This invention relates to an ignition system for internal combustion engines.

An object of this invention is to produce an ignition system which can utilize a high voltage without the attendant problems of burning and pitting of the breaker points within the conventional distributor.

A further object of this invention is to provide a circuit that will maintain uniform high voltage when engine speeds increase to very high r.p.m.'s.

A further object of this invention is to provide an electronic transistorized circuit which may be superimposed on the conventional ignition system of an internal combustion engine such as is commonly found in an automobile or similar land, air or water vehicles, such that the improved circuit may be added to the basic ignition circuit of the vehicle and the normal starting means, distributor means, spark coil means and ignition devices in the cylinder may be used in conjunction with the invention.

Other objects and characteristics of the invention will appear in the specification and will be apparent from the accompanying drawings of which:

FIG. 1 is a wiring diagram of a transistorized ignition system for automobile operation for a negative ground system.

FIG. 2 is a wiring diagram of a transistorized ignition system for automobile engine operation for a positive ground system.

The present electric ignition system used in internal combustion engines with emphasis on modern automobile engines has not had any radical improvement since its initial innovation. This consists of the 6 or 12 volt car battery connected through the ignition switch to the primary of the ignition coil, and then through the distributor points which make and break contact by mechanical actuation of the Distributor cam which is rotated by the rotation of the engine crankshaft. The primary of the ignition coil usually consists of about 150 to 250 turns of heavy insulated wire wound on a bundle of iron wires. The high voltage secondary coil is also wound over this core. As a transformer it is very inefficient, but luckily it does not depend so much on transformer action as it does to transform the stored peak energy in its primary to its secondary windings which is connected to the spark plugs.

As the points are in series with the primary of the transformer, the following problems are created:

(a) The inductive energy stored by the point equals approx. 900 watts causing burning and arcing at the instant of break. At this instant a spike voltage of several hundred volts is developed across the points. This spike voltage actually contains the energy which is transferred to the secondary and stepped up to about 15,000 to 20,000 volts. This is what causes the burning and pitting of the points.

(b) The current through the points is therefore limited to allow a reasonable point life.

(c) The electric energy stored in the coil (\frac{3}{2}L \cdot I^2 \cdot T) must therefore be limited for the same reason. L is generally large as I is relatively small and the time constant of the system is long. This leads to a drop off of high voltage at higher r.p.m. of the engine.

(d) The output voltage (and energy) is a function of the current broken and the speed of break consequently poor starting results (dx/dt).

(e) Erosion of the plugs causes an increased burning and pitting of the points. This necessitates replacement of both every 5000 to 10,000 miles.

(f) Full power not available because of incomplete combustion at the top of the power stroke. This is due to inefficient energy at the spark gap.

In conclusion, to obtain satisfactory energy in the spark gap for maximum results would reduce the distributor point life enough to necessitate constant replacement.

Until recently, methods to overcome the above listed inadequacies have been too complicated and expensive. However, the present power germanium PNP transistor lends itself perfectly as an "ON and OFF" electronic switch capable of controlling heavy currents by a very low value of make and break control current.

Many methods have been tried to transistorize the ignition system with resultant failure as the high spike voltage will destroy the power transistor. The only successful method to date is to replace the ignition coil with a closed core type of transformer and draw a heavy current in the primary with only a few turns of wire thereby keeping the spark voltage down to a safe value for the average transistor. This results in complicated circuits and a very expensive high voltage ignition transformer which takes it out of the economy field.

In my invention, I have found a method to use a germanium power transistor (PNP) as a perfect "ON and OFF" switch controlled by a small amount of current (resistive) through the existing distributor points, and still retain the full power of the stored energy (about twice that of the present system) without exceeding the voltage operating limits of the transistor. This is accomplished using the existing distributor points and the existing stock ignition coil thereby making this a practical and economical method for production and use in all automobiles or other devices using internal combustion engines.

The following results can be expected if my invention is used in any automobile engine or similar engine:

1. Uniform high voltage at all engine speeds.
2. Uniform energy of spark for fixed loads.
3. Increased life of plugs.
4. Greatly increased life of distributor points.
5. Increased gasoline mileage due to better combustion.
6. Less carbon and engine wear due to better combustion.
7. Less oil contamination due to better combustion.
8. Better starting due to the removal of functional dependence of primary voltage on dx/dt of the points at low r.p.m. In my invention, instead of building up a magnetic field in the standard ignition coil and then interrupting the current to collapse the magnetic field which produces the high voltage spike, I operate the standard stock ignition coil by just passing a pulse of electrical energy through it which is close in amplitude but greater in total energy content to the spike it would normally develop by the interruption of the battery current through it. This high energy pulse is of very short duration. This high energy pulse is obtained by storing the energy in an auxiliary auto-transformer tapped at a particular ratio so that the induced spike voltage will not exceed the operating voltage of the transistors used and the spike is increased (directly proportional) by the ratio of the tapped winding to the total turns which supplies the pulsed power to the primary of the ignition coil (approximately 200 volts). The design of the auto-transformer is largely determined by the type of transistor used (collector current rating and voltage rating, collector to emitter). The cross sectional area of the iron laminations, the type of iron used, a magnetic closed circuit core, and open or partially open core, wire sizes, amount of turns, the turns ratio, or...
a transformer having a separate primary and secondary winding, may vary or be changed to better match a transistor or ignition coil, or for smaller space requirements.

For detailed operation, refer to FIG. 1 of drawing—explanation is for a 12 volt, neg. ground system. (A parts list, features, and design data of each item used is described.)

#—A PNP germanium power transistor having a very low saturation resistance, a low saturation voltage drop from collector to emitter and a good current gain at heavy currents.

#—A low value of resistance to provide a low resistance path to I_{dc} tends to minimize thermal runaway.

#—A calculated value of resistance to allow a proper amount of transistor base current to keep the transistor in saturated condition also tends to help control thermal runaway.

#—A silicon diode capable of passing 10 amperes which establishes a fixed emitter voltage to the base which reduces I_{dc} and gives temperature stabilization and also tends to help control thermal runaway.

#—A 10 watt zener diode with a voltage rating less than the maximum voltage rating of the transistor (collector to emitter).

#—A 12 volt relay (10 amp. contacts) connected to the ignition switch so that the total battery current will not pass through the ignition switch (to prevent bad contact) but will connect directly from the battery through the relay contact points. In some conditions this relay can be optional.

#—The auto-transformer briefly described previously. On a 1" square silicon iron closed core: from the common terminal to the tap—1 turn per volt to the value of the zener diode (item #5), 300 to 400 ampere turns. The total turns from common terminal to high end to be approximately 200 turns.

#—The existing ignition coil in the automobile or engine. If desired this can be replaced with an extra high voltage coil commercially advertised without any deleterious effects.

#—2 automobile headlight bulbs (6 volt—50 candle-power, RP. 11) for a 12 volt system and only one is used in 6 volt system. Instead of 2–6 volt bulbs in series they can be 12 volt bulbs in parallel to equal a current draw of approx. 7 amperes. These are used only for their ability to change resistance which increases almost linearly with voltage. A ballast resistance having the same characteristics can be used. As the engine r.p.m. increases this resistance decreases which partially compensates for the impedance increase of the coil #7 therefore tending to keep the current at a constant level thereby giving increased performance at high engine r.p.m. A fixed resistance may be substituted with a resulting drop in high voltage at high engine r.p.m. This item #9 will be referred to hereafter as the ballast resistance.

# and #—These parts are optional and are only included to accomplish quicker and more positive starting. # resistor allows more current to flow in the circuit only during starting to compensate for the voltage drop incurred. # is a 12 volt relay with 5 amp. contact points.

NOTE.—All reference to current flow is electron flow (neg. to positive).

Operation.—For automobile engines having the battery negatively grounded the circuit shown in FIGURE 1 is applicable.

Items # and # are optional. Satisfactory operation is obtained without them. To assure more positive starting they may be included. No further reference will be made to them.

When the ignition switch is closed the battery voltage is impressed across the circuit. If the distributor points are in closed position sufficient current flows into the base of transistor #1 to bring it to a saturated condition. The transistor #, the diode #4 and the lower end of the coil develop a forward voltage drop of approx. 2 volts. The ballast resistance #9 drops the balance of 10 volts and allows approx. 7 amperes to flow through the lower end of transformer #7. This transformer builds up a strong magnetic field in its core. When the distributor points open the transformer #1 goes to cut-off condition. The stored energy in the transformer core #7 becomes a high energy electrical pulse (approx. 200 v.) impacted across the primary of the ignition coil #8 which is stepped up in the secondary to a voltage high enough to jump the spark gap and continue until its energy is expended. The zener diode #5 protects the transistor #1 from transients or extra high spike voltage should the spark plug wires be off or disconnected. When the distributor points close again the complete cycle is repeated.

For engines with post. battery ground, FIG. 2 is applicable.

The parts list is the same except the identifying numbers are different.

Cross reference

FIG. 1 FIG. 2
#1 = #7
#2 = #5
#3 = #3
#4 = #6
#5 = #14
#6 = #13

Parts added in FIG. 2 which are not in FIG. 1

#—An NPN germanium 3 ampere power transistor having similar characteristics as transistor as transistors #7. #—A silicon diode similar to #6 except 3 amp. for the same purpose.

#—A calculated value of resistance to limit the collector current of transistor #1 to equal the base current required by transistor #7 plus that flowing through resistor #5.

Operation.—FIG. 2 applicable. Item #12 is optional (see explanation for items #10 and 11 in FIG. 1). When the ignition switch is closed the battery voltage is impressed across the circuit. If the distributor points are in closed position sufficient current flows into the base of transistor #1 to bring it to a saturated condition which in turn brings transistor #7 to a saturated condition. From here on the operation is the same as in FIG. 1. However, in this circuit a much lower current will be broken at the distributor points because the current gain is equal to the product of the current gains of transistors #1 and #7.

It is to be understood that the present invention is not limited to the particular construction described in the foregoing specification and shown in the accompanying drawings but also comprises any modifications within the scope of the appended claims.

My claims are:

1. In a multi-cylinder internal combustion engine using one or more of make and break distributor contact points and one or more ignition coils having a primary and a high voltage secondary winding in which the battery current is passed through the primary and interrupted by the distributor points to produce a high voltage spark at the spark plugs, an auxiliary transistorized circuit which comprises the addition of transistor means connected to operate as an “ON and OFF” switch by the distributor points making and breaking the control current to the base of one transistor, an auto-transformer, said auto-transformer adapted to store up a magnetic field when the base of said transistor means is activated by said distributor contact points closing and adapted to discharge its high energy pulse through the primary of the ignition coil resulting in a high voltage spark at the spark plugs,
5. In combination with a multi-cylinder internal combustion engine having a battery D.C. power supply, ignition distributor means, a spark coil, and ignition devices in each cylinder, said spark coil having a primary and a secondary winding, a circuit interposed between said distributor means and said spark coil which comprises: transistor means, said transistor means adapted to be activated by action of said distributor means, an auto-transformer, said auto-transformer having a first end and a second end, said auto-transformer having a terminal at said first end and a terminal at said second end and a tap at an intermediate point, said transistor means adapted to energize said auto-transformer at said intermediate tap and said first end terminal said terminals at the first end and second end connected in parallel with said primary windings of said spark coil, said secondary winding of said spark coil adapted to discharge a spark through said ignition devices.

3. Apparatus as described in claim 2 which includes a ballast resistance means in series with said auto-transformer, said ballast resistance means connected between said first terminal at said first end of said auto-transformer and negative potential, said ballast resistance adapted to change resistance value in proportion to applied load to maintain constant electrical current flow.

4. In combination with a multi-cylinder internal combustion engine, having a D.C. power supply with a positive ground, ignition distributor means, a spark coil, and ignition devices in each cylinder, said spark coil having a primary and a secondary winding, a circuit interposed between said distributor means and said spark coil which comprises: transistor means, said transistor means comprising a first transistor of PNP type, said second transistor of PNP type, said first transistor adapted to be activated by said distributor means, said first transistor adapted to activate said second transistor, said first NPN transistor adapted to supply its collector current into the base element of said second NPN transistor, an auto-transformer, said auto-transformer having a first end and a second end, said auto-transformer having a terminal at said first end and a terminal at said second end and a tap at an intermediate point, said second transistor means adapted to energize said auto-transformer at said intermediate tap and said first end terminal, said terminal at said first end and second end connected in parallel with primary windings of said spark coil adapted to discharge a spark through said ignition devices.

5. Apparatus as described in claim 2 which includes a voltage limiting device connected across said transistor means adapted to prevent voltage surge damage to said transistor means.

6. Apparatus as described in claim 5 which includes a Zener diode used as said voltage limiting device.

7. In combination with a multi-cylinder engine having a D.C. power supply, a negative ground, ignition distributor means, a spark coil, said spark coil having a primary and a secondary winding, and ignition devices in each cylinder, a circuit interposed between said distributor means and said spark coil which comprises: a germanium power transistor of PNP type, said PNP transistor having a base, a collector and an emitter; said collector of said transistor adapted to be brought to a saturated condition by said distributor means; resistance means, said resistance means connected between the base of said germanium transistor and ground adapted to limit base current flow to saturate said germanium transistor; a Zener diode, said Zener diode of voltage rating less than maximum rating of said germanium transistor, said Zener diode connected across said germanium transistor to prevent voltage surge damage, an auto-transformer, said auto-transformer having a first end and a second end, said auto-transformer having a terminal at said first end and a terminal at said second end and a tap at an intermediate point, said germanium transistor adapted to energize said auto-transformer at said intermediate tap and said first end terminal, said first end terminal and said second end terminal connected in parallel with said primary windings of said spark coil, said secondary winding of said spark coil adapted to discharge a spark through said ignition devices; a ballast resistance, said ballast resistance connected between said first terminal of said auto-transformer and negative potential, said ballast resistance adapted to change resistance value in proportion to applied load to maintain a constant level of electrical current flow.

References Cited by the Examiner

UNITED STATES PATENTS
2,066,959 6/1937 Cain ------------ 315-220 X
3,018,413 1/1962 Neapolitakis ---------- 315-220 X

GEORGE N. WESTBY, Primary Examiner.
RALPH G. NILSON, Examiner.
C. R. CAMPBELL, Assistant Examiner.