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J. A. OPPEL

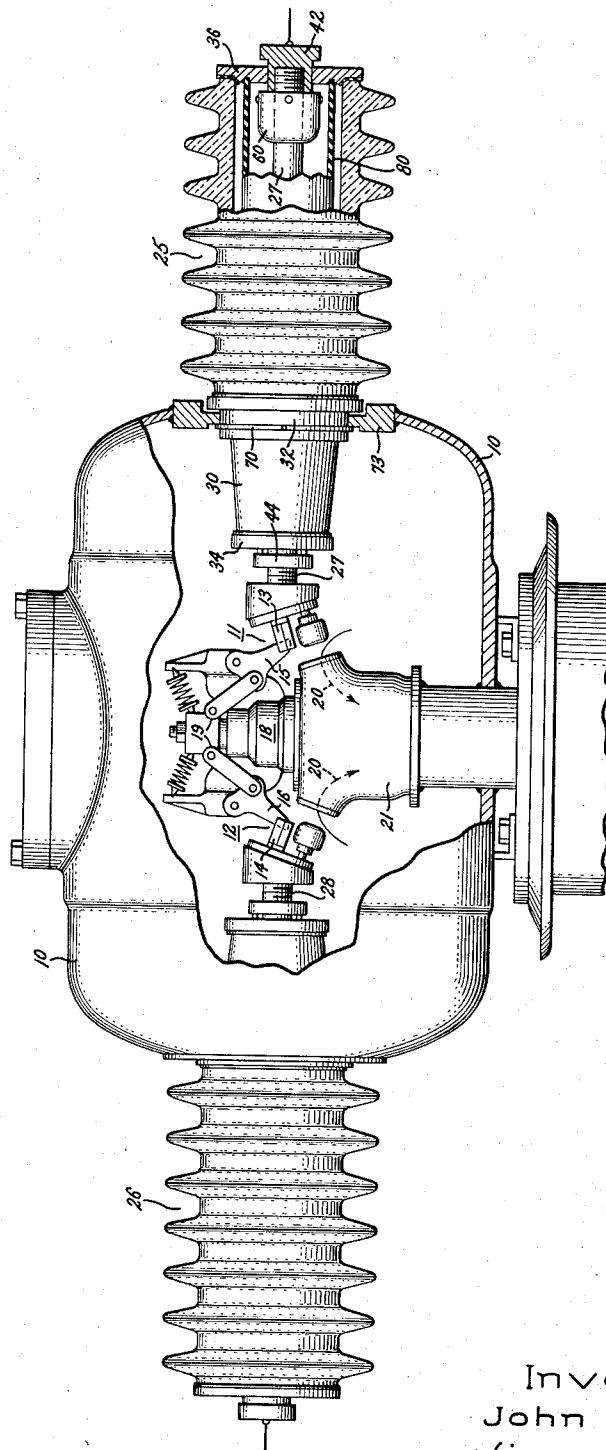
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BUSHING STRUCTURE FOR ELECTRIC APPARATUS

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2 Sheets-Sheet 1

Fig. 1.



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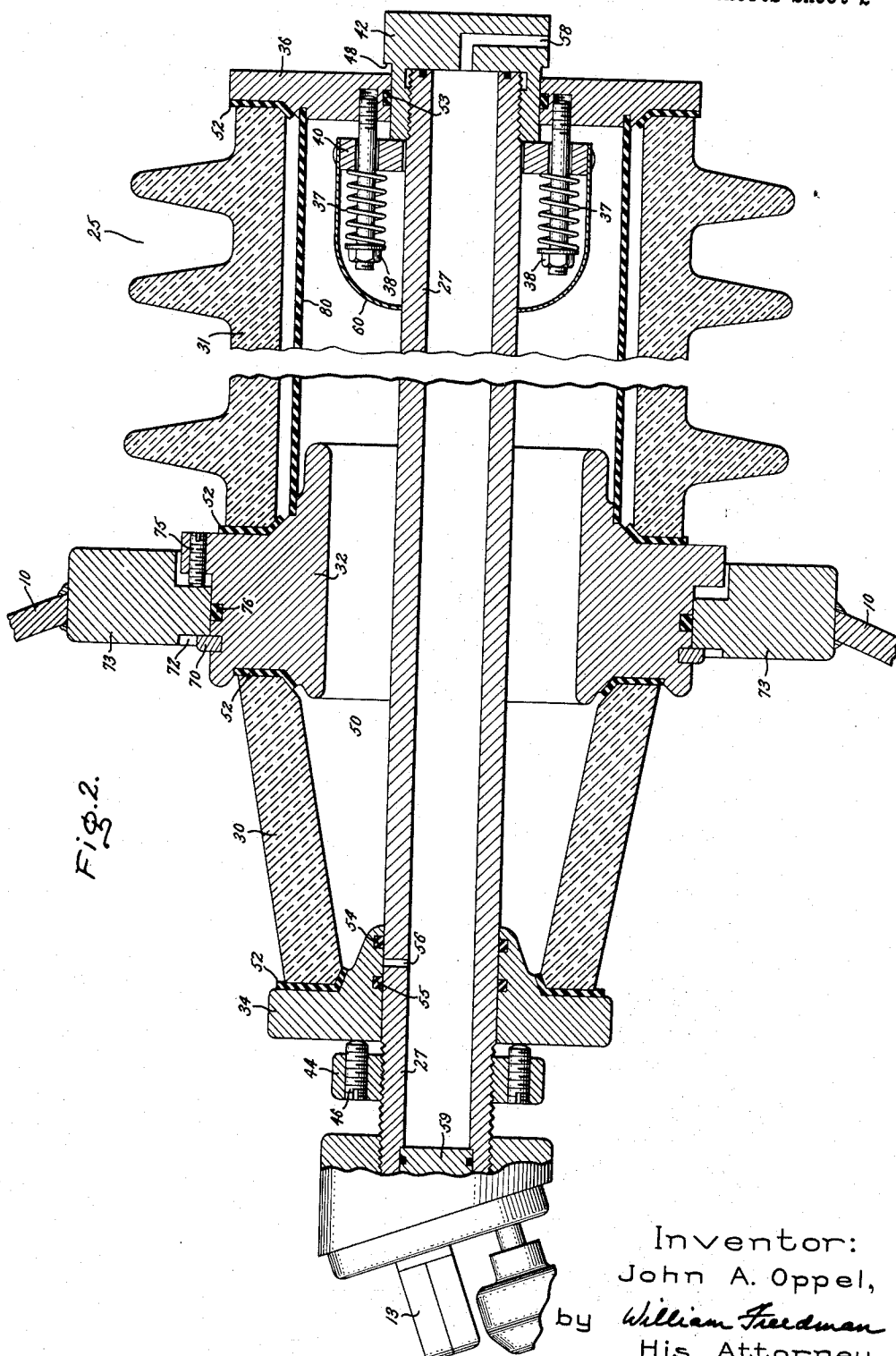
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BUSHING STRUCTURE FOR ELECTRIC APPARATUS

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5 Claims. (Cl. 174-18)

This invention relates to a high voltage terminal bushing for electrical apparatus and, more particularly, to a terminal bushing of the type that is filled with a pressurized insulating gas.

The usual high voltage bushing comprises a central conductive stud surrounded by housing means formed from a pair of tubular insulating shells. The insulating shells are customarily maintained in compression by clamping devices mounted at opposite ends of the central stud and bearing against opposite ends of the housing means. To allow the stud to expand and contract in response to temperature changes without damaging the insulating shells, it is customary to provide spring means between one end of the housing and the adjacent clamping device. The space between the stud and the housing constitutes a chamber filled with a dielectric medium. Suitable gaskets are provided to seal this chamber from the surrounding atmosphere, and the spring means holds these gaskets in compression in order to maintain the chamber sealed despite unequal expansion and contraction of the bushing parts.

In a bushing of the gas-filled type, pressurized gas fills the chamber between the stud and the housing means. This pressurized gas tends to produce forces opposing the action of the spring means, and this has resulted in complications. One of these complications is that it has been necessary heretofore to use relatively large and unwieldy spring means to withstand the opposing forces resulting from the pressurized gas and, at the same time, to perform its intended function of maintaining the insulating shells and the gaskets sufficiently compressed. The fact that the spring means has been large and unwieldy has necessitated locating it outside the bushing housing, thus unduly increasing the overall length of the bushing.

An object of my invention is to construct a gas-filled bushing in such a manner that a relatively small and weak spring device located internally of the bushing housing may be relied upon for compressing the gaskets and the insulating shells to the required extent despite the presence of a highly pressurized gas within the bushing.

Another object is to utilize the pressurized gas within the bushing for providing a portion of the force for maintaining one of the insulating shells and certain of the gaskets in compression.

In a preferred embodiment of my invention, I utilize my bushing for carrying electric power to and from a location within a tank containing pressurized insulating gas.

In such embodiment, another object of my invention is to utilize the pressure of the gas within the tank for helping to maintain one of the insulating shells in compression without allowing the pressurized gas within the tank to reduce the effectiveness of the spring means in maintaining the other insulating shell and the gaskets compressed.

Another object is to provide mounting means for the bushing which permits the bushing to be quickly installed and removed as a self-contained unit and which is capable of withstanding high forces tending to force the bushing out of its mounting, all without reliance upon the heavy bolts or studs heretofore conventionally used for mounting bushings.

In carrying out my invention in one form, I provide electric apparatus which comprises a tank containing pressurized gas and a terminal bushing extending through

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an opening in the tank. The bushing comprises a conductive stud and housing means including a pair of insulating shells surrounding the conductive stud to insulate the stud from the tank. The housing means forms a chamber about the stud which contains pressurized dielectric gas at a pressure lower than that of the gas within the tank. Adjustably mounted on the inner end of the stud is stop means rigidly bearing against the inner end of the housing means. Bearing against the outer end of the housing means is an annular sealing plate that closes off the outer end of the chamber. Secured to the outer end of the stud is a piston-like member of larger external diameter than the stud. This piston-like member is arranged for telescopic movement within the sealing plate during contraction and expansion of the stud and is provided with a seal disposed between the piston-like member and the sealing plate. Spring means acting between the piston-like member and the sealing plate is provided for loading the insulating shells in compression and for holding the sealing plate in sealed relationship relative to the housing means. The pressurized gas within the insulating chamber of the bushing acts through the piston-like member to apply tension forces to the stud through a path effectively bypassing the spring means. The spring means is located internally of the housing means at the outer end of the bushing.

For a better understanding of my invention, reference may be had to the following description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a side elevation view partly in section of an air blast circuit breaker comprising two bushings, each embodying one form of my invention.

FIG. 2 is a sectional view of one of the bushings disclosed in FIG. 1.

Referring now to FIG. 1, there is shown a gas-blast circuit breaker comprising a metallic tank 10 filled with a pressurized arc-extinguishing gas, such as air. Disposed within the tank 10 are two pairs 11 and 12 of separable contacts connected in series-circuit relationship. Each pair of separable contacts comprises a stationary contact 13 or 14 and a movable contact 15 or 16. The movable contacts 15 and 16 are adapted to be simultaneously separated from their respective stationary contacts 13 and 14 by means of an operating mechanism generally indicated at 18 acting through a set of connecting links 19. The operating mechanism and the contacts form no part of the present invention and therefore have not been shown in detail in FIG. 1. Preferably, however, these parts are constructed as shown and claimed in application S.N. 642,100, Beatty, filed February 25, 1957, now Patent No. 2,911,492, and assigned to the assignee of the present invention.

When the contacts are separated by the operating mechanism 18, an arc is formed across each inter-contact gap. This arc is quickly extinguished by the flow of pressurized gas from the tank 10 to the exterior of the tank via a path extending through the inter-contact gap and through a nozzle structure 21, as is indicated by the arrows 20. This flow of pressurized gas is controlled by suitable valve means (not shown) internally of the nozzle structure 21, and such valve means interrupts the flow of pressurized gas as soon as the arc is extinguished.

The stationary contacts 13 and 14 are respectively supported on the inner ends of terminal bushings 25 and 26 extending through aligned openings provided in the wall of tank 10. These bushings each have centrally disposed conductive studs 27 and 28 for carrying electric power to and from the contacts of the breaker through the openings in the wall of tank 10. When the contacts of the circuit breaker are open, the tank 10 is at approximately a mid-potential with respect to the two conductive studs 27 and 28. Under these open circuit conditions, the bush-

ings 25 and 26 serve to electrically insulate their respective conductive studs from the tank 10, as will soon be described. Since the bushings 25 and 26 are substantially identical, only one will be described in detail.

Referring now to FIG. 2, which is a detailed cross-sectional view of bushing 25, it can be seen that the bushing comprises a tubular housing 30, 31, 32 surrounding the conductive stud 27. This tubular housing is composed of a pair of tubular insulating shells 30 and 31, preferably of porcelain, and a metallic tubular support 32 disposed between the two shells 30 and 31. The inner porcelain shell 30 is disposed between the inner end of the stud 27 and the tank 10, whereas the outer porcelain shell 31 is disposed between the outer end of the stud 27 and the tank 10. Sealing plates 34 and 36 are disposed at opposite ends of the housing 30—32, and through these sealing plates are transmitted forces tending to compress the insulating shells 30 and 31, as will soon be apparent. A portion of the total force acting through the end plates 34 and 36 to compress the insulating shells 30 and 31 is derived from a plurality of compression springs 37 disposed within the outer insulating shell 31. Each of these compression springs 37 bears at one end against a suitable nut 38 attached to a bolt threaded into the end plate 36 and at its other end against a force-distributing washer 40 surrounding the stud 27 and abutting against a piston-like members 42 that is rigidly attached to the stud 27. It will therefore be apparent that the springs 37 tend to force the end plate 36 to the left and the piston-like member 42 to the right in FIG. 2.

The piston-like member 42 is prevented from moving to the right by a stop 44 which is threaded on the other end of the stud 27 and which carries jack screws 46 bearing the outer face of the lefthand sealing plate 34. Thus, the springs 37 urge the sealing plates 34 and 36 against the insulating shells 30 and 31 in a direction to compress the shells. The force exerted by these springs 37 can be adjusted simply by adjusting the jack screws 46, which are threaded in the stop 44. When the jack screws 46 are adjusted in a direction to increase the spacing between the parts 44 and 34, they force the piston 42 to the left to further compress the springs 37 thereby increasing the insulator compressing forces. Correspondingly, adjustment of the jack screws 46 in an opposite direction decreases the forces exerted by springs 37. Even though the springs 37 are located internally of the bushing housing 30—32, it is a simple matter to obtain an indication of the extent to which they are compressed. This can be done simply by measuring the distance between a shoulder 48 provided on the piston 42 and the other surface of sealing plate 36.

Between the housing 30—32 and the stud 27 there is a closed, generally-cylindrical chamber 50 sealed at its opposite ends by the sealing plates 34 and 36. This chamber 50 contains a pressurized gas of high dielectric strength, such as sulfur hexafluoride. This pressurized gas provides the dielectric strength necessary to prevent breakdowns between the stud 27 and the tubular metallic supporting ring 32, which is at the same potential as the tank 10. For preventing leakage of the pressurized gas from chamber 50 or from the tank 10 into the chamber 50, suitable gaskets 52 are provided at opposite ends of each of the porcelain shells 30 and 31. These gaskets 52 are compressed by the previously-described insulator compressing forces transmitted from springs 37 through the sealing plates 34 and 36, and, thus, the gaskets are effective to preclude leakage at both ends of each of the two insulating shells 30 and 31.

Leakage of pressurized gas from the chamber 50 through the sliding joint between the outer sealing plate 36 and the piston 42 is prevented by means of a suitable O-ring 53 located in an annular groove in the inner periphery of the sealing plate 36. A similar O-ring 54 is provided in the inner periphery of the sealing plate 34 to prevent leakage of pressurized gas from the chamber 50

through the sliding joint between the sealing ring 34 and the conductive stud 27. Adjacent the O-ring 54 is another O-ring 55 which prevents leakage of pressurized air from the tank 10 along the outer periphery of the conductive stud 27. The region between the O-rings 54 and 55 is at atmospheric pressure by virtue of a passage 56 extending through the tubular stud 27 into communication with the bore of the tubular stud 27. The bore of the tubular stud 27 is at atmospheric pressure by virtue of a passageway 58 extending through the piston member 42 to the surrounding atmosphere and by virtue of a plug 59 at the inner end of the stud 27 preventing communication between the bore 27 and the interior of tank 10. This double O-ring arrangement 54, 55 with the intervening space vented to atmosphere is advantageous in preventing any interchange of gases within the bushing 25 and the tank 10 inasmuch as any leakage past either O-ring is vented to atmosphere rather than being allowed to contaminate the other gas.

The pressurized gas that is contained within the chamber 50 acts on the sealing plates 34 and 36 in a direction to oppose the action of the springs 37 in compressing the gaskets 52 and the insulators 30, 31. To withstand these opposing forces and at the same time provide the required force for compressing the gaskets and insulators, it has been necessary heretofore to use considerably heavier springs than those shown. In the disclosed bushing, springs of reduced size can be utilized for performing these functions because a portion of the forces resulting from the pressurized gas in chamber 50 is borne by the piston 42, thus subtracting from the forces that would have been exerted by the gas on the sealing plate 36 had the piston 42 been absent. Not only does the presence of piston 42 reduce the forces exerted on sealing plate 36, but also any forces exerted on piston 42 are transmitted through the stud 27 to inner insulator 30 in the form of compressive loading on the insulator 30 and the gasket 52 at the opposite ends of the insulator 30. The magnitude of the forces so transmitted is dependent upon the difference between the area enclosed by the O-ring 53 and that enclosed by the O-ring 54. To the extent that forces are transmitted in this manner through the piston 42 and the stud 27 to force the sealing plate 34 against the insulator 30, the springs are additionally relieved of the burden of withstanding the tendency of the pressurized gas in chamber 50 to separate the end plates 34 and 36 from the housing 30—32.

By enabling springs of reduced size to be relied upon for performing the required compressing functions, it has been possible to locate the springs inside the housing 30—32 instead of outside the housing as has generally been the practice heretofore. By locating the springs inside the housing 30—32, substantial reductions in the overall length of the bushing have been achieved as compared to bushings where the springs have been externally located. To prevent electrical stress concentrations from occurring near the sharp edges of the spring assembly, a shield 60 of smooth external configuration is provided for enclosing the springs 37. Because the internal region at the outboard end of the bushing is a region of low dielectric stress in comparison to those regions closer to the metallic supporting ring 32 where the gap is smaller, no significant reductions in breakdown voltage result from locating the enclosed spring assembly internally of the bushing housing.

Another advantage derived from locating the springs at the outboard end of the bushing (instead of at the inboard end) is that the position of the contact assembly 13 remains virtually unchanged despite changes in the pressure of the gas within the tank 10 or the bushing 25, and despite thermal expansion of the conductor 27. Changes in gas pressure do not significantly change the contact position because the position of the contact is determined by the rigid parts, 30, 34, 44, 46 which are substantially unaffected in dimension by variations in

pressure within the tank 10. Thermal expansion of conductor 27 does not significantly change the contact position because conductor 27 is free to expand at its outer end without displacing its inner or contact end.

It is to be noted that the springs 27 maintain the gaskets 52 and the insulators 31 and 32 compressed despite unequal expansion of the conductor 27 and the housing means 30—32. The sliding relationship of the piston 42 within the sealing plate 36 allows this independent expansion and contraction to occur without damage to the insulators.

It has been proposed in certain electrical apparatus containing pressurized gas to allow for free communication between the insulating space within the bushing and that within the remainder of the apparatus. In contrast to this approach, I isolate the insulating chamber 50 within the bushing from the space within tank 10. As a result of this isolation, I am able to utilize for the bushing a gas which is more suited for insulating purposes and for the tank 10 a gas which is more suited in this particular device for arc-extinguishing purposes. As a further result of this isolation, I am also free to use widely different pressures in the tank 10 and in the bushing chamber 50, selecting for each of these spaces the pressure best suited for the intended function. In the disclosed breaker, the pressure within the tank 10 is between 400 and 500 p.s.i. whereas the pressure within the chamber 50 of the bushing is only about 40 or 50 p.s.i. By using this materially lower pressure in the bushing, the size of my springs and the wall thickness of my insulator 31 can be drastically reduced as compared to the spring size and the wall thickness that would be needed if the high pressure tank space were allowed to freely communicate with the chamber 50.

The higher pressure within tank 10 helps to maintain the inner insulator 30 in compression and yet does not, in any significant way, reduce the effectiveness of the spring means 37, 38 in performing its desired function inasmuch as the higher pressure gas is isolated from the insulating chamber 50 of the bushing.

For holding the bushing 25 in place within its opening in the wall of tank 10, an annular locking ring 70 having a radially-extending split is provided. This locking ring 70, which has an unstressed diameter slightly smaller than the diameter of the groove 72 in which it is fitted, is snapped into this external groove 72 in the outer periphery of the tubular supporting member 32 and bears against the internal face of a reinforcing ring 73 welded to the tank wall 10. The tubular supporting member 32 has a flange external to the tank 10, and this flange carries jack screws 75 threaded therinto. When these jack screws 75 are tightened, the reinforcing member 73 of the tank wall is clamped between the split locking ring 70 and the jack screws 75. The high gas pressure within tank 10 acts in a direction to force the bushing 25 out of the tank, but the split ring 70 easily withstands this relatively high force inasmuch as the resultant stresses are distributed generally uniformly about substantially the entire periphery of the support member 32. A suitable O-ring seal 76 is provided about the outer periphery of the support member 32 to prevent leakage of pressurized gas therearound.

The split-ring type fastening means 70, 72, 75 is highly advantageous for a number of different reasons. First of all, it allows the bushing 25 to be quickly and easily installed in the breaker or removed from the breaker. Installation of the bushing is accomplished simply by slipping the bushing minus the split ring 70 into the tank opening from outside the tank, then snapping the split ring 70 in place from inside the tank, and then tightening up on the jack screws 75. Removal of the bushing is accomplished by first loosening the jack screws slightly, removing the split locking ring 70, and then sliding the bushing out. It will be noted that the bushing is installed and removed as a completely assembled unit. This not

only contributes to the ease and speed at which these steps can be performed but also allows the bushing to be tested apart from the breaker and allows it to be assembled at a more convenient location. The split ring type fastening means 70, 72, 75 is much less expensive than the bolted connections previously used and also can be sealed by a simple O-ring (as shown at 76) without the need for providing seals about each bolt hole as has frequently been the case when conventional bolted connections were used. It is to be noted also that the bolts needed for a conventional bolted connection would have to be quite large in view of the high pressure in the tank 10 and the relatively large area of the tank opening. Split ring 70 can easily withstand this load since the load is distributed substantially uniformly about the entire outer periphery of the support member 32.

It should be noted that internally of the porcelain shell 31, there is provided a tubular sleeve 80 of insulating material having an outside diameter slightly less than the inside diameter of the porcelain shell 31. The purpose of this sleeve 80 is to minimize the volume of gas that is available to eject porcelain particles in the remote event that the porcelain shell 31 should become severely damaged. In this regard, only the small volume of gas between the sleeve 80 and the shell 31 is available for such ejection. The sleeve 80, which has a bursting strength exceeding that of the porcelain shell 31, would effectively isolate the shell 31 from the gas inside of the sleeve 80 under these conditions.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects and I, therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In electrical apparatus comprising a tank containing pressurized gas, a terminal bushing extending through an opening in said tank with its inner end inside said tank and its outer end outside said tank, said bushing comprising: a centrally disposed conductive stud, housing means including a pair of insulating shells surrounding said conductive stud and insulating said stud from said tank, one of said insulating shells being disposed between the outer end of said stud and said tank and the other of said insulating shells being disposed between the inner end of said stud and said tank, said housing means forming about said stud a chamber containing pressurized insulating gas at a pressure lower than that of the gas within said tank, stop means adjustably mounted on the inner end of said stud and bearing rigidly against the inner end of said housing means, an annular sealing plate bearing against the outer end of said housing means and closing off the outer end of said chamber, a piston-like member rigidly secured to the outer end of said stud and arranged for telescopic movement within said sealing plate during contraction and expansion of said stud, said piston-like member having a larger external diameter than the diameter of said stud in the region where said stud enters said chamber from said tank, means providing a seal between said sealing plate and said piston-like member, spring means acting between said piston-like member and said sealing plate for loading said insulating shells in compression and for holding said sealing plate in sealed relationship to said housing means, said spring means being located internally of one of said insulating shells, the pressurized gas within said chamber acting through said piston-like member to apply tension forces to said stud through a path effectively bypassing said spring means.

2. The apparatus of claim 1 in combination with sealing means at the inner end of said bushing for isolating

said chamber from the pressurized gas space within said tank and for precluding pressurized gas from said tank from leaking around said stud into said chamber, said sealing means at the inner end of said bushing enclosing a predetermined area which is substantially smaller than the area enclosed by the sealing means disposed between said sealing plate and said piston-like member.

3. In electrical apparatus comprising a tank, a terminal bushing extending through an opening in said tank with its inner end inside said tank and its outer end outside said tank, said bushing comprising: a centrally disposed conductive stud, housing means including a pair of insulating shells surrounding said conductive stud and insulating said stud from said tank, one of said insulating shells being disposed between the outer end of said stud and said tank and the other of said insulating shells being disposed between the inner end of said stud and said tank, said housing means forming about said stud a chamber containing pressurized insulating gas, stop means adjustably mounted on the inner end of said stud and bearing rigidly against the inner end of said housing means, an annular sealing plate bearing against the outer end of said housing means and closing off the outer end of said chamber, a piston-like member rigidly secured to the outer end of said stud and arranged for telescopic movement within said sealing plate during contraction and expansion of said stud, said piston-like member having a larger external diameter than the diameter of said stud in the region where said stud enters said chamber from said tank, means providing a seal between said sealing plate and said piston-like member, spring means acting between said piston-like member and said sealing plate for loading said insulating shells in compression and for holding said sealing plate in sealed relationship to said housing means, said spring means being located internally of one of said insulating shells, the pressurized gas within said chamber acting through said piston-like member to apply tension forces to said stud through a path effectively bypassing said spring means.

4. Electrical apparatus comprising a tank containing pressurized fluid at a pressure higher than the pressure external to said tank, said tank having a wall containing an opening for receiving a terminal bushing, the terminal

bushing extending from outside said tank through said opening into said pressurized fluid, said bushing comprising a pair of insulating shells and a tubular supporting member mounted between said shells, an annular groove in the outer periphery of said tubular supporting member, a radially-split locking ring disposed within said groove and bearing against an annular inner surface of said tank wall adjacent said opening, sealing means disposed between the outer periphery of said tubular supporting member and the inner periphery of said opening for preventing the leakage of pressurized fluid about said outer periphery and jack screw means between said tank wall and said tubular supporting member for holding said locking ring against said inner surface.

5. In combination, a tank containing pressurized fluid, a high voltage terminal bushing extending through a wall of said tank, said bushing comprising a tubular conductive stud and housing means surrounding said stud, said housing means forming about said stud a chamber isolated from the pressurized fluid within said tank and containing pressurized insulating fluid at a pressure different from that of the fluid within said tank, an end plate forming an end wall of said chamber and located between said chamber and the fluid within said tank, said end plate having an inner peripheral portion closely surrounding the outer periphery of said tubular conductor, a pair of axially spaced O-rings disposed between said inner periphery of the end plate and the outer periphery of the tubular conductor for respectively sealing the fluid within said tank and the fluid within said chamber against leakage along said outer periphery of said tubular conductor, and means for maintaining the space between said O-rings at a lower pressure than the pressure within either said tank or said chamber comprising a passageway communicating at its opposite ends with the space between said O-rings and the space within said tubular conductor.

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