

[54] **MAGNETO-DYNAMO-OPERATED
IGNITION DEVICE FOR MULTI-
CYLINDER ENGINES**

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315/209 CD, 315/209 SC

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[58] Field of Search315/209 CD, 209 SC, 209 R,
315/211; 123/148 E, 148 DK, 148 F, 148
ND, 149 A, 149 D

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[57] **ABSTRACT**

A magneto-dynamic-operated ignition device for a multi-cylinder engine comprising a magneto dynamo, a plurality of discharge capacitors and a plurality of ignition coils; said magneto dynamo having a 2-pole rotor, an even-pole stator and an armature coil wound on every other pole of said stator poles, the number of which is determined depending on the number of cylinders; said discharge capacitors and ignition coils being equal in number to or half as many as the cylinders. Discharging circuits of the discharge capacitors are interrupted by a common rectifier which is controlled by ignition timing signals from ignition timing dynamos.

7 Claims, 10 Drawing Figures

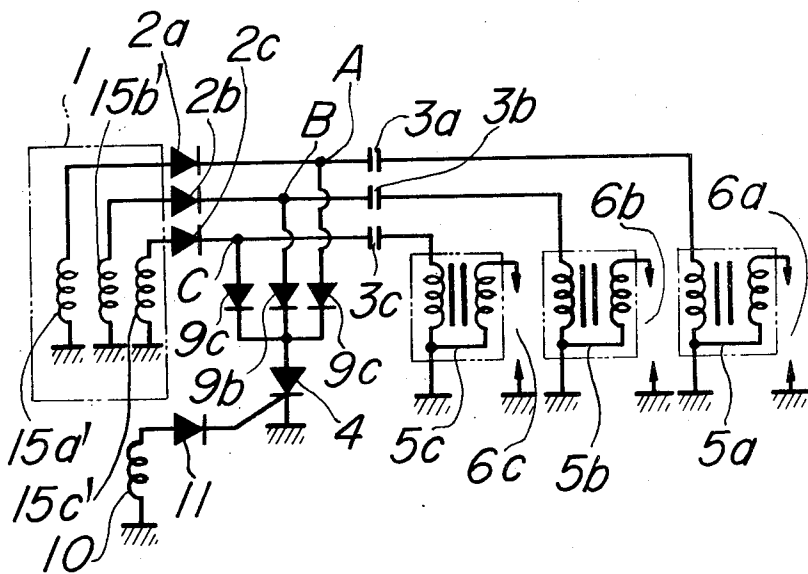


FIG. 1

PRIOR ART

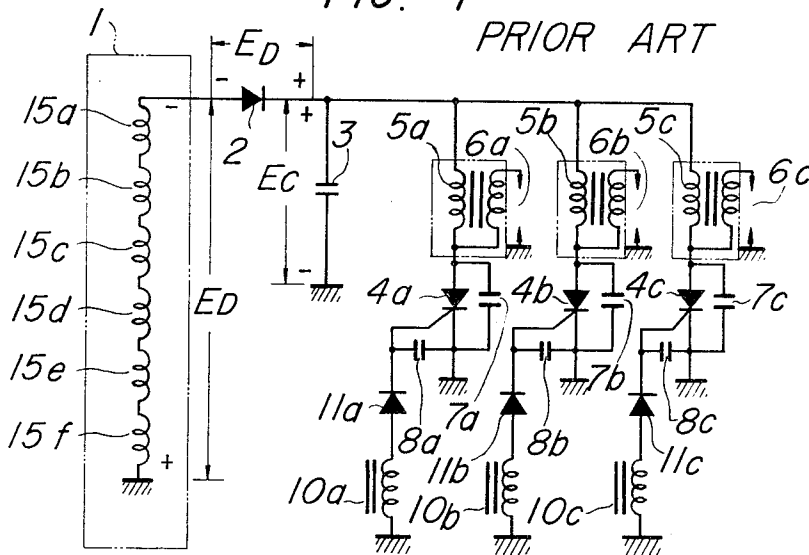


FIG. 2

PRIOR ART

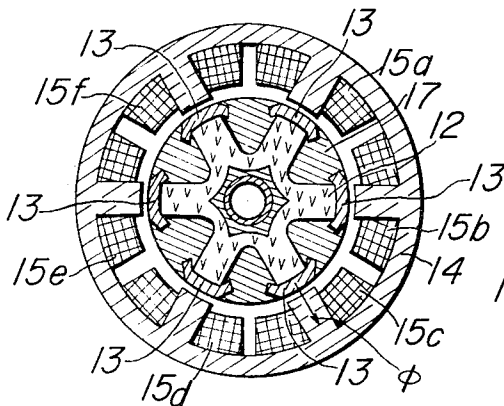


FIG. 4

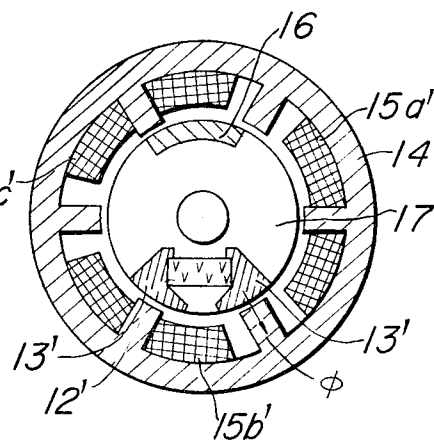
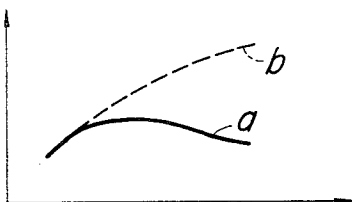


FIG. 3



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FIG. 5

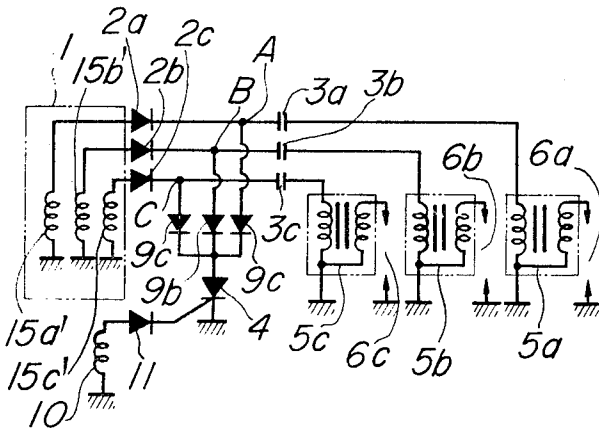


FIG. 7

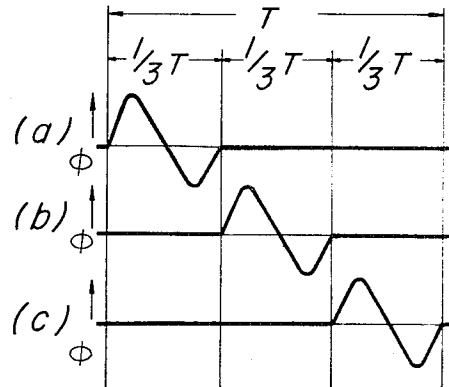


FIG. 6a

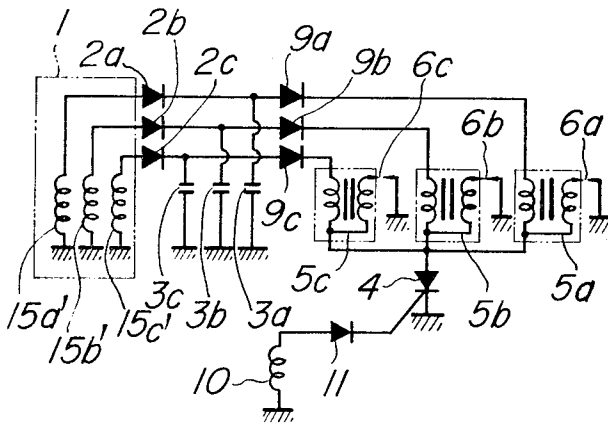


FIG. 8

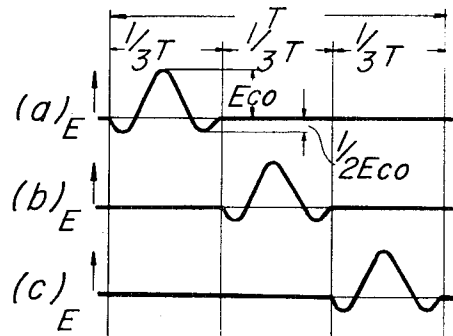


FIG. 6b

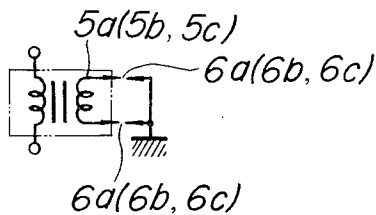
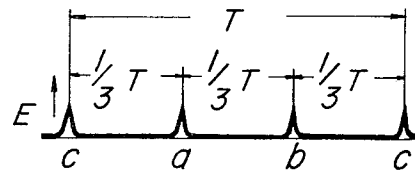


FIG. 9



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MAGNETO-DYNAMO-OPERATED IGNITION DEVICE FOR MULTI-CYLINDER ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a capacitor-discharge ignition device mounted on an engine of an automotive vehicle.

2. Description of the Prior Art

Hitherto, a capacitor-discharge ignition device for multi-cylinder engines has been arranged that such each cylinder is independently provided with an ignition coil, a controlled rectifier connected in series with the ignition coil and the gate of the controlled rectifier is applied with a trigger signal derived from an ignition timing dynamo exclusive to the controlled rectifier. Such an arrangement, however, has a disadvantage in that the controlled rectifier for one of the cylinders is apt to be wrongly operated by a signal derived from one of the ignition timing dynamos belonging to any other cylinder. Moreover, as a plurality of armature coils of the magneto dynamo are connected in series for producing a high ignition voltage to charge a discharge capacitor which is served to all the cylinders, it is necessary for the magnet dynamo to have a capability to withstand a high voltage and to be provided with a plurality of permanent magnet poles, which inevitably results in an uneconomical production cost and a high temperature rise of the armature coils in operation.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a magneto-dynamo-operated ignition device for a multi-cylinder engine, in which a magneto dynamo is employed as a power supply for charging a discharge capacitor and an high ignition voltage is produced at the secondary of ignition coils by discharging the capacitor; the ignition device comprising a magneto dynamo having a 2-pole rotor and a stator with poles of the even number which are determined according to the number of cylinders and with armature coils wound on every other pole thereof, and discharge capacitors and ignition coils respectively as many as or half as many as the cylinders; discharging circuits of the discharge capacitors being energized or cut off by a common rectifier which is controlled by ignition timing signals from the ignition timing dynamos.

By applying the device of this invention to a 2-cycle 3-cylinder engine, the capacitor voltage is made stable and erroneous energization of an unwanted ignition coil by the energization of a given ignition coil and reverse rotation of the 2-cycle engine are completely eliminated. Further, although two more capacitors and three more diodes are used than in the conventional device, rotor magnets are reduced to one third, the reverse breakdown voltage of the diodes to about one half, expensive SCRs' to one, capacitors for preventing erroneous energization to zero, and ignition timing dynamos to one. As a result of the saving of the various components, the circuit is simplified, thereby achieving considerable economy.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an electric circuit of the conventional ignition device.

FIG. 2 is a diagram showing the construction of the conventional magneto dynamo.

FIG. 3 is a graph showing the characteristic curves of capacitor charging voltages with respect to the revolutions of this device as compared with the conventional device.

FIG. 4 is a diagram showing a section of the magnet dynamo incorporated in the device according to the invention.

FIG. 5 is an electric circuit diagram showing an ignition device according to an embodiment of this invention.

FIG. 6a is an electrical circuit diagram showing the device according to another embodiment of the invention.

FIG. 6b is a diagram for explaining an example of the wider application of this invention.

FIGS. 7 to 9 are diagrams for explaining the operations of the device according to this invention, in which FIG. 7 is a diagram showing variations of the magnetic flux inside the armature coils, FIG. 8 showing waveforms of voltages produced in the armature coils and FIG. 9 showing positions of the ignition timing dynamos for the generation of ignition timing signals.

A well-known conventional capacitor-discharge ignition device of this kind employs a magneto dynamo shown in FIG. 2 as a power supply and its electrical circuit is constructed as shown in FIG. 1. Such a device will be described below with reference to FIGS. 1 and 2, taking as an example a 2-cycle 3-cylinder engine with which the device is used.

An AC voltage generated by a magneto dynamo 1 is rectified by a diode 2 and stored in a discharge capacitor 3. Charges stored in the capacitor 3 are released through parallel circuits respectively including ignition coils 5a, 5b and 5c and rectifiers 4a, 4b and 4c (hereinafter referred to as SCRs') with control electrodes which are energized through diodes 11a, 11b and 11c by ignition timing signals supplied from ignition timing dynamos 10a, 10b and 10c. The ignition timing signals are supplied by the timing dynamos sequentially to the gates of the three SCRs' once for every rotation of the crank shaft of the engine, thereby generating ignition sparks from ignition plugs 6a, 6b and 6c through ignition coils 5a, 5b and 5c. Capacitors 7a, 7b, 7c, 8a, 8b and 8c are inserted to prevent any erroneous energization of a rectifier with the control electrodes for a cylinder which might be caused by an interference signal generated while another cylinder is in operation, thereby limiting the energizing signals to those from the timing dynamos.

The construction of the magneto dynamo 1 used in the above-described circuit is illustrated in FIG. 2. Since a 2-cycle 3-cylinder engine requires three ignitions for every rotation of the crank shaft, a rotor 17 which is driven by the crank shaft comprises a 6-pole magnet 12 and magnetic-pole cores 13 arranged on its salient poles. The stator 14, like the rotor 17, has 6 salient poles on which are respectively wound armature coils 15a, 15b, 15c, 15d, 15e and 15f connected in series with each other.

In the capacitor-charging magnet dynamo with the above-described circuit arrangement and construction, the reverse voltage E_p applied to the diode 2 is the sum of the non-load voltage of the magneto dynamo 1 and

capacitor voltage E_c , and is so high as to make it necessary to raise the breakdown voltages of the parts involved. In addition, more heat is generated by the armature coils due to the 6-pole magnet 12 and due to an iron loss in the stator 14. Again, the voltage characteristic of the capacitor assumes a dotted curve of FIG. 3, from which it is understood that the voltage is low at a low dynamo speed and increases to a higher level with an increase in the speed of the dynamo, resulting in a great range of variation in the capacitor voltage. This presents the problem of providing a special voltage-protective circuit for obtaining stable capacitor charging voltages over the whole speed range if this device is to be employed for use with an automotive engine which covers a wide range of speeds. Further, the most serious problem is the fact that the rectifiers are often energized erroneously in spite of the provision of the preventive capacitors 7a, 7b, 7c, 8a, 8b and 8c.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The construction of a magneto dynamo according to this invention is illustrated in FIG. 4, while an electric circuit of the device according to the invention employing such a dynamo is illustrated in FIG. 5. A stator 14 has 6 poles with armature coils 15a', 15b' and 15c' wound on every other pole. Voltages generated at the armature coils 15a', 15b' and 15c' are respectively stored in discharge capacitors 3a, 3b and 3c through diodes 2a, 2b and 2c. A rotor 17 has a transmuted 2-pole construction in which a 2-pole rod magnet 12' and magnetic cores 13' disposed on the poles are supported on a non-magnetic material, with a balance weight 16 arranged on the opposite side. The magnetic poles of the rotor 17 are, like those of the stator 14, arranged at an angle of 60°. (This is due to the 6 poles possessed by the stator 14.) Now, let the number of turns of the armature coils be N , inductance L , average current in the coils I and magnetic flux per pole ϕ in the conventional device, and the number of turns of the armature coils N' , inductance L' , average current in the coils I' and magnetic flux per pole for the device according to the invention. In order for the charging voltage of the capacitor of the device according to the invention to be the same as that of the conventional device, it suffices if the number of turns of each of the armature coils 15a', 15b' and 15c' is the same as the total number of turns of the series armature coils 15a, 15b, . . . 15f, provided the magnetic flux ϕ is equal for both devices. The armature coils of the conventional device goes through a 3-cycle power-generating action for every revolution of the rotor, while, in the device according to the invention whose rotor has 2 poles, each of the armature coils 15a', 15b' and 15c' performs only one cycle of power generation for each turn of the rotor 17. This results in value of current I' one third as small as the current I produced in the case of the conventional device, and therefore it suffices to provide a coil with a section one third as small as that of the conventional device, the heating effect due to the current being the same, making it possible to have the number of the winding turns three times more than that in the case of the conventional device with the same winding space. Further, since windings are provided on every other pole in the device according to the invention instead of on all of

the six poles as in the conventional device, twice as much winding space is available per pole as in the case of the conventional device. In all, six times as many windings as in the case of the conventional device can be provided on every other pole of the stator 14, with the result that the number of turns N' which is equal to the total number of turns 6N of the conventional device can be realized in one armature coil. As regards the inductance of each coil, the inductance of all the coils which are connected in series in the case of the conventional device is 6L. By contrast, the number of turns of an armature coil per pole is six times as large in the device of the invention, and since the inductance is proportional to the square of the number of turns, the inductance per pole of the device according to the invention is $6^2L = 36L$. From this it will be understood that the series inductance involved in the charging of the capacitor is six times as high as in the conventional device ($36L/6L = 6$). When the engine is at low speed, the frequency of the voltage produced is low and therefore the voltage drop due to the inductance inserted in series for charging the capacitor is negligible, but at high velocity the frequency of the voltage generated is high resulting in a larger voltage drop due to the inductance. According to the invention, therefore, the voltage drop due to the inductance prevents overvoltage of the capacitor-charging voltage at high speed, making it possible to obtain a stable characteristic of the capacitor-charging voltage as shown by the solid line a of FIG. 3. Further, the reduction of the magnet to one third of the one used in the conventional device results in a lower magnet cost, whereas the reduction of iron loss of the stator core to one third of that in the conventional device causes less heat to be generated.

The electrical circuit of the device according to the invention will be explained below in detail mainly with reference to FIG. 5. The armature coils 15a', 15b' and 15c' the construction of which is described above are connected in series with the diodes 2a, 2b and 2c, capacitors 3a, 3b and 3c, and ignition coils 5a, 5b and 5c respectively, thereby forming an ignition circuit. The secondary terminals of the ignition coils are connected with ignition plugs 6a, 6b and 6c of the cylinders respectively, while the terminals A, B and C which are connected with diodes 2a, 2b and 2c and capacitors 3a, 3b and 3c are also connected in parallel with an SCR4 through the diodes 9a, 9b and 9c. When the SCR4 is made to conduct by ignition timing signals from the ignition timing dynamo, charges stored in the capacitors 3a, 3b and 3c are discharged through the ignition coils 5a, 5b and 5c respectively. The output of the timing dynamo 10 is such that the ignition timing signals are produced three times for every turn of the crank shaft. The magnetic fluxes ϕ in the armature coils 15a', 15b' and 15c' undergo changes as shown in FIGS. 7(a), 7(b) and 7(c) respectively with regard to the rotational angle θ of the rotor 17 of the magnet dynamo 1. Let the period of one cycle of the rotor 17 to T, and then from the fact that the rotor has two poles, it follows that the magnetic fluxes in the armature coils are periodically produced at every $1/3T$ of the interval. The result is the generation in the armature coils 15a', 15b' and 15c' of voltages E , as shown in FIGS. 8(a), 8(b) and 8(c) respectively, in which each of the reverse voltages is one half of each of the capacitor-charging voltages E_{co} ,

with a voltage cycle being produced in each coil. Now, assuming that the timing signals as shown in FIG. 9 are applied to the gate of the SCR4 at points of voltage variations as indicated in FIGS. 8(a), 8(b) and 8(c), the voltage generated at the armature coil 15a' (FIG. 8(a)) is charged in the capacitor 3a. The charges stored at the capacitor 3a are discharged through the diode 9a, SCR4 and ignition coil 5a at point a of FIG. 9 where the SCR4 begins conducting. The resultant discharging current in the capacitor 3a generates a high voltage at the secondary of the ignition coil 5a, thereby making ignition sparks obtainable at the ignition plug 6a. Then a voltage as shown in FIG. 8(b) is produced at the armature coil 15b' and charged to the capacitor 3b in the same manner as in the case of capacitor 3a. SCR4 conducts and the capacitor 3b is discharged, thereby generating a high voltage at the secondary of the ignition coil 5b to produce ignition sparks at the ignition plug 6b. In like manner, ignition sparks can be obtained at the ignition plug 6c at point c of FIG. 9 by means of the armature coil 15c'.

It will be seen from the above description that the voltage generated at the armature coil 15a' is charged to the capacitor 3a corresponding thereto, and the charges in the capacitor 3a are discharged through the corresponding ignition coil 5a at point a of FIG. 9 when the other capacitors 3b and 3c are uncharged. For this reason, no high voltage is generated at the secondary of the coils 5b and 5c at point a of FIG. 9, completely eliminating the trouble of erroneous ignition. The same is true for ignition points b and c of FIG. 9, at which ignition sparks completely free from erroneous ignition are supplied to the ignition plugs 6b and 6c respectively. Also, since the reverse voltage generated at an armature coil and which does not act to charge the capacitor is one half as low, it is possible to reduce the breakdown voltage in the reverse direction of the diodes 2a, 2b and 2c. Another feature of the invention is that, in the case of reverse rotation which sometimes occurs in a 2-cycle engine, voltages generated in the armature coil are in opposite polar states with respect to the polarity of the voltages shown in FIG. 8. When considering the armature coil 15c' specifically, reverse rotation of the rotor (in the direction opposite to that indicated by arrow θ) causes the capacitor 3c to be charged at a voltage which is one half the capacitor voltage for the forward rotation. However, since a timing signal is applied to the SCR4 at point b of FIG. 9 to energize the SCR4, the charges stored in the capacitor 3c at that point pass a discharging current in the ignition coil 5c, thereby generating a high voltage in the ignition plug 6c. This voltage is about one half of that produced in the forward rotation, and therefore less capable of firing the fuel. In addition, the firing position involved is the one where ignition sparks are produced at the ignition plug 6b in the forward rotation, and therefore the piston of the cylinder of the ignition plug 6c is at the bottom dead center, with the result that even if the fuel is successfully ignited, the piston is unable to develop a turning effort large enough to maintain the reverse rotation of the engine. The same is true for the armature coils 15b' and 15a', thereby completely preventing the reverse rotation of the 2-cycle engine.

An electrical circuit of another embodiment is shown in FIG. 6a, in which the component elements are rear-

ranged without affecting the operation at all. This embodiment is also applicable to a 6-cylinder engine if a double ignition coil circuit which generates ignition sparks simultaneously at two ignition plugs is formed as shown in FIG. 6b by connecting an ignition plug to both terminals of the secondary winding of each ignition coil.

The above-described embodiment shows an ignition device mounted on a 2-cycle 3-cylinder engine. However, unless the double ignition coil circuit of FIG. 6b is employed, this invention is primarily intended to employ a magnet dynamo 1 including a combination of a 2-pole rotor and 2n-pole stator in the case of a 2-cycle engine with n cylinders, and a magnet dynamo 1 including a combination of a 2-pole rotor and a stator with at least n poles or 2n poles in the case of a 4-cycle engine with an even or odd number of cylinders respectively (n: the number of cylinders). Especially, in the case where the discharge capacitors 3a, 3b and 3c are charged in steps, the number of stator poles is further increased by the number of times equal to that of the steps and armature coils are wound on every other pole.

I claim:

1. In a magneto-dynamo-operated ignition device for a multi-cylinder engine, in which a magneto dynamo is employed as a power supply; a plurality of discharge capacitors charged thereby equal to at least the number of cylinders, secondary windings of a plurality of ignition coils equal to at least one half the number of cylinders producing high ignition voltages by discharging said capacitors associated with each coil; comprising: the magneto dynamo having a 2-pole rotor and a stator with poles of even number determined in accordance with the number of cylinders, and armature coils wound on every other stator pole, a plurality of discharging circuits of said discharge capacitors being selectively energized through a common rectifier with a control electrode which is controlled by an ignition timing signal from the ignition timing dynamo produced for each cylinder as said rotor engages magnetically with each armature coil.

2. A magneto-dynamo-operated ignition device for multi-cylinder engine comprising:

- a magneto dynamo having a plurality of charging coils adapted to produce a plurality of output voltages successively for every one rotation thereof;
- a plurality of charging circuits connected to said plurality of charging coils respectively, each of said charging circuits including, a capacitor for storing electric charges supplied from the corresponding one of said output voltages of said charging coils;
- discharging means comprising a plurality of discharging circuits corresponding to said plurality of charging circuits respectively;
- a switching means connected commonly to said plurality of discharging circuits, each of said discharging circuits including, ignition coil means for delivering an ignition voltage to a plug connected thereto and being connected to said capacitor of the corresponding charging circuit for discharging the stored electric charges of said capacitor through and

means for closing said switch element periodically in synchronism with the rotation of the engine.

3. The magneto-dynamo-operated ignition device of claim 2 wherein said magneto dynamo comprises:

- a stator having a plurality of substantially equally spaced poles whose number is two times a number of cylinders of the engine and armature coils wound on alternate ones of said poles, and
- a rotor having two poles disposed thereon with a space substantially equal to that between two adjacent ones of said poles of said stator, said armature coils producing output voltages successively in accordance with the rotation of said rotor.

4. The magneto-dynamo-operated ignition device of claim 2 wherein said plurality of charging circuits correspond to said armature coils, respectively, each of said charging circuits further including a first diode connected through said capacitor associated therewith to the corresponding one of said armature coils for charging said capacitor with electric charges, when said corresponding armature coil produces said output voltage.

5. The magneto-dynamo-operated ignition device of claim 2 wherein said discharging means further includes: a second diode and said ignition coil means including primary and secondary coils, said primary coil being connected through said second diode to said capacitor of the corresponding charging circuit, for

discharging said electric charges charged in said capacitor therethrough; thereby producing a high ignition voltage at said secondary coil when said switching means is closed, said secondary coil being connected to two plugs mounted on a

6. The magneto-dynamo-operated ignition device of claim 2 wherein said means for closing said switch element comprises: an ignition timing generator for producing signals successively; each at a predetermined time relating to the desired ignition timing of said cylinders after said capacity of any one of said charging circuits has been charged, said signals being applied to said switching means thereby closing the same periodically.

7. The magneto-dynamo-operated ignition device of claim 2 wherein said engine has an even number of cylinders and said magneto dynamo comprises: a stator having a plurality of substantially equally spaced poles whose number is equal to the even number of said cylinders, armature coils wound on alternate ones of said poles, and a rotor having two poles disposed thereon with a space substantially equal to that between two adjacent ones of said poles of said stator, said armature coils producing output voltages successively in accordance with the rotation of said rotor.

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