

March 29, 1960

G. H. DINGMAN
IGNITION APPARATUS

2,930,826

Filed Sept. 14, 1956

3 Sheets-Sheet 1

FIG. 1

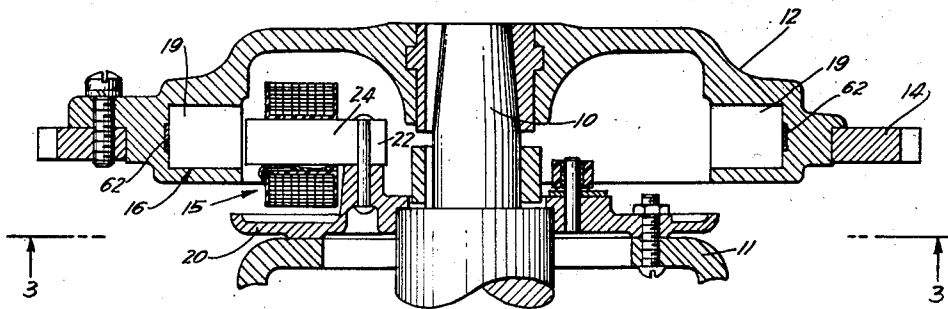
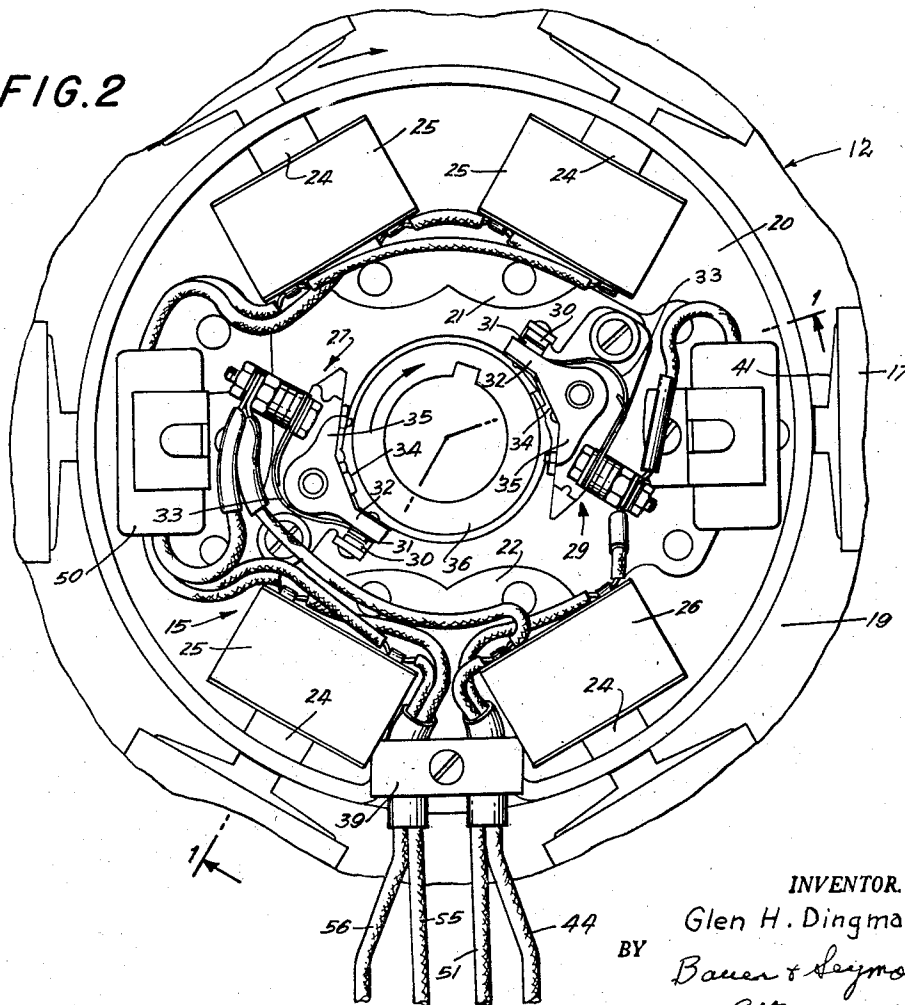


FIG. 2



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3 Sheets-Sheet 2

FIG. 3

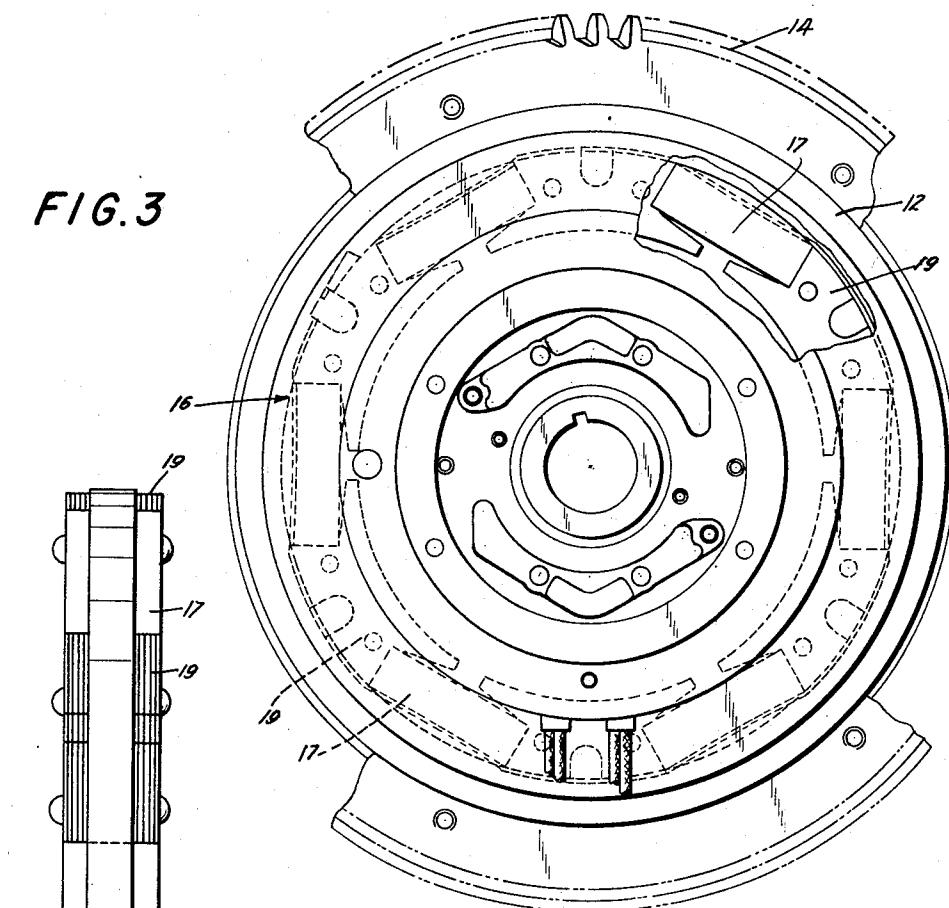
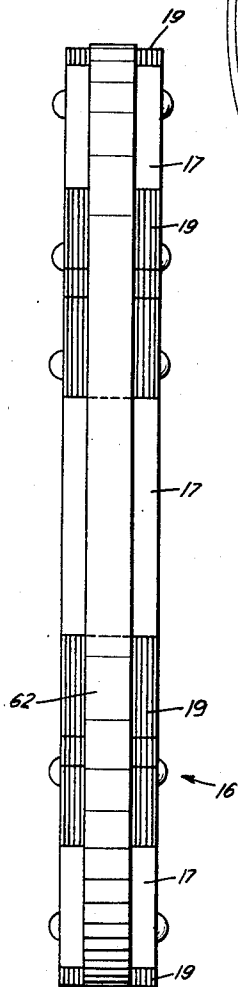


FIG. 5



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3 Sheets-Sheet 3

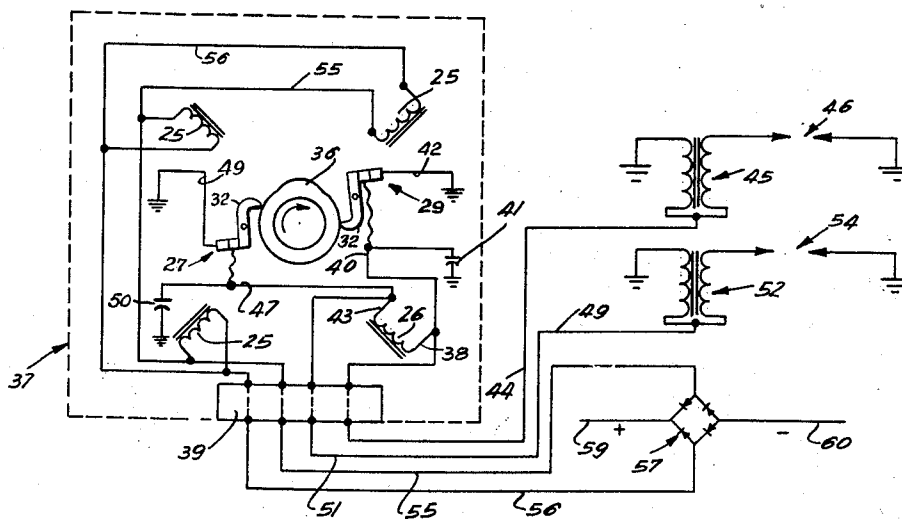
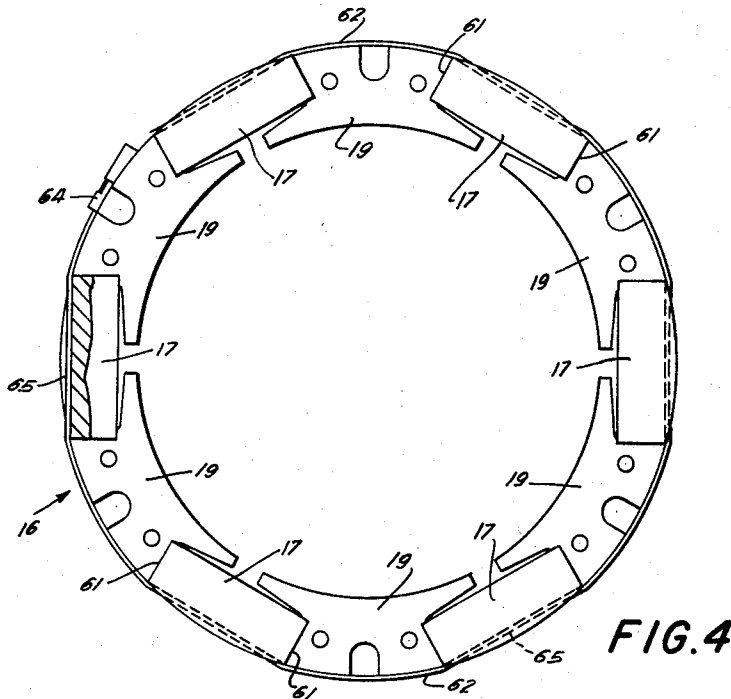


FIG. 6

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IGNITION APPARATUS

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16 Claims. (Cl. 123—149)

This invention relates to electrical apparatus and more particularly to means for producing sparks such as those employed in ignition systems for internal combustion engines.

One of the objects of the present invention is to provide a novel electrical system for producing timed sparks, as in an ignition system for internal combustion engines.

Another object of the invention is to provide a simplified electrical system for producing timed sparks alternately in two spark discharge devices.

A further object of the invention is to provide simplified means, of light weight construction which may be housed in a comparatively small space, for producing a series of electrical sparks adapted for igniting a combustible mixture in the combustion chamber of an engine or the like.

Another object is to provide a novel ignition system for two cylinder internal combustion engines wherein the cylinders fire alternately.

Still another object of the invention lies in the provision of novel ignition system of the type indicated wherein low voltage is employed throughout the major portion thereof.

Yet another object is to provide a novel combination of an ignition system and a current generating system which may be used, for example, for charging a battery, wherein some of the elements of the combination function as parts of both the ignition system and the current generating system.

A still further object is to provide an improved method of making a rotor carrying permanent magnets, such rotor being employed in the apparatus of the invention.

The above and further objects and novel device of the invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended as a definition of the limits of the invention.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is a fragmentary view in axial section through the upper end of an outboard motor incorporating the ignition and battery charging system of the invention, certain parts of the apparatus being shown in elevation, the section being taken generally along the line 1—1 of Fig. 2,

Fig. 2 is an enlarged view in plan of the stator of the electrical system of the invention, such figure fragmentarily showing portions of the magnets and pole pieces of the rotor cooperating with the stator, the pole pieces being shown in "neutral" position with respect to the pole shoes of the stator,

Fig. 3 is a view in horizontal section through the apparatus of Fig. 1, the section being taken generally along the line 3—3 of Fig. 1, the flywheel being shown

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fragmentarily and the magnets and pole shoes thereon being shown in dotted lines,

Fig. 4 is a view in plan of a composite rotor insert, made up of permanent magnets and interposed pole pieces, prior to the incorporation of such insert into the flywheel of an engine, a portion of one magnet being shown in section,

Fig. 5 is a view in end elevation of the composite insert of Fig. 4, and

Fig. 6 is a schematic wiring diagram of the illustrated embodiment of ignition and battery charging system of the invention.

The embodiment of the invention illustrated in the drawings, by way of example, is in the form of an ignition and battery charging system for a two cylinder, two cycle internal combustion engine such as an outboard motor. The energy source for the system is in the form of a combined magneto and generator unit disposed on the upper end of the motor, the rotor of the unit being incorporated in the flywheel of the motor, and the stator of the unit being supported on the frame of the motor beneath the flywheel in a position to cooperate therewith.

In the drawings, the upper end of the crankshaft of the motor is designated 10, the portion of the frame of the motor, fragmentarily shown, is designated 11, and the flywheel secured to the crankshaft is designated 12. The flywheel is shown as having an outer ring gear 14 thereon, whereby the motor may be started electrically by starter means (not shown). The combined ignition and battery charging system of the invention, as it will be evident in Figs. 1 and 2, is located mainly within and beneath the flywheel, whereby it is protected from the weather, spray, etc. The stator of the apparatus, generally designated 15, is of annular form and surrounds the upper end of the crankshaft. The rotor, generally designated 16, is composed of a series (six shown) of permanent magnets 17 with interposed pole pieces 19 embedded in the metal forming the body of flywheel 12.

The construction of stator 15 will be apparent upon consideration of Figs. 1 and 2. As there shown, an annular stator supporting plate 20 is mounted upon the upper end of motor frame 11 coaxially of crankshaft 10. Plate 20, which is made of non-magnetic material such as aluminum, carries two diametrically opposed horizontally disposed cores 21, 22, such cores each being of a somewhat broad U-shape wherein the legs 24 thereof extend radially of the crankshaft. The outer end of each leg is positioned close to the inner periphery of the rotor and functions as a pole shoe. Core 21 carries similar coils 25 on its legs, such coils being a part of the battery charging or current generating device. Core 22 carries on one leg thereof a similar current generating coil 25, and on the other leg a coil 26 which functions as the ignition coil for the motor.

Also mounted on plate 20 are two diametrically opposed switch or breaker assemblies 27, 29, which are of similar construction. The breaker assemblies are interposed in the circuits from the ends of the ignition coil to the respective spark discharge devices. As will be apparent hereinafter, one such breaker assembly functions to energize the spark discharge device for one cylinder of the motor from the ignition coil, and the other breaker assembly energizes the spark discharge device for the other cylinder from the ignition coil.

The breaker assemblies are of conventional construction; each has a pair of normally closed breaker points one of which, designated 30, is fixed, and the other of which, 31, is movable to open the circuit through the contacts at the proper time. As shown, the movable

contact is carried on the end of a first arm 32 of a first-class lever 34, such lever being constantly urged toward contact-closing position by a leaf spring 33 (Fig. 2). The end of the second arm 35 of the lever cooperates with a cam 36 which is keyed to crankshaft 10. Cam 36 has a single rise thereon, the rise being so located and of such radial height that at the beginning of a 360° cycle of turning of the crankshaft the contacts of both breaker assemblies are closed, after a suitable interval the contacts of one breaker open while the contacts of the other remain closed, then the contacts of such first assembly are closed, next the contacts of the second breaker assembly are opened, and finally the contacts of the second breaker assembly are closed.

It will be apparent that as the pole pieces of the rotor move past the outer ends or shoes of the legs 24 of cores 21 and 22, they subject each core to flux of alternating polarity, such flux in turn inducing an alternating voltage in each of coils 25 and 26. When the coils are closed-circuited a current flows in them in such direction that the magnetic flux produced by such current tends to resist a change of the flux in the core. Upon opening of the circuit of the ignition coil 26 by breaker 27 or 29, which in the present system preferably takes place when current flow in such coil is generally at a maximum, the flux produced by the current instantly collapses, thereby inducing a voltage surge in the ignition circuit. The ignition system of the present invention employs such phenomena in a novel manner whereby one ignition coil supplies the ignition needs of two cylinders and the breaker points which create the timed voltage surges in the ignition coil likewise function to energize the spark discharge devices for the respective cylinders in the proper time sequence.

The manner of functioning of the ignition system will perhaps be best understood upon reference to Fig. 6. As there shown, the current generating portion of the illustrated ignition and battery charging system is schematically indicated as a unit 37 having a connecting panel 39 through which connections are made to the spark discharge devices and to the external portion of the circuit of the battery charging device. A first end 38 of coil 26 is connected to the movable contact of breaker assembly 29 by wire 40, such wire being connected, as shown, to ground through condenser 41. The fixed contact of assembly 29 is connected to ground by wire 42. The first end 38 of coil 26 is connected by wire 44 to one end of the primary of a step-up transformer 45 which is preferably located close to its respective electrical discharge device, such as a spark plug schematically indicated at 46. Transformer 45 is connected to one electrode of device 46. The other end of the primary of transformer 45 is connected to ground, as is the other electrode of the plug. Conveniently, the electrically conducting frame of the motor forms the ground, although it will be understood that a separate common conductor forming one side of the various circuits may be employed, if desired.

The other end 43 of ignition coil 26 is connected to the movable contact of breaker assembly 27 by wire 47; the fixed contact of such assembly is connected to ground by wire 49, a condenser 50, similar to condenser 41, connects wire 47 to ground. End 43 of coil 26 is connected by conductor 51 to one end of the primary of a second step-up transformer 52 which is connected to its respective discharge device such as a spark plug 54. Device 54 and transformer 52 are connected to ground in the same manner as device 46 and transformer 45.

In a typical operating cycle for a two cylinder two cycle internal combustion engine employing the ignition system of the above described embodiment of the invention, the following events take place:

0° (position of motor flywheel).—At this point breaker assembly 27 is in closed position. Breaker assembly

29 now opens. This collapses the flux in the ignition coil 26, thereby inducing a voltage surge in the primary of transformer 45. Such voltage surge is transformed into a high tension by transformer 45, so that spark plug 46 discharges.

120°—Breaker assembly 29 now closes. As a result current builds up in ignition coil 26.

180°—Breaker assembly 27 now opens. This collapses the flux in the ignition coil 26, thereby inducing a voltage surge in the primary of transformer 52. Such voltage surge is transformed into a high tension by transformer 52, so that spark plug 54 discharges.

300°—Breaker assembly 27 closes and remains closed to 360° (or 0°) at which time a new cycle begins.

The battery charging portion of the illustrated system is made up of the coils 25, which cooperate with rotor 16 to produce alternating current, and a rectifier for the thus generated current. Coils 25 are shown connected in parallel by wires 55 and 56, which lead through panel 39 to a full wave rectifier 57. Wires 59 and 60 conduct direct current from the rectifier to a battery (not shown) to charge the battery. In some instances, where a higher voltage is desired, the coils 25 may be connected in series rather than in parallel. Also, where the current generated by coils 25 is to be used for heating or lighting purposes, the rectifier 57 may be dispensed with.

The coil 25 which is on stator core 22 exerts a desirable control on the voltage induced in ignition coil 26, particularly at high engine speeds, by, in effect, robbing some of the flux from the leg 24 on which coil 26 is disposed. As a result, the ignition voltage is levelled off as engine speed increases, and the life of the spark plugs is accordingly increased.

The invention includes a novel and advantageous method of retaining the permanent magnets and interposed pole pieces in assembled relationship while they are being incorporated as an insert into the flywheel casting.

The magnets 17, which are generally of rectangular parallelepiped form, have their opposite ends received within seats 61 in the opposite ends of pole pieces 19. The pole pieces are built up of laminations riveted together. The inner faces of the pole pieces overlie the magnets to some extent, and lie along an imaginary cylinder having a diameter slightly larger than the effective diameter of the pole shoes on the stator cores. The outer surfaces of the magnets and pole pieces lie generally upon a second, larger imaginary cylinder.

In making the combined rotor and flywheel, the magnets 17 and pole pieces 19 are assembled as in Fig. 4, after which they are tied together as a unitary rotor by a peripherally extending tie member 62 which is tightened around the rotor parts and is secured in a conventional manner by a tie connector 64. In order to hold the tie member in position on the assembled rotor, the magnets, the pole pieces, or both may be provided with tie member-positioning formations. In the illustrated embodiment, the outer face of each of the magnets 17 is provided with a central longitudinally extending shallow groove 65, the bottom of which is flat. The tie member 62 when tightened overlies the outer faces of the pole pieces and lies within grooves 65, so that it is retained against sidewise movement with respect to the rotor. Tie member 62 is made of a material which retains its integrity and substantial strength at the casting temperature of the metal forming the body of the flywheel 10. When the flywheel body is made of aluminum a tie member 62 made of iron or steel is satisfactory.

The thus assembled and tied together rotor is placed in a suitable mold as an insert, and the flywheel body-forming metal is cast about it.

The tie member 62 remains as a part of the insert, as is evident in Fig. 1.

The described method of assembling and holding to-

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gether the rotor parts is of advantage because of its speed, the accuracy of location of the rotor parts, and the simplicity of the means required in the mold to insure the accurate placement of all rotor parts with respect to each other, and the accurate centering of the rotor assembly in the flywheel. Thus the cast flywheel requires little if any machining to correct unbalance.

Although only one embodiment of the invention is illustrated in the drawing and described in the foregoing specification, it is to be expressly understood that the invention is not limited thereto. For example, the ignition system of the invention may be used to advantage without the current generating or battery charging system. Various changes may also be made in the design and arrangement of the parts illustrated as well as in the materials herein suggested as suitable without departing from the spirit and scope of the invention as it will now be understood by those skilled in the art.

What is claimed is:

1. Ignition apparatus comprising a coil, means to subject the coil to cyclically varying magnetic flux to induce cyclically varying voltage in the coil, means to close the circuit through the coil at first and second periods spaced from each other in the cycle, two electrical discharge devices one of which is operatively associated with one end of the coil and the other of which is associated with the other end of the coil, means operatively to connect the one discharge device to the one end of the coil at the end of the first period, and means operatively to connect the other discharge device to the other end of the coil at the end of the second period.

2. Ignition apparatus comprising a coil, means to subject the coil to cyclically varying magnetic flux to induce cyclically varying voltage in the coil, a separate electrical discharge device operatively associated with each end of the coil, switching means selectively operatively connecting each end of the coil to a common conductor or to its respective discharge device, and means to operate the switching means in timed relationship with the cycle of flux variation so that the circuit through the coil is closed, then the first end of the coil is operatively connected to its discharge device, then the circuit through the coil is closed, and then the second end of the coil is operatively connected to its discharge device.

3. Ignition apparatus comprising a coil, means to subject the coil to cyclically varying magnetic flux to induce cyclically varying voltage in the coil, a separate electrical discharge device connected to each end of the coil, a separate switch connected to each end of the coil and in shunt with the respective discharge device, and means to operate the switches in timed relationship with the cycle of flux variation so that the two switches are cyclically opened and closed, the apparatus being so constructed and arranged that when one switch is open the other is closed, and that both switches are in closed position to close the circuit through the coil just prior to the opening of each switch.

4. Ignition apparatus comprising a coil, a plurality of spaced magnetic poles movable relatively past the coil to subject it to cyclically varying magnetic flux, a separate electrical discharge device connected to each end of the coil, a separate switch connected to each end of the coil and in shunt with the respective discharge device, and means to operate the switches in timed relationship with the movement of the poles so that the switches are cyclically opened and closed, the apparatus being so constructed and arranged that when one switch is open the other is closed, and that both switches are in closed position to close the circuit through the coil just prior to the opening of each switch.

5. Ignition apparatus comprising a stator supporting a coil, a rotor having a plurality of spaced magnetic poles movable past the coil to subject it to cyclically varying magnetic flux, a separate electrical discharge device connected to each end of the coil, a separate switch con-

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nected to each end of the coil and in shunt with the respective discharge device, and means to operate the switches in timed relationship with the movement of the poles so that the switches are cyclically opened and closed, the apparatus being so constructed and arranged that when one switch is open the other is closed, and that both switches are in closed position to close the circuit through the coil just prior to the opening of each switch.

6. Ignition apparatus as defined in claim 5, wherein a voltage step-up transformer is interposed in the circuit between each end of the coil and the respective discharge device.

7. Ignition apparatus for an internal combustion engine having a driving shaft, said apparatus comprising a stator having an ignition coil, a rotor driven in timed relationship with the driving shaft and having a plurality of spaced magnetic poles movable past the coil to subject it to cyclically varying magnetic flux, two electrical discharge devices, each of said discharge devices being connected between the respective end of the coil and a common conductor, two sets of breaker points mounted on the stator and spaced apart about the axis of the rotor, and means connected to the rotor and cooperating with the sets of breaker points to open them sequentially, the sets of breaker points being connected between the respective ends of the coil and said common conductor in shunt with their respective discharge devices, the apparatus being so constructed and arranged that both sets of breaker points are closed at first and second periods spaced from each other in the cycle and that following the first period a first set of breaker points opens so as to discharge the first discharge device, and that following the second period the second set of breaker points opens so as to discharge the second discharge device.

8. Ignition apparatus for an internal combustion engine having a frame and a crankshaft, said apparatus comprising a stator having an ignition coil, a rotor driven in timed relationship with the crankshaft and having a plurality of spaced magnetic poles movable past the coil to subject it to cyclically varying magnetic flux, two electrical discharge devices, each of said discharge devices being connected to the respective end of the coil, two sets of breaker points mounted on the stator and spaced apart about the axis of the rotor, and means connected to the rotor and cooperating with the sets of breaker points to open them sequentially, the sets of breaker points being connected between the respective ends of the coil and the frame of the engine in shunt with their respective discharge devices, the apparatus being so constructed and arranged that both sets of breaker points are closed during first and second periods spaced from each other in the cycle, and that immediately following the first period a first set of breaker points opens so as to discharge the first discharge device, and that immediately following the second period the second set of breaker points opens so as to discharge the second discharge device.

9. Ignition apparatus for a two cylinder internal combustion engine having a frame and a crankshaft, said apparatus comprising a stator having an ignition coil, a rotor driven in timed relationship with the crankshaft and having a plurality of spaced magnetic poles movable past the coil to subject it to cyclically varying magnetic flux, an electrical discharge device in each cylinder, the discharge devices being connected to the respective ends of the coil, two sets of breaker points mounted on the stator and spaced apart about the axis of the rotor, and means connected to the rotor and cooperating with the sets of breaker points to open them sequentially, the sets of breaker points being connected between the respective ends of the coil and the frame of the engine in shunt with their respective discharge devices, the apparatus being so constructed and arranged that both sets of breaker points are closed during first and second periods spaced from each other in the cycle, and that immediately

following the first period a first set of breaker points opens so as to discharge the first discharge device, and that immediately following the second period the second set of breaker points opens so as to discharge the second discharge device.

10. Ignition apparatus for a two cylinder two-cycle internal combustion engine having a frame, a crankshaft, and a flywheel mounted on the crankshaft, said apparatus comprising a stator having an ignition coil with a core mounted on the frame, a plurality of spaced magnetic poles on the flywheel movable past the core of the coil to subject it to cyclically varying magnet flux, an electrical discharge device in each cylinder, the discharge devices being connected to the respective ends of the coil, two sets of breaker points mounted on the stator and having operating means spaced 180° apart about the axis of the flywheel, and a cam having a single rise connected to the crankshaft and cooperating with the operating means for the sets of breaker points to open the sets of breaker points sequentially at equally spaced intervals, the sets of breaker points being connected between the respective ends of the coil and the frame of the engine in shunt with their respective discharge devices, the apparatus being so constructed and arranged that both sets of breaker points are closed during first and second periods spaced 180° from each other in the cycle, that during the first and second periods the rate of flux variation in the core of the coil is high, and that immediately following the first period a first set of breaker points opens so as to discharge the first discharge device, and that immediately following the second period the second set of breaker points opens so as to discharge the second discharge device.

11. Ignition and electric current generating apparatus comprising a stator having a core, two coils on said core, one of said coils being a current generating coil and the other being an ignition coil, a plurality of spaced magnetic poles movable past the core to subject it to cyclically varying magnetic flux, a current-delivering circuit connected to the generating coil, an electrical discharge device, one end of the discharge device being connected to one end of the ignition coil, the other end of the ignition coil being connected to a common conductor to which the other end of the discharge device is connected a set of breaker points mounted on the stator, and means cooperating with the breaker points periodically to open and close them in timed relationship to the flux variation in the core, the breaker points being connected in shunt with the discharge device, the apparatus being so constructed and arranged that when the set of breaker points opens the discharge device is discharged.

12. Ignition and electric current generating apparatus for an internal combustion engine having a frame and a crankshaft, said apparatus comprising a stator having a core, two coils on such core, one of said coils being a current generating coil and the other being an ignition coil, a rotor driven in timed relationship with the crankshaft and having a plurality of spaced magnetic poles movable past the core to subject it to cyclically varying magnetic flux, a current-delivering circuit connected to the generating coil, an electrical discharge device having one end thereof connected to the frame of the engine, the one end of discharge device being connected to one end of the ignition coil, a set of breaker points mounted on the stator, and means connected to the rotor and cooperating with the breaker points periodically to open them in timed relationship to the flux variation in the core, the breaker points being connected between said one end of the coil and the frame of the engine in shunt with the discharge device, the apparatus being so constructed and arranged that when the set of breaker points opens the discharge device is discharged.

13. Ignition and electric current generating apparatus for a two cylinder internal combustion engine having a frame and a crankshaft, said apparatus comprising a

stator having a core, two coils on said core, one of said coils being a current generating coil and the other being an ignition coil, a rotor driven in timed relationship with the crankshaft and having a plurality of spaced magnetic poles movable past the core to subject it to cyclically varying magnetic flux, a battery-charging circuit connected to the generating coil, rectifier means in said circuit, an electrical discharge device in each cylinder, the discharge devices being connected to the respective, opposite ends of the ignition coil, two sets of breaker points mounted on the stator and spaced apart about the axis of the rotor, and means connected to the rotor and cooperating with the sets of breaker points to open them sequentially, the sets of breaker points being connected between the respective ends of the coil and the frame of the engine in shunt with their respective discharge devices, the apparatus being so constructed and arranged that both sets of breaker points are closed at first and second periods spaced from each other in the cycle, and that immediately following the first period a first set of breaker points opens so as to discharge the first discharge device, and that immediately following the second period the second set of breaker points opens so as to discharge the second discharge device.

14. Ignition and electric current generating apparatus for a two cylinder two-cycle internal combustion engine having a frame, a crankshaft, and a flywheel mounted on the crankshaft, said apparatus comprising a stator having two cores disposed 180° apart about the axis of the flywheel, two coils on each core, three of said coils being current generating coils and the other being an ignition coil, a plurality of spaced magnetic poles on the flywheel movable past the cores to subject them to cyclically varying magnetic flux, a battery-charging circuit connected to the generating coils, rectifier means in said circuit, a spark plug in each cylinder, the spark plugs being connected to the respective ends of the ignition coil, two sets of normally closed breaker points mounted on the stator and having operating means therefor spaced 180° apart about the axis of the flywheel, and a cam having a single rise connected to the crankshaft and cooperating with the sets of breaker points to open them 180° apart, the sets of breaker points being connected to the frame of the engine in shunt with their respective spark plugs, the apparatus being so constructed and arranged that both sets of breaker points are closed during first and second periods spaced 180° from each other in the cycle, that during the first and second periods the rate of flux variation in the core of the coil is high, and that immediately following the first period a first set of breaker points opens so as to discharge the first spark plug, and that immediately following the second period the second set of breaker points opens so as to discharge the second spark plug.

15. Ignition apparatus comprising a coil, a plurality of spaced magnetic poles movable relatively past the coil to subject it to cyclically varying magnetic flux, a first electrical discharge device connected to a first end of the coil, a second electrical discharge device connected to the second end of the coil, first and second switches connected to the respective ends of the coil and in shunt with the respective discharge devices, and means to operate the switches in timed relationship with the movement of the poles so that the switches are cyclically opened and closed, the apparatus being so constructed and arranged that when one switch is opened the other is closed, that both switches are in closed position to close the circuit through the coil just prior to the opening of each switch, and that current travels in the coil toward the first end thereof and into the first discharge device when the first switch is opened, and current travels in the coil toward the second end thereof and into the second discharge device when the second switch is opened.

16. Ignition apparatus for an internal combustion engine having a frame and a crankshaft, said apparatus

comprising a stator having an ignition coil, a rotor driven in timed relationship with the crankshaft and having a plurality of spaced magnetic poles movable past the coil to subject it to cyclically varying magnetic flux, two electrical discharge devices, each of said discharge devices being connected to the respective ends of the coil, two sets of breaker points mounted on the stator and spaced apart about the axis of the rotor, and means connected to the rotor and cooperating with the sets of breaker points to open them sequentially, the sets of breaker points being connected between the respective ends of the coil and the frame of the engine in shunt with their respective discharge devices, the apparatus being so constructed and arranged that both sets of breaker points are closed during first and second periods spaced from each other in the cycle, and that immediately following the first period and at substantially peak current flow in

the coil a first set of breaker points opens so as to discharge the first discharge device, and that immediately following the second period and at substantially peak current flow in the coil the second set of breaker points opens so as to discharge the second discharge device.

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