March 6, 1951 G. L. McCUTCHAN 2,544,430

METHOD OF MAKING SHIELDED ELECTRICAL CONDUCTORS

Original Filed Feb. 24, 1945 2 Sheets-Sheet 1

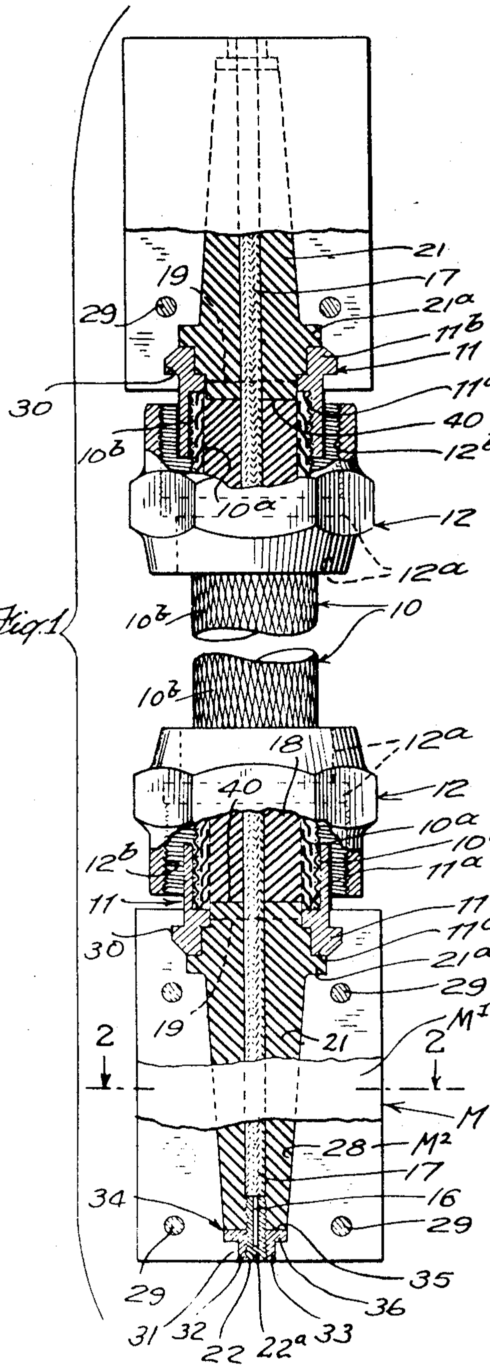
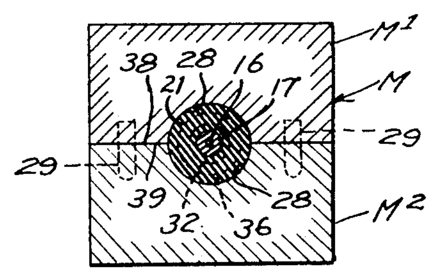


Fig. 1.

Fig. 2.



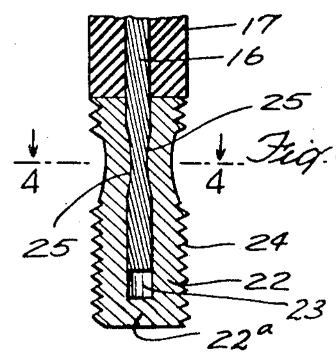
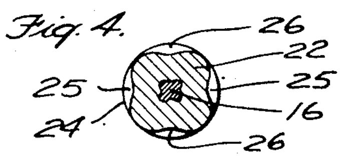


Fig. 3.

Fig. 4.



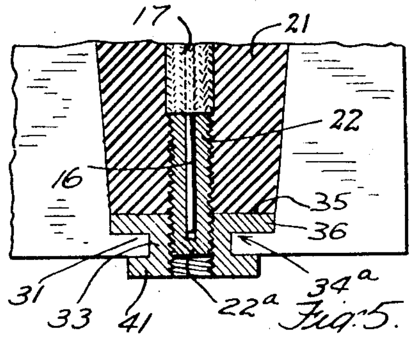


Fig. 5.

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METHOD OF MAKING SHIELDED ELECTRICAL CONDUCTORS

Original Filed Feb. 24, 1945 2 Sheets-Sheet 2

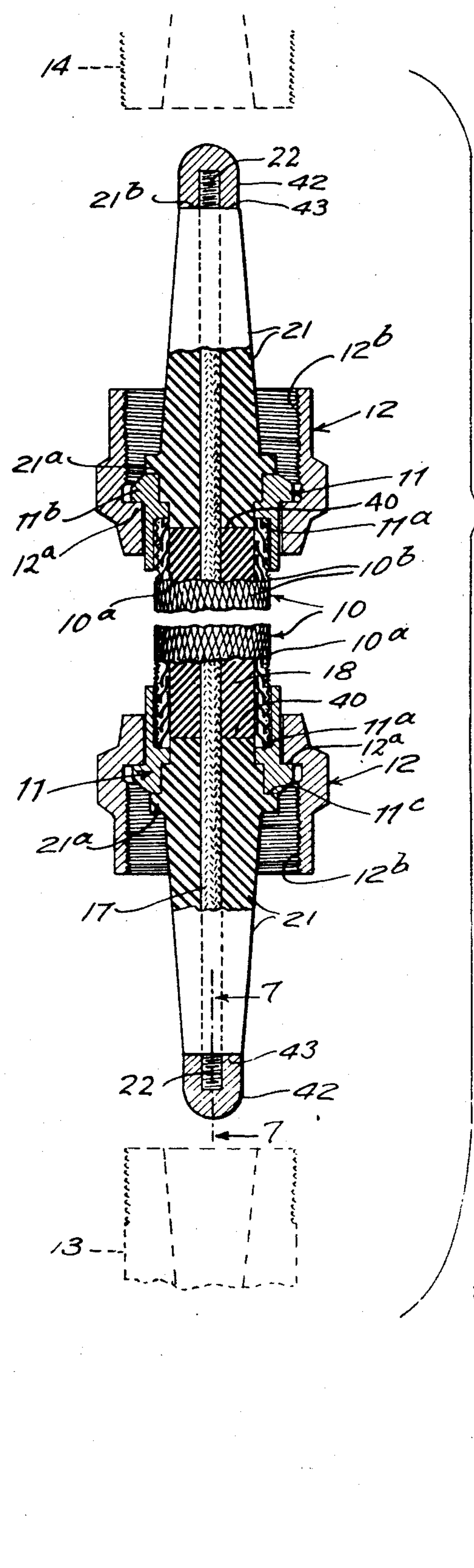

Fig. 6.

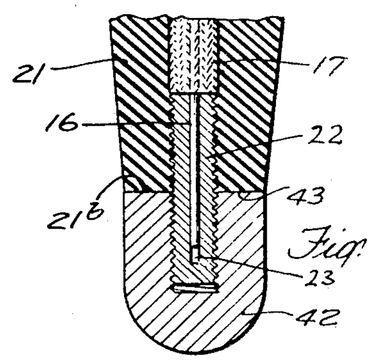

Fig. 7.

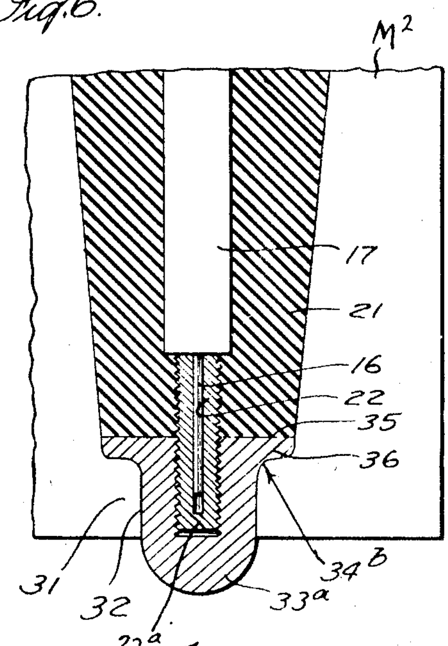

Fig. 8.

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UNITED STATES PATENT OFFICE

2,544,430

METHOD OF MAKING SHIELDED ELECTRICAL CONDUCTORS

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Original application February 24, 1945, Serial No. 579,625. Divided and this application January 15, 1948, Serial No. 2,378

4 Claims. (Cl. 29—155.5)

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This invention relates to radio-shielded electrical conductor and terminal or connector construction and particularly to method and apparatus for making what are sometimes known as radio-shielded spark plug leads such as are employed in extending the electrical circuit connections from the manifold to individual spark plugs in internal combustion engines, and is a division of my copending application Serial No. 579,625, filed February 24, 1945, and subsequently abandoned.

One of the objects of this invention is to provide a method for making a structure of the above-mentioned character in which terminal insulating members, at one or both ends of the radio-shielding conduit in which the conductor with suitable insulating material is contained, may be dependably and reliably molded onto the projecting end or ends of the conductor without causing detrimental shift inwardly of the conduit itself.

Another object is to provide a method for making a structure of the above mentioned kind while dependably preventing such bending or distortion of the conductor within the conduit, more particularly kinking of the wire at the end or ends of the conduit, as will cause disturbance of the desired dielectric relationships, and more particularly as will cause a condition where corona or breakdown effects are encouraged or can be brought into being.

Another object is to provide a practical and reliable method for molding, externally of the conduit and about the projecting portion of the conductor, an insulating element under suitable conditions of pressure and the like that will avoid detrimental shift or kinking of the conductor relative to the parts or elements enveloping it.

Another object is to provide a method by which a metal terminal and an insulating sleeve or bushing may be dependably interrelated, both mechanically and dielectrically, to each other and to the shielding conduit and to the portion of the conductor projecting from the latter, and more particularly to achieve such interrelation where the conductor is per se insulated.

Another object is to provide a method by which a durable and dependable mounting is provided for a metal terminal or connector element at the extreme end of the conductor projecting from the shielding conduit and for an insulating sleeve or bushing thereabout, and in a manner whereby undesirable or detrimental shift of the conductor inwardly of the conduit during processing of the insulating sleeve may be dependably avoided.

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Another object is to provide a practical and dependable method and apparatus for mounting a metal terminal onto the end of the conductor and for molding about the conductor, intermediate of its end and the shielding conduit, an insulating sleeve under conditions of pressure in a manner to reliably avoid detrimental shifting of the terminal or its mounting or of the conductor relative to the shielding conduit, the insulating sleeve itself, and related parts.

Another object is, in general, to provide an improved spark plug lead construction and an improved method of achieving the same, and other objects will be in part obvious or in part pointed out hereinafter.

The invention, accordingly, consists in the features of construction, combinations of elements, arrangements of parts, and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which are shown certain illustrative embodiments of the mechanical features of my invention—

Figure 1 is an elevation, partly broken away and partly in central horizontal section, of a spark plug lead as it appears in one step of its fabrication and as it appears in relation to certain molds;

Figure 2 is a transverse sectional view along the line 2—2 of Figure 1;

Figure 3 is an enlarged central longitudinal sectional view of a terminal mounting;

Figure 4 is a transverse sectional view along the line 4—4 of Figure 3;

Figure 5 is a fragmentary view showing a modified form of apparatus employable in relation to the molds of Figure 1;

Figure 6 is an elevation showing the completed spark plug lead;

Figure 7 is a sectional view on a larger scale as seen along the line 7—7 of Figure 6; and

Figure 8 is a fragmentary view illustrating a modification of method and structure employable in the process step illustrated in Figure 1.

Similar reference characters refer to similar parts throughout the several views of the drawings.

Referring, first, to Figure 1, I preferably employ a conduit, generally indicated by the reference character 10, which, for purposes of effecting radio-shielding, is metallic and preferably comprises a flexible tube 10ᵃ made of helically wound, corrugated strip sheet-metal—such as is shown in United States Patent No. 1,198,392—employing, if desired, suitable means, such as solder, for achieving improved tightness and strength—in the manner shown and described in United States Patent No. 2,127,943—and preferably a covering 10b of braided metal strands—as shown and described in United States Patent No. 1,340,818—snugly envelops the flexible tubing 10a, being, of course, flexible therewith. The ends of the conduit 10 are received in suitable counter-bores 11a of a suitably shouldered ferrule 11, to which they are secured in any suitable way to effect a sealed connection, for example, as by soldering. The ferrules 11 have shoulders or flanges 11b, with which engage the end shoulders 12a of nuts 12, internally threaded as at 12b, whereby the respective ends of the conduit 10 and related parts, later described, may be secured, for example, to the externally-threaded shielding barrel or well 13 of a spark plug and to a similarly externally-threaded cylinder, or well, or socket 14 associated with the manifold (not shown) in which the various spark plug conductors are contained. By means of the nuts 12, a mechanically secure connection to the parts 13 and 14 may be made, and, moreover, in coaction with other parts later described, dependable sealed junctions can be effected—all while achieving, also, a desirable quick detachability of the lead and terminal structural unit.

Extending within the conduit 10, and suitably insulated therefrom, is a conductor 16, which is preferably flexible and, hence, may be a stranded conductor. The high potential energy required to energize the spark plug is conveyed by way of conductor 16. To insulate conductor 16 from the radio-shielding metal parts of the conduit 10 I prefer to employ an insulating covering 17 about the wire 16, and this insulation 17 may be of any desired or suitable construction or composition, or of combinations of insulating compositions or elements, preferably adequate to dependably insulate the wire 16 for the voltage of the energy it is to carry, with usual or appropriate margins of safety. The wire 16 extends preferably coaxially of the conduit 10, which contains a suitable insulating compound 18 which can, if desired, be of a dielectric strength such as to provide for the adequate insulation of the wire 16 from the conduit 10 independently of the insulating covering or sheath 17 which, in such case, need not be employed, if desired, in so far as certain features of my invention are concerned. The compound 18 may be of any desired composition of material, preferably relatively flexible, and where the insulation 17 about the wire 16 is omitted, the consistency of compound 18 is preferably such as to coact in maintaining the conductor substantially coaxially within the conduit 10, or any other known means may be employed to maintain substantial coaxial relation.

With the insulating sleeve 17 about the wire 16, however, many advantages are achieved; for example, precise coaxial relation need not be provided for; the compound 18 can, desirably, be of more advantageous consistencies, preferably relatively soft or flowable, and thus better achieve, particularly when under compression, a more efficient and more reliable filling of all of the space within the conduit 10 and about the insulated conductor 16—17, and thus better guard against corona effects and against possible dielectric breakdown.

Any suitable means may be employed to inject the insulating compound 18 into the space between the conductor and the internal walls of the conduit, as by injecting a suitable quantity thereof upon completion of the assemblage of the ferrules and nuts to the conduit 10, and, by means of the nuts, suitable connection may be made to any suitable apparatus for injecting the material 18.

Having injected a suitable quantity of the compound 18 into the space between the conductor and the conduit walls, the compound 18 being in suitable plastic condition and being, illustratively, made up of any suitable uncured rubber-like material—such as natural rubber, any of the synthetic rubbers, or the like—each suitably compounded, such of the compound 18 as projects beyond the outer ends of the ferrules 11 is removed or cleaned off, so as to leave the end boundary of the material 18 substantially along a plane indicated at 19. Thereupon a suitable insulating material—such as a material analogous to that employed in making up the compound or filler 18—is made ready to be applied to the substantial length of conductor projecting beyond the plane 19. Illustratively, the material may be in the form of tape-like elements which are wrapped about the projecting portion of the conductor, the wrapping being carried on preferably in a manner to simulate generally the ultimate shape or configuration which it is desired to provide. In Figure 1 the insulating material or compound so applied is indicated by the reference character 21, and in its initial application it is made to extend up against the end plane 19 of the compound or filler 18 and also to fill in the angularities at the outer ends of the ferrules 11, and to provide a shoulder 21a which abuts flat-wise against the annular end face 11c of the ferrule 11.

However, before applying the insulating compound 21 to the projecting portions of the conductor, I first apply to the end of the conductor 16—which, where it has an insulating sheath 17, is suitably bared by stripping the insulating sheath 17 thereof throughout a short length at its outer end—a metal sleeve or tube-like element 22 (see Figure 3) which supports a contact or connector element later described and which has a hole 23 in it to snugly receive the wire 16, onto which it is sleeved, to bring its one end into abutting relation to the end annular face of the insulating sheath 17. The tube-like element 22 is preferably closed at its outer end, as at 22a. The external diameter of the element 22 may substantially match the external diameter of the insulating sheath 17, but it may be of lesser diameter, as shown in Figure 8. Suitable means are then employed to insure a dependable mechanical and electrical connection between the wire 16 and the metal element 22. In the illustrative form, element 22 is preferably threaded externally, as at 24.

Where it is desirable to avoid the use of solder or the like—as may be the case where soldering fluxes may detrimentally affect the materials employed, or may subsequently encourage corrosion—I effect such mechanical and electrical interconnection by compressing the metal element 22 radially inwardly so as to cause the resultant restriction of the hole or bore 23 to securely clamp or grip the wire 16. In Figure 3 such clamping restriction is indicated at 25, and may be effected by any suitable means—preferably by a suitable tool or implement—that compresses the heavy-walled tubular element 22 radially inwardly from diametrically opposed sides, as is better indicated in Figure 4, and such operation of such an implement may be repeated throughout as many angularly-displaced, diametrically-opposed portions as may be desired, illustratively, and as indicated in Figure 4, by repeating such radially inward compression at points, indicated at 26, displaced 90 degrees from the points 25. A dependable mechanical anchorage of the part 22 to the wire 16 results, and the resultant cold-flow of metal effects also good electrical interconnection between the two parts throughout substantial or large areas of contact.

Such clamping action is preferably confined to the upper portion, as viewed in Figure 3, of the part 22, for some mutilation of the external threads results, and the free half-portion or so of the part 22 with its threads remains unmutilated. As indicated in Figure 1, the uncured insulating compound 21 is applied also about the just-mentioned upper portion of the member 22, thus also covering over and interlocking with the mutilated threads.

The mass of insulating compound 21, at each end of the structure, is now ready to be conformed to its final, finished shape or configuration, and for this purpose I preferably employ a sectional mold M, conveniently made up of two blocks M^1 and M^2 of metal, each provided with a mold cavity 28, the two mold cavities 28 being complemental to each other, and, when assembled and brought in face-to-face contact, as shown in Figure 2, the complemental mold cavities 28, 28, preferably circular in cross-section, provide a configuration of the shape and dimensions which it is desired to give the insulating material 21. The mold sections M^1, M^2 may be provided with suitable dowels and dowel cavities, indicated at 29, to guide and align them for assembly one to the other, and are preferably also provided with arcuate recesses 30, each of 180 degrees extent, shaped to snugly envelop and encase portions of the outwardly-projecting radial flange or shoulder 11^b of the ferrules 11, so that the mold sections M^1 and M^2 can envelop the flange or shoulder 11^b and thereby become dependably secured to the conduit and ferrule assembly, the nuts 12 being at each end sleeved away from the ferrules so as not to interfere with the application of the mold sections.

The sectional mold M has an end closing wall 31, half of which is in one mold section and the other half being in the other mold section, the end wall 31 being provided with a cylindrically walled hole 32, of which half is in each half-portion of the end wall 31 of the mold sections, and the end hole 32 envelops and receives therein the correspondingly-diametered shank 33 of a member 34 that is internally threaded so that it may be screwed onto the threaded end portion of the part 22 which is anchored to the wire 16, as above described, thus serving to rigidly and dependably center and align the extreme end portion of the conductor 16 and to hold it coaxially of the companion mold cavities 28—28. The member 34 preferably also is dimensioned or shaped to provide at its inner end an end face 35 that is of substantial or suitable area in relation to certain forces and actions that take place—all as is later explained—and, in the embodiment shown in Figure 1, this end face 35 may be formed by the end face of an annular flange 36 projecting from the threaded hub 33, having an external diameter to snugly fit it into the complemental mold cavities 28, 28 when the two mold sections are tightly pressed together.

The member 34, as is preferred where it is to serve as an end terminal, is preferably of metal, and also preferably it is applied to the member 22, which thus serves as a mounting member, just prior to the application, as by wrapping, of the compound 21, so that it may function as an end support or barrier for the latter and also as a general guide to the diameter to which the compound 21 is to be applied.

The material 21—which may be applied by hand, particularly when wrapped—is applied in an amount somewhat in excess of the volume of the mold cavity 28, 28 when the two sections are brought tightly together, and, hence, when the sections of the mold are applied externally thereto, it requires the application of adequate force or pressure to bring the sections of the mold together and to bring their mating faces 38 and 39 into substantial contact, with the result that the moldable or plastic compound 21 is subjected to increasing compression as the escape orifice between the approaching mold faces 38—39 is diminished and finally closed.

The substantial pressure thus exerted upon the compound 21 not only compacts it tightly against and about the conductor structure which it envelops, including the exposed part of the threaded tube member 22, but it also is made to partake of flow or movement in directions parallel to the axis of the mold cavity 28—28. The resultant hydraulic force or pressure is exerted against the end face 35 of the member 34, the area of which is great enough so that the total force exerted against it holds the member 34 tightly and securely against the inside face of the end wall 31 of the mold, thus anchoring the extreme end of the wire 16 against movement inwardly away from that end wall so that flow or movement of the compound 21 takes place axially toward and into the interior of the ferrule 11 and conduit 10, without taking with it the wire which, in the preferred embodiment, comprises the conductor 16 and the insulating jacket or sheath 17; this axial flow or displacement of the compound 21 acts somewhat like a piston upon the compound or filler 18 within the conduit 10, engaging it initially at the plane 19 and subjecting the compound 18 to substantial compression within the conduit 10, thus contributing toward compacting of the filler material 18 against both the conductor and the walls of the conduit. During this action at one end of the spark plug lead, any suitable means may be employed at the other end to prevent the exerted axial pressure upon the filler 18 from causing it to emerge from the other end, and a convenient means for this purpose is illustrated, in Figure 1, in the form of a sectional mold and wire anchored thereto similar to those just described, so that the processing steps may be carried on substantially simultaneously at both ends of the spark plug lead, the closed mold at one end, with its already anchored conductor and compressed insulating compound 21, serving to block escape of filler material 18 while the compression at the remaining end is being concluded.

Were the wire 16 not to be held against axial inward movement during the compression of the external sleeve compound 21, at either end, the flow or movement of the compound 21, in a direction inwardly of the ferrule 11 or conduit 10, exerts such a grip upon the conductor structure which it envelops as to move that portion of the conductor that projects from the conduit 10 bodily toward and inwardly of the conduit itself, causing a kinking of the conductor, usually within the conduit 10 and in a region closely adjacent its end; and this action is greatly enhanced where the conductor has an insulating jacket, such as the jacket 17, of substantial diameter for thereby the jacket exposes a relatively large surface of contact throughout which the moving compound 21 engages and grips it to carry it along. Even though the jacket 17 of the wire 16 may be of sufficient dielectric strength to function at the operating voltages of the system, the kinking just described provides in the wire one or more bends of usually small radius, not concentric with the metal conduit 10, and it is at such a bend or bends that dielectric stresses can become concentrated, with the possibility of resulting in dielectric breakdown or puncture, usually preceded by corona effects. Such kinking is less liable to occur where bare conductor is used—though the forces acting upon it, to kink or bend it, can be of substantial magnitude, according to circumstances—and kinking is greatly facilitated where the bare conductor is stranded, as is desirable for greater flexibility. However, the method and construction according to my invention have been found dependably to prevent such detrimental bending or kinking.

Any suitable means (not shown) may be employed to force the mold sections together to exert the above-described hydraulic forces and to hold them securely assembled upon having brought their mating faces 38—38 into engagement with each other; such a means may be a screw clamp or the like, which, in holding the mold sections together, thus also holds the assembled mold securely to the ferrule 11. With both ends of the spark plug lead thus provided with assembled and clamped molds, as indicated in Figure 1, the entire entity may now be subjected to suitable heat treatment to effect curing of the compound 18 within the conduit 10 and of the compound 21 at each of the terminal ends, it being noted that the compounds are so selected as to materials and compounding thereof that the filler compound 18 in the conduit 10 becomes integrally joined or united with the compound 21 at each end thereof, thus forming a continuous and uninterrupted insulating envelope about the conductor from one end thereof to the other. Where rubber, or synthetic rubber, or like materials are employed, the curing or heat treatment effects vulcanization thereof, and, though, in Figure 1, there appears a line of demarkation, at 40, between the compound 18 and the compound 21, it will be understood that this line or plane, in the completed article, is but the region of interflow or intermingling between the compounds where they are integrally united as though no dividing line or plane had been employed in processing them. Dielectric strength is thus in these regions not impaired, nor does there result a possible leakage path or paths at the line or plane 40. Preferably the materials employed for the filler 18 and also for the sleeve insulating material 21 are compounded, in known manner, to include ingredients so that, upon the application of heat for curing or vulcanization, swelling of the compounds takes place, thus increasing the already-applied compression, and thus also I may guard against the creation of crevices or voids such as would be caused if substantial shrinkage took place during or after curing.

The curing having been completed, the mold sections are removed and the resultant radio-shielded spark plug lead is ready for installation, and the member 34 may serve as an end contact or conductive terminal with which electrical connection may be made to the electrode or contact elements in the spark plug well 13 or the manifold sleeve 14, it being noted that the now-cured compound 21, at each end, provides a shoulder 21a which, at either end of the spark plug lead, abuts against the externally-threaded part 13 or 14, as the case may be, so that, when nuts 12 are tightened up, the annular shoulder 21a is under compression and serves as a gasket to seal the mechanical junction effected by the threaded connections.

The part 34 above described may take other forms or configurations. For example, it may take the form shown in Figure 5, and indicated at 34a, where, in addition to the hub 33 and the flange 36 that provides the pressure-responsive face 35, it is also provided with an end annular flange 41, thus to provide an annular recess between the flanges 36 and 41 adaptable for the attachment therein or thereto of certain types or kinds of electrical connecting devices. Where it takes such a form, the sectional end wall 31 of the mold sections is given a thickness to be accommodated in this annular recess so that the end flange 41 overlies the outer face of the end wall 31 and thus serves as a rigid mechanical anchorage of the part 34a, and, hence, of the mounting tubular member 22 and the conductor 16, and thus the above-described detrimental kinking may also be prevented.

Or, the device 34 of Figure 1 or the device 34a of Figure 5 may be made to serve only temporarily as a means coacting to hold the conductor against inward axial movement, so that after curing, as above described, the part 34 or the part 34a, as the case may be, is removed from the metal mounting element 22 by simply unscrewing it therefrom, and onto the exposed threaded portion of the mounting member 22 any suitable form of contact or terminal element may be threaded, such as the dome-like contactor or terminal 42 of Figure 7. The terminal cap 42, in such case, is preferably provided with an end face 43 dimensioned to match the end face 21b of the now-cured insulating compound 21, which, as above indicated, may be and preferably is compounded and cured so that it has a suitable degree of resiliency, particularly where its shouldered portion 21a is to function as a gasket; the conductive terminal member 42 of Figure 7 may then be simply threaded onto the projecting threaded shank of the mounting member 22 to an extent to exert some compression against the end of the member 21, thus locking it in place, and, where the insulating sleeve member 21 is resilient, a highly dependable locking is effected due to the compression of the resilient material and its resultant resiliency or follow-up action in maintaining dependable holding engagement with the end face of the member 42.

The above-described arrangement for effecting and utilizing hydraulic pressure or force in the compounds to act upon an end face, such as the faces 35 of Figures 1 and 5, to tension the wire or conductor against hydraulic pressures or forces acting elsewhere along its length in a direction to tend to weaken it, has been found in practice to be dependable and efficient, and rejects because of the above-mentioned kinking and its detrimental effects, virtually eliminated. Moreover, these advantages can be achieved without having to exercise extremes of precision, or, stated differently, they can be achieved under circumstances providing greater tolerances; for example, it is not vital that the outside end face of the flange 36 in the arrangement of Figure 1 engage the inside face of the end mold wall 31, even though the threaded connection of the part 34 to the mounting member 22 permits quick adjustment to bring that relationship about if it is desired, for the parts 34, at both ends of the construction, can occupy positions such that the flange 36 is out of contact with and spaced inwardly somewhat from the end wall 31. In such case it is preferred to avoid substantial taper at the end of the mold cavity 28—28, so that the flange 36 in effect functions as a piston that is slideable, with a snug sliding fit along the end portion of the mold cavity. The compound 21 having been initially applied in a quantity in excess of the desired final volume, is then made, when the mold sections are forced together, to function as a motivating fluid under pressure to act against the inside face 35 of the piston-flange 36, effecting some movement of the part 34 so as thus to subject the conductor 16 to tension—an action which may be continued or maintained during curing when the heating of the compounds causes them to swell or expand. Where such piston-like movements at either or both ends take place, they are limited by the engagement of the part 34 with the end mold wall 31, the mold and these actions thus insuring that all of the parts successively produced thereby are uniformly dimensioned or standardized throughout, even though there may be some variation in over-all length of the conductor and part 34 assembled thereto, when initially assembled to the molds.

The element that may be employed at either or both ends may, as above already indicated, assume various shapes or configurations, particularly where it is desired to have it function ultimately also as a contact or conductive terminal. Thus the part 34 of Figure 1 may be given a shape like that indicated at 34^b in Figure 8, in which, again, there is present the flange 36 of a size and shape to tension or hold the conductor 16 in response to hydraulic pressures exerted by the compound 21; but the hub portion is given a dome shape, as indicated at 33^a, with external curved surfaces suitably merging into the flange 36, which may also be provided with curved external surfaces, if desired, and as indicated in Figure 8. The hole 32 in the end wall 31 of the mold may, if desired, be also given suitable curvatures to match those of the part 34^b when the latter has its movement toward the left in Figure 8 limited by engagement of the flange 36 with the end wall 31. Thus the member may serve not only as a hydraulically-responsive element to prevent kinking of the conductor, but also as a terminal contact member of any desired or suitable configuration.

As earlier above pointed out, it is preferred that the outer end tube-like element 22 be closed off, as at 22^a. Thereby certain additional advantages and coactions are achieved, in that gases under pressure, such as might be developed to a substantial extent in a spark plug well, are precluded from entering the completed terminal construction by way of the hollow interior of the mounting element 22 or by way of any spaces between the conductor therein and the walls of the hole in the element 22. If gases under pressure were to find ingress into the internal structure, it is possible, particularly when the terminal structure or lead is removed from the spark plug or other well, that the resultant internal gas under pressure bloats or somewhat inflates the insulating jacket 17 about the conductor 16, effecting separation between the two. Where the insulating jacket 17 includes, as is preferred, some suitable means such as internal or external braiding or wound tension elements, such bloating or inflation can be resisted, but the possibility still exists that such gas under pressure would seep or find its way along or through the region or regions where the reinforcing elements exist and thus effect an internal cleavage within the jacket 17 itself. Such effects are undesirable, in that they also affect detrimentally the dielectric strength of the terminal insulator, effecting undesired redistribution of dielectric stresses and tending, therefore, to give rise to electrical breakdown. However, by closing off the end of the element 22—and that relation is preferably achieved by not drilling the hole 23 all the way through the element 22, leaving an end closing wall 22^a that is integral with the part 22—such ingress of gas under pressure may be avoided.

Moreover, good adhesion between the insulating compound 21 and the external portion of the mounting element 22 is effected in the manner earlier above described, and in providing the threads 24 also through that portion of element 22 with which the compound 21 directly engages, any possible path for leakage therealong of gas under pressure is made materially longer than the shortest distance from the end annular face of the terminal insulator 21 to the inner end face of the mounting element 22, and thus tendency for gas leakage along such a path is substantially counteracted.

As above indicated, the filler 18 and the material of the terminal insulator 21 may be compounded out of any suitable insulating materials and ingredients, all for the purposes above described. Illustratively, and preferably, neoprene is employed for both, the compounding thereof being suitably or appropriately varied according to the respective characteristics desired for the filler 18 and terminal insulators 21. Whatever materials are employed, such as those earlier above mentioned, the respective compounding thereof for the filler 18 and for the terminal insulators 21 may be effected, in any known manner, to give the filler 18, when cured, a Shore durometer reading on the order of 15 and a Shore durometer reading for the material of the insulators 21, when cured, on the order of 65. Where substantial swelling of the filler 18 during cure is desired, suitable ingredients are added in the compounding thereof to cause materially greater swelling thereof during heat treatment than it might normally have, and also some control of the factor of swell may be effected by correspondingly controlling the extent and character of mechanical working of the compound, as on mill rolls. Additions, during mechanical working, of oils—such as an oil of petroleum base, or of other suitable oleaginous substances which become well and highly dispersed throughout the material—may also be employed to materially increase the swelling characteristics, and, when employed, they have the additional advantage of plasticizing the compound and acting as a lubricant, to facilitate injection of the filler 18 into the space between the conductor and the internal walls of the conduit; in such case the rubber-like base material employed is preferably selected from the types that are oil-resistant, of which neoprene is a good illustration. And it will be understood that other fillers and ingredients usually employed in otherwise plasticizing and processing rubber or rubber-like materials—and including plasticizing agents, vulcanizing agents, accelerators, retardants, or the like—may and preferably are also employed in respective amounts or proportions to give the desired processing and curing characteristics.

It will thus be seen that there has been provided a method and apparatus by which the various objects hereinbefore set forth, together with many thoroughly practical advantages, are successfully achieved. It will be seen that there has been provided a method for making radio-shielded electrical conductor and terminal constructions in which detrimental kinking of the wire or conductor is dependably avoided, and that the same can be readily and efficiently carried on in practice with the attainment of dependably uniform results.

As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. The improvement in the method of manufacturing radio-shielded leads having a flexible fluid-tight conduit that has a fitting at an end thereof for mechanical attachment of the lead and that has therein a relatively flexible conductor with relatively flexible insulating compound filling the annular space between the conductor and the conduit, said conductor projecting beyond said end of the conduit and beyond the end faces of said relatively flexible insulating compound, the said improvement comprising securing to the end of the conductor a piston-like member, and conforming under pressure an insulating material about the projecting portion of the conductor by means of a mold secured in fluid-tight relation to said fitting and having a mold cavity with an end portion in which said piston-like member is receivable thereby to cause the material under pressure to exert force against said piston-like member to cause it to slide along a conforming cylinder portion of said mold cavity in a direction away from said conduit to hold the conductor against axial movement and against kinking under the drag of insulating material that otherwise would move axially in a direction inwardly of the conduit.

2. The improvement in the method of manufacturing radio-shielded leads having a flexible fluid-tight conduit that has a fitting at an end thereof for mechanical attachment of the lead and that has therein a relatively flexible conductor with relatively flexible insulating compound filling the annular space between the conductor and the conduit, said conductor projecting beyond said end of the conduit and beyond the end face of said relatively flexible insulating compound, the said improvement comprising securing on to the end of the conductor a mounting element and piston-like member conforming and curing under pressure a curable moldable insulating compound about the projecting portion of the conductor and against the inner face of said piston-like member and about the adjacent portion of said mounting member by detachably securing to said fitting a mold having a mold cavity to shape the insulating compound and cause the compound under pressure to exert force upon said piston-like member, applying said force to said member to resist axial movement of the conductor inwardly of the conduit under the drag imposed thereon by compound forced in a direction inwardly of the conduit itself, and to slide said piston-like member along a conforming cylinder portion of said mold cavity in a direction away from said conduit whereby said relatively flexible conductor is tensioned during cure and held against material radial displacement relative to both of said compounds.

3. The improvement in the method of manufacturing radio-shielded leads having a flexible fluid-tight conduit that has a fitting at an end thereof for mechanical attachment of the lead and that has therein a relatively flexible conductor with relatively flexible insulating compound filling the annular space between the conductor and the conduit, said conductor projecting beyond said end of the conduit and beyond the end face of said relatively flexible insulating compound, the said improvement comprising securing to the end of the conductor a conductive mounting element and piston-like member conforming and curing under pressure a curable moldable insulating material about the projecting portion of the conductor by a mold that is in fluid-tight connection with said fitting and has a mold cavity with an end portion to accommodate said element and piston-like member whereby expansion of the insulating material under pressure in the mold exerts force on said piston-like member to slide said member in a direction away from said conduit and resists the exertion by said material of such forces of compression upon the conductor within said first-mentioned and flexible insulating compound as would cause detrimental kinking or radial displacement thereof.

4. The method of claim 2 in which after completion of the conforming and curing of said insulating compound said piston-like member is removed and there is secured in its place a conductive terminal contact having an end face substantially mating the end face of said cured insulating material.

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