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[54] AUXILIARY SPARK STARTING CIRCUIT FOR IGNITION SYSTEMS

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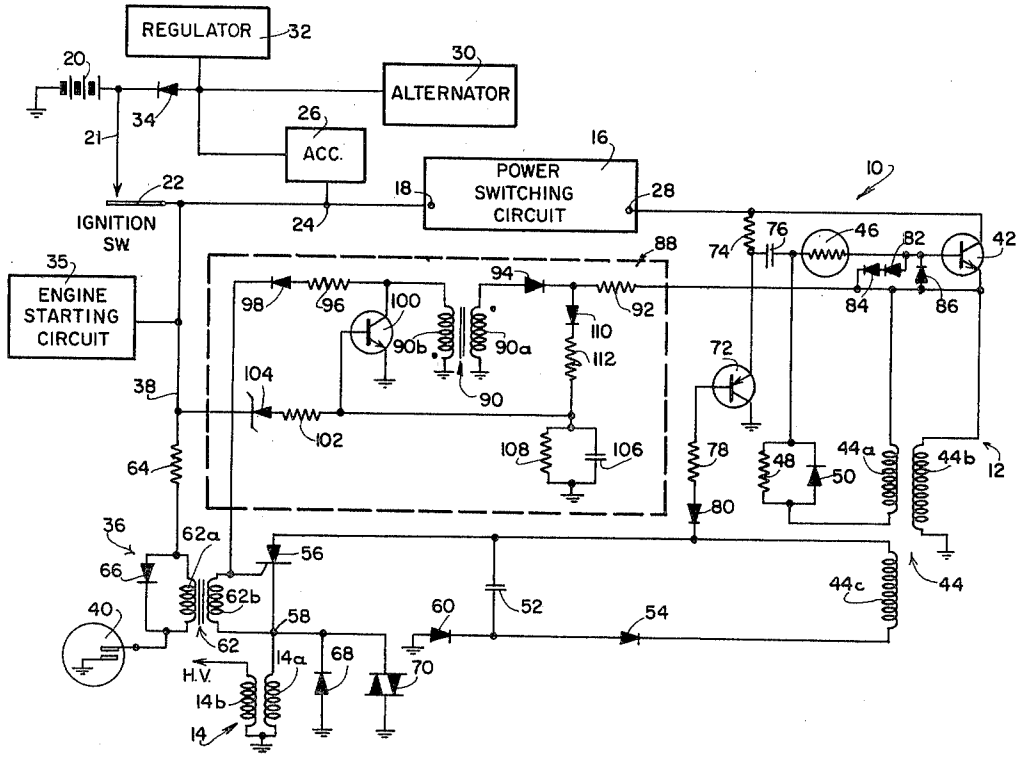
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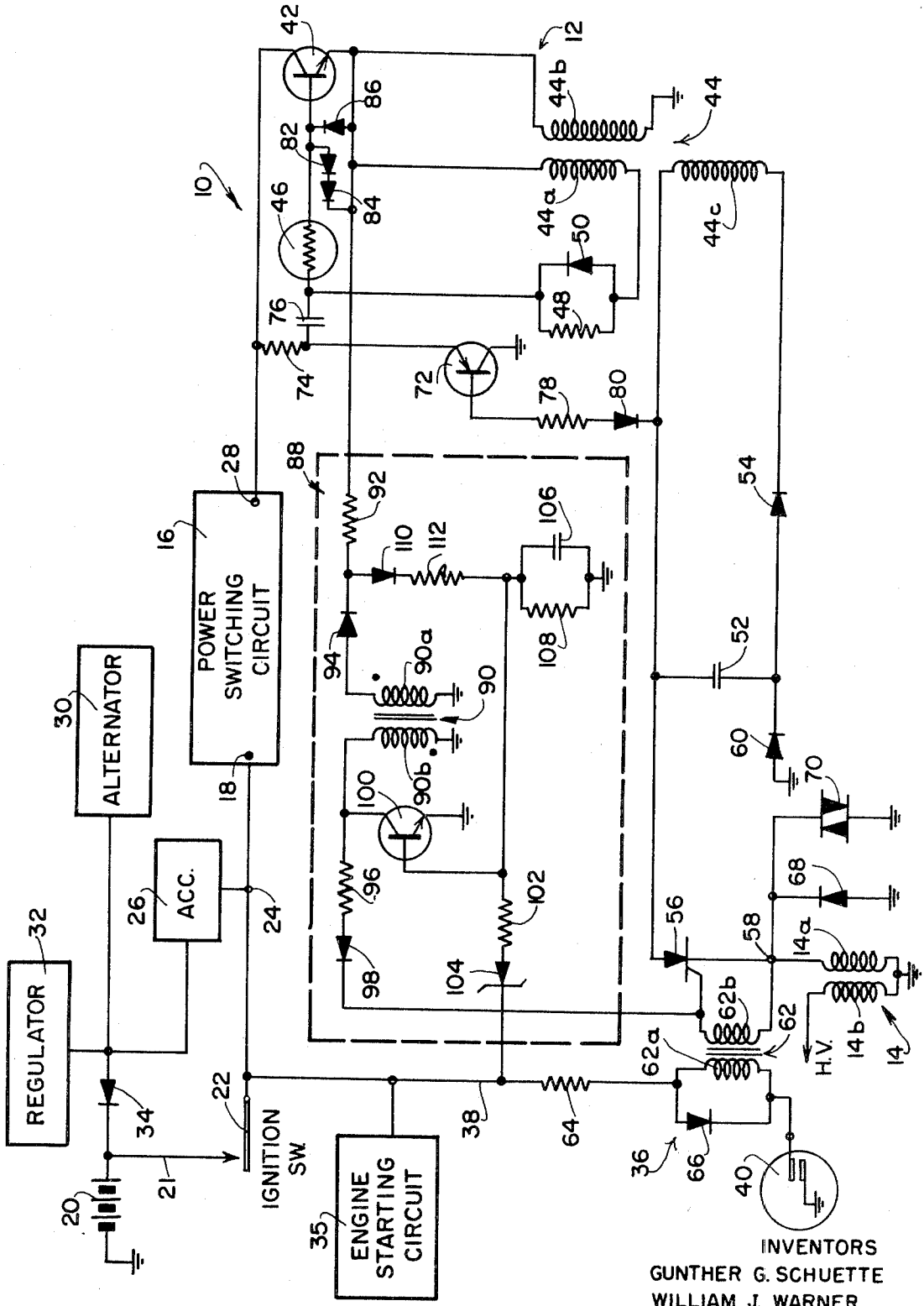
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[57] **ABSTRACT**

An ignition discharge capacitor is provided for applying pulses to an ignition coil in synchronization with external switching means such as the breaker-points of an automobile. A controlled oscillator is responsive to a reference voltage device which, when a normal voltage value is applied thereto, disables the oscillator. On starting, when the voltage applied thereto is below the normal voltage value, the oscillator will oscillate to produce auxiliary trigger pulses to cause a multitude of spark discharges at the spark plugs of the internal combustion engine in addition to the initial pulse from the ignition capacitor.

10 Claims, 1 Drawing Figure





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AUXILIARY SPARK STARTING CIRCUIT FOR IGNITION SYSTEMS

BACKGROUND OF THE INVENTION

This invention relates generally to ignition systems of the type providing a high-voltage, low-current energy pulse to the primary winding of an ignition coil, and more particularly to an improved capacitor discharge ignition system.

Although the invention herein disclosed has particular utility when used in combination with capacitor discharge ignition systems, it should be understood that this invention can be used in combination with other types of electronic ignition systems.

Capacitor discharge ignition systems, i.e., systems which utilize a capacitor for intermittently discharging a relatively high-voltage energy pulse through an ignition coil, have found relatively widespread and popular use in connection with internal combustion engines. SUch capacitor discharge ignition systems have several advantages over conventional Kettering ignition systems. One of the advantages obtained from a capacitor discharge ignition system is that the power drain from the automobile battery is substantially reduced when using such ignition systems. Another advantage is that a spark of a higher voltage, i.e., higher fuel igniting properties, can be generated more readily with a somewhat rundown storage battery connected thereto, than could otherwise be obtained by a conventional ignition system. Yet another advantage obtained from capacitor discharge ignition systems is that the spark potential generated at spaced-apart electrodes within a spark plug remains substantially constant over a much wider range of engine speed than otherwise can be obtained from conventional ignition systems.

Although capacitor discharge ignition systems provide high-energy pulses to the spark plugs during the starting sequence of an internal combustion engine there may be experienced some difficulty in starting the engine for various reasons unrelated to spark discharge potentials. For example, the appropriate fuel mixture may not be obtained during the initial starting operation of the engine and spark discharges of different timed sequences may be required, that is, a more retarded spark may provide quicker starting of the engine. However, means to automatically retard the ignition spark of the internal combustion engine only during the starting sequence thereof may be relatively complicated and expensive.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide means readily incorporated in an electronic ignition system to generate auxiliary or shower of spark discharges at the spark plugs of an internal combustion engine to increase the starting ability of the engine during the starting sequence.

Another object of this invention is to provide an auxiliary spark starting circuit for electronic ignition systems which is inexpensive to manufacture, efficient and reliable in operation, and which will operate over a wide range of voltages below the normal voltage of the power supply connected thereto.

Briefly, the ignition system of the illustrated embodiment includes an energy storage capacitor for receiving and storing a relatively high-voltage energy pulse. The stored energy is then synchronously discharged from the storage capacitor, as for example by means of opening the breaker-points of the automobile, and applied to the primary winding of an ignition coil through a current control device such as a silicon-controlled rectifier. Preferably, the energy pulse applied to the storage capacitor is developed in the secondary winding of a step-up transformer, the primary windings thereof being connected to a transistor and together therewith forms a single swing blocking oscillator. A trigger amplifier stage may be coupled to the secondary winding of the transformer to initiate conduction of the transistor of the blocking oscillator. Suitable regenerative feedback circuit means are provided between the output of the transistor blocking oscillator and its base electrode to drive the transistor rapidly to a current saturated condition. Upon completion of the current saturated condition of this transistor, a reverse voltage feedback will occur in one of the primary windings of the transformer to render the transistor nonconductive. Regardless of time duration between spark discharges, the transistor remains nonconductive until the next spark discharge occurs whereupon the single swing blocking oscillator will again deliver an energy pulse to the storage capacitor. The circuit parameters of the single swing blocking oscillator are selected so as to provide a pulse output therefrom with a relatively high-frequency sufficient to substantially immediately recharge the storage capacitor to place it in readiness for a subsequent discharge to produce another scheduled spark at a given spark plug within the internal combustion engine. Although the illustrated embodiment discloses a capacitor discharge ignition system of the type using a single swing blocking oscillator to apply energy pulses to the storage capacitor, it will be understood that any suitable energy pulsing circuit can be used. Most advantageously, a controlled oscillator circuit is coupled to the blocking oscillator to receive an oscillator starting signal for initiating operation of the controlled oscillator immediately after energy has been discharged from the storage capacitor into the ignition coil of the automobile to produce a scheduled spark discharge. The controlled oscillator has an output circuit thereof coupled to the triggering circuit of the ignition system to apply auxiliary trigger pulses thereto which, in turn, provides auxiliary or a shower of spark discharges at the spark plug immediately after the scheduled spark discharge has occurred. The auxiliary spark discharges increase the starting ability of the engine during the starting sequence. A charging circuit is associated with the controlled oscillator to receive portions of each cycle of operation of the oscillations ultimately to charge to a value sufficient to render the controlled oscillator inoperative. Therefore, the number of auxiliary spark discharges generated after the scheduled spark discharge has occurred is determined by, among other things, the number of pulses required to raise the voltage in the charging or control circuit to a level to disable the controlled oscillator. Also, a reference voltage device is connected between the power source of the controlled oscillator to disable it immediately after the engine has started running. This is accomplished by sensing the voltage value of the input terminal and disabling the controlled oscillator during normal voltage values, and allowing oscillation of the controlled oscillator during reduced voltage values, such as when there is a voltage drop across the battery during high-current draw therefrom by the starter motor.

The controlled oscillator includes inductance means, herein illustrated as the primary winding of a transformer, to receive a starting signal from the single swing blocking oscillator, after which the transformer secondary will gate the silicon controlled rectifier at the end of the charging pulse on the storage capacitor in a recurrent manner until the voltage level on the control circuit will render the shunting transistor conductive to terminate the oscillations. The frequency of these oscillations is determined by the frequency response of the single swing blocking oscillator system.

DESCRIPTION OF THE DRAWINGS

The single figure of the drawings is a schematic wiring diagram of the illustrated embodiment of this invention wherein the controlled oscillator is shown connected in circuit with a capacitor discharge ignition system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An ignition system designated generally by reference numeral **10** includes an energy-pulsing circuit **12** for applying spark producing energy pulses to the primary winding **14***a* of an ignition coil **14** which has the secondary winding **14***b* thereof readily connectable to any suitable spark utilization means such as the distributor of an automobile engine. The

energy-pulsing circuit **12** may be provided with a power-switching circuit **16** such as described in copending application Ser. No. 1,597, filed Jan. 9, 1970 assigned to the same assignee as this application which has a circuit point **18** thereof arranged for connection to an external power source **20** via a line **21**. An ignition switch **22** has one end thereof connected to the line **21** for applying power to a circuit point **24** on the other side of ignition switch **22** when the switch is actuated to its closed circuit condition. The switch **22** also applies battery power to a plurality of accessory devices such as light bulbs, fan motors, radios, etc., and the accessories are illustrated as a single group designated by reference numeral **26**. Closure of the switch **22** also energizes the power-switching circuit **16** to apply operating potential to a circuit point **28** from which the energy-pulsing circuit **12** receives its operating voltage. Abnormal voltage conditions sensed by the power-switching circuit **16** will automatically and instantaneously remove power from circuit point **28** to prevent overvoltages from being applied to the ignition system thereby protecting the various active electronic components thereof, and substantially instantaneously removing the power therefrom when the ignition switch **22** is actuated to the open circuit condition instantaneously to turnoff the automobile engine.

During normal operating conditions, the potential at circuit point **24** is that provided by the power source **20** or, when the engine of the automobile is running, a slightly increased voltage as provided by an alternator **30** and a voltage regulator **32** which are also connected to the circuit point **24**, directly or indirectly, through various accessory wiring as is well known in the art. The normal regulated voltage output as applied to circuit point **24** is in the order of 13 to 15 volts and also serves to charge the battery **20** through a protection diode **34** which is forward biased when the voltage at the alternator **30** is more positive than the voltage at the battery **20**. However, upon reduction of the voltage at alternator **30**, for example by shutting off the engine, reverse current flow from the battery **20** to the alternator **30** is prevented by the blocking condition of the diode **34**.

Also connected to circuit point **24** is an engine starting circuit **35** preferably of the key-actuated type used in automobiles such that rotation of an ignition key to a first position will close ignition switch **22** and further rotation of the ignition switch to a second position will actuate the engine starting circuit to energize the starting motor ultimately to effect running of the automobile engine. The starting motor of the automobile engine requires high current to produce sufficient power to turn over the engine during the starting sequence thereof. This high-current drain through the starting motor of the engine reduces the effective voltage of the battery **20** so that the potential applied to circuit point **24** during this high-current drain is usually in the order of 8 to 10 volts.

Most advantageously, a controlled oscillator **88** is connected in circuit with the ignition system **10** to provide self-sustained controlled oscillations which, in turn, provide auxiliary trigger pulses to the ignition system. These auxiliary trigger pulses generate auxiliary spark discharges at the spark plug of the automobile engine substantially instantaneously after the scheduled spark discharge has occurred to increase the starting ability of the engine during the starting sequence, that is during high-current drain of the battery when the starting motor is energized.

A triggering circuit **36** has one end thereof connected to the circuit point **24** via a line **38** and the other end thereof intermittently connected to ground potential via an external breaker-point assembly **40** which may be located within the ignition distributor of the automobile engine. However, it will be understood that any suitable external pulse signal information can be used in place of the mechanical breaker-point assembly **40**, as for example, a magnetic pulse output or a light signal output generated in synchronism with the internal combustion engine.

The energy-pulsing circuit **12** includes a transistor **42** which has the collector electrode thereof connected to circuit point **28** and the emitter electrode thereof connected to a pair of primary windings **44***a* and **44***b* of a pulse-forming step-up transformer **44**. The primary winding **44***a* has the other end thereof connected to a temperature responsive resistor **46** through a parallel network comprising a resistor **48** and a diode **50**. This circuit provides a regenerative feedback loop to the base electrode of transistor **42** to cause the transistor **42** rapidly to achieve a saturated current condition. Upon complete saturation, or substantially complete saturation, of transistor **42** a reduction in the rate of change or current in primary windings **44***a* and **44***b* provides a reversal of polarity within the winding **44***a* quickly to render the transistor **42** nonconductive, which condition remains until a starting pulse is again applied to the transistor **42**. Therefore, transistor **42** together with its associated components form a single swing, blocking oscillator circuit which generates a step-up voltage in the secondary winding **44***c* of the transformer **44** and applies this increased voltage to an energy storage capacitor **52**. Only a positive pulse of energy can be stored in capacitor **52** because of the series connected diode **54** which, blocks current flow in one direction allowing capacitor **52** to become and remain charged, and which conducts current flow in the opposite direction to storage capacitor **52**.

The energy stored in capacitor **52** is then applied to the primary winding **14***a* of the ignition coil **14** through a switching circuit herein illustrated as including a silicon-controlled rectifier **56** which has its anode connected to capacitor **52** and its cathode connected to a circuit point **58** which, in turn, is arranged for connection to the primary winding **14***a* of the ignition coil **14**. A diode **60** is connected in series with the diode **54** at the junction of capacitor **52** and provides a current path to ground potential for the secondary winding **44***c* for voltages of a given polarity, Thus dampening any ringing effect within the closed loop formed by the winding **44***c*, capacitor **52**, and diode **54** within a relatively short period of time after the capacitor **52** is discharged.

The pulsing circuit **36** includes a pulse-forming transformer **62** which has a primary winding **62***a* connected to circuit point **24** through a resistor **64** and to the mechanical breaker-point assembly **40**. A secondary winding **62***b* is connected between the gate and cathode of silicon-controlled rectifier **56** to apply turn-on gate pulses thereto to render the silicon-controlled rectifier highly conductive to discharge capacitor **52** into the primary winding **14***a* in synchronism with the opening of the breaker-point assembly **40**.

Upon closing of the mechanical breaker-point assembly **40**, current will flow from the positive potential at terminal **24** through the resistor **64** and the primary winding **62***a* of the pulse-forming transformer **62**. However, this initial current flow provides a negative potential at the secondary winding **62***b* and, as such, has no affect on the silicon-controlled rectifier **56**. However, upon subsequent opening of the mechanical breaker-point assembly **40** current flow through the primary winding **62***a* is abruptly terminated and the magnetic field within the transformer **62** rapidly collapses to produce a positive polarity pulse within the secondary winding **62***b* to trigger the silicon-controlled rectifier **56** to its highly conductive state. This action, as mentioned hereinabove, rapidly discharges capacitor **52** through the primary winding **14***a* of the ignition coil **14** to generate a scheduled high-voltage spark at the output thereof. A diode **66** is connected across the primary winding **62***a* substantially to reduce and dampen the reverse kickback voltage which may occur within the pulse forming transformer **62**.

Connected in parallel with the primary winding **14***a* of the ignition coil **14** is a diode **68** and a bidirectional threshold-switching device **70**. The device **70** may be any suitable voltage dependent resistance means which serves to prevent voltage breakdown of the diode **68** which, in turn, serves to rectify the oscillations in the primary winding **14***a* after a high-voltage spark discharge has occurred.

If desired, a triggering amplifier may be used with the single swing blocking oscillator formed by transistor **42** and trans-

former 44 to apply the necessary reinitiation pulse to the transistor 42 for the next cycle of operation so that another energy pulse will be applied to capacitor 52 and stored therein. The triggering amplifier is herein disclosed as including a transistor 72 forming an emitter-follower circuit with a resistor 74 connected to the emitter electrode thereof and the circuit point 28 of the power-switching circuit 16 for receiving an operating potential. The output of the transistor 72 is coupled to the base electrode of transistor 42 through a coupling capacitor 76. The base electrode of transistor 72 is connected to one end of the capacitor 52 and secondary winding 44*c* through a resistor 78 and a diode 80. When the silicon-controlled rectifier 56 is rendered conductive to discharge capacitor 52 into the primary winding 14*a*, the potential across capacitor 52 and across the secondary winding 44*c* rapidly decreases substantially to zero. Thus, at this point in time a slight ringing current is generated between the capacitor 52 and secondary winding 44*c* so that a short duration negative potential is sensed at the cathode of diode 80 to forward bias the diode which, in turn, renders the triggering transistor 72 conductive. This negative potential applied to the cathode of diode 80 also serves to commutate the silicon-controlled rectifier 56 to an off condition immediately after discharge of capacitor 52. When transistor 72 is rendered conductive a negative pulse is applied through coupling capacitor 76 to the base electrode of transistor 42. However, this negative pulse reverse biases the transistor 42 and has no effect on the conduction of the transistor. However, shortly thereafter the potential at diode 80 rapidly changes a positive potential to reverse bias the diode and render transistor 72 nonconductive. This action will produce a positive pulse through capacitor 76 which, in turn, will initiate operation of transistor 42 to deliver another energy pulse to capacitor 52. It will be noted that a slight time delay exists between the time capacitor 52 is discharged and the time transistor 42 is again rendered conductive to apply another energy pulse to the capacitor 52.

A pair of series connected diodes 82 and 84 are connected between the base and emitter electrodes of transistor 42 and serves as reference potential means for the forward voltage drop between the base and emitter of transistor 42 to prevent damage thereto during normal operating conditions. Also, a diode 86 has its anode connected to the emitter electrode thereof. During the collapse of the magnetic field within transformer 44, and substantially immediately thereafter, the diode 86 is forward biased to dampen any tendencies of self-sustained oscillations within the blocking oscillator circuits and provides backswing limiting in such a fashion that the repetition rate and duty cycle of the single swing blocking oscillator are not materially affected.

In accordance with this invention This ignition system 10 includes the controlled oscillator circuit 88 to provide a plurality of auxiliary trigger pulses to the gate electrode of silicon-controlled rectifier 56 immediately after the prescribed scheduled pulse has been applied thereto by the opening of breaker-point assembly 40. The controlled oscillator 88 includes an inductance element, here being illustrated as the primary winding 90*a* of a coupling transformer 90, which receives an oscillator start signal from the emitter electrode of transistor 42. This oscillator starting signal is coupled to the inductance element to provide a rapidly increasing magnetic field therein, and after termination of the start signal the inductance element operates at the natural frequency of the blocking oscillator for a period of time determined by the control circuit. In the illustrated embodiment the oscillator start signal from transistor 42 is coupled by means of a resistor 92 and a diode 94.

The transformer 90 has a secondary winding 90*b* which may have any suitable turns ratio relative to the primary winding 90*a* but is preferably in the order of a one-to-one ratio with respect to the primary winding 90*a*. The secondary winding 90*b* is coupled to the gate electrode of silicon-controlled rectifier 56 by any suitable means to apply auxiliary trigger pulses thereto, this coupling being herein illustrated as a resistor 96 and a diode 98.

To disable the controlled oscillator 88 during normal running conditions of the automobile engine a current control device is provided to short circuit the output portion of the controlled oscillator when normal operating potential is applied to line 38. One means of accomplishing this disabling function is to utilize the transistor 100 connected in parallel with the secondary winding 90*b* with the base electrode of transistor 100 connected to line 38 through a resistor 102 and a reference voltage device 104. The reference voltage device may be a zener diode which has a breakover voltage sufficient, when considered with the other resistance in series therewith, to be rendered conductive when 12 volts or more is sensed at line 38 to forward bias the transistor 100 which, in turn, when in its low-resistance condition shunts the secondary winding 92*b*. The substantially short circuit condition across the secondary winding 90*b* is reflected to the primary winding 90*a* to terminate oscillations of the controlled oscillator. However, during the starting sequence of the engine, with the engine-starting circuit 35 energized and heavy current flow being drawn from the battery 20, the voltage at line 38 is reduced by 2 to 4 volts. Therefore, the voltage at line 38 will be between 8 and 10 volts thus causing a current blocking condition of the reference voltage device 104 to render transistor 100 nonconductive. During this condition, oscillations generated within the primary winding 90*a* are transformer coupled to the secondary winding 90*b* and therefrom delivered to the gate electrode of silicon-controlled rectifier 56. After the engine has started running the engine starting circuit 35 is deenergized and the voltage on line 38 increases to the normal battery voltage and the reference voltage device 104 is rendered conductive to disable the controlled oscillator circuit by causing conduction of transistor 100.

A novel feature of this invention is the provision of means to control the number of auxiliary trigger pulses following the scheduled pulse which is inversely proportional to the voltage on line 38 during the starting sequence of the engine. That is, the normal voltage value of 12 volts on line 38 will exceed the breakover voltage value of the reference voltage device 104 and apply a charge on a capacitor 106. However, when the voltage on line 38 decreases during the starting sequence capacitor 106 discharges from its previous voltage level to the voltage level on line 38 through the forward bias direction of the reference voltage device 104. The reduction of voltage charge on capacitor 106 is sufficient to render transistor 100 inoperative. Capacitor 106 is shunted by a resistor 108 and together therewith forms an RC time constant sufficient to allow capacitor 106 to receive energy pulses from the primary winding 90*a* of transformer 90 during oscillations thereof. That is, each oscillatory pulse generated within the primary winding 90*a* has a half-cycle of a given polarity thereof delivered to capacitor 106 through a diode 110 and a resistor 112. The repetition rate of the pulses applied through 110 and 112 is sufficiently high, as compared to the RC time constant of capacitor 106, resistor 108, and resistor 102, to allow capacitor 106 to charge ultimately to a value rendering transistor 100 conductive. FOr example, if the battery 20 is a fully charged battery in proper operating condition the voltage drop at line 38 during the starting sequence will be less than the voltage drop when the battery 20 is not fully charged or is in poor operating condition. Therefore when a good battery is used it would take fewer pulses through diode 110 and resistor 112 to charge capacitor 106 and render transistor 100 conductive to disable the controlled oscillator 88. This will cause a given number of auxiliary pulses to be applied to the gate electrode of silicon-controlled rectifier 56. However, when the battery 20 is in poor operating condition the number of auxiliary pulses are automatically increased by the fact that the initial charge on capacitor 106 is reduced and the number of pulses from primary winding 90*a* required to raise the charge on capacitor 106 to a level sufficient to render transistor 100 conductive is increased. Therefore, the number of auxiliary trigger pulses applied to gate electrode of silicon-controlled rectifier 56 when the battery 20 is in poor operating condition is increased to further increase the ability of the engine to start running during the starting sequence.

Once the engine has started running the engine starting circuit **35** is deenergized and the voltage potential at line **38**, because of the decreased current draw from battery **20** and because of the output of alternator **30** and voltage regulator **32**, increases to the normal voltage value of 13 to 15 volts to cause breakover of the voltage reference device **104** to bias transistor **100** to a conductive condition thereby automatically disabling the controlled oscillator circuit **88**.

Therefore, the present invention provides means automatically to apply auxiliary trigger pulses to an electronic ignition system during the starting sequence of an automobile engine to increase the starting properties of the engine, and means for automatically disabling the auxiliary pulses once the engine has started running.

We claim:

1. An ignition system for an internal combustion engine for applying a spark producing voltage to the primary windings of an ignition coil to generate a spark discharge between spaced-apart electrodes associated with the secondary winding of the ignition coil in synchronization with external pulse information, comprising:

a power source;

storage means for receiving and storing electrical energy; an energy pulsing circuit coupled between said power source and said storage means to apply a pulse of energy to said storage means after a previous pulse of energy has been dissipated therefrom;

a triggering circuit coupled to said energy pulsing circuit for initiating operation thereof in response to said external pulse signal information to produce a scheduled spark discharge at desired electrodes associated with the ignition coil; circuit means coupled between said energy pulsing circuit and said triggering circuit to receive an initiating signal from said energy pulsing circuit for initiating operation of said circuit means to develop auxiliary trigger pulses subsequent to the scheduled spark discharge; and output coupling means connected between said circuit means and said triggering circuit to apply the auxiliary trigger pulses thereto at a repetition rate greater than the repetition rate of the external pulse signal information during a staring sequence of the internal combustion engine to apply a series of high-voltage spark discharges between the spaced-apart electrodes immediately following said scheduled spark discharge and continuing until said circuit means is rendered inoperative before the next external pulse signal is applied to said triggering circuit to produce a next scheduled spark discharge.

2. The ignition system of claim **1** wherein said energy pulsing circuit includes a transistor and a step-up transformer forming a single swing blocking oscillator, and a kickback pulse generated during operation of the single swing blocking oscillator is coupled to said circuit means to develop said initiating signal and charging means associated with said circuit means to accumulate said kickback pulses ultimately to disable said circuit means.

3. The ignition system of claim **1** including a threshold voltage device connected between said power source and said circuit means, said threshold voltage device being rendered conductive when the voltage value of the power source is a normal voltage value thus disabling said circuit means, and said threshold voltage device being rendered nonconductive when the voltage value of said power source is below its normal voltage value to render said circuit means operative to produce said auxiliary trigger pulses during the starting sequence of the internal combustion engine.

4. The ignition system of claim **1** including a transformer having primary and secondary windings, a current control device having load electrode connected across the secondary winding of said transformer, and a control electrode coupled to said power source to disable the output of said secondary winding during normal voltage value conditions of said power source and to allow the output of said secondary winding to be delivered to said trigger circuit when the voltage value of said power source is below its normal voltage value.

5. The ignition system of claim **4** further including a threshold voltage device connected between the control electrode of said current control device and said power source.

6. The ignition system of claim **4** including a charging circuit coupled to the control electrode of said current control device, said charging circuit receiving portions of each oscillation of the controlled oscillator, ultimately to charge to a value sufficient to render said current control device conductive to disable said controlled oscillator after a given number of cycles of operation thereof.

7. The ignition system of claim **6** including means connected between said charging circuit and said power source to apply an initial charge in said charging circuit indicative of the voltage value of said power source, and the number of pulses applied to said charging circuit from said controlled oscillator being inversely proportional to the voltage value of said power source during the engine's starting sequence of the internal combustion engine to provide a greater number of pulses at the output of said controlled oscillator for low-voltage conditions of said power source and a lesser number of pulses at the output of said controlled oscillator for an increased voltage of said power source.

8. The ignition system of claim **1** wherein said circuit means include a charging circuit for receiving portions of each auxiliary trigger pulse produced therein ultimately to charge to a turn off value which cuts short the number of auxiliary trigger pulses produced by said circuit means.

9. The ignition system of claim **1** wherein said circuit means includes a threshold voltage device connected to said power source for sensing a reduced voltage value of said power source to enable operation of said circuit means, and to sense a normal voltage value of said power source to disable said circuit means.

10. The ignition system of claim **1** wherein said circuit means includes a transformer having a primary winding to receive said starting signal, said primary winding forming the inductance of a controlled oscillator, said transformer having a secondary winding for receiving the oscillations in said primary winding to apply such oscillations in the form of auxiliary trigger pulses to said triggering circuit;

a transistor having its load electrodes connected across said secondary winding and its control electrode coupled to said power source;

a zener diode connected between said control electrode of said transistor and said power source to render said transistor conductive and disable said controlled oscillator during normal voltage value condition of said power source and to render said transistor nonconductive to allow operation of said controlled oscillator when the voltage value of said power source is below its normal voltage value; and

a charging capacitor connected to said control electrode of said transistor, said charging capacitor receiving a portion of each oscillation of said controlled oscillator, ultimately to charge to a value sufficient to render said transistor conductive to disable said controlled oscillator after a given number of cycles of operation.

* * * * *