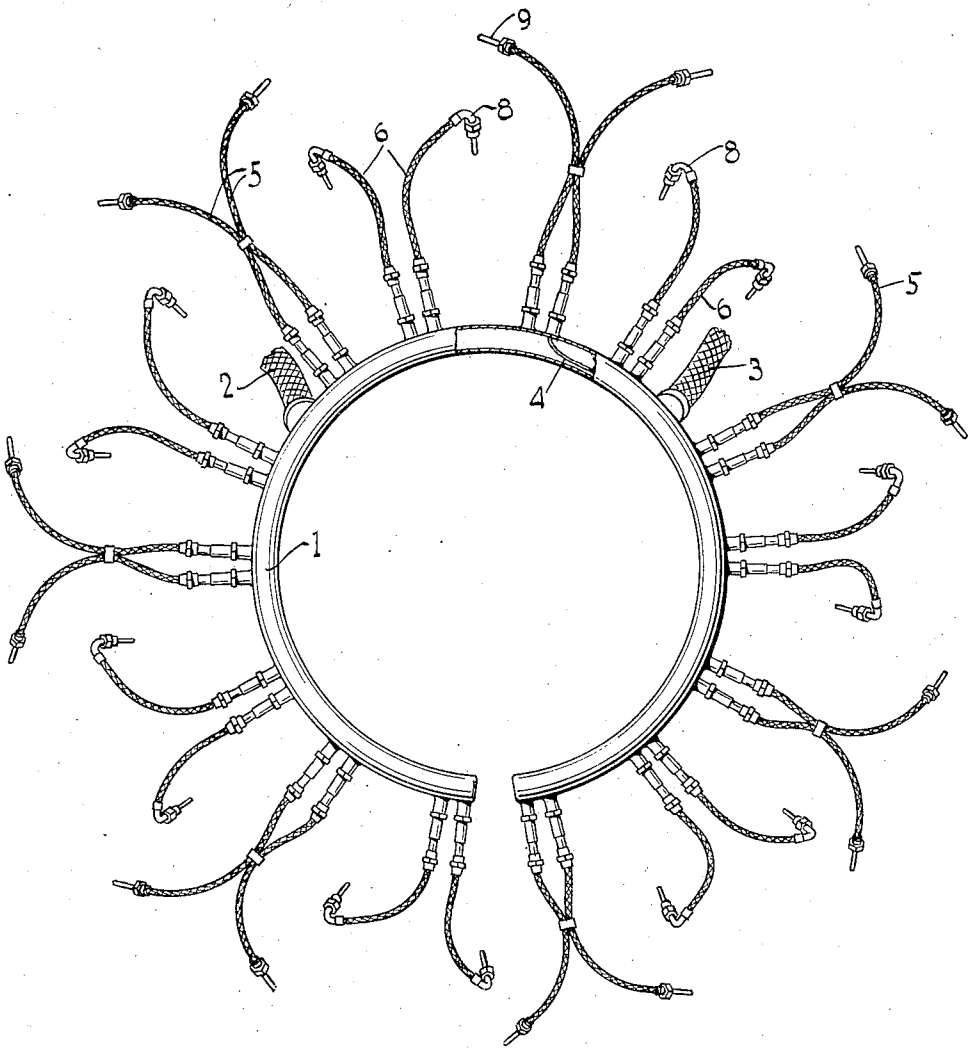
June 11, 1946. D. INGALLS 2,402,049

RADIO SHIELDED SPARK PLUG LEAD

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Fig. 1.



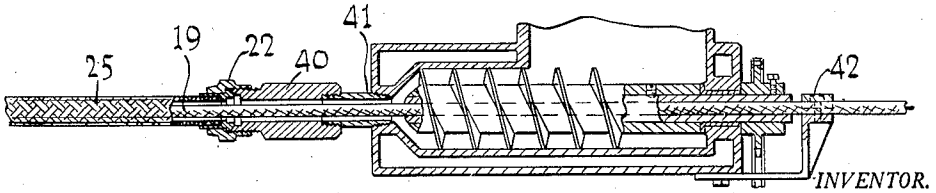


Fig. 12.

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RADIO SHIELDED SPARK PLUG LEAD

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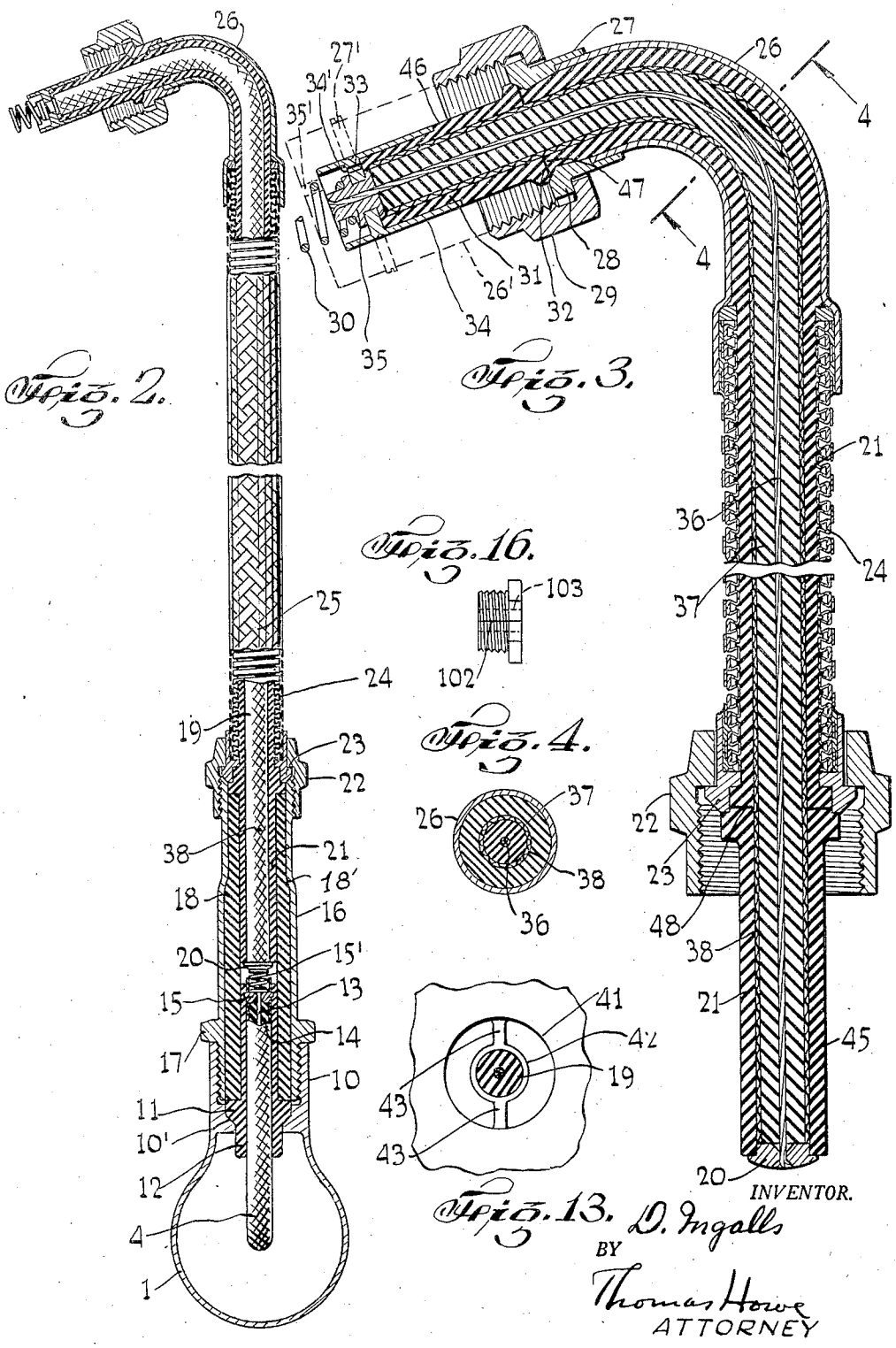


Fig. 2.

Fig. 3.

Fig. 16.

Fig. 4.

Fig. 13.

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RADIO SHIELDED SPARK PLUG LEAD

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Fig. 5.

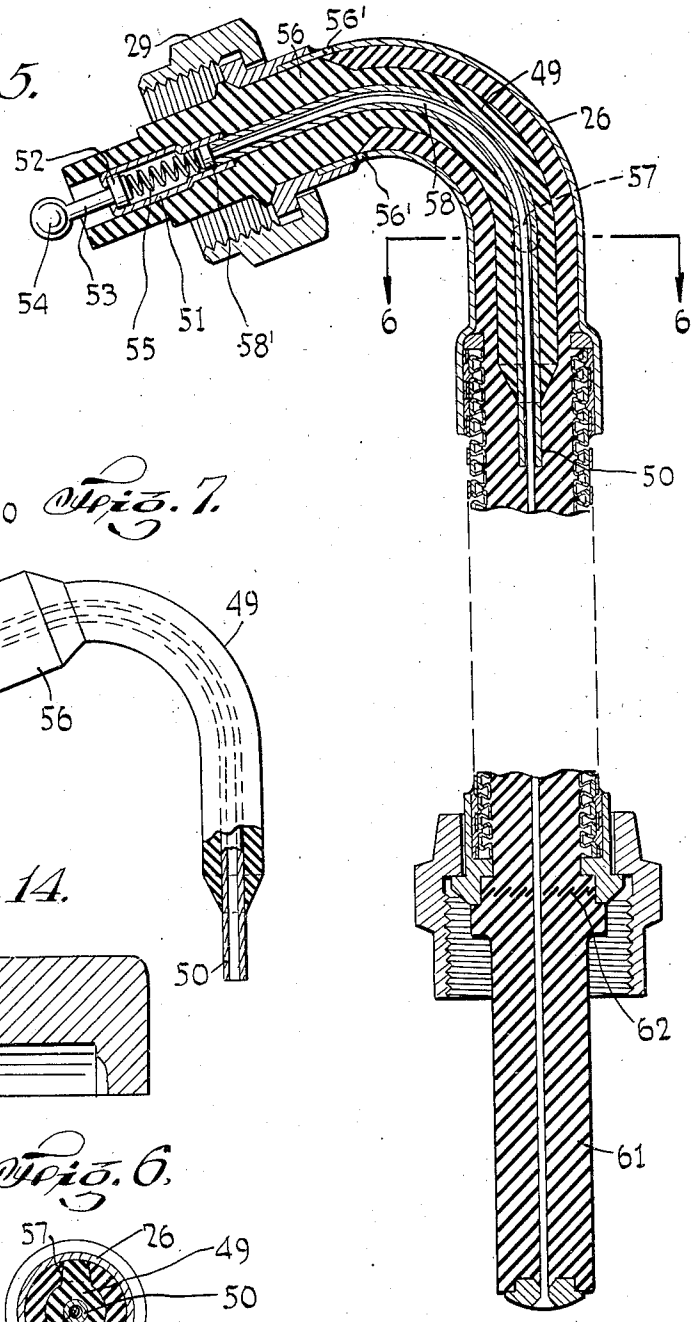


Fig. 15.

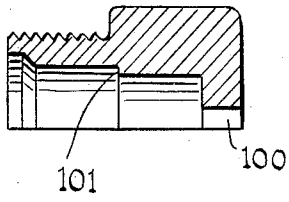


Fig. 7.

Fig. 14.

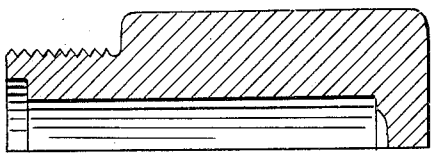
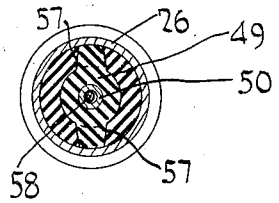


Fig. 6.



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Fig. 8.

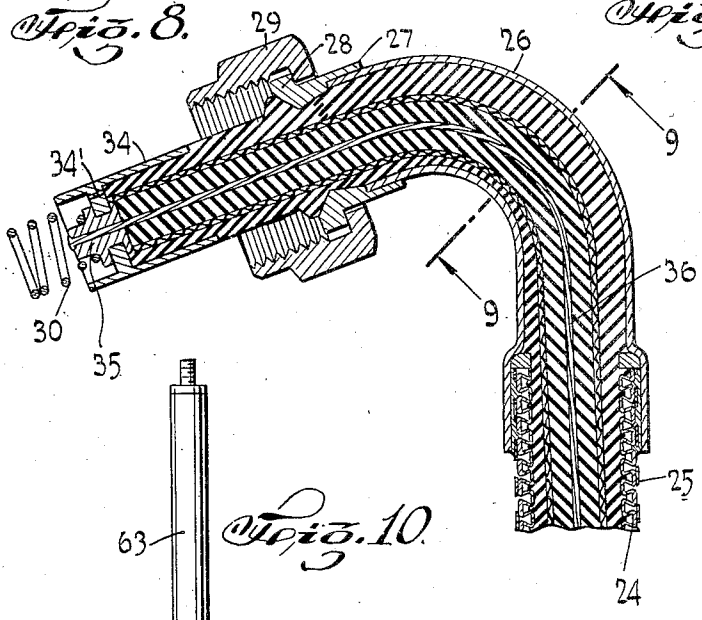


Fig. 10.

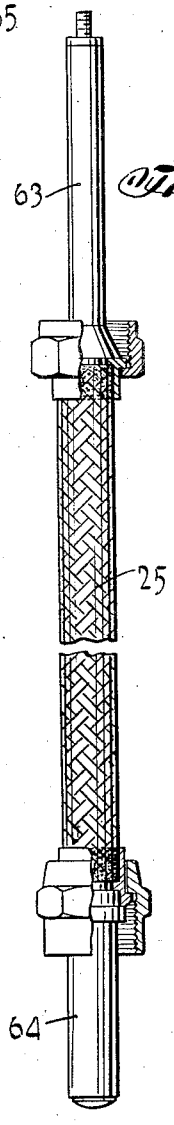


Fig. 9.

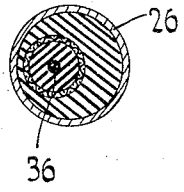
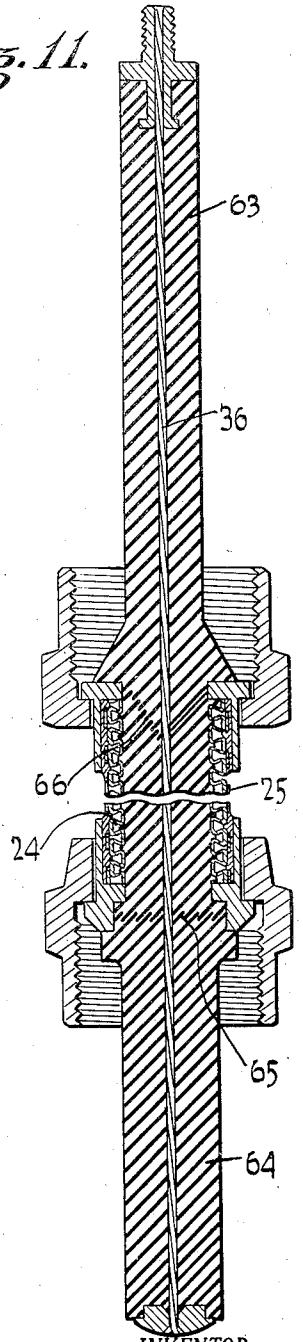


Fig. 11.



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Patented June 11, 1946 2,402,049

UNITED STATES PATENT OFFICE

2,402,049

RADIO-SHIELDED SPARK PLUG LEAD

David Ingalls, Westfield, N. J., assignor to Titeflex, Inc., Newark, N. J., a corporation of New Jersey

Application October 9, 1942, Serial No. 461,506

23 Claims. (Cl. 123—148)

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This invention relates to radio shielded spark plug leads in a radio-shielded ignition system of an internal combustion engine, which leads extend from the manifold to the individual spark plugs and whereby electrical connection is established between the ignition conductors of the manifold and the electrodes of the spark plugs and also radio shielding for the electrical conductors between the manifold and the barrels or radio shields of the spark plugs, is provided.

In radio-shielded spark plug leads as referred to, it has been found that in their use upon an internal combustion engine the spaces between the radio shielding conduit of a lead and the electrical cable therein there is liable to be present a condensate producing moisture therein and that there may be traces of chemicals therein either or both of which is likely to have a deteriorating effect upon the insulation of the electric cable whereby the insulating and other dielectric properties of the insulation may be impaired or destroyed with consequent undesirable results. The reason for the condensate and other deleterious moisture or vapors within the lead as referred to, it is believed, may be due to seepage from the engine cylinder about the spark plug or perhaps from influx of moisture from the outside atmosphere through joints which are supposed to be fluid tight but which, especially under the influence of changing altitudes, as where the apparatus is on an aeroplane, may not prove to be entirely tight. It is proposed, according to the present invention to provide an insulating filler about the electric cable and within the radio-shielding conduit of superior dielectric and other qualities which shall so occupy spaces within the conduit and about the electric cable that the noxious moistures or gases will be excluded therefrom.

The spark plug leads are especially liable to require repair or replacement because of their exposure to the heat of the adjacent engine or for other reasons. It is, therefore, of great importance that the lead, both as to its conductor cable and its shielding conduit, in other words, the spark plug lead as a whole, should be readily detachable from the spark plug and manifold so that it can be replaced by another lead with little labor and without disturbing the remainder of the ignition system. It is, therefore, an important object of the invention to provide a spark plug lead having a filling between the conductor cable and its conduit as described, which shall be complete in itself and may be independently manufactured and stored and may, at any time,

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be put into service and be readily attached to and detached from the manifold and the spark plug whereby the spark plug lead, as described, may be readily removed from its position in the ignition system and a similar spare lead may be easily inserted in place thereof.

A further object of the invention is to provide a space-filling material in the lead as described which shall be molded in position within the conduit whereby stresses or strains which would deteriorate the dielectric value of the filling material are absent as contrasted with the bending of material previously set, attention being particularly called to the filling of the spark plug elbow employed in many spark plug leads.

It is desirable that the spark plug lead should be flexible, and it is a further object of the invention to provide a lead with a molded filler as specified which shall be flexible.

It is a further object of the invention, in order to position the conductor cable within the elbow of the lead that an insert be molded, prior to its insertion into the elbow, into the shape which it is to have after its insertion within the elbow, and any spaces then remaining in the elbow may be filled by suitable insulating material molded therein. It will be observed that under these conditions neither the insert nor the filling material will be bent after being set and consequently the strains or stresses injurious to the dielectric qualities, occasioned by such bending, will be avoided.

It is a further object of the invention to have the insulation on the protruding ends of the lead adapted to be connected with the manifold and spark plug respectively, integral with the filling material of the lead. This prevents any cleavages or cracks between the end portions and the main body of the filler within the lead conduit whereby the insulation and other dielectric qualities in relation to the cable might be impaired or the parts might become dislocated.

While the filler employed for the main body of the lead may have good dielectric and other qualities and be admirably adapted for use where enclosed in the conduit, the exposed ends of insulation at the ends of the conduit may be subject to a condition to which the inner filling material is not best adapted and hence may not produce the best results if of the same material as the main filler. Thus if the exposed insulation ends are exposed to grease or oil to which the interior filler compound is not sufficiently resistant such ends might be injured. Also the exposed insulation end might be subject to greater heat or other

conditions to which the filler of the main body of the tube was not adapted. It is, therefore, a further object of the invention to provide an end or ends of the insulation, which ends are integrally joined with the main body of the filler for reasons as stated, and which end or ends are of different material from the main body of the filler within the conduit.

It is a further object of the invention to provide a main body of filler of less heat resistance, that is, becoming fluid at a lower temperature, than the ends of the insulation which are integrally joined therewith. The main body of the conduit filler substance may be of such a nature that it will be of sufficient consistency to retain itself in position within the conduit at normal temperatures, and hence during the forming operation, but will become more or less fluid from heat in service as by the heat from the engine. The ends integral with this filler, however, being of greater heat resistance will maintain their solid condition thereby holding the lead in proper relation to the spark plug and manifold and also serving to hold the main body of the filler, which has become more or less fluid under heat, within the conduit. The fluidity of the main body of the filling material will permit the conduit to freely vibrate and flex with comparative independence of the cable itself and also permit slight bends in the conduit without corresponding bends in the cable, such cable bends having a tendency to possibly deteriorate the dielectric qualities of the insulation of the cable and increase the corona possibility, and yet at all times the conduit about the cable will be filled with the filler and the objectionable condensate etc. excluded.

Other and ancillary objects of the invention will appear hereinafter.

In the construction of the radio shielded spark plug lead, the pre-formed conductor cable which is placed in the conduit usually comprises a conductor having an insulating cover thereon. Where the present invention is employed the conductor wire alone without insulation on it may be placed in the conduit. In the case where the conductor wire covered by insulation before insertion in the conduit, is employed, the filler material as referred to will be filled into the spaces outside of the insulation introduced into the conduit with the conductor, but where the bare wire without insulation upon it is introduced into the conduit, the filler will extend between the conductor and the tube. In any event the filler fills in the spaces about the conducting cable as it is pre-formed and introduced into the conduit whether or not the conductor wire of the cable has insulation pre-formed on it or not. It is to be understood that the word "cable" as used herein, unless specifically indicated otherwise, refers to the conductor structure which is introduced into the conduit whether it is the bare conductor without insulation or whether it is an insulated conductor, that is a conducting wire with insulation upon it.

In the accompanying drawings which illustrate the invention—

Fig. 1 is a front elevation, partly in section, of a radio-shielded harness for the ignition of an internal combustion engine particularly intended for aeroplanes;

Fig. 2 is a side elevation, partly broken away and partly in section, on an enlarged scale, of one of the spark plug leads of the apparatus of Fig. 1 and embodying the invention, the manifold being also shown in section to show the relationship of the spark plug lead to it, there being but one conductor shown in the manifold, other conductors serving the other leads being omitted for the sake of clearness;

Fig. 3 is a longitudinal section, on an enlarged scale, partly broken away, of the complete radio shielded spark plug lead of Fig. 2, such lead being shown in full lines, the dotted lines indicating a mold secured thereto in the formation of the lead;

Fig. 4 is a section on the line 4—4 of Fig. 3;

Fig. 5 is a longitudinal section, partly broken away, of a modified construction of the lead;

Fig. 6 is a section on the line 6—6 of Fig. 5;

Fig. 7 is a side elevation, broken away to show a longitudinal section, of a pre-molded insert for the elbow of the lead as shown in Fig. 5;

Fig. 8 is a longitudinal section of a portion of a spark plug lead embodying the invention, the remainder of the lead being broken away, showing a modified construction of the cable, conduit and filler at the lead elbow;

Fig. 9 is a section on the line 9—9 of Fig. 8;

Fig. 10 is a side elevation, partly broken away and partly in section, of a modified form of lead embodying the invention, the spark plug end being in line with the main portion of the conduit instead of being provided with an elbow;

Fig. 11 is a longitudinal section, on an enlarged scale and partly broken away, of the lead as shown in Fig. 10;

Fig. 12 is a sectional view, partly broken away and partly in elevation, showing the mold at the manifold end of the lead and the manner of securing the cable at that end and the relation of the filler extruder thereto during the filling operation;

Fig. 13 is a fragmentary view, on an enlarged scale, showing a support for the cable in the extruder exit;

Fig. 14 is a longitudinal section, on the scale of Fig. 3, of a mold half for forming an insulated end;

Fig. 15 is a similar view, on the scale of Fig. 3, of a mold half for molding another form of insulation end; and

Fig. 16 is a side elevation, on an enlarged scale, of a plug for closing a mold end.

Referring to the drawings, there is shown in Fig. 1, a radio shielding harness for the ignition conductors of an internal combustion engine which comprises, as is usual with harnesses of this type, a hollow, metal, arc-shaped manifold 1, usually located at the front of the engine receiving the ignition conductors from the magnetos through the radio shielding conduits 2 and 3. The conductors as 4 within the manifold are connected with the respective spark plugs through individual flexible spark plug leads 5 and 6, each of the leads 5 having a straight connecting plug or projection 7 for connecting with the spark plugs at the rear of the engine cylinders, while at the end of each of the leads 6 is an elbow 8 through which the plug or projection 9 for connecting with the spark plug at the front of an engine cylinder is connected. While the manifold will contain conductors sufficient to serve all of the spark plugs, but a single conductor is shown in the drawing, the others being omitted for the sake of clearness.

At each of the points of connection of the spark plug leads with a manifold, the manifold is provided (see Fig. 2) with an outlet socket 10 which is internally threaded and has an inwardly extending flange having the inclined face 10' upon

which rests the flange 11 on the soft rubber sleeve 12. The cable 4 comprising the metal conductor 13 (usually stranded for additional flexibility) and the rubber compound insulation 14 thereon as is usual with insulated wires or cables, is tightly fitted in the sleeve 12 and has a metal terminal 15 connected to the end of the conductor 13 and bearing against the end of the insulation 14 and within the rubber sleeve 12. Secured to the terminal 15 and in good electrical connection therewith is a metal spring 15'.

The metal sleeve 16, rotatable by means of a wrenchhold 17 of hexagonal periphery, is screw-threaded in the member 10 and has the insulating line 18 of molded "Bakelite" or other suitable insulating material. When the sleeve 16 and its insulating lining are screwed down against the flange 11, this flange acts as a gasket against the inclined face 10' and thereby seals off all communication from the interior of the manifold 1 through the socket 9 and also forces sleeve 12 tightly against the exterior of the cable 4 whereby the cable is firmly held and all openings between the sleeve and the cable are firmly sealed and closed.

The cable 19 of the spark plug lead is similar to the cable 4 and comprises the conductor 36 and the insulation 37 thereon. Braided tightly on the outside of the insulation 37 is a braid 38 of cotton or other non-metallic material, this braid and the exterior of the cable being covered by a lacquer. The cable 19 has secured to the end of its conductor a terminal 20 which, when the spark plug lead is in attached position, bears against the spring 15' whereby the conductor 4 of the manifold and the conductor of the cable 19 of the spark plug lead are detachably connected together, it being obvious that if the lead be detached and the cable 19 moved away, the terminal 20 and the spring 15' will be mechanically separated and the electrical connection between them broken.

The detachable spark plug lead comprises the cable 19 surrounded by suitable insulating material or filler 21 (which will be more particularly referred to hereafter) telescoping within the sleeve 18, the lead being secured to the metal body 16 by means of a nut 22 screw-threaded to the body 16 and engaging with a shoulder on the metal ferrule 23. This ferrule is soldered to a conduit comprising the flexible, metal, strip-formed, helically-corrugated tube 24 which may be as shown and described in Patent No. 1,198,392, Louis H. Brinkman, September 12, 1916, which tube is ordinarily tight and strong but may have solder in its seam for insuring tightness and strength, as shown and described in the Patent No. 2,127,943, R. H. Stone, August 23, 1938, such conduit also comprising a braided covering 25 of metal strands as shown and described with relation to Fig. 5 of the Patent No. 1,340,818, L. H. Brinkman, May 18, 1920.

In detaching the spark plug lead from the manifold the sleeve 18 of insulation might be drawn out of or dislocated in the metal sleeve 16 as the projecting cable end surrounded by the filler 21 is withdrawn therefrom if some means were not provided to prevent it. To prevent the accidental withdrawal or dislocation of the sleeve 18 with relation to the sleeve 16 as referred to, a shoulder 18' is formed upon the inside of the sleeve 16 by making the outward (away from the manifold) portion of the sleeve of less inside diameter than the inward portion (nearer the manifold). The insulating sleeve 18 having a corresponding shoulder which comes against the shoulder 18', the part of the sleeve 18 inwardly of the shoulder being of greater outside diameter than the portion of the sleeve outwardly of the shoulder, the sleeve 18 is effectively held against moving outwardly with relation to the metal sleeve 16, but when the metal sleeve 16 with the insulating lining sleeve 18 are disconnected from the manifold, the sleeve 18 may be readily removed, and a new one inserted, through the larger end of the sleeve 16.

The metal spark plug lead conduit comprises at its other (spark plug) end a metal elbow 26 which is soldered at one end to the corrugated tube and braid as described. At its other end the elbow has the ferrule 27 soldered to it. This ferrule 27 has a flange 28 engaged by a nut 29 by which the elbow is secured to the shielding barrel or cylinder of a spark plug in the manner as shown and described in the Patent No. 2,278,448, D. Ingalls, April 7, 1942. As in the Patent No. 2,278,448, the insulated conductor or cable 19 is adapted to extend within the metal shielding barrel or cylinder for the spark plug, and the conductor for the cable is provided with a spring 30 for making contact with the spark plug electrode when the elbow is secured to the spark plug shielding cylinder by the nut 29 as described. It will be observed that the protruding end of the cable 19 is surrounded by suitable insulation 31 having the shoulder 32 which is borne against by the ferrule 27 so as to form a stop limiting the inward movement of the insulating sleeve and enclosed cable and insuring that the cable and its surrounding insulation will be carried along with the nut as it is screwed home upon the metal shielding sleeve on the spark plug, the conductor of the cable 19 being secured to the hollow metal terminal 35 secured in the diaphragm 33 integral with the ferrule 34 of ceramic material about the end of the insulation 31 and fitting into a recess therein.

The space within the corrugated tube 24 and the metal elbow 26 not occupied by the cable 19 is substantially filled with the insulating material 21 of suitable dielectric and heat and corona resisting properties as well as other necessary and desirable characteristics whereby the objectionable condensate or other noxious elements are excluded from the conduit. Such a material is rubber or compounds thereof, such as is used for the insulation on flexible insulated wires, or rubber-like material, such as a synthetic rubber, for instance neoprene or compounds thereof. Other suitable plastics or moldable insulating materials having the desired dielectric and other properties might be employed. In forming the lead the cable 19 is secured at one end to the terminal 35 and the ferrule with the end of the cable is inserted into the mold 26' in which it closely fits. This mold is tightly drawn against the flange 28 by means of a nut 29 with which it is in screw-threaded engagement, its interior being cylindrical except that at its inner end it conforms to the shape of the shoulder 32. The ferrule is thrust to the bottom of the mold and secured therein by the set screws 27'. The spring 30 is omitted during this operation of forming the lead. The cable 19 in this forming operation passes through the elbow 26, the tube 24 and the mold 40 which is connected with the exit 41 of an extruder, and thence through the extruder screw to a clamp 42 in line with the tube 24. The cable in and adjacent to the ferrule 34, by reason of its stiffness, and being secured

to the ferrule, tends to extend in a direction axially of the ferrule. That portion of the cable, however, passing through the tube **24** is placed under tension a suitable amount by pulling upon the cable at the right of the clamp **42** (see Fig. 12) and when the desired cable position and tension has been attained is secured by closing the clamp **42** upon the cable. This tension in the cable will draw the upper end of the curved portion within the elbow toward the inner side of the elbow and will position the cable through the tube **24** in a more or less central position by reason of the cable stiffness and tension. If, however, it deviates from a central position the consequences will not be of great importance and the cable when insulated as shown may even come against the metal conduit as, regardless of the position of the cable the filler will substantially fill the spaces in the conduit not occupied by the cable so that condensate or injurious elements as referred to are excluded from the conduit. The pull of the cable within the conduit upon the inner end of the curved cable within the elbow may draw the cable closer to the inside than the outside of the elbow as shown for instance in Fig. 8. The result of this construction is that the thickness of the insulating filler compound between the cable and the outside of the elbow is greater than that between the cable and the inside of the elbow. This strengthens the dielectric and insulating properties of the filler at an advantageous location in that the tensional stresses on the cable insulation is greatest at its outer side which detracts from its insulating and break-down resisting properties at the outer side of its bend with greater possibilities of break-down at that location. The thickening of the insulation filler at the outer side of the bend counteracts the liability of such break-down.

The mold **40** is secured at one end to the conduit to be filled by means of the nut **22** and at the other end with the exit **41** of the extruder. If necessary or desirable a further support for the cable **19** may be provided in the exit **41** of the extruder by means of a hub (see Fig. 13) **42** supported from the walls of the exit by spokes **43** between which the extruded filler material may pass. The parts being in position and the cable having been adjusted as described, the filler material is extruded from the extruder through the mold **40**, the conduit, including the tube **24** and the elbow, into the mold **26'** and within the ferrule **34**, the condition and manner of extruding such materials being well understood in the art. To permit ready influx of the extruded material one or more vents as **34'** may be provided in the ferrule diaphragm **33** and one or more vents **35'** in the bottom of the mold **26'**. The conduit and molds having been filled, the mold **40** is detached from the extruder outlet and the cable **19** severed. A plug (see Fig. 16) split at the plane **102** and having the central circular channel **103** for the passage of the cable, is then screwed into the end of the mold **40** to prevent escape of the extruded material, such plug fitting closely about the cable which extends outside the mold and is cleaned of extruded material outside the mold cavity. The whole filled structure comprising the conduit and molds is then subjected to suitable heat and the filler of rubber or rubber-like materials or compounds thereof is "cured" as is well understood. Even without "curing," although its properties are improved thereby, the extruded material will be

molded in position and will substantially fill the voids in the conduit and exclude the undesirable condensate, etc., from the conduit. After the curing and setting of the filling material, the molds **26'** and **40** are removed, the terminal **20** is secured to the conductor **36** of the cable at the end of the insulation **45** protruding outside the ferrule **23** at the manifold end and formed within the mold **40**, and the spring **30** at the spark plug end, for establishing connection of the cable conductor with the spark plug electrode, is secured to the terminal **34**, the insulating material **46** which protrudes beyond the metal conduit having been formed in the mold **26'**. The detachable spark plug lead is thus complete as a self-contained, filled, radio-shielded structure which is readily attachable and detachable to and from the manifold so as to be placed in stock or used as spare, and is readily assembled in the ignition system and may be readily placed in position to replace an injured or deteriorated spark plug lead which may be as readily removed.

The treatment of the filler as described insures the removal of stresses and strains therein and causes it to be accurately molded in the spaces of the conduit and in the projections beyond the conduit which are molded integral with the filler on the interior of the conduit, the material from the end of the projection at one end through the conduit and to the end of the projecting material at the other end, being integral; also, the filling material being molded substantially in the position which it occupies in the finished structure, there is no bending of the material after it has become set whereby stresses or strains would be developed in it thereby impairing its qualities as a dielectric and rendering it more liable to damage by corona effect and from other causes.

The forming of the protruding portions of the filler compound integral with the filler within the conduit is an important feature as insuring mechanical strength and guarding against mal-adjustment or separation of the parts whereby the insulation and other electrical characteristics might be seriously impaired.

The provision of the slick but somewhat roughened surface upon the exterior of the insulation of the cable as before referred to, prevents sticking of the entering extruded rubber-like filling material so that there is assurance of the proper passage of the rubber of the material along the cable within the conduit, but the roughened surface opposes some resistance to the passage of the incoming material so that a tendency is created to cause the filler to move radially outwardly toward the inner wall of the metal conduit as well as longitudinally; also this roughness provides a certain amount of interlocking between the filler material and the cable whereby resistance to relative longitudinal movement is increased in the completed structure.

The filler about the cable in the lead will substantially fill the space within the conduit not occupied by the cable no matter what the position of the cable within the conduit may be, even extending into the corrugation of the flexible metal tube, so that all condensate and undesirable elements are excluded from the conduit. Even if there should be some small spaces in the corrugations not filled by the filler, such spaces will be sealed off so as to exclude the condensate, etc., therefrom.

It will be observed that the conductor of the spark plug lead as described will be entirely radio-

shielded, the projections beyond the metal conduit being shielded at the spark plug end by being within the metal barrel of the spark plug and at the manifold end by being within the metal sleeve 16 of the connecting body for the detachable lead, also the lead will be flexible by reason of the facts that the corrugated flexible tube 24 and its braided covering 25 are flexible, the filler 21 of rubber-like material is also flexible and the cable 19 is flexible; and further the cable is securely insulated and superior dielectric properties and resistance to corona effect are provided by the filler between the metal conduit and the cable.

Natural rubber and compounds thereof have certain characteristics which are not found in certain rubber-like materials such as synthetic rubbers, for instance neoprene. While a rubber compound forms a good filler within the conduit as referred to, the protuberances of insulation beyond the end of the conduit are exposed when the lead is detached from the spark plug and manifold, and inasmuch as natural rubber is liable to be deteriorated by coming in contact with gasolene, grease or other petroleum products, and the synthetic product neoprene is not subject to such deteriorating influence, it is often desirable that one or both of the projections of insulation beyond the ends of the conduit shall be of neoprene, while the filler upon the inside of the conduit may be of a rubber compound. Accordingly the lead may be made with the extruded rubber compound within the conduit between the planes 47 and 48 thus terminating at substantially the ends of the conduit, being only slightly within such ends. The protruding cable covering insulation 45 and 46 outside the planes 47 and 48 may be of neoprene, the neoprene coalescing with or being integrally joined with the conduit filling rubber compound, all the exposed cable covering insulation outside the conduit being neoprene. In constructing such a lead the cable is placed within the conduit, being secured to the extruder at the manifold end, and, at the spark plug end of the conduit, the cable projects beyond the conduit by a suitable amount, this cable end not being supplied with the ferrule nor secured in any way, and the conduit is secured to the extruder. The rubber compound is then extruded into the conduit about the cable until it reaches the plane 47. The conduit is then detached from the extruder and the cable severed at the appropriate length. All rubber compound is then cleaned from the cable outside the plane 48 and the contact terminal 30 is secured to the end of the cable conductor 38.

The portion of the cable extending outside the plane 48 is then wrapped with the requisite neoprene and that portion of the cable at the spark plug end which is outside the plane 47, the ferrule, terminal and spring being absent, is also wrapped with neoprene. The neoprene on each of the ends is then molded to the desired shape by placing thereabout a longitudinally split mold which has screw threads at its ends upon its exterior. The split mold about the end 45 is of exactly similar halves, one of which is illustrated in Fig. 14. These halves are clamped together about the neoprene and the closed mold is firmly secured in position at the end of the conduit by means of the nut 22 engaging with its threads and similarly the split mold at the spark plug end is of two exactly similar halves, one of which is illustrated in Fig. 15. These halves are clamped together about the neoprene and the closed mold is held firmly by the nut 29. The split mold at the spark plug end has in each half (see Fig. 15) the semi-circular opening which with the similar opening in the other mold half forms a round hole through which the cable passes with a reasonably tight fit. Also the mold is adapted by the shoulder 101 within the mold to form the recess in the end of the neoprene into which the ferrule 34 fits. The entire assembly, with the split molds attached, is then subjected to molding and curing heat. After such heating the rubber compound and neoprene are given an opportunity to set after which the split molds are removed.

By the operations as described the neoprene which, at each end, contacts with the main filler rubber compound through the inner open end of the mold, coalesces with such compound so that in the complete lead the neoprene at each end is integral with the rubber compound. The split molds having been removed as stated, and the cable cut to a suitable length, the cable conductor is suitably bared of insulation, the ferrule 34 is placed in the recess about the end of the neoprene and the conductor of the cable is secured to the terminal 35 secured to the ferrule so that the ferrule and terminal are secured to the end of the cable. The spring 30 is then secured to the terminal 35.

The material of the projecting ends of the molded insulation might be of other material than neoprene to meet desired conditions and also the material of the filler within the conduit might be varied whereby the desired dielectric, corona resisting, heat resisting or other properties are produced at desired points of the lead.

Referring to Figs. 5, 6 and 7, there is therein shown a modified form of detachable lead which is the same as shown and described in connection with Figs. 2 to 4 except that the arrangement and construction at the spark plug or elbow end is modified, and further that the cable is simply a conductor without insulation thereon, the filler about the cable coming directly against the conductor. A separately molded structure as shown in Fig. 7 is made by separately molding neoprene or other suitable insulating material 49 about a metal tube 50 having secured to it at one end a larger metal tube 51 to provide a recess for receiving a spring and plunger as will now be referred to.

Within the tube 51 is a piston 52 connected by a neck 53 with the contact ball 54 adapted to be pressed against the electrode of the spark plug by a spring 55 interposed between the metal head 53' electrically secured to the end of the conductor 38, and the piston 52. The edge of the tube 51 is bent inwardly beneath the piston to retain the piston within the tube. The premolded neoprene member as shown in Fig. 7 is inserted endwise into the elbow portion into the position as shown in Fig. 5, being centered within the elbow by means of the enlarged portion 56 which fits within the end of the metal elbow 26, while adjacent its other end projections 57 extending from the neoprene fit within the end of the elbow 26. The rubber-like filler extruded about the cable will pass between the projections 57 and fill the elbow about the neoprene 49 until it comes against the shoulder 60 on the neoprene. One or more vents 56' may be provided for allowing the extruded material to readily reach all points desired. The device may then be cured as described in connection with the structure of Figs. 2 and 3 when the extruded filler and the

separately molded part will coalesce and become integral.

It will be seen that by the arrangement of the insert of the separately molded neoprene part (Fig. 7) in the elbow 26, the conductor will be accurately, centrally positioned. Also the inserted molded part being separately molded and not bent after being set, and the insulating filler about the insert being molded in the elbow, neither the insert nor the insulating filler will be bent after being set, so that no deleterious stresses or strains will be imposed upon them such as would be caused by bending after the material had become set.

At the manifold end (opposite the elbow) the protruding projection 61 of different material having the desired characteristics and integrally joined with the filler within the conduit, as for instance at the plane 62, may be formed in the same manner as the projecting end of neoprene at the manifold end of the lead of Figs. 2 and 3.

While the cable of the structure of Fig. 5 has been shown and described as simply a conductor (without insulation) it will be apparent that the cable might also include insulation as in the cable of Figs. 2 and 3, with the conductor bared of such insulation to enable it to pass through the tube 50.

Referring now to Figs. 10 and 11, there is therein shown a lead the same as in Figs. 2 and 3 except that the cable consists of the conductor only without insulation, except that the insulation and the conductor protruding from the spark plug end of the conduit, namely the protuberance 63, is in line with the straight portion of the conduit rather than extending from an elbow and except that the joint of the insulation on the spark plug protuberance 63 with the main filler compound is cone-shaped. As in the structures of Figs. 2 and 3, the insulation protuberance 64 at the manifold end of the lead may be of a different material from the filler within the conduit and integrally joined thereto at a plane as 65 within the conduit. Also the insulation of the protuberance 63 may be of a different material from the filler within the conduit and integrally joined therewith within the conduit along the cone-shaped surface 66 in a similar manner, the cone-shaped surface providing a larger area of engagement between the protuberance and the filler within the conduit.

It may be of advantage in some conditions and under some circumstances, to employ a filler for the radio shielding conduit of the lead which shall be a suitable fluid instead of a set substance, such as the rubber-like compounds hereinbefore referred to, the fluid substantially filling the conduit and excluding therefrom undesirable condensate etc. as before referred to. The fluid filler allows relative movement of the cable and conduit to a limited extent thereby rendering the lead more flexible and reducing the vibration and flexing of the cable itself as the conduit vibrates and flexes, small bends in the conduit not necessarily causing a similar bend in the cable, and under all conditions the fluid filler will substantially occupy the space in the conduit not occupied by the cable. The filler, fluid under operating conditions, may be realized by the use of a material as the main filler in the conduit which has sufficient body to be retained therein while the protruding end insulators are molded thereon as before referred to, but which material will become more or less fluid when the operation of the adjacent engine or other cause increases the temperature of the lead.

Vinylite resins are admirable material for such a filler, having a body permitting manufacture and becoming more or less fluid at higher temperatures and also possessing desirable dielectric and insulating properties. The main body of the lead may be filled with vinylite, neoprene ends molded thereto and the whole heated to cause the necessary curing. The vinylite will become quite fluid at 150° F. but will be prevented from leaking out of the lead by the molded neoprene ends which remain solid at that temperature.

While the invention has been illustrated in what are considered its best applications it may have other embodiments without departing from its spirit and is not, therefore, limited to the structures shown in the drawings.

What I claim is:

1. A detachable radio-shielded spark plug lead for connecting a manifold conductor with a spark plug, comprising in combination a metal conduit adapted at its ends to be connected with a spark plug shield and the manifold respectively, a cable within said conduit, the conductor of said cable having terminals at its ends adapted to engage respectively with a spark plug electrode and a manifold conductor terminal and insulating filling material in said conduit and rendering space therein not occupied by said cable substantially filled whereby deleterious elements are excluded from said conduit and an insulation end projecting outside said conduit at each of the conduit ends, said insulation ends being integral with the first mentioned insulating material said terminals being located on said projecting insulation ends.

2. A detachable radio-shielded spark plug lead for connecting a manifold conductor with a spark plug, comprising in combination a flexible metal conduit adapted at its ends to be connected with a spark plug shield and the manifold respectively, a cable within said conduit, the conductor of said cable having terminals at its ends adapted to engage respectively with a spark plug electrode and a manifold conductor terminal and non-fluent, flexible, insulating filling material in said conduit and rendering space therein not occupied by said cable substantially filled whereby deleterious elements are excluded from said conduit, and insulation ends projecting outside the conduit at both ends thereof, said insulation ends being integral with the first mentioned insulating material.

3. A detachable radio-shielded spark plug lead for connecting a manifold conductor with a spark plug, comprising in combination a metal conduit adapted at its ends to be connected with a spark plug shield and the manifold respectively, a cable within said conduit, the conductor of said cable having terminals at its ends adapted to engage respectively with a spark plug electrode and a manifold conductor terminal and insulating filling material in said conduit and rendering space therein not occupied by said cable substantially filled whereby deleterious elements are excluded from said conduit and an insulation end projecting outside said conduit and of a different material from that of the aforesaid insulating material and integral therewith.

4. A detachable radio-shielded spark plug lead for connecting a manifold conductor with a spark plug, comprising in combination a metal conduit adapted at its ends to be connected with a spark plug shield and the manifold respectively, a cable within said conduit, the conductor of said cable having terminals at its ends adapted to engage respectively with a spark plug electrode and a

manifold conductor terminal and insulating filling material in said conduit and rendering space therein not occupied by said cable substantially filled whereby deleterious elements are excluded from said conduit, and insulation ends projecting outside the conduit at both ends thereof and of different material from the first mentioned insulating material and integral therewith.

5. A detachable radio-shielded spark plug lead for connecting a manifold conductor with a spark plug, comprising in combination a metal conduit adapted at its ends to be connected with a spark plug shield and the manifold respectively, a cable within said conduit, the conductor of said cable having terminals at its ends adapted to engage respectively with a spark plug electrode and a manifold conductor terminal and insulating filling material in said conduit and rendering space therein not occupied by said cable substantially filled whereby deleterious elements are excluded from said conduit, said conduit comprising an elbow and said cable being closer to the inside than the outside of said elbow.

6. A detachable radio-shielded spark plug lead for connecting a manifold conductor with a spark plug, comprising in combination a metal conduit adapted at its ends to be connected with a spark plug shield and the manifold respectively, a cable within said conduit, the conductor of said cable having terminals at its ends adapted to engage respectively with a spark plug electrode and a manifold conductor terminal and insulating filling material in said conduit and rendering space therein not occupied by said cable substantially filled whereby deleterious elements are excluded from said conduit, said conduit comprising an elbow and a separately molded insert therein.

7. A detachable radio-shielded spark plug lead for connecting a manifold conductor with a spark plug, comprising in combination a metal conduit adapted at its ends to be connected with a spark plug shield and the manifold respectively, a cable within said conduit, the conductor of said cable having terminals at its ends adapted to engage respectively with a spark plug electrode and a manifold conductor terminal and insulating filling material in said conduit and rendering space therein not occupied by said cable substantially filled whereby deleterious elements are excluded from said conduit, the said filling material having ends joined thereto which become fluid at a higher temperature than said insulating filling material.

8. In a radio shielded ignition system for an internal combustion engine the combination with a radio shielding manifold casing, of a conductor therein having a terminal adapted to be connected with the cable of a spark plug lead, a spark plug lead detachable from said manifold and comprising a metal radio shielding conduit and a cable therein and projecting therefrom and a terminal for connecting said cable with the aforesaid terminal of the conductor within the manifold, means for connecting said spark plug lead with said manifold comprising a metal sleeve and an insulating lining sleeve therein, means for detachably connecting said metal sleeve to said manifold, means for detachably connecting said metal sleeve to said conduit of the spark plug lead, the end of said cable extending within said insulating lining sleeve, and means for preventing withdrawal outwardly of said lining sleeve from said metal sleeve.

9. In a radio shielded ignition system for an internal combustion engine the combination with a radio shielding manifold casing, of a conductor therein having a terminal adapted to be connected with the cable of a spark plug lead, a spark plug lead detachable from said manifold and comprising a metal radio shielding conduit and a cable therein and projecting therefrom and a terminal for connecting said cable with the aforesaid terminal of the conductor within the manifold, means for connecting said spark plug lead with said manifold comprising a metal sleeve, and an insulating lining sleeve therein, means for detachably connecting said metal sleeve to said manifold, and means for detachably connecting said metal sleeve to said conduit of the spark plug lead, the end of said cable extending within said insulating lining sleeve, said metal sleeve having an inward projection engaging said insulating sleeve to prevent withdrawal outwardly of said lining sleeve from said metal sleeve.

10. In a radio shielded ignition system for an internal combustion engine the combination with a radio shielding manifold casing, of a conductor therein having a terminal adapted to be connected with the cable of a spark plug lead, a spark plug lead detachable from said manifold and comprising a metal radio shielding conduit and a cable therein and projecting therefrom and a terminal for connecting said cable with the aforesaid terminal of the conductor within the manifold, means for connecting said spark plug lead with said manifold comprising a metal sleeve, an insulating lining sleeve therein, and means for detachably connecting said metal sleeve to said conduit of the spark plug lead, the end of said cable extending within said insulating lining sleeve, said metal sleeve being of different internal diameters and having its larger diameter inwardly of its smaller diameter and said insulating lining sleeve being of different external diameters with its larger diameter inwardly of its smaller diameter.

11. In a radio shielded ignition system for an internal combustion engine the combination with a radio shielding manifold casing, of a conductor therein having a terminal adapted to be connected with the cable of a spark plug lead, a spark plug lead detachable from said manifold and comprising a metal radio shielding conduit and a cable therein and projecting therefrom and a terminal for connecting said cable with the aforesaid terminal of the conductor within the manifold, means for connecting said spark plug lead with said manifold comprising a metal sleeve, an insulating lining sleeve therein, means for detachably connecting said metal sleeve to said manifold, and means for detachably connecting said metal sleeve to said conduit of the spark plug lead, the end of said cable extending within said insulating lining sleeve, said metal sleeve having both its interior and exterior diameters, outwardly away from said manifold, greater than its inside and outside diameters, respectively, adjacent the manifold and said insulating lining sleeve having a portion adjacent said manifold of greater exterior diameter than a portion outwardly thereof, whereby engaging shoulders are formed on said metal sleeve and said insulating lining sleeve.

12. A detachable radio-shielded spark plug lead for connecting a manifold conductor with a spark plug, comprising in combination a metal conduit adapted at its ends to be connected with a spark plug shield, and the manifold respectively, a cable within said conduit, the conductor

of said cable having terminals at its ends adapted to engage respectively with a spark plug electrode and a manifold conductor terminal and insulating filling material in said conduit and rendering space therein not occupied by said cable substantially filled whereby deleterious elements are excluded from said conduit and an insulation end projecting outside said conduit at each of the ends of said conduit, said terminals being located on said projecting insulation ends.

13. A radio shielded spark plug lead for internal combustion engines comprising, in combination, a fluid tight radio shielding conduit, an insulated conductor partially within and projecting from said conduit, means to connect said conduit with a spark plug shield, additional flexible resilient insulating material molded around the entire length of the conductor and filling the entire space between the conductor and conduit, the additional insulation projecting from the conduit being integrally molded with the additional insulation within the conduit, and a flexible resilient insulating shoulder integral with the additional insulation at the end of the conduit.

14. A detachable radio shielded spark plug lead for internal combustion engines comprising in combination a fluid tight radio shielding conduit, an insulated conductor partially within and projecting from said conduit and having open terminals on its ends, means to connect said conduit with a spark plug shield and an ignition manifold, additional flexible resilient insulating material molded around the entire length of the conductor and filling the entire space between the conductor and conduit, the additional insulation projecting from the conduit being integrally molded with the additional insulation within the conduit, and flexible resilient insulating shoulders integral with the additional insulation at the ends of the conduit.

15. A radio shielded spark plug lead for internal combustion engines comprising in combination a fluid tight radio shielding conduit, an insulated conductor partially within and projecting from said conduit, means to connect said conduit with a spark plug shield, additional flexible resilient insulating material molded around the entire length of the conductor and filling the entire space between the conductor and conduit, the additional insulation projecting from the conduit being of a composition different from but integrally molded with the additional insulation within the conduit.

16. A detachable radio shielded spark plug lead for an internal combustion engine comprising, in combination, a flexible metallic fluid tight conduit, fittings at the ends thereof, an insulated conductor within the conduit and projecting from the ends thereof having open terminals on its ends, additional moldable insulating material filling the space between the conductor and the conduit and surrounding the projecting ends of the conductor, said additional insulating material within the conduit being of a composition which hardens less readily during vulcanizing than the additional insulating material which surrounds the projecting ends of the conductor.

17. A detachable radio shielded spark plug lead for an internal combustion engine comprising, in combination, a flexible metallic fluid tight conduit, fittings at the ends thereof, an insulated conductor within the conduit and projecting from the ends thereof having open terminals on its ends, additional moldable insulating material filling the space between the conductor and the conduit and surrounding the projecting ends of the conductor, the said additional insulating material within the conduit being of a composition different from that of the additional insulating material surrounding the projecting ends of the conductor, and the latter being more resistant to heat than the former.

18. A detachable radio shielded spark plug lead for an internal combustion engine comprising, in combination, a flexible metallic fluid tight conduit, fittings at the ends thereof, an insulated conductor within the conduit and projecting from the ends thereof having open terminals on its ends, additional moldable insulating material filling the space between the conductor and the conduit and surrounding the projecting ends of the conductor, and a gasket-like annular projection formed in the additional insulating material at each end of the conduit.

19. A connector for a radio shielded spark plug lead having a fluid-tight conduit surrounding an insulated conductor which projects from the end thereof thru a fitting by which the conduit is attached to a spark plug comprising in combination a yieldable insulated plug-in portion projecting from the end of said fitting, the insulation of which is molded integrally with the insulation of the conductor and which extends upwardly into the fitting and a yieldable resilient insulating shoulder integral with said plug-in connector insulation at the location of the initial projection of the plug-in portion from the conduit.

20. A connector for a radio shielded spark plug lead having a fluid tight conduit surrounding an insulated conductor which projects from the end thereof thru a fitting by which the conduit is attached to a spark plug comprising in combination a yieldable insulated plug-in portion projecting from the end of said fitting, the insulation of which is molded integrally with the insulation of the conductor and which extends upwardly into the fitting and a threaded conducting stud molded within said plug-in portion for associating the conductor with an electrode of a shielded spark plug.

21. A radio shielded spark plug lead for internal combustion engines comprising, in combination, a fluid tight radio shielding conduit, a conductor covered with flexible insulating material of sufficient strength to insulate the conductor and the metal shielding conduit from each other should the two parts become axially displaced from each other rather than situated in co-axial relationship, said conductor partially within and projecting from said conduit, means to connect said conduit with a spark plug shield, additional flexible resilient insulating material molded around the entire length of the conductor and filling the entire space between the conductor and conduit, the additional insulation projecting from the conduit being of a composition different from but integrally molded with the additional insulation within the conduit.

22. A radio shielded spark plug lead for internal combustion engines comprising, in combination, a fluid tight radio shielding conduit, an insulated conductor partially within and projecting from said conduit, means to connect said conduit with a spark plug shield, additional flexible resilient insulating material molded around the entire space between the conductor and conduit, the additional insulation projecting from the conduit being of a composition different from but integrally molded with the additional insula-

tion within the conduit, the junction between the internal and external additional insulation effected along a cone shaped area of such a shape that any line drawn along the junction from the conductor to the conduit is longer than the radial distance between the two.

23. A radio shielded spark plug lead for an internal combustion engine comprising, in combination, a fluid tight radio shielding conduit, a cable partially within and projecting from the

end of said conduit, means to connect said conduit with a spark plug shield, flexible resilient material moulded around the entire length of the cable filling the entire space between the cable and conduit and projecting from the end of the conduit, and a flexible resilient insulating shoulder integral with the insulating material at the end of the conduit.

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