July 27, 1937. E. B. NOWOSIELSKI 2,088,384

IGNITION APPARATUS

Filed April 17, 1935

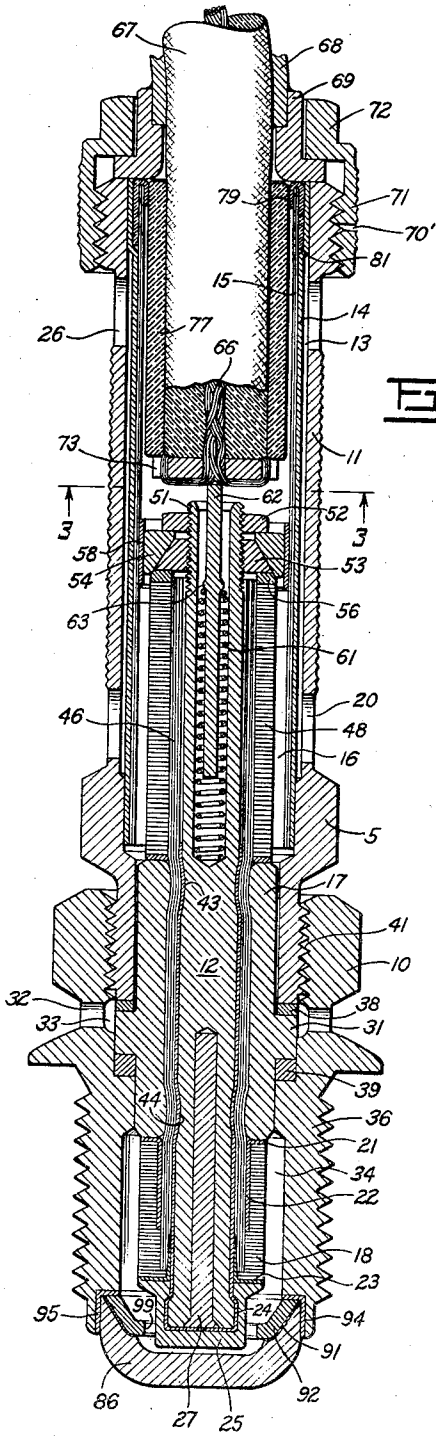


Fig. 2

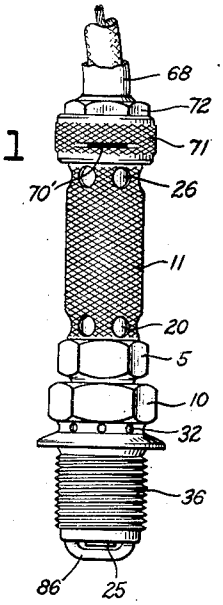


Fig. 1

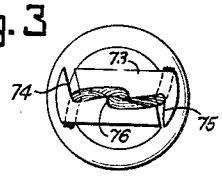


Fig. 3

Fig. 4

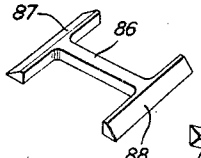


Fig. 5

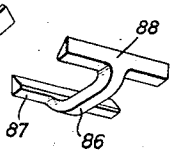


Fig. 6

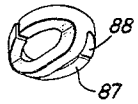


Fig. 7

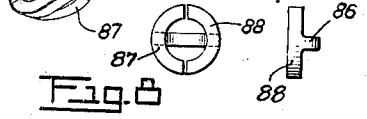


Fig. 8

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2,088,384

IGNITION APPARATUS

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Application April 17, 1935, Serial No. 16,882

11 Claims. (Cl. 123—169)

This invention relates to spark-plugs, and more especially to spark-plugs for aviation engines. The severe service conditions which are imposed on spark-plugs for airplane motors are familiar to those skilled in the art, as is also the importance of enclosing all parts of the high-tension current-carrying system by a continuous metallic shield to prevent interference with the reception of signals by adjacent radio receiving sets, and also to protect the exposed parts of the ignition system from detriment by the elements or otherwise.

The object of this invention is to provide a spark-plug, and more especially a shielded spark-plug, the construction of which is such as to prolong its life and to insure its effectiveness in such service, and to afford convenience, and which is economical to manufacture.

The invention comprises novel features of great utility in spark-plugs, and novel combinations of elements making an improved spark-plug and an improved assemblage of the spark-plug and its high-tension conductor.

Some of the objects are to provide improved electrodes including novel methods of constructing and assembling the electrodes, and of adjusting the spark gap; to provide improved heat deflecting and cooling means; and to provide improvements in the manner of insulating the current; including a novel method of insuring against development of "pipes" along the edges of the rolled mica sheets employed as part of the insulating means.

Further objects are to provide a shielded spark-plug of compact construction; to make it easy to remove and insert the conductor, and to establish the electrical connections; to guard against injury to insulation parts of the spark-plug and conductor as the result of such operations; to lock the conductor securely against accidental withdrawal; to insure good electrical connection for the high-tension current to the plug, to the end that the spark-plug may not fail to function; to relieve the conductor shielding of strain and to insure its electrical connection with the body of the spark-plug; to provide an improved terminal for detachably connecting the insulated high-tension conductor with the plug, in a socket of which the conductor is inserted; to provide a shielded spark-plug having a swiveled connection through which the conductor is passed and which has a terminal constructed to be fitted into the shield extension of the plug and to be locked thereto securely yet detachably, the same construction providing a swivel which enables the cable to be turned in any direction; and to provide other improvements and advantageous combinations the nature of which will appear.

In the accompanying drawing forming part hereof:

Fig. 1 is a view in elevation of one embodiment of the invention;

Fig. 2 is a longitudinal sectional view of the plug shown in Fig. 1 but on an enlarged scale;

Fig. 3 is a bottom plan view of certain of the inner elements of the plug as viewed along the plane indicated at 3—3 in Fig. 2;

Figs. 4 to 8 inclusive, indicate the appearance of the element 86 of Figs. 1 and 2 as it passes through the successive stages in the process of forming it into its final condition.

For the purpose of a shielded aviation spark-plug the metal body 10 of the plug is provided with a shield extension 11 which extends upward considerably above the upper end of the spindle 12 to enclose the spindle and the electrical connection between the same and the conductor which leads the high-tension current to the spindle. This shield extension is preferably in one piece with the attaching nut 5, though such unity is not necessary.

Instead of completely closing the space between the shield extension 11 and spindle 12, I provide a cooling and ventilating chamber 13 in the form of an annular space between the shield extension 11 and a long thin cylindrical metallic sleeve 14 having low thermal conductivity, and lined with a tube 15 formed of rolled mica constituting the wall of a second chamber 16 bounded at its lower end by the upper surface of the compressible metal gland 17, and at its upper end by a novel heat deflecting and sealing assembly to be further described. The gland 17, instead of resting directly upon the lower mica stack 18, as is the usual practice, is in contact with the upper end 21 of a sleeve 22 provided for the purpose of absorbing the heat which finds its way into the mica stack 18 and deflecting said heat to the gland 17 and outer wall of the plug. Two other heat deflecting sleeves are shown at 23, and 24, the former resting on the upper surface of the electrode cup 25 secured in position on the base of the spindle 12 by a pressure sufficient to change the cross-section of the upper end of the cup (initially of uniform bore) and cause its contour to conform to that of the spindle base. The part 24 is in the nature of a continuous jacket enclosing the spindle 12 and its insert 27 of some metal (such as copper or silver) having higher conductivity than the material—

steel, preferably—used in the spindle proper. This sleeve or jacket 24 is shown as closed at its lower end but this closure occurs only after the jacket has been positioned upon the spindle, the jacket being initially, merely a thin tube open at either end. After being placed around the spindle the extending portion of the lower end is bent inwardly to lie flat against the bottom surface of the spindle 12 and its insert 27—in other words, to occupy the position indicated in Fig. 2. It will be noticed further that the jacket 24 extends upwardly to a point just above the end of the gland 17 and the point where the centrally bored portion of the spindle begins. Due to the reduction in cross-sectional area at this point, and also by reason of the termination of the jacket 24 at this point, there is a tendency to cut off much of the upward flow of heat through the spindle 12 and to deflect the heat flow outwardly and radially into the copper gland 17 from which much of the heat is directly dissipated by the cooling blast circulating adjacent the central shoulder 31 of the gland 17, such circulation being produced by reason of the radial openings 32 and the annular chamber 33 communicating therewith. The sleeves 23 and 22 coact with the jacket 24 in diverting heat from the spindle 12 and the electrode 25 to the annular chamber 34 and the copper gland 17, and from said chamber and gland to the atmosphere by way of shell 36 and radial openings 32. In or adjacent the plane of these radial openings 32 there is provided a thrust washer 38 through which pressure is applied to the gland 17, and a compressible washer 39 is provided to insure a firm bond or seal preventing the escape of the confined cylinder gases, the pressure being applied as a result of threading the shield extension 11 into the shell 10, the two elements just mentioned being correspondingly threaded as indicated at 41.

As shown clearly in Fig. 2, the spindle 12 is of reduced diameter at two or more points as indicated at 43 and 44; and the jacket 24, the rolled mica tube 46, and the soft metal gland 17 are pressed snugly against these peripheral depressions in the spindle as one of the plug assembling operations. This operation of applying pressure laterally results not only in a firm seal around the spindle 12 but also eliminates any longitudinally extending crevices or "pipes" which have heretofore been a source of leakage characteristic of rolled mica insulating tubes. The wrapping of the mica sheets one around the other tends to leave such crevices running longitudinally of the wrapping, but by producing kinks at several points along the length of the wrapping, as indicated, I have found it possible to eliminate this source of trouble.

As a means of maintaining the mica stack 48 in the compressed condition and at the same time applying radial pressure to hold the mica lining 15 of the inner metallic sleeve 14 in position, and at the same time effecting an additional path for the transfer of heat directly to the said sleeve 14 from which it may be radiated to the atmosphere by the cooling current of air flowing along the chamber 13 and the radial apertures 20 and 26, I propose to thread the upper end 51 of the spindle 12 and apply to said threaded portion 51 a pair of threaded collars or nuts 52 and 53, the latter having an external taper to receive a correspondingly internally tapered gland 54 of softer material such as copper so that it may, when subjected to the pressure applied by the tightening of nut 52, form a firm bond with the washer 56 and also with the expansion ring 58 which grips the mica lining 15 at a point approximately midway between its ends, this lining 58 being inserted and expanded in the tube 14 prior to the assembly of said tube within the shield extension 11. The associated elements 52, 53, 54 and 56, on the other hand, are first assembled separately in position upon the inner plug assembly, and the latter is then dropped in place within the shell 36 prior to bringing the shield extension assembly into position. Also prior to attaching the upper assembly there is inserted within the hollowed portion of the spindle, a coil spring 61 and a contact pin 62 having a circumferential shoulder 63 against which the upper end of the spring 61 abuts to urge said pin upwardly into position to contact the radially spread strands of the current conducting wire 66 when the latter is installed in place. Associated with the wire 66 is its covering 67 of insulating material, its outer metallic sheath 68, the swivel connection 69 soldered or otherwise secured thereto, and the attached coupling nut 71, all of which are brought into assembled relationship with the parts previously described.

As noted above the inner end of the conductor 66 extends below the insulating material 67 for a certain distance so that the strands may be spread apart to provide better contact with the end of the pin 62. The method of fastening the spread apart ends of the conductor is indicated best in Fig. 3 and includes the provision of a flat metallic plate 73 having a pair of notches 74 and 75 cut therein on opposite sides of the central aperture 76 through which the conductor 66 passes. Each of the spread apart sections of the stranded conductor is inserted into position within each of the slots 74 and 75 and thereupon the plate 73 is pinched at either end to partially close the slots, the slot 75 being shown in the partially closed position which it assumes after the pinching operation. The cable and plate 73 are then held in the assembled relation indicated in Fig. 2 by the provision of a retainer or spacer sleeve 77 of insulating material such as porcelain glass or bakelite, the upper end of the spacer 77 terminating in the plane of the lower surface of the swivel member 69. Also the upper outer surface of the spacer 77 is in contact with the inwardly and downwardly turned end of a ferrule 79 of low thermal conductivity, the outer portion of which rests upon the shoulder 81 formed near the upper end of the heat dissipating inner wall 14 of the shield extension assembly.

As above indicated, one of the important features of the invention concerns the outer or grounded electrode and method of its manufacture and installation. The first step is to secure an H shaped metallic piece 86 of suitable heat and spark resisting qualities while at the same time a sufficiently good conductor. Such a piece is indicated in Fig. 4. This piece is then subjected to a bending operation to bring it into substantially the form indicated in Fig. 5. Next the parallel sides 87 and 88 are turned into semi-circular arcs which preferably do not quite join (as indicated in Figs. 6 and 7) the cross-connecting portion remaining in the form to which it is initially bent, as shown in Fig. 5. The final step in formation of the electrode is to shape the upper annular surface formed by the semi-circular parts 87 and 88 so that in transverse section it will have the final appearance indicated in Fig. 2. When thus completed the electrode receives a thin dished washer 91 of

soft metal such as copper and then a second dished washer **92** of harder material and preferably the same material as the electrode **86** itself. The installation and completion of the electrode assembly is then obtained in the following manner: The shell **36** is placed on a table or workbench with its lower counter-bore **94** uppermost, a thin cup-shaped liner **95** of soft metal, preferably the same material as that of the piece **91**, and centrally apertured to a diameter corresponding to the diameter of the chamber **34**, is then inserted in the recessed end **94**. The electrode assembly consisting of the parts **86**, **91** and **92** is then placed in position within the inverted cup member **95** and the assembly consisting of the parts **36**, **95**, **92**, **91** and **86**, is then placed in a hydrogen gas furnace or other suitable heat chamber and subjected to a temperature sufficient to cause a fusion or welding along the surfaces of the elements **95** and **91**, with the result that the five elements above enumerated become fused into a permanently welded single unit. This unit is then removed from the furnace, the core assembly, the shield extension assembly, and upper cable assemblies successively attached thereto in the respective manners above indicated. When this complete assembly has been accomplished it will be found that the inner electrode **25** occupies a position approaching that of the transverse portion **86** of the outer electrode and also approaching that of the inner cylindrical edge **99** of the thimble **92**, forming an auxiliary spark gap, the clearances therebetween being such that the spark will normally jump from the relatively broad surface of the electrode **25** to the correspondingly broad plane surface of the cross-piece **86** of the ground electrode; but if for any reason this normal path of the spark is obstructed—as for example by the formation of ice particles—the spark can then jump from the cylindrical surface of the electrode **25** to the above described cylindrical surface **99** of the thimble **92** which may therefore be considered as a part of the completed electrode. In fact, it is, of course, possible to have the elements **92**, **91** and **86** originally formed as an integral whole rather than being composed of three subsequently united pieces as shown.

It will be noted that the mica tube **46** terminates somewhat above the lower flange of the heat conducting sleeve **23** of copper or other metal, and that therefore a plurality of the mica disks **18** lie between the end of the mica tube and the said flanged portion of the sleeve. This arrangement has the advantage of facilitating maximum heat transfer from the mica assembly **18** and deflecting such heat to the jacket **24** as well as to the sleeve **22**, and at the same time provides a better degree of protection for the lower ends of the layers constituting the completed tube **46**. It will also be observed that the cylindrical portion of the sleeve **23** is externally tapered to facilitate a snug grip and seal between parts **46**, **23** and **24**. In the second embodiment of the invention, as shown in Figs. 8, 9 and 10 there are many elements which are identical in their structure arrangement and functioning to the elements designated by corresponding reference characters in Figs. 1 to 3 inclusive, and these corresponding elements will not be further discussed in detail. The differentiating elements are as follows:

For claims to the unclaimed features disclosed herein, and also disclosed in one or more of my co-pending applications numbered 62,524; 121,216; 121,217; 134,396; and 146,092, filed respectively on February 5, 1936; January 18, 1937; January 18, 1937; April 1, 1937; and June 2, 1937, reference is to be made to said co-pending applications, or to divisions hereof.

What is claimed is:

1. A spark plug comprising the combination of a central spindle, a body having a shield extension thereon, a heat radiating inner tube coaxial therewith, an insulating sleeve lining said tube, and means for circulating a cooling medium in the space between said extension and inner tube.

2. A spark plug comprising the combination of a central spindle, a body having a shield extension thereon, a heat radiating inner tube coaxial therewith and extending above said spindle, an insulating sleeve lining said tube, and means for circulating a cooling medium in the space between said extension and inner tube, and means within said tube for directing a flow of heat to said tube lining.

3. A spark plug comprising the combination of a central spindle, a body having a shield extension thereon, a heat radiating inner tube coaxial therewith, and means for rapidly transferring heat from said spindle to the space between said extension and inner tube.

4. A spark plug comprising the combination of a central spindle, a body having a shield extension thereon, a heat radiating inner tube coaxial therewith, means for rapidly transferring heat from said spindle to the space between said extension and inner tube, said heat transferring means including a metallic ring of high heat conductivity fitting closely against the thinly lined inner surface of said radiating tube, and additional metallic means forming a continuous heat flow path from said spindle to said metallic ring.

5. A spark plug comprising the combination of a central spindle, a body having a shield extension thereon, a heat radiating inner tube coaxial therewith, a heat conducting metallic jacket surrounding the spindle, and means for rapidly transferring heat from said jacket to the space between said extension and inner tube, said heat transferring means including a metallic ring of high heat conductivity fitting closely against the thinly lined inner surface of said radiating tube, and metallic wedging means forming a continuous heat flow path from said spindle to said metallic ring.

6. A spark plug comprising the combination of a central spindle, a body having a shield extension thereon, a heat radiating inner tube coaxial therewith, a heat conducting metallic jacket surrounding the spindle and terminating intermediate the spindle ends, thereby leaving a free annular space for heat radiation along the upper length of the spindle, and means for rapidly transferring heat from said free annular space to the space between said extension and inner tube.

7. A spark plug comprising the combination of a central spindle, a body having a shield extension thereon, a heat radiating inner tube coaxial therewith, a heat conducting metallic jacket surrounding the spindle and terminating intermediate the spindle ends, thereby leaving a free annular space for heat radiation along the upper length of the spindle, and means for rapidly transferring heat from said free annular space to the space between said extension and inner tube, said heat transferring means including a metallic ring of high heat conductivity fitting closely against the thinly lined inner surface of

said radiating tube and additional metallic means forming a continuous heat flow path from said spindle to said metallic ring.

8. A spark plug comprising the combination of a central spindle, a body having a shield extension thereon, a heat radiating inner tube coaxial therewith, a heat conducting metallic jacket surrounding the spindle, and terminating intermediate the spindle ends, thereby leaving a free annular space for heat radiation along the upper length of the spindle, and means for rapidly transferring heat from said free annular space to the space between said extension and inner tube, said heat transferring means including a metallic ring of high heat conductivity fitting closely against the thinly lined inner surface of said radiating tube, and metallic wedging means forming a continuous heat flow path from said spindle to said metallic ring.

9. A spark plug comprising the combination of a central spindle, a body having a shield extension thereon, a heat radiating inner tube coaxial therewith, and means for rapidly transferring heat from said spindle to the space between said extension and inner tube.

10. A spark plug comprising the combination of a central spindle, a body having a shield extension thereon, a heat radiating inner tube coaxial therewith, and means for rapidly transferring heat from said spindle to the space between said extension and inner tube, said heat transferring means including a metallic ring of high heat conductivity fitting closely against the thinly lined inner surface of said radiating tube, and additional metallic means forming a continuous heat flow path from said spindle to said metallic ring.

11. A spark plug comprising the combination of a central spindle a body having a shield extension thereon, a heat radiating inner tube coaxial therewith, and means for rapidly transferring heat from said spindle to the space between said extension and inner tube, said heat transferring means including a metallic ring of high heat conductivity fitting closely against the thinly lined inner surface of said radiating tube, and metallic wedging means forming a continuous heat flow path from said spindle to said metallic ring.

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