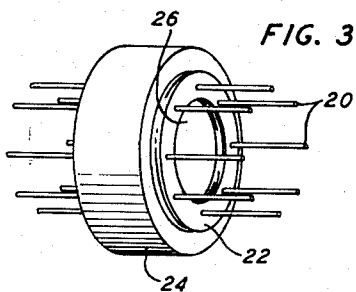
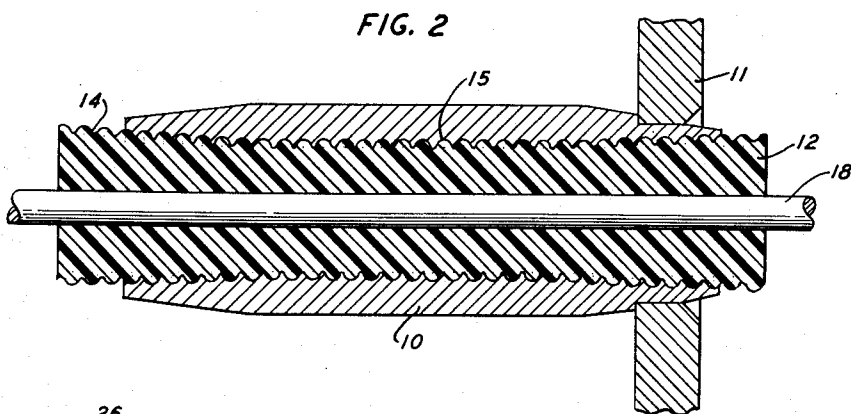
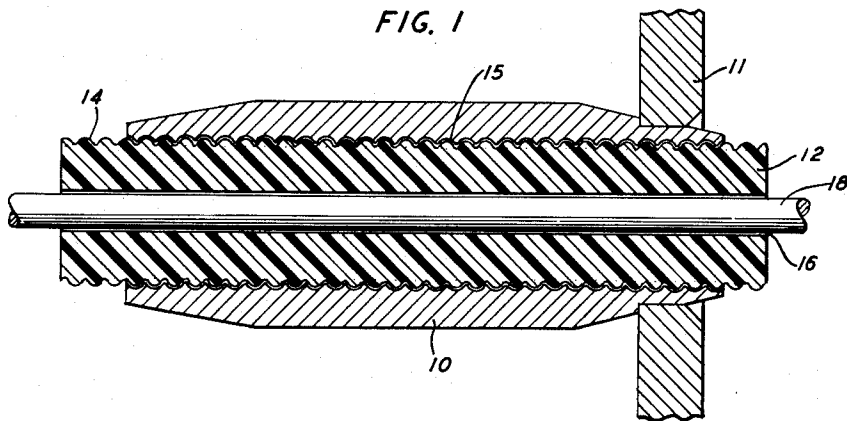


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A. W. ZIEGLER
HERMETIC SEAL TERMINAL
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HERMETIC SEAL TERMINAL

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This invention relates to hermetic seal terminals and particularly to hermetic seal terminals that are subject to very high pressures.

A hermetic seal terminal is employed in hermetically enclosing electrical components. Generally, the terminal comprises an insulator about which an external metallic member is disposed and through which a lead-in conductor extends. The external metallic member is hermetically secured to the container enclosing the component, and the lead-in conductor is connected to a lead of the component. For the container to provide a hermetic enclosure about the component, a hermetic seal must be achieved between the conductor and the insulator and between the insulator and the metallic member.

In hermetic seal terminals designed to withstand pressure differentials of 10,000 p.s.i. and higher, glass and ceramic have been used almost exclusively as the insulating material, since other dielectric materials have not been capable of maintaining a hermetic seal at such high pressures. However, these glass to metal and ceramic to metal terminals suffer from several disadvantages. The coefficients of linear expansion of the insulator and the metal parts of the terminal are not perfectly matched and consequently there is always a residual strain at the interfaces between the insulator and the metal parts. Thus, despite careful processing control to minimize these strains, these terminals remain subject to thermal and mechanical shock. Moreover, when these terminals are used in a high relatively humidity, electrical potentials placed across them frequently result in metal particles migrating to cause a conducting path to form on the insulator. This phenomenon is known as tracking. Glass insulators are more subject to tracking than the ceramic insulators but both types suffer to some extent a deterioration of insulation resistance due to deposits of foreign substances. In addition to these disadvantages, these terminals are costly.

An object of this invention is to provide a hermetic seal terminal that utilizes neither glass nor ceramic as the insulating material and yet is capable of withstanding pressures of 30,000 p.s.i. or more.

Another object of this invention is to provide a hermetic seal terminal that is capable of withstanding both thermal and mechanical shock.

A further object of this invention is to provide a hermetic seal terminal that is simple in construction, inexpensive to manufacture, and easy to assemble.

These and other objects of this invention are realized in an illustrative embodiment thereof wherein the high pressure hermetic seal terminal comprises an internally threaded, relatively heavy walled, metallic sleeve that is disposed about an externally threaded, cylindrical, dielectric bushing, the bushing being provided with an axial bore through which a conductor extends. The roots and crests of the external thread of the bushing and the internal thread of the sleeve are rounded and the difference between the major diameter of the external thread and the major diameter of the internal thread, between the minor diameter of the external thread and the minor diameter of the internal thread, and between the pitch diameter of the external thread and the pitch diameter of the internal thread are substantially the same. The sleeve is circumferentially deformed along a portion of its length to radially compress the sleeve about the bush-

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ing and radially compress the bushing about the conductor.

Because of the particular configuration of the mating threads, the radial compression results in a continuous interface between the sleeve and the bushing and between the bushing and the conductor. The interengagement between the internal and external threads prevents the bushing from elongating, and as a result a very high hydrostatic pressure is generated in the bushing. This hydrostatic pressure provides a high pressure hermetic seal between the sleeve and the bushing and between the bushing and the conductor.

This terminal possesses many of the advantages and is capable of many of the uses of the terminal disclosed in Patent 2,957,041, issued to me on October 18, 1960. However, the instant terminal has several advantages not found in the prior terminal. The present terminal uses no ceramic parts and, therefore, it is not subject to tracking and it is not subject to corona due to the breakdown of the gases in the voids between the ceramic parts and the metallic members when the lead-in conductor is carrying a high voltage. In addition, it is simpler in construction and less expensive to manufacture than the prior terminal.

A complete understanding of the terminal and of these and other features and advantages thereof may be gained from consideration of the following detailed description taken in conjunction with the accompanying drawing wherein two embodiments of the terminal are illustrated. It is to be expressly understood, however, that the drawing is for the purpose of illustration and description and is not to be construed as defining the limits of the invention.

In the drawing:

FIG. 1 is a sectional view of the high pressure hermetic seal terminal of this invention showing the relationship between the external threads of the cylindrical bushing and the internal threads of the sleeve prior to circumferential deformation of the sleeve;

FIG. 2 is the same as FIG. 1 after the sleeve has been radially compressed about the bushing; and

FIG. 3 is a perspective view of a second embodiment of the terminal.

Referring now to the drawing and FIG. 1 in particular, the terminal of this invention includes a relatively heavy walled metallic sleeve 10. The sleeve is either an integral part of an end plate 11 of a container, not shown, or is a separate member hermetically secured to the end plate prior to the formation of the seal. In either case, the end plate itself may be either integral with the container or a separate member hermetically secured thereto as is known in the art. The sleeve 10 may be formed from any of the several materials used for such purposes in the art, as the seal formed in accordance with this invention is not dependent upon the chemical properties of the metal parts. The aluminum, brass, copper, nickel, silver alloys and steels may all be employed.

A cylindrical dielectric sealing bushing 12 is situated within the sleeve 10, and the external surface of the bushing and the internal surface of the sleeve are provided with mating threads 14 and 15, respectively, the threads having a particular configuration that is hereinafter described in detail.

A preferred material of which this bushing is to be composed is polytrifluorochloroethylene, a hard, tough, thermoplastic material. This is a dielectric material which has practically no molecular water and has practically no moisture permeability and thereby provides an effective vapor seal. In addition, the bushing is chemically stable and is unaffected by organic oxides, alkalis, or oxidizing agents. It has mechanical properties adapting it well to the purposes of the invention, such as a

ready machinability, a high shear strength (as shown by a compressive strength in the vicinity of 50,000 p.s.i. or more), and a high modulus of elasticity (the modulus in tension being in the vicinity of 250,000 p.s.i.). Other dielectric materials, particularly organic polymeric dielectrics, having comparable properties can be used. A polytrifluorochloroethylene found suitable is that sold under the trademark Kel-F, grade 300, the average molecular weight of which is reported as about 400,000.

The bushing 12 has a longitudinal hole 16 extending therethrough and a lead-in conductor 18 is positioned therein. The conductor advantageously may be the lead of the electric apparatus or device housed within the container for which the terminal provides a hermetic seal, thereby obviating the necessity of a joint or soldered connection within the container between the apparatus lead and the inner end of the lead-in conductor of the terminal. The lead-in conductor may be formed from any of the many conductor materials found in the art. Brass, bronze, copper, Monel metal, nickel, nickel silver and Phosphor bronze may all be used. In addition, the conductor does not have to be specially treated. Instead bare wire can be used just as it comes from the die as long as it is free from longitudinal grooves.

In the fabrication of the terminal, if the conductor 18 is not the lead of the apparatus or device to be hermetically enclosed, the conductor is secured to the lead, and if the metallic sleeve 10 is not integral to the end plate 11 of the enclosure, the sleeve is hermetically secured to the end plate. The apparatus or device is placed within the enclosure and the end plate is hermetically joined to the enclosure, the conductor 18 having been extended through the sleeve 10. The conductor 18 is then inserted through the longitudinal hole 16 in the bushing 12 and the outer end of the conductor is held fast to prevent the conductor from twisting while the bushing is threaded into the sleeve.

With the elements of the terminal assembled, the metallic sleeve 10 is radially compressed about the bushing 12. This compression is advantageously performed by a single stroke tool that applies a substantially uniform compressive force to the entire circumference of the portion of the metallic sleeve that the tool engages. By applying such a uniform compressive force to a relatively heavy walled sleeve, the sleeve is uniformly compressed about the bushing. A relatively heavy walled sleeve is one that cold flows evenly when subjected to a compressive force. A sleeve that is too thin crimps when subjected to a compressive force, while a sleeve that is too thick inhibits the transfer of the compressive force to the bushing. In one specific embodiment a brass sleeve having an outside diameter of .435 inch and an internal thread having a pitch diameter of .257 inch was reduced to an outside diameter of .398 inch.

As shown in FIG. 2, the radial compression of the relatively heavy walled sleeve 10 about the bushing 12 reduces the diameter of the sleeve and the bushing along the portions thereof that the compressive force is applied, moving the internal threads 15 of the sleeve into engagement with the external threads 14 of the bushing and moving the internal surface of the aperture 16 in the bushing into engagement with the external surface of the conductor 18. Advantageously, the compressive force is only applied to the middle portion of the metallic sleeve, and only the middle of the sleeve and the bushing are thereby reduced in diameter. As a result, the ends of the sleeve and bushing assume an outwardly flaring plug-like shape that assists the terminal in withstanding a high pressure differential between its ends. In the embodiment depicted in FIGS. 1 and 2, the desired center compression is obtained by tapering the ends of the sleeve.

The radial compression of the bushing 12 by the sleeve 10 acts to elongate the bushing. However, except for a small amount of elongation at the moment the compression takes place, the bushing is prevented from elongating

by the interengagement between the external threads 14 of the bushing and the internal threads 15 of the sleeve. As a consequence, the radial compression of the bushing results in the generation of a hydrostatic pressure in the bushing midway between the ends, and because the bushing has a high modulus of elasticity, the hydrostatic pressure generated is a very high one. This very high hydrostatic pressure assures that the radial compression of the bushing by the sleeve causes the bushing to be in a like manner radially compressed about the conductor.

Since the bushing 12 is prevented from elongating by the threads 15 of the sleeve gripping the threads 14 of the bushing, it is advantageous to have the pitch of the threads (i.e., the distance from any point on a thread to the corresponding point on an adjacent thread measured parallel to the axis) small so as to provide a large number of threads per inch and, thereby, a large number of gripping elements per inch. Furthermore, because the threads provide a potential leak path between the bushing and the sleeve, by having a large number of threads per inch, the length of the path is increased and the possibility of leakage therethrough reduced.

With this same problem in mind, it is advantageous to use a single thread, that is, a thread whose lead (i.e., the distance a screw thread advances axially in one turn) is equal to its pitch, thereby providing a single long path rather than a multiple of shorter paths.

The efficacy of the terminal as a high pressure hermetic seal depends, however, upon the threads having a particular configuration. The major diameter (i.e., the largest diameter of a thread), the minor diameter (i.e., the smallest diameter of a thread), and the pitch diameter (i.e., the diameter of an imaginary cylinder the surface of which would pass through the threads at such points as to make equal the width of the threads and the width of the spaces cut by the surface of the cylinder) must be selected so that the clearance between the root of the external thread 14 and the crest of the internal thread 15 and between the crest of the external thread 14 and the root of the internal thread 15 are substantially the same as the clearance between the sides of the internal and the external threads. Another way of saying this is that the difference between the major diameter of the external thread and the major diameter of the internal thread, between the minor diameter of the external thread and the minor diameter of the internal thread, and between the pitch diameter of the external thread and the pitch diameter of the internal thread must be substantially the same. Thus the internal and external threads conform to each other as closely as possible and when the sleeve 10 is compressed about the bushing 12, a continuous interface is formed between the sleeve and the bushing. This continuous interface assures that no paths exist through which leakage may occur. In addition, it assures that the bushing is uniformly compressed so that a continuous interface is formed between the bushing and the conductor.

Commercial threads, on the other hand, are designed to provide far greater clearance between the roots and the crest than between the sides. This is particularly pronounced between the crest of the external thread and the root of the internal thread. The use of commercial threads would result in there being voids between the internal threads of the sleeve and the external threads of the bushing. These voids, besides providing a leakage path between the bushing and the sleeve, would provide alternate regions of high and low pressure. The alternate regions of high and low pressure would cause cold flow of the bushing to take place, resulting in the loss of the very high hydrostatic pressure in the bushing which in turn would result in the loss of the seal between the bushing and the conductor.

Another requirement imposed on the thread in order to avoid alternate regions of high and low pressure is

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that the roots and crests of the threads be rounded. It is difficult, if not impossible, to escape high and low pressure regions when sharp edges are compressed against one another.

Aside from the above requirements, the shape of the internal thread 15 of the sleeve 10 and the external thread 14 of the bushing 12 are advantageously determined by the relative shear strength of the materials from which the sleeve and the bushing are formed. In a terminal of optimum design, when the shear strength of the material from which the bushing is formed is less than the shear strength of the material from which the sleeve is formed, the thread of the bushing will not have the same shape as the thread of the sleeve. Instead, as shown in FIGS. 1 and 2, the thread of the bushing will have wide lands and narrow grooves while the mating thread of the sleeve will have narrow lands and wide grooves. In addition, the optimum thread will have a thread height that is approximately one half the thread pitch. This shallow thread increases the roundness of the thread and reduces the amount of material removed in cutting the thread.

A final consideration in the design of the terminal is providing the bushing with a sufficient land area (i.e., number of lands times the area at the base of each) to withstand the shear stress imposed upon the thread. In this regard the length of bushing over which the compressive force is applied should be no less than approximately twice the major diameter of the thread.

Referring now to FIG. 3, a second embodiment of a hermetic seal terminal comprises a plural lead-in conductor terminal in which a plurality of lead-in conductors 20 are spaced about and extend through an annular dielectric bushing 22. Both the external and the internal surfaces of the bushing are threaded, and an internally threaded metallic sleeve 24 is disposed about the bushing while an externally threaded metallic hub 26 is disposed within the bushing. The requirements set forth with regard to the threaded interface in the first embodiment apply to both threaded interfaces in the second embodiment, and the hermetic seal is formed in the same way. This terminal can serve as the header or end plate of a hermetic enclosure.

Although the sleeve, bushing, lead-in conductor, and hub if there is one, can be separate elements that are assembled, in the manner hereinbefore described, prior to the formation of the seal, the terminal can also be manufactured as an integral unit with the bushing molded with the conductor in place therein and with it in place within the sleeve. In such an integral unit the threads can be annular elements, or in other words have zero pitch, but in all other ways the threads will be governed by the same considerations as set forth above. The sleeve will be reduced in diameter in the manner described above after the hermetic lead-in conductor is connected to the lead of the component to be hermetically enclosed and after the sleeve is hermetically secured to the enclosure.

Furthermore, although the above described embodiments include lead-in conductors, in some situations it may be desirable to use the terminal merely as a plug and in this instance the lead-in conductors are eliminated and the bushing is a solid member. These and other modifications and alterations may be made without departing from the spirit and the scope of the invention.

What is claimed is:

1. A high pressure hermetic seal terminal comprising

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an internally threaded metallic sleeve, an externally threaded cylindrical dielectric bushing positioned within the sleeve, and a lead-in conductor extending longitudinally through the bushing, both the roots and the crests of the external and internal threads being rounded and the clearance between the root of the internal thread and the crest of the external thread and between the crest of the internal thread and the root of the external thread initially being substantially the same as the clearance between the sides of the internal thread and the sides of the external thread, the sleeve being subsequently radially compressed along its length, reducing the diameter of the sleeve and the bushing and forming a continuous interface between the bushing and the sleeve and between the bushing and the conductor, the interengagement between the internal and external threads preventing the bushing from elongating and thereby generating a very high hydrostatic pressure in the bushing that provides a hermetic seal between the sleeve and the bushing and between the bushing and the conductor.

2. A high pressure hermetic seal terminal comprising an internally threaded metallic sleeve, an externally threaded dielectric bushing positioned within the sleeve, the bushing having high shear strength, a high modulus elasticity, practically no molecular water, and practically no moisture permeability, and a conductor extending longitudinally through the bushing, the roots and the crests of the external and internal threads being rounded and the difference between the major diameter of the external thread and the major diameter of the internal thread, between the minor diameter of the external thread and the minor diameter of the internal thread, and between the pitch diameter of the external thread and the pitch diameter of the internal thread being substantially the same, the sleeve being radially compressed along its length, reducing the diameter of the sleeve and the bushing, the interengagement between the internal and the external threads preventing the bushing from elongating and causing the bushing to be pressed against the sleeve and the conductor to form a hermetic seal therebetween.

3. A high pressure hermetic seal terminal comprising an internally threaded metallic sleeve and an externally threaded bushing positioned within the sleeve, the roots and the crests of the external and internal threads being rounded and the difference between the major diameter of the external thread and the major diameter of the internal thread, between the minor diameter of the external thread and the minor diameter of the internal thread, and between the pitch diameter of the external thread and the pitch diameter of the internal thread being substantially the same, the sleeve being radially compressed along its length, reducing the diameter of the sleeve and the bushing, and the interengagement between the internal and the external threads preventing the bushing from elongating and causing the bushing to be pressed against the sleeve to form a hermetic seal therebetween.

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