Nov. 23, 1965 N. VASSOS **3,219,753**

GAS-IMPERVIOUS ELECTRICAL FEEDTHROUGH FOR USE BETWEEN TWO ZONES OF DIFFERING PRESSURES

Filed May 15, 1963 3 Sheets-Sheet 1

Fig.1

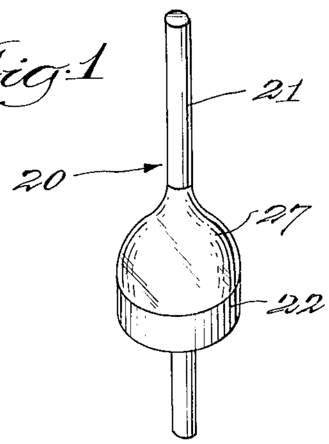


Fig.2

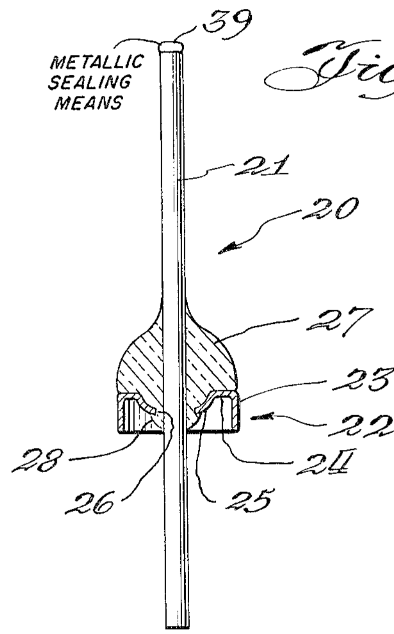


Fig.5

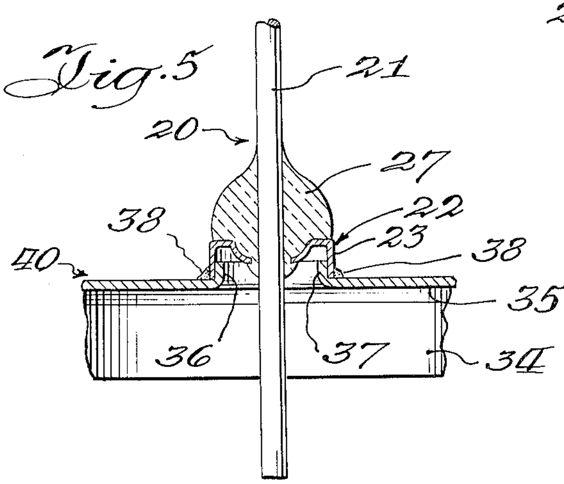


Fig.3

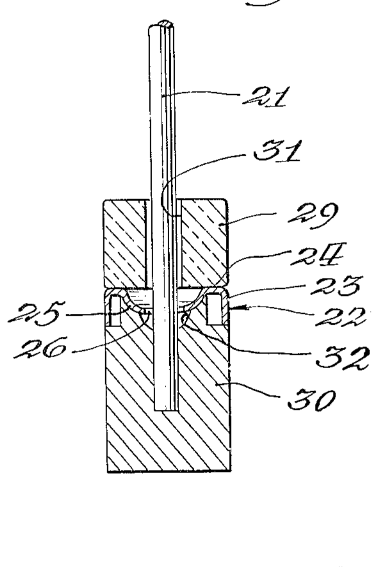
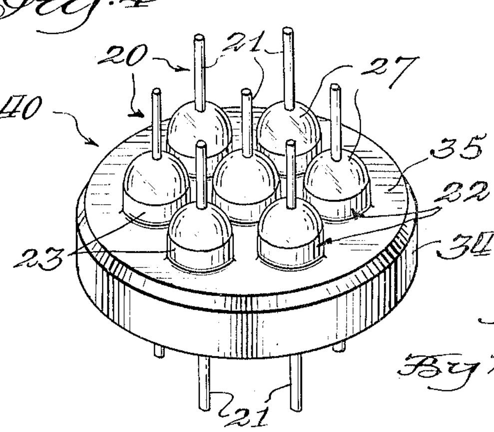


Fig.4



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GAS-IMPERVIOUS ELECTRICAL FEEDTHROUGH FOR USE BETWEEN TWO ZONES OF DIFFERING PRESSURES

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Fig. 6

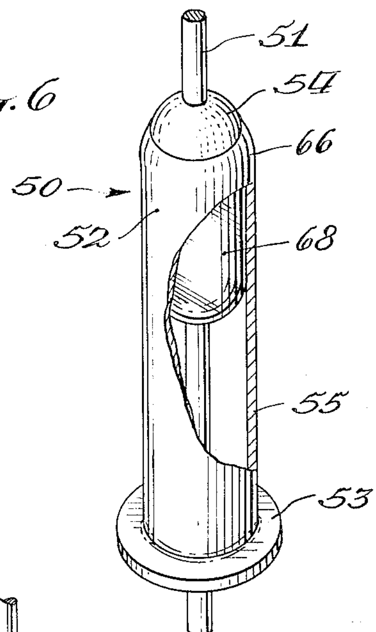


Fig. 7

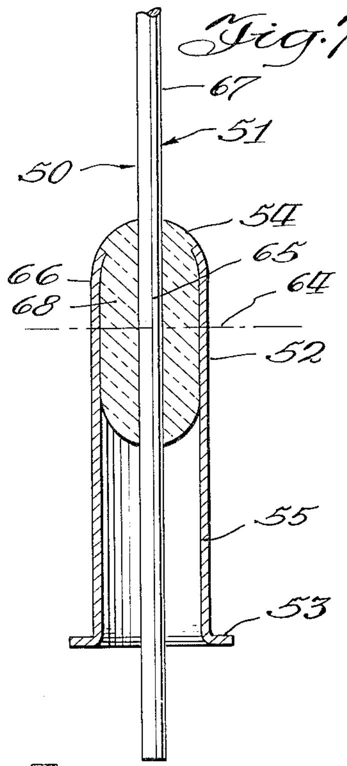


Fig. 8

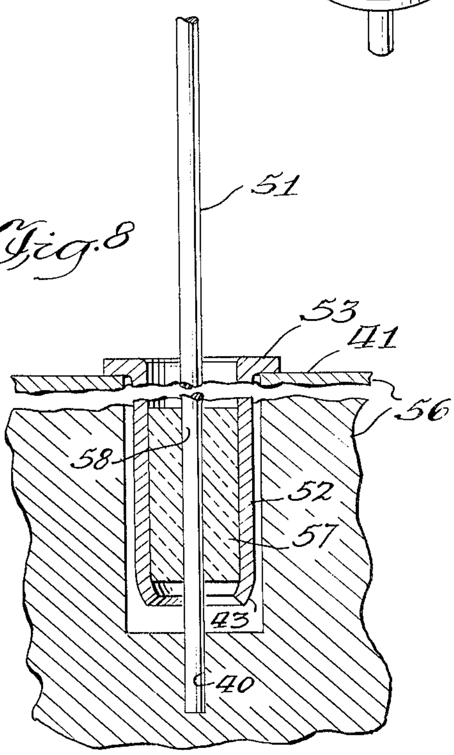
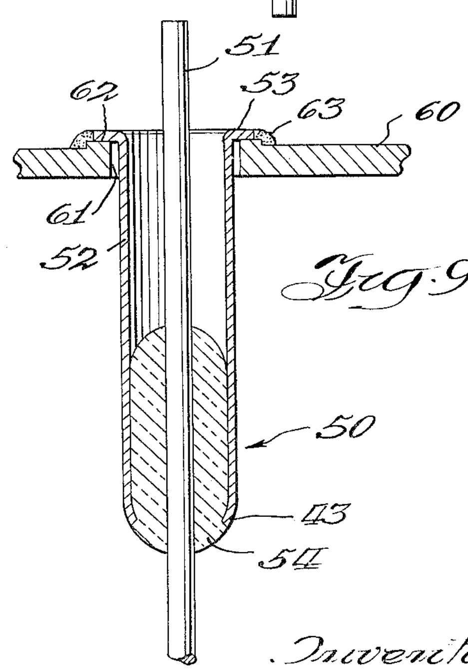


Fig. 9



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GAS-IMPERVIOUS ELECTRICAL FEEDTHROUGH FOR USE BETWEEN TWO ZONES OF DIFFERING PRESSURES

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Fig. 10

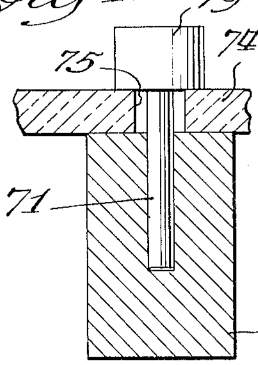


Fig. 11

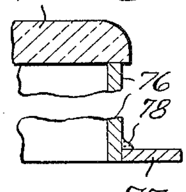


Fig. 12

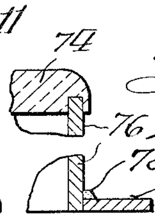


Fig. 13

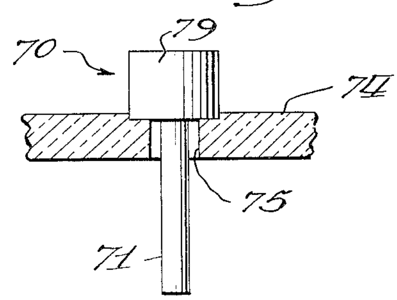


Fig. 14

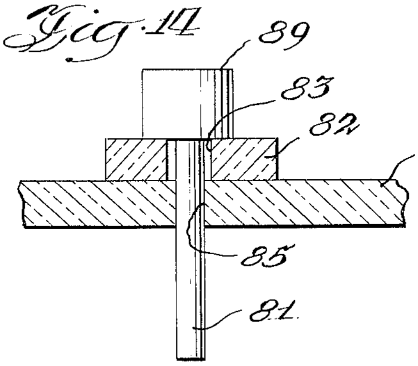


Fig. 16

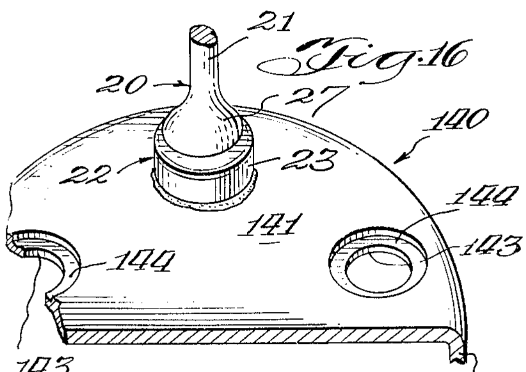


Fig. 15

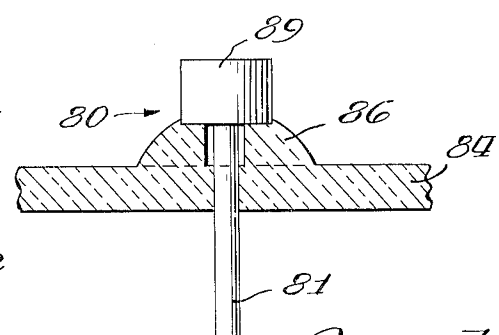
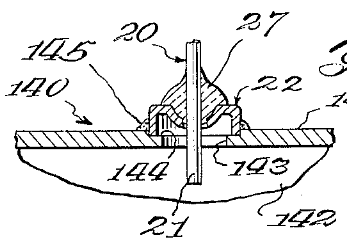


Fig. 17



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United States Patent Office

3,219,753

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3,219,753

GAS-IMPERVIOUS ELECTRICAL FEEDTHROUGH FOR USE BETWEEN TWO ZONES OF DIFFERING PRESSURES

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Filed May 15, 1963, Ser. No. 280,568
7 Claims. (Cl. 174—152)

The present invention relates generally to electrical feedthroughs which extend through a wall to electrically connect a pair of terminals on respective opposite sides of the wall, and more particularly to feedthroughs which electrically connect a first terminal in a zone of very low pressure (e.g., 1×10^{-6} torr or lower) and a second terminal in a zone of relatively high pressure (e.g., atmospheric pressure).

Such pressure differentials exist between the interior and exterior of a low pressure testing system vessel. In such a system the extremely low interior pressures are obtained after the entire system, including the electrical feedthroughs, are assembled in place. Typically, the interior of the vessel is initially partially evacuated by conventional roughing pumps; and, to assure attainment and maintenance of the desired low pressures, the entire vessel is subjected to a bake-out which causes gaseous molecules in the walls of the vessel to be emitted into either the atmosphere or the interior of the vessel from where these gaseous molecules may be removed by conventional pumping means (e.g., a diffusion pump).

It is important that electrical feedthroughs for use in such low pressure systems constitute a sealed assembly of the various components to prevent entry of gases from the high pressure zone to the low pressure zone between which the feedthrough extends. It is also important that the feedthrough be capable of withstanding the aforementioned bake-out without breaking the seal among the various components.

In accordance with the present invention, an electrical feedthrough is provided, for extension between a zone of very low pressure and a zone of relatively high pressure, which feedthrough includes a sealing arrangement among the components which prevents leakage of gas from the high pressure zone through the feedthrough components to the low pressure zone, and which will withstand the heat of the bake-out without interrupting the seal among the components.

Other features and advantages are inherent in the structure claimed and disclosed or will become apparent to those skilled in the art from the following detailed description in conjunction with the accompanying drawings wherein:

FIGURE 1 is a perspective view of an embodiment of a feedthrough constructed in accordance with the present invention;

FIGURE 2 is a vertical sectional view of the feedthrough of FIGURE 1;

FIGURE 3 is a vertical sectional view illustrating the components of the embodiment of FIGURES 1 and 2 prior to the assembly of the components;

FIGURE 4 is a perspective view illustrating an assembly including several feedthroughs of the type illustrated in FIGURE 1;

FIGURE 5 is a vertical sectional view illustrating in detail the attachment of a feedthrough to the assembly shown in FIGURE 4;

FIGURE 6 is a perspective view, partially broken away, and partially in section, illustrating another embodiment of a feedthrough constructed in accordance with the present invention;

FIGURE 7 is a vertical sectional view of the feedthrough of FIGURE 6;

FIGURE 8 is a vertical sectional view illustrating the components of the feedthrough of FIGURES 6 and 7 prior to assembly of the components;

FIGURE 9 is a vertical sectional view illustrating the attachment of the feedthrough of FIGURE 6 to an assembly constituting a portion of a system with which the feedthrough is intended to be used;

FIGURE 10 is a vertical sectional view illustrating components of a further embodiment of a feedthrough, in accordance with the present invention, prior to the assembly of the components;

FIGURE 11 is a fragmentary vertical sectional view illustrating a step in assembling a component of the embodiment of FIGURE 10 in a tubular arrangement;

FIGURE 12 is a fragmentary vertical sectional view, similar to FIGURE 11, with the component in an assembled condition with respect to the tubular arrangement;

FIGURE 13 is a fragmentary vertical sectional view illustrating the components shown in FIGURE 10 in an assembled condition;

FIGURE 14 is a vertical sectional view illustrating components of still another embodiment of a feedthrough, in accordance with the present invention, with the components in an unassembled condition;

FIGURE 15 is a vertical sectional view of the embodiment of FIGURE 14 with the components in an assembled condition;

FIGURE 16 is a fragmentary perspective view illustrating another embodiment of an assembly for feedthroughs of the type illustrated in FIGURE 1; and

FIGURE 17 is a vertical sectional view of the assembly of FIGURE 16.

Referring initially to FIGURES 1 through 3, there is illustrated an embodiment, indicated generally at **20**, of an electrical feedthrough constructed in accordance with the present invention. Embodiment **20** includes a first member in the form of a wire or rod **21** composed of molybdenum, a metal having good electricity-conducting characteristics; a mounting cup or member, indicated generally at **22**, also composed of molybdenum; and a glass sealing means **27** constituting a seal and insulator between cup **22** and rod **21** and maintaining them in the relative positions illustrated in FIGURES 1 and 2.

Rod **21** and cup **22** are initially supported, in an unassembled condition, on a graphite jig **30** in the relative positions illustrated in FIGURE 3. A tubular glass slug **29**, having an opening **31** for receiving rod **21**, is positioned atop a rearward face **24** of cup **22**. Rod **21** extends through an opening **26** in a dimple **25** extending in a forward direction axially of rod **21**. Also extending forwardly from cup **24**, in the same direction as dimple **25**, is a peripheral cup flange **23**.

To obtain a tenacious bond between glass seal **27** and the surfaces of rod **21** and cup **22**, the latter two are, before assembly of the components, subjected to an oxidizing treatment, or are coated with chrome which in turn is subjected to an oxidizing treatment. As a result, the molybdenum wire **21** and cup **22** are coated with a tenacious oxide which is readily bondable to the glass of seal **27**. One typical oxidizing treatment comprises heating the molybdenum wire and cup with a torch in air. Another treatment comprises coating the molybdenum rod and cup with chromium and heating them in a wet hydrogen atmosphere. This produces a very tenacious chrome oxide on the surface of the molybdenum rod and cup.

After the unassembled components have been arranged in the configuration illustrated in FIGURE 3, the arrangement is heated to melt glass slug **29** which flows downwardly into the recess formed by dimple **25** and through opening **26** in dimple **25** into the recess **32** in graphite jig **30**. The arrangement is then cooled and removed from the jig as a completed feedthrough of assembled components illustrated in FIGURES 1 and 2. In the assembled condition, rod **21** and cup **22** are bonded together, in a sealed gas-tight arrangement, by the glass means **27** having a portion **28** extending through opening **26** in cup dimple **25**.

To assure the desired type of seal between the components **21**, **22**, and **27**, and to assure that the seal is maintained during the subsequent bake-out to which the feedthrough is subjected (as a part of the aforementioned system), it is important that seal **27** be composed of a glass having thermal expansion characteristics substantially identical to those of cup **22** and rod **21**. The latter two components are composed of molybdenum, and glass compositions having the same thermal expansion characteristics as molybdenum, are alumino silicate glasses identified as Codes 1720 and 1723 by Corning Glass Works, Corning, New York. These glasses are described in a bulletin prepared by the Industrial Bulb Sales Department of Corning Glass Works, Corning, New York, issued February 15, 1961, and entitled, "Product Information, Calcium Alumino Silicate Glass, Glass Codes 1720 and 1723."

Because the glass of seal **27** has the same thermal expansion and contraction characteristics as the molybdenum from which rod **21** and cup **22** are composed, the glass seal **27** and the molybdenum rod and cup **21**, **22**, respectively, will remain in tight, sealing engagement, during all heat-ups and cool-downs to which the feedthrough is subjected, whether the heat-ups and cool-downs occur during the assembly of the components of the feedthrough or during the subsequent bake-outs to which the feedthrough may be subjected.

Another important property for the components of feedthrough **20** is an imperviousness to gas, so as to prevent gas leakage through the individual components of the feedthrough when the latter extends between zones of vastly different pressures. With respect to cup **22**, cross-rolling the molybdenum sheet material from which cup **22** is fabricated increases the density of the molybdenum cup in all directions, and the problem of gas-leakage between grains in the microstructure of the molybdenum cup material is essentially eliminated.

Because molybdenum rod **21** is subjected to deformation in a longitudinal direction, during the drawing of the rod, gas leakage radially through the rod and outwardly through the side surfaces thereof is not a problem. However, the microcrystalline grains in the microstructure of rod **21** are elongated in the direction of drawing, and leakage through the tip or free end of rod **21** may be a problem. To offset this problem, the tip of rod **21** which is exposed to the relatively high pressure zone is coated by fusing thereto a brazement **39** (e.g., composed of copper-gold brazing alloy), as illustrated in FIGURE 2. This prevents the leakage of gas from a relatively high pressure zone through the tip of rod **21**.

Seal **27** has good gas-impervious properties when composed of a glass of the type described above (Corning Codes 1720 and 1723).

Referring to FIGURES 4 and 5, there is illustrated an assembly **40** including a plurality of feedthroughs **20**. Assembly **40** includes a ring **34**, composed of a material such as stainless steel, and a flange or plate **35** mounted and attached to the top of ring **34**, as by brazing. Plate **35** is preferably composed of copper, for reasons to be subsequently described, and includes a plurality of openings **36** each defined by an upstanding rim **37**. Rim **37** is dimensioned to be slidably received within flange **23** of cup **22**, in the manner illustrated in FIGURE 5; and rim **37** thus functions to maintain cup **22** in a centered position, preparatory to attaching feedthrough **20** to assembly **40** by brazing cup flange **23** to assembly plate **35**, e.g., at **38**. Brazing **38** may be composed of copper-gold.

It is desirable that plate **35** be composed of copper because the latter is relatively resilient, and, during brazing of cup flange **23** to assembly plate **35**, expansion and contraction of the two can be accommodated by the relatively resilient plate rim **37** which will yield and then spring back in accordance with said expansion and contraction. This also helps to assure a tight seal among the components of assembly **40**.

Referring now to FIGURES 6 and 7, there is illustrated another embodiment, indicated generally at **50**, of a feedthrough constructed in accordance with the present invention. Feedthrough **50** includes a rod or wire **51**, composed of molybdenum, a mounting tube **52** composed of an alloy such as Kovar (registered trademark of Westinghouse Electric Corporation), having thermal expansion and contraction characteristics substantially identical to those of molybdenum rod **51**; and glass means **54** constituting a seal holding tube **52** and rod **51** together in a gas-impervious, sealed, electricity-conducting feedthrough.

The feedthrough components **51**, **52**, **54** are initially assembled by arranging them in the configuration shown in FIGURE 8. An opening **40** in a graphite jig **56** supports rod **51**, and a jig upper surface **41** supports a flange **53** of tube **52**, to mount the rod and the tube in upright coaxial positions. A glass slug **57** is supported atop an inwardly crimped terminal portion **43** on tube **52**, and slug **57** has an opening **58** for receiving rod **51**. The entire arrangement is subjected to heat, thereby melting the glass and causing it to flow; so that upon cooling and solidification of the glass the components are arranged in the configuration shown in FIGURES 6 and 7.

In this configuration all of glass seal **54** encloses and insulates an intermediate portion **65** of rod **51**, and substantially all of seal **54** is enclosed within tube **52**. In very high voltage systems, it is desirable to remove a portion **66** of tube **52** adjacent the uninsulated part **67** of rod **51** which projects upwardly (as viewed in FIGURE 7) from the glass seal **54**. This can be accomplished by using an etchant to remove a portion **66** of the tube down to, e.g., the dash-dot line **64** in FIGURE 7. Removal of a substantial portion **66** of tube **52** eliminates the danger of a short circuit between uninsulated rod portion **67** and tube **52**. A substantial portion **68** of glass seal **54** is not enclosed by tube **52** in the embodiment wherein a portion **66** of tube **52** is removed by etching.

Referring now to FIGURE 9, there is illustrated the assembly of feedthrough embodiment **50** to a plate **60** typically composed of stainless steel and having an opening **61** defined by a raised portion or shoulder **62** upon which rests a flange **53** projecting radially outwardly at an end of tube **52**. Tube **52** and shoulder **62** are connected together by welding or brazing, at **63**. The composition of tube **52**, when the latter is composed of Kovar alloy, is as follows:

Element:	Weight percent
Nickel	29.
Cobalt	17.
Iron	Remainder.
Manganese	0.50 maximum.
Silicon	0.20 maximum.
Carbon	0.06 maximum.
Aluminum	0.10 maximum.
Magnesium	0.10 maximum.
Zirconium	0.10 maximum.
Titanium	0.10 maximum.

The total of aluminum, magnesium, zirconium and titanium should not exceed 0.20 weight percent.

To prevent gas leakage through the end of rod **51** exposed to higher pressure zone, the tip of rod **51** should be coated with brazing such as the brazing **39** at the tip of rod **21** in FIGURE 2. Also, to prevent gas leakage through tube **52**, it is important that the tube be composed of a material other than molybdenum, which in tubular form does not have satisfactory gas leakage-preventing properties.

Inasmuch as feedthrough **50** is assembled to a stainless steel plate **60** (FIGURE 9) it would be desirable to utilize a tube **52** composed of stainless steel, because this would facilitate the thermal attachment of tube **52** to plate **60**. However, a stainless steel tube presents problems in situations where gas leakage from the higher pressure zone through the feedthrough is undesirable. This is because the thermal expansion properties of stainless steel are not substantially identical to those of molybdenum rod **51** and glass seal **54** (composed of glass of the type described previously with respect to the composition of glass seal **27** in embodiment **20** illustrated in FIGURES 1 and 2). Thus, during heat-ups and cool-downs, such as those occurring during assembly and bake-outs of the feedthrough, minute leakage openings could form between the glass seal **54** and the tube **52**, if the latter were composed of stainless steel.

However, in some situations where leakages of this nature are not a problem (e.g., in space vehicles wherein the feedthrough extended between a terminal on the interior of a space vehicle and a terminal in space) stainless steel could be used for tube **55**. In outer space there is no disadvantage to have a minute leak-through of gases from the interior of the space vehicle into outer space because the vacuum in space would not be effected. An advantage of a stainless steel tube is that it may readily be brazed to a stainless steel plate **60** utilizing, e.g., a copper-gold brazing alloy. This is much simpler than the heli-arc welding procedure required to assemble a Kovar tube to a stainless steel flange.

An advantage of embodiment **50** is that a substantial portion of tube **52** adjacent flange **53** is not filled with glass seal **54**. Therefore, in situations where the tube is welded or brazed to plate **60**, the glass seal is so far removed from the area where the welding or brazing is being performed, that the welding and/or brazing has no undesirable thermal effect on the glass seal.

Referring now to FIGURE 10, there is illustrated a setup for assembling a fourth embodiment **70** of a feed through constructed in accordance with the present invention. The setup includes a graphite jig **73** which mounts a molybdenum wire or rod **71** in an upright position. At the top of rod **71** is a molybdenum head **79**. A glass mounting plate **74**, having a composition similar to that of the glass slugs **29** and **57** in embodiments **20** and **50** respectively, rests atop jig **73** and includes an opening **75** through which rod **71** extends.

The entire setup illustrated in FIGURE 10 is subjected to heat, whereupon the glass plate **74** softens allowing molybdenum head **79** to penetrate or press downwardly into the softened glass **74**. This effects a seal between head **79** and glass **74**. The resulting configuration is illustrated as **70** in FIGURE 13.

After the components **71**, **79** and **74** are assembled in the manner shown in FIGURE 13, the glass plate **74** is mounted so that the outer edges thereof rest atop a molybdenum tube **76** outwardly from the bottom of which extends a flange **77** (e.g., of stainless steel) attached to tube **76** by brazing as at **78**. The setup illustrated in FIGURE **11** is then subjected to heat which causes glass **74** to soften and to sink downwardly relative to tube **76**, in effect causing the upper portions of tube **76** to penetrate or press into glass **74** and effect a connection between glass **74** and tube **76**. Because glass **74** and molybdenum tube **76** have similar thermal expansion characteristics, subsequent heat-ups and/or cool-downs will not affect the leak-proof seal between plate **74** and tube **76**.

Referring to FIGURE 14, there is illustrated a setup for producing still another embodiment of a feedthrough constructed in accordance with the present invention. In the setup of FIGURE 14, a molybdenum rod or wire **81** is supported in an upright position (e.g., by a jig not shown but similar to that illustrated in the setup of FIGURE 10) and rod **81** terminates at an upper molybdenum head **89** connected to rod **81**. Head **89** rests atop a glass slug **82** typically of the same glass composition as slugs **29** and **57** and including an opening **83** through which rod **81** extends. Glass slug **82** is supported atop a sapphire mounting plate **84** including an opening **85** through which rod **81** extends.

When the components are arranged in the setup illustrated in FIGURE 14, the entire setup is subjected to heat which causes the glass slug **82** to soften, and the weight of molybdenum head **89** causes the latter to press downwardly into glass slug **82**, to effect a seal between head **89** and the glass slug. At the same time, the softened glass slug flows substantially into the configuration illustrated in FIGURE 15, and, in addition, forms a tight, leak-proof bond with sapphire plate **84**. The resulting embodiment is illustrated generally at **80** in FIGURE 15 and includes a molybdenum wire or rod **81** terminating at a molybdenum head **89**, sapphire plate **84**, and a glass seal **86** binding the components **81**, **89** and **84** together into a leak-proof, gas-impervious feedthrough.

In embodiment **80** there is a minimum amount of glass as a component of the feedthrough, compared, for example, to the embodiment **70** illustrated in FIGURE 11. Accordingly, the possibility of a gas leakage through glass **86** is further minimized. Sapphire plate **84** is not susceptible to gas leakage, and the sapphire plate and glass seal **86** effect an extremely good mutual bond.

Referring to FIGURES 16 and 17, there is illustrated an assembly **140** normally mounting a pluraiity of feedthroughs such as **20**. Assembly **140** includes a plate **141**, composed of molybdenum, and having a depending rim **142** and a plurality of openings **143** each peripherally surrounded by a recessed plate portion **144**. Flange **23** on cup **22** of feedthrough **20** has a downwardly depending terminal end portion which is received within and rests upon recessed plate portion **144**; and feedthrough rod **21** extends through opening **143**. Flange **23** is secured to plate **141** at **145**, e.g., by brazing.

Because cup **22** and plate **141** are both composed of molybdenum, and thus have the same thermal expansion characteristics, there is no danger of a leak developing between the two during the expansion and contraction thereof caused by bakeout or other heating to which the assembly is subjected.

As previously described molybdenum rod **21** and cup **22** are chrome plated and the chrome is oxidized. Molybdenum plate **141** is subjected to the same treatment. The resulting coating of chrome oxide on plate **141**, on cup **22** and on rod **21** prevents the molybdenum, of which these three elements are composed, from oxidizing at the high temperatures of bakeout.

In brazing various components together, a brazing alloy which may be used advantageously in securing molybdenum to copper, molybdenum to molybdenum, stainless steel to stainless steel, and copper to stainless steel, contains 65% copper and 35% gold with a 1010° C. liquidus. To secure Kovar to stainless steel, a brazing alloy of copper-gold-nickel, having 1030° C. liquidus, is advantageous.

A stainless steel which may be used for ring **34** and for tube **52** is AISI type No. 304 containing, in weight percent, 0.08 maximum carbon, 18.0–20.0 chromium, 8.00 to 11.00 nickel, 2.00 maximum manganese, and the balance iron, a non-magnetic, austenitic, readily weldable alloy.

In summary, the invention relates to a feedthrough for extension between two zones of respectively differing pressures. The feedthrough, composed of materials which render it completely non-magnetic, includes an elongated, drawn, metallic, electricity-conducting first member having opposite ends each for positioning in a respective one of the two pressure zones. Also included are a mounting member, having an opening through which the drawn member extends, and glass means constituting a gas-leak-preventing seal between and in contact with the two members. At least the draw member and the glass means, and preferably also the mounting member, have the same thermal expansion characteristics. Fused at that end of the drawn member which is to be located in the zone of higher pressure is metallic sealing means for preventing gas leakage through the end and between the elongated grains in the miscrostructure of the drawn member.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

What is claimed is:

1. A gas-impervious, electrical feedthrough for extension between two zones of respectively differing pressures, said feedthrough comprising:
- a drawn, elongated molybdenum first member for conducting electricity between said two zones;
- said first member having a pair of opposite ends at least one of which is a free end for positioning in a respective one of said two pressure zones;
- said first member having elongated microcrystalline grains in its microstructure;
- a gas-impervious, metallic mounting member having an opening through which said first member extends;
- glass sealing means at said opening, between and in contact with said first member and said mounting member, for preventing a gas leak through said opening and for providing electrical insulation between the first member and the mounting member;
- a tenacious oxide on at least those portions of said first member and said mounting member which are in contact with said glass sealing means;
- said first member, said mounting member and said glass sealing means having the same thermal expansion characteristics;
- and metallic sealing means fused at said free end of said first member for preventing gas leakage longitudinally through the first member and through said free end;
- said feedthrough being composed entirely of non-magnetic material.

2. A feedthrough as recited in claim 1 wherein:
- said mounting member is composed of cross-rolled molybdenum sheet;
- said glass sealing means is composed of alumino silicate glass;
- and said metallic sealing means is composed of copper-gold alloy.

3. A feedthrough as recited in claim 1 wherein:
- said mounting member has flange extending in a direction axially of said first member;
- said flange being concentric with said opening and spaced therefrom in a radial direction relative to the opening.

4. In combination with the feedthrough of claim 3:
- a plate having an opening therein;
- said plate including a rim concentrically surrounding said plate opening at the opening;
- said rim extending integrally from said plate;
- said rim being slidably received within said flange on said mounting member of the feedthrough;
- said first member of the feedthrough extending through said plate opening;
- and means securing said flange to said plate.

5. A combination as recited in claim 4 wherein:
- said mounting member of the feedthrough is composed of cross-rolled molybdenum sheet;
- said plate is composed of copper;
- said glass sealing means of the feedthrough is composed of alumino silicate glass;
- and said securing means is a brazement of copper-gold alloy.

6. In combination with the feedthrough of claim 3:
- a plate having an opening therein;
- said plate including a recessed plate portion concentric with and surrounding said opening at the periphery of the opening;
- said flange on the mounting member of the feedthrough having a terminal end portion received in and supported by said recessed plate portion;
- means securing said flange to said plate;
- said first member of the feedthrough extending through said plate opening;
- said mounting member being composed of cross-rolled molybdenum sheet and said plate being composed of molybdenum.

7. A gas impervious, electrical feedthrough for extension between two zones of respectively differing pressures, said feedthrough comprising:
- a drawn, elongated molybdenum first member for conducting electricity between said two zones;
- said first member having a pair of opposite ends at least one of which is a free end for positioning in a respective one of said two pressure zones;
- said first member having elongated microcrystalline grains in its microstructure;
- a gas-impervious mounting member having an opening through which said first member extends;
- glass sealing means at said opening, between and in contact with said first member and said mounting member, for preventing a gas leak through said opening;
- a tenacious oxide on at least those portions of said first member which are in contact with said glass sealing means;
- said first member, said mounting member and said glass sealing means having the same thermal expansion characteristics;
- and metallic sealing means fused at said free end of said first member for preventing gas leakage longitudinally through the first member and through said free end;
- said feedthrough being composed entirely of non-magnetic material.

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