July 12, 1960 R. U. CLARK 2,944,325

METHOD OF MAKING HERMETICALLY SEALED ELECTRIC TERMINALS

Original Filed April 27, 1953

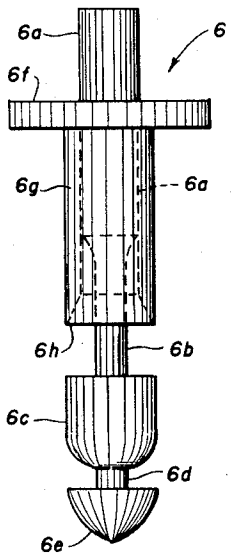


Fig. 1

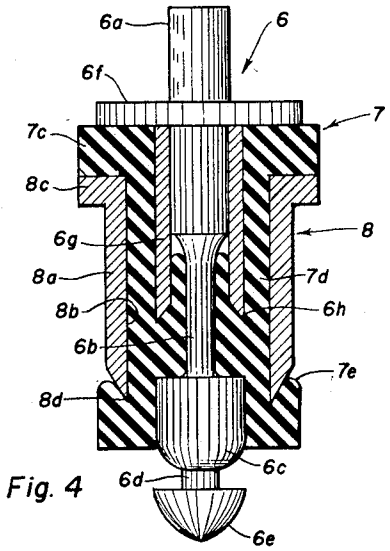


Fig. 4

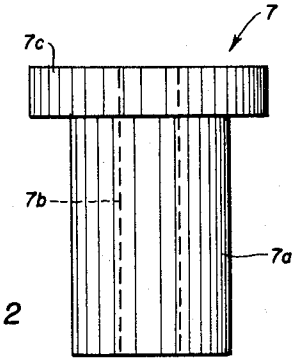


Fig. 2

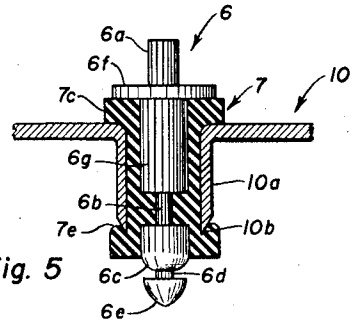


Fig. 5

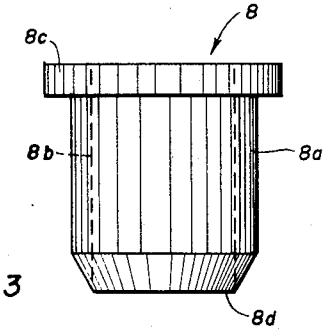


Fig. 3

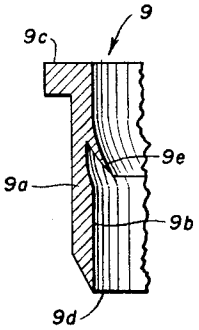


Fig. 3A

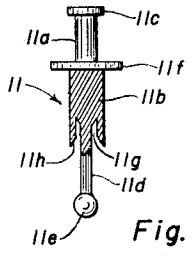


Fig. 6

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METHOD OF MAKING HERMETICALLY SEALED ELECTRIC TERMINALS

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Original application Apr. 27, 1953, Ser. No. 351,317, now Patent No. 2,774,812, dated Dec. 18, 1956. Divided and this application Dec. 6, 1956, Ser. No. 626,647

3 Claims. (Cl. 29—155.55)

The present invention relates to electrical terminals and lead-ins and the like, and pertains more particularly to improved methods of making and assembling hermetically sealed terminals and lead-ins.

This application is a division of my application Serial No. 351,317, filed April 27, 1953, for an Hermetically Sealed Electric Terminal.

Prior terminals or lead-in bushings have broken down or have otherwise proven unsatisfactory under severe service conditions due to impacts or shocks, atmospheric conditions of wide ranges of temperature, humidity, and pressure conditions, as well as due to excessive heating and stresses in the associated equipment. Other contributing causes of failure have been attributed to damage due to faulty and improper installation, subjection to higher voltage and amperage conditions than the ratings for which the terminals were designed, and due to numerous other factors.

These and other difficulties have been either completely or largely overcome by my improved methods of making such terminal constructions, the relative arrangement and installation of the component parts and the improved methods and materials utilized in their manufacture and assembly. In its simplest form my improved terminal comprises essentially a metal electrode or central stud and a surrounding tubular metal shell between which is squeezed in a novel relationship a resilient plastic insulating cup or insert having high dielectric strength and resistance to heat. The metal stud may preferably be barbed and provided with enlargements on its shank as well as a recess or re-entrant space having a relatively sharp knife edge at the mouth of the recess. The metal shell may be similarly provided with a sharp chamfer or knife edge which cuts into the plastic insert in a manner which improves the hermetic seal. The insert may preferably be formed of a plastic material having high insulation resistance, extremely low moisture adsorption, cold flowing and memory shrinkage characteristics such as for example Teflon, or tetrafluoroethylene. The completed terminal acquires extremely high hermetic sealing properties by initially pre-assembling the insert in the shell, then inserting the stud part way into the insert causing large distortion of the same, permitting the latter to relax and accelerating its partial return by heating before completion of the assembly, all preferably done within a vacuum.

It is accordingly a major object of the present invention to provide an improved method of making a terminal construction which is readily capable of providing hermetic sealing by the use of improved materials and methods which are reasonable in cost, fool-proof in application and which stand up longer and more satisfactorily under severe operating conditions. It is a further object to provide improved methods of making terminal constructions of improved semi-resilient high resistance type which more readily retain their hermetic sealing properties and maintain their high insulating characteristics under severe conditions of ultra high frequencies,

extremes in temperatures and pressures, as well as to withstand sudden impacts and shocks. A further object resides in an improved method of forming and assembling the plastic insert by initial heating and stretching, then cutting, forming and assembling, preferably within a vacuum, and subsequently re-heating the entire assembly to accelerate its return and filling of the spaces within the terminal due to the memory characteristics of the material by which it derives its high hermetic sealing properties.

Other objects and advantages of the present invention reside in the improved methods and details of making the components and their assembly, and these and other objects and advantages will become apparent to those skilled in the art after reading the following description taken in conjunction with the accompanying drawings, forming a part hereof, in which:

Fig. 1 is a detail view of the barbed metallic electrode stud;

Fig. 2 is a similar view of the plastic insert;

Fig. 3 is a like view of the metallic shell;

Fig. 3A is a sectional view of a modified metallic shell;

Fig. 4 is a sectional view of the terminal assembly comprising the components shown in Figs. 1, 2 and 3;

Fig. 5 is a similar sectional view of a modified form of the terminal assembly mounted within an extruded hole in a panel; and

Fig. 6 is a modified form of electrode stud.

Referring to Fig. 1 the stud **6** comprises a cylindrical metallic shank portion **6***a*, preferably of metal having good electrical conducting qualities, having a reduced diameter neck portion **6***b*. The lower end of the stud **6** is provided with integral barbed portion **6***c* and a pointed terminal barb **6***e* intermediately connected by a short neck portion **6***d*. A flanged metallic tube having a tubular wall **6***g* and a flange **6***f* is forced down along the shank **6***a* on which it fits tightly extending partially over the neck portion **6***b*. The tubular wall **6***g* is of an axial length which exposes a portion of the main shank **6***a* above the flange **6***f* to provide an upper electrical terminal and also exposes a portion of the neck portion **6***b* adjacent the bulb portion **6***c*. The flange **6***f* and the tube **6***g* may be sweated upon the shank **6***a*, or alternatively these parts may be formed integrally with each other. The lower end of the wall **6***g* is internally ground with a chamfer or bevel to provide a sharp knife edge **6***h*.

Fig. 2 shows the insert **7** which may preferably be formed of Teflon (tetrafluoroethylene) or a similar plastic composition material having a memory characteristic. I have found Teflon highly satisfactory for the insert of my improved seal, this material withstanding compression pressures of several thousand p.s.i. under which it may distort due to its cold flowing qualities up to about 35% from which it may relax to under a 15% distortion when most of the distorting pressure is relieved. The material used has very high insulation resistance and pratically zero moisture adsorption, having a practical range of hardness of from 55 to 70 durometer scale. The insert is preferably made from tubing or tubular stock of an outside diameter slightly greater than that of the flange **7***c*. The tubing is then heated to from 200 to 400 degrees F. and stretched in the manner of an elastic cord while heated. The plastic insert **7** is permitted to cool and is cut or formed to provide the flange **7***c* and preferably formed as a flanged tube with a tubular wall **7***a*, having a central bore **7***b* and an integral flange or shoulder **7***c*. The bore **7***b* is preferably of lesser diameter than the outside diameter of the portions **6***c*, **6***e* and **6***g* of the stud **6** which is forced within the bore **7***b*. Similarly the outside diameter **7***a* is slightly greater than the bore **8***b* of the metallic

sleeve 8 into which the insert 7 is also forced. All of these parts are dimensioned to take the maximum advantage of the shrinkage or memory characteristics of the particular material of which the insert is formed.

Fig. 3 shows the tubular metal shell component 8, which may preferably be formed of brass or other metal having a tubular wall 8*a*, with a central bore 8*b* and an integral flange 8*c*, which may have an outside diameter approximately the same as that of the flange or shoulder 7*c*. The lower terminal is preferably bevelled to form the sharp knife edge 8*d*. In Fig. 3A there is shown a modified form of the shell component, identified by the numeral 9, having a similar wall 9*a*, internal bore 9*b*, flange 9*c*, and knife edge 9*d*, but with its bore 9*b* provided with an extra internal sharp edge annular ring 9*e*. This helps to push the plastic insulator insert 7 in so it can be bored or sliced into by the tubular stud extension 6*g* provided with the internal knife edge chamfer 6*h*.

The terminal is preferably assembled as follows: After the insert 7 has been cut and formed as described above and has been permitted to become cooled it preferably is in the shape shown in Fig. 2, with the exception of course that for purposes of convenience it has been illustrated to a greatly enlarged scale, as have the other components in each of the figures. The insert 7 is then forced into the shell or sleeve 8, when making the terminal assembly of Fig. 4, until the bottom of the flange or shoulder 7*c* rests against the flange or shoulder 8*c* of the shell 8. The barbed electrode 6 is then forced into the central hole or bore 7*b* of the insert 7 about half way. The barb-like point 6*e* and the rounded cylindrical bulb or enlargement 6*c*, as well as the electrode tube 6*g*, expand the insert 7 which has considerable cold flow. In the case of the double knife edged shell 9 the electrode 6 is forced in far enough so that the annular inner ridge 9*e* in the shell is opposite the space between the end 6*h* of the electrode tube 6*g* and the squared end of the inner barb or enlargement 6*c*, or opposite the necked portion 6*b* of the electrode stud. The material of the insert 7 is then allowed to relax for several hours at room temperature, or preferably at an elevated temperature which may be at or about the distortion temperature, or preferably 5 to 15% above the initial distortion temperature of from 200 to 400 degrees F. when the tubing was first heated and stretched. The plastic material of the insert 7 has considerable memory and tends to return or shrink back almost to its original shape, or about 85% return thereto. The insert may be initally compressed under pressures of several thousand p.s.i. which may distort it up to about 35% from which it may relax or return to under 15% of the initial distortion when it is relieved of most of the distorting pressure.

By thus partially assembling the terminal and waiting a few hours or more while it relaxes at room temperature the hole 7*b* in the insert gradually becomes small again and starts to curl around the knife edge 6*h* and back up into the tube 6*g*. As stated above this waiting time may be shortened materially by the secondary heating of the assembly which considerably accelerates the relaxation and return of the plastic material of the insert.

The electrode 6 then is pushed all the way into the insert 7, while the latter is disposed within the shell 8, causing the lower end of the insert 7 where it expands beyond the end of the shell 8 to curl outwardly slightly and eventually, as it shrinks back, to cut itself into a tapered joint conformation against the knife edge 8*d*, which joint contact remains and retains itself under a reasonable amount of shrinkage tension. In this relationship the inner bulb 6*c* is positioned so as to expand the insert 7 at the knife edge 8*d* and the adjacent portions 6*d* and 6*e* form a connection point. This final insertion of the electrode 6 to the point at which its flange 6*f* bottoms against the insert flange 7*c*, is preferably done in a vacuum, such as in an evacuated assembly tank, receptacle or the like. The flange 7*c* is compressed in this assembling operation between the flanges 6*f* and 8*c* and after the insert 7 relaxes and returns to its maximum, under the influence of its extreme memory characteristics, and the assembly assumes the relative relationship shown in Fig. 4 in which it forms the completed terminal. The slicing into or cutting back of the insert material against the sharp knife edges 6*h* and 8*d* which it bites into under its shrinkage tension forms what amounts to a ground joint providing both internal and external seals against the tube walls 6*g* and 8*b* respectively which takes care of all expansion and contraction of the metal components under the temperature changes to which they may be subjected and which results in a terminal of extremely high hermetic sealing properties. The improved terminal when made with a brass or like shell 8 can be soldered or welded into a panel, header or like part. Other metals than brass could of course be used which would be desirable for welding. Relatively high temperature solders are preferable and where the electrode shell is a separate piece it would preferably be sweated on. In the completed terminal, as shown in Fig. 4, the upstanding shank 6*a* and the exposed neck and lower barb 6*d* and 6*e* form the connection points to which the conductors may be attached by any of the known and acceptable methods. The barb end may be made having other configurations such as ball shapes or hollow-ended for roll-back after assembly.

My improved terminal is also adapted for use in an extruded hole in a panel 10 as illustrated in the assembly shown in Fig. 5. The panel 10 is preferably formed with a cylindrical wall portion 10*a* which is provided with a knife edge 10*b* and the assembly of the terminal shown in this figure may preferably be the same as described above with the hole in the panel 10 being substituted for the shell 8 of the previous modification. My improved terminal is also applicable to manufacture in the eyelet type and it will be obvious that it may be assembled with a flanged and knife edge eyelet substituted for the extruded hole in the panel 10, with the eyelet soldered, welded or sweated into a hole in a panel or the like in a well known manner when finally installed in the apparatus or terminal equipped unit. The electrode 6 and the shell 8 may preferably be formed of brass, with any suitable finish, or a number of other satisfactory metals may be utilized. The flange 6*f* and the tube shell 6*g* may be soldered or sweated upon the shank 6*a* of the electrode or these portions may be formed or cut as integral portions of the electrode as illustrated in the modified form of Fig. 6, terminating in a ball end 11*e* suitable for wire wrapping and can be manufactured in a number of automatic machines now available for making similar small parts. It will be appreciated that my improved terminals will normally be considerably smaller than those which have been illustrated in the drawings which have been made to greatly enlarged scales for convenience, and the terminals are capable of being produced in a wide variety of sizes to suit individual requirements.

As indicated above Teflon, or tetrafluoroethylene is ideally suited for the insert but other plastic materials having the desired characteristics may be used. The improved terminal has very low power losses even when used at ultra-high frequencies and when assembled in an evacuated tank as described, it maintains good hermetic sealing properties over a temperature range of from −100 degrees F. and lower up to +550 degrees F.

Other forms and modifications of the present methods utilized in the manufacture and assembly of the improved terminal, which occur to those skilled in the art after reading the foregoing description are intended to come within the scope and spirit of the present invention as more particularly set forth in the appended claims, in which I claim:

1. The method of making an hermetically sealed elec-

trical terminal assembly within a tubular wall defining an opening comprising the steps of forming an insert from a cold flowing plastic material with an axial bore, said material having a restoring memory after distortion, inserting said plastic insert into said tubular wall opening, forming a metallic stud with a reduced diameter shank portion and a surrounding tubular portion defining an intermediate re-entrant space, placing said tubular wall, said insert and said stud in an evacuated assembly receptacle, inserting said metallic stud within said insert in such manner that the plastic material thereof is distorted and cold flowed into said re-entrant space within said tubular portion of said stud to form a seal thereagainst, and heating said assembly to accelerate the movement of said plastic material into said re-entrant space.

2. The method of producing an hermetically sealed electrical terminal within a flanged tubular shell comprising the steps of forming a sharp edge on said tubular shell facing away from the shell flange, forming a flanged axially bored insert of an insulating material of the class having memory characteristics such that after being distorted returns to its original shape, inserting said insert within said tubular shell, forming a metallic stud having an enlarged terminal portion and a sharp edge portion facing said terminal portion, inserting the terminal portion of said stud axially through the bore of said insert under vacuum conditions within an evacuated assembly enclosure such that said stud causes displacement and distortion of said insert around the sharp edges of said shell and said stud with the flanges of said shell and said insert in pressing contact whereby as the material of said insert returns under said memory characteristics to shrink axially and expand laterally it flows against, and around, both said sharp edge portions against the restraint of said contacting flanges forming hermetic seals thereagainst.

3. The method of hermetically sealing an electrical conductor within an opening in a panel and insulating said conductor from said panel; comprising the steps of forming said conductor with a flange at a first end portion, with an enlargement at its opposite end portion and with a knife edge tubular re-entrant portion intermediate said end portions; forming a flanged tubular insulating member with a central bore; forcing said flanged insulating member into said panel opening until the flange of said member abuts said panel, adjacent said opening; forcing the enlargement end of said conductor through the axial bore of the flanged end of said insulating member under high mechanical pressure and under greatly reduced atmospheric pressure until the flange of said conductor meets the flange of said insulating member; and permitting said assembly comprising said wall, said insulating member and said conductor to cool and relax while still under said mechanical pressure to thereby effect an hermetic seal between the insulating member and the edge of said panel opening and between said member and said conductor knife edge re-entrant portion.

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