

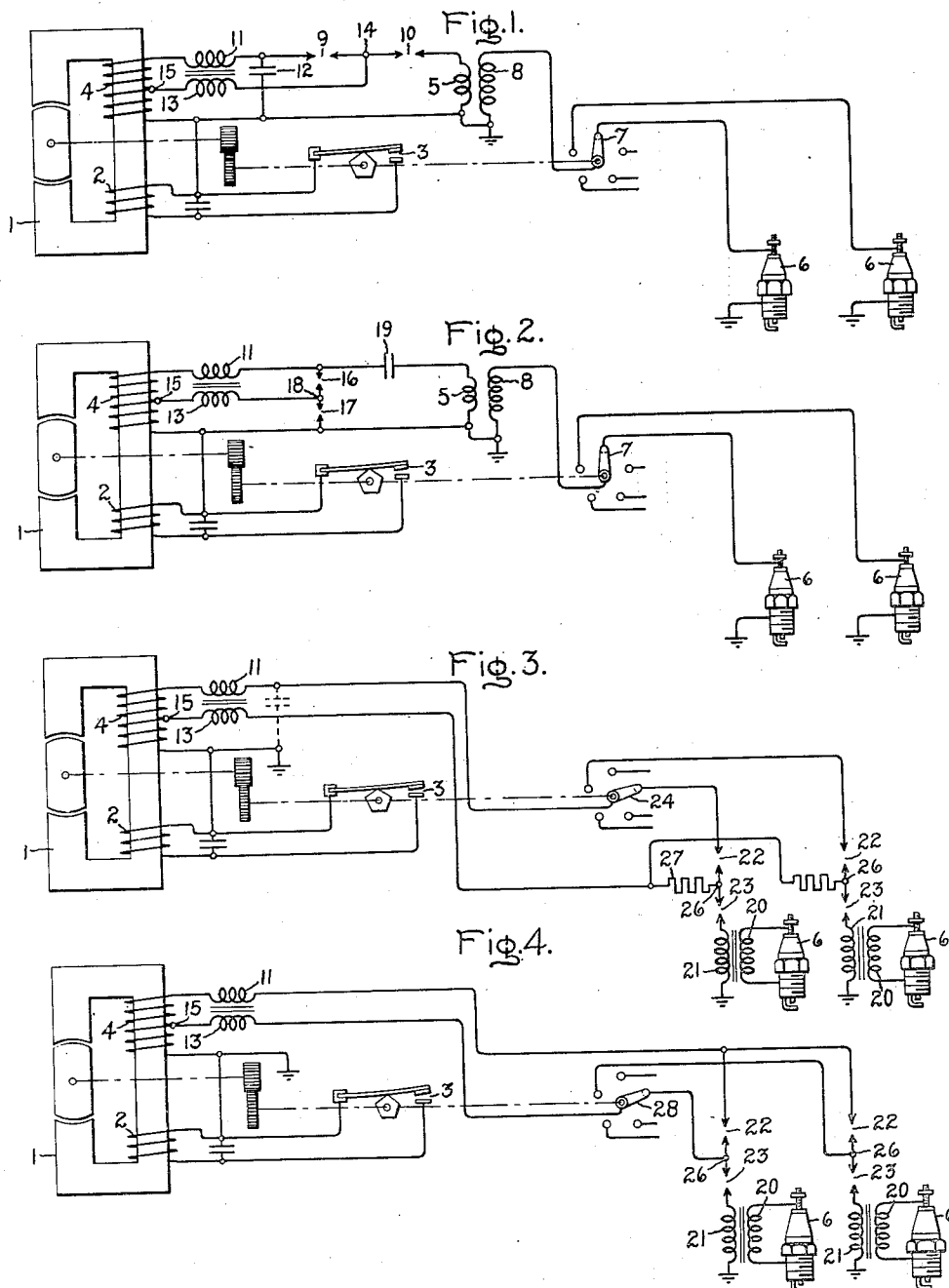
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IGNITION SYSTEM

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IGNITION SYSTEM

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Our invention relates to electrical discharge systems and in particular to ignition systems for internal combustion engines utilizing a high frequency electrical discharge for the spark plug circuit.

An object of our invention is to provide an improved electrical discharge system.

Another object of our invention is to provide an improved electrical discharge system in which the timing of the discharge can be very accurately determined by the application of a surge voltage to a part of the circuit providing for the breakdown of the discharge member in the system.

A further object of our invention is to provide an improved ignition system utilizing high frequency electrical impulses for energizing the discharge member.

Further objects and advantages of our invention will become apparent and our invention will be better understood from the following description referring to the accompanying drawing, and the features of novelty which characterize our invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In the drawing, Fig. 1 is a schematic representation of an electrical discharge system adapted to be used for the ignition of an internal combustion engine; Fig. 2 is a schematic diagram of another embodiment of our invention applied to the ignition system of an engine; Fig. 3 is a schematic diagram of a further embodiment of our invention applied to an ignition system for an engine; and Fig. 4 is a schematic diagram of still another embodiment of our improved electrical discharge system as applied to an ignition system.

Our invention is particularly applicable to electrical discharge systems of the kind in which the discharge and the electrical discharge member, such as a spark plug for an internal combustion engine, is of a high frequency character and is obtained by intermittently charging a storage condenser and discharging it automatically by the breakdown of a series discharge gap into a circuit in which high frequency oscillation can readily take place. This circuit may be the spark plug circuit or a circuit coupled to the spark plug circuit through a high frequency transformer. In high frequency ignition circuits of the type employing a magneto as a source of voltage and a series gap having a substantially constant breakdown voltage, the maximum energy required at the spark plugs must be produced at the minimum magneto speed, as the en-

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ergy supplied to the plugs per spark is controlled by the gap breakdown voltage and not by the speed of the magneto. This limits the maximum high frequency voltage available and tends to leave a surplus of energy to be dissipated in a high frequency unit at high magneto speeds. According to our invention, two discharge spark gaps are connected in series such that their combined series breakdown voltage is of the order of, and preferably just slightly greater than, the maximum value of a voltage applied to the condenser, and the gaps are adapted to be discharged by applying to the connection between the two series connected gaps a trigger or surge voltage obtained by a peaking transformer or a suitable choke inductance energized in any suitable manner, as by the charging current of the storage condenser. This charging current to the condenser and the voltage applied generally to the system may be provided by any suitable source of voltage, such as a conventional magneto generating system or a suitable alternating current generator. In general, in carrying out our invention, it is necessary that the voltage applied to the common junction or connection point of the two spark gaps be controlled and maintained at a definite fraction of the total voltage applied to the system. With this arrangement, a suitable voltage surge or peak is superimposed on the voltage already applied to the main circuit to the junction of the two gaps, and thereby causes a breakdown of one of the gaps, such that substantially full voltage of the source of electrical voltage is applied across the other of the gaps, causing a breakdown of the other spark gap, resulting in an electrical discharge of the electrical discharge member, such as a spark plug, which is suitably connected to the circuit by suitable circuit closing means such as a distributor and a transformer.

In the drawing, we have shown in Fig. 1 an arrangement in which a conventional magneto 1 provided with a primary winding 2 and a breaker 3 is adapted to induce a desired voltage in a magneto secondary winding 4 which provides a suitable source of voltage for the system. The secondary winding 4 is connected across a primary winding 5 of a step-up transformer of the high frequency type which is adapted to be connected to electrical discharge members, such as spark plugs 6, through a distributor 7 and a high frequency transformer secondary winding 8. The primary winding 5 of the high frequency transformer is connected in this embodiment in series with two series connected spark gaps 9 and 10

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which are preferably of the sealed quenched type and through a primary winding 11 of a peaking transformer. A storage condenser 12 is also connected across the magneto secondary winding 4 and the primary winding 11 of the peaking transformer, such that as the voltage of the storage condenser 12 reaches its maximum, the charging current in the primary of the peaking transformer 11 reaches its minimum value. The peaking transformer is provided with a secondary winding 13 having a terminal 14 connected to the common or midpoint of connection between the two spark gaps 9 and 10 and is provided with another terminal 15 connected to a point of suitable potential in the generating circuit, in the illustrated arrangement the midpoint of the magneto secondary winding, so that the potential across the gaps 9 and 10 is divided, such that neither gap will break down prior to the application of a tripping or triggering voltage. Thus, where the individual breakdown voltages of the spark gaps 9 and 10 are equal, the secondary winding 13 of the peaking transformer may be connected to the midpoint or mid-voltage point in the generating or charging circuit of the system. When the voltage peak is applied to the junction point 14 between the two spark gaps 9 and 10, either the gap 9 or the gap 10 will rupture, depending upon the phasing of the applied voltage, and the breakdown of either gap provides for the application to the other gap of the full voltage of the source of electrical voltage which at this instant is substantially the voltage of the storage condenser 12, thereby causing the breakdown of the remaining gap and the discharge of the energy of the condenser 12 through the two gaps 9 and 10 and the primary winding 5 of the high frequency transformer. Since the spark gaps do not rupture until the capacitance 12 is nearly fully charged, only one spark occurs for each operation of the contact breaker 3, irrespective of the magneto speed.

In Fig. 2, we have shown an ignition system provided with essentially the same elements as those of the system shown in Fig. 1, in which a magneto 1 is provided with a primary winding 2 and a breaker 3 for inducing a suitable voltage in a magneto secondary winding 4 connected through a high frequency step-up transformer primary winding 5 to a plurality of electrical discharge plugs 6, a distributor 7 and a secondary winding 8 of the high frequency transformer. As in the arrangement shown in Fig. 1, a peaking transformer having a primary winding 11 is connected to one terminal of the source of voltage, which is the magneto secondary winding 4, and to one terminal of two series connected spark gaps 16 and 17, while the peaking transformer secondary winding 13 is connected to a common or midpoint 18 between the two quenched spark gaps 16 and 17 and to a midpoint 15 of the magneto secondary winding 4. In this instance, a storage capacitor 19 is connected in series with the high frequency transformer primary winding 5 and the peaking transformer primary winding 11, such that the two spark gaps 16 and 17 are connected across the charging condenser 19 and the high frequency transformer primary winding 5. The operation of this system is essentially the same as that of Fig. 1, in that as the charging current of the capacitor 19 reaches a minimum value, a surge voltage is applied to the midpoint 18 between the two spark gaps 16 and 17, causing a breakdown of one of the spark gaps and providing for the application of substantially full voltage of

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the source of electrical voltage, the storage capacitor 19, across the other of the spark gaps which causes breakdown of this other spark gap and an electrical discharge of the spark plugs 6.

In Fig. 3, we have shown another embodiment of our invention in which each of the spark plugs 6 is provided with an individual high frequency step-up transformer having a secondary winding 20 connected across the terminals of each of the spark plugs 6 and a primary winding 21 connected in series with a pair of series connected quenched sealed spark gaps 22 and 23. In this system, the voltage of the source of voltage supply is distributed in a conventional manner by a distributor 24 to each of the spark gap circuits for each individual spark plug 6 and is connected in series with the primary winding 11 of a peaking transformer supplied with voltage from a magneto secondary winding 4 and having a peaking transformer secondary winding 13 connected to the midpoint 15 of the magneto secondary winding 4 and permanently connected to each of the midpoints 26 between each set of quenched spark gaps 22 and 23. With such an arrangement, the main voltage is applied across the two series connected spark gaps 22 and 23 at substantially the same instant as the surge or peak voltage is applied to the midpoint 26, such that one of the two spark gaps 22 and 23 is ruptured, thereby impressing substantially full voltage across the other of the spark gaps which then breaks down and impresses full voltage across the high frequency transformer primary winding 21, and thereby energizes the spark plugs 6 through the high frequency transformer secondary winding 20. An impedance 27 is connected between the terminal of the peaking transformer secondary winding 13 and each of the midpoints 26 in order to avoid misfiring by increasing the impedance between the circuits to the separate spark plugs 6.

Fig. 4 illustrates another embodiment of our invention in which the spark plugs 6 are each provided with a separate high frequency step-up transformer having a secondary winding 20 connected across the spark plugs and a primary winding 21 connected in series with a pair of series connected quenched sealed spark gaps 22 and 23 which are permanently connected across the source of voltage supply, including the magneto secondary winding 4, and the primary winding 11 of the peaking transformer. A surge or trigger voltage is applied to the common or midpoint 26 between the two spark gaps 22 and 23 by a distributor 28 which is connected in series with the secondary winding 13 of the peaking transformer in order to apply the surge or trigger voltage to the midpoint 26 between the spark gaps 22 and 23 to cause a breakdown of one of the spark gaps, providing for the application of substantially full voltage of the source of electrical voltage across the other of the spark gaps, causing breakdown of this other spark gap and a resultant application of full voltage across the high frequency transformer primary winding 21, with a consequent discharge of the electrical discharge member or spark plug 6. The remaining conventional portions of this ignition system are numbered the same as those in the other figures of the drawing and operate in a similar manner. If it is desired to operate the system over a voltage range greater than two to one, this can be obtained by inserting an inductance in the lead forming the junction between the two spark gaps and the secondary winding of the peaking transformer where the value of the inductance is such as not to interfere

with the operation of the main circuit of the system.

While we have illustrated and described particular embodiments of our invention, modifications thereof will occur to those skilled in the art. We desire it to be understood, therefore, that our invention is not to be limited to the particular arrangements disclosed, and we intend in the appended claims to cover all modifications which do not depart from the spirit and scope of our invention:

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An electrical discharge system comprising a pair of series connected spark gaps, a source of voltage having two connections for high voltage and an intermediate voltage connection, means for connecting said high voltage connections across two series-connected spark gaps, a voltage-dividing circuit connection for connecting the common connection of said series-connected spark gaps to said intermediate voltage connection of said voltage source whereby a predetermined fraction of the maximum supply voltage is maintained across each spark gap, and means for introducing into said voltage-dividing circuit connection a supplemental triggering voltage to cause a breakdown of one of said spark gaps whereby maximum supply voltage is applied to the other spark gap to cause breakdown thereof.

2. An electrical discharge system comprising a pair of series-connected spark gaps, a source of voltage comprising a winding having two connections for high voltage and a tapped intermediate voltage connection, means for connecting the high voltage connections of said winding across said series-connected spark gaps, a voltage-dividing connection for connecting the common connection of said series-connected spark gaps to said intermediate voltage connection of said winding whereby a predetermined fraction of the voltage across the high-voltage connections of said winding is maintained across each spark gap, and means for introducing into said voltage-dividing circuit connection a supplemental triggering voltage to cause breakdown of one of said gaps whereby the voltage across the high connections of said winding is applied across the other spark gap to cause breakdown thereof.

3. An ignition system comprising a magneto having an output winding provided with two connections for high voltage and an intermediate voltage connection, an oscillatory discharge circuit connected across the high voltage connections of said magneto, said discharge circuit comprising two parallel branches one of which includes capacitance means and the other of which includes two series-connected spark gaps, a voltage-dividing circuit connection connecting the common connection of said series-connected spark gaps and the intermediate voltage connection of said magneto whereby a predetermined fraction of the magneto high voltage is maintained across each spark gap, means for introducing to said voltage-dividing circuit connection a supplemental triggering voltage to cause breakdown of one of said spark gaps whereby the magneto high voltage output is applied to the other spark gap to cause breakdown thereof and a flow of oscillatory current in said discharge circuit,

and spark plug means energized by the flow of current in said discharge circuit.

4. An ignition system comprising a magneto having an output winding provided with two connections for high voltage and an intermediate voltage connection, an oscillatory discharge circuit connected across the high-voltage connections of said magneto, said discharge circuit comprising two parallel branches one of which includes a storage condenser and the other of which includes two series-connected spark gaps, a voltage dividing circuit connection connecting the common connection of said series-connected spark gaps and the intermediate voltage connection to said magneto whereby a predetermined fraction of the magneto high voltage output is maintained across each spark gap, a transformer having a secondary winding connected in series with said voltage-dividing connection and a primary winding energized from a source of supply, said transformer providing a supplemental triggering voltage to cause breakdown of one of said spark gaps whereby the magneto high voltage output is applied to the other spark gap to cause breakdown thereof and a flow of oscillatory current in said discharge circuit, and spark plug means energized by the flow of current in said discharge circuit.

5. An ignition system comprising a magneto having an output winding provided with two connections for high voltage and an intermediate voltage connection, an oscillatory discharge circuit connected across the high voltage connections of said magneto, said discharge circuit comprising two parallel branches one of which includes a storage condenser and the other of which includes two series-connected spark gaps, a voltage-dividing circuit connection connecting the common connection of said series-connected spark gaps and the intermediate voltage connection of said magneto whereby a predetermined fraction of the magneto high voltage is maintained across each spark gap, a transformer having a secondary winding connected in series with said voltage-dividing connection and a primary winding connected in the charging circuit of said storage condenser, said transformer providing a supplemental triggering voltage to cause breakdown of one of said spark gaps whereby the magneto high voltage output is applied to the other spark gap to cause breakdown thereof and a flow of oscillatory current in the discharge circuit, and spark gap means energized by the flow of current in said discharge circuit.

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