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ULTRA-HIGH FREQUENCY IGNITION DEVICE

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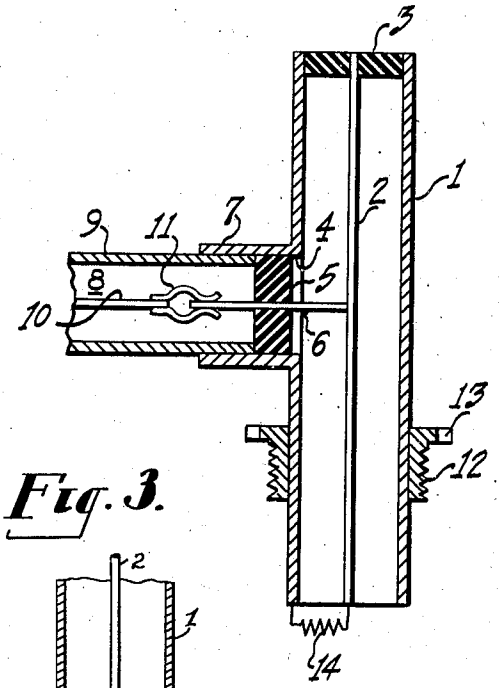



Fig. 1.

Fig. 3.



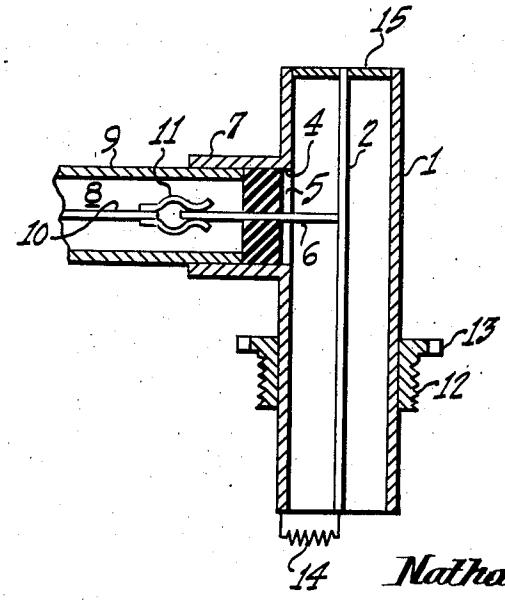




Fig. 2.

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## ULTRA-HIGH FREQUENCY IGNITION DEVICE

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8 Claims. (Cl. 123—145)

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This invention relates generally to ignition systems for internal combustion engines and particularly to ignition plugs of the type in which a metallic element is raised to a sufficiently high temperature by electrical means to cause ignition.

Present ignition systems for aircraft use have the distinct disadvantage that considerable radio interference is generated by the high potentials and comparatively low frequencies involved. Numerous ignition shielding devices are known for decreasing the inherent radio interference in said systems, but such devices have limited utility due to wide variations in moisture, pressure and temperature gradients encountered in radio aircraft operation. For example, when an airplane flies through a cloud, considerable condensation may occur within the shielding surrounding the high tension spark plug leads, resulting in reduced efficiency of the ignition system and objectionable radio interference. Moreover, at low pressures experienced at extremely high altitudes, sparkover may occur in the ignition distribution system thereby causing engine failure. Various methods, including the use of air pumps, have been devised for exhausting the moisture or increasing the air pressure within the high tension electrostatic ignition shielding, but the additional apparatus required added weight and has other serious disadvantages.

A further disadvantage of present ignition systems lies in the inherent unreliability of spark plugs. The operation of spark plugs is hampered by the corrosion, erosion, and the accumulation of carbon deposits, and as a result a large percentage of airplane engine failures are caused by failure of the spark plugs.

The instant invention is an improvement upon the system described in the copending U. S. application of Francis X. Rettenmeyer Ser. No. 445,046 filed May 29, 1942, entitled Ultra-high frequency ignition system. This copending application discloses and claims an ultra-high frequency ignition system which utilizes the advantages of low inherent radiation from low impedance high frequency transmission lines or from wave guides which couple an ultra-high frequency pulse generator to tuned sparking devices which comprise quarter wave sections of concentric transmission line. The system thus described, by utilizing ignition voltages of ultra-high frequency considerably above the normal frequencies used for radio transmission, and by employing low impedance ignition energy transmission lines, greatly reduces radio interference and provides

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efficient ignition under normally adverse conditions.

The instant invention comprises an improvement over the ultra-high frequency sparking type ignition plug disclosed in the copending application described heretofore. Briefly, one embodiment of this invention comprises a plug having a resistive element such as a wire or a thin conducting film on an insulating support. A pulse generator such as a storage capacitor and mechanical or electronic switch, or alternatively any type of ultra-high frequency ignition generator, such as, for example, the type described in the copending application mentioned heretofore, may be employed for deriving ignition power. This power is transmitted by low impedance coaxial transmission lines or waveguides which interconnect the ignition generator and the ignition plugs. Suitable impedance transforming means are employed at both generator and plug to obtain efficient transfer of power.

The present invention differs from the type of plug described in the copending application mentioned heretofore in that substantially no sparking occurs in the ignition plug. The resistive element may be a relatively rigid metallic conductor providing a relatively high resistance at the operating ignition frequency. Since high frequency currents flow substantially only on the surface of a conductor, extremely high temperatures on the conductive surface may be obtained in extremely short time intervals, and when the ultra-high frequency energy is removed, the thermal capacity of the interior of the conductor rapidly cools the extremely hot surface portions.

Among the objects of the invention are to provide an improved ultra-high frequency ignition plug. Another object of the invention is to provide an improved ultra-high frequency ignition plug wherein ultra-high frequency energy is utilized to heat a resistive element disposed within the combustion chamber. A further object of the invention is to provide an improved ultra-high frequency ignition plug wherein ultra-high frequency energy derived from a low impedance concentric transmission line is applied to a concentric line forming the plug which provides voltage transformation to derive relatively high ignition currents which may be applied to a resistive element connected between the high current terminals of the concentric line plug. Another object of the invention is to provide an improved ultra-high frequency ignition plug comprising a concentric transmission line having a length of the order of an even multiple of one

quarter wavelength, and having one end thereof short-circuited and the other end thereof terminated in a resistive ignition heating element. Another object of the invention is to provide an improved ultra-high frequency ignition plug comprising a concentric transmission line having a length of the order of an odd multiple of one quarter wavelength, and having one end thereof open-circuited and the other end thereof terminated in a resistive ignition heating element. Another object of the invention is to provide an improved ultra-high frequency ignition plug having plug connection means for terminating a coaxial ignition transmission line. A further object is to provide an ignition plug having a resistive heating element comprising a thin metallic film deposited upon an insulating refractory material.

The invention will be further described by reference to the accompanying drawing of which Figure 1 is a cross-sectional elevational view of one embodiment thereof, Figure 2 is a cross-sectional elevational view of a second embodiment thereof, and Figure 3 is a fragmentary cross-sectional view of a modification of the devices of Figs. 1 and 2. Similar reference characters are applied to similar elements throughout the drawing.

Referring to Figure 1, the ignition plug comprises an outer cylindrical conductor 1 coaxial with and substantially surrounding an inner conductor 2. The resultant coaxial transmission line section is open-circuited at one end but effectively sealed by an insulating gas tight plug 3. A circular or rectangular opening 4 in the outer cylindrical conductor 1 includes an insulating plug 5 which effectively seals the opening and supports a second internal conductor 6 which passes therethrough. One end of the second internal conductor 6 is terminated at a selected point on the first internal conductor 2 while the other end is terminated adjacent the open end of a conductive sleeve 7 which projects from the aperture 4 normal to the outer cylindrical conductor 1. The second internal conductor 6 and the conductive sleeve 7 are formed to receive and terminate a low impedance concentric ignition transmission line 8 which includes an outer conductor 9 and an inner conductor 10, the latter terminating in a suitable contact clip 11 for engaging the second inner conductor 6. The low impedance ignition transmission line is connected to any suitable source of ultra-high frequency ignition energy.

The outer cylindrical conductor 1 includes a threaded sleeve 12 adapted to engage the conventional threaded spark plug port. The threaded plug sleeve 12 may include a flattened portion 13 adapted to provide suitable surfaces for engagement with a spark plug wrench. The ends of the coaxial conductors 1 and 2 extending into the combustion chamber are terminated in a resistive element 14.

As explained heretofore, the connection of the second inner conductor 6 to the first inner conductor 2 provides suitable voltage transformation for applying relatively high ignition voltages at ultra-high frequency to the resistive element 14. The heating of the resistive element 14 will be provided substantially only on the surface portions thereof due to the "skin effect" of ultra-high frequency currents. The resistive element 14 preferably should be substantially rigid and adapted to withstand extremely high temperatures and shocks due to explosions within the combustion chamber. The element also should have sufficient mass to provide ample heat capacity for quickly reducing surface temperature during the intervals between ignition energy pulses.



The relative dimensions of the ignition plug and the point of connection between the second internal conductor 6 and the first internal conductor 2 will depend upon the ignition frequencies employed and upon the voltage transformation desired, since it should be understood that standing waves will be established intermediate the conductors 1, 2.

The essential difference between Figures 1 and 2 is that, in the latter embodiment of the invention, the end of the ignition plug coaxial line portion remote from the resistive element 14 is short-circuited by means of a conductive plug 15. Otherwise, the two devices are identical except that the connection between the second inner conductor 6 and the first inner conductor 2 must be located properly to establish standing waves along the internal conductor 2. The modification disclosed in Figure 2 provides a more compact ignition plug since the portion remote from the resistive element 14 may be considerably shorter while still providing standing waves along the inner conductor 2.

The resistive element 14, employed in either of the embodiments of the invention described in Figs. 1 and 2, may comprise a thin metal film 16 deposited by sputtering or by chemical means on some insulating refractory material 17 such as glass, quartz or ceramic, as illustrated in Figure 3.

The ignition energy may be in the form of either short radio frequency or unidirectional current pulses. Voltage transformation between the low impedance transmission line and the resistive element may be accomplished as described heretofore or in any other manner known in the art. Furthermore, the transmission lines interconnecting the ignition voltage source and the ignition plugs may comprise either concentric conductors or wave guides coupled thereto in any known manner.

I claim as my invention:

1. An ignition plug for an ultra-high frequency ignition system including a resistive element, means for applying ultra-high frequency currents to said element to raise the surface temperature of portions thereof during predetermined time intervals and means integral with said element for reducing the temperature of said surface portions thereof intermediate said predetermined intervals.

2. An ignition plug of the type described in claim 1 characterized in that said resistive element comprises a relatively thin metallic film, and wherein said last mentioned means comprises a refractory material supporting said film.

3. A tuned ignition device for ultra-high frequency ignition energy including an elongated center electrode, a coaxially disposed outer electrode surrounding said center electrode and forming a concentric line section therewith, resistive means providing an ignition element connecting one end of said center electrode to the proximate end of said outer electrode, and connecting means for said ultra-high frequency energy connected intermediate the ends of said center electrode and to said outer electrode.

4. A tuned ignition device for ultra-high frequency ignition energy including an elongated center electrode, a coaxially disposed outer elec-

trode surrounding said center electrode and forming a concentric line section therewith, resistive means providing an ignition element connecting one end of said center electrode to the proximate end of said outer electrode, means connecting together the remaining proximate ends of said center and said outer electrodes and connecting means for said ultra-high frequency energy connected intermediate the ends of said center electrode and to said outer electrode.

5. Apparatus of the type described in claim 3 including externally separable contact means for connecting said connecting means to an ignition energy transmission line, and characterized by the fact that said connection to said center electrode provides effective impedance matching between said transmission line and said ignition element.

6. Apparatus of the type described in claim 4



including externally separable contact means for connecting said connecting means to an ignition energy transmission line, and characterized by the fact that said connection to said center electrode provides effective impedance matching between said transmission line and said ignition element.

7. A resonant ignition device for ultra-high frequency ignition energy including an elongated center electrode equivalent substantially to some odd multiple of one quarter wavelength of said energy and a resistive ignition element terminating said electrode for generating ignition temperatures in response to ultra-high frequency energy applied to said electrode.

8. Apparatus of the type described in claim 3 including threaded mounting means for supporting said outer electrode in operable relation to a complementary device.

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