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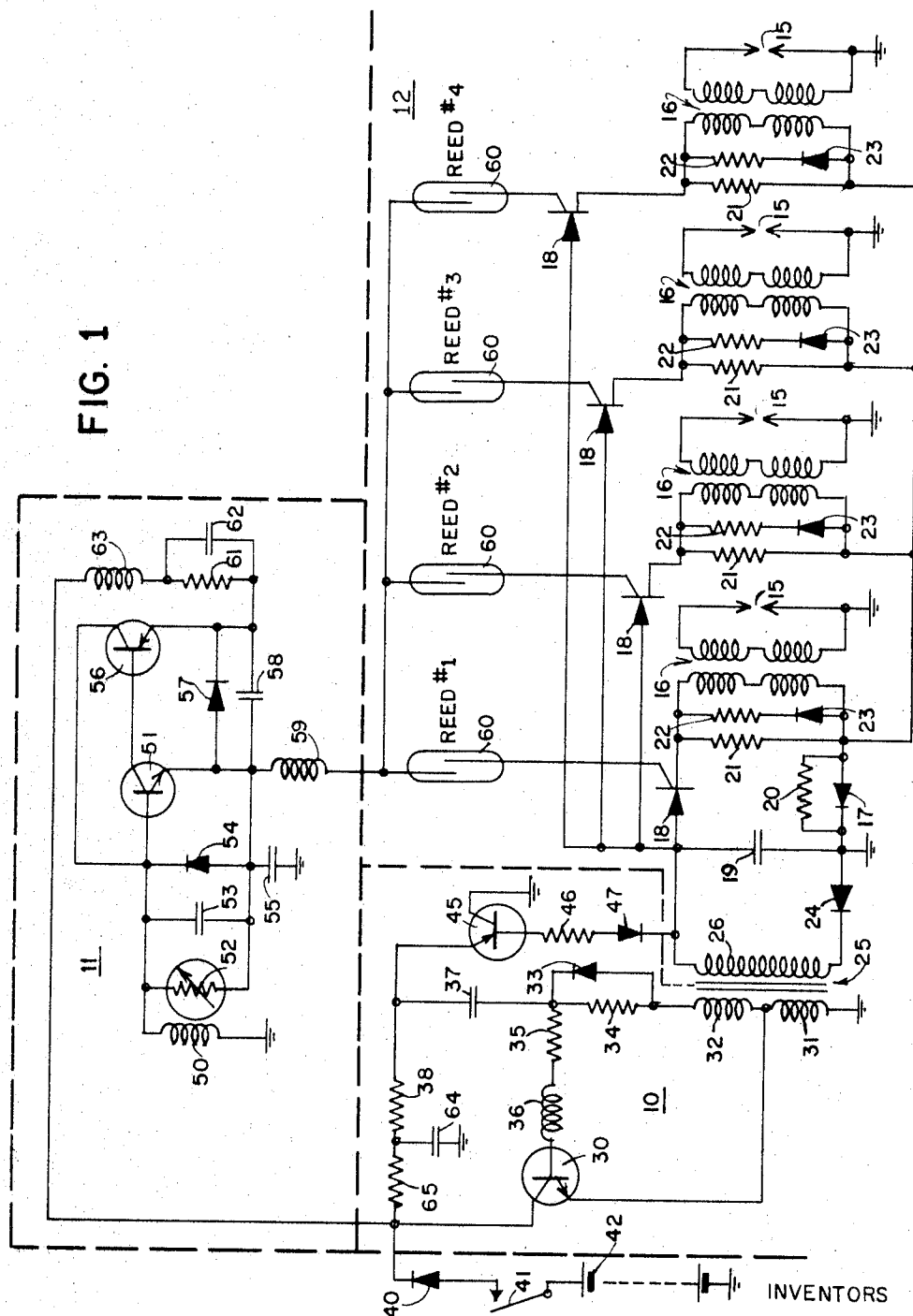
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FIG. 1



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FIG. 3

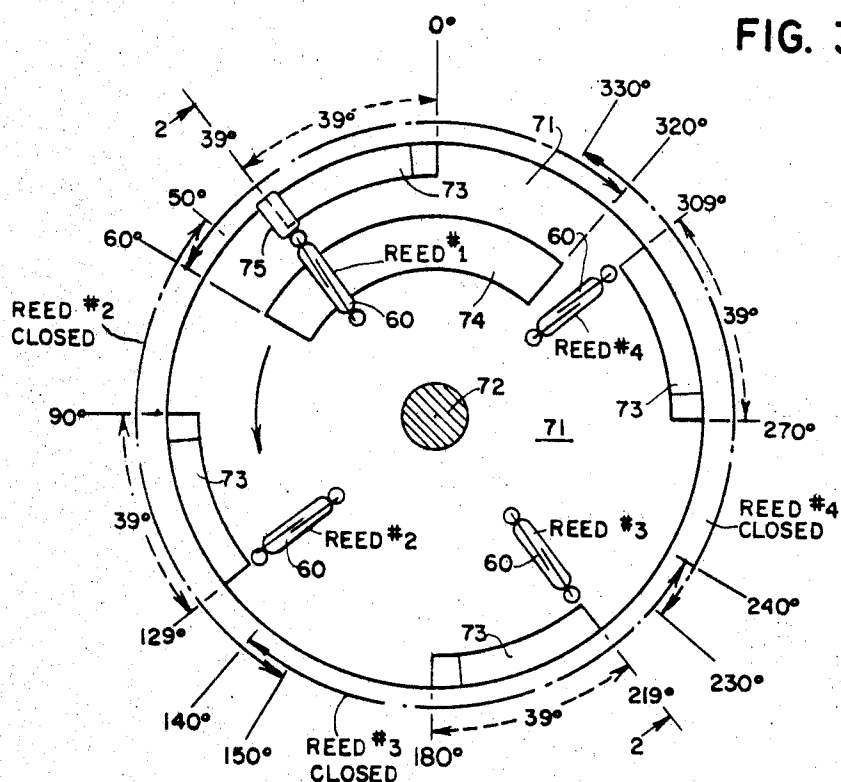
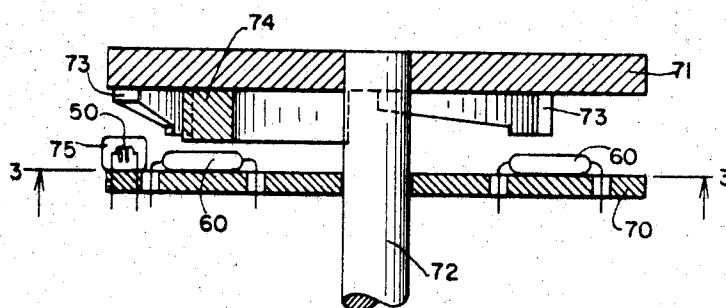


FIG. 2



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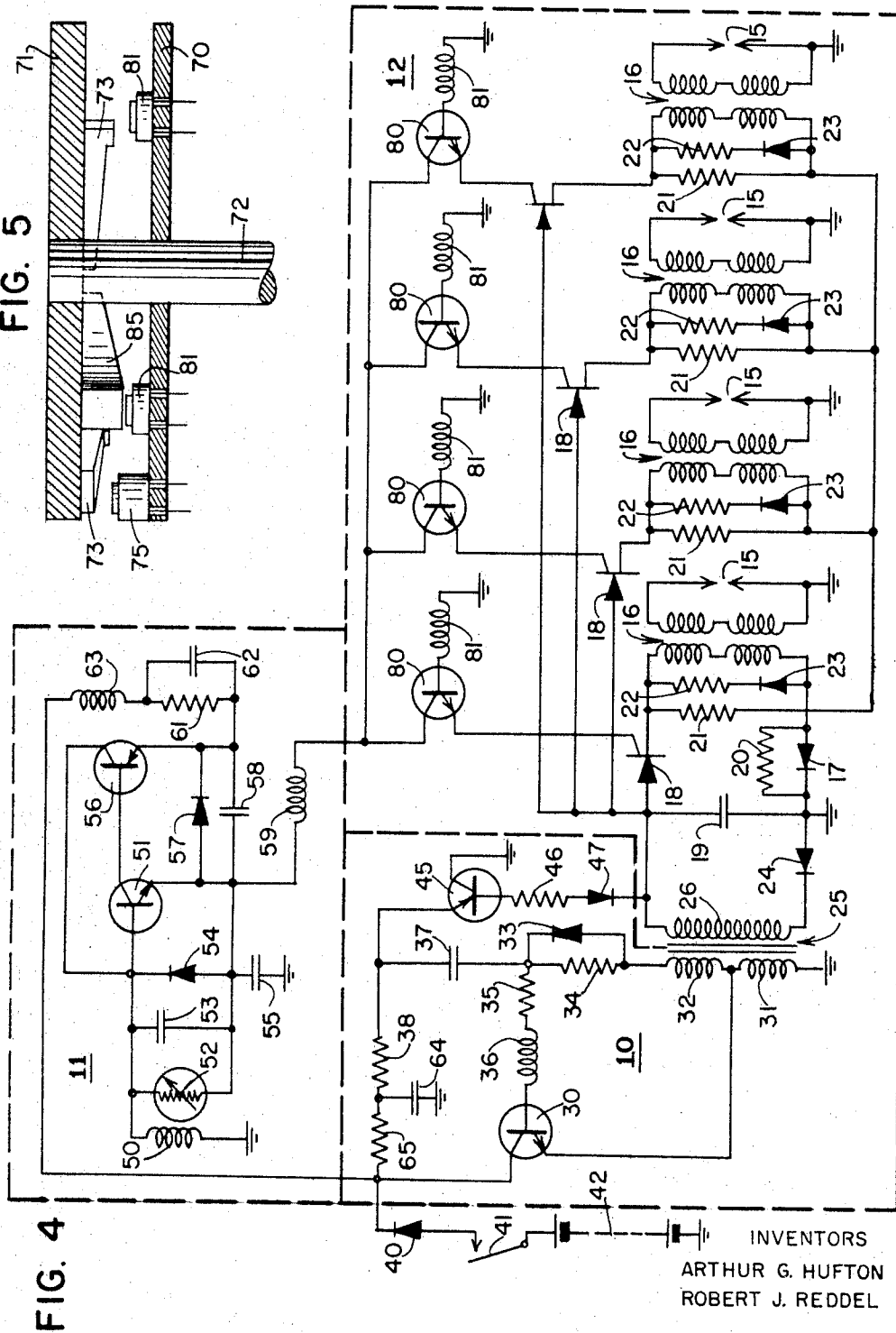
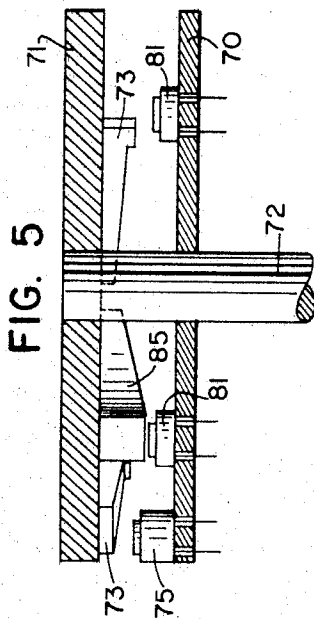
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Sheet 3 of 3



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6 Claims

ABSTRACT OF THE DISCLOSURE

A capacitor discharge ignition system for a multi-cylinder internal combustion engine which utilizes a main pickup unit and a plurality of reed switches placed on a mounting plate in spaced relation to the positions of shaped pole elements and a magnet spaced on a steering disc. The steering disc is rotated by the engine and the magnet sequentially closes the reed switches, each one of which is coordinated to a respective cylinder. The shaped pole elements which are driven past the main pickup unit produce a pulse in that unit, which is connected by the reed switch to trigger a silicon controlled rectifier (SCR) for discharging the capacitor to provide a spark at an associated spark plug for firing the same. In another embodiment individual pickups replace the reed switches and the magnet generates a pulse in the pickup which gates on a transistor to trigger the SCR.

This invention relates to ignition systems for internal combustion engines, and more particularly to an improved system which performs spark distribution for a multi-cylinder internal combustion engine.

Many ignition systems for internal combustion engines have been proposed which utilize electronic circuitry to produce ignition pulses in an ignition coil. Such systems have advantages over systems which utilize mechanical breaker contacts for producing the ignition pulses in that they are more reliable and produce higher voltage pulses at the extreme ends of the speed range over which they operate. Many of such systems, however, retain mechanical switch devices for distributing the ignition pulses to the particular cylinders. Mechanical devices for distribution often present the same drawbacks as do the mechanical breaker contacts insofar as pitting of the contact surfaces and thus reliability and operational life are concerned.

It is an object of this invention to provide an ignition system for internal combustion engines which performs the distribution function electronically.

It is another object to provide an improved and economical ignition system having electronic switching means for distribution which are mechanically synchronized with magnetic pickup means.

A feature of the invention is the provision of an ignition system having semiconductor switches for applying pulses to the individual spark devices in the cylinders of an engine and a control circuit for actuating said switches in turn including a rotating disc having shaped pole elements for producing firing pulses in a pickup coil and a further pole element which actuates fixed pickup devices for applying switching pulses to said switches so that the firing pulses are applied therethrough to the individual spark devices.

Another feature of the invention is the provision, in an ignition system for a multi-cylinder internal combustion engine, of an electronic steering device having a plurality of reed switches which are operated by a magnet according to the particular firing cycle of the engine and a main pickup unit to produce triggering pulses when a plurality of shaped pole elements varies the magnetic flux in the

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main pickup unit after the coordinated reed switch has been closed.

A further feature of the invention is the provision, in an ignition circuit for a multi-cylinder internal combustion engine, of a main pickup unit and a plurality of reed switches spaced on a mounting plate in predetermined positions in accordance to the positions of shaped pole elements and a magnet spaced on a steering disc rotating in accordance with the engine to close the reed switch coordinated to the respective cylinder to be fired immediately after one of the shaped pole elements produces a pulse in the main pickup unit to trigger a spark at the spark plug of the coordinated cylinder.

A further feature of the invention is the provision of an electronic steering device having a plurality of pickup devices which generate a bias voltage for transistor means when a magnet passes the device and varies the magnetic flux in the device, and a main pickup unit to produce a triggering pulse when a shaped pole element varies the magnetic flux in the main pickup unit after the coordinated transistor means has been rendered conductive.

The invention is illustrated in the drawings in which:

FIG. 1 is a circuit diagram of the ignition system having reed switches for completing the triggering circuit according to the invention;

FIG. 2 is an enlarged sectional view of the mechanical steering device taken along the line 2-2 of FIG. 3; and

FIG. 3 is a sectional view of the mechanical steering device taken along the line 3-3 of FIG. 2;

FIG. 4 is a circuit diagram of the ignition system having transistors for completing the triggering circuit;

FIG. 5 is an enlarged sectional view of the mechanical steering device.

In a specific form, the invention may be used advantageously in an ignition system for a four cylinder internal combustion engine. It includes a discharge capacitor and four ignition circuits each having a silicon controlled rectifier for triggering the discharging of the capacitor to produce the firing spark for the four cylinders of the engine. A blocking oscillator is coupled to the discharge capacitor for charging the same. Each silicon controlled rectifier is coupled with its control electrode through a reed switch to a common preamplifier which includes a main pickup coil. The reed switches are spaced equidistantly apart on a circumference of a mounting plate which also supports the main pickup coil. A steering disc positioned opposite to the mounting plate is coupled to the engine crankshaft for rotation therewith. On a circumference of the steering disc corresponding to that of the reed switches a magnet is positioned which extends over an arc of about 100° so that always at least one reed switch is closed when the steering disc is rotating. At the steering disc on the circumference opposite to the pickup coil four shaped pole elements of an arch length of about 40° are disposed equidistantly apart. The magnet and the reed switches are spaced in relation to the shaped pole elements and the main pickup coil in such a way that that reed switch is closed which corresponds to the respective cylinder to be fired when the coordinated shaped pole element passes by producing a voltage pulse in response to changing flux in the main pickup coil.

Instead of reed switches, magnetically triggered transistors can be used to actuate the distributing rectifiers. In this case, the control electrode of each silicon controlled rectifier is coupled through a transistor to the common preamplifier. The base electrode of each transistor is connected to a pickup coil which is spaced on the mounting plate instead of the reed switches. The magnet which successively passes by each pickup coil is preferably

sloped and induces a bias voltage in the coil to render the coordinated transistor conductive.

Referring now to the drawings, the circuit shown in FIG. 1 is for use with a four cylinder engine with a four stroke cycle. It is to be understood, however, that the ignition system of the invention can be adapted to engines of other numbers of cylinders within the scope of this invention.

The electric circuit of the ignition system comprises a blocking oscillator 10, a preamplifier 11 and an ignition control circuit 12. The ignition control circuit 12 provides a spark gap or spark plug 15 and a high tension transformer 16 for each cylinder. The secondary winding of each high tension transformer 16 is connected across a respective spark gap. The primary winding of the transformers 16 are connected via a common diode 17 to one plate of a capacitor 19, and separately via silicon controlled rectifiers 18 to the other plate of the capacitor 19.

The diode 17 is bypassed by resistor 20. A resistor-diode combination 21, 22, 23 is connected in parallel with the primary winding of transformer 16. The capacitor 19 is further connected through diode 24 to the secondary winding 26 of charging transformer 25. The primary winding 31, 32 of the charging transformer 25 is coupled to the blocking oscillator 10.

The blocking oscillator 10 comprises a transistor 30 the emitter of which is connected to a tap of the primary winding 31, 32 of transformer 25. The two portions 31 and 32 of the primary winding are wound in opposing sense and one end is connected to the reference potential whereas the other end of the primary winding is connected in series through diode 33, resistor 35 and coil 36 to the base of transistor 30. The diode 33 is bypassed by resistor 34. The junction of resistor 35 and diode 33 is connected through capacitor 37 and resistors 38 and 65 in series to the collector of transistor 30. The junction of resistors 38 and 65 is connected through capacitor 64 to reference potential. The collector is further connected via diode 40 and the ignition switch 41 to the positive terminal of a battery 42. The negative terminal of the battery is connected to the reference potential.

A starting circuit for the electric circuit of the ignition system is connected between the anode of the silicon controlled rectifiers 18 and the junction of resistor 38 and capacitor 37. This starting circuit comprises a transistor 45 in grounded collector mode, resistor 46 and diode 47 series connected to the base of transistor 45.

The preamplifier 11 includes a main pickup coil 50 connected between the base of transistor 51 and reference potential. The base of transistor 51 is further connected via diode 54 in parallel to capacitor 53 and thermistor 52 to one plate of the capacitor 55, the other plate of which is connected to the reference potential. The collector of transistor 51 is connected to the base of transistor 56 and the base of transistor 51 is connected to the collector of transistor 56. The emitters of both transistors 51 and 56 are combined through diode 57 and in parallel through capacitor 58. The emitter of transistor 51 is also connected to capacitor 55 and further through coil 59 to read switches 60 which connect the control electrodes of the respective silicon controlled rectifiers 18 with the preamplifier 11. The emitter of transistor 56 is further connected through resistor 61 and coil 63 to the diode 40 with the resistor 61 being parallel connected to capacitor 62.

For timing of the ignition pulses with respect to the engine position, the main pickup coil 50 and the read switches 60 are attached to a mechanical steering device which is shown in FIGS. 2 and 3. The steering device comprises a mounting plate 70 and a steering disc 71 attached to the crankshaft 72 of the internal combustion engine. On the circumference of the rotating disc 71, four shaped pole elements 73 are mounted for varying the magnetic flux in the main pickup coil 50 which is mounted in the pickup unit 75 on the mounting plate 70 in close

proximity to the shaped pole elements 73. Each shaped pole element 73 has a long arcuate leading portion followed by a small step. As the steering disc moves in the direction of the arrow (FIG. 3) the space between the shaped pole element 73 and the pole piece of the pickup unit 75 will decrease at a gradual rate according to the curved surface of element 73. Then, as the step passes by the pole pieces of the main pickup unit, the gap decreases at a very high rate causing a high flux change in the main pickup coil.

The four reed switches 60 are mounted on the circumference of plate 70, which corresponds to the circumference along which a magnet 74 is mounted on the steering disc 71. The magnet covers a 100° segment section of a circle. Since the four magnetically operated reed switches are spaced 90° apart, two adjacent reed switches are closed for an overlapping portion of 10° when the magnet is rotating and passes the magnetically operated reed switches. The circular arch along which each reed switch is closed is shown in FIG. 3 with dash-dotted arrows.

In considering the operation of the ignition system it will be assumed that ignition switch 41 is closed for starting the engine. The positive potential of the battery is then applied through diode 40 and resistors 65 and 38 to the emitter of transistor 45. This potential renders transistor 45 conductive so that a slightly reduced positive potential appears at its base. This potential is applied through resistor 46 and diode 47 to capacitor 19 and charges that capacitor. As soon as one of the reed switches 60 is closed and a positive potential is applied from the preamplifier 11 to the control electrode of the corresponding silicon controlled rectifier 18, in a way to be described subsequently, the silicon controlled rectifier is rendered conductive and discharges capacitor 19 through the high tension transformer 16. Almost the full voltage across capacitor 19 is thus applied across the primary winding of transformer 16 in a very short time causing the rapid build-up of current. This action induces a high voltage in the secondary winding according to the turns ratio of the transformer 16. This high voltage is then applied to the spark plug 15 for firing the fuel mixture in the respective cylinder of the internal combustion engine.

Conduction of transistor 45 occurs only when the system is first energized. After the first charging cycle, the blocking oscillator 10 is externally triggered by each discharging of the capacitor 19 through the ignition transformer 16, when the silicon controlled rectifier is rendered conductive. This external triggering is accomplished by the conduction of the appropriate SCR which causes current to flow through the secondary winding 26 of transformer 25. This current through the secondary winding of transformer 25 produces a magnetic flux which induces a voltage in the winding 32 such that a positive potential is applied via diode 33, resistor 35 and coil 36 to the base of transistor 30 rendering such transistor conductive. As soon as the transistor 30 first begins to conduct, the change in current through the transistor develops a voltage across winding 31 of transformer 25. The resulting voltage in the emitter circuit is inverted in the base circuit so that the winding 32 drives the base positive increasing the emitter current rapidly and continuing the forward bias of the transistor 30. This current builds up continuously until saturation of the transistor. Since the current through the saturated transistor is constant, the induced voltage in winding 32 decreases and biases the transistor towards turn off. Due to the regeneration between emitter and base the current through transistor and thus through winding 31 drops rapidly inducing a pulse in the secondary winding 26 of transformer 25 which is of the right polarity and sufficient to charge the capacitor 19. Since capacitor 19 is a short circuit at that time, the overload is reflected into the secondary winding 26 which causes a high current flow because of the regeneration effect. The building up period of the blocking oscillator and the time

for fully charging of capacitor 19 is very short so that full voltage appears across the capacitor 19 in less than 1 millisecond. This is far less than the time between two succeeding ignitions even at high engine speeds.

The silicon controlled rectifiers 18 in the capacitor discharge ignition circuit are individually triggered conductive through the magnetically operated reed switches 60, by firing pulses produced by the preamplifier 11. The preamplifier applies a positive bias to the control electrode of the respective silicon controlled rectifier when a positive pulse is generated in the main pickup coil 50 by means of the mechanical timing and steering device. The operation of the mechanical steering device will occur in the manner described subsequently.

In consideration of the operation of the preamplifier it will be assumed that one of the reed switches 60 is closed so that a positive pulse across the main pickup coil 50 renders transistor 51 conductive. This produces a DC current through transistor 51, coil 59, reed switch 60, silicon controlled rectifier 18, the primary winding of the high tension transformer 16 and diode 17 to ground potential. When transistor 51 is turned on it will conduct current from the emitter of transistor 56 through the base and thus turn on transistor 56. Since the collector of transistor 56 is connected to the base of transistor 51, its collector current is drawn from the base of transistor 51 which holds it on so that it is a locking on device. When transistor 51 is locked on, the capacitor 62 charges up rapidly and provides a sharp triggering pulse at the control electrode at the silicon controlled rectifier. As soon as the capacitor 62 becomes fully charged, the resistor 61 bypassing the capacitor 62 will conduct insufficient current to maintain the flow of current through transistors 51 and 56 so that they switch off. The capacitor 62 now discharges in less than 1 millisecond through resistor 61 and becomes ready for the next triggering operation.

For accomplishing timing and spark distribution, the reed switch 60 related to the engine cylinder which is under compression will be closed by the magnet 74 passing this reed switch. Shortly afterwards one of the four shaped pole elements 73 passes the main pickup unit 75 and produces a positive pulse in the main pickup coil 50 which, as already described, triggers that silicon controlled rectifier 18 connected by means of the closed reed switch 60 to the preamplifier 11. During the rotation of the disc the magnet 74 always closes the next succeeding reed switch 60, whereas the shaped pole elements 73 generate successively the positive pulses in the main pickup coil 50, as they pass the main pickup unit 75. Each shaped pole elements 73 covers an arc of 39°. The elements are spaced at the steering disc 71 equidistant apart so that each rotation of the disc produces four triggering pulses. Since magnet 74 covers an arc of 100° and is positioned on the disc so that it reaches the reed switch about 20° before the corresponding shaped pole element reaches the pickup unit, only the ignition circuit of the cylinder to be fired is connected to the preamplifier when the triggering pulse occurs. As it can be seen in FIG. 3, the triggering pulse occurs within a time period when only one reed switch is closed corresponding to an arc indicated with dotted arrows.

Referring now to FIG. 4, there is shown the circuit of another embodiment of the invention. This circuit is generally similar to the circuit shown in FIG. 1. The only difference is that instead of the reed switches 60, magnetically triggered transistors 80 are used. The emitters of the transistors 80 are connected to the control electrode of a coordinated silicon controlled rectifier and the collectors of the transistors 80 are connected to the preamplifier. The bases of the transistors 80 are connected through a pickup device 81 to a reference potential.

The transistors 80 are rendered conductive by the generation of a voltage pulse in the pickup device 81. For this purpose the device 81 is spaced on the mounting plate 70 at the place of the reed switch 60 according to FIG.

2 so that a voltage is induced when the magnet 85 on the rotating disc passes by the device 81. The magnet 85 has a sloped shape and is spaced on the rotating disc 71 in such a relation to the shaped pole elements 73 that the transistor 80 is conducting when a pulse is produced in the main pickup unit 75.

It may, therefore, be seen that the invention provides an improved ignition circuit for an internal combustion multi-cylinder engine which performs a distributorless spark distribution. Since any mechanical friction is avoided no mechanical wear occurs. The invention prevents energy losses because of the elimination of sparks jumping and the need of any adjustment of the engine timing after initial setup. By using a shaped pole element for generating the triggering pulse the advancing of the timing of the ignition pulses is provided automatically with respect to the engine speed so that no elaborate circuitry is needed to perform the necessary advancing function.

We claim:

1. A spark ignition system for an internal combustion engine having a plurality of spark devices and an ignition circuit with a discharge capacitor and means for charging the capacitor, including in combination, a plurality of ignition coil means individually coupled to the spark devices, a plurality of semi-conductor switch means individually connecting the discharge capacitor to said ignition coil means, a rotary member coupled to the engine for rotation therewith, pulse generator means including a plurality of shaped pole elements on said member and pickup means cooperating with said pole elements for generating firing pulses in said pickup means when said shaped pole elements pass said pickup means to produce therein firing pulses at times determined by the speed of the engine, distributor means including switch means individually connecting said pulse generator means to each of said semiconductor switch means, a further pole element on said rotary member, said switch means being sequentially closed and opened by said further pole element to selectively connect a potential to each of said semiconductor switch means for sequentially triggering the same, thereby discharging said capacitor through said coil means to provide timed ignition pulses to the spark devices.

2. The spark ignition system of claim 1 wherein said switch means include a plurality of reed switches each responsive to said further pole element for individually series connecting said pulse generator means to said semiconductor switch means.

3. The spark ignition system of claim 1 wherein said switch means includes a plurality of semiconductor means having input means, said semiconductor means individually series connecting said pulse generator means to said semiconductor switch means, the system further including, a plurality of additional pickup means individually connected to said input means and being responsive to said further pole element for applying sequential pulses to said semiconductor means to render the same conductive.

4. In a spark ignition system for a multi-cylinder internal combustion engine, an ignition circuit having a discharge capacitor and control devices for discharging the capacitor for triggering the spark, a blocking oscillator coupled to the ignition circuit for charging the capacitor, a mounting plate supporting a pickup unit and a steering disc coupled to the engine crankshaft for rotation therewith having shaped pole elements for generating firing pulses in the pickup unit when the shaped pole elements pass the pickup unit to produce a firing spark at a point determined by the angle of velocity of the crankshaft, the combination including a preamplifier connected to said pickup unit, a plurality of reed switches spaced on a circumference of the mounting plate equidistant apart, each said reed switch coupled between the preamplifier and a respective control device, a magnet mounted to the steering disc in a predetermined position with relation to the

shaped pole elements opposite to the circumference on which the reed switches are mounted, said magnet being rotated past said reed switches to sequentially open and close the same, said plurality of shaped pole elements being spaced on a circumference of the steering disc equidistant apart for sequentially producing a firing pulse in the pickup unit after each reed switch has been closed by the passing, said closed reed switch coupling the firing pulse from said preamplifier to a respective control device to provide a timed ignition spark.

5. A spark ignition system according to claim 4 wherein four reed switches are placed on the mounting plate 90° apart and the magnet placed along a circumference of the steering disc covers a 100° arc so that the ends of the closing periods of the reed switches overlap, and wherein each shaped pole element covers about a 39° arc providing firing pulses at about a time intermediate to the period of the corresponding reed switches being closed.

6. A spark ignition system for a multi-cylinder internal combustion engine including an ignition circuit having a discharge capacitor and control devices for triggering the spark, and a blocking oscillator coupled to the ignition circuit for charging the capacitor, including in combination, a mounting plate supporting a main pickup unit and a steering disc coupled to the engine crankshaft for rotation therewith having shaped pole elements for generating firing pulses in said pickup unit, said shaped pole elements pass said pickup unit to produce a firing spark at a point determined by the angle of velocity of the crankshaft, a preamplifier connected to said main pickup unit, a plurality of pickup devices different from said main pickup unit spaced on a circumference of the mounting

plate equidistant apart, distributor means including a plurality of semiconductor means coupled between said preamplifier and the control devices having control electrodes, each said control electrode connected to a respective pickup device, a magnet mounted to the steering disc in a predetermined position with relation to said shaped pole elements opposite to the circumference on which said pickup devices are mounted to generate a pulse in said pickup devices and to render a respective one of said semiconductor means conductive before the firing pulse is produced in said main pickup unit, said plurality of shaped pole elements being spaced on a circumference of a steering disc equidistant apart for successively producing firing pulses in said main pickup unit after the respective semiconductor means has been rendered conductive by passing said magnet past said pickup device to provide a triggering pulse.

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