

United States Patent

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 Continuation of application Ser. No.
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3,358,665	12/1967	Carmichael et al.	123/148 E
3,405,347	10/1968	Swift et al.	123/148 E X
3,447,004	5/1969	Falge	123/148 AC
3,447,521	6/1969	Piteo	123/148 E
3,464,397	9/1969	Burson	123/148 E
3,465,739	9/1969	Burson	123/148 E X

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[54] **ALTERNATOR AND COMBINED BREAKERLESS
 IGNITION SYSTEM**
 9 Claims, 15 Drawing Figs.

[52] U.S. Cl. **307/10 R,**
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 [51] Int. Cl. **F02p 3/06**
 [50] Field of Search **307/10 R;**
 123/148 AC, 148 E, 149; 310/153; 320/14;
 322/91; 323/58; 315/209, 218

[56] **References Cited**
UNITED STATES PATENTS
 2,790,914 4/1957 Dingman **307/10 R**

ABSTRACT: An alternator for use with an internal combustion engine includes a rotor having a plurality of generating magnets and a stator carrying a number of coils in which voltages are induced by the movement of the generating magnets therepast. One of these coils is used to charge the capacitor of an associated capacitor discharge ignition system for the engine, and triggering of the ignition system to control the discharge of the capacitor and firing of the associated spark plug is achieved by a trigger signal producing means including a magnet separate from the generating magnets, a trigger coil, and irregularities such as pins on the rotor for varying the flux of the trigger magnet through the trigger coil in response to rotation of the rotor.

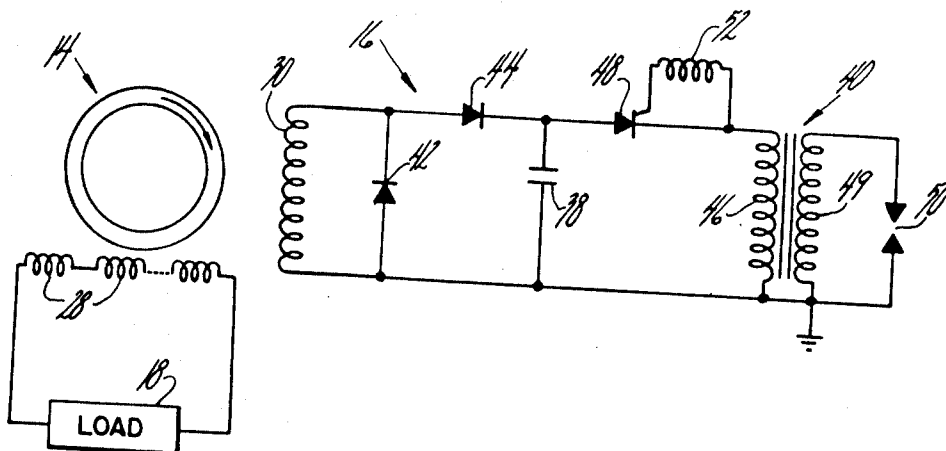


FIG. 1

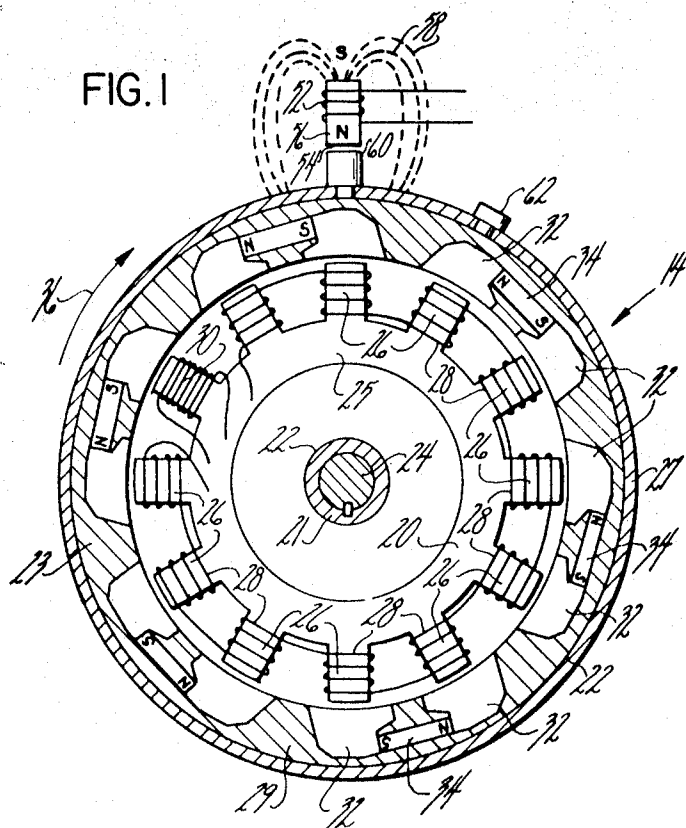
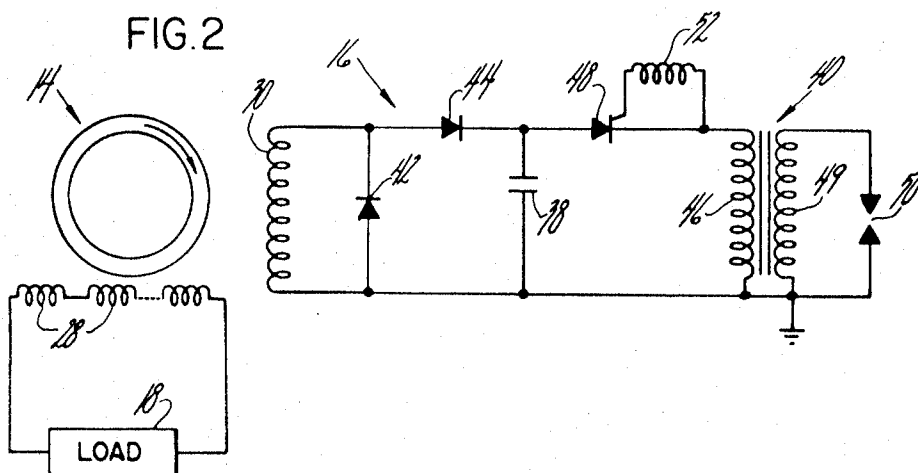


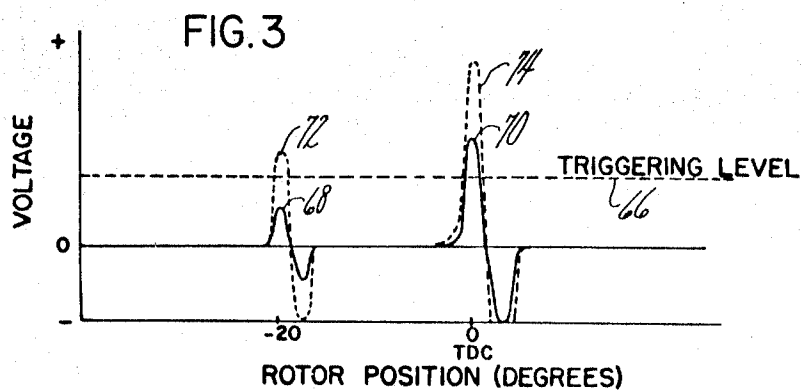
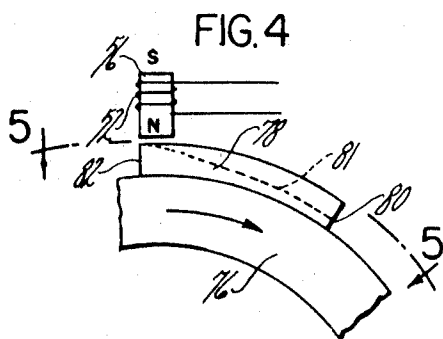
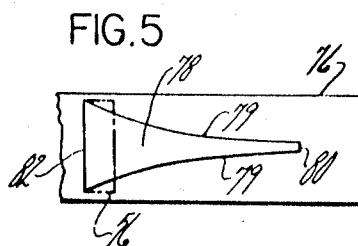
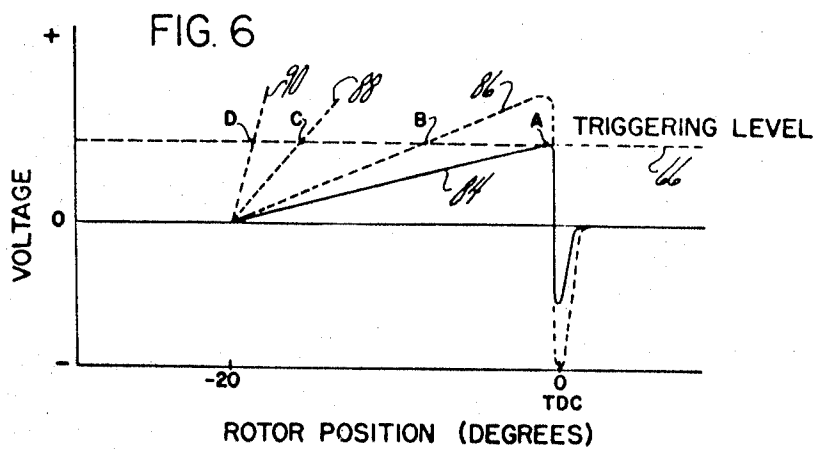
FIG. 2

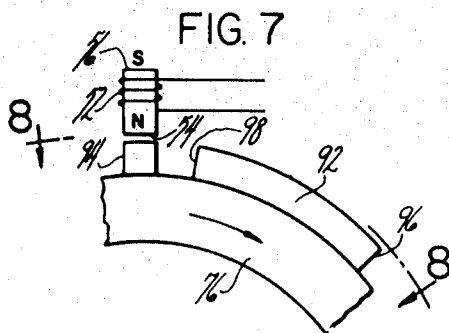
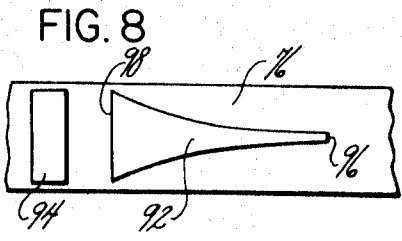
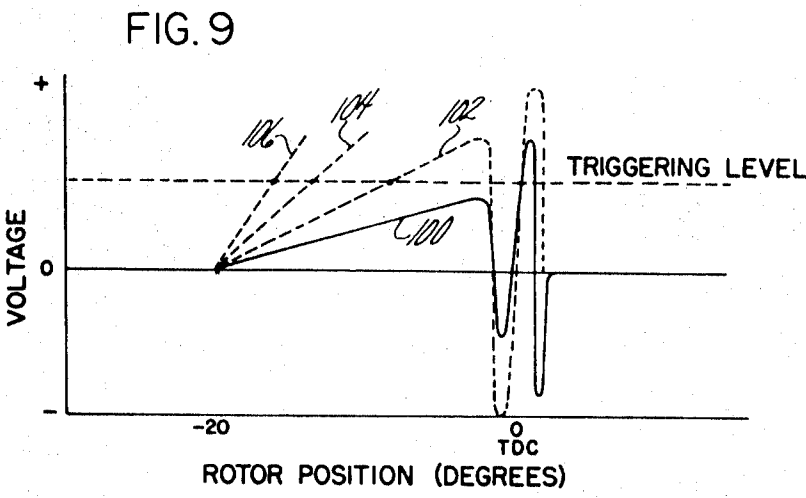
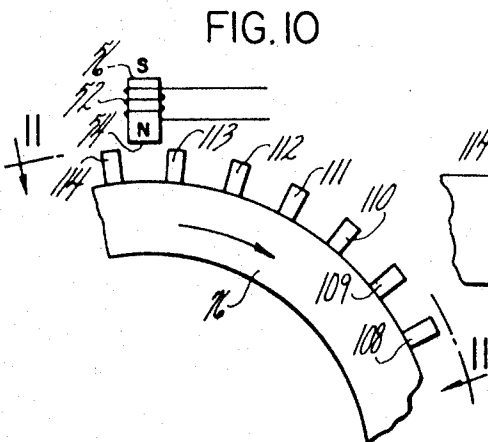
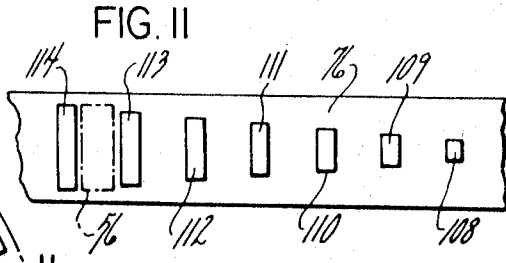


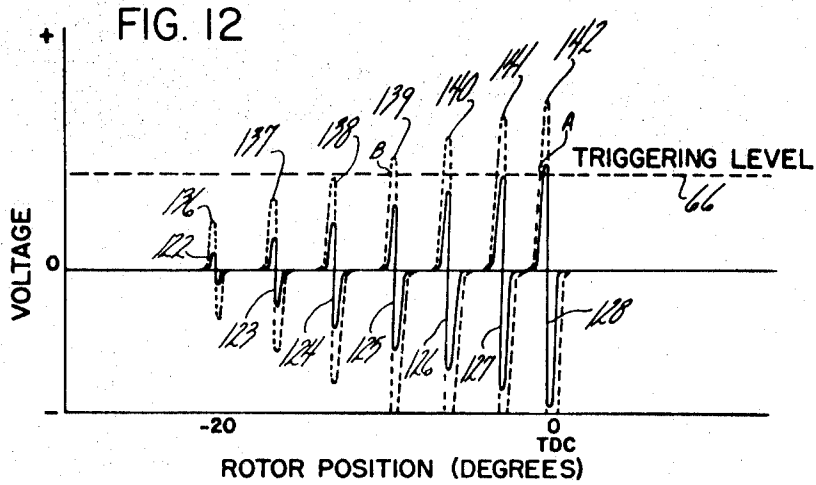
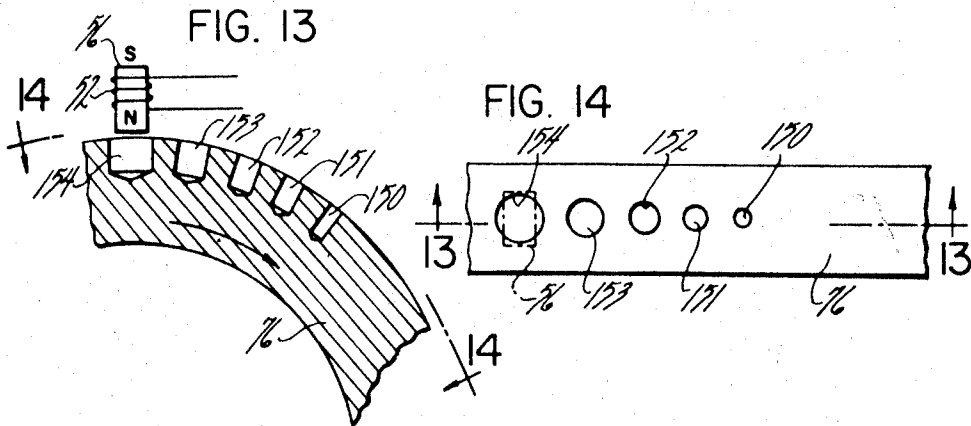
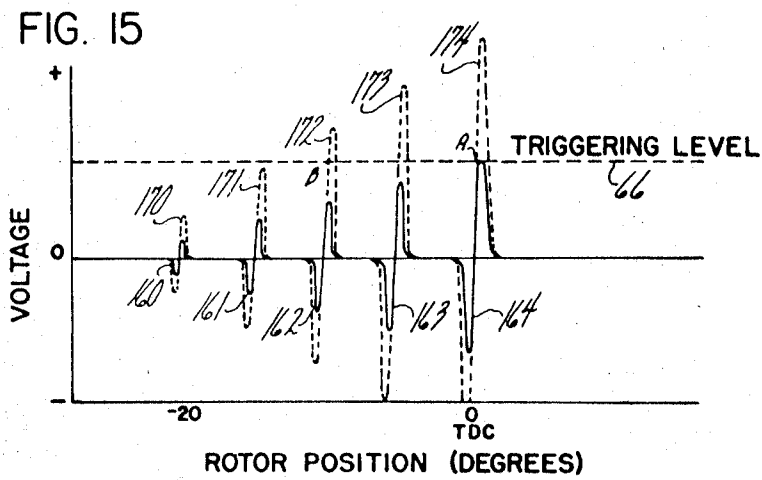
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ALTERNATOR AND COMBINED BREAKERLESS IGNITION SYSTEM

This application is a continuation of copending application Ser. No. 834,847, filed June 19, 1969 and entitled "Alternator and Combined Breakerless Ignition System," which application in turn is a division of previous application Ser. No. 675,429, filed Oct. 16, 1967 and entitled "Inductively Triggered Breakerless Ignition System With Automatic Spark Advance."

BACKGROUND OF THE INVENTION

This invention relates to ignition systems for spark ignited engines, and deals more particularly with a breakerless ignition system for use in combination with an alternator driven by the associated engine.

Several different breakerless ignition systems have been proposed in the past wherein the conventional mechanical breaker is replaced by a transistor, silicon controlled rectifier, thyatron or other electronic switch element controlled by a triggering signal. These systems are generally desirable in that they can usually be made more reliable than equivalent mechanical breaker systems and, being less subject to mechanical wear and deterioration, have a longer service life. Nevertheless, up to this time, the providing of an automatic spark advance in breakerless systems has presented problems, and the absence of a good means for obtaining an automatic advance has in many cases been a drawback to the acceptance of breakerless systems. Also, the providing of high voltage power for effecting the spark at the spark plug and the provision of suitable trigger signals has caused other problems.

The general object of this invention is, therefore, to provide a breakerless ignition system having a simple, inexpensive and reliable means for producing the high voltage power required for the firing of a spark plug and also for providing a suitable trigger signal for controlling the timing of the firing. A further object is to provide such a system which lends itself well to the further provision of a simple, inexpensive and reliable means for automatically producing an advance in the timing of the spark as the speed of the associated engine increases. In the description which follows, the invention is described in conjunction with an ignition system utilizing a condenser as a storage device for storing electrical power used to obtain the spark at the spark plug, and this is the presently preferred application. This, however, should not be taken as limiting the scope of the invention, as the invention, in its broader aspects, may be applied as well to ignition systems utilizing other types of storage devices.

SUMMARY OF THE INVENTION

The invention resides in the combination of an alternator and breakerless ignition system for use with an internal combustion engine. The alternator includes a rotor carrying a plurality of generating magnets and a stator having a plurality of load coils and one or more high-voltage coils for use with the ignition system. The voltage produced by the high-voltage coil or coils is used to charge a capacitor or other storage device which is discharged through a step-up transformer to produce a still higher voltage used to produce a spark at the associated spark plug. Discharge of the capacitor is controlled by a triggered electronic switch device such as a silicon controlled rectifier triggered by triggering signals appearing in synchronism with the rotation of the rotor. These triggering signals are in turn produced by a triggering magnet separate from the generating magnets, a triggering coil, and irregularities, such as pins on the rotor, for varying the flux of the triggering magnet through the triggering coil in response to the rotor rotation. Preferably the triggering magnet is located externally of the rotor with the triggering coil being wound upon it.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view taken through an alternator comprising part of an ignition system embodying this invention.

FIG. 2 is a schematic wiring diagram of an ignition system of which the parts shown in FIG. 1 are a part.

FIG. 3 is a diagram illustrating the voltage waveform induced in the triggering coil of FIG. 1 during each revolution of the rotor.

FIG. 4 is a fragmentary view illustrating another form of irregularity which may be used on the rotating part of an ignition system.

FIG. 5 is a development of the surface of the rotating part of FIG. 4 taken along the line 5—5 of that figure.

FIG. 6 is a diagram illustrating the voltage waveform produced in the triggering coil during each revolution of the rotor of FIG. 4.

FIG. 7 is a fragmentary view showing another form of irregularity which may be used on the rotating part of an ignition system embodying this invention.

FIG. 8 is a development of the surface of the rotating part of FIG. 7 taken along the line 8—8 of that figure.

FIG. 9 is a diagram illustrating the signal induced in the triggering coil during each revolution of the rotor of FIG. 7.

FIG. 10 is a fragmentary view showing another form of irregularity which may be used on the rotating part of an ignition system embodying this invention.

FIG. 11 is a development of the surface of the rotating part shown in FIG. 10 and taken along the line 11—11 of that figure.

FIG. 12 is a diagram showing the signal produced in the triggering coil during each revolution of the rotating part of FIG. 10.

FIG. 13 is a fragmentary sectional view showing another form of irregularity which may be used on the rotating part of an ignition system embodying this invention.

FIG. 14 is a development of the surface of the rotating part of FIG. 13 taken along the line 14—14 of that figure.

FIG. 15 is a diagram showing the signal produced in the triggering coil during each revolution of the rotating part of FIG. 13.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning to the drawings and first considering FIGS. 1 and 2, the ignition system 16 there shown includes an alternator 14 which is attached to the associated engine and which is used to provide both power for the ignition system and power for a load 18 separate from the ignition system. The load 18 may, for example, constitute a charging circuit for a battery used for starting the engine and/or a circuit including lights or other auxiliary electrically powered equipment. The alternator 14 includes a stator 20 fixed to the stationary structure of the engine and a rotor 22 which is fixed to a shaft 24. The shaft 24 is one which is rotated in synchronism with the operation of the engine and may be the crankshaft or camshaft of the engine. In any event, the shaft 24 in the illustrated case is one which rotates at the same speed as the engine crankshaft so that a given angular displacement of the crankshaft results in an equivalent angular displacement of the rotor. The rotor has a central hub 21 which is received on the shaft 24 and an axially extending rim or flange 23 connected to the hub by a radial web (not shown).

The stator 20 is located inside of the rotor 22 in the space between the hub 21 and rim 23 and includes a core 25 of laminated magnetic material having twelve equally angularly spaced radially outwardly extending poles 26, 26. Eleven of the poles 26, 26 receive associated windings 28, 28 having a relatively low number of turns, for example, 15 turns, of relatively heavy wire, and these windings are connected in series with one another as shown to provide a source of alternating power for the load 18. The twelfth pole 26, however, receives a winding 30 made up of a large number of turns, for example 4,000 turns, of relatively fine wire and this winding is used to provide a source of higher voltage power for the ignition system 16.

As shown in FIG. 1, the rotor rim or flange 23 is comprised of an outer band or shell 27, which is made of iron or steel or other magnetic material, and an annular insert 29. The insert 29 is made of a nonmagnetic base material, such as aluminum, and has six magnet assemblies embedded therein with each such assembly consisting of two pole pieces 32, 32 and a tangentially charged generating magnet 34. The pole pieces 32, 32 provide a series of twelve alternately magnetically charged pole faces on the inner surface of the rotor rim. It will, therefore, be obvious that as the rotor 22 is rotated, the magnet assemblies induce alternating voltages in the various coils 28, 28 and 30 with the voltage induced in the coil 30 being relatively high in comparison with that induced in each of the coils 28, 28. During normal operation, the rotor 22 is rotated by the engine in the direction of the arrow 36.

Considering the ignition system 16 of FIG. 2 in more detail, this system in addition to the energizing coil 30 includes a condenser 38 connected across the coil 30 and a step-up transformer 40. A diode 42 connected in parallel with the coil 30 rectifies the power supplied to the condenser 38 so that only positive pulses are transmitted thereto, and another rectifier 44 connected in series with the coil 30 prevents the charge on the condenser 38 from returning to the coil 30 during the negative portion of each cycle. The condenser 38 is also connected across the primary winding 46 of the transformer 40 through a silicon controlled rectifier 48. Therefore, when the condenser 38 is charged and the silicon controlled rectifier 48 triggered from a nonconducting to a conducting state, the condenser is discharged through the primary winding 46 to produce a surge of current through the primary winding, which induces a high voltage in the secondary winding 49 and accordingly produces a spark at the spark plug 50 or other spark gap ignition device connected to the secondary winding 49.

In accordance with the invention the triggering of the silicon controlled rectifier 48 is controlled by a triggering coil 52 connected between its gate and cathode terminals. The triggering coil 52 is in turn, as shown in FIG. 1, located adjacent the outer surface of the alternator rotor 22 and is part of an assembly including a core of magnetic material around which the coil 52 is wound and having a magnetic pole face 54 facing inwardly toward the rotor. Associated with the coil core is a source of magnetic flux or magnetomotive force for establishing a flux circuit of which the coil core is a part. The coil core may in some instances be part of a laminated iron piece and the source of magnet flux a separate permanent magnet fixed to such iron piece. In the illustrated case, however, the coil 52 is wound on a radially charged permanent triggering magnet 56 which therefore serves both as a magnetic core for the coil and as a source of magnetic flux. The triggering magnet 56 has a north pole at its inner end and a south pole at its outer end. Lines of magnetic flux therefore tend to flow from one pole of the magnet to the other and, as shown by the flux lines 58, 58 of FIG. 1, part of the path for this flow of flux tends to be through the outer magnetic shell 27 of the rotor flange. The amount of flux flowing through the magnet 56 accordingly depends, among other things, on the reluctance of the airgap between the pole face 54 and the adjacent surface of the rotor rim and, as part of the invention, irregularities are provided on the rim so that the airgap reluctance is substantially different at different rotor positions.

In the embodiment shown in FIG. 1 these irregularities are provided by two pins 60 and 62 fixed to the magnetic shell 27 of the rotor and extending outwardly therefrom. The outer portions of the pins 60 and 62 are cylindrical and of substantially the same diameter but the leading pin 62 is of a substantially shorter height than the trailing pin 60. The pins are spaced circumferentially of the rotor about 20° from one another and are axially aligned with the pole face 54 of the magnet 56. During each revolution of the rotor 22, the short pin 62 first passes beneath the magnet 56 and then 20° later the tall pin 60 passes beneath the magnet. When the short pin 62 passes beneath the magnet it reduces to some extent the

reluctance of the flux path through the coil 52 and a small voltage wave is induced in the coil. When the taller pin 60 later passes the magnet 56 the reluctance of the flux path is further reduced and a larger voltage wave is induced in the coil. The peak values of the voltage waves induced in the coil 52 as the pins pass the magnet is dependent on the rate of change of the reluctance and therefore on the speed of the rotor, and the height of the pin 60 and other parameters are chosen such that even at low cranking speeds the voltage induced in the coil 52 by the passage of the tall pin 60 is sufficient to trigger the silicon controlled rectifier 48.

The nature of the voltages induced in the triggering coil 52 and the way in which advance of the spark is achieved is better understood by reference to FIG. 3. In this figure, the solid lines indicate the waveforms obtained at a low rotor speed and the broken lines indicate the waveforms obtained at a higher rotor speed. The horizontal line 66 indicates the voltage level required to trigger the silicon controlled rectifier 48. The pin 62 passes the magnet 56 at the low rotor speed and the wave 70 is that induced in the coil as the tall pin 60 passes the magnet. The voltage wave 68 does not rise to the triggering level but the wave 70 does reach and exceed such level. Triggering of the silicon controlled rectifier to produce a spark at the spark plug 50, therefore, occurs upon the appearance of the wave 70, and the tall pin 60 which causes the production of this wave is so located on the rotor 22 that the wave 70 occurs at approximately the rotor position equivalent to the top dead center position of the engine crankshaft. The wave 72 indicates the wave produced by the passage of the short pin 62 at the high rotor speed and the wave 74 indicates that produced by the passage of the tall pin 60 at the same high speed. Both of these waves have values which exceed the triggering level 66 and, therefore, the silicon controlled rectifier will be triggered by the initial wave 72 to cause a spark at the spark plug 50. In the illustrated case, the short pin 62, as mentioned, is located approximately 20° in advance of the tall pin 60 and therefore at the high rotor speed the firing of the spark plug occurs approximately 20° in advance of the position at which firing occurs at low speed.

From the foregoing, it should be obvious that many different changes may be made from the illustrated system of FIGS. 1 and 2 without departing from the invention. For example, the triggering coil and core assembly may be associated with any part rotated in synchronism with the engine and need not necessarily be associated with the rotor of an alternator. Also, the advance as provided by the coil and magnet assembly may be used with other electrically triggered switching devices such as transistors and thyatrons, and the ignition system itself need not necessarily be a capacitor discharge system. The pins 60 and 62 may also be moved to different angular spacings to vary the degree of advance provided between high and low speed operation and, if desired, a larger number of pins may be used to provide a number of different degrees of advance at different speeds. In fact, the nature of the irregularities on the rotating part may take many different forms some of which are shown by way of example in the other figures of the drawings and described below.

In FIGS. 4 and 5, the rotating part corresponding to the rotor 22 of FIG. 1 is shown at 76 and has an irregularity on its outer surface formed by a circumferentially elongated protrusion 78 having such a shape that the voltage induced in the triggering coil 52, as the protrusion passes the magnet 56, has a ramp-shaped waveform starting at a low value when the leading end of the protrusion reaches the magnet and increasing steadily to a high value when the trailing end of the protrusion reaches the magnet. As shown by the solid lines of FIGS. 4 and 5, the protrusion 78 has a constant height, but has an axial width which increases in a nonlinear fashion in going from its leading end 80 to its trailing end 82. The length of the air gap between the protrusion 78 and the pole face 54 therefore remains constant but its area decreases as the protrusion 78 is moved past the magnet 56. As is well known the voltage induced in a coil, such as the triggering coil 52, is directly re-

lated to the rate of charge of the magnetic flux passing therethrough, and the amount of flux is directly related to the reluctance of the flux path. Therefore, in order to induce a steadily increasing voltage in the coil 52 the reluctance of the flux path should change in such a manner that it increases, as the magnet 56 goes from the leading end 80 to the trailing end 82 of the protrusion 78, in accordance with the square of the displacement of the magnet from the leading end 80. Such a changing reluctance may be obtained, as shown in FIG. 5, by shaping the protrusion with curved sides 79, 79 the curvature of which is such that the area of the protrusion covered by the magnet 56 at any point along the protrusion is approximately directly related to the square of the displacement of the magnet from the leading end 80.

Due to fringing from the sides 79, 79 of the protrusion 78 a curvature of the sides 79, 79 which yields an exact second order relation between the airgap area and its displacement from the leading end 80 may not in all cases produce a sufficiently straight ramp-shaped waveform in the triggering coil, and therefore the curvature may have to depart from such ideal curvature, and be determined best by trial and error, in order to obtain the desired waveform. Also, it is not necessary that the protrusion have a constant height and, as shown by the broken line 81 of FIG. 4, the desired changing reluctance may be obtained by varying both the height and the width of the protrusion 78.

It will be obvious that the steepness of the ramp-shaped waveform induced in the triggering coil 52 by the passage of the protrusion 78 is dependent on the speed of the rotating part 76, the ramp increasing in steepness as the speed increases. In FIG. 6 the line 84 indicates the waveform produced at a low speed corresponding to the cranking speed of the engine. The line 86 represents the waveform produced at a slightly higher speed, the line 88 represents the waveform produced at a still higher speed, and the line 90 the waveform produced at close to maximum speed. The points A, B, C and D indicate the points at which triggering of the associated silicon controlled rectifier 48 occurs for each of the represented speeds and, therefore, it will be noted from FIG. 6 that as the speed increases the point at which firing occurs advances, the maximum advance being determined by the angular extent of the protrusion 78 which in the illustrated case is shown to be approximately 20°.

One possible disadvantage of the single circumferentially elongated protrusion 78 of FIGS. 4 and 5 is that the point of firing at low cranking speed is not definitely fixed and may vary to an undesirable extent. To overcome this, an arrangement such as shown in FIGS. 7 and 8, and embodying this invention, may be employed wherein the irregularity on the rotating part 76 includes a circumferentially elongated protrusion 92 and a second separate protrusion 94 spaced from the trailing end 98 of the protrusion 92. Similarly to the protrusion 78 of FIGS. 4 and 5 the protrusion 92 is so shaped as to induce a generally ramp-shaped voltage waveform in the coil 52 as it passes the magnet 56 and as shown in FIGS. 7 and 8 has a constant height and has a narrow leading end 96 and gradually increases in width in going to its trailing end 98. The protrusion 94 is of the same height and width as the trailing end 98 of the protrusion 92. The voltage waveform induced in the coil 52 of FIGS. 7 and 8 is shown for different rotor speeds in FIG. 9, the line 100 representing the waveform produced at low cranking speed, the line 102 the waveform produced at a higher speed, the line 104 the waveform produced at still higher speed, and the line 106 the waveform produced at or near a maximum speed. From FIG. 9 it will be observed that for each speed of the rotor the waveform produced consists of an initial generally ramp-shaped portion produced by the elongated protrusion 92 and a subsequent spike-shaped portion produced by the protrusion 94. At low speeds the ramp-shaped portion does not rise to the triggering level, but the spike-shaped portion does rise beyond the triggering level to cause triggering and firing. Furthermore, the spike-shaped portion occurs at a definite rotor position and therefore it definitely fixes the timing of the firing at low speeds.

FIGS. 10 and 11 show an arrangement including a number of protrusions on the rotating part 76 for causing the firing to occur at any one of a number of definite rotor positions according to the rotor speed. In the illustrated system, these protrusions consist of seven lugs or ribs, 108 to 114, equally spaced from one another along approximately a 20° extent of the circumference of the rotating part 76. The lugs 108 to 114 are of substantially the same height so as to have concentric end faces but, as shown in FIG. 11, are of varying axial extent and are so arranged as to be of an increasing axial length in going from the leading lug 108 to the trailing lug 114. As shown in phantom in FIG. 9, the magnet 56 is of a rectangular cross section and of such a size that its pole face 54 is at least as large as the outer face of the largest or trailing lug 114. Therefore, as each lug is brought in succession into alignment with the magnet 56, the airgap thickness remains unchanged but the area over which the airgap extends is varied.

The waveform produced by the arrangement of FIGS. 10 and 11 is shown in FIG. 12 with the solid lines showing the waveform at low speed and the broken lines showing the waveform at a higher speed. At the illustrated low speed the first small voltage wave 122 is produced by the leading lug 108 and the subsequent waves 123, 124, 125, 126, 127 and 128 are produced respectively by the lugs 109, 110, 111, 112, 113 and 114. Similarly, at the higher illustrated speed the smallest wave 136 is again produced by the lug 108 and the subsequent waves 137, 138, 139, 140, 141 and 142 are produced respectively by the lugs 109, 110, 111, 112, 113 and 114. At the illustrated low speed firing occurs at point A where the wave 128 produced by the lug 120 crosses the triggering level 66, all other waves failing to rise to such level. At the higher illustrated speed, however, the waveform 139 produced by the lug 111 rises to the triggering level and therefore firing occurs at the point B, the previous pulses 136, 137 and 138 failing to rise to the triggering level. At still other speeds of the rotating part, the magnitude of the waveforms may be greater or less than that shown by the broken lines of FIG. 12 so that as the speed of the rotating part increases from its lowest speed to its highest speed, the spark will occur in succession at the positions determined by the various lugs. That is, at the lowest speed, firing occurs when the lug 114 passes the magnet 56. At a slightly higher speed firing will occur when the lug 115 passes the magnet 56 and at still higher speeds firing will occur when the other lugs pass the magnet.

In addition to the irregularities being formed by protrusions on the surface of the rotating part they may also be formed by recesses in such a part, and such an arrangement is shown in FIGS. 13 and 14 wherein irregularities are formed by a number of holes 150, 151, 152, 153 and 154 drilled in the part, the holes being angularly spaced from one another and of a gradually increasing diameter in going from the leading hole 150 to the trailing hole 154. The action of the holes on the coil 52 is substantially the same as that produced by the protrusions in FIGS. 10 and 11 except that the polarity of the waveform is reversed. FIG. 15 shows the waveform produced by the device of FIGS. 13 and 14, the solid lines representing the waveform obtained at a low speed and the broken lines showing the waveform obtained at a higher speed. At the illustrated low speed the small leading opening 150 first passes the magnet 56 and slightly reduces the reluctance of the flux path through the magnet 56 to induce a small voltage wave 160 in the coil 52. As the subsequent openings 151, 152, 153 and 154 pass the magnet they reduce the reluctance of the flux path by increasing amounts and produce increasingly larger voltage waves 161, 162, 163 and 164, respectively. The largest wave 164 is the only one which crosses the triggering level 66 and, therefore, firing occurs at the point A. At the higher speed illustrated, the waves 170, 171, 172, 173 and 174 correspond respectively to the openings 150, 151, 152, 153 and 154 and firing occurs at the point B on the wave 171, this wave being the first one to cross the triggering level 66.

Again, it should be understood that the drawings and description are not to be construed as defining or limiting the scope of the invention, the claims which follow being relied upon for that purpose.

I claim:

1. In an electrical system for a spark ignition engine the combination comprising: an alternator having a stator fixed relative to the stationary structure of said engine and a rotor rotated in synchronism with the operation of said engine, said stator including a plurality of poles consisting of a first group of poles containing more than one pole and a second group of poles containing at least one additional pole, a first group of windings each of which is received on a respective one of said first group of poles, a second group of windings each of which is received solely on a respective one of said second group of poles, said rotor including a plurality of generating magnets which cooperate with said stator poles to induce voltage waveforms in said windings as said rotor rotates, a load circuit, means connecting said first group of windings to said load circuit so as to provide electrical power thereto, a spark gap ignition device, an electrical storage device connected with said second group of windings for storing electrical power provided by said second group of windings, means including an electronic switching device connected with said storage device for controlling the transmission of power from said storage device to said spark gap device and for causing the occurrence of a spark at said spark gap device as said switching device is switched from a first state to a second state, a triggering coil separate from said stator located adjacent said rotor and coupled with said switching device and operable to switch said switching device from said first state to said second state when the voltage across said triggering coil reaches a predetermined level, a triggering magnet separate from said generating magnets, and means providing a circuit for the magnetic flux of said triggering magnet which circuit passes through said triggering coil and has a reluctance dependent on the angular position of said rotor so that different magnitudes of voltage are induced in said triggering coil at different angular positions of said rotor.

2. The combination defined in claim 1 further characterized by said storage device being a capacitor.

3. The combination defined in claim 1 further characterized

by said rotor including an outer circumferentially extending rim of magnetic material surrounding said stator and within which said generating magnets are received, said triggering coil being located adjacent the outer surface of said rim, and said magnetic flux circuit providing means for said triggering coil including an irregularity on said outer surface of said rim.

4. The combination defined in claim 3 further characterized by said irregularity comprising a protrusion extending radially outwardly from said outer rim surface.

5. The combination defined in claim 3 further characterized by said irregularity comprising a recess formed in said outer rim surface.

6. The combination defined in claim 1 further characterized by said rotor including an outer circumferentially extending rim of magnetic material surrounding said stator and within which said generating magnets are received said triggering coil being located adjacent the outer surface of said rim, and said magnetic flux circuit providing means for said triggering coil including at least two angularly spaced irregularities which are of substantially different configurations so as to induce voltage waveforms of substantially different peak magnitudes in said triggering coil as they move therepast.

7. The combination defined in claim 1 further characterized by each of said windings of said first group of windings having a low number of turns in comparison to the number of turns of each of said windings of said second group so that each of said windings of said second group has induced therein a substantially higher peak voltage than that induced in each of said windings of said first group.

8. The combination defined in claim 1 further characterized by said second group of poles being comprised of only one pole and said second group of windings being comprised of only one winding received solely on said only one pole.

9. The combination defined in claim 8 further characterized by said only one winding having a substantially larger number of turns than each of said windings of said first group of windings.

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