L. J. LE PONTOIS.

IGNITION DEVICE FOR GAS ENGINES.

APPLICATION FILED OCT. 21, 1908.

1,045,859.

Patented Dec. 3, 1912.

2 SHEETS—SHEET 1.

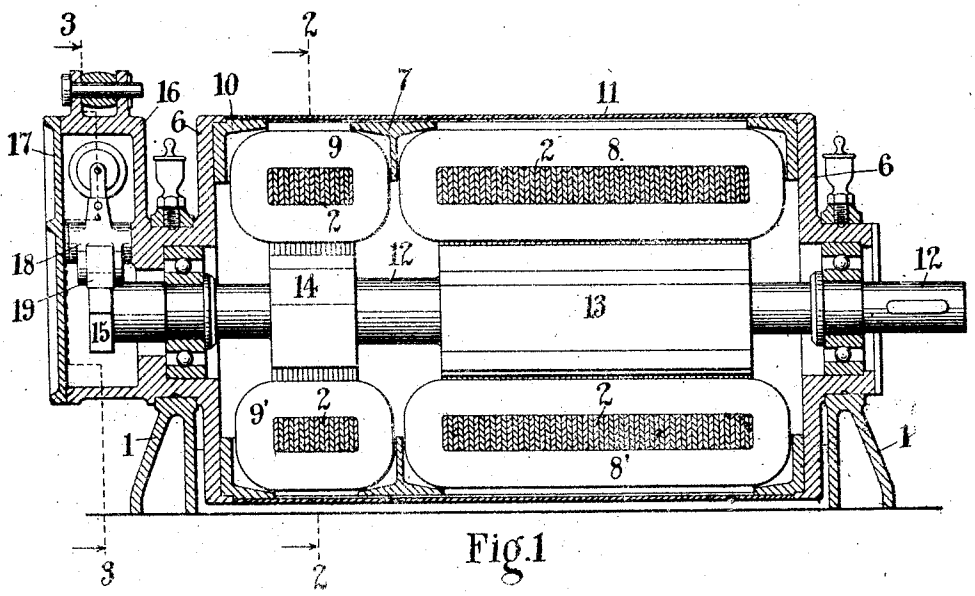

Fig.1

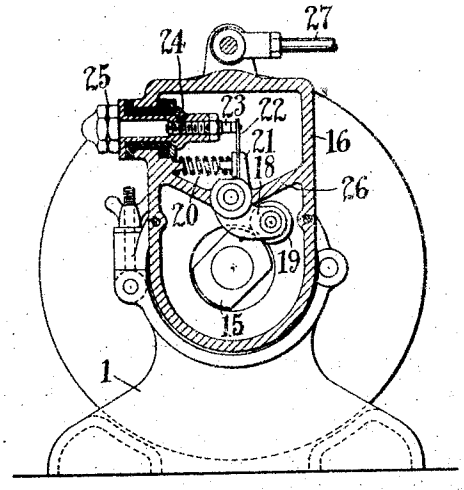

Fig.3

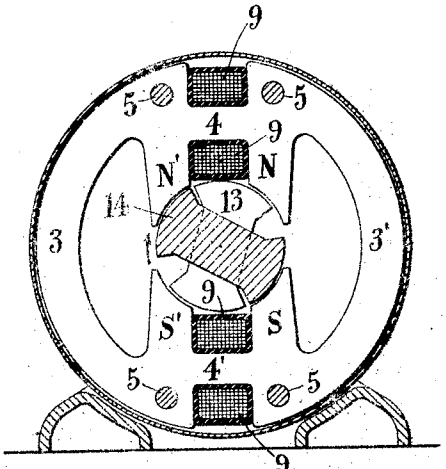

Fig.2

Witnesses:
Edmund C. Dubocq.
Geo. H. Kerr.

Leon J. Le Pontois Inventor
By his Attorneys
Edwards, Sager & Wooster.

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2 SHEETS—SHEET 2.

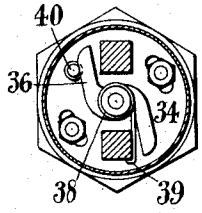

Fig.5

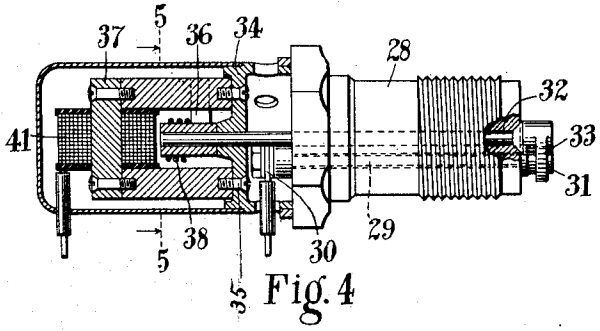

Fig.4

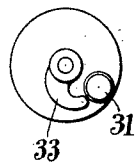

Fig.6

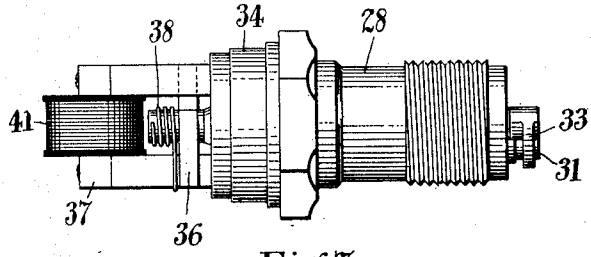

Fig.7

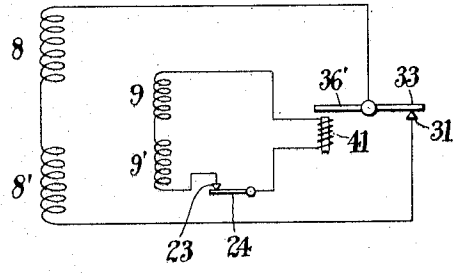

Fig.8

Witnesses:
Edmund O. Dubocq.
Geo. H. Kerr.

Leon J. Le Pontois Inventor
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UNITED STATES PATENT OFFICE.

LEON J. LE PONTOIS, OF NEW ROCHELLE, NEW YORK, ASSIGNOR, BY MESNE ASSIGNMENTS, TO H. W. JOHNS.

IGNITION DEVICE FOR GAS-ENGINES.

1,045,859. Specification of Letters Patent. Patented Dec. 3, 1912.

Application filed October 21, 1908. Serial No. 458,773.

To all whom it may concern:

Be it known that I, LEON J. LE PONTOIS, a citizen of the French Republic, residing at New Rochelle, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Ignition Devices for Gas-Engines, of which the following is a full, clear, and exact specification.

My invention relates in general to improvements in the method and means of igniting explosive gases in internal combustion enginnes, and more particularly to the so-called "touch spark" or "make and break method".

It further relates more especially to that type of ignition device known as "electro-magnetic spark plugs". In such spark plugs the sparking electrodes are separated from each other by the agency of a suitable electro-magnet energized by the same current which is interrupted at the spark terminals and have the advantage of facilitating changes in the timing of the ignition during operation of the engine. These electro-magnetic spark plugs have heretofore been subject to various objections, among which may be stated their unreliability in operation at high speeds, owing to the increased self-induction of the electro-magnet for separating the electrodes and owing to the inertia of the moving parts. Their operation is also rendered unsatisfactory by reason of the electrodes becoming coated with oil or carbon deposits. Furthermore, the short length of the arc established at each break between the electrodes due to the vibrating action is also objectionable because gases do not have free access to the arc and because the heat of the spark is partially dissipated by conduction through the mass of the electrodes instead of being imparted to the gases. By my invention, these and other objections are overcome.

In accordance with my invention, the functions previously performed by a single current are divided, and I provide in addition to the ignition circuit an auxiliary circuit which serves to interrupt the ignition circuit so as to cause the electrodes to become separated from each other to a distance comparable in length to that which can be obtained by mechanical means. Furthermore, I arrange the energizing circuit of the electro-magnet so that the latter will be energized slightly ahead of the time at which the ignition should occur in order to correctly time the ignition and to produce an ample spark of suitable length. The lag due to self-induction of the electro-magnet and the inertia of the moving elements is thus compensated for regardless of the speed of the engine.

In my preferred form the currents differing in phase for ignition and for actuating purposes are derived from an alternating current generator which serves to supply alternating currents to circuits differing in phase, and in which the rise and fall of the alternating waves are in such relation to the engine that the ignition occurs in accordance with the alternations derived from the generator.

These and other features of my invention will be understood from the following description and accompanying drawings, in which—

Figure 1 is a longitudinal cross-section of my preferred form of generator; Fig. 2 is a cross-section thereof on the line 2—2 of Fig. 1; Fig. 3 is a cross-section on the line 3—3 of Fig. 1; Fig. 4 is a side view, partly in section and partly broken away, of the electro-magnetic spark plug; Fig. 5 is a cross-section on the line 5—5 of Fig. 4; Fig. 6 is an end view of the spark plug; Fig. 7 is a side view thereof; and Fig. 8 is a diagram indicating the connections.

My preferred form of alternating current generator is of the inductor magneto type, in which the generating windings are stationary, thus obviating the use of any brushes or sliding contacts.

Referring to the structure of this generator shown in Figs. 1, 2 and 3, the same comprises pedestals 1, 1 for supporting the machine as a whole and having bearings for permitting the angular adjustment of the external element of the machine to any fixed position desired for adjusting the time of maximum current generation. The external field element is circular in general outline and comprises two portions built up of laminæ 2 of the form shown in Fig. 2. Each lamina of iron or steel comprises permanently magnetized hardened portions 3, 3′ having integral therewith the soft iron polar projections N, N′ and S, S′, as well as soft iron connecting bridges 4, 4′. The soft iron polar extensions and connecting bridges

may sometimes be removably secured to the permanently magnetized portions 3, 3′ of hardened iron, but I prefer to form all of these parts in an integral lamina or plate, as indicated in the drawings. Each of the plates 2 may be magnetized by placing the surfaces of the two opposing central portions in close proximity respectively to the north and south poles of a powerful magnet, which will complete its magnetic circuit through the portions 3, 3′ and develop two consequent poles of opposite polarity in the central opposing portions. The extensions N, N′ will therefore assume one polarity, say north, while the extensions S, S′ of the opposite central portion will assume the opposite or south polarity. I have obtained the best results by placing the plates 2 in close proximity to the magnetizing electro-magnet, as above referred to, while the plates are at a temperature of 715 degrees C. The portions 3, 3′ which are to be permanently magnetized are then suddenly cooled and hardened while under the influence of the magnetic field. The central portions comprising the polar extensions and the connecting bridges 4, 4′ remain annealed, and when the plate is removed from the influence of the electro-magnet, the central portions are magnetized only by the inductive action of the permanently magnetized portions 3, 3 By thus providing an integral plate which is hardened and permanently magnetized in inner portions, while having soft iron portions of high permeability, I obtain magnetic circuits of minimum reluctance, and also secure great strength and rigidity in the magnetic structure. It will be noted that the form of the field structure secures a very compact arrangement, giving small size to the machine. I may, if desired, provide means for assisting the magnets in maintaining a high field strength, such as described in my pending application Serial No. 443,023, filed July 11, 1908, but such particular construction and arrangement of circuits form no part of my present invention.

The plates 2, after being built up to form the field or frame, are clamped together in any suitable manner, as by through-bolts 5, and supported as a whole by end plates 6, which are rotatably mounted in the pedestals 1. The field frame, as shown in Fig. 1, comprises two sets of plates 2 spaced apart by a ring 7. Wound around the bridge portions 4, 4′ of one set are the main generating coils 8, 8′, which may be connected in series or in parallel with each other, as desired, and which supply the ignition circuit. Wound around the bridge portions 4, 4′ of the other set of plates 2 are the generating windings 9, 9′ which may be connected in series or in parallel with each other, and which supply current to the coil of the electro-magnetic means for separating the sparking electrodes. Between the two sets of the laminæ and the end plates 6 are placed spacing rings 10 for the purpose of allowing the space for the end turns of the generating windings. Around the entire field frame is a non-magnetic sheathing 11 for protecting the parts.

Within the extensions formed upon the end plates 6 are roller bearings for supporting the shaft 12, which in turn supports an inductor or rotor 13 coöperating with one set of plates and the generating windings 8, 8′, and also supports an additional inductor or rotor 14 which coöperates with the other set of plates and the generating windings 9, 9′. The form of the inductors is shown in Fig. 2 and they are displaced angularly with reference to each other, as indicated in Fig. 2 for the purpose as hereinafter described. The shaft 12 will be driven by the gas engine whose sparking is to be controlled and the gearing or other driving connection will be such as to give a certain definite relation of the speed and position of the inductors to the engine.

With reference to the generation of current or electromotive force in the two sets of generating windings, a general statement as to one set of windings will apply to the other, as the actions are similar in each, with the exception that by reason of the angular displacement of the inductors, the phase of electromotive force and current in one set of windings will be different from that in the other.

Referring more particularly to Fig. 2, it will be seen that the magnetic flux tends to take the path from the poles N, N′ to the poles S, S′, returning through the permanently magnetized portions 3, 3′. By reason of the rotation of the inductor 14, however, the magnetic flux through the generating coils 9, 9′ is alternated in direction and thereby causes an alternating electromotive force to be generated in said coils. With the position of the inductor 14 shown in Fig. 2, the same furnishes a direct path for the magnetic flux from the pole N′ to the pole S, and then in one path through the yoke portion 3′ and through the coil 9 and bridge portion 4 to the pole N′, and in another path from the pole S through the coil 9′ and bridge portion 4′, thence through the yoke portion 3 back to the pole N′. Assuming the rotation in the direction of the arrow, it will be seen that as the rotor passes from the position shown in Fig. 2, the reluctance of the circuit will be increased tending to cause a decrease in the strength of the magnetic flux through the generating windings, and when the roter 14 is passed to the position extending between the poles N and S′, it will be seen that the direction of the mag-

netic flux through the generating coils is thereby reversed; thus the path will be from the pole N through the inductor to pole S′, and then in one path through the yoke 3 and generating coil 9 to pole N, and in another path from S′ through the generating coil 9′ and yoke portion 3′ to the pole N. The direction of flux through the generating coils is therefore opposite in direction to that occurring when the rotor is in the position shown in Fig. 2, and consequently the rapid reversal of magnetic flux caused by the change in position of the rotor will cause an electromotive force to be generated in the generating coils. As the rotation of the inductor 14 is continued, the magnetic flux through the generating coils will be varied and reversed accordingly, and it will be seen that for each complete revolution of the inductor 14, two complete alternating current waves will be generated. The same is true of the generation of electromotive force and current in the generating windings 8, 8′.

At one end of the shaft 12 is mounted a cam 15. United with one of the end plates 6 is a casing 16, which, together with a cover plate 17, incloses the cam 15 and parts controlled thereby. Pivotally mounted within the casing is an arm 18 carrying a roller 19 adapted to engage the cam 15. A spring 20 extending between the part of the casing 16 and an extension 21 from the arm 18, tends to maintain the roller 19 in constant engagement with the cam. The extension 21 carries a flexible contact strip 22, which, being controlled by the movement of the arm 18 and cam, is adapted to make and break connection with a fixed contact 23. The latter is supported by a metal portion 24 which extends through and is insulated from the casing 16, and is provided at its outer end with a terminal 25. A web 26 is formed within the casing 16 for the purpose of preventing oil from being thrown into the upper compartment in which the contacts are located. The casing 16 is shown as having a rod 27 connected to the upper portion thereof, and by means of this rod the operator may adjust the position of the field elements and other parts angularly with reference to the shaft, the whole being movable in the pedestals 1, 1.

The electro-magnetic spark plug comprises the usual main portion 28 adapted to make a threaded engagement with the head of an engine cylinder, and extending through the portion 28 is an insulated rod 29 having a terminal 30 at one end adapted for connection to a circuit and an electrode 31 at the other end. In the center of the plug is located another rod 32, which is angularly movable and carries at its inner end an arm 33 forming the other electrode. The main plug supports a frame 34, which is secured to the plug by bolts 35, the said bolts passing through slots in the frame 34 so as to allow angular adjustment of the frame 34 and its parts with reference to the main portion of the plug and the fixed electrode 31. The outer end of the rod 32 extends through the frame 34 and carries fixed thereto a movable armature 36 having two portions adapted to cooperate respectively with the two poles of a core 37 of an electro-magnet. A spring 38 encircles the outer end of the rod 32, one end of the spring being fixed thereto or to the sleeve of the armature 36, and the other end engaging one of the poles of the core 37, as indicated at 39 in Fig. 5. This spring tends to force the armature 36 away from the poles of the magnet against a pin 40 fixed to the frame 34, and thereby tends to hold the electrode 33 normally in engagement with the fixed electrode 31. The poles of the electro-magnet are shown as being secured to the non-magnetic frame 34 by screws, and it will be understood that these poles and the core 37 may be laminated if desired. The coil 41 of the electro-magnet is shown as being formed upon the core 37.

The generating coils 8, 8′ are connected in a circuit which includes the electrodes 31, 33, current from one lead passing to the terminal 30, through rod 29 to the electrode 31, thence to electrode 33 and rod 32 which is grounded on the engine, the current returning to the other terminal of the generating windings through a ground connection. Current from one terminal of the windings 9, 9′ passes through the electro-magnetic coil 41 and is then grounded and passes by the grounded connection through the flexible strip 22 and fixed contact 23 to the terminal 25, from which connection is made to the other terminal of the coils 9, 9′. These connections are diagrammatically indicated in Fig. 8, the ignition circuit being shown as including the coils 8, 8′ in series and including the fixed electrode 31 and movable electrode 33. The windings 9, 9′ are shown connected in series and including the magnetic coil 41 and the contacts 23, 24 of the interrupter shown in Fig. 3. The coil 41 is diagrammatically shown in Fig. 8 as acting upon an armature 36′ for causing the make and break between the electrodes 31, 33. The connections and circuits are indicated for ignition in a single cylinder, and it will be understood by those skilled in the art that application of this invention may be made to any desired number of cylinders.

From the above description of the operation of the generator, it will be understood that for each revolution of the rotor two positive current waves and two negative current waves are generated in each set of windings. I preferably so shape the polar projections and the rotors in relation there-

to, as shown in Fig. 2, that the two current or electromotive force waves in say the positive direction are very abrupt and attain a high magnitude, whereas those in the opposite, or say negative direction, are less abrupt and more uniform and attain a lesser magnitude. The parts are arranged so that the ignition contacts are separated approximately at the peak of the current waves in the circuit of the windings 8, 8′, and I preferably utilize the two more uniform waves appearing in the circuit of windings 9, 9′ for the purpose of actuating the armature 36 for separating the ignition electrodes. Thus for producing the spark I use sharp waves having high peaks for a short period and so obtain all possible available energy for spark discharge, whereas for magnetic operation I preferably utilize smooth waves, which secures better operation by reason of the self-induction of the circuit. The relationship of the armatures 13, 14 for obtaining this operation with the respective waves would be obtained by placing them at an angular relation of approximately 90 degrees. It being desirable, however, to compensate for self-induction and inertia of the magnetically operated parts, the armature 14 is advanced angularly a certain amount so that, as shown in Fig. 2, the angular displacement of these armatures is less than 90 degrees for the purpose of this compensation.

In operation, the shaft of the generator will be driven from that of the engine in fixed relation thereto, and it will be understood from the above that the electro-motive force of the coils 9, 9′ is generated slightly in advance, as regards phase, of the electromotive force generated in the windings 8, 8′. By reason of this advance in phase, the self-induction of the actuating circuit and inertia of the moving parts, such as the armature 36 and rod 32, are compensated for so that when the maximum current of a sharp wave from the generating windings 8, 8′ is supplied to the ignition circuit, the electro-magnetic device will cause the electrodes to be separated. The cam 15 is so adjusted in relation to the other parts that the contact 22 will be forced into engagement with the contact 23 and cause current to flow in the coil 41 so that the armature 36 will be attracted by the magnet poles and separate the electrodes upon the occurrence of maximum electromotive force of a smooth wave in the windings 9, 9′. The closing of the circuit of coil 41 thus tends to secure a rapid movement of the movable electrode 33, and together with the advance in phase of the electromotive force in windings 9, 9′, will secure a separation of the electrodes at the time of maximum current flow in the ignition circuit. It will be seen that the electro-magnetic actuating device thus secures a quick separation of the contacts and also a separation to such a distance as will produce a spark of considerable length. Furthermore, as this separation occurs at the time of maximum current flow of a sharp wave in the ignition circuit, a heavy spark will be obtained. When the cam allows the contacts 22, 23 to separate, the armature will snap back to its normal position by the action of the spring which allows the ignition circuit to be again closed, and upon the next closure of the circuit of the electromagnet by the action of the cam the above-described operation will be repeated.

It will be understood that various modifications may be made in the form of apparatus used, as well as in the arrangements of the circuits, without departing from the scope of my invention.

Having thus described my invention, I declare that what I claim as new and desire to secure by Letters Patent, is:

1. An ignition device comprising an alternating current source, sparking electrodes, an ignition circuit, electro-magnetic means comprising an auxiliary circuit for separating said electrodes, and means whereby the electromotive forces impressed upon said circuits are displaced in their phase relation to each other.

2. An ignition device comprising sparking electrodes, an ignition circuit, an alternating current source in said circuit, electro-magnetic means comprising an auxiliary circuit for separating said electrodes, an alternating current source in said auxiliary circuit, and means whereby the electromotive forces of said sources are displaced in their phase relation to each other.

3. An ignition device comprising electrodes, an ignition circuit, an alternating current source in said circuit, electro-magnetic means comprising an auxiliary circuit for separating said electrodes, an automatic circuit closer in said auxiliary circuit, an alternating current source in said auxiliary circuit, and means whereby the electromotive forces of said sources are displaced in their phase relation to each other.

4. An ignition device of the make-and-break type comprising sparking electrodes, a source of alternating electromotive force, means for conducting current from said source to said electrodes, electromagnetic means for separating said electrodes, and functionally related controlling means for causing said electrodes to be separated when the current passing through said electrodes from said alternating source has a maximum value.

5. An ignition device of the make-and-break type comprising sparking electrodes, electromagnetic means for separating said electrodes, a source of alternating electromotive force, means for applying out-of-

phase waves of electromotive force to said electrodes and to said means respectively, and functionally related means for causing said electrodes to be separated when the current passing through said electrodes from said source has a maximum value.

6. An ignition device of the make-and-break type comprising sparking electrodes, electromagnetic means for separating said electrodes, a source of alternating electromotive force, means for causing an electromotive force wave from said source to be applied to the circuit of said electromagnetic means, which is in advance of the electromotive force wave applied to the circuit of said electrodes, and functionally related means for causing said electrodes to be separated when the current passing through said electrodes has a maximum value.

7. An ignition device of the make-and-break type comprising sparking electrodes, electromagnetic means for separating said electrodes, a source of alternating electromotive force, means for applying out-of-phase waves to said electrodes and to said electromagnetic means respectively, means for controlling the circuit of said electromagnetic means, and functionally related means for closing said controlling means when the alternating electromotive force applied to said electromagnetic means has a maximum value.

8. An ignition device of the make-and-break type comprising a spark plug having make-and-break electrodes, means normally holding said electrodes closed, electromagnetic means mounted on said plug for separating said electrodes, circuit connections for the ignition circuit and electromagnetic circuit respectively, and means for supplying energy from an alternating current source to said circuits and for causing the electromotive force of the energy impressed upon one of said circuits to be displaced in phase with reference to that impressed upon the other of said circuits.

9. An ignition device of the make-and-break type comprising sparking electrodes, electromagnetic means for separating said electrodes, a source of alternating current electric energy supplying electromotive force waves of an abrupt character and waves of a less abrupt character, and means for causing said electromagnetic means to be controlled by a wave of a less abrupt character and to interrupt the current through the electrodes when a current wave of abrupt character passes through said electrodes.

In testimony whereof I affix my signature, in presence of two witnesses.

LEON J. LE PONTOIS.

Witnesses:
GEO. U. KERR,
GEO. A. HOFFMAN.