

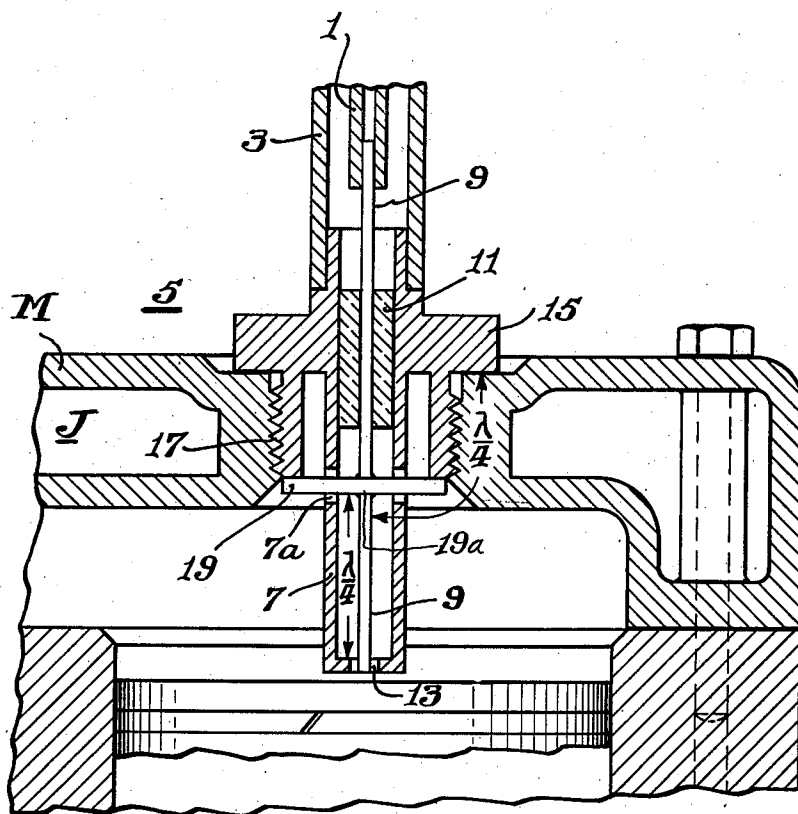
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SPARK PLUG

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SPARK PLUG

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5 Claims. (Cl. 315—39)

This invention relates to an improved spark plug for use with internal combustion engines of the type (e. g. aircraft motors) employing high frequency (microwave) ignition systems.

It has heretofore been proposed (see copending application Ser. No. 445,046 to Francis X. Rettenmeyer, filed May 29, 1942) to provide an aircraft motor with an ignition system employing ignition voltages of a frequency considerably above the frequencies normally used for radio communication purposes. Such ignition systems possess many advantages over conventional low frequency ignition systems. Among these advantages are: (a) satisfactory operation is maintained at high altitudes, (b) interference with radio communication is obviated without the use of cumbersome and expensive shielding systems and (c) spark-over caused by vapor condensation, low atmospheric pressure, or carbonization of insulation is eliminated.

The spark plugs employed in such high frequency ignition systems have heretofore included either a transformer adjacent to the plug or have comprised simply a section of a concentric line wherein the leading end of the inner conductor comprises the high potential electrode and the adjacent end of the outer cylindrical conductor comprises the outer or grounded electrode of the plug. It is necessary in any event to provide a gas-tight inner bushing at an appropriate point between the inner and outer electrodes of the plug in order to maintain the pressure within the cylinder of the engine. These mica and/or porcelain bushings usually employed are poor heat conductors and difficulties may arise due to overheating of the inner electrode of the plug adjacent to the "voltage loop" or spark-gap.

Accordingly, the principal object of the present invention is to provide an improved spark plug of the general character described and one wherein means are provided for dissipating excess heat from the inner or high potential electrode.

This principal object is achieved in accordance with the invention in a microwave spark plug of the type comprising a cylindrical outer electrode and an inner electrode by the provision of a heat conductive connection between said electrode and the motor block (and hence the cooling system) at a point removed from the spark-gap or "voltage loop" a distance which may be described as corresponding substantially to the electrical equivalent of from one-eighth to a quarter-wave length, of the particular ignition frequency employed.

Another and important object of the invention

is to achieve the foregoing object in an electrically efficient and mechanically compact spark plug structure and one which may be accommodated in plug seat or bore of standard design.

The latter object is achieved by the provision on the outer surface of the plug of a bushing of a novel construction but having a thread of standard pitch for seating the plug in the motor block, and the several parts of the plug are so designed, positioned and arranged, in accordance with the principle of the invention, that the high potential inner electrode is in heat transfer relation with the motor block, and hence with the cooling system of the engine, through the said bushing.

In Fig. 1, 1 designates the inner and 3 the outer conductor of a low impedance transmission line or coaxial cable which will be understood to be connected at one end to a source of high frequency voltages, not shown, and at its opposite end to a spark plug 5 which is constructed in accordance with the principle of the present invention. This spark plug 5 comprises a hollow cylindrical outer electrode 7, a concentric rod-like inner electrode 9, and a gas-tight mica, porcelain or other suitable insulating bushing 11 mounted within the bore of the outer electrode and through which the inner electrode extends to form a spark gap 13 at a "voltage loop" adjacent to the lower or inner terminal of the plug. The plug 5 has a circumferential metal flange or nut 15 on its outer surface adjacent to its upper end and this nut 15 is provided on its lower surface with a dependent circular metal bushing 17 which is spaced from the cylindrical electrode 7, and is threaded on its outer surface for engagement with complementary threads in the wall of the motor block M. It will be observed upon inspection of the drawing that there are a number (in this case, two) of oppositely located apertures 7a in the wall of the outer cylindrical electrode 7 intermediate its ends and that there is a rod or metal strip 19 which extends at a right angle from the inner electrode 9 through these apertures 7a to the circular threaded bushing 17. This metal connection 19 is provided, in accordance with the invention, for the purpose of maintaining the inner high potential electrode 9 in heat transfer relation with the threaded metal bushing 17, and hence with the cooling system of the engine which in the instant case is shown as comprising a water jacket J but which may comprise air cooled fins, or the like, not shown.

Since the outer cylindrical electrode 7 is connected through the nut 15, metal bushing 17 and metallic member 19 to the high potential electrode

It is important that this connection present the proper impedance to the ignition voltage at its point (19a) of connection to the said inner electrode, 9. This is achieved by so matching the impedance of the said heat conductive connection with the impedance of the inner conductor (from the point 19a to the spark-gap 13) that standing waves are minimized in the transmission line above the point 19a.

The exact physical length of the plug between the spark-gap 13 and the point 19a at which the heat conductive strip 19 is connected to the inner conductor 9 may be somewhat less than one-quarter of the wave length of the ignition frequency (it may be as small as one-eighth of said wave length) as determined by the ratio of the surge impedance of the transmission line to the impedance of the spark-gap 13 when a spark is present. Irrespective (within the indicated limits) of the exact distance between the gap 13 and the point 19a it is important that the impedance and hence the physical length of the heat conductive connection (as measured from the point 19a to the nut 15 on the outer electrode 7) be so chosen that it will balance the reactance (at point 19a) which obtains by reason of the fact that the length of the line (7 and 9) beneath the point 19a is less than one-quarter of the wave length of the ignition frequency. (As above indicated, the length of the inner conductor 9 as measured from the gap 13 to the point 19a is made less than one-quarter of the wave length of the ignition frequency because the impedance of the line at the spark-gap 13 is greater, before firing, than the characteristic impedance of the line.) In practice, the ideal length of the above described heat conductive conduction (like the length of the inner conductor 9 as measured from the spark-gap 13 to the point 19a) will ordinarily correspond to a figure within the limits of one-eighth to one-quarter of the wave length of the ignition frequency. Thus, where the wave length of ignition frequency employed is, say, 10 centimeters, (it may be less) the ideal length of both of the above mentioned parts of the plug may be approximately from 1.25 to 2.5 centimeters. If a longer plug is desired these dimensions may be multiplied by $2n-1$ where n is the multiplier. Thus, wherever in the appended claims reference is made to a dimension or a distance which is "substantially the electrical equivalent of a quarter wave of the ignition frequency" it will be understood that the said phrase is intended to include not only dimensions within the range of $\lambda/8$ and $\lambda/4$ but also dimensions or distances which are equivalent in electrical effect.

What is claimed is:

1. A spark plug for use with an internal combustion engine employing a microwave ignition system, said spark plug comprising inner and outer electrodes terminating in a spark-gap, a metal bushing on said outer electrode for seating said plug in a bore in the cylinder head of said engine, and a heat conductive member connected between said inner electrode and said metal bushing within said cylinder.
2. A spark plug for use with an internal combustion engine employing a high frequency ignition system, said spark plug comprising concentric inner and outer electrodes terminating in a spark-gap at a point corresponding to the voltage loop, a metal bushing on said outer electrode for seating said plug in a bore in the cylinder head of said engine and a conductive connection between said inner electrode and said metal bushing within said cylinder at a point removed from said spark-gap a distance which is substantially the electrical equivalent of a quarter-wave length of said high frequency for maintaining said inner electrode in heat transfer relation with said metal bushing.
3. The invention as set forth in claim 2 and wherein said heat conductive connection has a length corresponding substantially to the electrical equivalent of a quarter-wave length of said high frequency between its points of connection with said inner and outer electrodes.
4. A spark plug for use with an internal combustion engine employing a microwave ignition system, said spark plug comprising inner and outer electrodes terminating in a spark-gap, a metal bushing on said outer electrode for seating said plug in a bore in the cylinder head of said engine, said outer electrode having an aperture therein adjacent to said metal bushing, and a heat conductive member connected between said inner electrode and said metal bushing through said aperture.
5. A spark plug for use with an internal combustion engine employing a high frequency ignition system, said spark plug comprising a hollow cylindrical electrode having an open end, a concentric inner electrode, a gas-tight insulating bushing in said cylinder through which said inner electrode extends to form a spark-gap at a voltage loop adjacent to said open end of said outer electrode, and a conductive connection between said inner and outer electrodes in the space between said insulating bushing and said voltage loop for dissipating heat from said inner electrode.

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