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SPARK PRODUCING APPARATUS AND ADAPTORS THEREFOR

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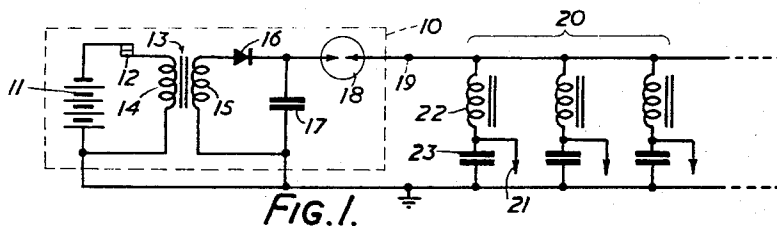
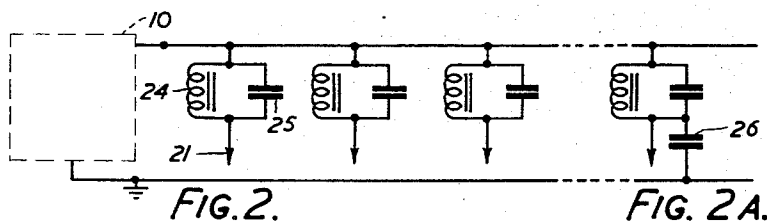


FIG. 2A.

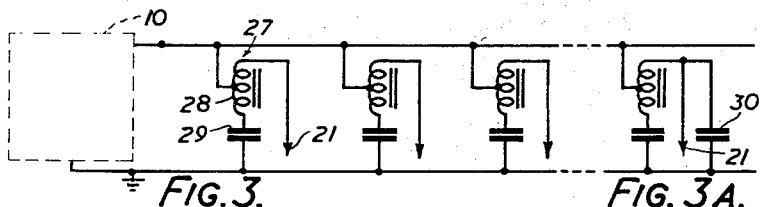


FIG. 3A.

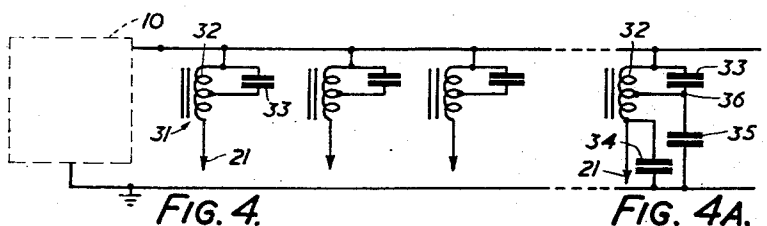


FIG. 4A.

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This invention relates to spark producing apparatus, and adaptors therefor, for use more particularly, but not exclusively, with sparking plugs of the "surface leakage" type. Surface leakage plugs are used for various purposes, such as ignition in gas turbine engines and rotor tip jet combustion chambers in helicopters. In such plugs the electrodes are bridged by a surface of a semiconductor material. Such sparking plugs may be fired by connecting a charged condenser (herein termed the main condenser) across the electrodes, an initial small discharge through leakage paths in the semiconductor surface serving to ionise the gas in the vicinity of the semiconductor and so create an ionised path through the gas between the electrodes through which path the remainder of the main condenser charge passes in the form of a spark. The main condenser of the spark producing apparatus is usually charged substantially continuously by a simple direct current system, conveniently from an intermittent or alternating current supply through a step-up transformer and a rectifier, and is usually connected to the sparking plug, when it has been charged to a voltage of the order of 2 kv., through a series spark gap designed to break down at this voltage.

It has not hitherto been practicable to spark more than one plug from one such spark producing apparatus since if two or more plugs are connected in parallel to the main condenser a spark will occur only at the plug which ionises first. It is not possible to distribute spark energy from the main condenser to two or more sparking plugs through a simple jump-spark distributor because the voltage is too low to provide reliable ionization.

It is an object of the present invention to provide a spark producing apparatus which can supply two or more sparking plugs and which does not employ a distributor.

According to one form of the present invention, spark producing apparatus comprises a main condenser, a charging system for the main condenser, and means for connecting the main condenser, when charged, to at least two parallel connected branches each including a sparking plug, each of the said branches having capacitance and inductance which form a low loss time delay circuit which is connected to the plug and the delay period of which is of the same order of time as the time required to ionise the slowest of the various plugs which are connected to the spark generator.

Plugs which, by reason of excessive wear or other defect, take an unreasonable time to ionise, should not be used.

The time delay circuits are essentially oscillatory circuits which act as low loss wave traps which delay the transmission of an applied impulse for a fraction of the oscillatory cycle. The duration of the oscillating cycle of these circuits should therefore be such that the delay they provide is sufficient to give all of the plugs a reasonable time to ionise.

Low loss is an essential requirement since any resistance in the circuit not only decreases the efficiency of

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the circuit but also reduces the energy of the subsequent discharge. This requirement is met by providing an inductive winding of low impedance wound on a core of low loss, high permeability material. High permeability enables the desired high inductance to be achieved with a winding of relatively few turns and consequently of low resistance. Low eddy current loss is necessary because of the high rate of change of current through the winding. Suitable materials for the core are those commonly used in high frequency circuits of various kinds where high permeability and low eddy current loss are important, for instance compressed powdered iron or a magnetic ferrite such as "ferroxcube."

In one form of the invention each branch comprises an inductive winding and a condenser connected in series, the sparking plug of this branch being connected to the junction between the said condenser and the inductance in parallel with this condenser. It is known that in an oscillatory system consisting of inductance and capacitance in series, the voltage across either member can greatly exceed the applied voltage, and this feature is taken advantage of in the above arrangement to increase the ionising voltage on the plugs.

In another form of the invention the inductive winding and the condenser in each branch are connected in parallel. In this case the parallel-connected oscillatory system is connected between the output terminal of the spark generator and the plug. Additional capacity may be provided by connecting a condenser in parallel with the plug.

In another form of the invention the inductance in each branch consists of an auto-transformer the primary winding of which is connected in series with a condenser and the secondary winding of which is connected in series with the plug, the said condenser being in parallel with the plug.

In a further form of the invention in which the inductance in each branch consists of an auto-transformer the primary winding of which is connected in parallel with a condenser and the secondary winding of which is connected in series with the plug.

Both circuits using auto-transformers may be tuned to resonance by the addition of extra capacitance, for instance by connecting an additional condenser in parallel with the plug or, in the last mentioned circuit using an auto-transformer, between the intermediate connection of the auto-transformer and earth.

If shielded plug leads are used their natural capacity may in some cases provide sufficient additional capacitance to replace some of the condensers referred to.

Circuits in which a voltage step-up across the plugs is achieved, namely circuits having inductance and capacitance in series and circuits employing auto-transformers, can be arranged to provide sufficient output voltage to operate open gap plugs as well as surface leakage plugs.

The inductive windings in the several branches are wound on separate cores so that the branches are inductively independent of each other.

Since the spark producing apparatus of the present invention involves only additions to the known types of spark producing apparatus designed for individual surface leakage plugs, these additions can conveniently take the form of an adaptor designed for use with a suitable existing form of spark producing apparatus.

The invention may be performed in various ways and several specific embodiments will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows an ignition system in which in each branch leading to a sparking plug there is inductance in series with the plug and capacitance in parallel with the plug.

Figure 2 shows an ignition system in which inductance and capacitance connected in parallel are provided in each branch.

Figure 2A shows a modification of the system of Figure 2 with additional capacitance connected in parallel with the plug.

Figure 3 shows an ignition system in which the inductance in each branch is in the form of an autotransformer, and the capacitance is in series with the primary winding of the auto-transformer.

Figure 3A is a modification of the system of Figure 3 with additional capacitance connected in parallel with the plug.

Figure 4 shows an ignition system in which capacitance is connected in parallel with the primary winding of an auto-transformer in each branch.

Figure 4A shows a modification of the system of Figure 4 with additional capacitance connected in parallel with the plug and additional capacitance connected across part of the auto-transformer and the plug.

In the ignition system shown in Figure 1 there is a conventional charging circuit 10 consisting of a source of direct current 11, a contact-breaker 12 and a voltage step up transformer 13 the primary winding 14 of which is intermittently connected across the source of direct current 11, i.e. whenever the contacts of the contact-breaker 12 are closed. The transformer secondary winding 15 is connected through a rectifier 16 to a main storage condenser 17. The condenser 17 is connected through a spark gap 18 to the output terminal 19 of the charging circuit.

Although the values of the charging circuit may vary considerably depending on requirements, in one particular embodiment the source of direct current 11 has a voltage of 24 volts and the step-up ratio of the transformer 13 is 15 to 1, the actual surge voltage applied to the primary winding when the contact breaker opens being 200 to 300 volts. The capacity of the condenser 17 is 6 microfarads and the breakdown value of the spark gap 18 is 2000 volts.

The operation of the charging circuit 10 is as follows. At each break of the contact-breaker 12 an energy impulse passes from the transformer 13 to the condenser 10 which is thus progressively charged. When the charge of the condenser attains the break-down value of the gap 18, this gap breaks down and becomes conductive whereupon the stored energy in the condenser 17 can pass through this conductive gap and the terminal 19 to an external circuit 20.

The external circuit consists of a number of parallel connected branches each containing a sparking plug 21.

In each branch there is an inductive winding 22 connected in series with the sparking plug, while a condenser 23 is connected in parallel with the sparking plug.

The values of the components in the branches in this and other embodiments to be described can be varied considerably, but in one particular instance the inductive winding 22 consists of 15 turns of copper wire of 1.2 millimetres diameter wound on a core of a magnetic ferrite of 0.25 square inch cross-sectional area. The capacity of the condenser 23 is 0.05 microfarad. The characteristic of the oscillatory system comprising the series-connected inductive winding 22 and the condenser 23 in each branch is such that it acts as a low loss wave trap which delays the transmission of the energy pulse from the main condenser 17 to the plug 21 in the respective branch upon break-down of the spark gap 18, for a period sufficient to permit all the sparking plugs in the external circuit 30 to ionise, whereby the energy from the main condenser 17 will discharge through, and create a spark at each of the sparking plugs 21. Moreover in the said series-connected oscillatory system the voltage across either of the two components 22 or 23 of this system will greatly exceed the applied voltage, whereby the ionising voltage of each plug 21 is increased.

In the arrangement shown in Figure 2 there is an identical charging circuit 10, and in each branch of the external circuit an inductive winding 24 is connected in parallel with a condenser 25. This parallel-connected oscillatory system is connected directly in the plug lead of the branch. If desired, as shown in Figure 2A, additional capacitance can be provided by connecting a condenser 26 between the said parallel connected oscillatory system and earth.

In the arrangement shown in Figure 3, the inductance in each branch of the external circuit is in the form of an autotransformer 27, the secondary winding of which is connected to the sparking plug 21. A condenser 29 is connected in series with the primary winding 28. In a modification as shown in Figure 3A, an additional condenser 30 is connected in parallel with the plug 21.

Figure 4 shows another embodiment in which the inductance is in the form of an auto-transformer 31. In this case the primary winding 32 is connected in parallel with a condenser 33.

In a modification shown in Figure 4A an additional condenser 34 is connected across the plug 21 and a further additional condenser 35 is connected between the junction 36 (between the auto-transformer primary winding 32 and the condenser 33) and earth.

If shielded plug leads are used their natural capacity may in some cases be such that these leads themselves constitute the equivalent of the additional condensers 26 of Figure 2A or 30 of Figure 3A or 34 of Figure 4A.

In the embodiment illustrated in Figure 2 the voltage applied to the sparking plug 21 will in general only be sufficient to fire a sparking plug of the surface leakage type. In the other embodiments, however, in which there is either an inductance and capacitance in series in each branch as in the case of Figure 1, or in which an auto-transformer is provided as in Figures 3 and 4, the increased voltage thereby obtainable at the plug may be sufficient to enable a sparking plug of the air gap type to be used.

In all the embodiments described the degree of isolation achieved between the branches is such that a plug can be short-circuited without cutting out the sparks at the remaining plugs.

In the embodiments described the inductive windings in the several branches are wound on separate cores.

Since the external circuits of the spark-producing apparatus of the present invention, i.e. the external circuit 20 in Figure 1 and the corresponding external circuits in the remaining figures involved can be applied to known types of spark-producing apparatus 10 designed for use with individual surface leakage plugs, the components of each such external circuit can conveniently be incorporated in an adapter designed for connection to suitable existing forms of spark-producing apparatus such as the circuit 10.

What I claim as my invention and desire to secure by Letters Patent is:

1. Spark producing apparatus comprising a main condenser, means for charging said main condenser, at least two parallel-connected branches reactively isolated from each other, a sparking plug in each said branch, means providing capacitance and means providing inductance in each of said branches, said capacitance-providing means and inductance-providing means constituting a low-loss time delay circuit connected to the sparking plug in the respective branch and having a delay period of the same order of time as the time required to ionise the slowest of the said sparking plugs, and means for simultaneously connecting said main condenser when charged to all said parallel-connected branches.

2. Spark producing apparatus according to claim 1, in which said means for connecting said main condenser to said branches comprises a spark gap.

3. Apparatus according to claim 1, in which said inductance-providing means in each said branch consists

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of an inductive winding of low impedance and a core of low-loss, high-permeability material on which said inductive winding is wound.

4. Apparatus according to claim 3, in which said capacitance-providing means comprises a condenser, and said inductive winding and said condenser are connected in series in the respective branch, and said branch includes a conductor connecting the sparking plug thereof to a point intermediate between said condenser and said inductive winding in parallel with said condenser.

5. Apparatus according to claim 3, in which said capacitance-providing means comprises a condenser connected in parallel with said inductive winding in the respective branch.

6. Apparatus according to claim 1, in which said inductance-providing means of each said branch consists of an auto-transformer having a primary winding and a secondary winding, and said capacitance-providing means comprises a condenser, and which includes means connecting the sparking plug of said branch in series with said secondary winding and means connecting said condenser in series with said primary winding in parallel with said plug.

7. Apparatus according to claim 6 including an auxiliary condenser in each branch and means connecting said auxiliary condenser in parallel with the sparking plug of the respective branch.

8. Apparatus according to claim 1, in which said inductance-providing means comprises an auto-transformer having a primary winding and a secondary winding, and said capacitance-providing means comprises a condenser,

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and which includes means connecting said secondary winding of said auto-transformer in series with the sparking plug of the respective branch, and means connecting said condenser in parallel with said primary winding.

9. Apparatus according to claim 8 including an auxiliary condenser in each branch and means connecting said auxiliary condenser in parallel with the sparking plug of the respective branch.

10. An adapter for use in connection with spark producing apparatus and a plurality of sparking plugs, said spark producing apparatus comprising a main condenser, a charging system for said main condenser, and means for connecting said main condenser when charged to the adapter, and said adapter comprising at least two parallel-connected branches each adapted for connection to a separate sparking plug, each of said branches being reactively isolated from each other and including means providing capacitance and means providing inductance, said capacitance-providing means and said inductance-providing means constituting a low-loss time delay circuit having a delay period of the same order of time as the time required to ionise the slowest of said sparking plugs.

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