

[54] **ELECTRIC GENERATOR FOR SPARK
IGNITED ENGINE**

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[58] Field of Search 123/149 D, 148 E,
123/149 R, 149 A

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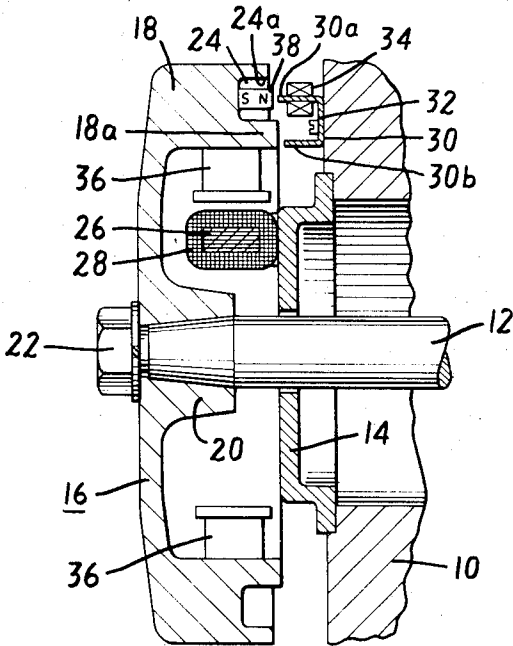
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[57] **ABSTRACT**

A cup-shaped rotor is provided on the inner wall with plural permanent magnets and on the annular end with an annular groove. With the rotor rotated in synchronism with the operation of an engine the magnets successively pass past a stationary coil forming a part of a capacitor discharge system for generating the electrical power to produce the spark while a permanent magnet disposed within the groove periodically passes past another stationary coil to generate a voltage permitting the spark to be produced to ignite the engine.

8 Claims, 2 Drawing Figures



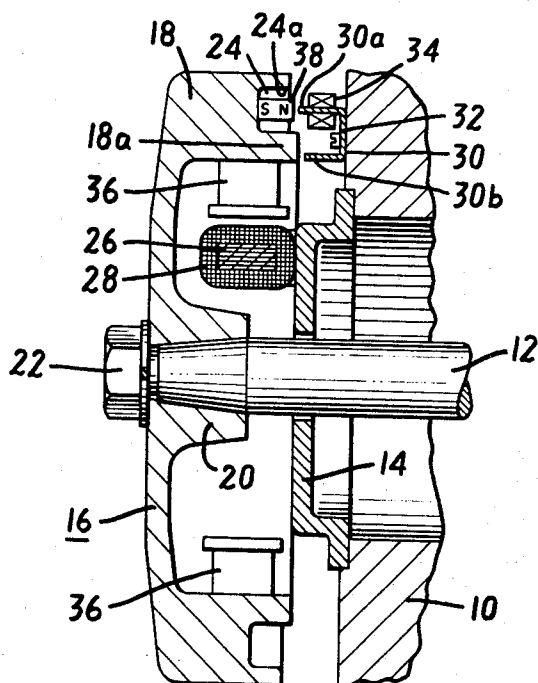


FIG. 1

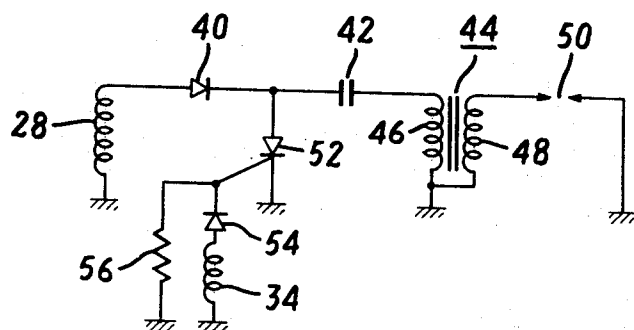


FIG. 2

ELECTRIC GENERATOR FOR SPARK IGNITED ENGINE

BACKGROUND OF THE INVENTION

This invention relates to an electric generation device including a combination of two generating coils for use with a spark ignited engine.

There have been already known electric generators for supplying the ignition device for an internal combustion engine. They are normally of the permanent magnet type and adapted to be driven by the associated engines to produce outputs of alternating current. The output of alternating current from such a generator is then applied to the ignition device for the engine where it is rendered intermittent by a set of electric contacts involved mechanically opened and closed in synchronism with the operation of the engine to produce from the associated ignition coil a high voltage for ignition.

Lately, the ignition devices of the type referred to have been and are improved as internal combustion engines per se have increased in both performance and useful life. For example, semiconductor switches such as thyristors or switching transistors have taken the place of the mechanically opened and closed contacts as above described. Those semiconductor switches have much improved the performance of the ignition devices because they are closed and opened through the application of the electrical signal thereto with no mechanical mechanism introducing an abrasion or a decrement in the switching operation. On the other hand, semiconductor switches are required to be operatively associated with the electric generator for producing the electrical signal to control the same. In other words, ignition devices utilizing a semiconductor switch must include two generators one for ignition purpose and the other for the purpose of operating the semiconductor switch.

Therefore a question arose as to how the two generators as above described would be constructed and there have been already proposed attempts to construct those two generators into a unitary structure. For example, one form of such unitary generator structures is disclosed in U.S. Pat. No. 3,447,521 entitled "Breakerless Ignition System with Automatic Spark Advance Using Triggering Coil" issued on June 3, 1969 to Michael J. Piteo. According to the cited U.S. Pat. No. 3,447,521, a magnet assembly fixed to a single rotor member has operatively associated therewith a pair of triggering coils for triggering a semiconductor switch involved and a generating coil for generating electrical power to produce the spark with a pair of separate stators disposed about the outer periphery of the rotor to accommodate the triggering and generating coils or generators respectively. The use of the single rotor member coupled to the two generators is effective for rendering the entire system small-sized. However, the rotor member is formed essentially of aluminum or other nonmagnetic material. If that rotor member is attempted to be formed essentially of a magnetic material the same structure as disclosed in the cited patent can not be adopted. Particularly, in case the rotor member is formed of a magnetic material, any attempt to render the entire generator device small-sized leads to a tendency to increase a magnetic leakage flux flowing through the magnetic rotor member. It is, therefore, desirable to provide a generation device for use with a spark ignited engine small in size, low in leakage flux

and high in performance. As above described, the rotor member has disposed about the outer periphery a pair of stators in which the triggering and generating coils are located respectively. This measure presents an obstacle to make the entire generator device compact.

Accordingly it is an object of the invention to provide a new and improved electric generation device for use with a spark ignited engine including a pair of generating coils operatively coupled to a single rotor member formed of a magnetic material while it is small in size and high in performance.

It is another object of the invention to provide an electric generation device of the type as described in the preceding paragraph including a rotor member having disposed on the outer periphery no stator including either of the generating coils therein.

SUMMARY OF THE INVENTION

The invention accomplishes the above objects by the provision of an electric generation device for use with a spark ignited engine, comprising a rotor member formed of a magnetic material to include an annular surface and driven by the engine. A first stationary magnetic core is disposed opposed to the rotor member, and a first generating coil is inductively disposed around the first stationary magnetic core to generate a voltage in response to the rotational movement of the rotor member. A second stationary magnetic core is disposed opposed to the rotor member, and a second generating coil is inductively disposed around the second stationary magnetic core to generate a voltage in response to the rotational movement of the rotor member, characterized by a recess disposed on the annular surface of the rotor member, and a permanent magnet including a first magnetic pole and a second magnetic pole disposed within the recess. The first magnetic pole is joined to the rotor member and the second magnetic pole is magnetically isolated from the rotor member. The permanent magnet is rotatable along with the rotor member to produce the voltage across the second generating coil.

BRIEF DESCRIPTION OF THE DRAWING

The above and other objects and features of the invention will be better understood from the following detailed description when considered in conjunction with the accompanying drawing in which:

FIG. 1 is a sectional view, partly in elevation of an electric generation device for use with a spark ignited engine constructed in accordance with the principles of the invention; and

FIG. 2 is an electric circuit diagram of an engine ignition system using the generation device shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing and particularly to FIG. 1, it is seen that an arrangement disclosed herein comprises a housing 10 (only one portion of which is illustrated) for a spark ignited internal combustion engine (not shown) and a crank shaft 12 loosely extending through one end of the housing 10 and including an end portion projecting beyond the latter to the exterior thereof. The engine may be one for driving a vehicle or an agricultural machine. The crank shaft 12 is surrounded in slightly spaced relationship by an apertured

stationary plate 14 of a substantially circular shape fixedly secured to the housing 10 on the outer and surface.

A cup-shaped rotor member generally designated by the reference numeral 16 is disposed in spaced opposite relationship with respect to the housing 10. More specifically, the rotor member 16 includes a cylindrical portion 18 projecting from the outer peripheral edge toward the housing 10 to form a gap therebetween, and a central thick portion 20 rigidly secured to the threaded end portion of the crank shaft 12 through a nut 22. The rotor member 16 may be substantially similar in shape to the rotor member of the conventional flywheel magnets. The cylindrical portion 18 is provided on the annular end surface 18a with a recess in the form of an annular groove 24 for the purpose as will be apparent hereinafter. The rotor member 16 is of any suitable magnetic material such as cast iron and formed into the desired shape, for example by a die casting technique.

Within the "cup" 16 a first stationary magnetic core 26 is suitably fixed to the stationary plate 14 on that surface thereof remote from the housing 10 and has a first generating coil 28 inductively disposed around the same. Also within the gap formed between the housing 10 and the cylindrical rotor portion 18 a second stationary magnetic core 30 of U-shaped cross section is fixedly secured to the housing 10 by means of screws 32 such that one leg 30a of the "U" faces the groove 24 on the end surface 18a of the cylindrical rotor portion 18 while the other leg 30b thereof faces the end surface 18a to form a very small gap therebetween. A second generating coil 34 is inductively disposed around the leg 30a of the "U."

The rotor member 16 is further provided on the inner wall surface of the cylindrical portion 18 with a first plurality of permanent magnets 36 disposed at predetermined angular intervals and at such positions that during the rotational movement thereof as will be described later they can sequentially face the first magnetic core 26 through a very small gap formed therebetween. In this connection it is to be noted that only one pair of adjacent magnets 36 are arranged to face the magnetic core 28 at a time. The permanent magnets 36 are magnetized radially of the rotor member 16 and alternate one another in the direction of magnetization. Therefore that pair of adjacent permanent magnets 36 passing past the magnetic core 28 causes a change in magnetic flux in the core through the associated segment of the cylindrical rotor portion 18.

As shown in FIG. 1, a second permanent magnet 38 is entirely accommodated at its predetermined position within the annular groove 24 on the end surface 18a of the cylindrical rotor portion 18. More specifically, the permanent magnet 38 has one end pole joined to the cylindrical rotor portion 18 and strictly to the bottom of the recess 24 by means of screws (not shown) extending therethrough in the end-to-end direction and the other end pole physically separated away from the opposed wall surfaces 24a of the groove 24 by a predetermined distance. The permanent magnet 38 is magnetized axially of the rotor member 16 or depthwise of the groove 24 and therefore the screws (not shown) fixing the magnet to the bottom of the recess extend through the magnet in the direction of magnetization. The magnet 38 is shown in FIG. 1 as being secured at the S pole to the cylindrical rotor portion 18 and has

the N pole magnetically isolated from that portion 18. If desired, the permanent magnet 38 may have the polarity reversed from that illustrated. It is to be noted that the legs 30a of the second magnetic core 30 is arranged to face the adjacent pole, in this case, the N pole of the second permanent magnet 38 once for each complete revolution of the magnet in a predetermined section thereof while a very small gap is formed therebetween. As above described, the other leg 30b of the magnetic core 30 always faces the land portion of the annular end surface 18a of the rotor member 16 during the rotational movement thereof with a very small gap formed therebetween. Thus the magnetic core 30 can pass past the generating coil 34 to change a magnetic flux flowing through the latter.

The arrangement illustrated is operated as follows:

When the associated engine (not shown) is put in operation the crank shaft 12 is rotated to rotate the rotor member 16 in synchronism with the operation of the engine while the rotor member 16 exhibits a flywheel effect. Therefore the rotating permanent magnets 36 causes a change in magnetic flux linked with the first generating coil 28 through the first magnetic core 26 resulting in the induction of an alternating current voltage thereacross. On the other hand, the second permanent magnet 38 in rotation will periodically reach its position, once for each complete rotation thereof, where it passes past the leg 30a of the second magnetic core 30 to produce and change a magnetic flux flowing along a magnetic path traced from the magnet 38 through the N pole thereof, the magnetic core 30, the adjacent portion of the end surface of the rotor member 16, the associated section of the cylindrical rotor portion and hence to the magnet through the S pole thereof and including the air gaps as above described. The changing magnetic flux affects the second generating coil 32 to induce an alternating current voltage across the latter. Now considering the magnetic leakage flux around the permanent magnet 38, there will be two magnetic leakage paths one of which passes from the N pole of the magnet 38 to either of the opposed wall surfaces 24a of the groove 24 and thence to the N pole through the associated section of the cylindrical rotor portion 18 and the other of which passes from the N pole to the engine's housing 10 and thence to the S pole through the associated section of the cylindrical rotor portion 18. The first-mentioned leakage path can have a high reluctance enough to sufficiently decrease, in the magnetic flux flowing therethrough through an increase in spacing between the N pole of the permanent magnet 38 and either of the wall surfaces 24a of the groove 24 on the cylindrical rotor portion 18. As to the second path, the magnetic leakage flux flowing therethrough can sufficiently decrease through an increase in the distance between rotor member 16 and the housing 10. If it is impossible to sufficiently increase the distance between the rotor member 16 and the housing 10, it is required only to make the groove 24 deep enough to sufficiently increase the spacing between the N pole of the permanent magnet 38 and the housing 10 while at the same time widening the spacing between the N pole and either of the wall surfaces 24a of the groove 24.

Unlike the arrangement illustrated, an arrangement may be conceived which comprises the magnetic pole piece projecting beyond the outer surface of the rotor member 16 and the magnetic core 30 having the per-

manent magnet 38 disposed therein and adapted to change in magnetic flux therein upon the magnetic pole piece passing past the magnetic core 38. For such an arrangement, it is undesirable to increase the length of the magnetic pole piece projecting beyond the rotor member because the resulting device becomes large-sized. Therefore it is desirable to sufficiently decrease the length of the projecting pole piece. This, however, leads to a decrease in difference between a reluctance occurring when the magnetic core 30 opposes to the magnetic pole piece and that occurring when the magnetic core 30 opposes to the rotor member 16 with the result that the magnetic leakage flux increases. This increase in magnetic leakage flux causes, of course, a decrease in output from the generating coil 34 and therefore in performance of the device.

It is essential to the invention to dispose the permanent magnet 38 within the groove 24. This eliminates the necessity of causing the magnetic pole piece to project beyond the outer surface of the rotor member 16 and is effective for rendering the device small-sized as well as increasing the performance. It is to be understood that the permanent magnet 38 has been magnetically isolated from the rotor member 16 by having the spacing formed between the N pole thereof and either of the wall surfaces 24a of the groove 24 but not by causing the magnet 38 to project beyond the rotor member 16. If the permanent magnet 38 has the N pole projecting beyond the rotor member 16 the N pole will be, of course, more sufficiently isolated from the rotor member 16 in the magnetic sense. Even in this event, the magnetic isolation will be more sufficiently accomplished with a magnetic pole piece projecting beyond the rotor member by a small length as compared with the case the pole piece otherwise projects from the rotor member. Also this decrease in the length by which the magnetic pole piece projects beyond the rotor member is particularly effective for engines for driving agricultural machines in that the generation device is free from troubles due to foreign matter caught by the device.

Referring now to FIG. 2 there is illustrated an ignition system for a spark ignited engine embodying the principles of the invention. The system illustrated comprises the first generating coil 28 as previously described in conjunction with FIG. 1, a semiconductor diode 40 and a capacitor 42 connected in series circuit relationship, and an ignition coil 44 including a primary winding 46 connected to the capacitor 42 and a secondary winding 48 with the coil 46 connected to ground. The secondary coil 48 includes one end connected to ground and also to the primary winding 44 and the other end connected to ground through a spark plug 50 located in the associated engine (not shown).

The junction of the diode 40 and the capacitor 42 is connected to an anode electrode of a thyristor 52 including a cathode electrode connected to ground. The thyristor 52 further has a gate electrode connected to a semiconductor diode 54 subsequently connected to the second generating coil 34 as previously described in conjunction with FIG. 1. The series arrangement of the diode 54 and generating coil 34 is connected across a resistor 56 connected to ground.

In operation the first generating coil 28 generates an alternating current voltage thereacross in the manner as previously described in conjunction with FIG. 1. Then the voltage is rectified by the diode 40 and the

rectified voltage charges the capacitor 42. At each time when the permanent magnet 38 (not shown in FIG. 2) passes past the magnetic core 34 (also not shown in FIG. 2) a triggering signal is produced across the generating coil 34. Then the triggering signal is applied through the diode 54 to the gate electrode of the thyristor 52 to trigger it to its conducting state. The now conducting thyristor 52 causes the charge on the capacitor 42 to discharge through the primary ignition winding 46 whereupon the secondary winding 48 induces a high voltage thereacross. Then the high voltage causes a spark discharge across the ignition plug 50 to ignite fuel charge in the engine (not shown).

Therefore it will be appreciated that the system of FIG. 2 utilizes the discharge of a capacitor and does not include breaker contacts previously employed. That is, it is of a contact-less type and accordingly it has a semi-permanent useful life while it is small in size.

It is to be noted that in the ignition system as shown in FIG. 2 the second generating coil 34 is effective for improving a signal-to-noise ratio of a triggering signal applied to the thyristor 52. This is because the permanent magnet 38 is disposed within the groove 24 on the annular end surface 18a of the rotor member 16. This measure causes the entire generation device to be small-sized while forming around the second generating coil 38 a magnetic path low in magnetic leakage flux. That low leakage flux is effective for substantially decreasing or minimizing the occurrence of noises other than the desired signal across the generating coil 34. Such noises induced across the generating coil 34 is objectionable particularly to the low speed operation of the engine, that is, for the desired signal low in peak amplitude. The triggering signal low in peak is difficult to be distinguished from noises and therefore the noises tend to give rise to erroneous ignition. Therefore an increase in signal-to-noise ratio of the triggering signal serves to prevent such noises from effecting any erroneous ignition.

While the invention has been described in conjunction with an ignition system utilizing the outputs from the generating coils 28 and 34 the same is equally applicable to a variety of devices controlled in accordance with the operation of the associated engines. For example, the output from the generating coil 34 may be used as input signals to a counter for counting the number of rotation of an engine.

Also while the invention has been illustrated and described in terms of a single preferred embodiment thereof it is to be understood that numerous changes in the details of construction and the arrangement and combination of parts may be made without departing from the spirit and scope of the invention. For example, the groove 24 may be disposed on the outer or inner wall surface of the cylindrical rotor portion 18 which is, in turn, accompanied by the associated magnetic core 30 with the generating coil 34 being disposed on the outer or inner wall surface of the cylindrical rotor portion. Then the permanent magnet 38 disposed within such a groove is magnetized radially of the rotor member 16. In every case it is important to dispose the core leg 30a such that it only faces the permanent magnet once for each complete rotation of the rotor member 16 in its predetermined section through a very small gap formed therebetween while the core leg 30b continuously face the rotor member 16 through a very

small gap formed therebetween during the rotational movement of the rotor member.

The groove 24 is not necessarily required to be annular. If desired, the groove may be formed on one portion of the annular end surface of the cylindrical rotor portion 18 with the same results as exhibited by the annular groove. While the recess on the end surface 18a of the cylindrical rotor portion 18 has been described as being in the form of a groove it is to be understood that the recess may be in the form of a step disposed on the end portion of the outer or inner wall surface of the cylindrical rotor portion. To this end, the outer or inner wall of the cylindrical rotor portion 18 may be radially cut away to a desired dimension. The step may extend entirely or partly on the outer or inner wall surface. Then the permanent magnet 38 is disposed on the recessed portion of the step thus formed.

If desired, the permanent magnet 38 may partly project from the recess with the results still sufficiently satisfactory as compared with the magnet entirely projecting from the recess. Furthermore the U-shaped core 30 may be fixedly secured to an extension of the stationary plate 14 rather than to the housing 10.

What we claim is:

1. An electric generation device for use with a spark ignited internal combustion engine, comprising, in combination, a driven rotor member formed of a magnetic material and having an axial annular recess, a first stationary magnetic core disposed opposed to said rotor member and disposed in a plane passing through said rotor within the periphery thereof, a first generating coil inductively disposed around said first stationary magnetic core to generate a voltage in response to the rotational movement of said rotor member, a second stationary magnetic core disposed extending into said axial annular recess opposed to said rotor member, a second generating coil inductively disposed around said second stationary magnetic core to generate a voltage in response to the rotational movement of said rotor member, on said annular surface of said rotor member, a permanent magnet including a first magnetic pole mounted on said rotor member in contact therewith and a second magnetic pole extending away from said rotor member magnetically isolated from said rotor member, said permanent magnet being rotatable along with said rotor member with said second pole passing adjacent said second generating coil to produce a voltage pulse in said second generating coil, said rotor member comprises a recess and said permanent magnet is accommodated within said recess in a position in which said second magnetic pole is spaced away from wall surfaces defining said recess thereby to be magnetically isolated from said rotor member.

2. An electric generation device as claimed in claim 1 wherein said recess is formed as an annulus on said annular surface of said rotor member, and said permanent magnet is disposed on one portion of the annular

recess.

3. An electric generation device as claimed in claim 1, including an ignition system, means connecting said second generating coil with said ignition system, and a semiconductor switch in said ignition system receptive of a control signal from said second generating coil for triggering thereof.

4. An electrical generation device for use with a spark ignited internal combustion engine, comprising, in combination, a driven rotor member formed of a magnetic material having a cup-shaped cross-section, a first permanent magnet disposed on an inner wall surface of a cylindrical portion of said rotor member, a first stationary magnetic core disposed to periodically face said first permanent magnet during the rotational movement of said rotor member, a first generating coil inductively disposed around said first stationary magnetic core to generate a voltage in response to the rotational movement of said first permanent magnet past said first generating coil, said rotor member having a recess disposed on an annular rim side face surface of a cylindrical portion of the said cup-shaped rotor member, a second permanent magnet disposed within said recess and having a first magnetic pole joined to said rotor member and a second magnetic pole magnetically isolated from said rotor member, a second stationary magnetic core disposed in a plane passing through said side face surface to periodically face said second permanent magnet during the rotational movement of said rotor member, and a second generating coil inductively disposed around said second stationary magnetic core to generate a voltage in response to the rotational movement of said second permanent magnet.

5. An electric generation device as claimed in claim 4 wherein said second stationary magnetic core is U-shaped and has a first leg facing said second magnetic pole of said permanent magnet only in a predetermined section of each complete rotation of said rotor member and second leg always facing the annular side face surface of said rotor member.

6. An electric generation device as claimed in claim 4 wherein said second permanent magnet is disposed substantially entirely within said recess and said second magnetic pole is spaced away from a wall surface defining said recess thereby to be magnetically isolated from said rotor member.

7. An electric generation device as claimed in claim 4 wherein said recess is on said annular surface of said rotor member is annular, and said permanent magnet is disposed on one portion of the annular recess.

8. An electric generation device as claimed in claim 4, including an ignition system having a semiconductor switch, means connecting said second generating coil to said ignition system to apply a control signal from said second generating coil for triggering said semiconductor switch.

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