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RADIO SHIELDED IGNITION APPARATUS

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This invention relates to ignition apparatus and more particularly to connecting means for high tension conductors especially adapted for use in radio-shielded ignition circuits for internal combustion engines and the like.

Heretofore much difficulty has been experienced in providing satisfactory connecting means between radio shielded high tension supply cables and, for example, the center electrodes of radio shielded spark plugs. It is universally recognized that the connection between a shielded spark plug and the conductor which connects it to a source of electrical energy is one of the weakest, if not the weakest link in the ignition system of an internal combustion engine. The major difficulty has been the provision of means for preventing arcing between the cable or spark plug terminal and the radio shielding means which is connected to ground. The connecting means which is most widely used at the present time for the above purpose has not proved entirely satisfactory from the standpoints of durability, dependability and ease of replacement or repair. All of these attributes are extremely important ones, particularly as regards aircraft engines, as will be realized when it is considered that ignition failures in aircraft engines endanger the lives of a great many people and cause the destruction of property valued at vast sums. Ignition failures also result in long and costly operating delays, due to the fact that it is extremely difficult and tedious at best to find the one or two spark plugs which are not functioning properly in a fourteen cylinder, double-ignition engine, for example. Such delays might be vital in military aircraft and are inevitably costly in commercial aircraft. Even after a non-firing spark plug is discovered by a skilled mechanic he may still have considerable difficulty in determining the precise cause or point of failure.

Accordingly, one of the objects of the present invention is to provide novel means adapted for use in ignition systems of internal combustion engines which will contribute materially to the reduction of casualties in aircraft and thus enhance the safety of human lives and property.

Another object of the invention is to provide novel connecting means for radio-shielded conductors which is durable and dependable in service and which accordingly reduces maintenance costs and operating delays.

Still another object is to provide apparatus of the above character which obviates the installation and replacement difficulties inherent in means heretofore provided for the same purpose.

A further object is to provide a novel connecting and insulating unit in means for connecting electrical conductors which may be readily assembled and disassembled for inspection and repair, thereby facilitating the discovery of ignition failures which might occur, as well as the elimination of the cause of failure.

A still further object is to provide novel means for connecting radio shielded conductors which means are simple in construction and may be readily and inexpensively manufactured in large quantities.

The above and further objects and novel features of the invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawing. It is to be expressly understood, however, that the drawing is for the purpose of illustration only and is not intended to define the limits of the invention, reference for this latter purpose being had primarily to the appended claims.

In the drawing wherein like reference characters refer to like parts throughout the several views:

Fig. 1 is a side elevation, partly in section and with parts broken away, illustrating one embodiment and one use of the invention;

Fig. 2 is an enlarged top view of a novel unit of the structure illustrated in Fig. 1;

Fig. 3 is a sectional side view of said unit, the section being taken substantially on line 3-3 of Fig. 2;

Fig. 4 is a bottom view of the unit shown in Fig. 3; and,

Fig. 5 is a detail view, partly in section of portions of said unit, the section being taken substantially on line 5-5 of Fig. 3.

A single embodiment of the invention is illustrated in the drawing, by way of example, in a form adapted for use in connecting an ignition cable and the radio shielding therefor to a radio-shielded spark plug in an internal combustion engine. It will be understood, of course, that the invention may be readily adapted for use at points in an ignition system other than at the spark plugs and also in other environments.

In the illustrated embodiment, the invention is shown embodied in a combination comprising a shielded spark plug 10, which for the most part is of the conventional type now in common use on aircraft engines, said spark plug including an externally threaded shell 11, adapted to extend into an opening provided in an engine cylinder. The shell supports a ground electrode

12 in any suitable well-known manner, as well as a nut 13 which in turn supports and is suitably insulated from a center electrode 14 which constitutes an electrical conductor. Surrounding the upper end of electrode 14 and projecting beyond the same is a metallic shielding barrel 15 which may be integral with or operatively secured to nut 13. The upper end of barrel 15 is provided with external threads 16 for a purpose to appear hereinafter and the inner wall thereof is lined with suitable electrical insulating means 17 which may consist of layers of mica. Other conventional insulation for electrically separating the center electrode and the grounded portions of the spark plug are shown at 18.

In order to prevent damage to and fraying of the upper end of insulating liner 17, the bore of barrel 15 is slightly enlarged at the outer end thereof and fitted with a ring 19 which has an inner diameter substantially equal to or slightly less than the inner diameter of said sleeve 17. Ring 19 is preferably secured in position by spinning a portion of the outer end of barrel 15 inwardly over the outer corner of the ring which is beveled. After the installation of ring 19, the end of barrel 15 may be machined to provide a smooth end surface.

For connecting the center electrode 14 with a source of high tension current (not shown) there is provided an insulated conductor 20 which may be shielded in any suitable manner to prevent interference with radio reception, such as by a flexible metallic conduit 21 and a rigid metallic elbow 22, said conduit and elbow being connected together by a ferrule 23 which telescopically receives the adjacent ends thereof and is soldered thereto. The other end of member 22 also has telescopic relation with and is soldered to a ferrule 24, the open end of which is provided with a tapered or conical bore 25 for a purpose to later appear. A nut 26 threaded for engagement with threads 16 has an internal flange 27 adapted to engage an internal shoulder on ferrule 24 for removably securing the conductor shielding 21, 22 to shielding barrel 15 of the spark plug.

As shown in Fig. 1, a portion of cable 20 extends beyond elbow 22 and ferrule 24 into spark plug barrel 15 for electrical connection with center electrode 14. For the purpose of holding the cable within the spark plug barrel in proper relation with respect to the center electrode terminal and for insuring against arcing between the exposed end of conductor 20 and the shielding means in the vicinity of the connection between elbow 22 and barrel 15, a spacer sleeve 28 of suitable insulating material is employed.

Novel means are comprehended by the invention for detachably securing conductor 20 to sleeve 28, said means in the form shown comprising a plate or washer 29 extending transversely to the axis and securedly fixed in the bore of sleeve 28 a short distance from one end of the latter. Washer 29 is anchored in said sleeve by means of a plurality of prongs 30 on the periphery thereof that pierce the inner wall of the sleeve (Fig. 5). To install plate 29 in sleeve 28 the former is bent to somewhat of a dish or cup shape, inserted in the sleeve and then flattened by use of a suitable tool to press points 30 into the inner wall of sleeve 28. Extending upwardly from the periphery of retaining washer 29 are a plurality of tabs 31 which serve a purpose to appear later, said tabs being

integral with or suitably secured to said washer. An opening 32 is provided in the center of plate 29 and loosely extending through said opening, preferably to the plane of the nearest end of sleeve 28, is a bushing 33 which consists of an annular flange or head portion 34 that engages the upper face of said plate and a reduced threaded portion or stem 35. A central bore 36 is provided in bushing 33 for receiving an uninsulated portion 37 (Fig. 1) of conductor 20, said portion being secured to the bushing by any suitable means such as soldering at the lower end thereof. Flange portion 34 is so shaped that tabs 31 will cooperate therewith to prevent turning of bushing 33 relative to washer 29 and, hence, sleeve 28. In the form shown, flange 34 is hexagonally shaped and three tabs 31 are provided for engaging flat portions of the flange periphery (Fig. 2). It will be understood that any other suitable cooperating means on washer 29 or tube 28 and bushing 33 may be provided for preventing this relative turning movement.

For securing bushing 33 and hence conductor 20, 37 against longitudinal movement relative to sleeve 28, a nut 38 is threaded onto portion 35 of the bushing and into engagement with the lower face of washer 29. The lower end of nut 38 is preferably slotted as at 39 for the insertion of a screw driver or other suitable tool. To insure a good electrical contact between conductor 37 and electrode 14, a coil spring 40 may be interposed between the latter and nut 38. A turn of said spring at one end fits into an annular groove on nut 38 whereby the gripping action of the spring holds it in proper position.

The upper end of sleeve 28 fits into the lower portion of ferrule 24 and against an internal shoulder 41 therein. The sleeve thus functions to space the bare end 37 of cable 20 and the uninsulated parts to which it is connected from the internally uninsulated portion of the shielding means a sufficient distance to prevent arcing or flash-overs under normal circumstances. In devices heretofore provided, wherein the cable conductor was connected to means permanently secured in the spacer sleeve, arcing often occurred due to the collection of moisture on the walls of the spacer element, to the reduction of the arcing gap by a strand of wire from conductor 37 being inadvertently bent back along the cable insulation during assembly, to the presence of solder or soldering flux along the wall of the sleeve inadvertently deposited there during the soldering of the cable in position, and to other apparently unavoidable causes, such as defects in the insulation itself and burning or carbonizing of the spacer sleeve by the intense heat generated in the spark plug. Failures of the above nature are generally not visible from the exterior of the assembly and accordingly cannot be readily discovered when the cable is permanently attached to the spacing sleeve. To remove the sleeve from the cable in prior devices meant breaking a soldered connection and resoldering the same. This was difficult if not impossible in the field. With the novel combination of elements comprehended by the present invention, the spacer sleeve may be readily and quickly removed from the cable for inspection and either put back in place thereon or replaced by a new one with little or no difficulty in the field as well as in the shop.

In assembling applicant's novel combination the bare end 37 of insulated cable 20 is extended

through passage 36 in bushing 33 and soldered to the end of stem portion 35, as at 42. There is thus no danger involved which might result in damage to the insulated spacer sleeve or in the deposition of solder or soldering flux on the walls of the sleeve. The cable and bushing are then inserted into sleeve 28 in which washer 29 has been installed in the manner above pointed out. The cable and sleeve are then secured together by means of nut 38 in the manner heretofore described. In this assembling operation there is no danger that a careless mechanic may bend a strand of the conductor back along the cable in the sleeve and thus reduce the flash-over distance between the end of the cable and the radio shielding in the vicinity of nut 26. If the insulating sleeve 28 should, for any reason, become damaged or wet the same may be readily replaced without the necessity for any soldering. The assembled spacer unit and cable constitutes, in effect, the plug portion of a plug and socket connection, the spark plug barrel constituting the socket.

In order to eliminate, insofar as possible, any chance that moisture may accumulate, by condensation or otherwise, in the connecting assembly above described, the space around cable 20 within sleeve 28 and radio shielding conduit 21, 22 is preferably filled with a resilient insulating material 43 which is not affected by changes of temperature. Also, the inner end of ferrule 24 is provided with conical seat 25 which coacts with a resilient grommet or washer 44 interposed between said ferrule and the upper end of barrel 15 to obviate the entrance of moisture into the latter.

There is thus provided novel means adapted for use in electrically connecting conductors and particularly for connecting conductors carrying high tension current in the ignition system of an internal combustion engine, such as the central electrode of a spark plug and the supply lead therefor. Novel means are provided whereby arcing between conductor connections and adjacent connections in radio shielding means for said conductors may be prevented, said means being adapted for quick assembly without the danger of causing damage to the parts which might result in failure during operation and for inspection and repair without the aid of any but ordinary tools.

Although only a single embodiment of the invention has been illustrated and described in detail, it is to be expressly understood that the same is not limited thereto but that various changes, such as in the design and arrangement of parts illustrated, may be made without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art. For a definition of the limits of the invention, reference is had primarily to the appended claims.

What is claimed is:

1. In apparatus of the class described, a spark plug having a center electrode, a shielding barrel surrounding said electrode and projecting beyond the end thereof and insulating means interposed between said shielding barrel and said electrode, an electrical conductor, a shielding conduit surrounding said conductor and insulated therefrom, said conductor having an end portion thereof projecting beyond said conduit into said shielding barrel, a rigid insulating sleeve surrounding the end portion of said conductor in said barrel, one end of said sleeve having abut-

ting relation with said conduit, means for securing said conductor to said sleeve adjacent the other end of the latter, said means comprising an annular element fixed in said sleeve, a metallic member secured to the end of said conductor, said member having a reduced portion slidably extending through said element and means threadedly engaging said reduced portion to secure said element and member together, resilient means for electrically connecting said last-named means and said electrode, and means for removably securing said conduit to said barrel.

2. In apparatus of the class described, a metallic shielding conduit, an electrical conductor in said conduit having a portion projecting beyond the end of the latter, means for electrically insulating said conductor from said conduit, a rigid insulating sleeve surrounding said projecting end of the conductor and butting against said conduit, an element having an opening therethrough fixedly secured in said sleeve, a metallic member soldered to the end of said conductor, said member having a portion engaging one surface of said element and a reduced threaded portion slidably extending through said opening, and a nut on said threaded portion engaging the opposite surface of said element.

3. In apparatus of the class described, an electrical conductor, radio shielding means for said conductor, means for insulating said conductor from said shielding means, a rigid insulating sleeve butting against said shielding means and surrounding a portion of said conductor projecting beyond the end of said shielding means, and means for removably securing said conductor to said sleeve including cooperating elements on said conductor and sleeve, and means threadedly engaging one of said elements to clamp a portion of the other of said elements between said threaded element and said last-named means for holding said elements in assembled relation.

4. In apparatus for connecting two radio-shielded, insulated electrical conductors in the ignition system of an internal combustion engine, the combination with one of said conductors of an insulating sleeve surrounding an end portion of said one conductor, means for removably securing said one conductor to said sleeve including an element secured to said sleeve internally thereof, a member secured to said one conductor, and means for securing said member to said element, said element and member having interfitting portions for preventing relative angular movement thereof.

5. In radio-shielded ignition apparatus for internal combustion engines or the like wherein the end portion of an insulated electrical conductor projects from one end of a metallic shielding conduit therefor, the combination with said conductor and conduit of an insulating sleeve butting against said conduit and surrounding the portion of said conductor projecting from said conduit, and means for removably securing said conductor to said sleeve including cooperating elements on said conductor and sleeve, and means threadedly engaging one of said elements and cooperating with the other of said elements to hold said elements in assembled relation.

6. In a radio-shielded ignition system for an internal combustion engine wherein two metallic shielding conduits are detachably secured together to enclose a first insulated electrical conductor projecting from one of said conduits into the other of said conduits for electrical connection with a second electrical conductor in and in-

ulated from said other conduit, the combination with said first conductor of an elongated sleeve of electrical insulating material surrounding the projecting portion of said first conductor, said sleeve having one end thereof butting against said first-named conduit, a flattened element having an opening therein secured in said sleeve adjacent the other end thereof, a metallic member secured to the end of said first conductor, said member having an externally threaded portion extending through the opening in said element and an enlarged portion engaging one surface of said element, a nut threaded onto said threaded portion into operative engagement with the other surface of said element, and resilient means adapted for electrically connecting said nut and said second conductor.

7. In radio-shielded ignition apparatus for internal combustion engines or the like wherein two metallic shielding conduits are adapted to be detachably secured together to enclose an insulated electrical conductor projecting from one of said conduits into the other, the combination with said conductor of a sleeve of insulating material surrounding the projecting end portion of said conductor, a thin washer element secured in said sleeve adjacent one end thereof, a mem-

ber abutting one face of said element and having a reduced portion extending through said element, means for securing said conductor to said member, and means removably secured to said reduced portion and cooperating with said washer element to hold said member against axial movement relative to said element.

8. In radio-shielded ignition apparatus for internal combustion engines or the like wherein two metallic shielding conduits are adapted to be detachably secured together to enclose an insulated electrical conductor projecting from one of said conduits into the other, the combination with said conductor of a tube of electrical insulating material surrounding the projecting end portion of said conductor and means for detachably connecting said tube and said conductor including an annular element fixedly secured in and across the bore of said tube, means on said conductor abutting said element and having a threaded portion extending therethrough, and means operatively engaging said threaded portion and said element to hold said conductor against longitudinal movement relative to said element.

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