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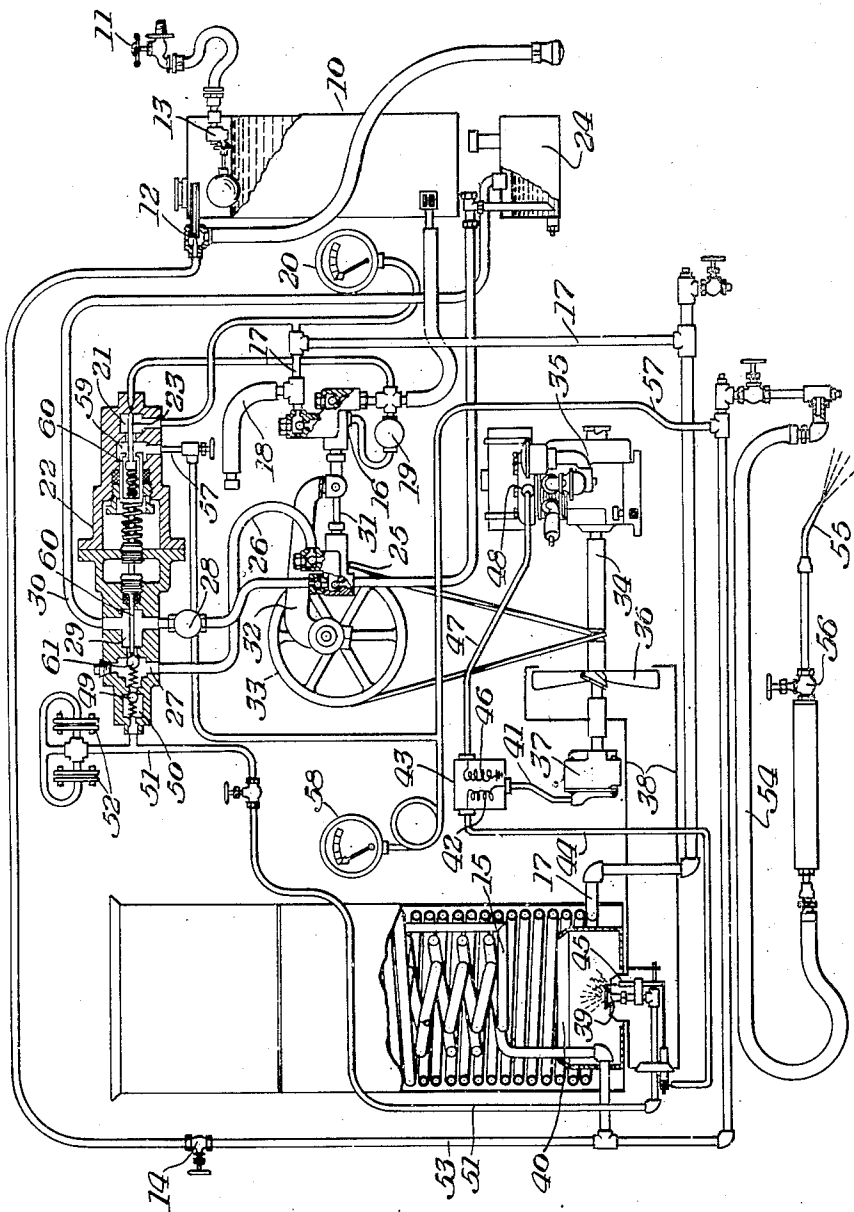
F. W. OFELDT
MULTIPLE SPARK CIRCUIT

2,456,076

Filed Nov. 23, 1943

2 Sheets-Sheet 1

Fig. 1



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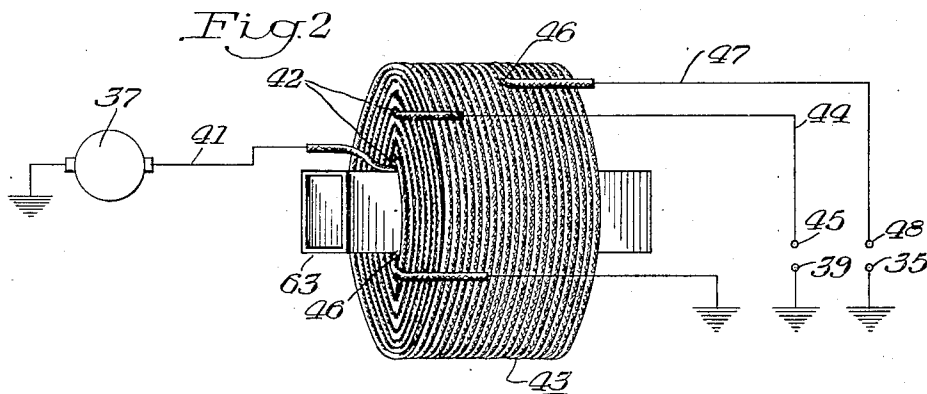
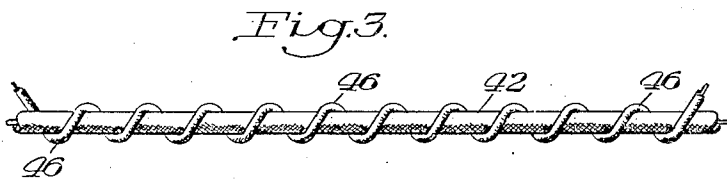
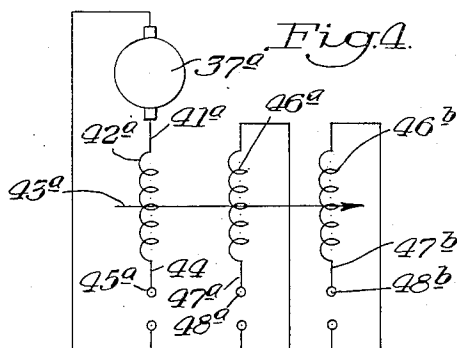
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UNITED STATES PATENT OFFICE

2,456,076

MULTIPLE SPARK CIRCUIT

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Application November 23, 1943, Serial No. 511,421

13 Claims. (Cl. 158—28)

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This invention relates generally to spark circuits and more particularly to a multiple spark circuit which provides an electrical spark for two or more spark plugs which may serve the same or different combustion chambers and which sparks are generated from the same source of power and the operation of one spark is dependent upon the operation of the other spark.

This invention may be advantageously employed for use in multiple ignition of internal combustion engines or to a spray cleaning machine which employs an internal combustion engine and a solution heating chamber. The internal combustion engine of the spray cleaning machine drives a magneto that furnishes a dual spark, one spark for operating the internal combustion engine and the other spark for igniting the fluid fuel that is burned in the heating chamber to heat the liquid spray mixture. The engine is also employed to drive a blower and a pump. The pump supplies a metered amount of the spray liquid and fuel to the combustion zone in the heating chamber where the burning fuel heats the spray liquid converting a portion thereof into vapor to produce a mixture under pressure the characteristics of which mixture are maintained by controlling the supply of liquid and fuel to the heating chamber.

The principal object of this invention is the provision of a multiple spark circuit wherein the operation of one spark is dependent upon the operation of another spark. Thus the failure of a portion of the circuit prevents the other portion of the circuit from operating and producing a hazardous destructive condition. This is particularly true if the internal combustion engine and the heating burner are to employ a highly volatile fuel such as gasoline which is one hundred octane or higher.

Another object is the provision of an electric circuit for producing a multiple spark system.

Another object is the provision of a transformer capable of supplying a multiple spark from a single source of spark generating supply.

Another object is the provision of a high frequency spark transformer.

Another object is the provision of a safety ignition control circuit for a spray apparatus.

The use of multiple spark circuits is not necessarily confined to spray generating apparatus or to dual spark ignition of internal combustion engines but in either of these applications this multiple spark circuit operates to produce a safety control of the apparatus. In the spray generating apparatus it insures the existence of a

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fuel ignition spark before the fuel can be delivered to the combustion chamber. In dual ignition circuits of an internal combustion engine it prevents the firing of one spark plug when the other fails, thereby preventing destructive heat due to delayed burning of the fuel. However this novel multiple spark circuit is applicable for uses where more than two simultaneous sparks are required and the sparks not necessarily associated with ignition.

Other objects and advantages will be apparent from the following description and claims.

In the accompanying drawings a practical embodiment of the spray generating apparatus is shown to illustrate the principles of this invention wherein:

Fig. 1 is a diagrammatic view showing a spray generating apparatus employing the multiple ignition circuit comprising this invention.

Fig. 2 is a perspective view of the transformer winding included in the structure shown in Fig. 1.

Fig. 3 is a view showing the simplest form of impedance coupling for use in the dual spark circuit comprising this invention.

Fig. 4 is a diagrammatic view of a multiple spark circuit having an impedance coupling comprising this invention.

The complete mechanism of the spray cleaning machine is shown schematically in Fig. 1 wherein the water reservoir or solution tank 10 is arranged to be supplied from two sources, the water tap 11 or from a stream or other similar source by means of the steam syphon 12. The machine must be in operation before the latter can function. The supply of water from the tap may be regulated by the float valve 13, whereas the supply of water furnished by the steam syphon is regulated by the valve 14 in the feed line connected to the outlet of the heating coil 15. Proper chemicals may be added to the solution tank and mixed with the water to provide the desired character of spray solution which is determined in accordance with its use.

The solution is withdrawn from the tank 10 by the positive displacement pump 16 which forces it in metered quantities through the feed line 17 to the inlet end of the heating coil 15. A cushion hose 18 is provided to modify the pulsations created by the positive displacement pump. A by-pass line having a valve 19 is provided to determine the delivery pressure of the pump. The adjustment of this valve is the principal factor in determining the saturation of the resulting spray. The valve 19 is therefore calibrated and is known as the saturation selector.

The feed line 17 is also connected to a pressure gauge 20 and to the outer chamber 21 of the master control valve 22 which, in response to high pressure and temperature conditions, opens the valve 23 and permits the solution to by-pass to the inlet of the pump and prevents the passage of liquid to the coil 15. This master control valve is the subject of United States Letters Patent 2,289,674 and 2,307,330.

Fuel is drawn and metered from the fuel tank 24 by the fuel pump 25 and is forced through the supply line 26 to the chamber 27 of the master control valve 22. The fuel pump is also provided with a by-pass line having a valve 28 which determines the delivery pressure of the pump and is also calibrated and is shown as the fuel metering valve. The by-pass line leads to the chamber 29 in the master control valve 22 which is connected by the line 30 which returns the fuel to the tank 24.

The fuel and the solution pumps are mounted with their pump chambers in axial alignment and the opposite ends of the piston 31 work in the chambers of the respective pumps, thus providing a duplex pump. An offset connecting rod 32 is secured at one end to the piston 31 through a ball and socket joint and its other end is connected to a crank pin on the pulley 33 which is driven by a belt from the shaft 34. The shaft 34 is directly connected to the shaft of the spark controlled motor, which in this instance is an internal combustion engine 35. This spark controlled motor drives the pumps, the fan or blower 36 and the spark generator, which in this instance is the magneto 37. The fan 36 is positioned within the duct 38 that conveys air to the burner 39 in the combustion chamber 40.

One side of the spark generator or magneto 37 is grounded and the other side is connected by the wire 41 to one end of the primary winding 42 of the transformer 43. The other end of the primary is connected by the wire 44 to the spark plug 45 adjacent the burner 39 in the combustion chamber 40. The secondary winding 46 of the transformer 43 is grounded at one end and the other end is connected through the wire 47 to the spark plug 48 of the internal combustion engine 35.

The magneto 37, being connected directly to the shaft 34 of the internal combustion engine, may be adjusted to induce a spark at the proper time to fire the spark plug 48 and thus operate the engine and at the same time produce a spark between the spark plug 45 and the burner 39 for igniting or maintaining the ignition of the fuel issuing from the burner. Other spark generators such as a spark coil may be used in place of the magneto.

When the fuel, discharged from the fuel pump 25 passes through the line 26 to the chamber 27 in the master control valve 22, reaches a predetermined pressure it will overcome the pressure of the spring biased check valve 49 and flow into the chamber 50 in the master valve 22 and thence travel through the feed line 51 to the burner 39 in the combustion chamber 40. A double diaphragm cushion 52 is connected to the fuel feed line 51 to smooth out the pulsations created by the positive displacement pump in a manner similar to that of the cushion hose 18 connected to the solution feed line 17. However the hose cushion 18 does not completely eliminate the pulsations created by the positive displacement solution pump 16.

The solution mixture of liquid and vapor of the liquid at the outlet end of the heating coil 15

is conveyed through the line 53 to the hose 54 and passes out the nozzle 55 where it flashes, forming a fine spray. The discharge of the spray mixture is controlled by the valve 56, the opening of which determines the pressure and temperature at which the machine is operated. A branch line 57 is connected to the discharge line 53 and is provided with an outlet pressure gauge 58 and terminates in the chamber 59 of the master control valve 22, which chamber is adjacent to the chamber 21. The pulsations due to the positive displacement solution pump 16 are transmitted from the pipe line 17 to the chamber 21 and travel past the by-pass valve 23 into the outlet pressure chamber 59 where they are effective on the plunger 60 to oscillate the plunger at a small magnitude in phase with the pulsations of the liquid. This eliminates the static gland pressure on the plunger 60 and makes is sensitive to movement due to slight pressure changes in the outlet line 53. Movement of the plunger 60 in response to these pressure changes thus regulates the operation of the by-pass fuel valve 61 at the other end of the plunger and thus controls the amount of fuel delivered to the burner 39, thereby controlling the mixture and the pressure of the spray solution discharging from the spray nozzle 55. If the valve 56 is shut off the pressure in the chamber 59 moves the plunger 60 further to the left, causing it to pick up the solution by-pass valve 23. Thus the output of both the solution and fuel pumps is completely by-passed.

The coils of the transformer 43 are shown in Fig. 2 and comprise the primary winding 42, which is nine feet in length, and the secondary winding 46, which is seventeen feet in length. These windings are wrapped around a $\frac{5}{8}$ " square spool 53 of insulating material, such as a hollow paper tube. The wire in both the primary and secondary windings is preferably made of insulated high tension spark plug wire approximately $9/32$ " in diameter. Both windings are started at the same time on the spool and wound in the same direction. The secondary winding 46 being the longer of the two naturally covers the primary winding. It is preferable to make the coil $1\frac{1}{4}$ " wide, which with the given length of the windings produce a single coil approximately $2\frac{1}{4}$ " in diameter. This coil of insulated wire is then impregnated and placed in a small steel box provided with three insulators for the passage of the lead wires to both ends of the primary winding and one end of the secondary winding. The other end of the secondary winding is soldered to the steel box which when mounted on the machine provides the ground return.

The box containing the transformer coil is filled with pitch to hold the coil in position and prevent a short between the windings due to corona action.

This air core transformer has been found to be very efficient as the sum of the maximum distances across the two spark gaps in the spark plugs 45 and 48 is equal to the maximum distance across a single spark gap energized by the same magneto. The total spark gap measurement is the determining factor. Assuming that the largest gap across which the magneto will send a spark is three-fourths of an inch, then the gaps of the spark plugs 45 and 48 may be any reasonable fraction thereof provided that the distance of the sum of both gaps does not exceed three-fourths of an inch. If the distance of the two gaps are less than the maximum permissible gap the spark across these gaps will have a higher

current capacity. Thus the desired spark conditions may be obtained by adjusting these gaps.

Ordinarily the potential impulse is generated in the secondary or field of the magneto instantaneously upon the occurrence of the break or change in the primary magneto circuit. This abrupt potential charge is instantaneous or of such high frequency that it induces an electrical charge in the secondary transformer winding 46 and both sparks are discharged substantially simultaneously, although it is believed that there may be a slight lag in the spark energized from the secondary winding 46 but for all practical purposes both sparks are substantially in phase and may be made to have the same characteristics. The impedance of the transformer is critical which is borne out by the fact that different dimensions of the coil and positions of the windings materially reduce its efficiency. Spiral pancake windings were found to be inefficient.

The high frequency of the potential charge generated in the secondary of the magneto suggests the use of a condenser in place of the transformer, in which case the magneto is connected directly to one spark plug and to one side of the condenser and the other side of the condenser is connected to the other spark plug. By comparison, the capacitance of the transformer windings is thus believed to be essential in obtaining the proper impedance for this type of circuit. However the use of a condenser for this purpose is not satisfactory because the engine will continue to operate even through the condenser is shorted, whereas the transformer provides a number of desirable safety features which are important to this invention.

The ignition of the internal combustion engine will cease, causing the engine and the fuel pump to stop if the burner ignition fails for any of the following causes: failure of the magneto, weak ignition spark, an open or short circuit in the transformer, a short circuit of the wiring or either spark plug, an open circuit in the wiring or if either of the spark gaps are too wide, or if the electrode of the burner spark plug becomes carbonized. The use of a transformer in this dual spark circuit thus protects the apparatus against these conditions which might otherwise create a hazardous or destructive condition if the fuel employed is a high octane gasoline and was permitted to accumulate creating an explosive mixture. Since the engine and the pumps cannot be started until perfect burner ignition is insured, there is no possibility of the fuel being discharged before the burner spark is produced to ignite it so that it burns at the proper time and under proper conditions.

This dual ignition circuit will function if the transformer is constructed by laying ordinary drop cord consisting of two conductors twelve feet long forming the windings side by side along the floor, or as indicated in Fig. 3. The primary conductor in the case of Fig. 3 is substantially one-half the length of the secondary conductor which is wrapped around the primary conductor. Although these types of transformers function they are not as efficient as the coil and they are not practical for use with the cleaning machine disclosed herein but may be suitable for other applications. Again an open impedance coupling of this character or a coil type transformer is not protected against corona action which is apt to develop a short circuit, causing a failure that could otherwise be avoided. It has also been determined that a coil containing the primary and secondary windings should be relatively short in

length and large in diameter and the dimensions previously given will operate satisfactorily in the particular installation described.

The transformer 43 which produces the multiple spark circuit was found to function properly when magnetos of different capacity were employed to generate the spark. The Fairbanks Morse magneto models "FMJ" and "FMO" have each been equally successful when used with the aforementioned transformer. However the "O" model is of larger capacity than the "J" model. These magnetos are believed to be of the permanent magnet type and one side of the secondary is internally grounded, which readily adapts this type of magneto for use with the spray generating apparatus, whereas the opposite electrodes of the respective spark gaps are also grounded to the frame of the machine. However a spark coil may be substituted as a spark generator in place of the magneto and the secondary circuits may be independent as indicated in Fig. 4.

It is believed that the impedance of the transformer should be selected in accordance with the number and nature of the spark gaps to be supplied whether there are two or more and the impedance coupling apparently does not have to be adjusted relative to the spark generator. But the windings forming the transformer impedance coupling 43 as shown in Fig. 2 must be connected to the circuit in a specific manner or the spark circuits will not function as efficiently. The conductors forming the primary 42 and secondary 46 are wound together in the same direction on the square paper core 63 with as many turns of the two wires as possible in the initial part of the winding. The end of the primary winding 42 which is adjacent the core 63 should be connected by the wire 41 to the spark generator 37 and the end of the secondary winding 46 adjacent the core should be connected to ground. The other ends of the primary and secondary windings should be connected by the wires 44 and 47 to the electrodes 45 and 48 respectively to get the best results. If the generator connection is switched to the other end of the primary winding without changing the secondary connections a spark will not be generated, but if the secondary connections are also switched the spark generated is feeble. It is believed that the instantaneous charge must surge through as many turns of the primary as possible to create the magnetic field before the surge begins to die out in order to produce the proper coupling that induces the proper current in the secondary and provides an efficient spark circuit. When the generator is connected to the outer end of the primary, the electric charge does not have the opportunity to develop as high an E. M. F. for the same ampere turns because of the overlapping secondary. This peculiar condition also explains why a two conductor length of drop cord or a single primary conductor with the secondary conductor wrapped therearound as shown in Fig. 3 will work when the changing of the connections to the transformer produces an inefficient result.

The diagrammatic view of Fig. 4 illustrates an impedance coupling transformer 43a connected in a spark circuit whereas the primary and each of the secondary circuits are wired independently of one another, thus eliminating the common ground return. The spark generator 37a is thus in series with the primary coil 42a and the spark gap 45a whereas the secondary windings 46a and 48b are each connected across their respective spark gaps 48a and 48b.

I claim:

1. In an electrical circuit, the combination of a high voltage source, a primary conductor and at least one secondary conductor, a like number of pairs of spaced electrodes as there are primary and secondary conductors forming spark gaps, electrical connections placing the high voltage source and the primary conductor and the electrodes of one of the spark gaps in a closed series circuit, and electrical connections placing the ends of each secondary conductor across the other electrodes of a respective spark gap, the conductors being proportioned and arranged relative to each other to form a coupling that will deenergize the sparks across all of the gaps if the spark of one gap fails.

2. The structure of the claim 1 characterized in that the primary conductor is nine feet long and approximately half the length of the secondary conductor.

3. The structure of claim 1 characterized in that the primary and secondary conductors of the impedance coupling are made up of insulated wire consisting of nine feet in the primary and seventeen feet in the secondary which are wound together in the same direction in the form of a coil.

4. The structure of claim 1 characterized in that the primary and secondary conductors of the coupling are made up of insulated wires initially wound together in the same direction in the form of a coil with nine turns in the primary and seventeen turns in the secondary.

5. The structure of claim 1 characterized in that the primary and secondary conductors of the coupling are made up of insulated wires consisting of nine feet in the primary and seventeen feet in the secondary which are wound together in the same direction in the form of a coil having an axial dimension of approximately one and one quarter inches.

6. The structure of claim 1 characterized in that the primary and secondary conductors of the coupling are made up of insulated wires consisting of nine feet in the primary and seventeen feet in the secondary which are wound together in the same direction in the form of a coil the diameter of which is substantially twice its axial dimension.

7. The structure of claim 1 characterized in that the primary and secondary conductors of the coupling are made up of insulated wires consisting of nine feet in the primary and seventeen feet in the secondary which are wound together in the same direction in the form of a coil having an axial dimension of approximately one and one quarter inches and impregnated with a material such as pitch.

8. The structure of claim 1 characterized in that the electrode of the spark gap in the primary series circuit remote of the primary winding is electrically connected to a selected electrode of each of the other spark gaps.

9. In an electrical circuit the combination of a high frequency electric source having a supply and return circuit connection, a coupling having an insulated primary conductor nine feet long and at least one insulated secondary conductor seventeen feet long placed in effective inductive relation with each other for their full lengths, a like number of pairs of spaced electrodes as there are primary and secondary conductors forming spark gaps, electrical connections placing the source of supply and the primary conductor and the electrodes of one spark gap and the return

to the source of supply in a closed series circuit, and additional electrical connections placing the ends of each secondary conductor across the other electrodes of a respective spark gap, the summation of the gaps between the electrodes of the spark gaps in the primary and secondary conductor circuits being not greater than a maximum single gap across which the source of supply is capable of sending a spark.

10. In a burner control circuit the combination of a burner, means for supplying fuel to the burner, spaced electrodes to provide a spark for igniting the fuel in the burner, a spark controlled motor for operating said fuel supply means, a second pair of spaced electrodes to provide a spark arranged to control the operation of said motor, a high voltage electric source controlled by the operation of the motor, a coupling having primary and secondary windings, electrical connections placing the high voltage electric source and the primary winding and the fuel igniting electrode in a closed series circuit, and electrical connections placing the ends of the secondary winding across the second pair of electrodes to control the operation of the motor.

11. The structure of claim 10 characterized in that one of the electrical connections in each of the primary and secondary circuits is made through a common ground.

12. In an electrical circuit, the combination of a high voltage source, a primary conductor and at least one secondary conductor, a like number of pairs of spaced electrodes as there are primary and secondary conductors forming spark gaps, an independent means controlled by each spark gap, electrical connections placing the high voltage source and the primary conductor and the electrodes of one of the spark gaps in a closed series circuit, and electrical connections placing the ends of each secondary conductor across the other electrodes of a respective spark gap, the conductors being proportioned and arranged relative to each other to form a coupling that will deenergize the sparks across all of the gaps if the spark of one gap fails, causing each of said means to cease functioning.

13. In an electrical circuit the combination of a plurality of pairs of spaced electrodes forming spark gaps, a high voltage source having one side connected to one electrode of a pair, a primary conductor electrically connected between the other electrode of said pair and the other side of the high voltage source to form an electrical circuit, and independent secondary conductors connected across a like number of the remaining pairs of electrodes as there are secondary conductors, said secondary conductors being proportioned and disposed with respect to the primary conductor to form a coupling that is effective to deenergize the sparks across all of the gaps if the spark across one gap fails.

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