

[72] Inventor **David T. Cavil**
Menomonee Falls, Wis.
 [21] Appl. No. **776,379**
 [22] Filed **Nov. 18, 1968**
 [45] Patented **May 11, 1971**
 [73] Assignee **Outboard Marine Corporation**
Waukegan, Ill.

3,311,783 3/1967 Gibbs et al. 123/148X
 3,356,896 12/1967 Shano. 123/148X
 3,461,851 8/1969 Stephens 123/149
 3,464,397 9/1969 Burson 123/148

Primary Examiner—Laurence M. Goodridge
Attorneys—Wheeler, Wheeler, House & Clemency and
 Robert K. Gerling

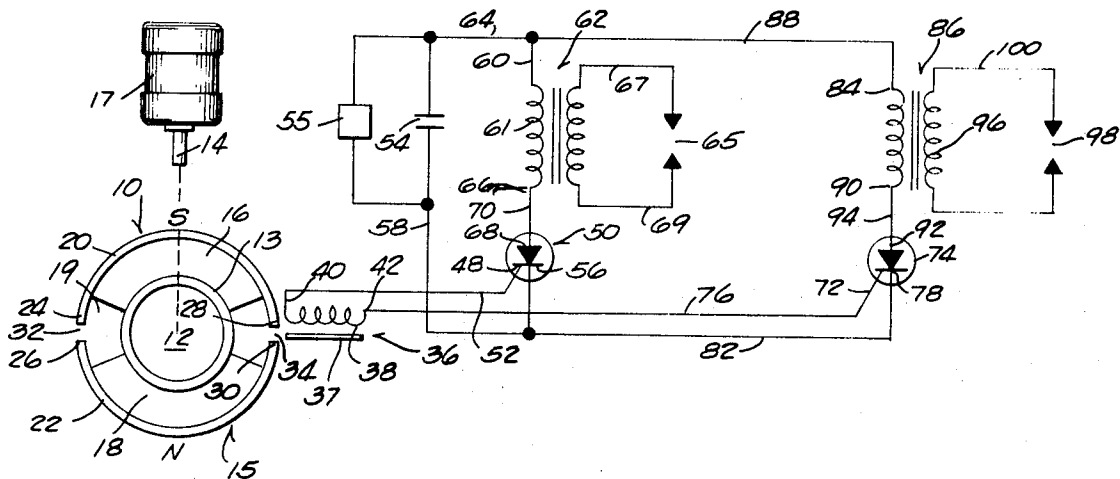
[54] **CONTACTLESS AND DISTRIBUTORLESS
 IGNITION SYSTEM**
 13 Claims, 12 Drawing Figs.

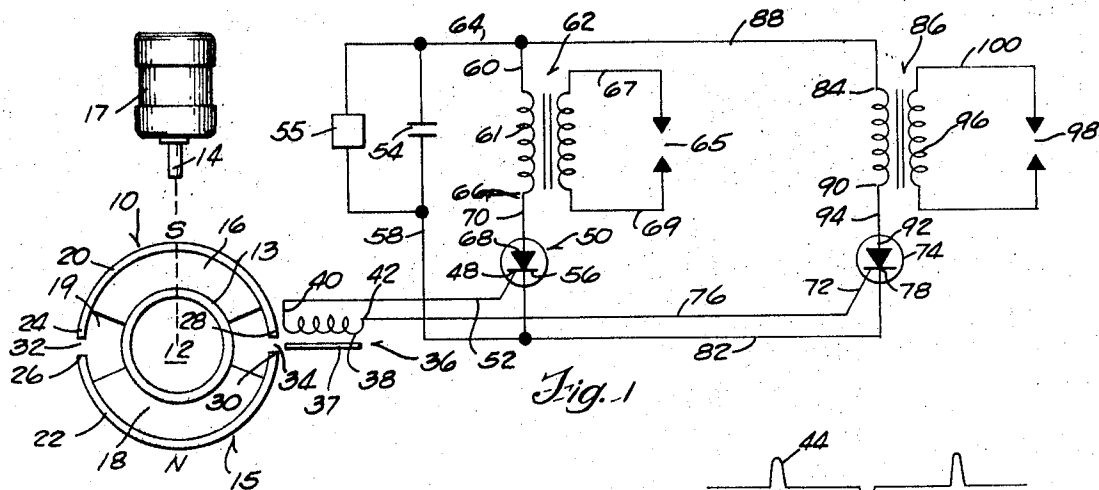
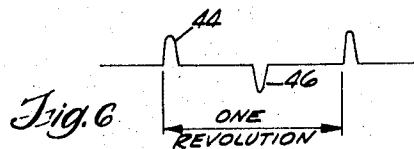
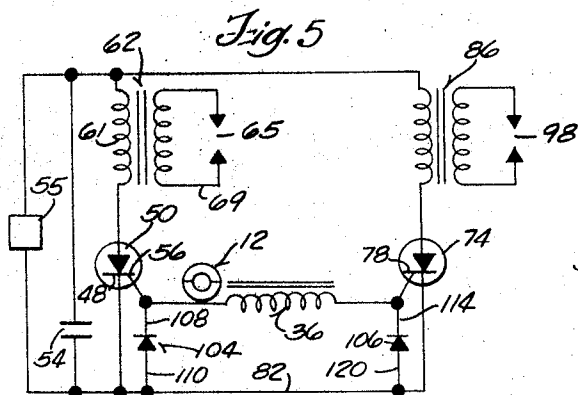
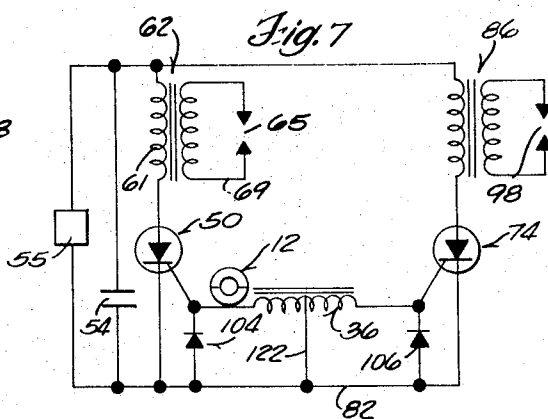
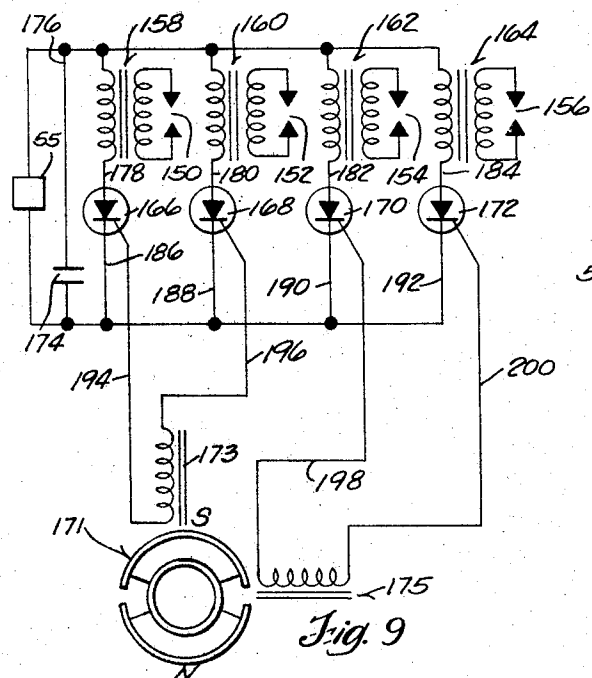
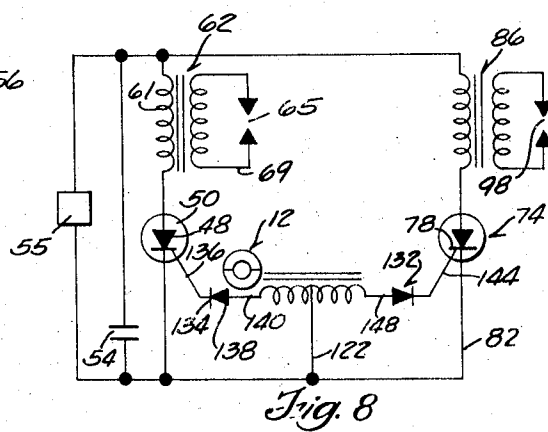
[52] U.S. Cl. **123/148,**
 315/209, 310/70, 123/149
 [51] Int. Cl. **F02p 3/02**
 [50] Field of Search 123/148
 (E), 149 (D); 315/209 (CD), 209; 322/71, 91;
 310/70.1, 153

[56] **References Cited**

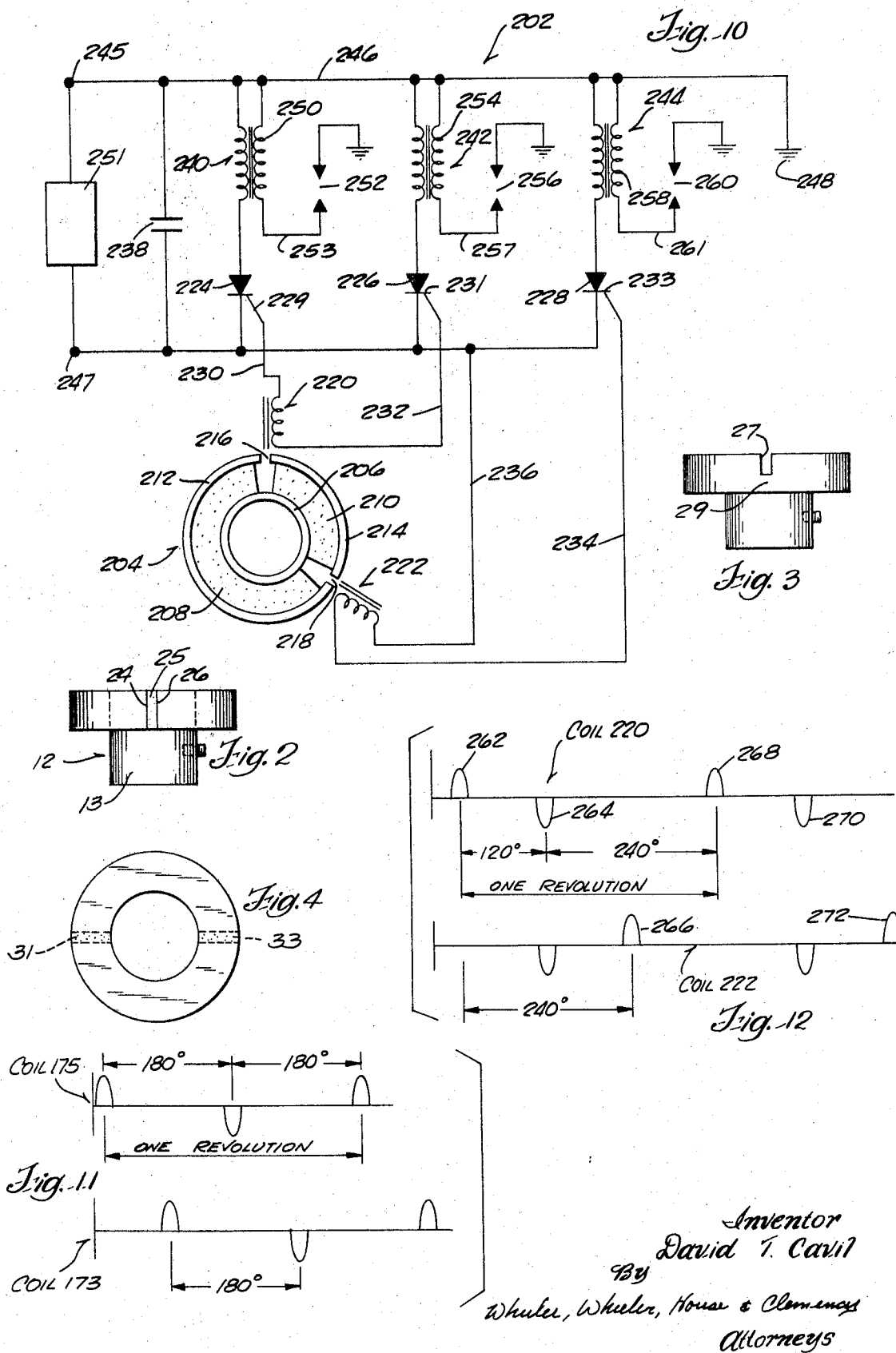
UNITED STATES PATENTS
 2,538,534 1/1951 Phelon 310/153

ABSTRACT: Disclosed herein is a contactless and distributorless capacitor discharge ignition circuit which is designed for an internal combustion engine and which employs a rotary pulse generator with a rotor which can be connected directly to the engine crankshaft for rotation therewith and which includes two circumferentially aligned magnet pole pieces in the form of circular ring sectors having a total angular span of slightly less than 360°. The ends of the pole pieces are spaced by narrow high reluctance gaps. The rotor induces one positive and one negative pulse in an adjacent trigger coil for each revolution to alternately make conducting two semiconductor switches to discharge a capacitor and create sequential ignition pulses in each of two ignition coils to fire spark plugs connected to the ignition coils.





Inventor
David T. Carril
By
Whuler, Whuler, House & Clemmery
Attorneys



CONTACTLESS AND DISTRIBUTORLESS IGNITION SYSTEM

BACKGROUND OF INVENTION

The invention relates to capacitor discharge ignition systems and more particularly to capacitor discharge ignition systems which utilize a rotary pulse generator to control conduction of a semiconductor switch which discharges a capacitor through the primaries of ignition coils to attain ignition voltages for the spark plugs.

SUMMARY OF INVENTION

The invention provides a contactless and distributorless capacitor discharge ignition circuit which employs a novel pulse generator to trigger or make conducting solid-state switching devices or thyristors to successively or sequentially discharge a capacitor through the primaries of separate ignition coils connected to each spark plug. The pulse generator includes a rotor which has two circumferentially arranged magnet pole pieces in the form of two circular ring sectors with the ends of the pole pieces spaced by narrow high reluctance gaps.

The pulse generator also includes a trigger coil located adjacent to the rotor. The trigger coil senses only a change in poles rather than the approach or recession of a pole. Thus, each revolution of the rotor induces one positive and one negative pulse in the trigger or pickup coil. In the embodiment of the invention in which two thyristors and two spark plugs are employed, one thyristor is made conducting by the positive pulse and the other thyristor is made conducting by the negative pulse. Thus, for every revolution of the pulse generator both spark plugs are fired.

A further embodiment of the circuit includes two trigger coils with the core axes forming an angle of 90° and four thyristor to fire four spark plugs. An additional embodiment utilizes two trigger coils and three thyristors to fire three spark plugs. The pulse generator for the latter embodiment has one pole piece with an arcuate extent of slightly less than 120° and a second pole piece of slightly less than 240°. The axes of the two trigger coils form an angle of generally 120°. The pulse generator in this embodiment induces two positive and two negative pulses for each revolution of the rotor.

Further objects and advantages of the invention will become apparent from the following disclosure.

DRAWINGS

FIG. 1 is a schematic view of an ignition system in accordance with the invention.

FIG. 2 is a side view of a modified form of the pulse generator shown in FIG. 1.

FIG. 3 is a further embodiment of the pulse generator.

FIG. 4 is an additional embodiment of the pulse generator.

FIG. 5 is a modified embodiment of the ignition system shown in FIG. 1.

FIG. 6 is the wave form produced by the rotary pulse generator in FIG. 1.

FIG. 7 is a further modified embodiment of the ignition system shown in FIG. 1.

FIG. 8 is an additional modified embodiment of the ignition system shown in FIG. 1.

FIG. 9 is an ignition system in accordance with the invention in which four spark plugs are utilized.

FIG. 10 is a further embodiment of the ignition system of the invention in which three spark plugs are employed.

FIG. 11 shows the wave forms produced by the pulse generator incorporated in the circuit shown in FIG. 9

FIG. 12 shows the wave forms produced by the pulse generator incorporated in the circuit shown in FIG. 10

DETAILED DESCRIPTION

In the drawings, FIG. 1 discloses a capacitor discharge ignition circuit which is generally designated 8 and which includes a rotary pulse generator or voltage generating means 10. The rotary pulse generator 10 has a rotor 12 including a steel collar 13 which is adapted to be connected to an output shaft 14 of an engine 17. The rotor can be integral with the engine flywheel assembly. The rotor also includes a magnet assembly 15 with two permanent magnets 16 and 18 which can be constructed of an aluminum, nickel and cobalt alloy or ferrite and which are in the form of circular ring sectors. The magnets 16 and 18 are arranged around the steel collar 13 and are spaced at their ends by gaps 19. The magnets 16 and 18 are provided with respective pole pieces 20 and 22. The pole pieces 20, 22 are also generally in the form of circular ring sectors but have a greater arcuate extent than the magnets 16 and 18. In the embodiment shown in FIG. 1, the ends 24, 26 and 28, 30 of the pole pieces 20, 22 are separated by relatively narrow air gaps 32, 34 so that the arcuate extent of each pole piece 20, 22 is less than 180°. Thus the pickup coil 36, hereinafter described in detail, senses only a change in poles rather than an approach or recession in poles as the rotor rotates. This results in two sharp pulses per revolution as shown in FIG. 6.

In the modified form of the pulse generator shown in FIG. 2, the ends 24, 26 of the pole pieces 20, 22 are brazed at 25 to fill the gaps and provide added rigidity. Since brass has approximately the same reluctance as an air gap the brass has no effect on the magnetic field.

Alternatively, the pole pieces can be separated by a slot 27, as shown in FIG. 3, which does not extend the full width of the pole pieces. The remaining small portion of steel 29, which joins the pole pieces 20, 22, will become saturated when the magnet assembly 15 is magnetized and serves in the same manner as a complete air gap. The pole pieces can also be formed from a solid ring of ferrite (FIG. 4) with sectors of the ring magnetized to form north and south poles which are separated by dead zones or highly saturated zones 31, 33 between the ends of the pole pieces 20, 22.

Although in the disclosed construction the trigger coil is located adjacent the periphery of the rotor, in the alternative, the trigger coil can be inside the magnet assembly of the rotor.

Referring to FIG. 1, during rotation of the rotor 12 a series of pulses are induced in a pickup coil or trigger coil 36 having a core 37 and a coil 38 with two terminals 40 and 42. The pickup coil 36 is located adjacent the periphery of the magnet assembly with the longitudinal axis of the core in radial alignment with the axis of rotation of the rotor. During one revolution of the rotor 12, one positive pulse 44 and one negative pulse 46 are induced in the pickup coil, as shown in FIG. 6. Inasmuch as the pole pieces 20, 22 are not separated by an appreciable distance the trigger coil senses only a change in poles rather than an approach or recession of a pole which would generate another pip or pulse on the wave form during one revolution of the rotor 12.

As shown in FIG. 1, the ignition circuit of the invention also includes a semiconductor switch or thyristor which can be a silicon controlled rectifier 50 which has a gate 48 connected to one of the terminals 40, 42 of the trigger coil by a lead 52.

The circuit also includes a storage capacitor 54 which is connected to a conventional charging source or power supply 55 which is not shown in detail and which can be, for example, a magneto or a storage battery and a DC-DC converter. The capacitor 54 is connected to the cathode 56 of the thyristor 50 by a lead 58. The other terminal or side of the capacitor 54 is connected to one terminal 60 of the primary 61 of a first ignition coil 62 by a lead 64. The ignition coil 62 forms part of the spark ignition means. The secondary 63 of coil 62 is connected to a spark plug or spark discharge means 65 which forms the other part of the spark ignition means by leads 67 and 69. The other terminal 66 of the first ignition coil 61 is connected to the anode 68 of thyristor 50 by a lead 70.

The other terminal 42 of the pickup coil is connected to the gate 72 of a second thyristor 74 by a lead 76. The cathode 78 of the second thyristor 74 is connected to the capacitor 54 by a lead 82. One terminal 84 of the primary of a second ignition coil 86 is connected to the capacitor by a lead 88. The other terminal 90 of the primary of the second ignition coil 86 is connected to the anode 92 of the second thyristor 74 by a lead 94. The secondary 96 of the second ignition coil 86 is connected to spark discharge means in the form of a spark plug 98 by leads 100 and 102.

In operation of the embodiment disclosed in FIG. 1, a positive pulse 44 (FIG. 6) is induced in the trigger coil 36 as the rotor 12 rotates and as the gap 34 passes the core 37 of coil 36. When terminal 40 of the trigger coil becomes positive with respect to terminal 42, a positive gate current occurs in the thyristor 50 causing it to conduct and discharge capacitor 54 through the primary 61 of ignition coil 62 and thus create an ignition voltage in the secondary to fire spark plug 65. When the rotor 12 is in this position, the gate of thyristor 74 is reverse biased and will not conduct. When the rotor rotates another 180°, the terminal 42 will become positive with respect to terminal 40. This causes thyristor 74 to become conducting to discharge the capacitor 54 through the primary of ignition coil 86 and fire spark plug 98.

In FIG. 5, a modified form of the circuit just described is disclosed. As in FIG. 1, the cathodes of the thyristors are connected by a lead 82. Two shunting diodes 104 and 106 have been added to the circuit to provide low impedance paths between the cathodes and the gates of each of the thyristors 50 and 74 for protecting the gates against a high reverse voltage. The cathode of the diode 104 is connected to the gate 48 of thyristor 50 by a lead 108 and the anode of diode 104 is connected to the cathode 56 of thyristor 50 by a lead 110. The cathode of diode 106 is connected to the gate 78 of thyristor 74 by a lead 114. The anode of diode 106 is connected to the cathode 78 of thyristor 74 by a lead 120.

Referring to FIG. 7, a further embodiment of the circuit is disclosed in which the circuit is identical with the FIG. 5 embodiment except for a center tap 122 on the trigger coil 36 which is connected to the lead 82. The center tap 122 provides more complete isolation of the thyristors than the arrangement shown in FIG. 5.

A further embodiment of the circuit is disclosed in FIG. 8 in which two diodes 130 and 132 are employed. In this circuit the diodes 130, 132 are directly connected between the gates of the thyristors and the terminals of the trigger coil. In this regard, the cathode 134 of diode 130 is connected to the gate 48 of thyristor 50 by a lead 136. The anode of diode 130 is connected to one side of the trigger coil by a lead 140. The cathode of diode 132 is connected to the gate 78 of thyristor 74 by a lead 144. The anode of diode 132 is connected to the other side of the trigger coil by a lead 148. This arrangement gives complete isolation of the two thyristors. Any current coming from either thyristor will go through the center tap 122.

FIG. 9 discloses a circuit which is utilized to fire four spark plugs 150, 152, 154 and 156. The circuit includes four ignition coils 158, 160, 162 and 164 and four thyristors 166, 168, 170 and 172. The pulse generator 171 includes two trigger coils 173 and 175 angularly spaced around the rotor at an angle of approximately 90°.

One terminal of the primaries of each of the ignition coils 158, 160, 162 and 164 is connected to one side or terminal of a storage capacitor 174 by a lead 176. The other terminal of the primary of the ignition coil 158 is connected to the anode of thyristor 166 by a lead 178. The other terminal of the primary of ignition coil 160 is connected to the anode of thyristor 168 by a lead 180. The other terminal of the primary of ignition coil 162 is connected to the anode of thyristor 170 by a lead 182. The other terminal of the primary of ignition coil 164 is connected to the anode of thyristor 172 by a lead 184. The cathodes of thyristors 166, 168, 170 and 172 are respectively connected to the other side or terminal of capacitor 174

by leads 186, 188, 190 and 192. The capacitor is connected to the power source 55.

One terminal of the trigger coil 173 is connected to the gate of thyristor 166 by a lead 194. The other terminal of the trigger coil 173 is connected to the gate of thyristor 168 by a lead 196.

One terminal of the trigger coil 175 is connected to the gate of thyristor 170 by a lead 198. The other terminal of the trigger coil 175 is connected to the gate of thyristor 172 by a lead 200.

In operation of the circuit disclosed in FIG. 9, the pulse generator induces one positive and one negative pulse in trigger coil 173 (FIG. 11) which are 180° apart for each revolution of the rotor. The positive pulse fires spark plug 150 and the negative pulse fires spark plug 152. For each revolution of the rotor 12 one positive and one negative pulse are induced in trigger coil 175 upon rotation of the rotor 180°. The pulses induced in the coil 175 are 90° out of phase with the pulses in the coil 173. The positive pulse fires spark plug 154 and the negative pulse fires spark plug 156.

FIG. 10 discloses a circuit which is generally designated 202 and which is intended for use with a three cylinder two cycle internal combustion engine. The circuit includes a modified form of pulse generator 204 which comprises a steel collar 206 and two permanent magnets 208 and 210 with respective pole pieces 212 and 214 separated at their ends by gaps 216 and 218. The pole piece 214 has an arcuate extent of slightly less than 120° and the pole piece 212 has an arcuate extent of slightly less than 240°. The pulse generator 204 also includes two trigger coils 220 and 222 with the centerlines or axes of the trigger coils aligned to form an angle of approximately 120°.

The circuit includes three thyristors 224, 226 and 228. The gate 229 of thyristor 224 is connected to one terminal of trigger coil 220 by a lead 230 and the gate 231 of thyristor 226 is connected to the other terminal of the trigger coil 220 by a lead 232. The gate 233 of thyristor 228 is connected to one terminal of the trigger coil 222 by a lead 234. The other terminal of the trigger coil 222 is connected to the cathodes of thyristors 224, 226, 228 by a lead 236 which is also connected to one side or terminal of a storage capacitor 238. The other side or terminal of the storage capacitor 238 is connected to one side of the primary and secondary of ignition coils 240, 242, 244 by a lead 246 which is grounded at 248.

The circuit includes two terminals 245, 247 which are connectable to a power source 251, such as a magnetor or a storage battery and a DC-DC converter for charging the capacitor 238. The secondary 250 of ignition coil 240 is connected to a spark plug 252 by a lead 253 and the secondary 254 of ignition coil 242 is connected to spark plug 256 by a lead 257. The secondary 258 of ignition coil 244 is connected to spark plug 260 by a lead 261.

FIG. 12 discloses pulse wave forms induced in trigger coils 220 and 222 during revolution of the rotor. The thyristor 224 is made conducting when the rotor is at the position shown in FIG. 10 by pulse 262, thus causing spark plug 252 to fire. Upon rotation of the rotor 120°, thyristor 226 will be made conducting by pulse 264 and spark plug 256 will fire. After revolution of the rotor 240° degrees from the point shown in FIG. 10, the thyristor 228 is made conducting by pulse 266 and spark plug 260 fires. During the next revolution spark plug 252 is fired by pulse 268, spark plug 256 is fired by pulse 270 and spark plug 260 is fired by pulse 272.

Although the disclosed circuits utilize a single storage capacitor, the use of a storage capacitor for each ignition coil is within the purview of the invention. Accordingly, use of the term "storage capacitor means" in the claims refers to use of a single capacitor with several ignition coils, a single capacitor for each ignition coil or any combination of capacitors and ignition coils.

I claim:

1. An ignition system for an internal combustion engine comprising a power source, storage capacitor means con-

ected to said power source, first and second spark ignition means, first and second semiconductor switches connecting said storage capacitor means and said spark ignition means, and pulse generating means including a rotor and a first trigger coil having one end connected to one of said switches and having the other end of said trigger coil connected to the other of said switches, said pulse generating means inducing one positive and one negative pulse per revolution in said trigger coil to alternately make conducting said semiconductor switches to successively discharge said storage capacitor means for alternately firing said spark ignition means.

2. An ignition system in accordance with claim 1 including a third spark ignition means, a third semiconductor switch connecting said capacitor means to said third spark ignition means and said pulse generating means, and a second trigger coil having an end connected to said third semiconductor switch, said second trigger coil having an axis at generally 120° with respect to the axis of said first trigger coil.

3. An ignition system in accordance with claim 1 including third and fourth spark ignition means, third and fourth semiconductor switches connecting said capacitor means to said third and fourth spark ignition means, and wherein said pulse generating means includes a second trigger coil having ends connected to said third and fourth semiconductor switches, said second trigger coil having an axis at 90° with respect to the axis of said first trigger coil.

4. An ignition system in accordance with claim 1 wherein said pulse generating means comprises a pair of magnetic pole pieces carried by said rotor, each of said pole pieces having an arcuate extent of less than 180°, and being aligned to form circular ring sectors, and said trigger coil is located adjacent to the periphery of said pole pieces.

5. An ignition system in accordance with claim 4 wherein said magnetic pole pieces comprise a ring of ferrite with north and south pole pieces and nonmagnetized zones of ferrite separating the ends of the pole pieces.

6. An ignition system in accordance with claim 4 wherein said pole pieces are separated by zones of highly saturated material.

7. An ignition system in accordance with claim 4 wherein said pole pieces are separated by high reluctance gaps.

8. An ignition system for an internal combustion engine comprising voltage generating means adapted to be driven in synchronism with an engine and including a trigger coil, said voltage generating means producing one positive and one negative voltage pulse per revolution, a first thyristor having a gate, a second thyristor having a gate, a storage capacitor, means connected to said storage capacitor for charging said capacitor, a first ignition coil, a second ignition coil, each of said ignition coils having a primary and a secondary, spark discharge means connected to the secondaries of said ignition coils, and circuit means connecting one end of said trigger coil to said first thyristor gate, connecting the other end of said trigger coil to said second thyristor gate, connecting one side of said capacitor to said primaries of said first and second ignition coils and the other side of said capacitor to the cathodes of said thyristors, connecting the other side of said primary of said first ignition coil to the anode of said first thyristor, connecting the other side of said primary of said second ignition coil to the anode of said second thyristor, and connecting the secondaries of each of said first and second ignition coils to said spark discharge means.

9. An ignition system for an internal combustion engine comprising first, second and third ignition coils, each ignition coil having a primary and a secondary, spark ignition means connected to the secondary of each of said ignition coils, a storage capacitor having first and second terminals, means connected to said storage capacitor to charge said capacitor, circuit means connecting said first terminal of said storage capacitor to the primary of each of said ignition coils, a first switch connected to the primary of said first ignition coil and to said second terminal of said capacitor, a second switch connected to the primary of said second ignition coil and to said

second terminal of said capacitor, a third switch connected to the primary of said third ignition coil and to said second terminal of said capacitor, and pulse generating means connected to said first, second and third switches and producing 3 pulses per revolution of the engine output shaft to successively make conducting said first, second and third switches to successively discharge said capacitor through said primaries of said first, second and third ignition coils to fire said spark ignition means, said pulse generating means including a first trigger coil having one end electrically connected to said first switch and having the other end thereof electrically connected to said second switch so as to actuate said first switch in response to current flow in said first trigger coil in one direction and to actuate said second switch in response to current flow in said first trigger coil in the opposite direction.

10. An ignition system in accordance with claim 9 wherein said pulse generating means comprises a rotor adapted to be connected to the engine output shaft, said rotor having two magnet pole pieces separated at their ends by high reluctance gaps, one of said pole pieces generally having an arcuate extent of 120° and the other of said pole pieces having an arcuate extent of generally 240°, and a second trigger coil connected to said third switch, said first and second coils being located at an angle of generally 120° about the center of the rotor.

11. The combination of an engine with an output shaft and an ignition system, said ignition system comprising a pulse generator including a trigger coil with first and second terminals, a rotor connected to said output shaft, a magnet assembly carried by said rotor, said magnet assembly including two arcuately extending pole pieces to induce one positive and one negative pulse in said trigger coil per revolution of said rotor, a first thyristor, a second thyristor, a storage capacitor, first and second spark discharge means, a first ignition coil, a second ignition coil, a power source, said power source being connected to said storage capacitor, a lead connecting one side of said storage capacitor to one side of the primaries of said ignition coils, a lead connecting the other side of said capacitor to the cathode of said first and second thyristors, a lead connecting the other side of the primary of said first ignition coil to the anode of said first thyristor, a lead connecting said first terminal of said trigger coil to the gate of said first thyristor, a lead connecting said second terminal of said trigger coil to the gate of said second thyristor, a lead connecting the other side of said primary of said second ignition coil to the anode of said second thyristor, a lead connecting the secondary of said first ignition coil to said first spark discharge means, and a lead connecting the secondary of said second ignition coil to said second spark discharge means.

12. An ignition system in accordance with claim 11 including third and fourth spark discharge means, third and fourth ignition coils, third and fourth thyristors, a second trigger coil having a longitudinal axis at generally 90° with the axis of said first trigger coil, circuit means connecting said third and fourth thyristors to said capacitor and to the primaries of said third and fourth ignition coils, and circuit means connecting said second trigger coil to the gates of said third and fourth thyristors, whereby upon one revolution of said rotor one positive and one negative pulse is induced in each of said trigger coils to successively make conducting said thyristors to sequentially discharge said capacitor through each of said primaries of said ignition coils to fire said spark discharge means.

13. An ignition circuit including a pair of spark plugs, a source of current, a pair of semiconductor switches each having an element for controlling current therethrough from said source to the respective spark plugs, and pulse generating means including a rotor and coil for causing alternate current flow in said coil in response to rotation of said rotor, said coil having ends respectively connected to the current controlling elements of said semiconductor switches to alternately operate said switches to pass current to said spark plugs in response to alternate current flow in said coil.

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,577,971

DATED : May 11, 1971

INVENTOR(S) : David T. Cavil

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 2, column 5, line 15, delete ", and", insert -- including --.

Signed and Sealed this

Seventeenth **Day of** *April 1984*

[SEAL]

Attest:

Attesting Officer

GERALD J. MOSSINGHOFF

Commissioner of Patents and Trademarks