

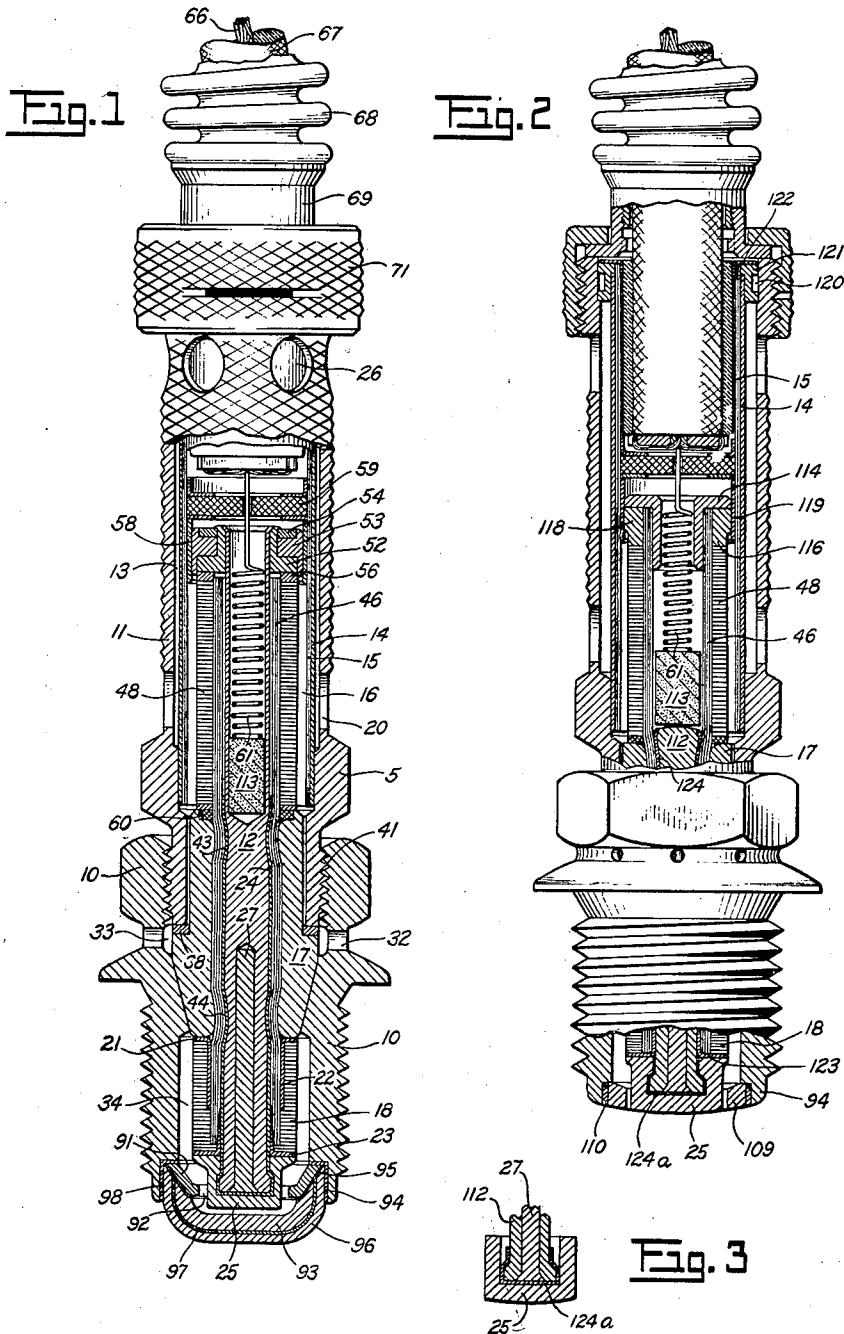
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IGNITION APPARATUS

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IGNITION APPARATUS

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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.

In the drawing, Figures 1, 2, and 3 are views partly in elevation and partly in section, each of Figures 1 and 2 illustrating a somewhat different embodiment of the invention. In many respects both embodiments correspond to the disclosure in my co-pending application No. 16,882, filed April 17, 1935, and this is particularly true of the features of the disclosure which are claimed in said copending application; and where identical elements appear in the several embodiments they are designated by similar reference numerals.

First describing Figure 1, reference character 11 designates a metallic extension of the metallic body 10. As shown this part 11 extends upwardly 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.

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. 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 washer 38 seated on the central ledge 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 10 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 to insure a firm bond or seal along the taper of the gland, thus 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.

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 peen or otherwise upset the upper edge of spindle 12 to hold it firmly against a metal sleeve 52 which is flanged at its lower end to receive an outer sleeve 53 located in place by a washer 54 adapted to form a seat against which sleeve 52 is firmly bonded by the same upsetting action as that which binds the spindle top thereto. These parts 52 and 53, when subjected to this upsetting pressure applied to the spindle top, act upon the lower washer 56 to compress the mica stack 48 and at the same time press against the expansion ring 58 to cause the latter to grip 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.

By the process above described the cap assembly and spindle, that is, the parts 12, 54, 53, 52 and 56, become a permanently integrated unit which, by reason of its extremely tight (but somewhat resilient) fit with the ring 58, is capable of transferring considerable heat from the upper part of the plug to the radiator tube 14. This heat transfer is accelerated by reason of the shunting effect of the asbestos heat barrier 59, and an additional asbestos heat barrier shown at 60.

After the cap assembly has been secured by the upsetting process above described, there is inserted within the hollowed portion of the spindle, a coil spring 61 having its upper end extending 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 se-

cured thereto, and the attached coupling nut 71, all of which are brought into assembled relationship with the parts previously described.

The lower electrode assembly consists of a cup shaped element 91 having its base cut away to form an annular space 92 around the central electrode 25 across which annular space the ignition current may pass, but normally does not, as there is a shorter path to the horizontally disposed transverse portion 93 which is preferably built up by taking two or more elements and uniting them successively to the convex surface of the cup shaped member 91 through the instrumentality of a thin cup-shaped liner 95 of soft metal (such as copper) which, upon application of a high temperature, will fuse sufficiently to form a permanently welded connection with the parts 91, 93 and 96, the two last named being similarly welded by the action of the heat upon the soft metallic lining 97 interposed therebetween. This assembling process also includes as its first step the placing of the outer shell 10 on a suitable table or tray with its lower, counterbored portion 94 uppermost, then inserting in said counterbored portion a thin cup-shaped liner 98 of soft metal, preferably the same material as that of the pieces 95 and 97. The next step is to successively add the elements 91, 95, 93, 97 and 96 and then place the assembly in a hydrogen gas furnace or other suitable heat chamber where it may be subjected to a temperature sufficient to cause a fusion or welding along the surface of the elements 94, 98, 96, 97, 93, 95 and 91, with the result that all these elements become fused into a permanently welded single unit. This unit is then removed from the furnace, and the core assembly, the shield extension assembly, and the upper cable assembly successively attached thereto in the respective manner heretofore 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 93 of the outer electrode and also approaching that of the inner cylindrical edge 92 of the thimble 91, 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 93 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 92 of the thimble 91 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 96 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 Fig. 2, there are many elements which are identical in their structure arrangement and functioning to the elements designated by corresponding reference characters in Fig. 1, and these corresponding elements will now be further discussed in detail. The differentiating elements are as follows:

In place of the transversely extending electrode 93, 96 of Fig. 1 I have shown in Fig. 2 a simpler form of electrode including a single surrounding member 109 adapted to be fused to the counterbored portion 94 of the shell with the aid of a single annular flux element 110. With this simple construction there is only a single direction, namely, the radial direction through which the high tension current may pass to the outer electrode 109 rather than the alternative radial and longitudinal directions which are possible in Fig. 1; but this single radial path is preferably adjustable by turning the inner electrode 25 about its longitudinal axis and thereby varying the amount of clearance between the parts 25 and 109, the opposing surface of which parts have non-conforming contours to make such spark gap variation possible.

The further differentiating feature of the embodiment shown in Fig. 2 is the elimination of the upper thin walled section of the central spindle and the substitution of a central spindle 112 which terminates adjacent the upper end of the member 17, at which point the enclosing jacket 24 also terminates. With this revised construction the transfer of the ignition current to the spindle occurs by way of the lower plane surface of the cylindrical block 113 of carbon or carbonaceous material rather than through the lateral surface thereof as in the construction shown in Fig. 1. The current is fed to the block 113 by the coil spring 61 in the same manner as in the construction of Fig. 1 but instead of being guided by the upper extension of the spindle said spring 61 is guided and positioned by the presence of an apertured cap 114 having a downwardly extending shank 116 which together with the upper portion serves to enclose and retain the upper end of the mica wrapper 46. The member 114 also constitutes a means of applying pressure to the annular retainer 118 or the mica assembly 48 and further operates to hold in place the expansion ring 119 corresponding to ring 58 of the construction shown in Fig. 1.

An additional differentiating feature in the embodiment shown in Fig. 2 is the elimination of the outwardly flaring upper end of the radiator tube 14 and the substitution of a spacer ring 121 acting in conjunction with an annular cap 122, to retain the upper end of the tube 14 and its mica lining 15 in close contact. Preferably, the spacer 121 is peripherally grooved as indicated at 120 to reduce the amount of metal at this point and thereby retard heat flow in this direction.

In Fig. 2 the jacket 124, instead of extending to the base of the spindle (as in Fig. 1) flares outward to form a flange 123 acting as a base for mica assembly 18 and mica wrapper 46. A thin cap 124a is first placed over the lower end of the spindle, and the electrode cap 25 is then attached, and forms a base for flange 123.

The novel method of integrating electrode ele-

ment 25 with the spindle 12 (or 112, as the case may be) is indicated in Fig. 3. Referring to said figure, it will be seen that the member 25 is originally in the shape of a cup having a straight bore sufficiently wide to fit over the jacketed end of the spindle. After assembly in this fashion, pressure is applied to cause the open end of the cup to close in against the reduced section of the spindle (just above the wider base) changing the shape of the cup to the extent indicated in Figs. 1 and 2, and thus making it undetachable from the spindle. In addition to this step of applying pressure to upset or "mushroom" the member 25, there may be a further step of applying heat to a sufficient degree to fuse the parts 25 and 112, the jacket 124a acting as the flux agent in the same fashion as in the fusing of parts 93 and 96 in Fig. 1. In the event that the intermediate member 124a is omitted, the union will be effected directly between parts 25 and 112.

Various changes, which will now appear to those skilled in the art, may be made in the form, details of construction and arrangement of the parts without departing from the spirit of the invention, and reference is therefore to be had to the appended claims for a definition of the limits of the invention. For claims to the unclaimed features disclosed herein, and also disclosed in one or more of my co-pending applications numbered 16,882; 62,524; 121,216; 121,217; and 134,396, filed April 17, 1935, February 5, 1936, January 18, 1937, January 18, 1937, and April 1, 1937, respectively, reference is to be made to said co-pending applications, or divisions thereof.

What is claimed is:

1. In a spark plug adapted to receive a high tension lead, and having a central spindle and a central electrode integrated with the base of said spindle, a sleeve of high thermal conductivity surrounding said spindle, said sleeve having a flanged base resting on the upper surface of said electrode, a second sleeve of insulating material surrounding said first-named sleeve and extending beyond the upper end of said spindle, a non-metallic block resting on the upper end of said spindle to conduct current thereto, said block being of lower thermal conductivity than said first-named sleeve, and means extending beyond the upper end of said insulating sleeve to electrically connect said high tension lead with said block.

2. In a spark plug adapted to receive a high tension lead, and having a central spindle and a central electrode secured to the base of said spindle, a sleeve of high thermal conductivity surrounding said spindle, said sleeve having a flanged base resting on the upper surface of said electrode, a second sleeve of insulating material surrounding said first-named sleeve and extending beyond the upper end of said spindle, a non-metallic block resting on the upper end of said spindle to conduct current thereto, said block being of lower thermal conductivity than said first-named sleeve, means extending beyond the upper end of said insulating sleeve to electrically connect said high tension lead with said block, and a barrier to heat flow surrounding said last-named means.

3. In a spark plug adapted to receive a high tension lead, and having a central spindle and a central electrode integrated with the base of said spindle, a sleeve of high thermal conductivity surrounding said spindle, said sleeve having a flanged base resting on the upper surface of said electrode, a second sleeve of insulating material

surrounding said first-named sleeve and extending beyond the upper end of said spindle, a non-metallic block resting on the upper end of said spindle, to conduct current thereto, said block being of lower thermal conductivity than said first-named sleeve, means extending beyond the upper end of said insulating sleeve to electrically connect said high tension lead with said block, and a barrier to heat flow surrounding said last-named means, said barrier being constituted by an asbestos disc disposed above the upper end of the insulating sleeve, but below the base of the high tension lead.

4. In a spark plug adapted to receive a high tension lead, and having a central spindle and a central electrode secured to the base of said spindle, a sleeve of high thermal conductivity surrounding said spindle, said sleeve having a flanged base resting on the upper surface of said electrode, a second sleeve of insulating material surrounding said first-named sleeve and extending beyond the upper end of said spindle, a carbonaceous block resting on the upper end of said spindle to conduct current thereto, said block being of lower thermal conductivity than said first-named sleeve, and means extending beyond the upper end of said insulating sleeve to electrically connect said high tension lead with said block.

5. In a spark plug adapted to receive a high tension lead, and having a central spindle, a sleeve of high thermal conductivity surrounding said spindle, a second sleeve of insulating material surrounding said first-named sleeve and extending beyond the upper end of said spindle, a non-metallic block resting on the upper end of said spindle to conduct current thereto, said block being of lower thermal conductivity than said first-named sleeve, and means extending beyond the upper end of said insulating sleeve to electrically connect said high tension lead with said block.

6. In a spark plug adapted to receive a high tension lead, and having a central spindle, a sleeve of high thermal conductivity surrounding said spindle, a second sleeve of insulating material surrounding said first-named sleeve, a non-metallic block resting on the upper end of said spindle to conduct current thereto, said block being of lower thermal conductivity than said first-

named sleeve, and means extending beyond the upper end of said insulating sleeve to electrically connect said high tension lead with said block.

7. In a spark plug adapted to receive a high tension lead, and having a central spindle, a sleeve of high thermal conductivity surrounding said spindle, a second sleeve of insulating material surrounding said first-named sleeve, a non-metallic block in contact with said spindle to conduct current thereto, said block being of lower thermal conductivity than said first-named sleeve, and means extending beyond the upper end of said insulating sleeve to electrically connect said high tension lead with said block.

8. In a spark plug adapted to receive a high tension lead, and having a central spindle, a sleeve of high thermal conductivity surrounding said spindle, a second sleeve of insulating material surrounding said first-named sleeve, a non-metallic block in contact with said spindle to conduct current thereto, said block being of lower thermal conductivity than said first-named sleeve, and means extending beyond the upper end of said insulating sleeve to electrically connect said high tension lead with said block, and a barrier to heat flow surrounding said last-named means.

9. In a spark plug adapted to receive a high tension lead, and having a central spindle, a sleeve of high thermal conductivity surrounding said spindle, a second sleeve of insulating material extending beyond the upper end of said spindle, a block resting on the upper end of said spindle to conduct current thereto, said block being of lower thermal conductivity than said first-named sleeve, and means extending beyond the upper end of said insulating sleeve to electrically connect said high tension lead with said block.

10. In a spark plug adapted to receive a high tension lead, and having a central spindle, a sleeve of high thermal conductivity surrounding said spindle, a second sleeve of insulating material surrounding said first-named sleeve, a block in contact with said spindle to conduct current thereto, said block being of lower thermal conductivity than said first-named sleeve, and means extending beyond the upper end of said insulating sleeve to electrically connect said high tension lead with said block.

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