March 25, 1952 N. FELICI 2,590,168

EXPLOSION ENGINE IGNITION

Filed Feb. 9, 1948 3 Sheets-Sheet 1

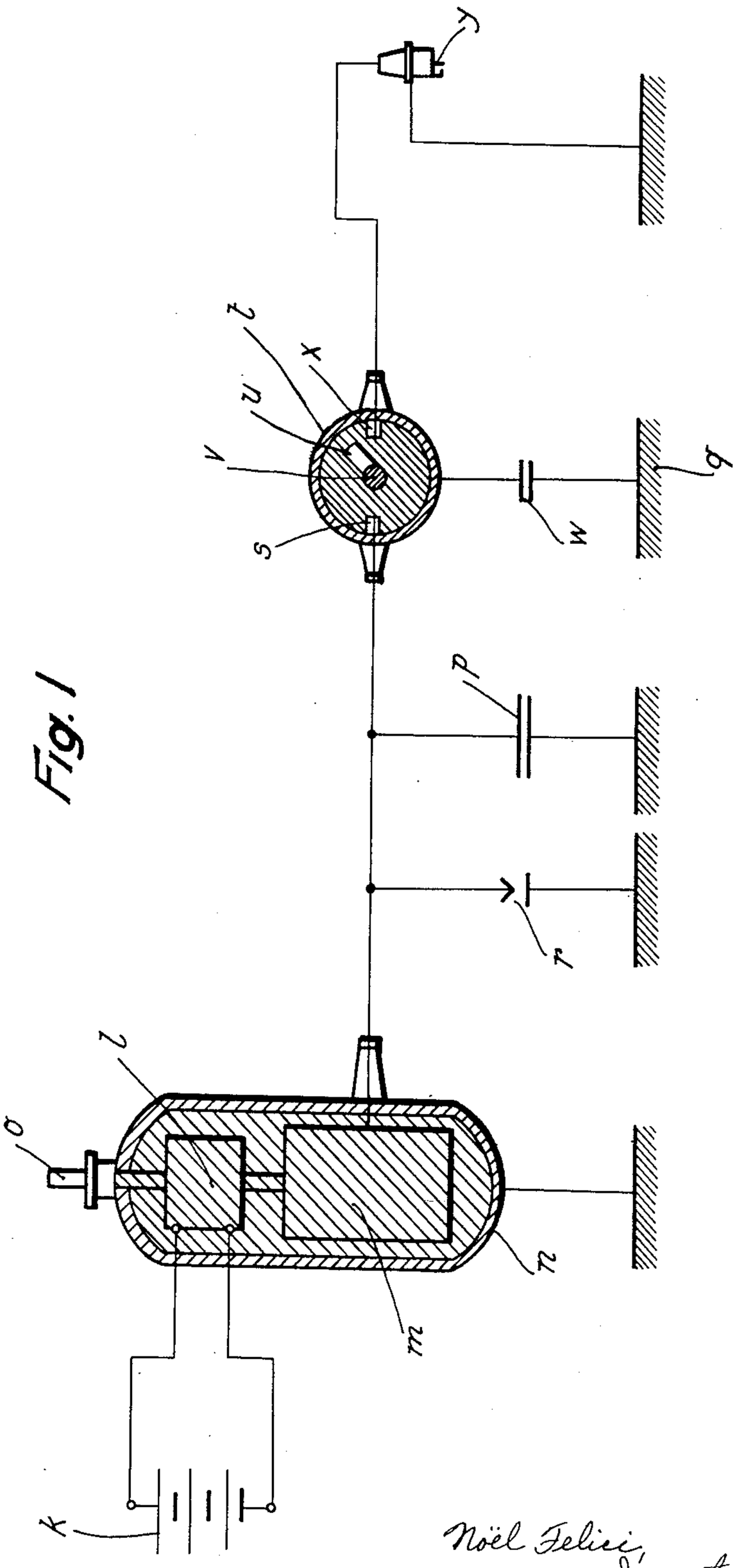

Fig. 1

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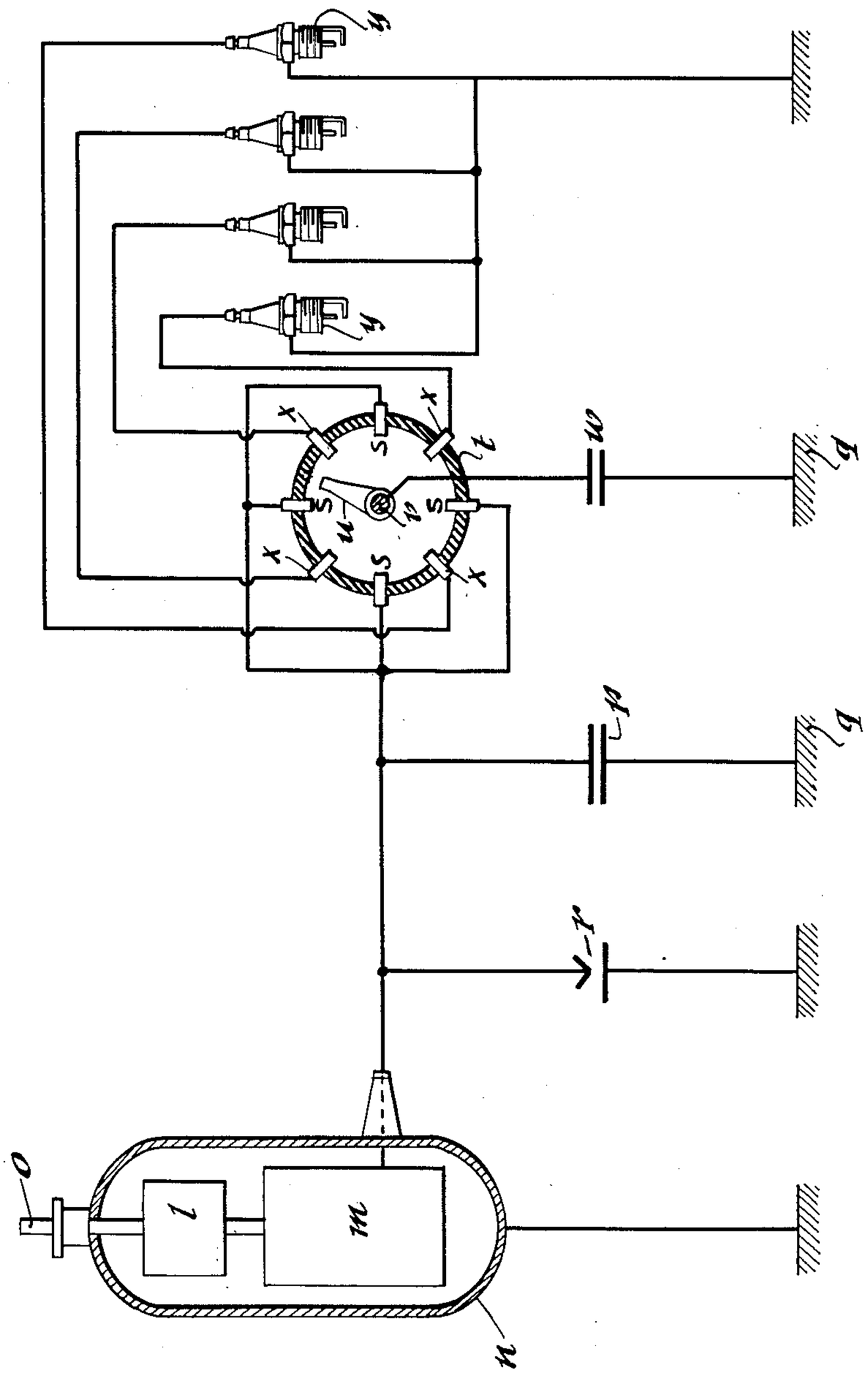
Fig. 2.



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3 Sheets-Sheet 3

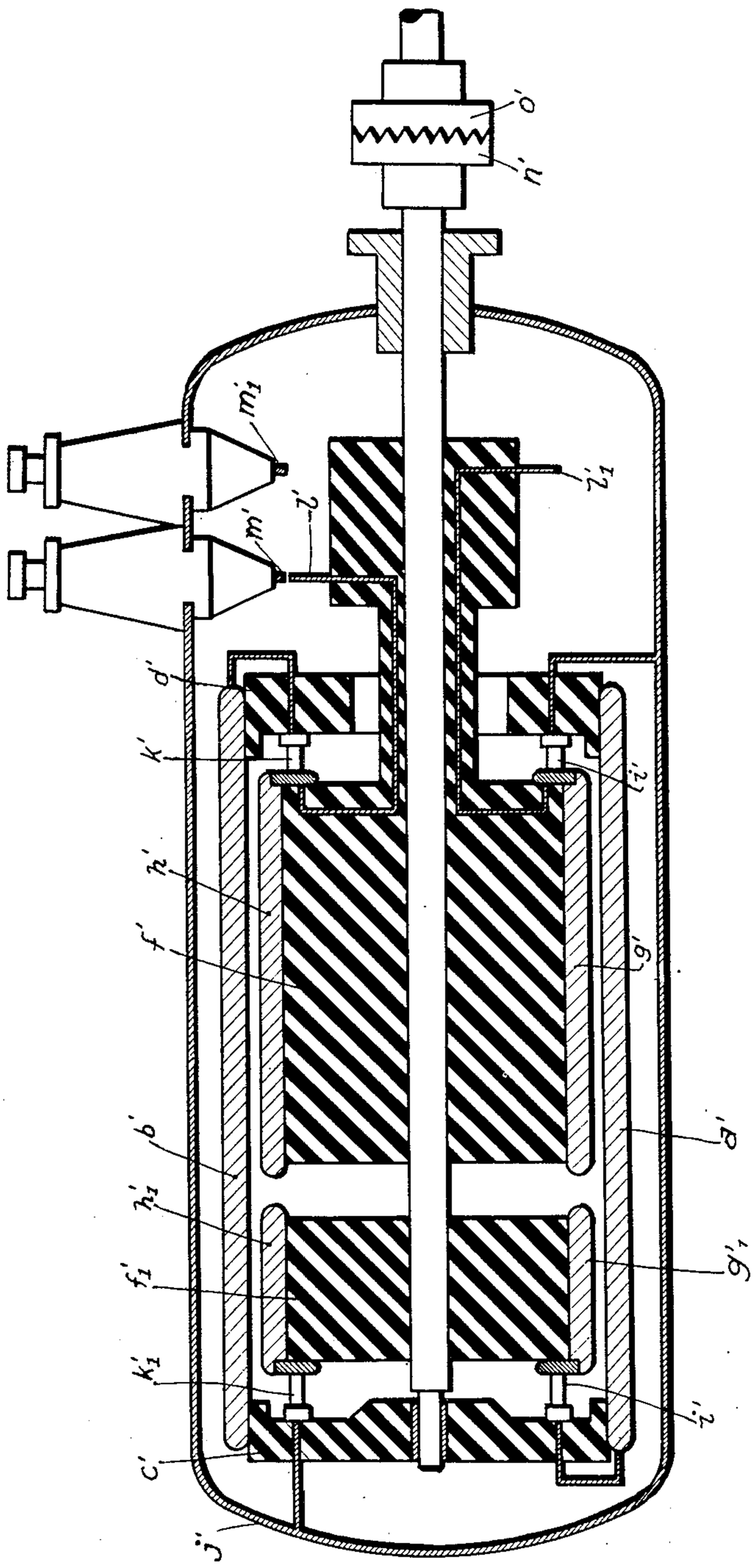

Fig. 3

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UNITED STATES PATENT OFFICE

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EXPLOSION ENGINE IGNITION

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In France February 20, 1947

14 Claims. (Cl. 315—223)

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It is known that in the electrical ignition devices, used nowadays in internal combustion engines, the capacitive phase of the spark, reflecting the discharge of the stray capacity of the constitutive members of the ignition device, plays the most important part in the ignition of the gaseous mixture, whereas the subsequent inductive phase of the spark, contributes but very little to the ignition.

It is known that the most amount of the electrical energy produced by such ignition devices is supplied during the inductive phase, and it is also known that this energy, set free during the inductive phase is not only practically useless, but also detrimental, because it contributes to heat the semi-conductive deposits formed on the sparking plug and, in carbonizing these deposits, causes them to become still more conductive, until they prevent the ignition.

Besides it is known that the energy set free during the inductive phase is the principal reason for the wear of the sparking points.

It is also known that a capacitive discharge, particularly when a gap is formed in the circuit connecting the capacitor to the sparking plug, which gap is bridged by the spark, is capable of destroying the soot existing on the sparking points which prevents a satisfactory ignition.

Furthermore it is known that such a capacitive discharge may secure of ensuring ignition with sparking plugs whose defective insulation causes misfires in the usual devices.

Finally it is known that it is advantageous to increase the ignition voltage, which results in increasing to a great extent the energy of the capacitive discharge and allows, furthermore, a greater spacing of the sparking points, spacing which is useful to prevent said points from getting dirty.

In spite of all the advantages of a purely capacitive discharge over the compound spark supplied by the presently known ignition devices, such a discharge could not conveniently be used hitherto. The connection of a condenser to the secondary winding of an electromagnetic ignition device excessively decreases the maximum voltage supplied by said device and, besides, does not entirely cancel the inductive phase, so that such an addition is more troublesome than useful.

The object of the present invention is to provide practical means to perform the ignition by means of a purely capacitive discharge at a high voltage with interposition of a gap on the ignition circuit, so as to benefit from all of the known

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advantages of such a discharge without encountering the above-mentioned drawbacks.

The invention essentially consists in using a static condenser charged by a high voltage electrical supply and suddenly connected to the sparking plug, at the exact moment of the ignition, by means of a suitable connection device.

The condenser may be charged by an electrical source of sufficient voltage and power output capacity. As the usual electromagnetic devices deliver only very limited voltages and have a low efficiency, it will be particularly advantageous to use as a source of electricity an electrostatic machine. One may, for instance, use an electrostatic machine of the same type as that described in my co-pending patent application Serial No. 760,896, filed July 14, 1947, now Patent No. 2,530,193 dated November 14, 1950. Such a machine may supply, for a negligible expense of mechanical power and under a very small bulk, the necessary amount of electrical energy at a voltage which may be as high as required, even with very low rotating speeds. The sudden connection between the condenser and the sparking plug, at a definite and adjustable moment, may be obtained, for instance, by an electrode moving in an air-tight housing filled with a fluid of very high dielectric strength and coming into proximity to another stationary electrode.

Possible embodiments of the invention are described hereafter with reference to the appended drawings in which:

Fig. 1 is a circuit diagram in which the high voltage supply is an electrostatic machine and the ignition is controlled by means of a rotating member.

Fig. 2 is a diagram of a similar circuit for a plurality of ignition members.

Fig. 3 shows a sectional diagrammatical view of an electrostatic machine in which the discharge controlling device is incorporated, and which is provided furthermore with the required capacitors which are necessary to carry out the invention.

Fig. 1 shows a device according to the invention in which the primary source of energy is a storage battery *k*, feeding an electric motor *l*, which drives a low power electrostatic generator *m*, of the same type as the generator described in the abovementioned patent application. The motor *l* and the generator *m* are confined in the same air-tight housing *n*. In case the battery *k* should be momentarily out of use, the generator *m* may be driven by a shaft *o*, extending out

of the housing, either by hand operation, or by the engine itself.

The high voltage current supplied by generator *m* charges a condenser *p* one terminal of which is connected to the frame *q* of the engine. The charging voltage is adjusted by a regulating device *r*, for instance a corona regulator. The other terminal of the condenser is connected to a stationary electrode *s* confined in an air-tight housing *t* of the control device or distributor filled with a fluid having a sufficient dielectric strength, such as oil, kerosene, nitrogen under a pressure higher than 4 atmospheres, hydrogen under a pressure higher than 8 atmospheres. Within housing *t* a movable electrode *u* fastened to a shaft *v* driven by the explosion engine rotates into contact with or into spark gap register with stationary electrodes *s* and *x* in succession. The electrode *u* is connected to a terminal of an ignition condenser *w* the other terminal of which is connected to the frame terminal *q*. It is preferable, as above indicated, to provide a gap in the circuits connected to the condensers and to the spark plugs and such gap may be provided between the movable electrode *u* and the stationary electrodes *s* and *x*. When the movable electrode *u* comes very near to the stationary electrode *s* in the embodiment of Fig. 1, a spark flashes across the gap between the two electrodes and the condenser *w* is charged by a fractional part of the electricity stored in condenser *p* the capacity of which is greater than that of condenser *w*. This condenser remains in a charged condition until the electrode *u*, in the course of its rotation, comes very near to the insulated electrode *x* connected to the sparking plug point *y*. The condenser *w* is then discharged as a spark flashes across the gap between the electrodes *u* and *x*, on the one hand, and between the points of the sparking plug, on the other hand. Electrode *u* then again comes very close to electrode *s*, the condenser *w* is recharged and the ignition can again be performed. In order that the moment of the ignition may be fixed with a sufficient accuracy, it is convenient to give to the circle travelled over by electrode *u* a sufficient diameter taking into account the dielectric strength of the fluid filling the housing *t* and the ratio between the rotating speed of electrode *u* and that of the engine.

The higher the dielectric strength of the fluid and the higher said ratio, the smaller can be the diameter of the circle travelled over by the electrode *u*.

By angular displacement of the tube or housing *t* about shaft *v* the moment of ignition may be adjusted at will. In providing, instead of one electrode *s*, four such electrodes connected to condenser *p*, as shown in Fig. 2, it is possible to charge condenser *w* four times instead of one for each rotation of the shaft *v*. Four discharge electrodes such as *x* connected respectively to four different sparking plugs may also be provided, so that the apparatus confined in housing *t* secures not only the ignition at the required moment but also the distribution of the sparks to the four sparking plugs in succession.

Fig. 3 shows a device according to the invention in which the electrostatic generator, synchronously driven by the explosion engine, and the discharge initiating device are assembled into a same housing, whilst the ignition condenser is provided, inside the generator itself, by the capacities of the stationary and movable inductive members of the latter.

The generator is of the type disclosed in the above-mentioned Patent 2,530,193. It comprises two semi-cylindrical stationary conductive inductor members *a'*, *b'* carried by two insulating flanges or supports *c'*, *d'* supported in the housing of the machine. The rotating shaft *e'* passes through the two supports *c'*, *d'* and carries two rotors *f'* and *f'*1. Each rotor comprises two approximately semi-cylindrical conducting members insulated from each other, that is, members *g'*, *h'* and members *g'*1, *h'*1, these members being fixed upon shaft *e'* but insulated therefrom. The rotor *f'* supplies the electricity used for the ignition. The movable carrier members *g'*, *h'* are charged, under the influence of member *a'*, through a brush *i'* electrically connected to the metallic and air-tight housing *j'* of the machine, this housing being filled with a fluid of high dielectric strength. The rotor *f'*1 and its carrier members *g'*1 and *h'*1 constitute an exciter for maintaining the inductor member *a'* at a predetermined potential difference with respect to the housing *j'*. In the position shown in Fig. 3 the carrier *g'* in inductive relation to the inductor member *a'* is connected through the brush *i'* to the housing so as to be at the same potential as this housing.

After half a revolution, the carriers *g'* or *h'* in succession supply a part of their charge through a brush *k'* to the stationary member *b'*. Then, at the moment of the ignition, they supply the discharge to the sparking plug by means of the movable electrodes *l'*, *l'*1 electrically connected to the carriers and which pass very close to stationary electrodes *m'*, *m'*1 supported by and in insulated relation to the housing. Each conveyer *g'*, *h'* thus supplies one spark per rotation. These sparks may be used in two different sparking plugs by providing two separate stationary electrodes *m'*, *m'*1 and proceeding in such a manner that one of the movable electrodes, say *l'*, passes near to the stationary electrode *m'*, whilst the other *l'*1 passes near to the stationary electrode *m'*1. In the case of a machine comprising four carriers, it is possible, in the same manner, to supply four sparks per rotation and to distribute them to four different sparking plugs. The adjustment of the moment of the ignition may be obtained by rotating the whole of the housing *j'* and of its contents, about the shaft *e'*.

The rotor *f'*1 is used to excite the generator by means of two brushes *i'*1, *k'*1 connected, the one to the housing *j'*, and the other to the inductor member *a'*. In order to make the starting easier when the apparatus has not been used for a long time, the shaft *e'* may be disconnected from its driving means through the medium of a claw coupling *n'*, *o'* and caused to rotate a few turns, for instance by hand, so as to initiate the excitation of the generator. The generator is then again coupled with the engine by means of the claw coupling and the engine may be started immediately.

In all the devices which have been disclosed the quality of the spark may, if desired, be independent of the speed of rotation whilst the electromagnetic ignition devices used at present do not supply sparks of constant quality, the quality decreasing at low speeds in the case of magnetos and at high speeds in the case of battery fed coils. To secure a good quality of the spark at very low speeds, it is only necessary with the device of the invention that the insulating properties of the ignition condenser should be satisfactory, that the leakage time constant of said condenser should be higher than 10 sec-

onds, for instance, which is very easily obtained. To obtain a good quality spark at very high speeds it is only necessary, in the case of the devices shown in Figs. 1 and 2, that the output of the high voltage generator should be sufficient. In the case of the device represented in Fig. 3, the amount of electricity supplied at each discharge being independent of the speed, the quality may be constant however great the speed.

The experiments which have been carried out have shown that the capacity of the condenser may be very low in most cases, for instance, as low as 20 electrostatic C. G. S. units. This indicates that the electric power supplied by the high voltage generating device in general may be very low, for instance a few tenths of a watt, while it usually reaches several watts and even several scores of watts in the electromagnetic ignition devices. Nevertheless, the device according to the invention may properly feed sparking plugs having a very small insulating resistance, for instance 1000 ohms, such sparking plugs being hardly serviceable with the presently used ignition devices.

What I claim is:

1. An ignition system comprising means providing a source of electrostatic potential difference, a static condenser, a spark gap ignition member, means for intermittently connecting said condenser across said source of electrostatic potential difference to charge said condenser, means cooperating with said intermittent connecting means for discharging said condenser to said ignition member upon interruption of the charging of said condenser and for preventing discharge of said condenser to said ignition member upon charging of said condenser, and means for confining said intermittent connecting means and said means cooperating therewith in a fluid medium having a dielectric strength substantially equal to that of a gas at a pressure not substantially less than 4 atmospheres.

2. An ignition system comprising means providing a source of electrostatic potential difference, a static condenser, a spark gap ignition member, means for intermittently connecting said condenser across said source of electrostatic potential difference to charge said condenser, means cooperating with said intermittent connecting means for connecting said condenser to said ignition member upon disconnection of said condenser from said source of electrostatic potential difference to discharge said condenser through the spark gap of said ignition member, and means for confining said intermittent connecting means and said means cooperating therewith in an atmosphere of a gaseous medium at a pressure not substantially less than 4 atmospheres.

3. An ignition system comprising means providing a source of electrostatic potential difference, a static condenser, a spark gap ignition member, a control device having a conductive element movable alternately into spark gap proximity to two stationary conductive elements, one of said stationary elements being connected to said source of electrostatic potential difference, the other of said stationary elements being connected to one terminal of said spark gap ignition member, one plate of said condenser being connected to said movable conductive element, the other plate of said condenser being connected to the other terminal of said ignition member, means for effecting movement of said movable conductive element into said spark gap proximity

to said stationary conductive element connected to said source of electrostatic potential difference to charge said condenser and thereafter into said spark gap proximity with said other stationary conductive element to discharge said condenser through said spark gap ignition member, and means for confining said movable and stationary conductive elements in an atmosphere of a gaseous dielectric medium at a pressure not substantially less than 4 atmospheres.

4. An ignition system comprising means providing a source of electrostatic potential difference, a primary static condenser, a spark gap ignition member, a control device having a conductive element movable alternately into at least spark gap proximity to two stationary conductive elements, one of said stationary conductive elements being connected to said source of electrostatic potential difference, the other of said stationary elements being connected to one terminal of said spark gap ignition member, one plate of said condenser being connected to said movable conductive element, the other plate of said condenser being connected to the other terminal of said ignition member, means for effecting movement of said movable conductive element into said proximity to said stationary conductive element connected to said source of electrostatic potential difference to charge said condenser and thereafter into said proximity with said other stationary conductive element to discharge said condenser through said spark gap ignition member, means for confining said movable and stationary conductive elements in an atmosphere of a gaseous dielectric medium at a pressure not substantially less than 4 atmospheres, and an auxiliary condenser of greater capacity than said primary condenser and connected across said source of electrostatic potential difference.

5. An ignition system as defined in claim 3 which comprises a corona regulator connected across said source of electrostatic potential difference.

6. An ignition device comprising a high voltage electrostatic generator having a rotatable shaft, a conductive capacitative carrier member carried by said shaft in insulated relation thereto for movement thereof about the axis of said shaft, a stationary conductive capacitative inductor member supported in continuous insulated relation to said capacitative carrier member and to said shaft, said stationary member being connected to said electrostatic generator so as to be charged thereby at a predetermined potential difference relative to said rotatable capacitative member and arranged in relation to said rotatable capacitative member to form a condenser therewith when said rotatable capacitative member is rotated into register therewith, an outlet terminal, a conductive element carried by said shaft in insulated relation thereto to rotate therewith and electrically connected to said rotatable capacitative member and adapted to come into proximity to and at spark gap distance from said terminal upon rotation of said rotatable capacitative member to a position angularly spaced from said stationary capacitative member to discharge said rotatable capacitative member through said terminal, and means for confining a gas under pressure in dielectric relation to said terminal and said element for spark discharge therein between said terminal and said element.

7. An ignition device as defined in claim 6 which comprises an auxiliary stationary con-

ductive capacitative member angularly displaced about the axis of said shaft from said first stationary capacitative member, and means for establishing electrical connection between said auxiliary stationary capacitative member and said rotatable capacitative member in said angularly displaced position concomitantly with said discharge of said rotatable capacitative member through said terminal.

8. An ignition device comprising a housing, a shaft supported within said housing for rotation thereof on its axis relative to said housing, a conductive capacitative carrier member carried by said shaft in insulated relation thereto for movement thereof within said housing about the axis of said shaft, a conductive capacitative inductor member supported by said housing in stationary relation thereto and continuously insulated therefrom and from said rotatable capacitative member and said shaft, said stationary member being arranged in relation to said rotatable capacitative member to form a condenser therewith when said rotatable capacitative member is rotated into register therewith, means connected to said members for charging said condenser when said capacitative members are in said registering relation, an outlet terminal within and carried by said housing in insulated relation thereto and adapted to be connected to a spark gap ignition member, a conductive element carried by and rotatable with said shaft in insulated relation thereto within said housing and connected to said rotatable capacitative member and adapted to come into proximity to and at spark gap distance from said terminal upon rotation of said rotatable capacitative member to a position angularly displaced from said stationary capacitative member to discharge said rotatable capacitative member through said terminal, and means for confining within said housing in dielectric relation to said conductive members and said conductive element and said terminal a gas under pressure not substantially less than 4 atmospheres to provide a medium of high dielectric strength in which said charging and discharging of said capacitative members and spark discharge between said conductive element and said terminal take place.

9. An ignition device comprising a conductive inductor member, a conductive carrier member, said members being supported for movement relative to each other into and out of electrostatic inductive relation to each other and being continuously insulated from each other during said movement, a discharge terminal, a conductive element movable together with said carrier member in said relative movement thereof with respect to said inductor member and electrically connected to said carrier member and adapted to come into proximity to and at spark gap distance from said terminal upon relative movement of said carrier member with respect to said inductor member out of inductive relation to said inductor member to discharge the charge carried upon said carrier member through said terminal, means connected to said inductor and carrier members to produce an electrostatic charge thereon at a predetermined difference of potential therebetween when in said inductive relation to each other, and means for confining said discharge terminal and said conductive element in a fluid medium having a dielectric strength substantially equal to that of a gas at a pressure not substantially less than 4 atmospheres.

10. An ignition system comprising means providing a source of electrical potential difference, a plurality of spark gap ignition members each having terminals at the respective sides of the spark gap thereof, a control device having a conductive element movable in a predetermined path of movement, said control device having stationary conductive elements respectively connected to given terminals of the respective spark gap ignition members and positioned in said predetermined path of movement of said movable conductive element intermediate between stationary conductive electrodes connected in common to one side of said source of electrical potential difference, a static condenser having one plate thereof connected to said movable conductive element of said control device and the other plate thereof connected in common to the other terminals of said ignition members, means for effecting movement of said conductive element in said path into at least spark gap proximity to a stationary conductive electrode so as to connect said condenser to said source of electrical potential difference to charge said condenser and thereafter to continue movement of said movable conductive element into at least spark gap proximity to the next adjacent stationary conductive element in said path of movement to disconnect said condenser from said source and to connect said condenser to the given terminal of a spark gap ignition member to discharge said condenser therethrough, said movable element thereafter in succession being effective to connect said condenser alternately to said source of electrical potential and to the respective other given terminals of said ignition members for similarly charging and discharging said condenser through said other ignition members in succession, and a housing enclosing said movable conductive element and the portions of said stationary conductive elements and of said stationary conductive electrodes that successively are brought into at least spark gap proximity to said movable conductive element as said movable element moves in said path, said housing being adapted to confine therein a dielectric gaseous material at a pressure not substantially less than 4 atmospheres.

11. An ignition system for ignition of explosion engines comprising means providing a high voltage electrostatic source, a static condenser connected across the terminals of said source, at least one ignition member capable of producing an ignition spark across the gap between the electrodes thereof, a control device comprising a rotating electrode driven by the engine and adapted to move into and out of close proximity to the electrodes of at least one pair of stationary electrodes in succession, one of the electrodes of said pair being connected to one of the poles of said condenser and the other electrode of said pair being connected to one of the electrodes of said ignition member, the other electrode of said ignition member being connected to the other pole of said condenser, and a second static condenser connected between said rotating electrode and said other pole of said first condenser, said rotatable electrode and said pair of stationary electrodes being arranged within a housing confining a gaseous medium at a pressure not substantially less than 4 atmospheres to provide an atmosphere of high dielectric strength, said stationary electrodes being arranged with respect to each other and with respect to said rotatable electrode to provide connection of said second

condenser in succession to said means providing the high voltage electrostatic source and to said ignition member respectively to charge said second condenser and to discharge said second condenser through said ignition member.

12. An ignition device for explosion engines comprising a high voltage electrostatic generator having a rotatable shaft and having a stationary conductive inductor member and conductive movable carrier members carried by said shaft for rotation therewith and continuously insulated from said inductor member, said shaft being operatively coupled with the shaft of the engine for rotation therewith and carrying at least one movable electrode connected to one of said conductive movable members, said movable electrode in the rotation of said shaft being adapted to move into and out of proximity to and at spark gap distance from a corresponding stationary electrode connected to an ignition member capable of producing an ignition spark in the inflammable mixture to be ignited, said generator and said electrodes being arranged within a housing containing a medium of high dielectric strength, the coupling between the engine and the shaft of the generator as well as the dimensions of the electrodes being such that the ignition member is connected to the conductive carrier members of the generator at the required moments for the ignition.

13. An ignition device for explosion engines comprising a high voltage electrostatic generator having a stationary conductive inductor member and having a rotatable shaft carrying as many movable conductive carrier members as there are cylinders in the engine, said carrier members being continuously insulated from said inductor member and being movable successively into and out of inductive relation to said inductor member upon rotation of said shaft, the shaft of said generator being operatively coupled with the engine shaft for rotation therewith and carrying the same number of electrodes as there are engine cylinders for movement of said electrodes with said movable conductive carrier members upon rotation of said generator shaft, said electrodes being respectively connected to the conductive movable carrier members of said generator and respectively being adapted to move in succession into and out of proximity to and at spark gap distance from the electrodes of a group of stationary electrodes in number equal to the number of said movable electrodes, said stationary electrodes being respectively connected to given terminals of the ignition members of the respective cylinders, the other terminal of

each of said ignition members being connected to a terminal of said generator, and means for connecting said carrier members to said generator terminal in succession when in inductive relation to said inductor member, said generator and said electrodes being arranged within an airtight housing containing a fluid medium of high dielectric strength, the coupling between the engine and the shaft of the generator as well as the dimensions and the positioning of the stationary and movable electrodes being such that each ignition member is connected to the conductive carrier members of the generator at the required moment for the corresponding ignition.

14. A control device for an ignition system supplied by a source of electrostatic potential difference and including a static condenser having a given plate connectible alternately to said electrostatic source and to a given terminal of a spark gap ignition member and having another plate connected to the other terminal of said ignition member, said control device comprising a housing, at least a pair of stationary conductive elements supported within said housing, a conductive element movable within said housing alternately into at least spark gap proximity to the stationary conductive elements of said pair, one of said stationary elements being connectible to said source of electrostatic potential difference, the other of said stationary elements being connectible to said given terminal of said spark gap ignition member, said movable conductive element being connectible to said given plate of said condenser, said housing cooperating with said stationary conductive elements and said movable conductive element to confine within the housing in dielectric relation to said conductive elements a gas under a pressure of not substantially less than four atmospheres to provide a medium of high dielectric strength.

NOËL FELICI.

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