the mechanical rotation of the generator and the electrical output. It is also well known that in order to maintain the voltage in phase with the current in an electromechanical generator, that the total impedance of the output circuit must be highly resistive. In other words, the inductive reactance of the generator must be insignificant with respect to the resistance of the total circuit.

In order to maintain these necessary phase relationships between the mechanical rotation of the generator and between the voltage and current output of the generator it is essential that the output circuit of the generator have a large total resistance. In order to accomplish this, the diode 69 is provided which is poled in a direction to prevent current flow from the terminal 65 through the low resistance of resistor 73 (15 ohms). Instead, current must flow through the resistor 67 which has a high resistance (5,600 ohms). Thus, when current flows out of the output terminal 65 of output winding 63, it flows into the highly resistive load 67. This not only prevents high currents from flowing in the generator circuit with a consequent high loading of the generator, but since the resistance of resistor 67 is many times greater than the inductive reactance of the winding 63 the voltage output of the output winding 63 is maintained in phase with the current.

The transistor 54 includes the rectifying junction or barrier between the emitter 57 and the base 60 which in a junction transistor takes the form of a p-n junction. Thus, current flowing from the output winding 62 to base 60 of this transistor through lead 61 and junction 78 encounters this rectifier that prevents current flow through the low resistor 58 (1.5 ohms). Instead, current must flow to ground or back to the negative terminal of the

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source of electrical energy 16 through resistor 76 (8,000 ohms), lead 77, lead 111, contact 98 of starting relay 94, lead 102, the armature of starting motor 103 and the lead 104. Current also flows to ground or negative terminal of the source of electrical energy 16 through the parallel path connected to junction 78 and comprised of resistor 81 (12,000 ohms), lead 82, lead 38, resistor 41 and the primary winding 15 of ignition coil 10.

Thus, the rectifiers represented by the diode 69 and the base-emitter of transistor 54 prevent current in either direction from the output winding 63 from flowing into a low resistance load. Instead, these currents must flow to ground or the negative terminal of the source of electrical energy 16 through the high resistances represented by resistors 67, 76 and 81.

As stated previously, the wave form shown in FIGURE 2 represents the output voltage appearing at terminal 62 of the output winding 63. Thus, during the positive portion of the wave form, the rectifying barrier represented by the base 60 and emitter 57 of transistor 54 is operative to prevent current flow through any low resistance leads, while during the negative portion of the cycle or wave form which will be positive at the terminal 65 of output winding 63, the diode 69 is operative for this purpose. It can be readily appreciated that if the diode 69 were not present, current would flow through the low resistance of resistor 73 (15 ohms) thereby loading the output winding 63 with a low resistance. This would cause an interference with the phase relationship of the mechanical and electrical systems of the output winding 63 and would also cause the current to lag the voltage to a very appreciable extent in the output winding 63. This can be appreciated by the circle diagram shown in FIGURE 3 that shows the magnitude and phase angle of the current as the resistance R_L of the output circuit of output winding 63 is varied from a large to a small value. This lagging current would turn the transistor 54 off and transistors 43 and 17 on at a later time in the ignition cycle with relation to the mechanical rotation of the engine and the electromechanical generator 64 and in relation to voltage wave form 121 since transistors are current sensitive devices. This would cut down the amount of dwell time and make it substantially indeterminate at various engine speeds. It would have a very adverse effect at high engine speeds. At these speeds the inductive reactance of the output winding 63 is the greatest with respect to the resistance in the circuit and this would cause the current to lag by the greatest amount. This would cut into the dwell time appreciably at high speeds where the dwell time is necessary for proper energization of the primary winding 15 of the ignition coil.

The rectifying barrier represented by the base-emitter junction of transistor 54 performs the same function as the diode 69 for the positive portion of the voltage wave form shown in FIGURE 2 and assures that ignition timing can be properly controlled.

In the invention the inductive reactance of the output winding 63 of electromechanical generator 64 during operation is insignificant with respect to the resistances 67, 76 and 81, but is significant with respect to the resistance of resistors 73 and 58. Thus, the rectifying barriers represented by diode 69 and the base-emitter circuit of transistor 54 that prevent the current flow through resistors 73 and 58 and forces it to flow through resistors 67, 76 and 81 maintain the current from output winding 63 in phase with the voltage developed.

Thus, with the present invention the voltage output from the electromechanical generator is substantially in phase with the current during both the negative and the positive excursions of the voltage wave form. Also, the voltage and the current maintain the proper phase relationships with the mechanical rotation of the generator and the engine because of the highly resistive loads seen by the generator during both the negative and the posi-

tive portions of the output voltage. This assures proper dwell times and proper control of ignition firing times.

It is to be understood that this invention is not to be limited to the exact construction shown and described but that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. A transistorized ignition system for an internal combustion engine comprising, an ignition coil having a primary winding, a source of electrical energy, a switching circuit means including a control transistor having a control electrode coupled to said source of electrical energy and said primary winding of said ignition for controlling the energization of said primary winding of said ignition in accordance with a signal applied to said control electrode of said transistor, an electrical generating means including a rotor driven in synchronism with the engine and an output winding for generating an alternating output, one terminal of said output winding being connected to said control electrode, a resistive circuit coupling each terminal of said output winding to one terminal of said source of electrical energy, the inductive reactance of said output winding when said electrical generating means is operated over the speed range of the internal combustion engine being sufficiently small with respect to said resistive circuits so as not to cause an appreciable phase shift between the voltage and current of said output winding, a resistive circuit and a rectifier connected in series coupling each terminal of said output winding to the other terminal of said source of electrical energy, the resistance of said last mentioned resistive circuits being significantly smaller than the resistance of said first mentioned circuits and the inductive reactance of said output winding when said electrical generating means is operated over the speed range of the internal combustion engine being significant with respect to the resistance of said last-mentioned resistive circuits, each of said rectifiers being poled to prevent current flow from said output winding through said last mentioned resistive circuits.

2. The combination of claim 1 in which one of said rectifiers is included in said control transistor and said last mentioned resistive circuits are biasing circuits for said control transistor.

3. A transistorized ignition system for an internal combustion engine comprising, an ignition coil having a primary and a secondary winding, a plurality of spark plugs, a distributor for sequentially connecting said secondary winding of said ignition coil with said spark plugs in timed synchronism with the operation of the engine, a source of electrical energy, a switching circuit means including a control transistor having a control electrode, said control transistor electrically coupled to said source of electrical energy and said primary winding of said ignition coil for controlling the energization of said primary winding of said ignition coil in accordance with a signal applied to said control electrode of said transistor, an electrical generating means including a rotor driven in synchronism with the engine and said distributor, said electrical generating means including an output winding for generating an alternating voltage output, one terminal of said output winding being connected to said control electrode, a resistive circuit coupling each terminal of said output winding to one terminal of said source of electrical energy, the inductive reactance of said output winding when said electrical generating means is operated over the speed range of the internal combustion engine being sufficiently small with respect to said resistive circuits so as not to cause an appreciable phase shift between the voltage and current of said output winding, a resistive circuit and a rectifier connected in series coupling each terminal of said output winding to the other terminal of said source of electrical energy, the resistance of said last mentioned resistive circuits being significantly smaller than the resistance of said first mentioned circuits and the inductive reactance of said

output winding when said electrical generating means is operated over the speed range of the internal combustion engine being significant with respect to said resistance of said last-mentioned resistive circuits, each of said rectifiers being poled to prevent current flow from said output winding through said last mentioned resistive circuits.

4. The combination of claim 3 in which one of said rectifiers is included in said control transistor and said last mentioned resistive circuits are biasing circuits for said control transistor.

5. A transistorized ignition system for an internal combustion engine comprising, an ignition coil having a primary winding and a secondary winding, a plurality of spark plugs, a distributor operated in timed synchronism with the internal combustion engine for sequentially connecting said spark plugs with said secondary winding, a source of electrical energy, a transistorized circuit means coupled to said primary winding of said ignition coil and said source of electrical energy for controlling the energization of said primary winding from said source of electrical energy, said transistorized circuit including a control transistor having output electrodes connected across said source of electrical energy and a control electrode, a voltage divider connected across said source of electrical energy including a serially connected first resistor, a diode and a second resistor, said diode being poled to permit current flow from said first resistor through said second resistor, said second resistor having a resistance substantially greater than said first resistor, an electromechanical generator operated in timed synchronism with the engine and including an output winding having an inductive reactance that is negligible with respect to the resistance of said second resistor but not negligible with respect to said first resistor when said electromechanical generator is operated at engine operating speeds, one terminal of said output winding being connected to the junction of said diode and said second resistor and the other terminal being connected to the control electrode of said transistor.

6. A transistorized ignition system for an internal combustion engine comprising, an ignition coil having a primary winding, a source of electrical energy, a control circuit means coupled to said source of electrical energy and said primary winding of said ignition coil for controlling the energization of said primary winding of said ignition coil from said source of electrical energy, said control circuit means including a solid state switching device having a rectifying barrier, a control electrode connected to said rectifying barrier, an electromechanical generator operated in timed synchronism with said distributor and the internal combustion engine and including an output winding, said control electrode connected to one terminal of said output winding, said rectifying barrier being poled to prevent current flow in one direction from said output winding through said rectifying barrier, and a second rectifying barrier connected to the other terminal of said output winding and poled to prevent current flow in the other direction from said output winding through said rectifying barrier, and means comprising resistors coupled to the terminals of said output winding for permitting current flow through said output winding, the inductive reactance of said output winding when said electromechanical generator is operated over the speed range of the engine being negligible with respect to the resistance value of said resistors.

7. A transistorized ignition system for an internal combustion engine comprising, an ignition coil including a primary winding and a secondary winding, a plurality of spark plugs, a distributor operated in timed synchronism with the internal combustion engine for sequentially connecting said spark plugs with said secondary winding, a source of electrical energy, a control circuit means coupled to said source of electrical energy and said primary winding of said ignition coil for controlling the energization of said primary winding of said ignition coil from said source

of electrical energy, said control circuit means including a semiconductor switching device having a p-n junction, a control electrode connected to said p-n junction, an electromechanical generator operated in timed synchronism with said distributor and the internal combustion engine and including an output winding, said control electrode connected to one terminal of said output winding, said p-n junction being poled to prevent current flow in one direction from said output winding through said p-n junction, and a second p-n junction connected to the other terminal of said output winding and poled to prevent current flow in the other direction from said output winding through said second p-n junction, and means comprising resistors coupled to the terminals of said output winding for permitting current flow through said output winding, the inductive reactance of said output winding when said electromechanical generator is operated over the speed range of the engine being negligible with respect to the resistance value of said resistors.

8. A transistorized ignition system for an internal combustion engine comprising, an ignition coil including a primary winding, a source of electrical energy, a transistorized circuit coupled to said source of electrical energy and said primary winding of said ignition coil including a transistor for controlling the energization of said primary winding of said ignition coil, an electromechanical generator operated in timed synchronism with the internal combustion engine and having an output winding generating an alternating output, said transistor including a base electrode, one terminal of said output winding connected to said base electrode, a voltage divider connected across said source of electrical energy including a serially connected first resistor, a diode and a second resistor, said diode being poled to permit current flow from said first resistor through said second resistor, said second resistor having a resistance substantially greater than said first resistor, an electromechanical generator operated in timed synchronism with the engine and including an output winding having an inductive reactance that is negligible with respect to the resistance of said second resistor but not negligible with respect to said first resistor when said electromechanical generator is operated at engine operating speeds, one terminal of said output winding being connected to the junction of said diode and said second resistor and the other terminal being connected to the base electrode of said transistor.

9. A transistorized ignition system for an internal combustion engine comprising, an ignition coil including a primary winding, a source of electrical energy, a switching circuit coupled to said source of electrical energy and said primary winding of said ignition coil including a semiconductor switching device for controlling the energization of said primary winding of said ignition coil, an electromechanical generator operated in timed synchronism with the internal combustion engine and having an output winding generating an alternating output, said semiconductor switching device including a control electrode, one terminal of said output winding connected to said control electrode, a resistor connected to said control electrode and one terminal of said output winding and means coupled in circuit with said source of electrical energy and the other terminal of said output winding for permitting current flow in a direction from said source of electrical energy toward said other terminal of said output winding but preventing current flow in a direction from said second terminal of said output winding toward said source of electrical energy, a resistor connected to said other terminal of said output winding, said resistors being coupled in

circuit with said source of electrical energy, the inductive reactance of said output winding when said electromechanical generator is operated over the speed range of the internal combustion engine being sufficiently small with respect to the values of said resistors so as not to cause an appreciable phase shift between the voltage and current of said output winding.

10. In a transistorized ignition system for an internal combustion engine the combination comprising, an ignition coil including a primary and a secondary winding, a plurality of spark plugs, a distributor connected to said secondary winding and said spark plugs for sequentially connecting said spark plugs to said secondary winding in synchronism with the operation of said engine, a source of electrical energy, a first transistor having an output circuit and a control circuit, said output circuit, said source of electrical energy and said primary winding of said ignition coil connected in series circuit, a second transistor including an output circuit and a control circuit, circuit means connecting said output circuit of said second transistor with the input circuit of said first transistor, a voltage divider connected across said source of electrical energy, said voltage divider including a first resistor, a diode and a second resistor connected in series, the resistance of said second resistor being many times greater than the resistance of said first resistor, said diode being poled to permit current flow through said first resistor, said diode and said second resistor in the order named, an electromagnetic generator having an output winding, said output winding having one terminal connected to the junction of said diode and said second resistor and the other terminal to said control circuit of said second transistor.

11. The transistorized ignition system for an internal combustion engine comprising, an ignition coil including a primary winding, a source of electrical energy, a transistorized circuit coupled to said source of electrical energy and said primary winding of said ignition coil including a transistor for controlling the energization of said primary winding of said ignition coil from said source of electrical energy, an electromechanical generator operated in timed synchronism with the internal combustion engine and having an output winding generating an alternating output, said transistor including a base electrode, one terminal of said output winding connected to said base electrode, and means connected to each terminal of said output winding for preventing a phase shift between the voltage and current in said output winding.

12. The combination of claim 11 in which said means comprises a resistor connected to said one terminal of said output winding and to one terminal of said source of electrical energy, and a second resistor connected to the other terminal of said output winding and to said one terminal of said source of electrical energy, the inductive reactance of said output winding of said electrical generator being insignificant with respect to the resistance values of each of said resistors when said electromechanical generator is operated over the speed range of the engine whereby a phase shift between the voltage and current of said output winding is prevented.

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