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RESONANT SPARK PLUG

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Fig. 1.

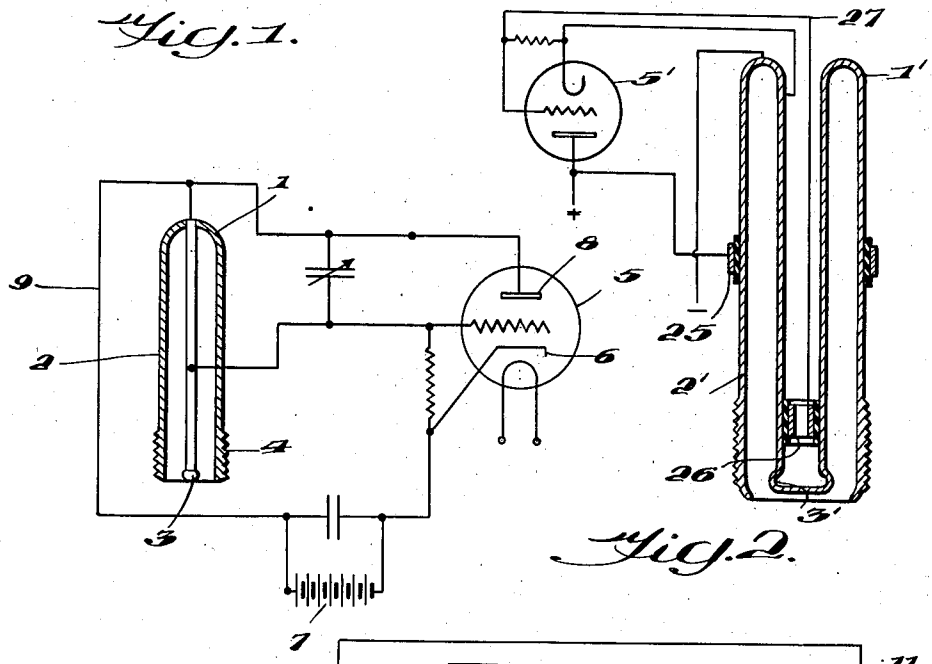
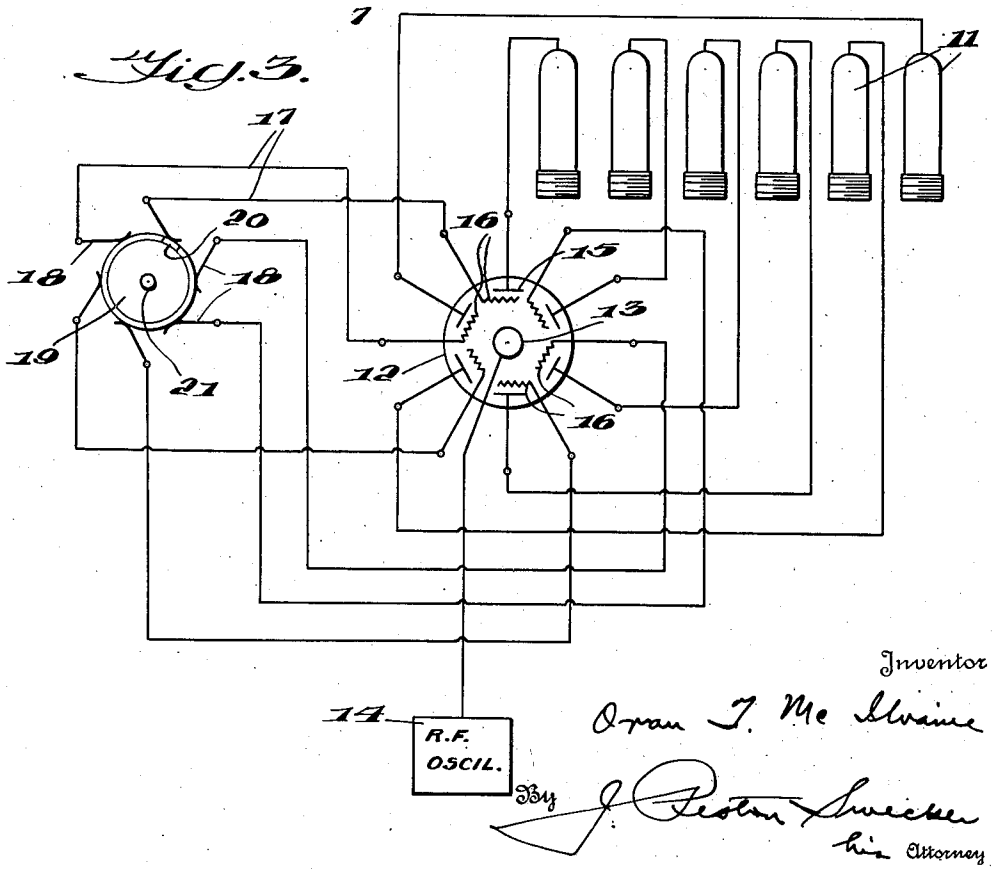


Fig. 2.

Fig. 3.



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RESONANT SPARK PLUG

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19 Claims. (Cl. 315—209)

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This invention relates to improvements in spark plugs, particularly such as may be operated at abnormal atmospheric conditions, as for instance, in airplanes used at high altitudes.

Spark plugs, such as have been used for a long time in all types of engines, including airplanes, have been constructed of a metallic casing with an electrode therein separated from the casing by an insulator usually of porcelain. When such spark plugs are used at high altitudes, such as in an airplane operated in the stratosphere, it is impractical and has been unsatisfactory in use for various reasons. When the airplane travels at high speed from the warm air at the surface of the earth into the subzero air at high elevations above the surface of the earth, this sudden change of temperature causes the porcelain insulators to crack, and become ineffective for insulating the parts of the spark plug which has been necessary in the conventional ignition system to produce ignition in the cylinders of the engine. Furthermore, the partial vacuum in which the airplane engine operates at high elevation causes short circuit readily of the distributor and motor. Other difficulties are encountered in such conditions, such as fouling of the plug due to the tendency for the collection of carbon and oil thereon, etc.

The object of this invention is to improve the construction of the spark plug, as well as the ignition system, to eliminate these difficulties, to enable the spark plugs to function practically and efficiently, even at high altitudes, to produce uniform sparking operation under different atmospheric conditions, while enabling the spark plug to be manufactured practically and inexpensively.

This object is accomplished by constructing the spark plug of all metal or other conducting material, without any insulator between the shell and the center contact of the plug but providing for the connection of these together in unitary relation and in contact with each other. The plug should be constructed of a fraction of a wave length, as for instance, one-fourth or one-half wave length, and is capable of developing a great amount of voltage across the plug when made in this way.

The plug is operated from a source of high frequency current, such as an electronic tube circuit, which may have provision for varying the supply of current thereto sufficiently to produce a discharge across the plug, whereby to ignite the fuel mixture in the engine cylinder.

I have shown examples of this invention in the accompanying drawings in which:

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Fig. 1 is a diagrammatic view of an ignition system, illustrating one embodiment of my invention;

Fig. 2 is a similar view showing another embodiment thereof; and

Fig. 3 is a diagrammatic view of an electronic distributing system for spark plugs.

Referring to Fig. 1, the spark plug is designated generally by the numeral 1, and is shown as constructed of a shell 2, provided with a center electrode 3. The shell 2 is of tubular form with a closed outer end and has the center electrode 3 extending concentrically thereof, in the form illustrated, to the open inner end of the shell where a gap is provided therebetween. The periphery of the shell 2 is shown as provided with screw threads 4, as a means of detachably connecting the spark plug with the cylinder or other chamber in which ignition may be desired. In this form, the plug may be screwed into the cylinder at this point, so that the gap at the open end of the plug is in open communication with the combustion chamber of the cylinder.

The center electrode 3 is rigidly fastened at its outer end to the closed end of the shell 2, and may be formed integrally therewith, as shown at 3' in Fig. 2. Both of these are preferably constructed of metal or other suitable electrically conducting material, directly in contact or integral, and not insulated from each other. Such insulation as ordinarily required heretofore is not necessary nor desirable, according to this invention.

The length of the spark plug 1, or 1' in Fig. 2, should be made a fraction of a wave length, such as one-fourth or one-half. The overall size of the plug may be comparable with that of an ordinary spark plug such as used heretofore. For instance, if the plug 1 or 1' is made of a length of ten centimeters, the wave length would be 20 centimeters, 40 centimeters or 80 centimeters, or some other harmonic or consonance thereof, whereby the plug would be in resonance with the small inductance of the short rod forming the center electrode 3 or 3'. The wave length may be changed to tune the plug to the desired frequency for efficient operation.

A radio frequency voltage is developed by the plug at the open end thereof, for which purpose I employ preferably an electronic tube 5, shown in Fig. 1 as a thermionic tube, having an indirectly heated cathode 6 connected to one side of a source of electrical supply, such as a battery 7, while the anode 8 of said tube is connected with the shell 2. The opposite side of the battery 7 is connected also with the shell 2, through a circuit 9, where-

by a series circuit is formed including the anode and cathode of the tube, and the source of electrical supply, and connected in parallel with the shell 2 of the plug 1.

When the tube 5 is energized, the radio frequency oscillation develops a voltage discharge at the open end of the tube around the electrode 3 which continues to be maintained so long as the tube is energized. This may be varied by controlling the supply of current to the tube, thereby varying the energizing thereof, and likewise the oscillation produced at the plug. This makes it possible to produce a great amount of voltage at the open end of the plug which gives a much hotter spark than has been possible heretofore with ordinary spark plugs, thereby increasing the efficiency of the engine.

At the same time, the plug operates efficiently, regardless of the surrounding atmospheric conditions, even when used at high altitudes. There is no insulation to crack and destroy the operative effect of the plug at low temperatures, nor possibility of short circuit. It is unnecessary to provide shields frequently required heretofore. At the same time the plug may be manufactured at low cost and much more efficiently than has been known in the prior art.

The form of the invention shown in Fig. 2 is substantially the same as that described above with respect to Fig. 1, except as indicated, that the electrode 3' is formed in one integral piece with the shell 2' of the tube. In this form also, a radio frequency discharge is produced by an electronic discharge tube 5', the cathode of which, either directly or indirectly heated, is connected with the electrode 3' at or adjacent its juncture with the shell 2', while the shell is connected with one side of a source of electrical supply, the opposite side of which is connected with the anode of the tube.

The anode is connected also with a metal ring 25 which surrounds the shell 2' and is insulated therefrom. A ring 26 also surrounds the inside of the tubular electrode 3' insulated therefrom, as by a mica sheet, which ring 26 is connected through a line 27 with the grid of the tube 5'. The rings 25 and 26 form plate condensers in the anode and grid circuits of the tube, being effectively insulated by mica or other insulation from the metal parts of the tube. By shifting these lengthwise of the shell and electrode, or by varying the thickness of the insulation or with the width of the rings, the plug is tuned to different frequencies. These condenser rings can be shifted also to get the proper node on the plug.

This form functions in the manner generally described above in connection with Fig. 1, being an alternative form of plug which nevertheless achieves the result described. As shown in Figs. 1 and 2, the center rod can be either solid or hollow, the latter permitting the connection to be made without passing into the cylinder chamber. However, a solid rod can be used satisfactorily and a current induced into it at resonance by a coil around the plug.

In using such a plug in a distributing system, the several plugs can be fired by means of a conventional distributing system which will provide for breaking the voltage lead to the tube, if a tube is used for each plug, or a common high frequency generator can be used, and this in turn distributed to each plug through a coaxial cable.

Another form of distributing system is shown in Fig. 3 which can be used with this form of spark plug as described above, or may be used, if desired, for firing conventional spark plugs, by distributing the voltage to the respective plug through the system, which plugs are in turn grounded in the usual way.

The invention is shown in Fig. 3 for operating a plurality of spark plugs, designated at 11. In the usual engine, the multiple cylinders thereof will require a plurality of spark plugs for operation. To provide for the proper discharge of high frequency current at the respective plugs, these may be connected in circuits to a multiple-element electronic discharge tube, as indicated in Fig. 3.

The tube is designated generally at 12, having a cathode 13 connected with the output of a radio frequency oscillator 14, provided with a source of electrical supply. The cathode 13 is common to a plurality of anodes 15, one for each plug 11, and connected to the center electrode thereof through an electric wire. Coaxial cables may be used for the leads to the plugs. Interposed between the cathode 13 and each anode 15 is a grid 16. The grids 16 are connected through wires 17 with brushes 18. The brushes 18 bear upon a rotary distributor member 19, carrying a contact 20 in position to engage the brushes successively. The rotor 19 is mounted on a shaft 21 geared to the drive shaft of the engine, and is electrically connected with the contact 20.

During the rotation of the shaft 21, the engagement of the contact 20 with a brush 18 will cause the corresponding grid to become grounded and thus short-circuited. This will cause an electronic discharge between the cathode 13 and the corresponding anode 15, which will then close the circuit to the corresponding plug 11, causing a high frequency discharge at the open end of the plug. This will continue successively for the respective plugs, which may be connected in any desired order for firing. Likewise, any desired number of plugs may be connected for operation in this manner.

I claim:

1. An all metal spark plug comprising an outer and an inner tubular electrode, each electrode being open at one end and closed at the opposite end, the closed end of the inner electrode being associated with the open end of the outer electrode for a disruptive high frequency discharge.

2. An all metal spark plug comprising an outer and inner tubular electrode, each electrode having an open and a closed end, the closed end of the outer electrode being in positive electrical contact with the open end of the inner electrode, said electrodes being spaced apart throughout the remainder of the plug and being adapted for a disruptive high frequency discharge at the open end of the outer tubular electrode.

3. An all metal spark plug comprising an outer and inner tubular electrode formed integral with each other and each having an open and a closed end, the closed end of the outer tubular electrode being formed integral with the open end of the inner tubular electrode, said electrodes being spaced apart throughout the remainder of the plug and being adapted for a disruptive high frequency discharge at the open end of the outer tubular electrode.

4. A resonant spark plug for fuel ignition of an internal combustion engine comprising a tubular inner electrode, an outer tubular electrode said tubular electrodes being associated to form a resonant cavity, and means carried by the inner

electrode for varying the resonance of the plug.

5. A resonant spark plug for fuel ignition of an internal combustion engine comprising an inner electrode, an outer tubular electrode, said electrodes being associated to form a resonant cavity and means carried by the outer electrode for varying the resonance of the plug.

6. A resonant spark plug for fuel ignition of an internal combustion engine comprising a tubular inner electrode, an outer electrode, said electrodes being associated to form a resonant cavity, means carried by the outer electrode for varying the tuned frequency of the plug, and means carried by the inner electrode for varying the resonance of the plug.

7. A resonant spark plug for fuel ignition of an internal combustion engine comprising a tubular inner electrode, an outer tubular electrode and a slidable coupling carried by the inner electrode, said electrodes being associated to form a resonant cavity whereby the resonance of the plug can be tuned to different high frequencies.

8. A resonant spark plug for fuel ignition of an internal combustion engine comprising an inner electrode, an outer electrode, said electrodes being associated to form a resonant cavity, and a slidable coupling carried by the outer electrode, whereby the resonance of the plug can be tuned to different high frequencies.

9. A resonant spark plug for fuel ignition of an internal combustion engine comprising a tubular inner electrode, an outer electrode, said electrodes being associated to form a resonant cavity, a slidable contact carried by the outer electrode, and a second slidable contact carried by the inner electrode, whereby the resonance and the harmonic node of the plug can be varied for different high frequencies.

10. A resonant spark plug for fuel ignition of an internal combustion engine comprising a tubular inner electrode, an outer electrode, said electrodes being associated to form a resonant cavity and an adjustable capacitor coupling carried within the inner electrode, whereby the resonance of the plug can be tuned to different high frequencies.

11. A resonant spark plug for fuel ignition of an internal combustion engine comprising an inner electrode, an outer electrode, said electrodes being associated to form a resonant cavity and an adjustable capacitor coupling carried by the outer electrode whereby the resonance of the plug can be tuned to different high frequencies.

12. A resonant spark plug for fuel ignition of an internal combustion engine comprising a tubular inner electrode, an outer tubular electrode, said electrodes being associated to form a resonant cavity, an adjustable capacitor coupling carried within the inner electrode, and an adjustable capacitor coupling surrounding the outer electrode, whereby the resonance of the plug can be tuned to different high frequencies.

13. In combination, an all metal resonant spark plug comprising an outer and inner tubular electrode, each electrode being open at one end and closed at the opposite end, the closed end of the outer electrode being in positive electrical contact with the open end of the inner electrode, said electrodes being spaced apart throughout the remainder of the plug and being adapted for a disruptive high frequency discharge at the open end of the outer tubular electrode, and adjustable means to vary the resonance of the plug.

14. In combination, an all metal resonant spark plug comprising an outer and inner tubular electrode, each electrode being open at one end and closed at the opposite end, the closed end of the outer electrode being in positive electrical contact with the open end of the inner electrode, said electrodes being spaced apart throughout the remainder of the plug and being adapted for a disruptive high frequency discharge at the open end of the outer tubular electrode, and an adjustable capacitor coupling carried within the inner electrode whereby the resonance of the plug can be tuned to different high frequencies.

15. In combination, an all metal resonant spark plug comprising an outer and inner tubular electrode, each electrode being open at one end and closed at the opposite end, the closed end of the outer electrode being in positive electrical contact with the open end of the inner electrode, said electrodes being spaced apart throughout the remainder of the plug and being adapted for a disruptive high frequency discharge at the open end of the outer tubular electrode, and an adjustable capacitor coupling carried by the outer electrode, whereby the resonance of the plug can be tuned to different high frequencies.

16. In combination, an all metal resonant spark plug comprising an outer and inner tubular electrode, each electrode being open at one end and closed at the opposite end, the closed end of the outer electrode being in positive electrical contact with the open end of the inner electrode, said electrodes being spaced apart throughout the remainder of the plug and being adapted for a disruptive high frequency discharge at the open end of the outer tubular electrode, an adjustable capacitor coupling carried within the inner electrode, and an adjustable capacitor coupling surrounding the outer electrode, whereby the resonance of the plug can be tuned to different high frequencies.

17. An all metal resonant spark plug comprising an outer metallic member, and an inner metallic member, said members being spaced apart at one point to form a spark gap..

18. An all metal tuned resonant spark plug comprising an outer metallic member, an inner metallic member, said metallic members being associated to form a resonant cavity, and means associated with the tubular members to tune the frequency thereof.

19. An all-metal resonant spark plug comprising an outer tubular metallic member, and an inner metallic member, said members being connected at one end and spaced apart at their opposite ends to form a spark gap.

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