

Dec. 13, 1966

A. SCHNEIDER ET AL

3,291,108

TRANSISTOR IGNITION

Filed Jan. 8, 1964

3 Sheets-Sheet 1

FIG. 2.

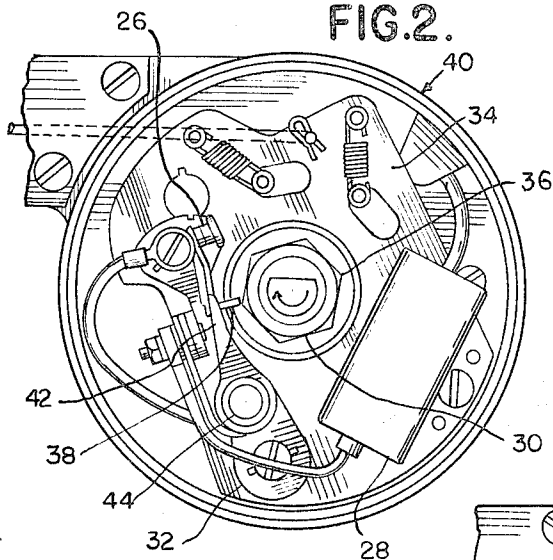


FIG. 1.

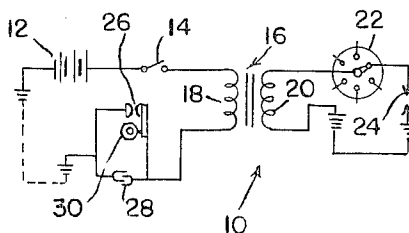


FIG. 4.

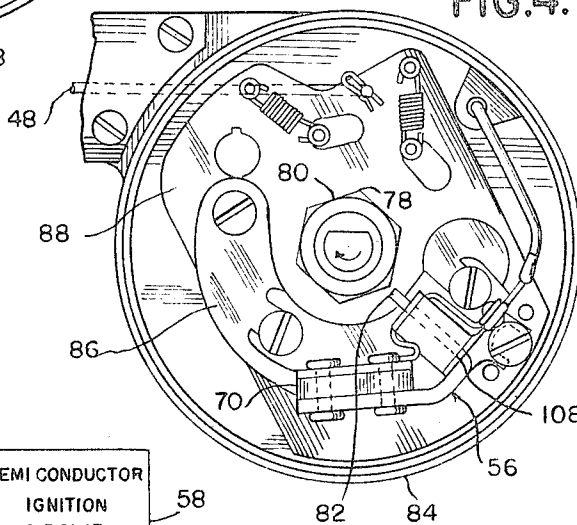
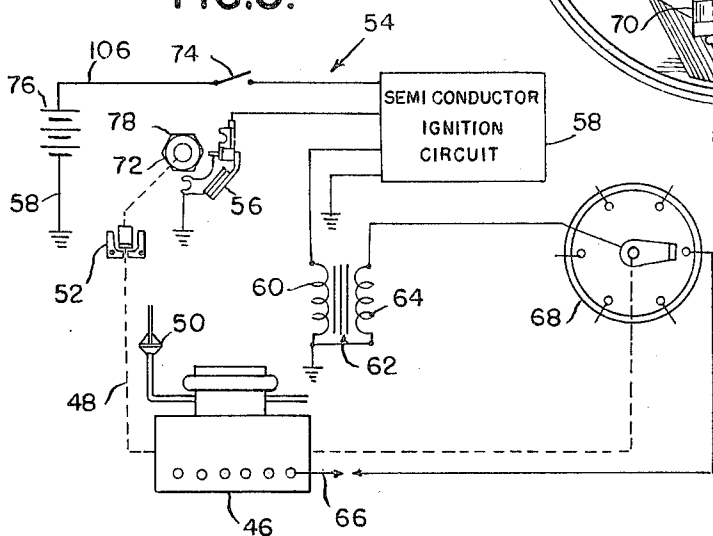


FIG. 3.



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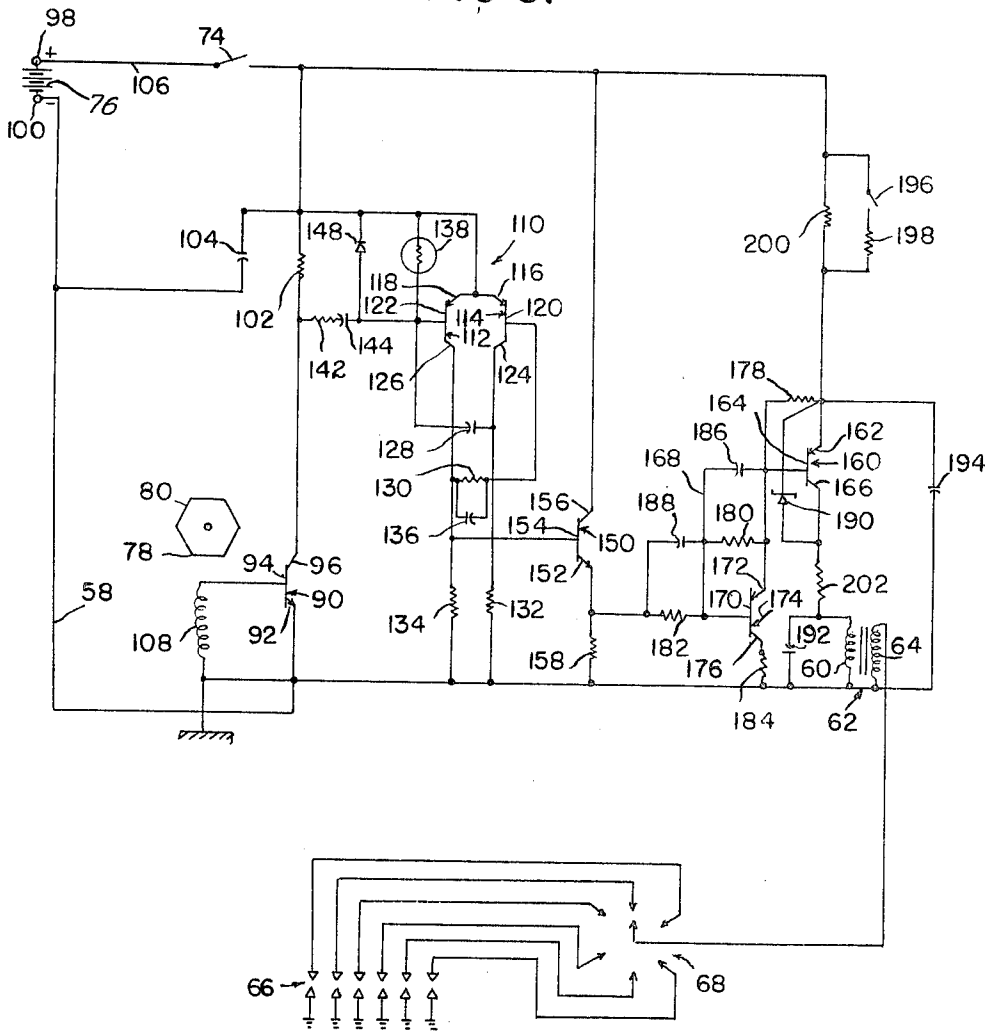
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FIG. 5.



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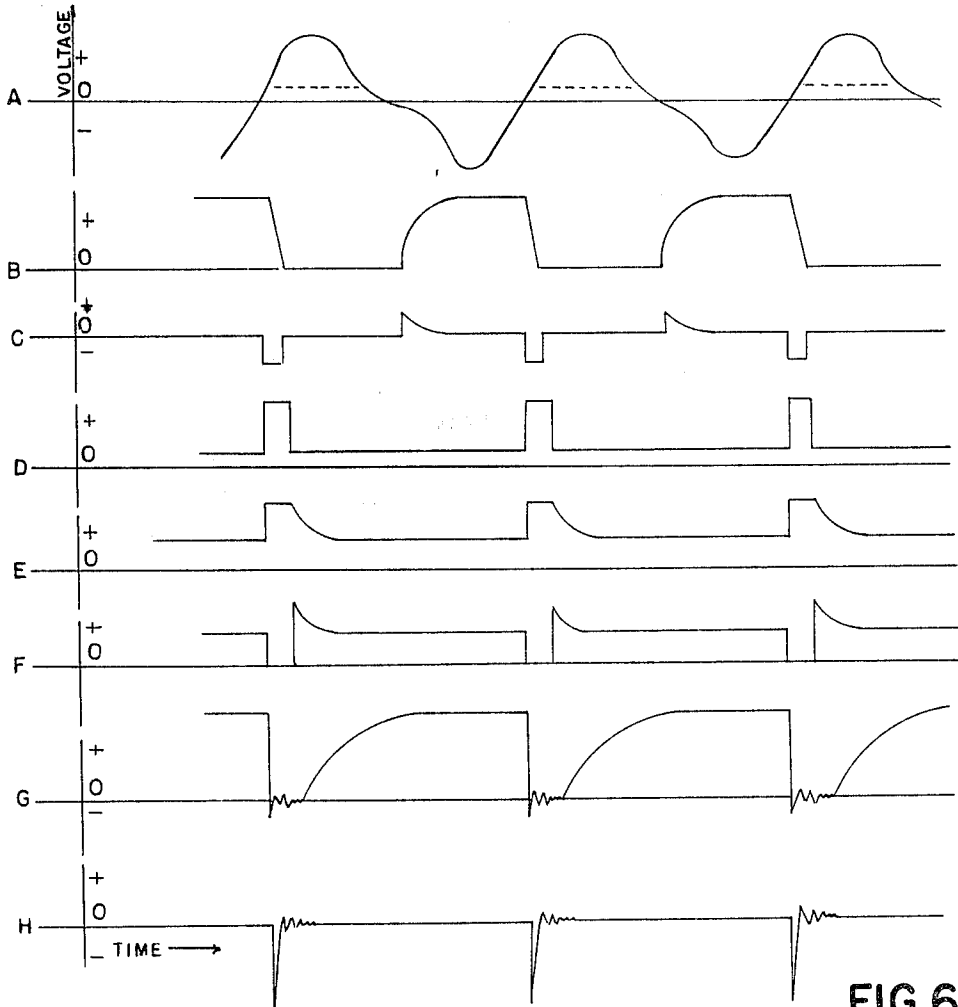
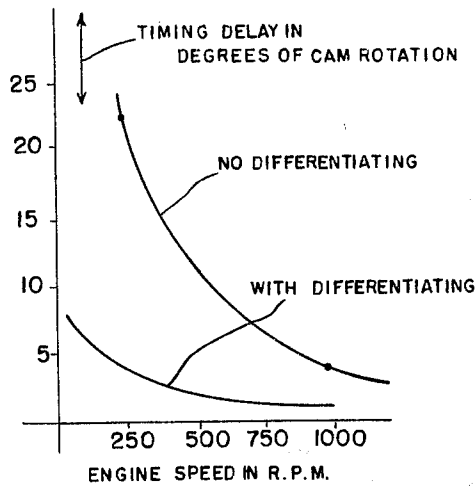


FIG.6.

FIG.7.



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3,291,108

TRANSISTOR IGNITION

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Filed Jan. 8, 1964, Ser. No. 336,418

13 Claims. (Cl. 123—148)

The invention relates to ignition systems including semi-conductors such as transistors and refers more specifically to a pulsed semi-conductor breakerless ignition system which may be installed or retrofitted as a conversion of the usual ignition system of an existing internal combustion engine so that the existing distributor cam may be used in combination with a magnetic pulse producing device to provide ignition timing.

The usual internal combustion engine ignition system including a rotary distributor cam and breaker points has inherent disadvantages in that during the constant making and breaking of the circuit through the primary ignition coil by separating the breaker points millions of times during running of the engine to which the ignition system is attached arcing occurs to burn away the breaker points. A further objection to the usual ignition system lies in the fact that it is inherently limited in current carrying capacity due to rapid deterioration of the points when switching high current.

In addition the rubbing block associated with the breaker points and the point mounting lever pivot mounting in the usual ignition system are subject to wear which causes considerable variance in point operation timing. Also, the usual ignition system is limited in efficiency at high engine speed since contact bounce non-uniformly reduces the dwell time of the contacts and the spark timing it materially different at the high engine speed.

Semi-conductor ignition systems of the type disclosed in the Kerr Patent No. 3,020,904 have been developed to overcome some of the indicated difficulties in the usual internal combustion engine ignition system. Ignition systems, such as that of Kerr, do not however entirely overcome breaker point deterioration or diminish rubbing block wear. Moreover, when an engine equipped with a Kerr type system shuts down with the contacts open, a thin oxide film can form on the contacts which is sufficient to interfere with the passage of the small current passing through these contacts and results in erratic switching of the transistor which switches the heavy coil current.

Pulsed semi-conductor ignition systems have therefore been developed, such as indicated in the Johnson Patent No. 2,852,584, which use no breaker points or breaker point mounting lever. The pulsed semi-conductor ignition systems developed have made use of magnetic pulse producing devices and timing wheels usually in conjunction with specially constructed distributors.

Prior pulsed semi-conductor ignition systems have however been complicated, expensive and often inefficient. In addition these prior ignition systems are particularly unsuited to converting or retrofitting existing internal combustion engines with a semi-conductor ignition system, since the known semi-conductor ignition systems usually make use of special magnetic pulse producing devices which are too large to be fitted into an existing distributor.

It is therefore one of the purposes of the present invention to provide an improved semi-conductor ignition system.

Another object is to provide a semi-conductor ignition system for converting or retrofitting existing internal combustion engines.

Another object is to provide a pulsed semi-conductor ignition system for converting or retrofitting existing internal combustion engines using the unmodified existing distributor cam to provide a timing pulse.

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Another object is to provide a pulsed semi-conductor ignition system for converting retrofitting existing internal combustion engines using the unmodified existing distributor cam to provide a timing pulse.

Another object is to provide a semi-conductor ignition system for an internal combustion engine including means for providing more nearly constant operating voltage over the speed range of the engine.

Another object is to provide a semi-conductor ignition system for converting or retrofitting an existing internal combustion engine requiring only a single wire leading from the existing distributor.

Another object is to provide a semi-conductor ignition system for an internal combustion engine having improved regulation of spark time over the speed range of the engine.

Another object is to provide a semi-conductor ignition system including a semi-conductor ignition circuit for permitting ignition operation with particularly low timing voltages.

Another object is to provide a semi-conductor ignition circuit including means for reducing ignition timing interference to a minimum.

Another object is to provide a semi-conductor ignition circuit including a switching semi-conductor and means for decreasing the switching time of the switching semi-conductor to reduce the energy dissipated thereby.

Another object is to provide a semi-conductor ignition circuit including a switching semi-conductor and means for protecting the switching semi-conductor from reverse voltage overload.

Another object is to provide a semi-conductor ignition circuit for an internal combustion engine including a magnetic pulse producing device operable in cooperation with the usual ignition distributor cam to produce ignition timing pulses, a monostable multivibrator energized by the ignition timing pulses and a switching semi-conductor responsive to the operating state of the multivibrator to switch the primary coil current of the ignition circuit off for a predetermined time at intervals depending on engine speed.

Another object is to provide a semi-conductor ignition circuit as set forth above wherein an amplifier and a differentiating network are provided between the magnetic pulse producing device and the multivibrator.

Another object is to provide a semi-conductor ignition circuit as set forth above wherein the multivibrator is compensated to produce particularly fast switching thereof.

Another object is to provide a semi-conductor ignition circuit as set forth above wherein the multivibrator is temperature compensated to provide more uniform ignition operation over a large range of temperatures.

Another object is to provide a semi-conductor ignition circuit as set forth above wherein an emitter follower is provided between the multivibrator and the switching semi-conductor to isolate the timing portion of the ignition circuit from circuit load changes.

Another object is to provide a semi-conductor ignition circuit as set forth above wherein a driver amplifier is provided for the switching semi-conductor.

Another object is to provide a semi-conductor ignition circuit as set forth above including means for decreasing the switching time of the switching semiconductor.

Another object is to provide a semi-conductor ignition system which is simple in construction, economical to manufacture and efficient in use.

These and other objects and features of the invention will become apparent as the description proceeds, especially

reference to the drawings and the following description of the preferred embodiment of the invention.

FIG. 1 is a schematic diagram of the ignition system of the invention.

cially when taken in conjunction with the accompanying drawings illustrating a preferred embodiment of the invention, wherein:

FIGURE 1 is a partly schematic, partly diagrammatic illustration of the usual ignition system of an internal combustion engine.

FIGURE 2 is a diagrammatic top view of a typical distributor used in the usual ignition system illustrated in FIGURE 1.

FIGURE 3 is a partly schematic, partly diagrammatic illustration of a semi-conductor ignition system constructed in accordance with the invention for converting or retrofitting an existing internal combustion engine.

FIGURE 4 is a diagrammatic top view of a distributor similar to that illustrated in FIGURE 2 converted or retrofitted with the necessary members of the semi-conductor ignition system illustrated in FIGURE 3.

FIGURE 5 is a schematic diagram of the semi-conductor ignition circuit of the semi-conductor ignition system illustrated in FIGURE 3.

FIGURE 6 illustrates the voltage wave shapes present at different points in the semi-conductor ignition circuit illustrated in FIGURE 5.

FIGURE 7 is a graph illustrating the advantage of providing the differentiating circuit illustrated in FIGURE 5 in a semi-conductor ignition circuit constructed in accordance with the invention.

With particular reference to the figures of the drawings, one embodiment of the present invention will now be considered in detail.

The usual internal combustion engine ignition system 10, illustrated in FIGURE 1, includes the battery 12, switch 14, ignition coil 16 including the primary winding 18 and secondary winding 20, a distributor including a rotor assembly 22 connected to a plurality of spark plugs 24 only one of which is indicated and distributor cam 30, breaker point assembly 32 including lever 42 and breaker points 26 and condenser 28 connected substantially as shown in FIGURE 1. In operation the cam 30 and breaker points 26 provide periodic breaking of the circuit through primary winding 18 of coil 16 in response to rotation of cam 30 to produce a decaying electric signal in the primary winding 18 of coil 16. The decaying electric signal in the primary winding 18 of coil 16 produces an electric signal in the secondary winding 20 of coil 16 which is distributed to the spark plugs 24 by the distributor rotor assembly 22.

In assembly the breaker point assembly 32, condenser 28 and distributor cam 30 appear as shown in FIGURE 2 in the usual ignition system distributor such as that disclosed in the Larges Patent No. 3,062,929. As shown in FIGURE 2, the breaker point assembly 32 is mounted on an angularly adjustable breaker plate 34. In operation each time a lobe 36 of distributor cam 30 rotates past the rubbing block 38, the breaker points 26 are caused to open due to rotation of the lever 42 as is well understood to break the circuit through the primary winding of the ignition coil.

As pointed out above, during relatively short operation of an internal combustion engine, the opening and closing of breaker points 26 occurs many hundreds or thousands of times. During such operation the rubbing block is subject to wear as is the pivot mounting means 44 for the lever 42. Thus the open time of the contacts, as well as the time of opening thereof, varies with engine use.

Further the current handling capacity of an ignition system, such as that illustrated in FIGURES 1 and 2, is limited by burning of the points 26 through arcing during operation. The existing ignition systems therefore require frequent maintenance including tune-ups in which the breaker point assembly 32 is replaced.

In accordance with the invention and as indicated in commonly owned copending patent applications, Ser. No. 309,790, filed September 18, 1963, and Ser. No. 312,535, filed September 30, 1963, an existing internal combustion

engine 46 driving a distributor cam through connection 48 and in combination with the usual battery 76, switch 74, ignition coil 62, distributor rotor assembly 68 and spark plugs 66 and the usual engine manifold vacuum and centrifugal distributor spark advance structures 50 and 52 may be converted or retrofitted to provide the pulsed semi-conductor ignition system 54, illustrated in FIGURE 3. In the converted or retrofitted semi-conductor ignition system 54 the breaker points are replaced by a magnetic pulse producing device 56 and a semi-conductor ignition circuit 58. The function of the semi-conductor ignition circuit 58 is to switch off current through the primary winding 60 of the ignition coil 62 to induce periodic high voltages in the ignition coil secondary winding 64 which are distributed to spark plugs 66 through the distributor rotor assembly 68 as before.

While the semi-conductor ignition circuit 58 may be used with the usual breaker points, or pulse producing devices and special distributor cams, as shown in FIGURE 3, a magnetic pulse producing device 56 including the magnet 70, core 82 and coil 108 is used in conjunction with the usual distributor cam 72 to provide the electric pulses necessary to cause the semi-conductor ignition circuit 58 to switch off the current to the primary winding 60 of the coil 62.

As shown in FIGURE 4, the magnetic pulse producing device 56 for producing a pulse of electric energy each time a lobe 78 of the usual distributor cam 80 passes the core member 82 is mounted in the distributor 84 which is similar to the distributor 40. In converting or retrofitting the distributor 40, the breaker point assembly 32 is removed from breaker plate 34 shown in FIGURE 2, and the magnetic pulse producing device 56 is mounted on the breaker plate 88 shown in FIGURE 4 so that the core member 82 is in close proximity to the usual distributor cam 80. The retrofitting of the internal combustion engine 46 is then completed by making the connections illustrated in FIGURE 3 between the usual ignition switch 74, the magnetic pulse producing device 56, the primary winding 60 of the ignition coil 62, the semi-conductor ignition circuit 58 and ground. It will also be understood that a system embodying the invention could be positive or negative ground, or ungrounded.

Particular conversion or retrofitting breaker plates for mounting the pulse producing device 56 and special cam structures secured to the usual distributor cams are considered in detail in the above referenced commonly owned patent applications together with special pulse producing devices. These structures will therefore not be discussed in detail herein.

It is preferable however to provide a particular semi-conductor ignition circuit 58 for use in the semi-conductor ignition system 54 illustrated in FIGURE 3 due to the necessarily small electric pulse provided by the magnetic pulse producing device 56 in conjunction with the usual distributor cam, the rise of which pulse may be particularly gradual. The semi-conductor ignition circuit 58 which permits the use of a small magnetic pulse producing device 56 in a pulsed type semi-conductor ignition system 54 and thus permits converting or retrofitting of existing internal combustion engines with a semi-conductor ignition system without supplying a new distributor and using other than the usual distributor cam in conjunction with the magnetic pulse producing device is shown best in FIGURE 5.

In the negative ground system shown, the semi-conductor ignition circuit 58 includes a semi-conductor amplifier 90 having emitter, base and collector elements 92, 94 and 96 respectively. The emitter and collector elements 92 and 96 of amplifier 90 are connected in series between the opposite terminals 98 and 100 of the battery 76 through the load resistance 102, conductor 106 and conductor 58 having ignition switch 74 therein. The emitter and base elements of the amplifier 90 are connected to the

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opposite ends of the coil 108 of the magnetic pulse producing device 56.

The capacitor 104 which is provided across the terminals 98 and 100 of the battery 76 is for stabilizing the battery voltage against transient conditions. Capacitor 104 is preferably a low dissipation, high capacity tantalum capacitor.

Thus the relatively small electric pulses developed in the magnetic pulse producing device 56 as the distributor cam 72 rotates due to the lobes 78 on the cam 80 coming close to the core 82 of the pulse producing device are amplified through the amplifier 90 to produce a relatively slow rising and falling electric signal across the load resistance 102 of amplifier 90.

The voltage wave form produced across the emitter and base elements of semi-conductor 90 which is the input signal to the transistor ignition circuit 58 from the magnetic pulse producing device 56 is as illustrated in FIGURE 6, Graph A wherein voltage is plotted against time with each cycle illustrated representing sixty degrees of rotation of distributor cam 72. The corresponding wave shape across the emitter and collector elements of the transistor 90 are illustrated in FIGURE 2, Graph B.

The signal from amplifier 90 is differentiated, in a manner to be described, and used to trigger a monostable multivibrator 110 which produces a timing signal for actuating the switching semi-conductor 160 to cut off current through primary winding 60 of ignition coil 62 for a predetermined length of time. The multivibrator 110 includes the two relatively small semi-conductors 112 and 114 having emitter elements 116 and 118, base elements 120 and 122 and collector elements 124 and 126 respectively.

As illustrated, the collector element 124 of semi-conductor 120 is connected to the base 122 of semi-conductor 112 through the capacitor 128 which controls the on time of semi-conductor 112. The collector 126 of semi-conductor 112 is in turn connected through a resistance 130 to the base element 120 of the semi-conductor 114. Normally-on semi-conductor 114 is in a low gain circuit with load resistor 132 while normally-off semi-conductor 122 is in a high gain circuit with the load resistor 134. The switching time of the multivibrator 110 is enhanced due to the positioning of the capacitor 136 in parallel with the resistance 130.

A thermistor 138 is positioned across the emitter base circuit of semi-conductor 112 to stabilize the multivibrator 110 which would otherwise have a tendency to oscillate or become a free running multivibrator at high temperatures. The thermistor lowers the gain of the semi-conductor 112 at higher temperatures. The thermistor 138 thus provides more constant operating characteristics of the semi-conductor ignition circuit 58 over a broad temperature range to provide easier cold starting of engine 46 than would be possible without thermistor 138.

Because the rise time of the current in resistor 102 is relatively long at slow engine speeds the consequent slow revolution of the distributor cam 72 and is considerably faster during high speed operation of the engine 46 and cam 72, the time at which the signal presented across the emitter base of semi-conductor 112 is of a magnitude to trigger the multivibrator 110 to its unstable condition would vary objectionably.

For example, if a zero time reference is considered at which no current flows through resistor 102, at a thousand revolutions per minute of the engine 46, the time in terms of degrees of rotation of the cam 72 before the current across the resistor 102 is sufficient to trigger the multivibrator 110 may be four degrees while at 250 revolutions per minute of the engine 46, this time in terms of degrees may have varied to twenty-two and one-half degrees as illustrated best in FIGURE 7 in which engine revolutions per minute are plotted against timing delay in terms of cam angle.

Obviously, it is desired to minimize the difference in

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time required to trigger the multivibrator at different engine speeds so that the timing of the engine may be more constant throughout its speed range and thus require less exterior compensation such as vacuum and centrifugal advance structures 50 and 52 on the distributor. Therefore, in accordance with the present invention and as shown in FIGURE 5, a differentiating circuit 140 including the resistor 142, the differentiating capacitor 144, the diode 148 and a resistor or thermistor 138 is provided between the amplifier 90 and the multivibrator 110.

In operation of the differentiating circuit, the initial current drawn by the amplifier 90 will be primarily through the emitter base circuit of the semi-conductor 112 and the thermistor in parallel with the emitter base circuit of semi-conductor 112 to produce charging of the capacitor 144 as limited primarily by the value of the time constant of the differentiating circuit 140. The differentiated signal developed from the signal across the load resistor 102 of amplifier 90, as shown in FIGURE 6, Graph C, is used to trigger the multivibrator 110 at a much earlier time at lower speeds than would be possible without the inclusion of the differentiating circuit 140 and amplifier 90 in semi-conductor ignition circuit 58. The trigger time with respect to the angular position of cam 72 is thus more nearly the same regardless of engine speed, as shown in FIGURE 7. Diode 148 merely provides a discharge path for the differentiating capacitor 144.

The output from the multivibrator 110 is taken from the high gain side thereof across the load resistor 134 and is fed to a semi-conductor 150 having emitter, base and collector elements 152, 154 and 156 respectively connected in an emitter follower circuit with the load resistor 158 as shown in FIGURE 5. The emitter follower circuit including the semi-conductor 150 is connected across the terminals of the battery 76 as are the amplifier 90 and multivibrator 110.

The wave shape of the signal out of the multivibrator across the load resistor 134 and the wave shape of the signal out of the emitter follower circuit across the load resistor 158 is as illustrated in FIGURE 6, Graphs D and E respectively. The emitter follower circuit isolates the multivibrator so that noise and changes in the load impedance in the ignition circuit after the multivibrator 110 does not significantly change the operating characteristics of the multivibrator 110. Thus, as shown in FIGURE 6, the switching signal from multivibrator 110 is of a constant duration without regard to engine speed whereby a more constant voltage is applied to spark plugs 66 over the speed range of engine 46.

The output signal of the emitter follower could be fed directly across the emitter base circuit of the switching semiconductor 160 having emitter, base and collector elements 162, 164 and 166 respectively. However, it is desired to cause switching of the switching semiconductor 160 at a particularly rapid rate to reduce the energy dissipated in the switching semi-conductor so that the switching semi-conductor will have a greater safety factor or a smaller cheaper switching semi-conductor may be used. Thus, a compensating circuit 168 is provided between the emitter-follower output and the emitter-base input of the switching semi-conductor 160.

The compensating circuit 168 includes the driving semi-conductor 170 connected in an amplifying circuit and including the emitter 172, base 174 and collector 176, the resistors 178, 180, 182 and 184 and the capacitors 186 and 188 connected as shown in FIGURE 5. Since the additional semi-conductor 170 is employed a lower gain less expensive switching semi-conductor 160 can be used.

In operation of the compensating circuit 168, the base current for the normally conducting switching semi-conductor 160 passes through the emitter base circuit of the semi-conductor 160 and through the emitter-collector circuit of the driver amplifier 170. The emitter-base current of the normally conducting driver amplifier 170 passes through the emitter-base circuit of semi-conductor

160 in conjunction with the parallel resistance 178, through the emitter-base circuit of semi-conductor 170 in parallel with resistor 180 and through the series resistors 182 and 158.

In operation during the off time of the emitter-follower circuit when the low gain side of the multivibrator 110 is conducting the semi-conductor 160 is conducting emitter-collector current and current is flowing in the primary winding of the ignition coil 62. In addition emitter-base current is flowing in switching semi-conductor 160 and both emitter-base and emitter-collector current is flowing in amplifier 170 so that the capacitors 186 and 188 charge in a direction which will provide a negative bias across the emitter-base junction of the switching semi-conductor 160 to dissipate the stored charge found thereon and complete turning off of the semi-conductor 160 at a substantially earlier time than would otherwise occur on conduction of the normally non-conducting emitter-follower 150 in response to conduction of the high gain side of multivibrator 110 and consequent switching off of driver amplifier 170 and switching semi-conductor 160.

When the multivibrator 110 is triggered to provide an output signal to the emitter-follower circuit the signal across resistor 158 in the emitter-follower circuit biases the driver amplifier 170 into an off condition which similarly biases the switching semi-conductor 160 into an off condition to halt the flow of current through the resistor 202 and the primary winding 60 of the ignition coil 62.

At this time capacitors 186 and 188 which have been charged during conduction of amplifier 170 and semi-conductor 160 are permitted to discharge through the extremely low impedance of the conducting emitter-follower semi-conductor 150 to reversely bias the emitter-base circuit of the switching semi-conductor 160 to increase the speed with which the semi-conductor 160 is switched off due to removing the stored charge therefrom.

Capacitor 194 is included to hold the voltage on the emitter of switching semi-conductor 160 substantially constant with respect to battery 76 during switching off of semi-conductor 160 so that the compensation thereof with the reverse bias on the emitter-base circuit may be accomplished.

It will be understood that a single resistor and capacitor, such as capacitor 186 and resistor 180 may be connected between the base element of the switching semi-conductor 160 and the emitter of the emitter-follower semi-conductor 150 to provide compensation for the switching semi-conductor 160. Further additional driver amplifiers, such as amplifier 170, and additional compensating capacitors and resistors may be provided if desired. Alternatively the driving amplifier 170 and all of the compensating resistors and capacitors may be deleted if desired. It will also be understood that the semi-conductor 150 and resistor 158 may be deleted and the resistor 182 directly connected to the collector 126, or the resistor 180 may be directly connected to collector 126. These alternatives are a matter of economy, it being apparent that use of presently more expensive high gain semi-conductors 160 and 112 would enable elimination of amplifier 170 and emitter-follower 150.

Further protection for the switching semi-conductor 160 is provided by means of the Zener diode 190 which prevents any current flow in a forward direction around the semi-conductor 160 and which prevents a reverse voltage of more than a predetermined amount across the switching semi-conductor in the usual manner of Zener diode.

Additional protection for the switching semi-conductor 160 against excessive energy dissipation due to the induced voltage in winding 60 of coil 62 while current is flowing in the semi-conductor 160 is provided by inclusion of the capacitor 192 in parallel with the primary winding 60 of the ignition coil 62. Thus, the rise time of the induced voltage will be in accordance with the resonant frequency of the inductance of winding 60 and capacitor

192 and will be lowered such that the semi-conductor 160 switches off while the voltage is still relatively low.

It will of course be understood that capacitors 192, 194, 186 and 188 may be eliminated from the semi-conductor ignition circuit 58 on elimination of the compensation and protection for the switching semi-conductor 160 provided thereby. In such case the switching semi-conductor should have larger energy dissipating and reverse break down voltage ratings than are necessary with the compensating and protection capacitors, which would increase cost.

Switch 196 is included in the circuit of the switching semi-conductor 160 to change the loading resistance provided by the loading resistors 198 and 200 during starting of the engine 46.

The output voltages across the resistor 202 in series with the primary winding 60 of the ignition coil 62 and the coil secondary spark voltage pattern for the semi-conductor ignition system 54 are as shown in FIGURE 6, Graphs G and H respectively.

Thus, one embodiment of a pulsed type semi-conductor ignition system has been disclosed which is particularly adapted but not necessarily limited to converting or retrofitting an existing internal combustion engine with a semi-conductor ignition while using the existing distributor and the original distributor cam. In particular, a specific semi-conductor ignition circuit including a switching semi-conductor which is compensated to increase the switching speed thereof and for safety against excessive reverse voltage and is timed by a monostable multivibrator triggered by a magnetic pulse producing device, the output of which is differentiated before it is fed to the multivibrator, has been detailed. The specific semi-conductor ignition circuit detailed permits the use of an extremely small pulse producing device in conjunction with the original distributor cam which is essential to simple economical and efficient converting or retrofitting of existing engines with semi-conductor ignitions.

While one embodiment of the invention has been considered in detail, it will be understood that other embodiments are contemplated. It is the intention to include all modifications of the invention as are defined by the appended claims within the scope of the invention.

What we claim as our invention is:

1. A pulsed semi-conductor ignition system which is breakerless in series with an ignition coil for converting a usual ignition system of an existing internal combustion engine having breaker points and a cam to a semi-conductor ignition system, which semi-conductor ignition system includes pulse producing means substituted for the breaker points and operated by the existing distributor cam connected to and driven by the engine in accordance with the speed thereof and an existing source of electric energy, and which ignition system is adapted to be connected between the existing source of electric energy, distributor and engine.

2. A semi-conductor ignition system for converting an existing internal combustion engine having an existing ignition system which existing ignition system includes a source of electric energy, an ignition coil including primary and secondary windings, spark plugs connected to said engine and distributor means including an existing distributor cam rotatable at a speed proportional to engine speed and a rotor assembly for distributing pulses of electric energy from the secondary winding of the ignition coil to the spark plugs, comprising semi-conductor switching means having emitter, base and collector circuits for completing an electric circuit from the source of electric energy through the primary winding of the ignition coil and for interrupting said circuit on switching thereof and a pulse producing device operably associated with the existing distributor cam for switching the switching means to periodically interrupt the circuit from the source of electric energy through the ignition coil primary winding in accordance with the speed of operation of the engine,

including a multivibrator connected across the source of electric energy, means for applying the output signal of the multivibrator to the bias circuit of the switching means for turning off the switching means in response to operation of the multivibrator in one operating condition and means for developing an electric signal from said existing distributor cam in accordance with the speed of the engine and for applying the developed electric signal to the multivibrator to trigger it into the one operating condition in accordance with engine speed.

3. Structure as set forth in claim 2 wherein the means for applying the output signal from the multivibrator to the bias circuit of the switching means includes an emitter follower semi-conductor circuit in parallel with the multivibrator across the source of electric energy having a base circuit connected to the side of the multivibrator having an output with the multivibrator operating in said one operating condition and an emitter follower output circuit connected to the base circuit of the semi-conductor switching means.

4. Structure as set forth in claim 3 and further including means for providing a reverse bias on the semi-conductor switching means during switching off of the semi-conductor switching means to reduce the switching time thereof.

5. Structure as set forth in claim 4 wherein the means for providing a reverse bias on the semi-conductor switching means comprises a capacitor and resistor connected in parallel and connected in series between the base circuit of the semi-conductor switching means and the output of the emitter follower circuit.

6. A semi-conductor ignition system for an internal combustion engine including a source of electric energy, an ignition coil including primary and secondary windings, spark plugs connected to said engine, distributor means including a distributor cam rotatable at a speed proportional to engine speed and a rotor assembly for distributing pulses of electric energy from the secondary winding of the ignition coil to the spark plugs, semi-conductor switching means having emitter, base and collector circuits for completing an electric circuit from the source of electric energy through the primary winding of the ignition coil and for interrupting said circuit on switching thereof and a pulse producing device operably associated with the distributor cam for switching the switching means to periodically interrupt the circuit from the source of electric energy through the ignition coil primary winding in accordance with the speed of operation of the engine, including a multivibrator connected across the source of electric energy, means for applying the output signal of the multivibrator to the bias circuit of the switching means for turning off the switching means in response to operation of the multivibrator in one operating condition and means for developing an electric signal from said distributor cam in accordance with the speed of the engine and for applying the developed electric signal to the multivibrator to trigger it into the one operating condition in accordance with engine speed.

7. Structure as set forth in claim 6 where the means for applying the output signal from the multivibrator to the bias circuit of the switching means includes an emitter follower semi-conductor circuit in parallel with the multivibrator across the source of electric energy having a base circuit connected to the side of the multivibrator having an output with the multivibrator operating in said one operating condition and a driver amplifier connected to the base circuit and across the collector circuit of the semi-conductor switching means and having a base circuit connected to the output of the emitter follower semi-conductor circuit.

8. Structure as set forth in claim 7 and further including means for providing a reverse bias on the semi-conductor switching means during switching off of the semi-conductor switching means to reduce the switching time thereof.

9. Structure as set forth in claim 8 wherein the means

for providing a reverse bias on the semi-conductor switching means comprises a capacitor and resistor connected in parallel and connected in series between the base circuit of the semi-conductor switching means and the output of the emitter follower circuit.

10. In a semi-conductor ignition circuit including an ignition coil having a primary and secondary winding, means for producing periodic electric pulses, a switching semi-conductor having a bias circuit for interrupting electric current through the primary winding of the ignition coil on switching thereof, switching means responsive to the electric pulses for switching the switching semi-conductor and a source of electric energy connected in series with the switching semi-conductor and the primary winding of the ignition coil; structure for providing reverse bias on the switching semi-conductor during switching thereof to decrease the switching time, comprising a resistor and capacitor connected in parallel with each other and in series with the bias circuit of the switching semi-conductor and a variable impedance between the resistor and capacitor in parallel and the emitter of the switching semi-conductor.

11. A semi-conductor ignition circuit for use in conjunction with an internal combustion engine or the like having the usual distributor and source of electric energy operably associated therewith, comprising an electromagnetic sensor positioned adjacent the usual distributor cam for developing electric pulses in accordance with the rotation of the distributor cam, an amplifier transistor having a collector emitter circuit connected across the terminals of the power supply, an ignition switch and a resistor in series with the collector emitter circuit of the amplifier transistor, said electromagnetic sensor being connected in bias circuit of the amplifier transistor, a multivibrator circuit including a pair of transistors having emitter-collector circuits in parallel with the emitter-collector circuit of the amplifier transistor, load resistors in series with the collectors of each of the multivibrator transistors, a differentiating circuit including a resistor and capacitor in series connecting the base of one of the multivibrator transistors to the collector of the amplifier transistor, a diode connected between the capacitor and one terminal of the source of electric energy for discharging of said differentiating circuit capacitor, temperature compensating means connected between the emitter and base of the one multivibrator transistor and a capacitor connected between the base of the one multivibrator transistor and the collector of the other multivibrator transistor and a capacitor and resistor in parallel connected between the base of the other multivibrator transistor and the collector of the one multivibrator transistor whereby the one multivibrator transistor is connected in a high gain temperature compensated circuit and the other multivibrator transistor is connected in a low gain circuit, an emitter follower transistor having an emitter collector circuit and a resistor in series connected in parallel with the multivibrator and having a base connected to the collector of the one multivibrator transistor, a switching transistor having an emitter collector circuit in series with a pair of resistors and the primary winding of the usual ignition coil connected in parallel with the emitter collector circuit of the emitter follower, a capacitor in parallel with the primary winding of the usual ignition coil, a capacitor connected between the emitter of the switching transistor and the other terminal of the source of electric energy, a Zener diode connected directly across the emitter collector circuit of the switching transistor, a resistor connected between the emitter of the switching transistor and the base thereof, a driver amplifier transistor having an emitter collector circuit and a resistor in series between the base of the switching transistor and the other terminal of the power supply, a capacitor and resistor in parallel connected between the base of the switching transistor and the base of the driver amplifier transistor and a second capacitor and resistor in parallel connected in series between the emitter of the emitter

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follower transistor and the base of the driver amplifier transistor.

12. A pulsed semi-conductor ignition system which is breakerless in series with an ignition coil for converting a usual ignition system of an existing internal combustion engine to a semi-conductor ignition system which ignition system is operable in conjunction with an existing distributor having an existing distributor cam which existing distributor is connected to and driven by the engine in accordance with the speed thereof and an existing source of electric energy, and which breakerless ignition system includes a magnetic pulse producing device positioned in juxtaposition to the existing distributor cam for providing pulses of electric energy to energize the ignition system in accordance with the speed of rotation of the existing distributor cam and which breakerless ignition system is adapted to be connected between the existing source of electric energy, distributor and engine.

13. A pulsed semi-conductor ignition system which is breakerless in series with an ignition coil for converting a usual ignition system of an existing internal combustion engine to a semi-conductor ignition system which ignition system is operable in conjunction with an existing distributor having an existing distributor cam which existing distributor is connected to and driven by the engine in accordance with the speed thereof and an existing

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source of electric energy, and which breakerless ignition system includes a pulse producing device positioned in juxtaposition to the existing distributor cam for providing pulses of electric energy to energize the ignition system in accordance with the speed of rotation of the existing distributor cam and which breakerless ignition system is adapted to be connected between the existing source of electric energy, distributor and engine.

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