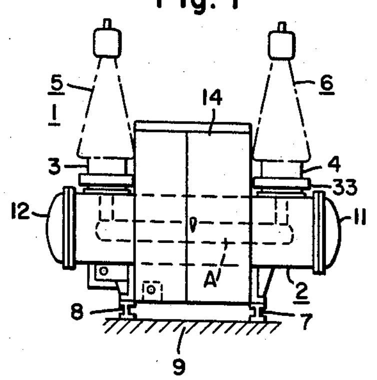
April 13, 1965 R. C. VAN SICKLE 3,178,505

TERMINAL-BUSHING CONSTRUCTION

Filed May 9, 1962 2 Sheets-Sheet 1

Fig. 1



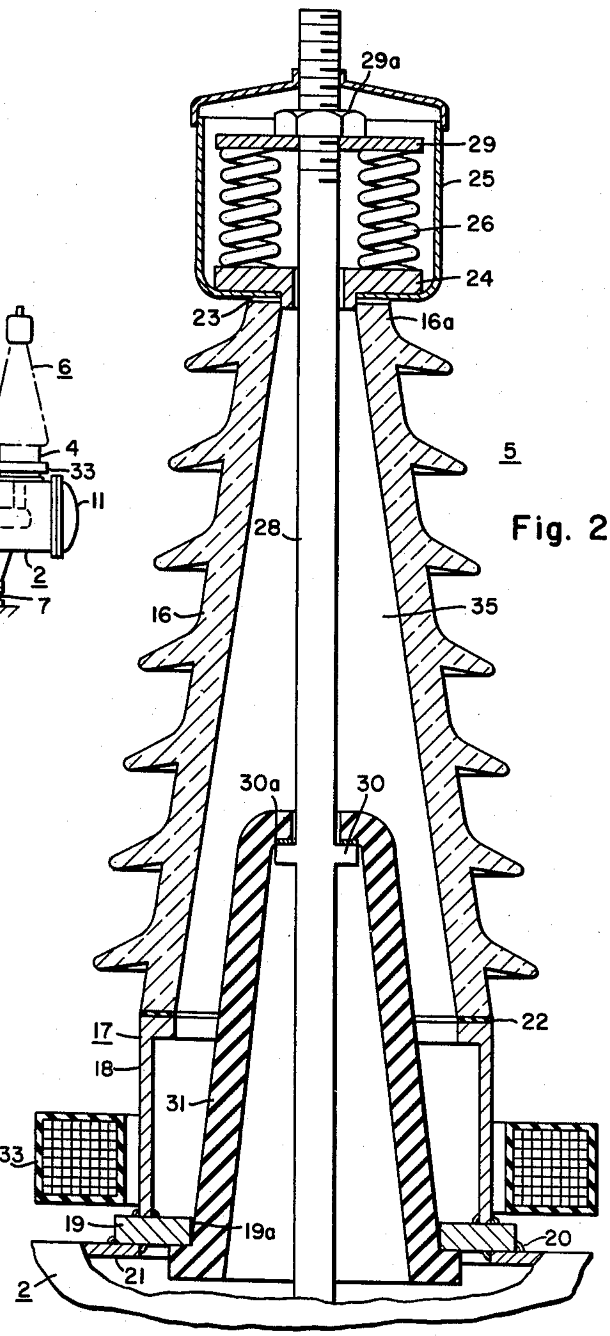


Fig. 2

WITNESSES

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PRIOR ART

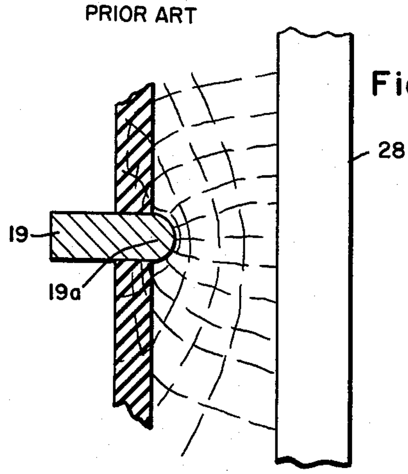

Fig. 3

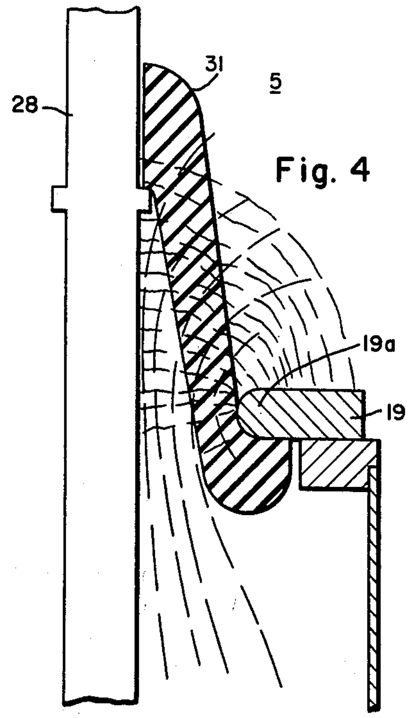

Fig. 4

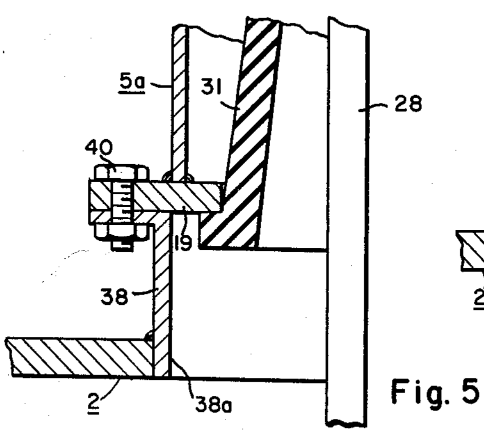

Fig. 5

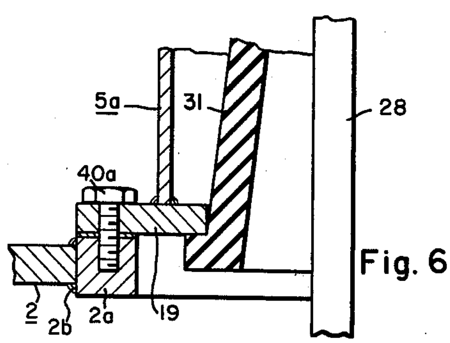

Fig. 6

3,178,505

TERMINAL-BUSHING CONSTRUCTION

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6 Claims. (Cl. 174—31)

This invention relates to terminal-bushing constructions in general and, more particularly, to a terminal-bushing construction of reduced length and preferably fluid-filled.

A general object of the present invention is to provide an improved terminal-bushing construction involving a reduced length and of highly-efficient dielectric conditions.

A more specific object of the invention is the provision of an improved gas-filled terminal bushing which may be rendered of reduced length by the use of a novel casing construction.

Yet a further object of the present invention is the provision of an improved terminal bushing, preferably of the sulfur-hexafluoride (SF_6) gas type, in which the interiorly-disposed bushing shell is inverted and is so located relative to the ground flange, that the dielectric conditions are improved to minimize consequently the possibility of internal flashover.

According to one aspect of the present invention, an insulating generally cone-shaped member is inverted, and is provided with hooked extremities, on flange portions so that one of said extremities or portions may at least partially encompass the inner edge of the ground flange ring, and the other of said extremities may be employed for attachment to the axially-extending conductor stud for assisting in transmitting the tensile force along the terminal bushing.

Further objects and advantages will readily become apparent upon reading the following specification, taken in conjunction with the drawings, in which:

FIGURE 1 is a side elevational view of a gas-filled circuit-interrupter construction utilizing terminal bushings incorporating features of the present invention;

FIG. 2 is an enlarged fragmentary detailed sectional view of the improved terminal-bushing construction of the present invention;

FIGS. 3 and 4 collectively illustrate the improvement in electrical field conditions by the employment of the improved terminal-bushing construction of the present invention;

FIG. 5 illustrates a modified type of terminal-bushing mounting construction; and

FIG. 6 illustrates an additional mounting construction.

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral 1 generally designates a circuit interrupter of the gas-filled type including a generally horizontally-extending, grounded metallic tank structure 2 having upstanding therefrom, at the extremities thereof, support collars 3, 4, into which protrude terminal bushings 5, 6.

As well known by those skilled in the art, attached to the interior ends of the terminal bushings 5, 6 is an arc-extinguishing assemblage A, which may be of the type set forth in United States patent application filed March 1, 1961, Serial No. 92,677, by Charles F. Cromer, and assigned to the assignee of the instant application. Since the present invention is not concerned with the circuit-interrupting assemblage, a description thereof is considered unnecessary and reference may be had to the aforesaid patent application for a description of the detailed structure thereof.

As shown in FIG. 1, the tank structure 2 is supported on support girders 7, 8, and these, in turn, are supported upon a suitable concrete slab 9, serving as a foundation. Disposed at the ends of the tank structure 2 are end covers 11, 12, which are preferably hinged about vertical hinge pins, and may be swung open so as to permit removal of the arc-extinguishing assemblage A in a manner more clearly disclosed in United States Patent 3,007,-021, issued October 31, 1961, to Thomas O. Prunty and Robert G. Colclaser, Jr., and assigned to the assignee of the instant application.

Situated in front of the tank structure 2 is a mechanism compartment 14, which houses suitable operating mechanism and compressor equipment, not shown, which is required for operation of the circuit interrupter 1. Reference may be had to United States patent application filed January 23, 1959, Serial No. 788,668, now United States Patent 3,057,983, issued Oct. 9, 1962, to Russell N. Yeckley, Joseph Sucha and Benjamin P. Baker, and assigned to the assignee of the instant application for a description of a suitable operating mechanism and gas-control equipment. As is the case with the arc-extinguishing assemblage A, such equipment constitutes no part of the present invention.

With reference to FIG. 2 of the drawings, it will be noted that the terminal bushing 5 comprises an outer weatherproof insulating shell 16 of generally conical shape, supported upon a ground-flange assembly, generally designated by the reference numeral 17. As shown, the ground-flange assembly 17 includes a cylindrical metallic ground flange collar 18 supported, as by welding, to an annularly-shaped ground flange ring 19. As shown in FIG. 2, the ground-flange ring 19 may be welded, as at 20, to an upper portion 21 of the tank structure 2.

Preferably, a gasket 22 is interposed between the exterior insulating shell 16 and the ground-flange assembly 17 to assist in making a gas-tight seal. In addition, an additional gasket 23 is provided at the upper end of the shell 16, being interposed between a spring seat 24 and the upper end 16*a* of the external shell 16 to obtain a gas-tight construction. An upper cap assembly 25 encloses a plurality of compression springs 26, which are utilized to place the external shell 16 under compression, while at the same time exerting tensile stress upon the axially-extending conductor stud 28. As shown, the conductor stud 28 has a spring-seat plate 29 adjustably secured thereto, as by a nut 29*a*. The plate 29 constitutes the upper seat for a plurality of annularly-disposed compression springs 26.

Disposed intermediate the ends of the axially-extending conductor stud 28 is an abutment 30, which may constitute a machined shoulder formed integrally with the stud 28. As shown in FIG. 2, the abutment 30 is in contiguous relationship with an interiorly disposed generally frusto-conically-shaped insulating shell 31. Preferably a gasket 30*a* is interposed to help distribute the load. As well known by those skilled in the art, the interiorly disposed insulating shell 31 is usually extended downwardly from the flange assembly 17 so that the lower extremity thereof is immediately adjacent the lower end of the conductor stud 28. However, it has been discovered that inverting the usual position of the insulating shell 31, and substantially telescoping the same upwardly within the upper outer shell 16 provides a desired support, and moreover improves the electrical stress conditions adjacent the inner end 19*a* of the ground-flange ring 19.

FIGS. 3 and 4 illustrate more in detail the improved electrical stress conditions which result by an application of the insulating shell 31 in the manner shown in FIG. 2. Because of the relatively high S.I.C. of the material of the shell 31, the electrical stress conditions adjacent the inner end 19*a* of the ground flange ring 19 is improved to minimize the possibility of internal flashover. In addition, by inverting the usual position of the shell 31, the overall axial length of the terminal bushing 5 is shortened, and this is a particularly important feature during shipment of the breaker to a customer by railway and in the height of the structure in which the breaker is used.

The electrical field within the terminal bushing 5 between the conductor stud 28 and the mounting flange 17 can be effectively controlled by the illustrated design of the insulators 16, 31. The maximum electrical stress of a conventional type terminal bushing will be at the conductor stud if its diameter is relatively small. On the other hand, the maximum electrical stress will be at the inside edge of the mounting flange if the flange is relatively thin and the inside surface has a relatively sharp corner or a relatively small radius.

In the present invention the relatively short insulator 31 passes through the electrical field between the flange 19 and the conductor stud 28. The relatively high S.I.C. of the ceramic makes possible a modification of the electrical field. By a suitable design, as shown, the insulator 31 may reduce the electrical stress around the flange 19; and, if this is the weakest area, thereby increase the dielectric strength of the bushing. FIGURE 3 illustrates the lines of equal potential between the conductor stud 28 and the flange of a conventional bushing. As shown, the conditions are assumed to produce high electrical stresses adjacent to the flange. On the other hand, FIG. 4 shows the lines of equal potential resulting from an application of the present invention. The insulating material, or ceramic, near the flange reduces the dielectric stress there, but increases the stress near the conductor 28. By a suitable proportion, the maximum stress within the gaseous insulation is held to a value considerably less than that of FIG. 3 and the dielectric strength of the terminal bushing 5 is, consequently, rendered much higher.

As well known by those skilled in the art, preferably a current transformer 33 encircles the ground-flange assembly 17 and provides a means of measuring the current being transmitted through the conductor stud 28 to the arc-extinguishing assemblage A. The insulating gas 35, which may be used interiorly of the shell 16 is preferably a high-dielectric-strength gas, such as sulfur-hexafluoride (SF_6) gas. However, it is to be clearly understood that other dielectric fluids than SF_6 may be used. Moreover, the particular constructional features of the present invention are applicable to terminal bushings using for example other insulating fluids, say even liquid, such as oil. It is, therefore, to be understood that the present invention is not limited to the use of a gas as the dielectric medium diesposed interiorly of the terminal bushing 5, but that any suitable dielectric medium may be employed, even air for the lower-voltage applications.

It will be observed that the upper insulating shell 16 is under compressive stress. Porcelain is able to assume such compressive stress, but for certain applications is not generally suitable for withstanding tensile stress. It may, therefore, be desirable to utilize as the material for the interiorly-disposed insulating shell 31 a suitable resinous material, such as a polyester resin, an epoxy resin, or other suitable resinous material, as well known by those skilled in the art. United States Patents 3,001,004 and 3,001,005 may be referred to in this connection.

It will be noted that FIG. 2 employs a construction in which the ground flange ring 19 is welded to the upper side 21 of the tank structure 2 so that assembly of the terminal bushing 5 must take place in connection with the tank structure 2 utilizing the openings into tank 2 through covers 11 and 12. However, as illustrated in FIG. 5, the terminal-bushing construction of the present invention need not be assembled within the tank structure 2 in piecemeal fashion. As shown in FIG. 5, the terminal bushing 5*a* may be assembled externally of the tank structure 2 as a unitary device and then subsequently

secured to a support collar 38 by mounting bolts 40 as a separate assembly operation.

FIG. 6 illustrates a slight mounting variation from the construction shown in FIG. 5 wherein the ground-flange ring 19 may be bolted directly, by bolts 40*a*, to the mounting ring 2*a* of the tank 2. As shown, the mounting ring 2*a* is welded, as at 2*b* to the tank 2.

From the foregoing description, it will be apparent that the present invention is particularly suitably for gas-filled type high-voltage terminal bushings. The bushing may be exposed to weather at one end and may project into a gas-filled chamber at the other end. The improved terminal bushing has the advantages of first shortening the overall height of the bushing by inverting the insulating member 31 on the lower end of the terminal bushing. A second very important feature of the terminal bushing of the present invention is the improvement secured in the insulating properties of the bushing by having porcelain, or other suitable insulating material, interposed between the conductor stud 28 and the nearest grounded parts of the flange assembly 17. As shown in FIG. 2, the insulating member 31 within the gas surrounds the flange 19 in which the bushing is mounted, and with its higher S.I.C. reduces the electrical stress adjacent to the edges and corners 19*a* of the flange 19. This makes it unnecessary to round the edges 19*a* and remove projections of the metallic grounded parts. Moreover, it has been illustrated how the bushing may be assembled in the apparatus 1 itself thereby reducing the number of seals and facilitating making and keeping the container 2 gas-tight. Finally, as illustrated in FIG. 5, it has been shown how a subassembly may be employed having a bolted flange for mounting over the entrance hole 38*a* in a gas-containing vessel.

Although there have been illustrated and described specific structures, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art, without departing from the spirit and scope of the invention.

I claim as my invention:

1. A terminal bushing including a first conical shell composed of insulating material and having both the small and large ends thereof open, a ground-flange assembly adapted to be mounted on electrical equipment and including a ground flange collar having a substantially uniform diameter substantially equal to the diameter of the large end of the first conical shell, the large end of the first conical shell substantially abutting against one end of the ground flange collar, a second conical shell composed of insulating material disposed partially within the first conical shell with the wall of the second conical shell tapering in the same direction as the wall of the first conical shell, the wall of the second conical shell being spaced from the wall of the first conical shell, the ground-flange assembly also including a ring of predetermined thickness secured to the other end of the collar and forming an annular shoulder, the second conical shell extending through said ring and having an outwardly extending annular flange portion at the large end thereof adjacent said ring and abutting against the annular shoulder formed by said ring whereby the second conical shell is secured against substantial movement farther within the first conical shell, the small end of the second conical shell having an axial bore therethrough of predetermined diameter, an axially-extending stud composed of conductive material extending through the first and second conical shells and through said axial bore, the stud having an annular flange at a predetermined position thereon and within the second conical shell, said last-named annular flange engaging the small end of the second conical shell adjacent the bore therethrough, a spring assembly mounted on the small end of the first conical shell and including springs and a spring-seat plate secured to the stud at a predetermined position thereon, and a cap enclosing the

spring assembly, the springs of the spring assembly exerting force between said spring-seat plate and the small end of the first conical shell whereby compressive stress is applied to the first conical shell and tensile stress is applied to the second conical shell by way of the stud and the annular flange thereon, the second conical shell being interposed in the electric field between the stud and the ground flange assembly and increasing the breakdown voltage of the bushing.

2. A terminal bushing according to claim 1 including in addition a gasket disposed between the cap enclosing the spring assembly and the small end of the first conical shell, another gasket disposed between the flange on the axially-extending stud and the adjacent wall of the small end of the second conical shell, and a further gasket disposed between the large end of the first conical shell and the adjacent end of the collar of the ground-flange assembly whereby there is provided a fluid-tight compartment including portions of the interiors of the collar and the first conical shell, and a dielectric gas disposed within and substantially filling said fluid-tight compartment.

3. A terminal bushing including a first conical shell composed of insulating material and having both the small and large ends thereof open, a second conical shell composed of insulating material and disposed partially within the first conical shell, the second conical shell having the large end thereof open and having an axial bore through the small end thereof, the wall of the first conical shell and the wall of the second conical shell tapering in the same direction, the wall of the second conical shell being spaced from the wall of the first conical shell, the second conical shell having an outwardly-extending annular flange portion at the large end thereof, a ground flange collar at ground potential and adapted to be mounted with one end thereof adjacent electrical apparatus, the collar having a diameter substantially equal to the diameter of the large end of the first conical shell and having the large end of the first conical shell disposed adjacent the other end thereof, a ring at said one end of the collar interposed between the collar and the electrical apparatus, the ring being secured to the collar and forming an annular shoulder against which the outwardly extending annular flange of the second conical shell abuts whereby the second conical shell is secured against substantial movement farther within the first conical shell, a stud of conductive material extending through the first and second conical shells by way of the bore in the small end of the second conical shell and having an annular flange at a predetermined position thereon, said last-named annular flange being inside the second conical shell and abutting against the small end of the second conical shell, and spring means mounted at the small end of the first conical shell and operatively secured to the stud whereby the spring means applies compressive stress to the first conical shell and applies tensile stress to the second conical shell by way of the stud and flange thereon, the second conical shell of insulating material producing an electric field distribution between the stud and the ground flange collar and ring secured thereto in which a substantial portion of the electrical stress occurs within the insulating material of the second conical shell, and the electrical stress in the space within the second conical shell, and the electrical stress in the space within the ground flange collar are reduced.

4. A terminal bushing according to claim 3 including in addition cap means enclosing the spring means, a gasket disposed between the small end of the first conical shell and the cap means, the cap means and gasket forming at the small end of the first conical shell a seal which prevents fluid in the first conical shell from escaping at the small end thereof, another gasket disposed between the large end of the first conical shell and the adjacent end of the collar, an additional gasket disposed between the flange on the stud and the small end of the second conical shell whereby a fluid-tight compartment is provided within the collar, the first conical shell and the cap means, and a dielectric fluid in said fluid-tight compartment.

5. A terminal bushing including a first conical shell composed of insulating material and having both the small and large ends thereof open, a second conical shell composed of insulating material disposed partially within the first conical shell, the wall of the first conical shell and the wall of the second conical shell tapering in the same direction, the wall of the second conical shell being spaced from the wall of the first conical shell, the small end of the second conical shell having an axial bore therethrough, a stud composed of conductive material extending through the first and second conical shells and through the axial bore in the small end of the second conical shell, the large end of the second conical shell being disposed outside of the first conical shell and having an outwardly-extending annular flange thereon, a ground flange assembly including a collar having a diameter substantially equal to the diameter of the large end of the first conical shell, one end of the collar substantially abutting against the large end of the first conical shell, an annular ring secured to the other end of the collar, the annular ring being of predetermined thickness with an outer diameter substantially greater than the outer diameter of the collar and an inner diameter substantially less than the inner diameter of the collar, the ring forming an annular shoulder against which the outwardly extending annular flange on the large end of the second conical shell abuts whereby the second conical shell is secured against substantial movement farther within the first conical shell, the portion of the ring extending radially beyond the outer wall of the collar having a plurality of bores at spaced intervals around the periphery thereof adapted to receive bolts for securing the ground flange assembly to electrical apparatus, the stud having an annular flange thereon, the last-named flange being within the second conical shell and abutting against the small end of the second conical shell, and spring means mounted at the small end of the first conical shell and operatively secured to the stud for applying compressive stress to the first conical shell and applying tensile stress to the second conical shell by way of the flange on the stud, the second conical shell being interposed in the electric field between the stud and the ground flange assembly and increasing the breakdown voltage of the bushing.

6. A terminal bushing according to claim 5 including in addition a cap enclosing the spring means, a gasket at the small end of the first conical shell and providing a sealing engagement with the cap, a further gasket between the large end of the first conical shell and the adjacent end of the collar, an additional gasket between the flange on the stud and the adjacent small end of the second conical shell to provide a fluid-tight chamber including a portion of the interior of the first conical shell, and a dielectric fluid in said chamber.

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