

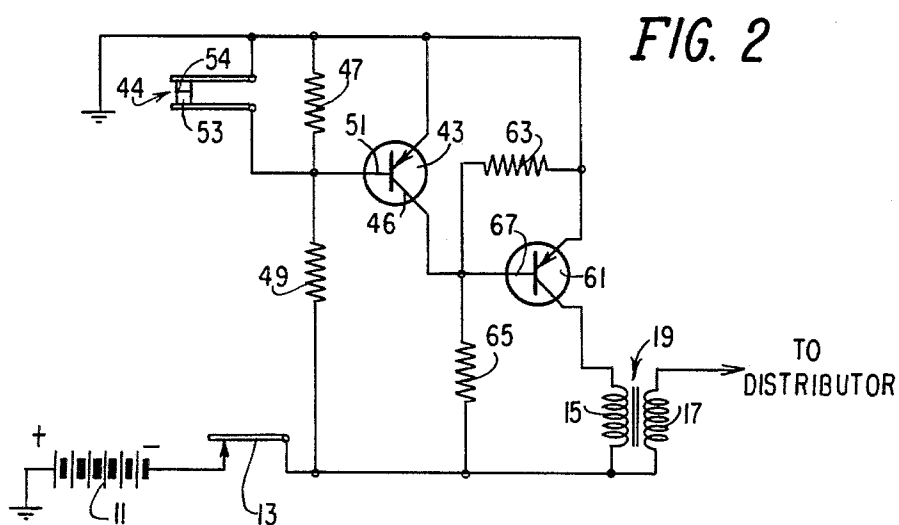
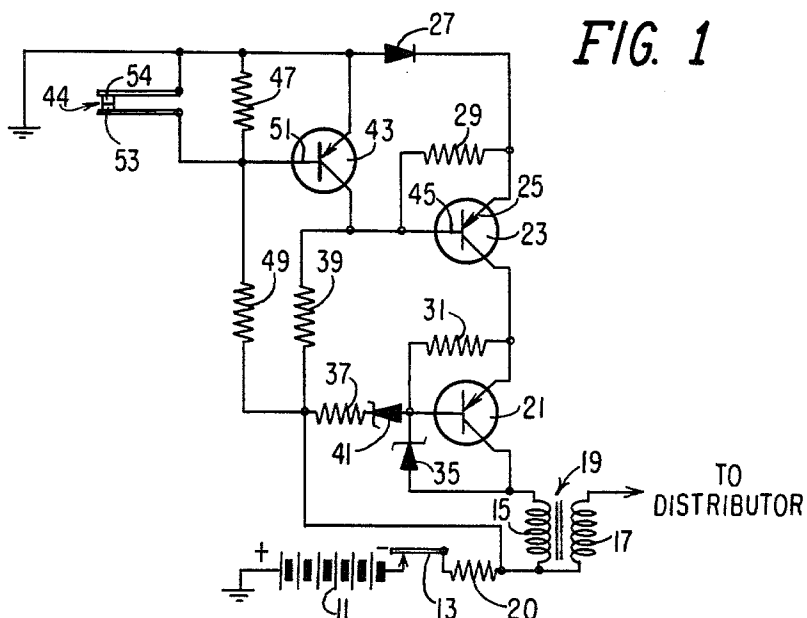
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ELECTRONIC CIRCUIT

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ELECTRONIC CIRCUIT

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This invention relates to ignition systems for internal combustion engines, and more particularly to a transistorized ignition system for an internal combustion engine having a positive ground electrical system.

In conventional ignition systems, a relatively large current is passed through a high voltage coil and interrupted by intermittently opening breaker points, thereby causing a large voltage to be developed across the coil and transmitted to the spark plugs. The voltage developed depends upon the breaking of the current applied to the induction coil.

One of the most frequent causes of trouble in conventional ignition systems, especially those used with automobile engines, is pitting, carbonizing and wear of the contacts of the breaker points. This occurs due to the interruption of high voltage and current which causes arcing across the points. Pitting, carbonizing and wear result in poor electrical contact and eventual failure of the system. Automobile users are normally required to replace the breaker points several times during the useful life of an automobile, even though condensers are generally connected in parallel with the breaker points to reduce arcing.

It has been proposed to interrupt the current through the spark coil by utilizing a transistor or a plurality of transistors, and controlling the conduction of the transistor by a relatively small current interrupted by the breaker points. Such systems considerably prolong the life of the breaker points by reducing the current passing there-through. Certain problems arise, however, in incorporating such ignition systems in automobile electrical systems wherein the positive side of the source of potential is directly connected to ground. This is because one side of the breaker points is usually grounded, and if a PNP output transistor is connected to be switched by the breaker points, it will be turned off when the points are closed and on when the points are opened. This is opposite to the sequence of the usual ignition systems.

The problem set forth can be overcome by changing the timing system to provide a new spark sequence, but this requires a major redesign of the engine. It would be possible to provide the desired sequence by the use of NPN transistors instead of PNP transistors, but at the present time NPN transistors of the required power and voltage rating are not commercially available. The proper timing sequence might be attained by use of a pulse transformer which reverses the polarity in the secondary winding, but this requires a very large pulse transformer for satisfactory operation, raising the cost to a prohibitive level.

Accordingly, it is an object of this invention to provide an improved positive ground ignition system for internal combustion engines.

Another object of the invention is to provide a positive ground ignition system suitable for replacing standard ignition systems with a minimum of alteration of existing apparatus.

Still another object of the invention is to provide a transistorized ignition system for positive ground electrical system utilizing PNP transistors and avoiding the need for a pulse transformer.

A feature of the invention is the provision of an electronic ignition system for internal combustion engines having positive ground electrical systems, which ignition

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system utilizes a cascade connected coupling transistor between the breaker points and the output transistor so that the output transistor will be cut off when the breaker points open.

Another feature of the invention is the provision of a two transistor ignition system for use in a positive ground electrical system and which includes an output transistor in series with an ignition coil, and which further includes a coupling transistor with the base and emitter thereof connected across the breaker points and with the collector thereof connected to the base of the output transistor to cut off the same when the points open.

Still another feature of the invention is the provision of a three transistor ignition system for use in a positive ground electrical system and which includes a pair of output transistors series connected with the ignition coil and which further includes a coupling transistor with the base and emitter thereof connected across the breaker points and with the collector thereof connected to a bias circuit for the output transistors to cut off the same when the points open.

In the drawing:

FIG. 1 is a schematic diagram of a circuit constructed in accordance with the invention; and

FIG. 2 is a schematic diagram of an alternative embodiment of the invention.

In accordance with the invention, an electronic ignition system utilizing PNP transistors is provided for use in a positive ground electrical system. A coupling transistor is used to couple the breaker points to the output transistor or transistors in order to attain the proper switching sequence. In one embodiment of the invention, two output transistors are connected in series with the high voltage ignition coil. A bias circuit is provided biasing the output transistors to be normally conducting. A coupling transistor has its output circuit connected to the bias circuit for the output transistors so that when it conducts the output transistors are cut off. The input circuit for the coupling transistor is connected across the breaker points such that when the breaker points are closed, the coupling transistor is cut off and when the breaker points are opened, the coupling transistor is turned on. In an alternative embodiment of the invention, only a single output transistor is used in series with the high voltage coil and the output of the coupling transistor is connected directly to the base of the output transistor.

Referring now to FIG. 1, a storage battery 11 has its positive terminal directly connected to ground and its negative terminal is connected through an ignition switch 13 to the primary winding 15 and secondary winding 17 of a high voltage ignition coil 19. A ballast resistor 20 may be included in series with switch 13. The opposite end of secondary winding 17 is connected to a distributor (not shown) for the internal combustion engine. The opposite end of primary winding 15 is connected in series with a pair of output transistors 21 and 23. The emitter electrode 25 of transistor 23 is connected through a diode 27 to ground. Diode 27 improves the switching action of the circuit and may be eliminated and satisfactory results will still be obtained. Resistors 29 and 31 forward bias transistors 23 and 21 respectively, and also help to temperature stabilize these transistors at elevated temperatures. Bias paths are completed through resistor 39 and ignition switch 13 for transistor 23, and through the emitter collector path of transistor 23; resistor 31, diode 41, resistor 37, and ignition switch 13 for transistor 21.

It will be apparent that transistors 21 and 23 are biased to be normally conducting, and as a result a field is established in primary winding 15 of ignition coil 19. Secondary winding 17 of ignition coil 19 has a sub-

stantially greater number of turns than the primary winding 15. Accordingly, there is a large step up of voltage through the transformer action of coil 19. In the event that transistors 21 and 23 are cut off, the collapsing field in the primary winding 15 of transformer 19 will induce an extremely high voltage in secondary winding 17 which may be applied through the distributor to the cylinders of the internal combustion engine.

Unequal values of resistors 37 and 39 make a correction for differences in voltages potential to ground between the bases of transistors 21 and 23, to thereby balance the saturation voltages of the transistors during conduction. Zener diodes 35 and 41 protect transistors 21 and 23 from excessive voltages in the reverse direction induced by the collapsing field in the primary 15 of ignition coil 19. These zeners 35 and 41 will break down at a voltage below the breakdown voltage of transistors 21 and 23. As an alternative, zener diodes might be connected across emitter-collector electrodes of transistors 21 and 23, or an additional zener diode might be connected across base-collector electrodes of transistor 23. Diode 41 prevents the source voltage from forward biasing the emitter to base circuit of transistor 23 during the period in which transistor 43 is conducting, as will be explained. A negative ground ignition system using a pair of output switching transistors connected in this manner is shown and described in the application of Madland, Serial No. 124,585 allowed January 14, 1965, and assigned to the assignee of the present invention.

A pair of breaker points 44, operable in timed relation with the internal combustion engine, are shown as in positive ground systems, with one terminal grounded. If a proper timing sequence is to be maintained when incorporating transistors in the system, the transistors 21 and 23 should conduct when the points are closed and be cut off when the points are opened. Direct connection of points 44 to transistors 21 or 23 would result in the opposite sequence. To retain the desired sequence, a coupling transistor 43 is used.

The emitter to collector path of transistor 3 connects the ground terminal with the base 45 of transistor 23. A bias circuit for transistor 43 is comprised of resistors 47 and 49 which form a voltage divider network from ground through switch 11 to the negative side of battery 13. The base 51 of transistor 43 is connected to the juncture between resistors 47 and 49, and also to one contact 53 of breaker points 44. The opposite contact 54 of breaker points 44 is grounded, and the points, which are operable in timed relation with the internal combustion engine, alternately open and close the path thereacross at each firing, as is well known in the art.

It will be apparent that when breaker points 44 are closed, transistor 43 will be biased to cut off, since the base 51 thereof will be at ground potential, the same potential as the emitter electrode thereof. Current flow through resistor 29 and resistor 39 will forward bias transistor 23, causing it to conduct through resistor 31, diode 41, and resistor 37. This forward biases transistor 21, causing current flow through the primary winding 15 of transformer 19. When breaker points 44 are open, current flow through resistor 47 will forward bias transistor 43 into conduction, raising the potential at the base of transistor 23 to ground and cutting off transistor 23. Since there will be no current flow through resistor 31, transistor 21 will likewise be cut off immediately, thereby causing the collapsing field in the primary winding 15 of transformer 19 to produce the necessary high voltage in the secondary winding 17 thereof. The proper timing sequence is present, since transistors 21 and 23 are conducting only when breaker points 44 are closed, and are cut off when breaker points 44 open.

Referring now to FIGURE 2, a single output transistor 61 is shown series connected with primary winding 15 of transformer 19. A resistor 63 in conjunction with resistor 65 provides forward bias for transistor 61. The

collector electrode 46 of transistor 43 is connected directly to the base 67 of transistor 61 and accordingly, when transistor 43 conducts, transistor 61 will be biased to cut off.

Transistor 43 is biased by resistors 47 and 49 to be conductive when breaker points 44 are open. When points 44 are closed, the ground potential will be placed on the base 51 of transistor 43 cutting off transistor 43 and permitting current flow through resistor 63 and base 67 of transistor 61. This forward biases transistor 61 into conduction, causing current flow through the primary winding 15 of transformer 19. Upon opening of points 44, transistor 43 once again becomes conductive, cutting off transistor 61 and causing the desired voltage collapse in primary winding 15. It might be desirable under certain conditions to connect a zener diode across the base and collector, or emitter and collector, of transistor 61 to protect the same from high reverse voltages.

It may therefore be seen that the invention provides an improved electronic ignition system for internal combustion engines having positive ground electrical systems. The system may be directly installed in a conventional positive ground electrical system without extensive mechanical alterations. Furthermore, the system utilizes PNP transistors without the need of a plus transformer to reverse the timing sequence.

What is claimed is:

1. An ignition system for intermittently energizing a high voltage ignition coil for an internal combustion engine having a positive ground electrical system, including in combination, a common emitter transistor switching means connected in series with the ignition coil, a bias circuit connected to said transistor switching means and basing the same to be normally conducting, a timing circuit for causing intermittent conduction of said transistor switching means and including breaker means having a common contact and closeable in timed relation with the internal combustion engine, a coupling transistor, and an input circuit for said coupling transistor connected to said timing circuit for controlling the conduction of said coupling transistor in response to opening of said breaker means, said coupling transistor further having an output circuit connected to said bias circuit and causing the same to bias said transistor switching means to cut off said transistor switching means conducting when said breaker means are closed and being cut off when said breaker means open to cause the ignition coil to develop a high voltage firing pulse.

2. An ignition system for intermittently energizing a high voltage ignition coil for an internal combustion engine having a positive ground electrical system, including in combination, common emitter transistor switching means connected in series with the ignition coil, a bias circuit connected to said transistor switching means and basing the same to be normally conducting, a pair of breaker points for causing intermittent conduction of said transistor switching means and having a common contact and closeable in timed relation with the internal combustion engine, a coupling transistor having base, emitter and collector portions, said base and emitter portions being connected across said breaker points, means biasing said coupling transistor into conduction upon opening of said breaker points, said coupling transistor further having an output circuit connected to said bias circuit and causing the same to bias said transistor switching means to cut off when said coupling transistor is conductive, said transistor switching means thereby conducting when said breaker points are closed and being cut off when said breaker points open to cause the ignition coil to develop a high voltage firing pulse.

3. An ignition circuit for intermittently energizing a high voltage ignition coil for an internal combustion engine having a positive ground electrical system with a pair of intermittently operable breaker points having a common side, said ignition circuit including in combina-

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tion, common emitter transistor switching means connected in series with the ignition coil, a bias circuit connected to said transistor switching means and biasing the same to be normally conducting, a timing circuit for connection to the breaker points to cause intermittent conduction of said transistor switching means, and transistor coupling means having an input circuit connected to said timing circuit and biasing said transistor coupling means into conduction upon opening of the breaker points, said transistor coupling means further having an output circuit connected to said bias circuit and causing the same to bias said transistor switching means to cut off in response to conduction of said transistor coupling means, said transistor switching means thereby conducting when the breaker points close and being cut off when the breaker points open to cause the ignition coil to develop a high voltage firing pulse.

4. An ignition circuit for intermittently energizing a high voltage ignition coil for an internal combustion engine having a positive ground electrical system with a pair of intermittently operable breaker points one side of which is grounded, said ignition circuit including in combination, common emitter transistor switching means adapted to be connected in series with the ignition coil, a bias circuit connected to said transistor switching means for biasing the same to be normally conducting, a coupling transistor having, base, emitter and collector portions, said base and emitter portions being adapted for connection across the breaker points, means connected to said coupling transistor for biasing the same into conduction upon opening of the breaker points, said collector portion of said coupling transistor being connected to said bias circuit and causing said transistor switching means to be cut off when said coupling transistor is conductive, said transistor switching means thereby conducting when the breaker points are closed and being cut off when the breaker points open to cause the ignition coil to develop a high voltage firing pulse.

5. An ignition circuit for intermittently energizing a high voltage ignition coil for an internal combustion engine having a positive ground electrical system with a pair of intermittently operable breaker points one side of which is grounded, said ignition circuit including in combination, first and second switching transistors having base, emitter and collector portions with said emitter portion of said first transistor being connected to said collector portion of said second transistor, means adapted to connect said emitter portion of said first transistor to ground, means adapted to connect said collector portion of said second transistor to the high voltage ignition coil, first bias means connected to said first transistor for forward biasing the same, second bias means connected to said second transistor for forward biasing the same and being energizable upon conduction of said first transistor, a third transistor having base, emitter and collector portions with said collector portion being connected to said base portion of said first transistor and said emitter portion adapted for connection to ground, a bias circuit connected to said third transistor for biasing the same conductive, and means adapted to connect said base and emitter portions of said third transistor across the breaker points to cut off said third transistor upon closure of the breaker points, said third transistor serving to cut off said first transistor and said second transistor when ren-

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dered conductive by opening of the breaker points to cause the high voltage ignition coil to develop a firing pulse.

6. An ignition circuit for intermittently energizing a high voltage ignition coil for an internal combustion engine having a positive ground electrical system with a pair of intermittently opening breaker points, said ignition circuit including in combination, a first transistor having emitter, base and collector portions, said collector portion being adapted for connection to the high voltage ignition coil and said emitter portion being adapted for connection to ground, a bias circuit connected to said first transistor for forward biasing the same, a second transistor having base, emitter and collector portions, said collector portion of said second transistor being connected to said base portion of said first transistor, said emitter portion of said second transistor being adapted for connection to ground, a bias circuit connected to said second transistor for forward biasing the same, and means adapted to connect said base and emitter portions of said second transistor across the breaker points to hold said second transistor cut off upon closure of the breaker points to permit conduction of said first transistor, opening of the breaker points thereby permitting conduction of said second transistor to cut off said first transistor and cause the ignition coil to develop a high voltage firing pulse.

7. An ignition circuit for intermittently energizing a high voltage ignition coil for an internal combustion engine having a positive ground electrical system with a source of negative potential and with a pair of intermittently openable breaker points, said ignition circuit including in combination, first and second transistors each having emitter, base and collector portions, means adapted to connect the emitter to collector paths of said first and second transistors in series between ground and the ignition coil to form an energizing circuit therefor, a bias circuit including resistance means connected respectively across said base and emitter portions of said first and second transistors for forward biasing the same and also including further resistance means connecting said base portion of said first transistor to the source of negative potential, a third transistor having base, emitter and collector portions, means adapted to connect said emitter portion of said third transistor to ground, means connecting said collector portion of said third transistor to said base portion of said first transistor to bias said first transistor to cut off when said third transistor is conductive, thereby opening said energizing circuit, a bias circuit connected to said third transistor for forward biasing the same, and means adapted to connect said base and emitter portions of said third transistor across the breaker points to hold said third transistor cut off when the breaker points are closed and to cause said third transistor to conduct when the breaker points are open, thereby cutting off said energizing circuit to cause the ignition coil to develop a high voltage firing pulse.

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