No. 869,208. PATENTED OCT. 22, 1907.

O. J. & A. M. LODGE.

ELECTRIC IGNITION OF EXPLOSIVES.

APPLICATION FILED APR. 10, 1903.

4 SHEETS—SHEET 1.

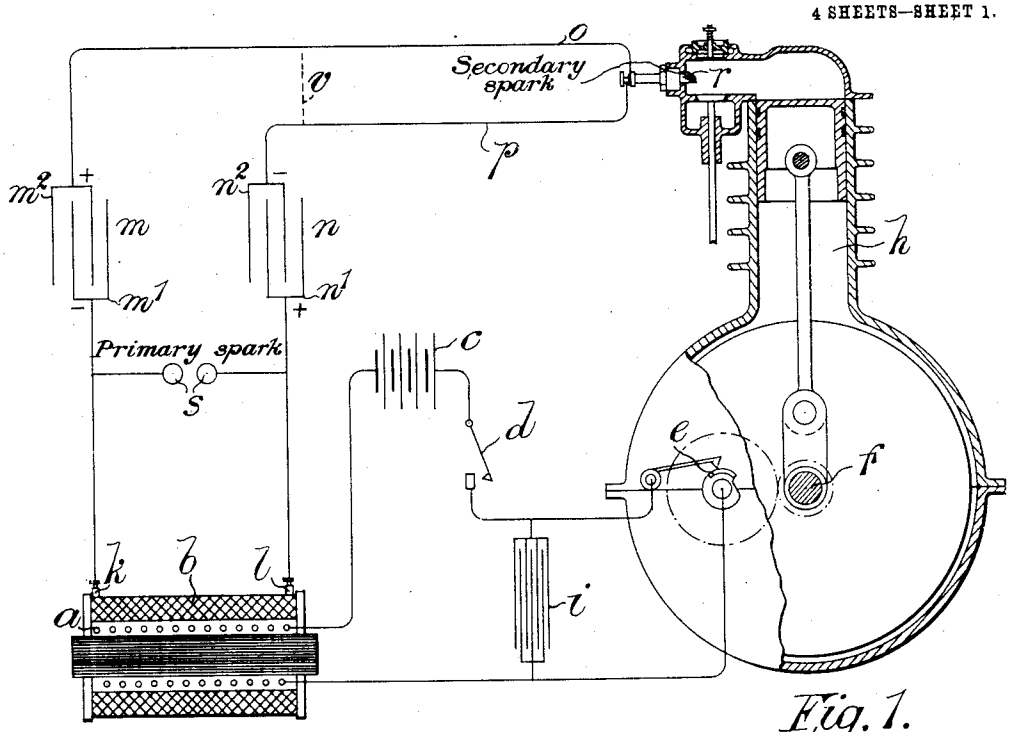

Fig. 1.

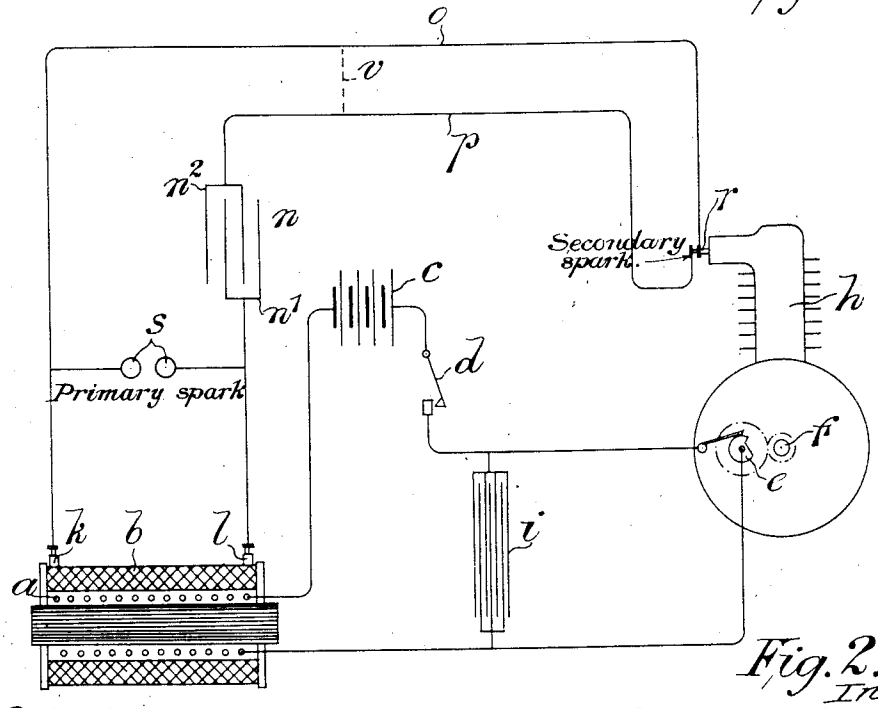

Fig. 2.

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4 SHEETS—SHEET 2.

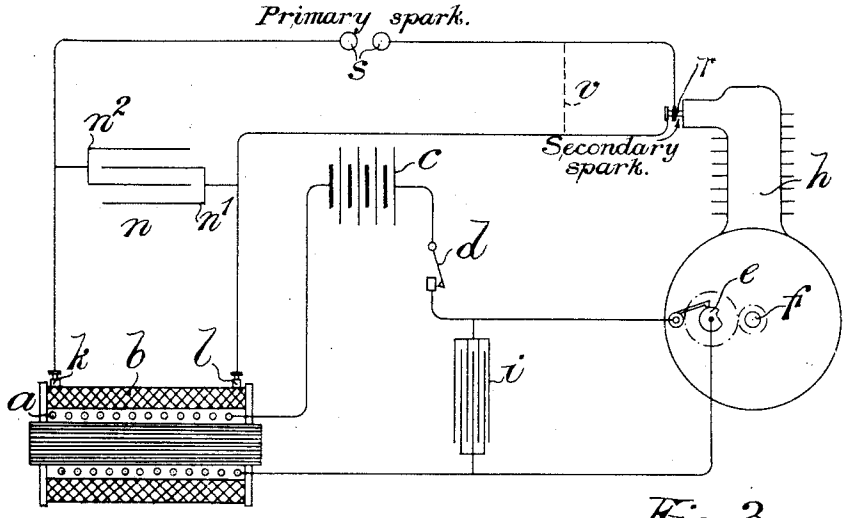

Fig. 3.

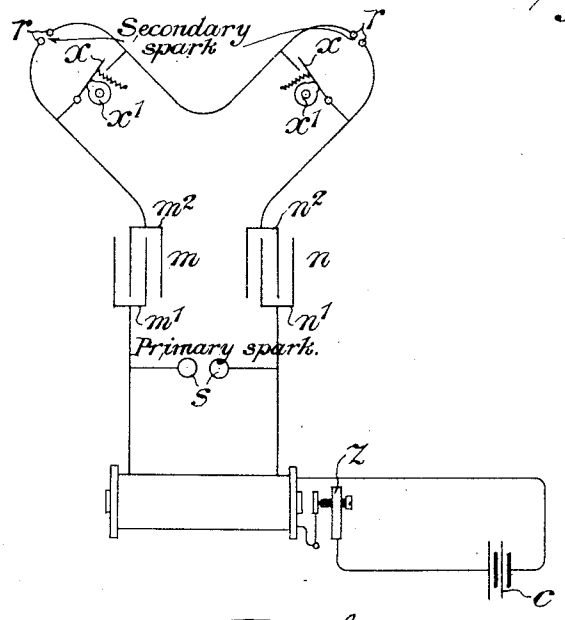

Fig. 4.

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4 SHEETS—SHEET 3.

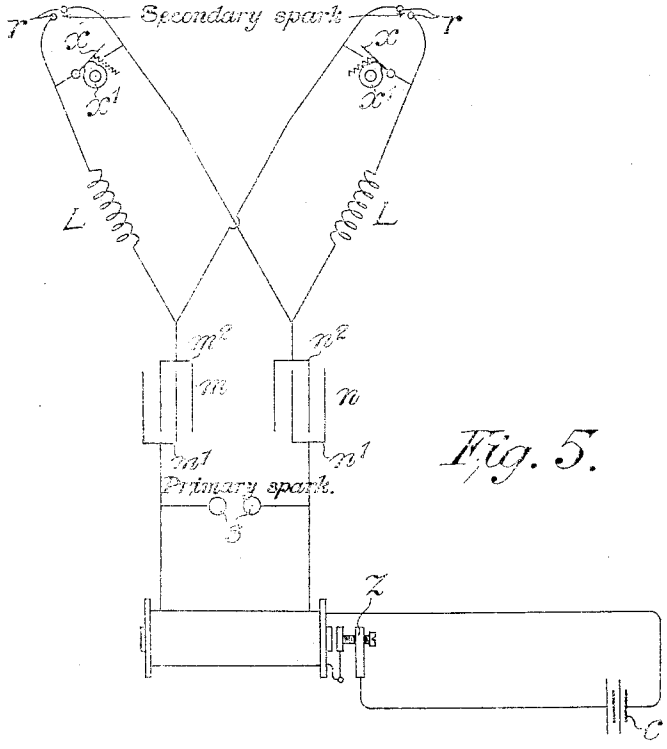

Fig. 5.

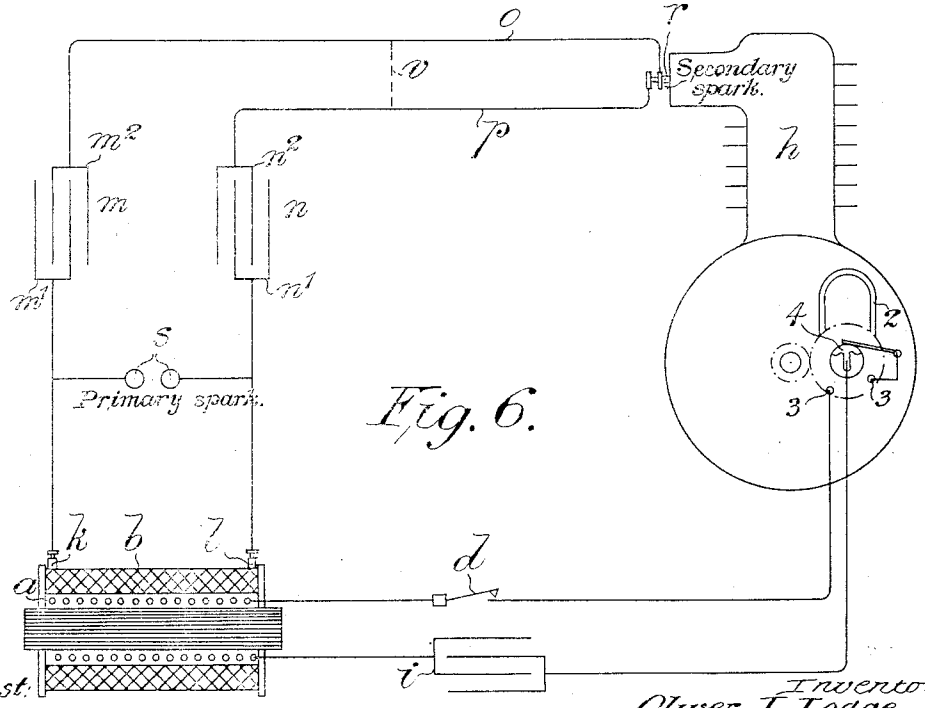

Fig. 6.

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4 SHEETS—SHEET 4.

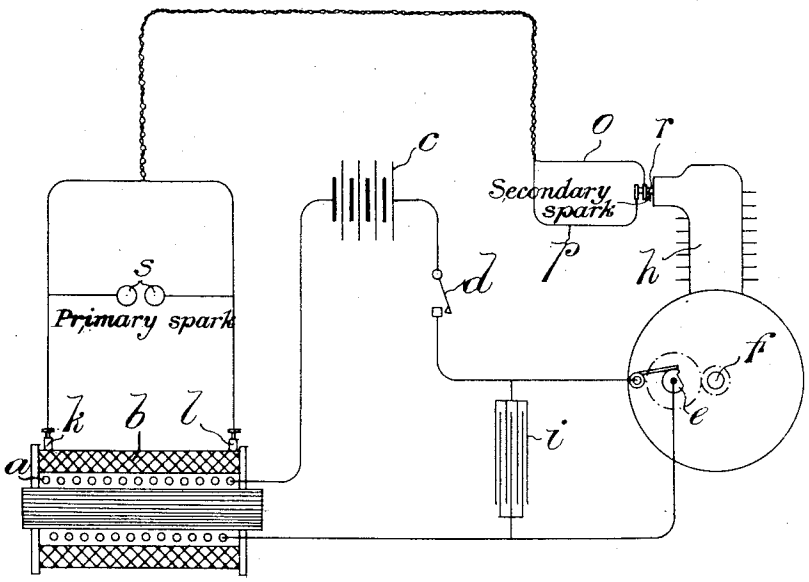

Fig. 7.

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UNITED STATES PATENT OFFICE.

OLIVER JOSEPH LODGE AND ALEXANDER MARSHALL LODGE, OF BIRMINGHAM, ENGLAND.

ELECTRIC IGNITION OF EXPLOSIVES.

No. 869,208. Specification of Letters Patent. Patented Oct. 22, 1907.

Application filed April 10, 1903. Serial No. 152,028.

To all whom it may concern:

Be it known that we, Sir OLIVER JOSEPH LODGE, Knight, a subject of the King of Great Britain and Ireland, principal of the University of Birmingham, and ALEXANDER MARSHALL LODGE, engineer, a subject of the King of Great Britain and Ireland, both of Mariemont, Edgbaston, in the city of Birmingham, England, have invented certain new and useful Improvements Relating to the Electric Ignition of Explosives, (for which we have have made application for Letters Patent in Great Britain, No. 2,162, dated January 29, 1903,) of which the following is a specification.

This invention relates to electric ignition for use in internal combustion engines, or for blasting or other similar purposes. For example, in internal combustion engines with ordinary electric ignition, and especially in oil engines, it is common for a charred oil deposit to take place on the plug, practically short circuiting the spark gap and preventing ignition.

Now the object of the invention is to render the effectiveness of the spark employed for ignition purposes practically independent of the insulation of the points between which it is caused to occur.

It has been pointed out by the first named of the present applicants that when a condenser or condensers are charged from a high potential electric supply and the electrostatic strain thereby produced is suddenly released by a primary spark taking place in the circuit, an impulsive rush of current will take place from one coat of the condenser or condensers to another and if a secondary spark gap be provided between the coats of the condenser or condensers a secondary spark caused by the impulsive rush of current will take place at the secondary spark gap. It has further been noted that such secondary sparks have the peculiar property that they are not materially affected by the defects in the insulation of the spark gap. The gap may even be short circuited by a loop of conducting material, without stopping the spark, on account of the self induction of the loop.

An advantage of our invention is that there is no need for specially insulating the wires leading to the secondary spark gap.

The present invention therefore consists in means for causing the secondary spark to effect the ignition of a combustible mixture either in an internal combustion engine, or in an exploder such as is used in firing explosives, so that the ignition may be rendered certain and independent of the insulation of the sparking points, provided always that the primary spark gap is kept clean and properly insulated.

It will be seen that the essentials of our system of spark ignition consist in a circuit which includes two spark gaps and one or more condensers, and in some cases an inductance, the whole forming an oscillating system, whose period depends jointly upon its total electrostatic capacity and its total self induction.

We are aware that in some previous systems of ignition two spark gaps have been employed, one inside the ignition chamber and one outside, but this has been done with a view to guarding against the short circuiting of the actual ignition spark gap by charred particles or the like preventing the tension in the wire reaching its maximum value; and some benefit has been thereby derived. Our invention, however, involves the special employment of a condenser or preferably a pair of condensers or Leyden jars in the circuit, in addition, so as to cause the precipitation of a secondary spark (having the peculiar properties mentioned above) immediately on the passing of the primary spark.

Referring to the accompanying drawings:—Figure 1 shows one modification of our invention partly in diagram, applied to the sparking plug of a petrol motor; Fig. 2 shows diagrammatically a similar arrangement but with one of the condensers in connection with the secondary circuit omitted; Fig. 3 shows also diagrammatically another arrangement of the connections, Fig. 4 shows a diagram of the connections necessary to produce secondary sparks in more than one cylinder, the secondary sparks being in series while, Fig. 5 shows a similar diagram but with the secondary sparks in parallel. Fig. 6 shows the primary coil excited by an alternator, while Fig. 7 shows how sufficient capacity may sometimes be secured by twisting together the secondary leads.

The same reference letters are used throughout the drawings to denote similar parts.

According to the modification of our invention which we prefer as the best arrangement, shown in Fig. 1, we use an ordinary induction coil having primary windings a, and secondary windings b. In the primary circuit we arrange a battery or other current source c, and switch d. We also arrange a mechanical break e suitably geared to the shaft f of the motor h. We preferably insert a condenser i in the primary, as a shunt across the point of make and break in the manner well understood.

Each of the secondary terminals k, l, we connect to one element m_1 n_1 of the separate condensers m, n, respectively, the other elements m_2 n_2 being connected by the leads o p to the terminals of the sparking plug r. The secondary terminals are likewise connected direct to the sparking point s, as shown. The condensers m n are preferably small strong capacities of the Leyden jar type, employing glass, ebonite, micanite or similar substance as the dielectric element.

A shunt across the gap indicated in the figure by the dotted line v is preferably provided in the sparking plug portion of the circuit to insure the charging of the condensers; this shunt should have either high resist-

ance or self induction or both, in order to prevent its sharing too much in the sudden discharge.

Considering, now, the action of the apparatus described above, every time a current is induced in the secondary circuit of the induction coil, a positive charge (for example) accumulates on the coat, n_1, of the Leyden jar, n, and a negative charge on the coat, m_1, of the jar, m, as indicated in Fig. 1. Charges of opposite sign are simultaneously induced respectively on the other coats of the jars, the function of the shunt, v, being to allow the jars to charge. While the jars are charging the electrostatic stress across the gap, s, continually increases until the resistance of the air breaks down and the ordinary primary spark passes. Meanwhile, however, it is to be noted that there has been no such growth of stress across the secondary gap, r, the difference of potential between the terminals of this gap remaining at zero. On the passing of the primary spark, the jars are discharged and the charges accumulated on the coats, m_2, n_2, are set free and surge impulsively along the wires, o, p. The shunt, v, however, which was sufficiently conductive to allow of the comparatively slow charging of the jars, offers a high resistance to the passage of the surging rush of electricity set free on the passing of the primary spark and induces the current to take the alternative path offered by way of the gap, r, thus giving rise to the secondary spark required.

The primary spark may be arranged in sight if desired and may be inclosed in sealed glass or gauze wire to prevent accidental explosions.

According to a second modification, shown diagrammatically in Fig. 2, we arrange the connections in just the same way as in Fig. 1, but we omit one of the condensers (say m); the action which takes place is substantially the same as that already described, but the circuit is less symmetrical. This method of connection may be convenient when one of the wires, viz. o, is earthed or replaced by an earth connection, as *e. g.* the frame of the machine.

In Fig. 3 we show diagrammatically a somewhat different arrangement of parts. The primary circuit of the coil is connected up as above; but one of the secondary terminals l for instance, we connect to one terminal of the sparking plug r; the other secondary terminal k and the other sparking plug terminal we connect to the terminals of the sparking point s. We also arrange the condenser n, between the secondary terminals of the coil, as shown in the figure; but instead of the spark gaps being connected in parallel through one or two condensers as in Figs. 1 and 2 we connect them in series and place the condenser in parallel with them both.

A shunt shown again by a dotted line with any desired amount of self-induction, should connect the wires connected to r, the function of the shunt, v, in this modification being not to insure the charging of the jar, n, as this operation can be effected directly by the coil, but to insure that the whole strain of the charge of the condenser n is thrown upon the clean insulated gap s as before. When this gap breaks down, the charge of the condenser n is liberated and rushing round the circuit, across the gap r precipitates the explosion desired.

From a consideration of Figs. 1, 2 and 3, it will be seen that the secondary spark may be defined as the spark caused by the impulsive electric rush from one coat of a condenser or pair of condensers suddenly excited across a gap of initially uniform potential by the sudden release of electrostatic strain which had previously existed across another spark gap in connection with the condenser.

For large gas engines or other purposes where it is thought desirable to fire the explosive mixture at more than one point several spark gaps may be arranged in series within the ignition chamber.

With the connections arranged as shown in Figs. 1, 2 and 3, the sparking plug, r, should be insulated from the motor body h.

When there are a number of cylinders to be fired at different times we prefer to use a coil arranged so as to give a steady stream of primary sparks (as *e g.* by the use of a battery and a trembler) and to insert the mechanical makes and breaks in several secondary spark circuits energized from this coil so that any one of them may be opened at the required time and the spark produced in the required place. In Fig. 4, two such sparking gaps r r are shown in series each being short circuited by paths of small resistance and inductance having switches x x normally closed but opened by mechanically operated makes and breaks such as the cams, x' so as to precipitate a secondary spark at the particular gap required. A battery c and trembler z are shown by way of example for exciting the coil.

In Fig. 5 the secondary spark gaps are shown in parallel instead of series with other reference letters as above. In this case each circuit acts as a shunt to the other one but this will not prevent the passing of secondary sparks especially if inductances L are inserted in the circuits.

We may also (see Fig. 6) use a magneto 2, having terminals, 3 geared to the motor and generating an alternating current preferably by means of revolving magnets, so as to avoid sliding contacts, and arrange an automatic "make" 4 in the circuit, so that the primary of the coil may be excited at the required instant. In this case the condenser i is either dispensed with or preferably placed in series with the alternator and coil primary and is of carefully adjusted capacity.

We also wish it to be understood that we may use any arrangement of parts having a capacity instead of an actual condenser, as shown in the drawings. Thus, for instance, in some cases the capacity secured by twisting together the secondary leads (as shown in Fig. 7) is sufficient for the purposes of our invention, while in other cases we may rely on the so-called Leyden jar action between the secondary and primary windings of an induction coil.

It will further be obvious that any form of transformer or oscillation converter may be used, without departing from our invention, as well as any device having capacity.

Having now described our invention, what we claim as new and desire to secure by Letters Patent is:—

1. In a system of spark ignition, apparatus for firing a combustible mixture, comprising in combination, a low tension circuit, a source of current in said circuit, an interrupter in said circuit, a high tension circuit inductively arranged with relation to said low tension circuit, a spark gap in said high tension circuit, condensing means placed in said high tension circuit and adapted to discharge across said spark gap, a sparking plug forming a

secondary spark gap disposed within the combustible mixture, means connecting said spark gap to the condensing means, and a connection normally keeping said sparking plug at the same potential, as and for the purposes described.

2. In a system of spark ignition, apparatus for firing a combustible mixture, comprising in combination, a low tension circuit, a source of current in said circuit, an interrupter in said circuit, a high tension circuit inductively arranged with relation to said low tension circuit, a spark gap in said high tension circuit, a sparking plug forming a secondary spark gap disposed within the combustible mixture, a condenser in parallel with said spark gaps and a connection in parallel with said secondary spark gap, as and for the purposes described.

In witness whereof we have hereunto set our hands in presence of two witnesses.

OLIVER JOSEPH LODGE.
ALEXANDER MARSHALL LODGE.

Witnesses:
HUME CHANCELLOR PINSENT,
FRANCIS MARTIN TOMKINSON.