

[72] Inventors Masao Shibagaki
Hiroshima;
Masayoshi Onishi, Himeji-shi, Japan
[21] Appl. No. 778,131
[22] Filed Nov. 22, 1968
[45] Patented Jan. 12, 1971
[73] Assignee Toyo Kogyo Co., Ltd., Hiroshima-ken and
Mitsubishi Denki Kabushiki Kaisha
Tokyo-to, Japan
[32] Priority Nov. 22, 1967, Nov. 6, 1968
[33] Japan
[31] Nos. 42-75037 and 43-81157

[56] References Cited
UNITED STATES PATENTS
3,192,911 7/1965 Tado 123/8JJ
3,229,674 1/1966 Muller 123/8JJ
3,242,916 3/1966 Coufal 123/148E
Primary Examiner—Laurence M. Goodridge
Attorney—Sughrue, Rothwell, Mion, Zinn & Macpeak

[54] IGNITION SYSTEM FOR MULTICYLINDER
ROTARY PISTON ENGINE
5 Claims, 8 Drawing Figs.

[52] U.S. Cl. 123/8.07,
123/148
[51] Int. Cl. F02b 53/12
[50] Field of Search 123/148A,
148C, 148DC, 148E, 8JJ, 8GOK, 8MC

ABSTRACT: An ignition system for a multicylinder engine has two ignition coils energized by an electrical source to generate two igniting voltages substantially at the same time. A plurality of trailing ignition plugs, one for each cylinder, are connected to one of the two ignition coils through a synchronously operable distributor for timed sequential energization, and a plurality of leading ignition plugs are connected in series to the other of the two ignition coils for simultaneous ignition.

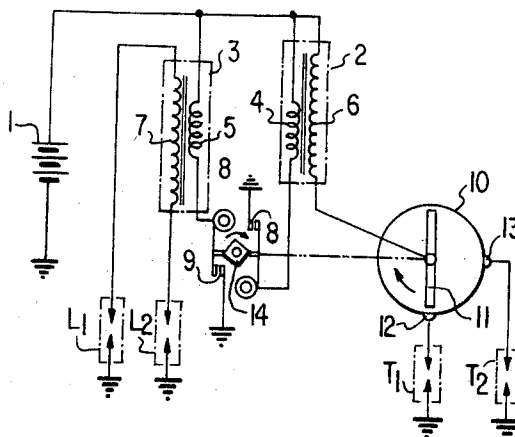


FIG. 1

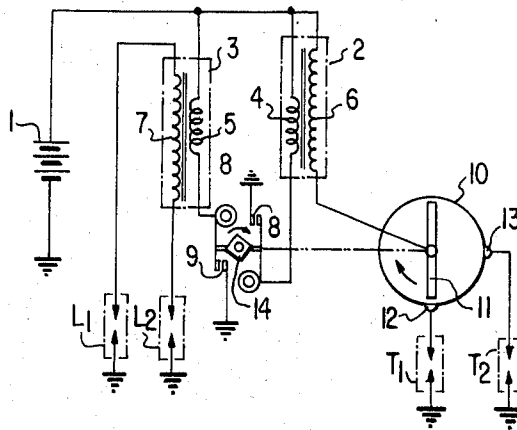
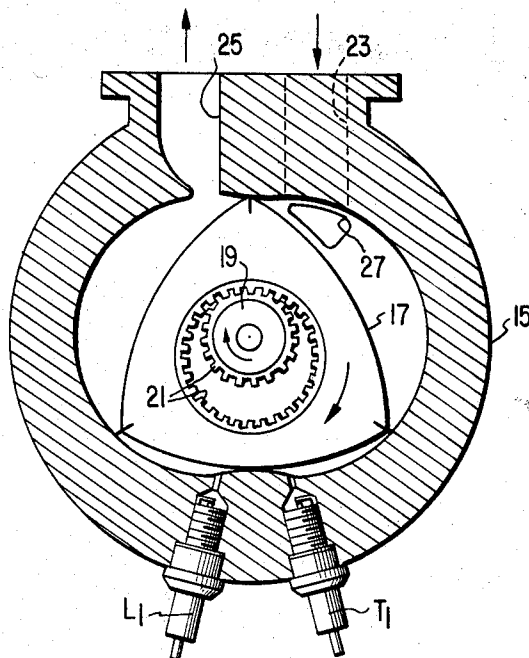


FIG. 2



INVENTORS.
MASAYOSHI ONISHI
MASAO SHIBAGAKI

BY *Lughrue, Rothwell, Miron, Zinn & Macpeak*
ATTORNEYS.

FIG. 3

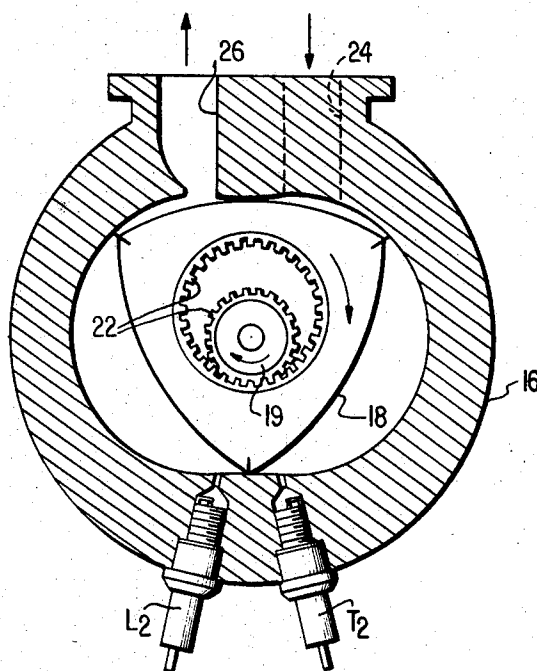
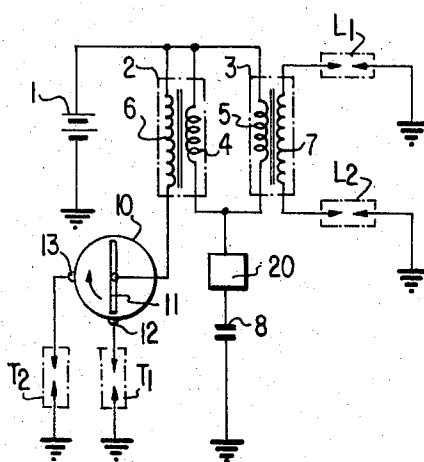


FIG. 4



INVENTORS,
MASAYOSHI ONISHI
MASAO SHIBAGAKI

BY *Lugheze, Lochwell, Min, Jim & Macpeak*
ATTORNEYS.

FIG. 5

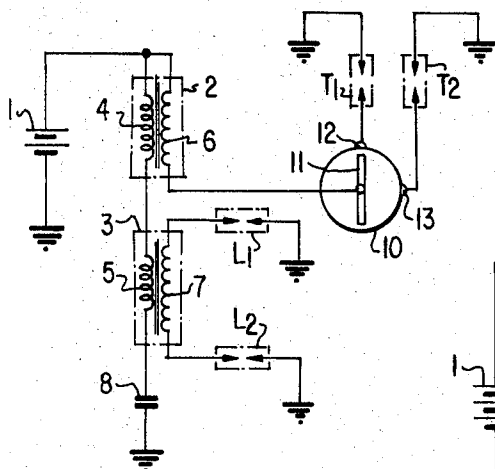


FIG. 6

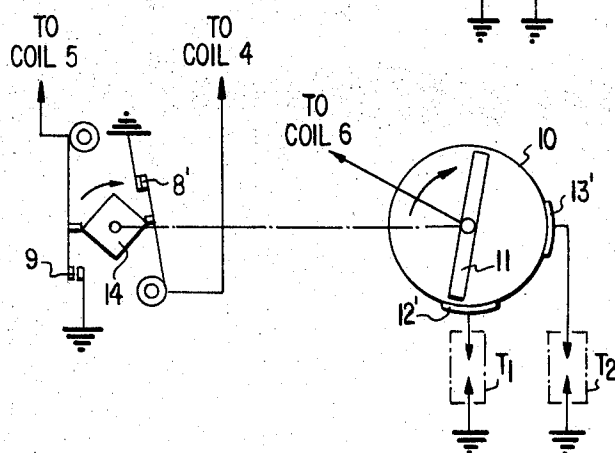
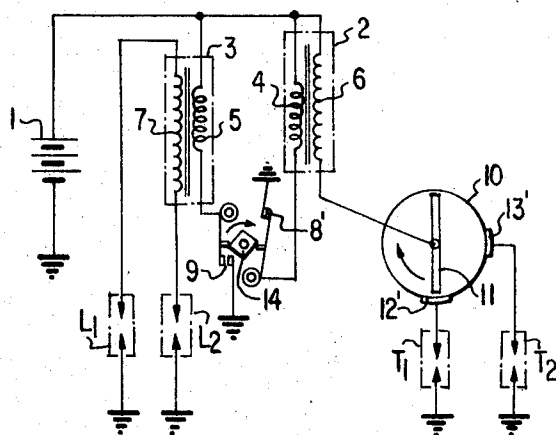
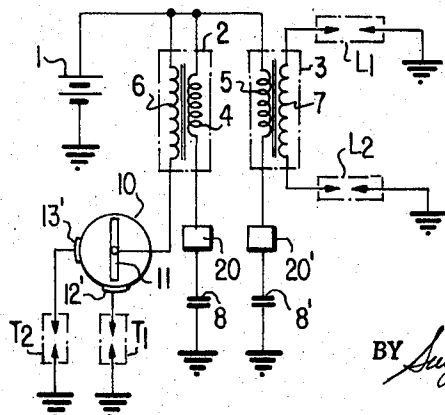


FIG. 7

FIG. 8



INVENTORS.
MASAYOSHI ONISHI
MASAO SHIBAGAKI

BY *Lughrue, Rothwell, Miron, Zinn & Macpeak*
ATTORNEYS.

IGNITION SYSTEM FOR MULTICYLINDER ROTARY PISTON ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a novel and useful ignition system for multicylinder rotary piston engines wherein two ignition plugs are mounted in each of the cylinders, one behind the other in the direction of rotation of the piston.

2. Description of the Prior Art

Heretofore, in engines such as rotary piston engines, two ignition plugs have been mounted in one cylinder in order to improve the starting performance of the engine. Where the two ignition plugs are connected in series to the secondary coil of the ignition coil for firing the two ignition plugs, the electrical energy obtained by the ignition coil is merely divided between the two ignition plugs. Therefore, it is difficult to increase the igniting energy so as to improve the starting performance of the engine.

In order to achieve the increase the igniting energy when using two ignition plugs the igniting energy may occur from two ignition coils with one ignition plug connected to its respective ignition coil. Where such a measure is applied to a multicylinder engine; a two-cylinder engine, for example, the first ignition plug in each of the cylinders is supplied with ignition voltage from the first ignition coil, while the second ignition plug in each of the cylinders is supplied with ignition voltage from the second ignition coil. In this case, however, it is necessary to provide separate distributor mechanisms for each of the ignition coils so as to ignite the first and second ignition plugs in each of the cylinders substantially at the same time. It is thus required to provide a plurality of conventional distributors, each housing therein, a distributor mechanism thereby making the system bulky and, adding at the same time, a corresponding number of driving mechanisms.

SUMMARY OF THE INVENTION

The present invention aims at avoiding the above-described disadvantages and provides a novel and useful ignition system therefor.

The present invention further provides a novel and useful ignition system which is particularly suitable for a rotary piston engine having a plurality of cylinders.

This is achieved by the novel construction of the ignition system of the present invention wherein two ignition plugs, i.e., a leading ignition plug and a trailing ignition plug, are mounted in each cylinder at such a position that the trailing ignition plug is behind the leading ignition plug in the direction of rotation of the piston and an apex of the piston passes over the trailing ignition plug and the leading ignition plug in sequence according to the rotation of the piston. At least two ignition coils are energized by an electric source such as a storage battery so as to generate igniting voltages substantially at the same time through switching means driven by the engine. Said trailing ignition plugs are connected to one of the ignition coils through one distributor which is also driven by the engine and operated synchronously with the switching means. Said trailing ignition plugs are directly connected in series with the other or the others of the ignition coils. Each of the cylinders have mounted therein, one of the trailing ignition plugs connected to the distributor together with one of the leading ignition plugs directly connected in series to the other ignition coil.

The trailing ignition plugs connected to the distributor are ignited successively in timed relation in response to the operation of the distributor so as to achieve the combustion of the fuel compressed in the combustion chamber of the cylinder for driving the engine, while all the leading ignition plugs directly connected in series to the other ignition coil are ignited simultaneously for ignition during idling, without affecting the combustion of the fuel except for the very cylinder having therein the trailing ignition plug which is being ignited by the distributor connected thereto.

Thus, the igniting energy is augmented while the number of the distributors required in the prior art multicylinder engine is reduced to the minimum thereby permitting a compact and simple ignition system.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic view showing the electric circuit for one embodiment of the ignition system in accordance with the present invention.

FIGS. 2 and 3 are cross-sectional views of two combustion chambers of a rotary piston engine, respectively, the pistons arranged therein being angularly displaced by 60° from each other.

FIG. 4 is a schematic view similar to FIG. 1 of an electric circuit of another embodiment of the ignition system of the present invention in which a semiconductor-type of switching device and switching contacts are used in place of rotatable cam means and contacts of FIG. 1.

FIG. 5 is a schematic view of the electric circuit of a further embodiment of the ignition system of the present invention, in which ignition coils are connected in series.

FIG. 6 is a fragmentary view of a modified form of rotatable cam means and contacts for providing a slight time lag in igniting the ignition plug connected to the distributor.

FIG. 7 is a fragmentary view showing another modification of the rotatable cam means and contacts to that shown in FIG. 1, where the inclination of a contact therein is reversed.

FIG. 8 is a view similar to that of FIG. 4 showing two semiconductor switching devices and switching contacts, each connected to respective ignition coils in place of a common semiconductor switching device and a switching contact of FIG. 4 and in which the two ignition coils are connected in parallel in order to provide a slight time lag in igniting the trailing ignition plug connected to the distributor.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, a storage battery 1 is connected, at its one terminal, to the chassis of an automobile while the other terminal is connected to ignition coils 2, 3 in electrical parallel relation to each other. Ignition coils 2, 3 include primary coils 4, 5 as well as secondary coils 6, 7, respectively. Switching contacts 8, 9 are respectively connected in series to primary coils 4, 5. The other end of each of the switching contacts 8, 9 are grounded.

A distributor 10 has a diametrically extending rotary electrode 11 and two stationary electrodes 12, 13 which are angularly displaced in phase by 90°. The rotary electrode 11 is connected to the secondary coil 6 of the ignition coil 2 which is also connected to the storage battery 1 in parallel relation to primary coil 4, while the stationary electrodes 12, 13 are connected to trailing ignition plugs T₁, T₂, respectively. As will be described below, these two trailing ignition plugs T₁, T₂ positively effect the combustion of the fuel in the combustion chambers in which they are mounted, respectively, when they are ignited successively as hereinafter described. The other terminal of each of the trailing ignition plugs T₁, T₂ is grounded. Two leading ignition plugs L₁, L₂ are connected in series to secondary coil 7 of the ignition coil 3. The other terminal of each of the leading ignition plugs L₁, L₂, is grounded.

A rotary cam means 14 is provided which effects the simultaneous opening and closing of switching contacts 8, 9 by the engagement of the contoured peripheral surface of the cam means 14 with projections, each secured to the arm of the respective switching contacts 8, 9.

In FIGS. 2 and 3, first and second cylinders 15, 16 each having a two-arcuate inner surface housed therein, rotors i.e. rotary pistons 17, 18, respectively. The rotors 17, 18 are generally in the form of regular triangles in cross section with their slightly convex-shaped sides connecting the neighboring apices, respectively. An output rotatable shaft 19 extends through central holes of the rotors 17, 18 and the driving force

is transmitted from the rotors 17, 18 to the output shaft 19 by regulation of gear means 21, 22 in a conventional manner. The output shaft 19 is rotated at a rotary speed three times greater than that of the rotors 17, 18 by the gear ratio of the gear means 21, 22.

Suction ducts 23, 24 are provided in the cylinders 15, 16, respectively, which terminate at a suction port 27 and a suction port (not shown). Exhaust ducts 25, 26 are also provided in the cylinders 15, 16, respectively, as shown. The ignition plugs T_1 , L_1 in FIG. 1 are mounted in the cylinder 15 at such a position that the trailing ignition plug T_1 is behind the leading ignition plug L_1 in the direction of rotation of the piston while the ignition plugs T_2 , L_2 are mounted in the cylinder 16 at the same relation as the plugs T_1 , L_1 .

As shown in FIGS. 2 and 3, the two rotors 17, 18 are relatively angularly displaced by 60° from each other.

As shown in FIG. 1, the rotary electrode 11 and the cam means 14 are mechanically connected to each other and are driven by the rotating output shaft 19 at a rotary speed of one-half of that of the output shaft 19.

Therefore, the ratio between the rotary speeds of the rotors 17, 18, the output shaft 19 and the distributor 10 is 2: 6: 3.

The relative position of the cam means 14 to the distributor 10 is so set that both the contacts 8, 9 are simultaneously opened when one of the ends of the rotary electrode 11 comes to the position opposite to any one of the two stationary electrodes 12, 13. Further, when the trailing ignition plug T_1 is electrically discharged, as the rotary electrode 11 moves to oppose the stationary electrode 12, the rotor 17 in the first cylinder 15 is in the angular position shown in FIG. 2 and the rotor 18 in the second cylinder 16 is in the angular position shown in FIG. 3.

In the device constructed as above, when the rotors 17, 18 are rotated in the directions as indicated by the arrows in FIGS. 2 and 3 and come to the positions shown in FIGS. 2 and 3, respectively, the contacts 8, 9 are opened and, at the same time, the rotary electrode 11 comes to the position opposite to the stationary electrode 12 thereby permitting the ignition plugs T_1 , T_2 and L_2 to be electrically discharged simultaneously. T_2 this time, since the working chamber of the first cylinder 15 in which the ignition plugs T_1 , L_1 position is in the position for effecting the ignition of the compressed fuel gas therein, the fuel is ignited and exploded by means of the plugs T_1 , L_1 so that the driving force is generated to rotate the rotor 17. At the same time, the working chamber of the second cylinder 16 in which the leading plug L_2 positions is in the stroke for exhausting the exploded gas, therefore, the pressure of the used gas in said working chamber of the second cylinder 16 is low and the temperature thereof is high thereby permitting the electrical discharge to be easily effected by the leading ignition plug L_2 so that sufficiently great discharging energy can be supplied to the leading ignition plug L_1 and the electrical discharge of the ignition plug L_2 provides no obstacle to rotor 18. Though the working chamber of the second cylinder in which the trailing ignition plug T_2 is positioned could possibly effect the ignition of the compressed fuel gas, since the trailing ignition plug T_2 is not electrically discharged, the ignition plug T_2 provides no obstacle to the rotor at that time.

When the rotors 17, 18 are further rotated by 60° from the positions shown in FIGS. 2 and 3, the rotary electrode 11 and the cam means 14 are rotated by 90° . The rotary electrode 11 comes to the position opposite the stationary electrode 13 thereby permitting the ignition plugs T_2 , L_1 and L_2 to be electrically discharged. In this condition, however, since the rotor 17 of the first cylinder 15 is in the position as shown in FIG. 3 while the rotor 18 of the second cylinder 16 is in the position shown in FIG. 2, the driving force is generated only in the second cylinder 16. The above successive operation is repeated each time the rotors are rotated by 60° so as to alternately effect the electrical discharge by the ignition plugs T_1 , L_1 , L_2 , or T_2 , L_1 , L_2 . The driving force is alternately generated in the cylinder 15 or cylinder 16 to thereby rotate

the output shaft 19 which is mechanically connected to the wheels (not shown) of the automobile.

In the system as described above, the distributor 10 is connected to the trailing ignition coil 2, and the ignition plugs T_1 , T_2 are connected to the distributor 10 while the leading ignition plugs L_1 , L_2 are connected to the ignition coil 3 so as to electrically discharge either of the ignition plugs T_1 , L_1 or the ignition plugs T_2 , L_2 simultaneously. This construction enables one to augment the igniting energy in either of the cylinders 15, 16, and, at the same time, it is only necessary to provide a single distributor 10. Therefore, the ignition device of the present invention can supply augmented igniting energy while the device can be made compact in comparison with the prior art ignition device in which two distributors are required.

In the embodiment shown in FIG. 4, the primary windings 4, 5, of the ignition coils 2, 3 are electrically connected in parallel to the storage battery 1 and the opposite ends of the coils 4, 5 are connected in parallel to each other and to a common switching device 20 which incorporates therein, a semiconductor element, such as a transistor and the like, so as to selectively permit the electric current to flow through the coils 4, 5. The switching contact 8 which is connected to the switching device 20 is opened when either of the cylinders is brought to the position for the ignition to thereby open the switching device 20. The switching contact 8 can be substituted by the output coil of a conventional electric signal generator. In this embodiment, since the electric current flows through the ignition coils 2, 3 or is cut out by means of a single switching device 20, it suffices to provide only one switching contact 8 or a single output coil of an electrical signal generator and to thereby permit the ignition device to be made compact and simple.

The above-described electrical signal generator is adapted to generate signal voltage when the engine comes to the ignition position, and, when the switching device is used, a signal amplifier, a wave-shaping circuit for the output voltage, etc., are connected between the output coil of the electrical signal generator and the switching device 20.

In the embodiment shown in FIG. 5, the primary coils 4, 5 of the ignition coils 2, 3 are electrically connected in series with each other. The electric current flowing therethrough, is controlled by means of a single switching contact 8. The switching contact 8 of this embodiment may also be replaced by the switching device 20 incorporating therein a semiconductor element. In either case, it is sufficient to provide only one contact or switching device as in the case of the embodiment shown in FIG. 4.

The embodiment shown in FIG. 6 is a modification of that shown in FIG. 1. In the embodiment of FIG. 6, the switching contact 88' is located in a slightly inclined position in comparison with the switching contact 8 of FIG. 1 so as to provide a slight time lag between the ignition caused by the opening of the contact 9 and the ignition caused by the opening of the contact 8 due to the inclined positioning of the contact 8'. As is apparent, the cam means 14 contacts the contact 8' shortly after the cam means 14 contacts the contact 9 due to the inclined positioning of the contact 8'. In order to permit the time lag between the ignition achieved by contact 9 and the ignition effected by the contact 8', the stationary electrodes 12', 13' of the distributor 10 are correspondingly made greater in length, in the direction of rotation of the rotary electrode 11. By this construction, the trailing ignition plugs T_1 and T_2 are respectively energized shortly after the idle ignition of the leading ignition plugs L_1 and L_2 has been effected.

It is apparent that the igniting performance is improved by providing a slight time lag between the idle ignition of the leading ignition plugs L_1 , L_2 and the effective ignition by either of the trailing ignition plugs T_1 , T_2 depending upon the positions of the plugs. In Fig. 7, a modification of the rotatable cam means and contacts to that shown in FIG. 1, wherein the inclination of the contacts 8' is reversed and the ignition plugs are ignited in the sequence of T and L.

In FIG. 8, a modification of the embodiment of FIG. 4 is shown in which a slight time lag is provided between ignition by the leading ignition plugs L_1, L_2 and ignition by either of the trailing ignition plugs T_1, T_2 in like manner to the embodiment of FIGS. 6 or 7. To this end, two switching devices 20, 20' and two switching contacts 8, 8' are provided which are connected separately to the primary coils 4, 5 of the ignition coils 2, 3, respectively, as shown in FIG. 7. The time lag is provided by the two sets of the switching devices 20, 20' and switching contacts 8, 8'.

The above-described embodiments have been shown as being applied to the two-cylinder engine. However, the device of the present invention is equally applicable to an engine having more than two cylinders.

In case the ignition device of the present invention is applied to a four-cylinder engine, four trailing ignition plugs T_1, T_2, T_3, T_4 are connected to the distributor 10 which is connected to the secondary coil of the ignition coil 2 so as to be successively supplied with the igniting voltage therefrom while the two leading ignition plugs L_1, L_2 are connected in series to each other to the secondary coil of the ignition coil 3 and the other two leading ignition plugs L_3, L_4 are connected in series to each other to the secondary coil of a further ignition coil. The sets of the ignition plugs T_1, L_1 and T_2, L_2 and T_3, L_3 and T_4, L_4 are mounted in the respective cylinders at such position that a trailing ignition plug T is behind a leading ignition plug L in the direction of rotation of the piston.

As described above, in accordance with the present invention, the starting performance of the engine is sufficiently improved by the supply of sufficient ignition energy, since the igniting energy given by the two ignition plugs is supplied to each of the cylinders. Further, since it employs only one distributor, the distributor and the switching mechanism can be incorporated in a common power-distributing device, thereby permitting the ignition device to be simple and compact in construction, light in weight, and produced at low cost.

We claim:

1. In an ignition system for a two-cylinder rotary piston engine the improvement comprising: trailing ignition plugs and leading ignition plugs, at least two ignition coils, one of said trailing ignition plugs being mounted in each of the cylinders together with one of said leading ignition plugs, means for connecting said leading ignition plugs to one ignition coil to energize all the ignition plugs connected thereto each time the ignition is to be effected in any of the cylinders and distributor means for connecting said trailing ignition plugs to another ignition coil for successive energization, and means for delaying the ignition by each of said trailing ignition plugs a slight time lag from the ignition of the leading ignition plug corresponding thereto.

2. In an ignition system for a multicylinder rotary piston engine having at least two rotary pistons, the improvement comprising: one leading ignition plug mounted at an appropriate position in each of the cylinders, one trailing ignition plug mounted in each of the cylinders behind said leading ignition plug in the direction of rotation of the piston, at least two ignition coils each adapted to generate an ignition voltage by switching means, a single distributor operated synchronously with said switching means, said trailing ignition plugs of all cylinders connected to one of said ignition coils through said distributor and said leading ignition plugs of all cylinders connected directly to the other of said ignition coils.

3. The ignition system as set forth in Claim 2 wherein means are provided to discharge said trailing ignition plug and said leading ignition plug simultaneously for all cylinders.

4. The ignition system as set forth in Claim 2, wherein means are provided to discharge said trailing ignition plug after a slight time lag from said leading ignition plug in each cylinder.

5. The ignition system as set forth in Claim 2 wherein means are provided to discharge said leading ignition plug after a slight time lag from said trailing ignition plug in each cylinder.