Nov. 15, 1966 G. R. KOCH 3,286,021

CABLE TERMINAL FOR USE WITH ELECTRON GUN APPARATUS

Filed June 1, 1965

3 Sheets-Sheet 1

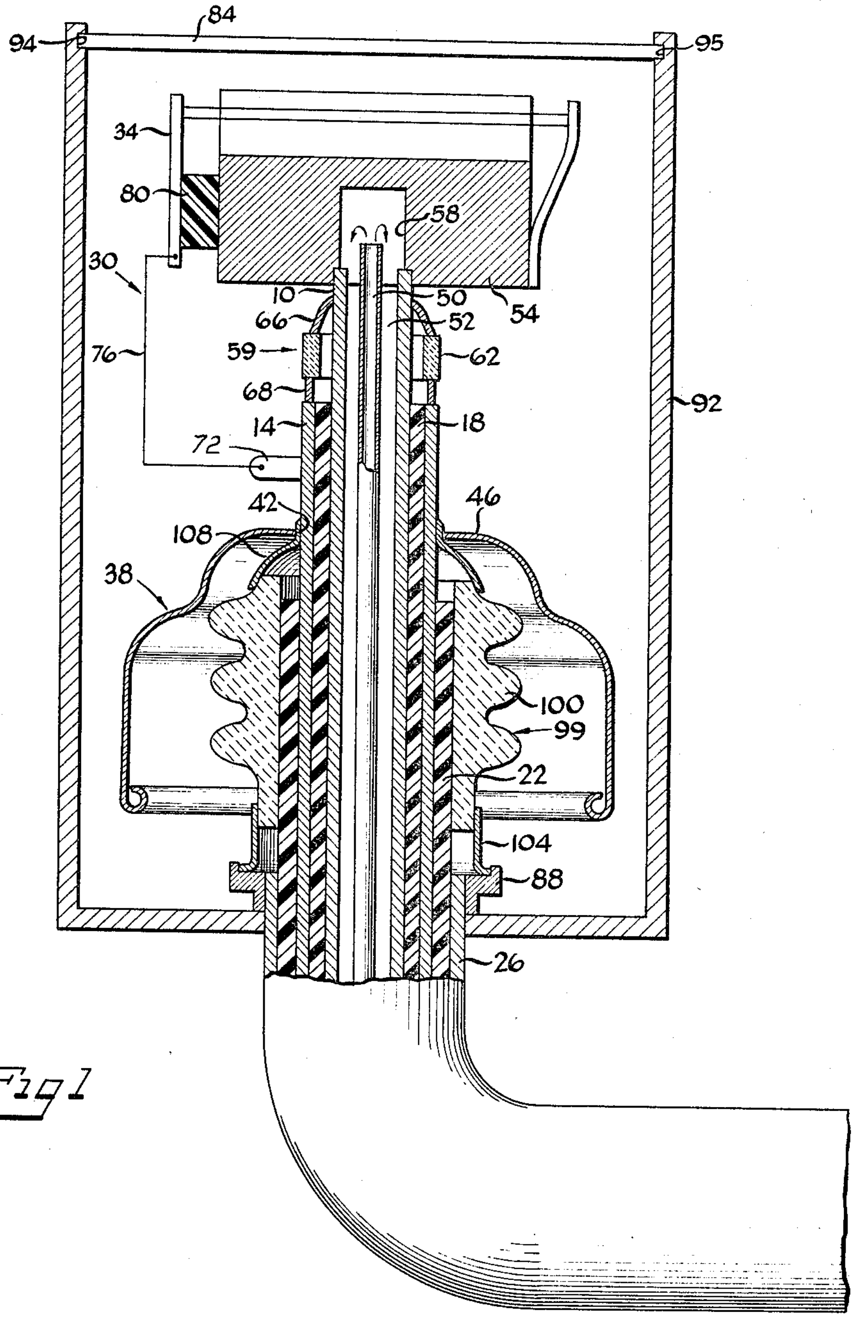

Fig 1

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Fig 2

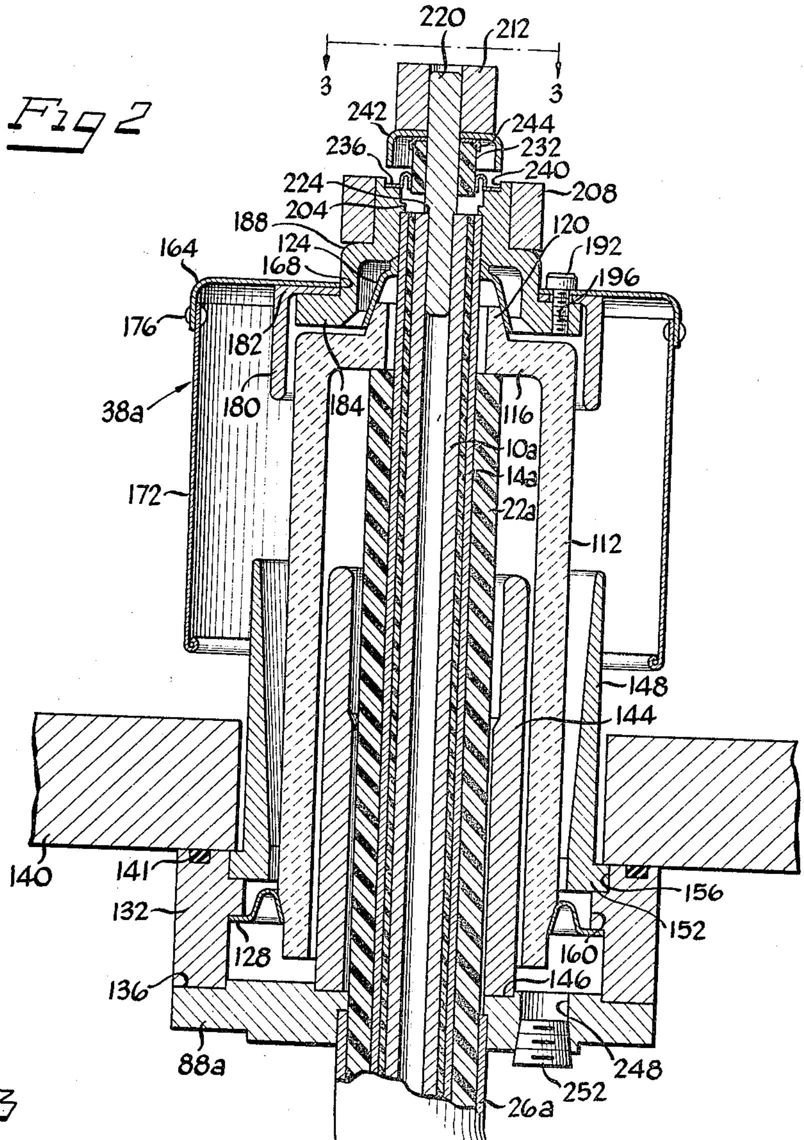
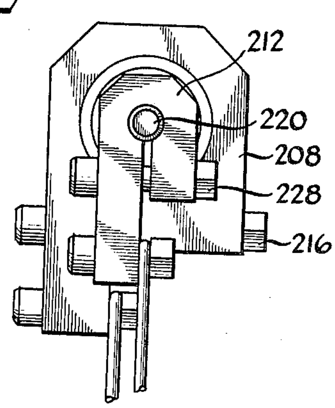


Fig 3



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Filed June 1, 1965 3 Sheets-Sheet 3

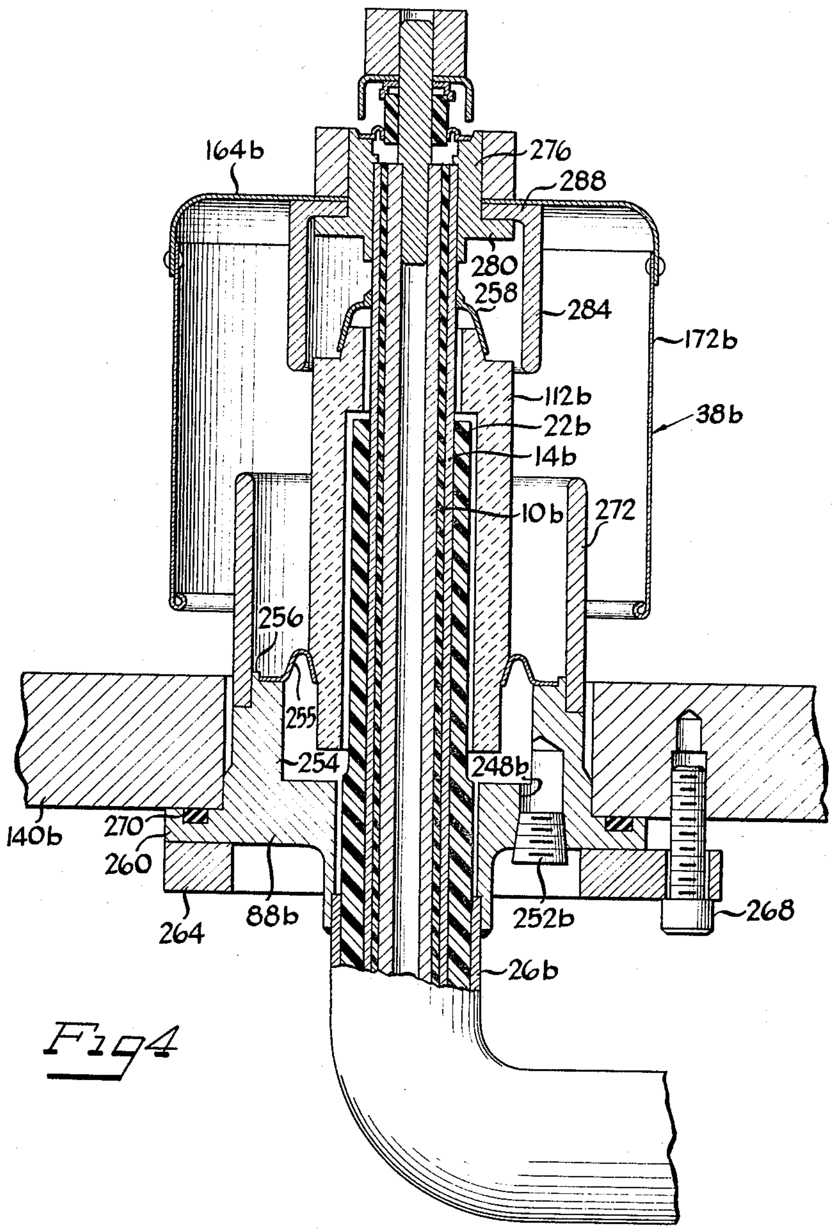

Fig 4

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United States Patent Office 3,286,021
Patented Nov. 15, 1966

3,286,021

CABLE TERMINAL FOR USE WITH ELECTRON GUN APPARATUS

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Filed June 1, 1965, Ser. No. 460,436
7 Claims. (Cl. 174—80)

The present invention relates generally to terminals for high voltage cables and more particularly is directed to a terminal for a high voltage coaxial cable adapted for supplying power to electrical apparatus employed in a high vacuum enclosure.

When electrical apparatus are employed in high vacuum enclosures, it is necessary to penetrate the walls of the enclosure in order to supply power to the electrical apparatus. For example, electrical apparatus such as electron beam guns in high vacuum furnaces have been employed in numerous operations, such as purification of metals, annealing, vapor-plating, etc. The electron beam gun provides a beam of electrons which is directed at the material to be treated, the electron gun and the material being treated being disposed within an evacuated enclosure. The electron gun typically includes a source of electrons, such as a heated cathode or filament, and an accelerating electrode which is maintained at a high positive potential relative to the cathode, thereby resulting in the establishment of a high electrostatic field for accelerating the electrons. In addition, a focusing electrode is usually provided in the electron gun for focusing the electrons into a beam. The electron beam is then directed onto the target material thereby heating it.

Numerous difficulties arise in providing electrical connections between the source of power and the electron gun bcause of the high currents and high potentials required in an electron beam gun apparatus. Also, the electrical connections penetrate the wall of the evacuated enclosure, and therefore preferably are provided with vacuum-tight seals. The insulating and shielding means associated with the electrical connections quickly lose their properties in the vapor filled and highly corrosive environments of a high vacuum furnace. In addition, radio frequency fields are generated in the furnace as a result of the excited state of the vapors present, which excited state is caused by the interaction of electrons within the vapor. The electrical connections are preferably shielded from these fields so as to prevent the same from affecting other associated electrical equipment. Moreover, the electrical connections must be such that personnel are protected from the high voltages used.

It is an object of the present invention to provide a terminal structure for a coaxial cable adaptable for supplying power to electrical apparatus disposed in a highly evacuated enclosure.

It is another object of the present invention to provide a compact terminal structure for a coaxial cable adaptable for supplying high levels of current and voltage to an electron gun disposed in an evacuated chamber.

It is another object of the invention to provide a compact and durable terminal structure for a coaxial cable for supplying power to an electron gun which terminal structure is provided with self-contained vapor shielding and high voltage insulation.

It is a further object to provide a terminal structure for a coaxial cable which structure supports and supplies power to an electron gun in an electron furnace.

Other objects and advantages of the present invention will become apparent from the following detailed

description when considered in conjunction with the accompanying drawings wherein:

FIGURE 1 is a schematic vertical cross-sectional view of one embodiment of the present invention;

FIGURE 2 is a vertical cross-sectional view of another embodiment of terminal structure constructed in accordance with the principles of the present invention, which is particularly adaptable for use with a plurality of electron beam guns in an electron beam furnace;

FIGURE 3 is a view taken along line 3—3 of FIGURE 2; and

FIGURE 4 is a vertical cross-sectional view of another embodiment of the terminal structure.

A coaxial cable constructed in accordance with the principles of the present invention is adaptable for use in conjunction with applications requiring the supply of relatively high voltages to electrical apparatus disposed in a high vacuum system. But, since it is particularly advantageous for supplying power to an electron gun in a high vacuum electron furnace, it is described in terms thereof.

Referring to the drawings and particularly to FIGURE 1, which illustrates a coaxial cable constructed in accordance with the present invention disposed in a vertical position, the cable generally includes a central conductor **10**, a second tubular conductor **14** disposed concentrically about the central conductor **10** and insulated therefrom by a sleeve **18** of insulation, a second sleeve **22** of insulation disposed on the first tubular conductor, and a third tubular conductor **26**, which terminates a predetermined distance from the end of the cable, disposed about the second sleeve of insulation **22**. The terminal portion of the cable includes means **30** for connecting the central conductor **10** and the second tubular conductor **14** to a filament **34** of the electron gun and a generally cup-shaped vapor shield **38**, fabricated of a conductive material. The vapor shield **38** is provided with an aperture **42** in its base **46** through which the second tubular conductor **14** and the central conductor **10** extend, with the second tubular conductor **14** being in electrical communication with the vapor shield **38**. In addition, the vapor shield **38** substantially encloses the sleeve **22** of insulation and is maintained in spaced relationship to the sleeve **22** and to the third tubular conductor **26**.

More specifically, the coaxial cable is adapted to supply both the power for operating the filament of the electron gun and the accelerating high voltage thereof. The cable extends into an evacuated enclosure (not shown) commonly referred to as an electron gun chamber in substantially vacuum-tight relationship therewith. The end of the cable is provided with a terminal which connects the cable to the electron gun. The terminal shown in FIGURE 1 is particularly adapted to support an electron beam gun and cool the same as well as supplying power thereto. The illustrated electron gun is generally similar to that disclosed in the pending application Serial No. 362,264, filed April 24, 1964, entitled, "Electron Furnace."

Preferably a cooling tube **50** is provided for supplying a suitable cooling fluid to cool the electron gun. The cooling tube **50** is disposed within the central conductor **10**, and is maintained in spaced relationship therewith, terminating adjacent a focusing electrode **54** of the electron gun, which focusing electrode is a generally rectangular block of conductive material. Thus, the coolant, which is preferably water, may flow out through the open end of the tube **50** and return to a suitable sink (not shown) through the annular spacing **52** between the tube **50** and the central conductor **10**. The tube **50** is fabricated of a non-conductive material, such as nylon, to prevent arcing between the central conductor **10** and the tube **50**.

The central conductor **10** is electrically coupled to the focusing electrode **54** which, in turn, is electrically connected to one end of the rod-shaped filament **34**. As shown, the central conductor **10** extends into an aperture **58** provided in the focusing electrode **54** and thereby also serves to support the focusing electrode **54**. The central conductor **10** is vacuum sealed to the walls of aperture **58** by suitable means such as brazing. The central conductor **10** is disposed concentrically about the cooling tube **50**, and is preferably fabricated of a tube of conductive material such as copper.

The second tubular conductor **14** communicates with the other end of the filament **34** to thereby heat the same. The second tubular conductor **14** is disposed concentrically about the central conductor **10**, being spaced therefrom by the first sleeve of insulation **18**. The second tubular conductor **14** terminates a predetermined distance below the end of the central conductor **10**.

Because of the high vacuum in the enclosure, it is preferable to construct the end of cable so that it is vacuum tight. In this connection, a first vacuum-tight seal **59** is provided between the second conductor **14** and the central conductor **10**. The vacuum-tight seal includes an annular sleeve of suitable insulation **62**, such as alumina, disposed intermediate the end of the second tubular conductor **14** and the central conductor **10**. The sleeve of insulation is maintained in position by disposing a pair of spider cups **66** and **68** at its upper and lower ends and the cups are respectively vacuum sealed to the central conductor **10** and the second tubular conductor **14** by suitable means such as brazing.

A terminal **72** is provided on the second tubular conductor **14** adjacent its upper end. A conductor **76** is connected between the terminal **72** and the filament **34**, for electrically connecting the second tubular conductor to the filament **34**. An insulating spacer **80**, fabricated of a suitable insulation, such as Teflon, is disposed intermediate a portion of the filament **34** and the focusing electrode **54** as shown. Thus, a complete electrical circuit is provided between the second tubular conductor **14** and the central conductor **10**. This circuit extends from the terminal **72** adjacent the end of the second tubular conductor **14**, through the conductor **76**, through the filament **34**, and through the focusing electrode **54** to the central conductor **10**.

Since the voltage drop across the filament **34** is relatively low, the central conductor **10** and the second tubular conductor **14** are generally at very nearly the same potential. Thus, the first sleeve of insulation **18**, disposed intermediate the central conductor **10** and the second tubular conductor **14**, may be relatively thin.

A rod-shaped accelerating electrode **84** of the electron gun is generally disposed adjacent to the focusing electrode **54** and parallel to the filament **34**. The accelerating electrode **84** is maintained at a very high positive potential with respect to the focusing electrode **54**, thereby establishing an electrostatic field through which electrons emitted from the filament **34** are accelerated. This is accomplished through maintaing the electrode **84** at ground potential by coupling it to the third tubular conductor **26**, which is grounded. In this connection an annular flange **88** is provided on the third tubular conductor **26** adjacent its end, and is preferably brazed thereto. A generally U-shaped, conductive support structure **92** is secured to the third tubular conductor **26** adjacent the flange **88** preferably by soldering. The support structure **92** extends upwardly and is secured to the accelerating electrode **84** by disposing the electrode **84** in a pair of opposed slots **94** and **95** provided in the walls of the structure **92**, thereby supporting the accelerating electrode **84** as well as electrically connecting it to the grounded third tubular conductor **26**. Since the filament **34** is supplied with a relatively high negative potential, while the accelerating electrode **84** is maintained at ground potential, the accelerating electrode **84** is at high positive potential with respect to the filament **34**, thus establishing the requisite electrostatic field.

Since there is substantial difference in potential between the second tubular conductor **14** and the grounded third tubular conductor **26**, the sleeve of insulation **22** disposed therebetween is relatively thick to preclude the occurrence of arc-over. The sleeve of insulation **22** extends beyond the flanged end of the third tubular conductor **26**, terminating between the end of the third tubular conductor **26** and the end of the second tubular conductor **14**. The sleeve of insulation **22** is preferably fabricated of a relatively stable material having a low vapor pressure, such as Teflon.

A second vacuum seal **99** is provided between the third conductor **26** and the second conductor **14**. The seal **99** also provides substantial mechanical support for the end of the cable. The vacuum seal **99** includes a high voltage insulating bushing **100** mounted on the flange **88**, and disposed about a predetermined portion of the insulating sleeve **22** extending above the flange **88**.

The bushing **100** is secured at its lower end to the flange **88** by a spider cup **104**, and is secured at its upper end to the first tubular conductor **14** by a second spider cup **108**. Preferably the spider cup **104** is vacuum sealed to the flange **88** by suitable means such as brazing. In addition, the spider cup **108** is preferably vacuum sealed to the second tubular conductor **14** and to the bushing **100**, thereby completing the vacuum seal between the third tubular conductor **26** and the second tubular conductor **14**. The bushing **100** is in the form of an annular sleeve of high voltage insulation, fabricated of a material **such as alumina and** has a generally ridge-shaped outer surface. The ridge-shaped outer surface is desirable in that it increases the creepage distance along the surface of the insulation and thereby prevents the occurrence of arc-over.

Since the bushing **100** is provided to minimize the existence of voltage creepage and thereby provide protection against arc-over by increasing the creepage distance, it is advantageous to protect the ridged surface of the bushing so that it retains its insulating properties. Such a protection is particularly desirable in view of the presence of conductive vapors in an electron furnace, which might be deposited on the surface of the bushing **100**. Thus, the vapor shield **38** is provided.

The vapor shield **38** is disposed about the insulating bushing **100** so as to substantially enclose it. The vapor shield **38** is generally in the form of an inverted cup with its base **46** positioned above the upper end of the bushing **100** and being electrically connected to the second tubular conductor **14**, and its lip portion being adjacent the lower end of the bushing **100**. Since the shield **38** is electrically connected to the second tubular conductor **14** it is maintained at a relatively high negative potential and thus serves to protect the insulating bushing **100**, which it encloses, from the deposition of conductive vapors. The vapor shield **38** is fabricated of a non-corrosive material, such as tantalum.

The terminal structure described above provides a durable shielded structure for supplying high levels of voltage to an electron gun, while minimizing the occurrence of arc-over. In addition, the particular configuration provides substantial shielding of the terminal structure from radio frequency pick up by providing a large shunting capacitance between the central and first tubular conductors and ground, thereby reducing the radio frequency components conveyed to other circuit elements. In this connection, the lower edge of the vapor shield **38**, which is at a high negative potential, is positioned relatively close to the flange **88** which is at ground potential. Because of this decreased spacing the capacitance is relatively high.

In FIGURE 2 a second embodiment of the present invention is shown, disposed in a generally vertical position, in which corresponding parts are designated by the same reference numerals as used in FIGURE 1, but followed by the letter "*a*."

The end of the cable is provided with a terminal for connecting the cable to an electron gun so as to provide support for the electron gun, if such is desired, as well as to supply power to it.

If desired a suitable coolant tube (not shown) may be disposed concentrically within the central conductor **10***a* for providing cooling of the focusing electrode structure of the electron gun.

The second sleeve of insulation **22***a* which is disposed intermediate the second tubular conductor **14***a* and the grounded third tubular conductor **26***a* extends a predetermined distance beyond the upper end of the third tubular conductor **26***a*, terminating below the upwardly extending end of the second tubular conductor **14***a*.

However, the second tubular conductor **14***a* is supplied with a very high potential with respect to ground. Thus, the insulating properties of the second sleeve of insulation **22***a* again afford insufficient protection against the eventual occurrence of arc-over between the portion of the second tubular conductor **14***a*, which extends beyond the second sleeve of insulation **22***a*, and the upper end of the grounded third tubular conductor **26***a*, as a result of the occurrence of voltage creepage. Thus, an elongated tubular high voltage ceramic insulator **112** is disposed in spaced relationship about the upper portion of the second sleeve of insulation **22***a*, extending generally from the upper end of the sleeve **22***a* to the upper end of the third tubular conductor **26***a*.

The ceramic insulator **112** is generally tubular in form, but has an inwardly extending shoulder **116** at its upper end, which terminates in a generally step-shaped portion **120** at its innermost end. The inwardly extending shoulder **116** is disposed upon the upper end of the second sleeve of insulation **22***a*, and is maintained in position by disposing a suitable spider cup **124** about the step-shaped portion **120** of the insulator **112**. Preferably the spider cup **124** is vacuum sealed to the portion **120** and to the second tubular conductor **14***a* by suitable means, such as brazing. Suitable support for the lower end of the ceramic insulator **112** is provided by disposing a spider cup **128** about the lower end of the insulator **112**. The spider cup **128** is also preferably vacuum sealed into position by suitable means, such as brazing. The ceramic insulator **112** is fabricated of a material which exhibits good structural strength as well as excellent electrical insulating properties, such as a high density alumina cylinder.

Support is provided for the spider cup **128**, which maintains the lower end of the insulator **112** in position, by disposing a relatively short cylindrical support member **132** in tight-fitting relationship about the exterior of the spider cup **128**, and brazing the connection. The lower end of the support member **132** is suitably secured within a stepped portion **136** provided on the outer end of the annular flange **88***a*. The flange **88***a* is preferably soldered to the end of the third tubular conductor **26***a* and supported by the support member **132**. The upper end of the support member **132** is secured to a rigid, grounded support structure **140** preferably fabricated of steel. Preferably an O-ring seal **141** is provided intermediate the support member **132** and the grounded support structure **140** to maintain a vacuum-tight seal therebetween. The support member **132** is fabricated of rigid, conductive material such as steel and thus couples the end of the third tubular conductor **26***a* to ground.

The voltage gradient along the surfaces of the insulator **112** tends to be greatest at its lower end where it is adjacent to the grounded flange **88***a*. Thus, the electric field is more concentrated in this region and corona discharge may occur. To minimize this possiblity means are provided to optimize the voltage gradient along these

surfaces, making it as low as possible, thereby precluding concentration of the electric field, so that corona discharge is unlikely to occur. Thus, a generally tubular voltage gradient controller **144** is disposed within the lower portion of the spacing intermediate the insulator **112** and the insulating sleeve **22***a* and is maintained in spaced relationship with both the insulator **112** and the insulating sleeve **22***a*. The lower end of the voltage gradient controller **144** is disposed in a slot **146** on the surface of the flange **88***a* and is thereby grounded. The upper end of the voltage gradient controller **144** extends beyond the lower end of the vapor shield **38***a*. The voltage gradient controller **144** is fabricated of a material such as steel, and serves to optimize the voltage gradient along the inner surface of the ceramic insulator **112**, making it as low as possible so as to prevent arc-over.

A voltage gradient controller **148** generally similar to the voltage gradient controller **144** is disposed about the exterior of the insulator **112** so as to similarly optimize the voltage gradient along the exterior surface of the insulator **112**. The lower end of the voltage gradient controller **148** has an outwardly extending shoulder **152** which is disposed within a slot **156** defined by the inner end of the support structure **140** and an inwardly extending shoulder **160** on the support member **132**. The lower end of the voltage gradient controller **148** is thus electrically coupled to the grounded support structure **140**. The upper end of the voltage gradient controller **148** extends upwardly approximately the same distance as the voltage gradient controller **144**. The wall of the voltage gradient controller **148**, which is also fabricated of steel, is of generally tapered thickness, such that it is thinner at its top and thicker at its bottom. As a result the upper portion of the wall of the voltage gradient controller **148** is spaced further from the ceramic insulator than is the bottom portion of the wall. This is advantageous since the voltage along the surface of the ceramic insulator **112** tends to be greatest along its upper portion, where it is closer to the upper end of the high voltage second tubular conductor **14***a*.

It is advantageous to provide protection for the surfaces of the high voltage insulator **112** in view of the vaporous environment in an electron beam furnace. If such a protection were not furnished conductive vapors might be deposited on the insulator **112** causing it to lose some of its insulating properties and possibly resulting in the occurrence of arc-over. Thus, the vapor shield **38***a* is provided which is generally in the form of an inverted cup comprising a base **164** having an aperture **168** and a cylindrical downwardly extending wall **172**, secured to the base **164** by suitable rivets **176**. The base **164** is disposed about the second tubular conductor **14***a*, and is maintained in position by securing it to a generally tubular steel support structure **180** having an inwardly extending shoulder **182**, which is secured to the lip **184** of a copper bushing **188**, disposed about the second tubular conductor **14***a*. The bushing **188** is preferably soldered to the second tubular conductor **14***a* and is maintained in electrical contact therewith. A cap screw **192** is inserted through corresponding apertures **196** in the base **164**, the support structure **180** and the lip **184**, and thereby maintains the base **164** in position. The cylindrical wall of the vapor shield **38***a* is of a larger diameter than the voltage gradient controller **148** and extends downwardly, terminating below the upper end of the voltage gradient controller **148**, thereby enclosing the insulator **112**.

Since the base **164** of the vapor shield **38***a* is electrically coupled to the second tubular conductor **14***a* through the copper bushing **188**, the vapor shield **38***a* is maintained at a very high negative potential with respect to ground and thereby serves to protect the insulator **112** from the deposition of conductive vapors on its surface. Moreover, the steel support structure **180** which is disposed about the upper end of the insulator **112** serves as an additional voltage gradient controller to optimize the voltage gradient along the upper portion of the exterior surface of the insulator **112** and prevent arc-over.

It is advantageous in certain instances to provide conductive clamp **208** and **212** disposed in electrical communication with the second tubular conductor **14***a* and the central conductor **10***a* respectively to which suitable conductors may be secured for supplying power to the filament (not shown) of the electron gun. The clamp **208** is disposed about the bushing **188**, thereby communicating electrically with the second tubular conductor **14***a*. The clamp **208** may then be electrically coupled to the filament (not shown). The clamp **208** is tightly secured about the bushing **188** by a bolt **216**.

A generally cylindrical, conductive lead terminal **220** having a shoulder **224** is disposed within the central conductor **10***a*. The shoulder **224** extends onto the upper end of the central conductor **10***a*, and serves to support the lead terminal **220** in its position in electrical contact with the central conductor **10***a*. The clamp **212** is disposed about the upper end of the lead terminal **220** in electrical communication therewith and is tightly secured thereto by a bolt **228**. The clamp **212** may then be electrically coupled to the cathode (not shown).

To prevent the occurrence of arc-over between the lead terminal **220** and the bushing **188** an insulating sleeve **232** of a material such as Teflon is disposed substantially about the portion of the lead terminal **220** which is intermediate the clamp **212** and the upper end of the central conductor **10***a*. The sleeve **232** is maintained in position by disposing a spider cup **236** extending between the sleeve **232** and a shoulder **240** provided on the upper end of the bushing **188**. The spider cup **236** is preferably vacuum sealed to the insulating sleeve **232** and to the shoulder **240** by suitable means, such as brazing.

In order to protect the insulating sleeve **232** from the deposition of a conductive coating on its surface, which would impair its insulating properties, a relatively small vapor shield **242** preferably fabricated of tantalum is disposed substantially about the sleeve **232**. The shield **242** is secured to a support structure **244** disposed on the upper end of the sleeve **232**.

It is generally desirable to prevent the occurrence of corona discharge in the spaces or voids present in the terminal structure. A suitable high dielectric strength material, preferably silicon grease is pumped into these voids through an aperture **248** provided in the flange **88***a*. The aperture **248** is then appropriately plugged or sealed by a plug **252**, positioned within the aperture **248**.

Thus, a cable and terminal have been provided containing shielding from the corrosive vapors present in an electron beam furnace and protection against arc-over so that a highly durable structure results. Moreover, the structure provides a relatively large capacitance between the high voltage conductors and ground, which results in shunting radio frequency components to ground, preventing adverse effects on other circuit elements.

Another embodiment of the present invention is shown in FIGURE 4, disposed in a generally vertical position. This embodiment is generally similar to the embodiment shown in FIGURES 2 and 3, and corresponding parts are designated by the same numerals as used in FIGURE 2, followed by the letter "*b*." This embodiment is particularly adaptable for providing excellent shielding against coating by vaporous material, as well as producing a low voltage gradient on the surface of the ceramic insulator **112***b*. In this embodiment, a voltage controller is not provided between the ceramic insulator **112***b* and the sleeve of insulation **22***b*. Therefore, the diameter of the insulator **112***b* is only slightly larger than the diameter of the sleeve of insulation **22***b*.

If it is desired to provide cooling for the focusing electrode structure of the electron gun, a suitable coolant tube (not shown) may be disposed concentrically within the central conductor **10***b*.

The annular flange **88***b*, which is preferably soldered to the third tubular conductor **26***b*, is provided with a generally tubular portion **254**, which extends upwardly to approximately the upper surface of the support member **140***b*. The tubular portion **254** encloses the lower end of the insulator **112***b*. The flange **88***b* serves as a support structure for the insulator **112***b*. In this connection a spider cup **255** is disposed between an upwardly extending lip **256** provided on the upper end of the tubular portion **254** and the insulator **112***b*, and is preferably vacuum sealed into position by suitable means, such as brazing. Another spider cup **258** is disposed about the upper end of the insulator **112***b*, and similarly is preferably vacuum sealed into position by suitable means, such as brazing.

The flange **88***b* is provided with an outwardly extending shoulder portion **260** which is disposed adjacent the lower end of the grounded support structure **140***b* The flange **88***b* is tightly secured to the support structure **140***b* by disposing an annular flange **264** below the shoulder portion **260** and securing the annular flange **264** to the support structure **140***b* by suitable screws **268**. In addition, an O-ring seal **270** is preferably provided intermediate the shoulder portion **260** and the grounded support structure **140***b* so as to provide a vacuum-tight seal therebetween.

In order to provide protection against voltage creepage, which may occur on the outer surface of the insulator **112***b*, a voltage gradient controller **272** is disposed about the insulator **112***b* and is spaced therefrom. The lower end of the voltage gradient controller **272** is disposed about the exterior of the lip **256** on the member **254** and is thereby maintained at ground potential, while the upper portion of the voltage gradient controller extends upwardly, terminating below the upper end of the insulator **112***b*.

The vapor shield **38***b* is disposed about the voltage gradient controller **272** and the insulator **112***b*. The wall **172***b* of the vapor shield **38***b* extends downwardly, terminating below the upper end of the voltage gradient controller **272**.

Support for the vapor shield **38***b* is provided by a bushing **276** disposed about the upper end of the second tubular conductor **14***b* and maintained in electrical communication therewith. The bushing **276** is provided with a flange **280** adjacent its lower end. A tubular vapor shield support structure **284** having an inwardly extending shoulder **288** is disposed on the flange **280**, with the shoulder **288** resting on the flange **280**. The support structure **284** extends downwardly, terminating adjacent the upper end of the insulator **112***b*, and thus serves as an additional voltage gradient controller to optimize the voltage gradient on the upper end of the insulator **112***b*. The base **164***b* of the vapor shield **38***b* is then disposed on the upper surface of the shoulder **288**, and is electrically coupled to the second tubular conductor **14***b* through the bushing **276**. The vapor shield **38***b* is thus maintained at a high negative potential with respect to ground and serves to protect the insulator **112***b* from the deposition of conductive vapors on its surface.

To prevent the occurrence of corona discharge a suitable dielectric material such as silicon grease is disposed in the spaces and voids in the terminal structure. Thus, the flange **88***b* is provided with the aperture **248***b* through which the silicon grease may be pumped into the spaces. The plug **252***b* is then disposed in the aperture **248***b*, sealing it.

Thus, a cable terminal has been provided having numerous advantages, as previously described. Although the cable terminal has been described as being particularly useful for supplying power to an electron beam gun in a high vacuum furnace, it should be noted that a cable terminal in accordance with the principles of the present invention is adaptable for supplying power to numerous other devices. For example, it may advantageously be employed for supplying power to accelerators, nuclear fusion devices and a wide variety of other electrical apparatus disposed in evacuated enclosures, especially when the walls of the enclosure are penetrated and it is desired to maintain the vacuum.

Various other changes and modifications may be made in the above-described terminal without deviating from the spirit and scope of the present invention.

Various features of the invention are set forth in the following claims.

What is claimed is:

1. A terminal for a high voltage coaxial cable adapted for supplying power to a filament and an accelerating electrode of an electron gun disposed in a high vacuum electron furnace which cable includes a central conductor, a second tubular conductor disposed concentrically about said central conductor and insulated therefrom, a sleeve of insulation disposed on said second tubular conductor, and a third tubular conductor disposed about said sleeve and terminating in spaced relation to the end of said cable, said terminal comprising means for connecting said central conductor and said second tubular conductor to the filament of said electron gun in vacuum sealed relationship therewith, and a generally cup-shaped vapor shield of conductive material having an aperture in its base through which said second tubular conductor and said central conductor extend, said shield being in electrical communication with said second tubular conductor and substantially enclosing said insulating sleeve in spaced relationship to said sleeve and said third tubular conductor.

2. A terminal for a high voltage coaxial cable adapted for supplying power to a filament and an accelerating electrode of an electron gun disposed in a high vacuum electron furnace which cable includes a central conductor, a second tubular conductor disposed concentrically about said central conductor, a relatively thin first sleeve of insulation disposed intermediate said central conductor and said second tubular conductor, a relatively thick second sleeve of insulation disposed on said second tubular conductor, and a third tubular conductor disposed about said second sleeve of insulation terminating in spaced relation to the end of said cable to thereby provide an uncovered portion of said second sleeve of insulation said terminal comprising means for connecting said central conductor and said second tubular conductor to the filament of said electron gun in vacuum sealed relationship therewith, means for connecting said third tubular conductor to the accelerating electrode of said electron gun, a sleeve of high voltage ceramic insulation disposed about said uncovered portion of said second sleeve of insulation and maintained in vacuum sealed relationship therewith, said sleeve of high voltage ceramic insulation having a generally ridge-shaped outer circumferential surface to minimize voltage creepage along the surface thereof, and a generally cup-shaped vapor shield of conductive material having an aperture in its base through which said second tubular conductor and said central conductor extend, said shield being in electrical communication with said second tubular conductor and substantially enclosing said sleeve of high voltage ceramic insulation in spaced relationship to said sleeve and said third tubular conductor.

3. A terminal for a high voltage coaxial cable adapted for supplying power to a filament and an accelerating electrode of an electron gun disposed in a high vacuum electron furnace which cable includes a central conductor, a second tubular conductor disposed concentrically about said central conductor, a relatively thin first sleeve of insulation disposed intermediate said central conductor and said second tubular conductor, a relatively thick second sleeve of insulation disposed on said second tubular conductor, and a third tubular conductor disposed about said second sleeve of insulation terminating in spaced relation to the end of said cable to thereby provide an uncovered portion of said second sleeve of insulation, said terminal comprising means for connecting said central conductor and said second tubular conductor to the filament of said electron gun in vacuum sealed relationship therewith, a sleeve of high voltage ceramic insulation disposed about said uncovered portion of said second sleeve of insulation and said second tubular conductor, said sleeve of high voltage ceramic insulation being maintained in spaced relationship with said second sleeve of insulation and said second tubular conductor, means for providing a vacuum seal between said third tubular conductor and said second tubular conductor, a first sleeve of conductive material disposed intermediate said second sleeve of insulation and said sleeve of ceramic insulation and spaced therefrom, a second sleeve of conductive material disposed about the exterior of said sleeve of ceramic insulation and spaced therefrom, means for electrically connecting one end of said first sleeve of conductive material and of said second sleeve of conductive material to ground, and a generally cup-shaped vapor shield of conductive material having an aperture in its base through which said second tubular conductor and said central conductor extend, said shield being in electrical communication with said second tubular conductor and enclosing said sleeve of high voltage ceramic insulation and the other end of said second sleeve of conductive material in spaced relation thereto.

4. A terminal for a high voltage coaxial cable adapted for supplying power to a filament and an accelerating electrode of an electron gun disposed in a high vacuum electron furnace which cable includes a central conductor, a second tubular conductor disposed concentrically about said central conductor, a relatively thin first sleeve of insulation disposed intermediate said central conductor and said second tubular conductor, a relatively thick second sleeve of insulation disposed on said second tubular conductor, and a third tubular conductor disposed about said second sleeve of insulation terminating in spaced relation to the end of said cable to thereby provide an uncovered portion of said second sleeve of insulation, said terminal comprising means for connecting said central conductor and said second tubular conductor to the filament of said electron gun, a sleeve of high voltage ceramic insulation disposed about said uncovered portion of said second sleeve of insulation, a tubular member of conductive material disposed about said sleeve of ceramic insulation and spaced therefrom, means for electrically coupling one end of said tubular member of conductive material to ground, and a generally cup-shaped vapor shield of conductive material having an aperture in its base through which said second tubular conductor and said central conductor extend, said shield being in electrical communication with said second tubular conductor and enclosing said sleeve of ceramic insulation and the other end of said tubular member in spaced relation thereto.

5. A terminal for a high voltage coaxial cable adapted for supplying power to a filament and an accelerating electrode of an electron gun disposed in a high vacuum electron furnace which cable includes a central conductor, a second tubular conductor disposed concentrically about said central conductor, a relatively thin first sleeve of insulation disposed intermediate said central conductor and said second tubular conductor, a relatively thick second sleeve of insulation disposed on said second tubular conductor, and a third tubular conductor disposed about said second sleeve of insulation and terminating in spaced relation to the end of said cable to thereby provide an uncovered portion of said sleeve of insulation, said terminal comprising clamp means in electrical communication with said central conductor and said second tubular conductor for coupling said central conductor and said second tubular conductor to the filament of

said electron gun, a sleeve of high voltage alumina insulation disposed about said uncovered portion of said second sleeve of insulation and being spaced therefrom, means disposed adjacent the surface of said sleeve of high voltage insulation for maintaining a low voltage gradient along the surface thereof, and a generally cup-shaped vapor shield of conductive material having an aperture in its base through which said second tubular conductor and said central conductor extend, said shield being in electrical communication with said second tubular conductor and substantially enclosing a predetermined portion of said sleeve of alumina insulation in spaced relation thereto.

6. A terminal for a high voltage coaxial cable adapted for supplying power to an electrical apparatus disposed in an evacuated enclosure which cable includes a central conductor, a sleeve of insulation disposed about said central conductor, a tubular conductor disposed concentrically about said insulated central conductor, said tubular conductor terminating in spaced relation to the end of said cable to provide an uncovered portion of said sleeve of insulation, said terminal comprising means for connecting said central conductor and said tubular conductor to said electrical apparatus, a sleeve of high voltage ceramic insulation disposed about said uncovered portion of said sleeve of insulation, a first sleeve of conductive material disposed intermediate said sleeve of insulation and an inner surface of said sleeve of ceramic insulation and spaced therefrom for optimizing the voltage gradient along said inner surface, a second sleeve of

conductive material disposed about the exterior of said sleeve of ceramic insulation and spaced therefrom for optimizing the voltage gradient along said exterior of said ceramic insulation, and means for electrically connecting one end of said first sleeve of conductive material and of said second sleeve of conductive material to ground.

7. A terminal for a high voltage coaxial cable adapted for supplying power to an electrical apparatus disposed in an evacuated enclosure which cable includes a central conductor, a first sleeve of insulation disposed about said central conductor, a second conductor disposed about said insulated central conductor, said second conductor terminating in spaced relation to the end of said cable to provide an uncovered portion of said first sleeve of insulation, said terminal comprising means for connecting said central conductor and said second conductor to said electrical apparatus, a sleeve of high voltage alumina insulation disposed about said uncovered portion of said first sleeve of insulation, a tubular member of conductive materal disposed about said sleeve of alumina insulation and spaced therefrom for optimizing the voltage gradient on said sleeve of alumina insulation, and means for electrically coupling one end of said tubular member of conductive material to ground.

No references cited.

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