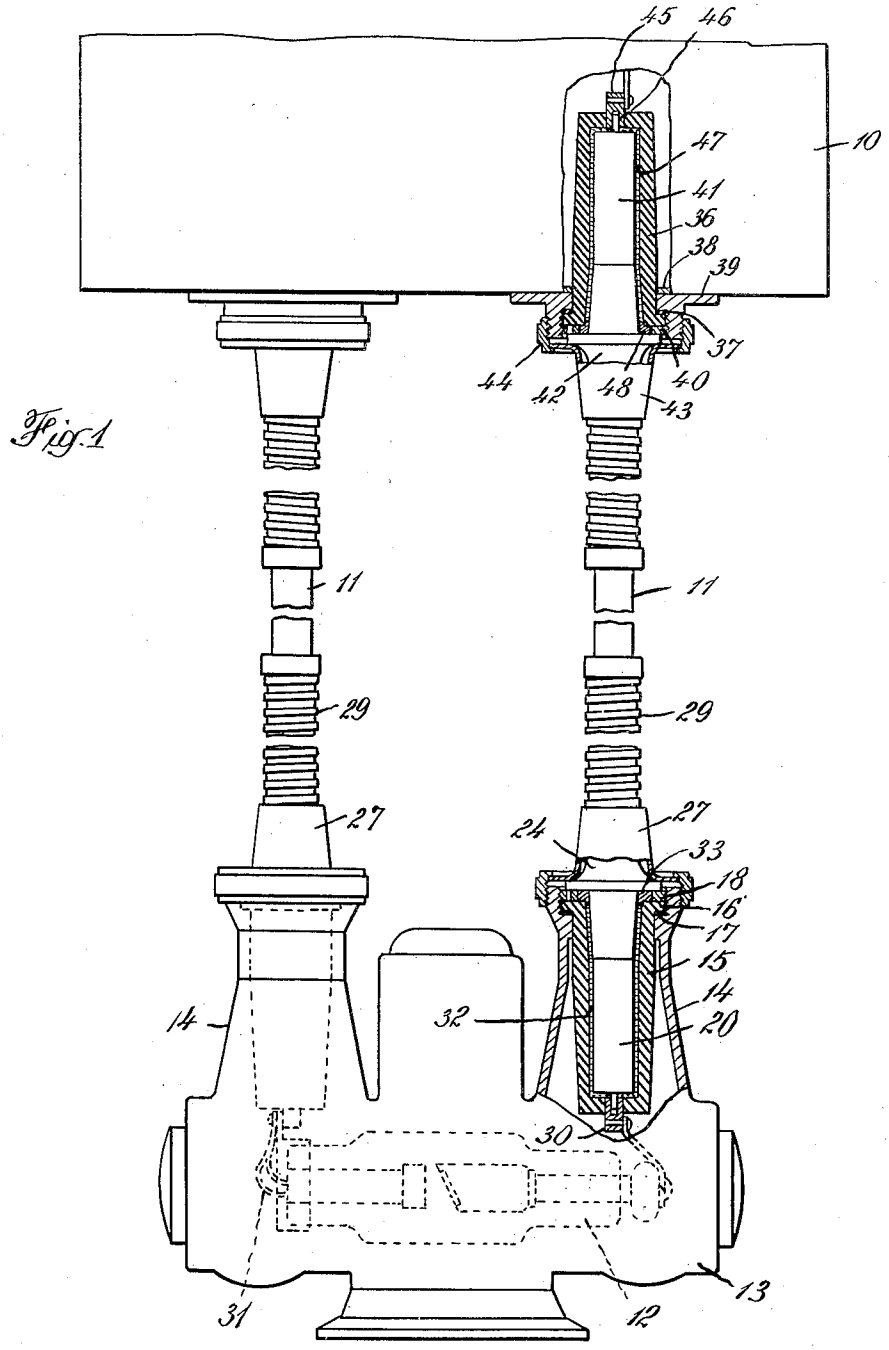
Feb. 17, 1942. T. H. ROGERS 2,273,538

X-RAY APPARATUS

Filed July 26, 1940 2 Sheets-Sheet 1

Fig. 1




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Filed July 26, 1940 2 Sheets-Sheet 2

Fig. 2,

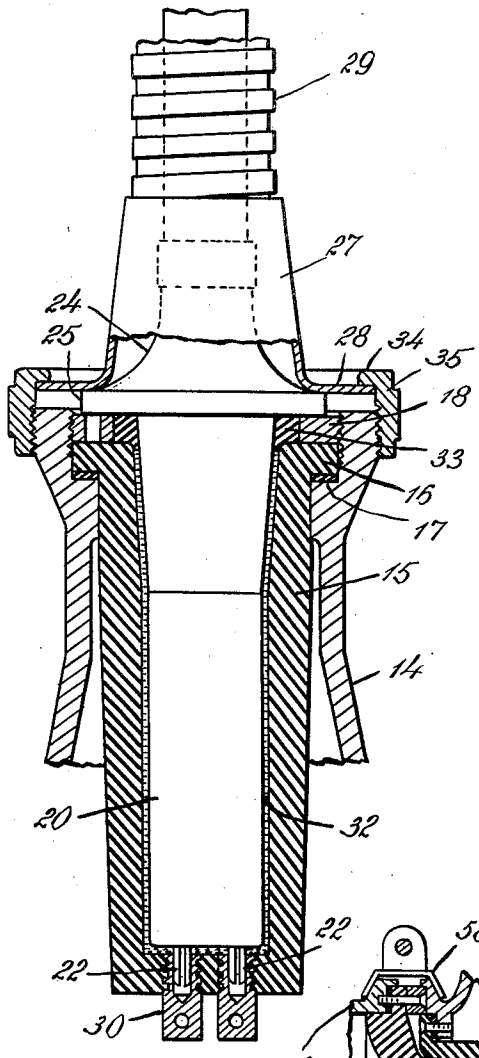



Fig. 3,

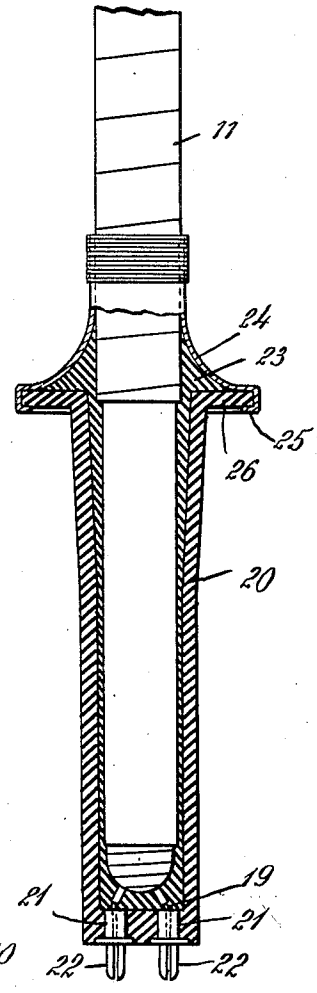
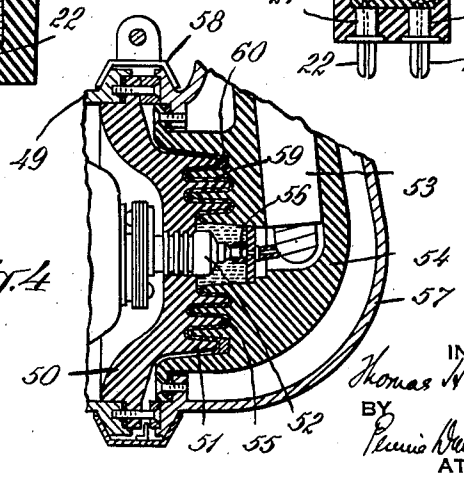



Fig. 4




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2,273,538

# UNITED STATES PATENT OFFICE

2,273,538

## X-RAY APPARATUS

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Application July 26, 1940, Serial No. 347,611

14 Claims. (Cl. 250—104)

This invention relates to high tension electrical equipment, such as X-ray apparatus, and is concerned more particularly with a novel means by which such equipment and its supply lines may be made entirely shockproof without the use of air as an insulating medium at any point. While the invention may be employed in connection with high tension apparatus of various kinds, it offers special advantages in the X-ray field. An adaptation suitable for use with X-ray apparatus will, accordingly be illustrated and described in detail for purposes of illustration.

In modern shockproof X-ray equipment, the tube is customarily mounted in a metallic housing filled with an insulating liquid, such as oil, and high potential energy is supplied to the tube from a source, such as a transformer, through heavily insulated cables provided with a metallic sheathing which is grounded and serves to ground the housing. The cables are preferably detachable from the housing and various forms of detachable connection are employed for the purpose. Such a connection commonly includes an insulating sleeve mounted on and enclosing one end of a cable and a socket of insulating material mounted on or within the housing. The sleeve carries an exposed terminal connected to a conductor within the cable and the socket is provided with a terminal exposed within its interior and connected to a terminal of the tube through a conductor within the housing. To establish the connection from the tube to the source through the cable, the sleeve is inserted in the socket so that the terminals of the sleeve and socket contact, after which the sleeve is secured in position by suitable clamping means.

In an installation such as that above described, the tube is insulated by the liquid in which it is immersed and the conductors within the cables are insulated by solid insulating material. Each sleeve and its socket are made to fit snugly but, for practical reasons, cannot be made with a sufficiently tight fit to exclude all air between them. The contacting terminals of the sleeve and socket are, therefore, insulated by air only in the space between the opposed surfaces of the sleeve and socket and such air insulation is the weak spot in the system.

The apparatus ordinarily operates at voltages of at least 50 PKV. between the terminals and ground so that the air path between the terminals and the grounded casing must be very long in order to prevent sparkover and this requires that the sleeve and socket be long and usually necessitates the provision of long necks on the housing for enclosing the sockets. The practical limitations are such that the sleeve and socket combination ordinarily used has a breakdown voltage under normal atmospheric conditions not greatly in excess of the voltage rating of the tube and the use of air insulation in the combination, therefore, represents a potential hazard.

Frequently X-ray equipment having detachable cable connections of the type now in common use is employed at high altitudes and in that case, the breakdown voltage of the detachable cable connections is reduced. A similar effect results from excessive humidity in the atmosphere. A flash-over for any reason destroys the insulating members of the connection and, since the equipment is frequently used in operating rooms where ether vapor may be present, a breakdown of the connection may ignite fumes and produce other serious results.

Another disadvantage of the air-insulated connections is that the high potential gradient causes the air therein to become ionized with resultant corona effects. These effects give rise to high frequency oscillations in the circuit involving the cable capacitance, which reduce the life of the cable. Also, corona always results in the formation of nitrous oxide which tends to corrode the contact terminals and may produce sufficiently poor contact as to affect the filament circuit adversely.

The present invention is, accordingly, directed to the provision of a novel cable connection for use in high tension electrical equipment, such as X-ray apparatus, which is readily detachable but does not involve the use of air as an insulator. The new connection has a longer life than those previously used because of the elimination of the liability of destructive sparkover and its use prevents impairment of the cable insulation and of the contacts resulting from development of corona. The new connection thus affords all the advantages of the prior connections while at the same time overcoming their disadvantages.

For a better understanding of the invention, reference may be had to the accompanying drawings in which

Fig. 1 is a view in elevation of an X-ray installation in which the new connection is employed, certain of the parts of the apparatus being illustrated in section;

Fig. 2 is a longitudinal sectional view, with parts shown in elevation, of one form of the new connection;

Fig. 3 is a view similar to Fig. 2 showing additional parts in section; and

Fig. 4 is a cross-sectional view illustrating the use of the invention in a different type of housing construction.

Referring to the drawings, the X-ray installation illustrated in Fig. 1 includes a source of high potential energy which may be a transformer including windings immersed in oil within a housing 10. Energy is supplied from the transformer through cables 11 to an X-ray tube 12 immersed in a body of insulating fluid, such as oil, within a

housing 13. In the installation shown, the cables are connected both to the transformer and to the tube terminals by the detachable connections of the invention, and the use of such connections both at the transformer and tube housing is desirable in certain installations, particularly when the transformer and tube are in the same room and detachment of the cables from both the tube and transformer may occasionally be required. In some installations, the transformer may be installed in a cabinet or in a room adjoining that in which the tube is to be used, and in those instances where sufficient space is available, conventional connections designed to prevent sparkover may be employed between the cables and transformer.

The tube housing is provided with a pair of open-ended necks 14 at each end of the tube and the end of each neck is closed by a socket 15 of insulating material which extends up into the neck a substantial distance and may be made of a suitable plastic. At its open end, the socket is provided with a circumferential flange 16 seated on a cushioning gasket 17 in a channel formed in the inner wall of the neck near the open end thereof, and the socket is held in place against the gasket by a ring 18 threaded into the end of the neck and bearing against the top of the flange.

The cable 11 is of the conventional type and it includes one or more conductors enclosed within solid insulation and is also provided with a metallic sheath which is grounded. At the end of the cable, a portion of the sheath and of the insulation is removed to expose bare portions of the conductors 19 and this end portion of the cable is enclosed within an insulating sleeve 20 having a closed end and of an outer form which corresponds as closely as practical with the shape of the interior of the socket 15. The sleeve is provided with a pair of terminals 21 embedded in the closed end thereof and extending through the end, and in the construction shown, the terminals have split projecting prongs 22. The bare ends of the conductors pass through bores in the terminals and are secured in place therein in any suitable manner. The space between the cable and the interior of the sleeve is filled with a body of suitable insulating compound 23 which encloses and insulates the bare portions of the conductors 19 and terminals 21. To the rear of the sleeve, a bell-shaped collar 24 is mounted on the cable and the rim 25 of its large end is spun over a circumferential flange 26 at the open end of the sleeve. The space within the collar is also filled with the insulating compound.

A bell-shaped clamping collar 27 is mounted on the cable in telescoped relation to the collar 24 and collar 27 has a flange 28 which overlies and rests upon the top of collar 24 near the outer edge of flange 26. The cable is also provided with means for preventing sharp bends therein near the detachable connection and, for this purpose, a flat wire spring 29 of suitable length encloses a portion of the cable and has one end lying within the collar 27.

The socket 15 is provided with terminals 30 equal in number to the contact terminals 22 of the sleeve and embedded in and extending through the closed end of the socket so that their projecting portions lie within the body of oil inside the housing 13. Connections 31 extend from the terminals 30 within the body of oil to the tube terminals at the adjacent end of the tube. The terminals 30 are socketed at their inner ends to receive the split prongs 22 of terminals 21.

While the external shape of the sleeve conforms closely to the internal shape of the socket, these parts cannot be made to fit air tight for practical reasons. Accordingly, the space between the sleeve and socket in the completed connection is filled with a body of deformable insulating or high dielectric material 32 which encloses the exposed portions of prongs 22, covers the inner ends of the terminal members 30, and extends up within the sleeve to the open end of the socket. The insulating material used for this purpose may be any suitable plastic compound which is somewhat fluent, such as petroleum jelly or heavy oil. In order to prevent the escape of the compound, the ring 18, which holds the socket in position, has an inner opening of greater diameter than that of the upper end of the insulator just below flange 26 and in the space thus provided is mounted a deformable sealing ring 33 of a suitable or insulating or high dielectric material which is not subject to deterioration when exposed to the fluent compound used to form the body 32. The ring 33 may be made of synthetic rubber or other material of that character and it is of such size and shape as to be compressed by flange 26 and forced down into the top of the space between the socket and sleeve when the latter is in operative position.

The ring 33 not only seals the fluent insulating material between the socket and sleeve so as to prevent escape of the material by leakage, but also acts to protect the material against the action of external conditions which would tend to reduce the effectiveness of the fluent insulation. Thus, the ring prevents moisture or dust from reaching the insulating material and prevents the infiltration of vapors, inflammable or otherwise, into the terminal. In operation, when the parts are heated, the insulation tends to expand, and the deformability of the material of which the ring is made enables it to permit such expansion while maintaining the seal at all times. The ring 33 being of synthetic rubber or other high dielectric material affords a dielectric path between the upper end of the socket 15 and the sleeve 20 sufficiently great to prevent electrical breakdown at potentials normally applied to the apparatus.

The sleeve may be held within the socket with the terminals of the sockets and sleeve in proper contacting relation by any suitable clamping means. In the construction illustrated, the flange 28 of collar 27 extends out nearly to the outer edge of the end of the neck 14 and it is engaged by the flange 34 of a ring 35 threaded on the neck. When the ring 34 is screwed down, it acts through flange 28 to force the sleeve 20 to its inmost position and in that operation flange 26 of the sleeve compresses the deformable ring 33 and forces it into firm contact with the opposed walls of the sleeve and socket so that it seals the insulating compound.

The connections by which the cables 11 are detachably connected to the transformer may be of the same construction as those employed at the tube housing, if desired, and the use of one such connection is illustrated in Fig. 1. At the transformer, the insulating socket 36 is mounted in an opening through the wall of housing 10 and has a flange 37 resting on a cushioning gasket 38 contacting with a shoulder formed within a bushing 39 attached to the outer wall of the housing and

surrounding the opening. The socket is held in place by a ring 40 threaded into the bushing 39 and within the socket is inserted the sleeve 41 mounted on the end of the cable. The cable is provided with a collar 42 corresponding to collar 24 and also mounted on the cable is a clamping collar 43 held in place by a ring 44 threaded on the end of bushing 39. The socket and sleeve are provided with contact terminals designated 45, 46, respectively, and the space between the socket and sleeve is filled with a body of insulating material 47 which is sealed by a ring of deformable material 48 forced into the outer end of the space by the flange on the sleeve.

With a connection of the construction described, the establishment of the connection is a simple, easy operation. The exterior of the sleeve and the interior of the socket are first wiped clean and dry, and the ring of deformable material 33, 48 is mounted on the sleeve and moved up against the flange thereon. A heavy coating of the fluent insulating material is then applied to all surfaces of the sleeve, after which the sleeve is forced slowly into the socket. Any excess insulating material forced out of the space between the socket and sleeve in this operation is wiped off and the clamping ring 34 is screwed down. At the completion of these operations, the entire space between the sleeve and socket which would otherwise be filled with air is filled with the fluent insulating material and danger of destructive sparkover is thus substantially eliminated through the space. When the connection is to be broken, the clamping ring is unscrewed and the sleeve withdrawn from the socket.

In the prior constructions, the use of air insulation in the space between the sleeve and socket has required that these parts be of substantial length to interpose a long path of travel between the contacts at the end of the sleeve and the nearest grounded part. In the case of the tube enclosure which is grounded through the clamping ring and the cable sheathing, the necessity of providing a long socket and sleeve has required that the housing have long necks for the sockets. With the new connection in which the contacts are insulated by a non-gaseous medium, the lengths of the socket and sleeve on the end of the cable may be substantially reduced so that the connection makes it possible to construct tube housings which have shorter necks and are thus lighter in weight and more compact than those previously employed.

The principles of the invention may be employed in connection with detachable cable terminations other than those above described and, in Fig. 4, there is illustrated a portion of the X-ray apparatus disclosed in Skehan and Machlett Patent 2,132,194 issued October 4, 1938, which has been modified to include the vapor-proof terminal of the invention. The patented apparatus includes a metallic housing 49, of which a portion of one end only is shown, and within the housing is an X-ray tube immersed in a body of oil. The housing has open ends, each of which is closed by an insulator 50 which is secured firmly in position by suitable means. The insulator is provided with a plurality of concentric flanges 51 on its exposed face and embedded in the insulator and extending therethrough is a terminal member 52. Mounted on the end of the cable 53 is an insulator 54 provided with concentric flanges 55 on its outer face which are constructed to fit between the flanges on the insulator 50 and terminal 56 is mounted in insulator 54 and is connected to the conductor within the cable by a connection extending through an opening in the insulator. The insulator 54 is enclosed within a metal sleeve 57 which extends along the cable a substantial distance. In assembling the parts, the insulators are placed so that their flanges interfit and the sleeve 57 is clamped to the end of housing 49 by a clamping ring 58, the terminals 52 and 56 making contact when the parts are thus secured together.

Although, in the construction described, the flanges of insulators 50 and 54 fit snugly, it is impossible for practical reasons to make them fit so tightly that air is excluded. Accordingly, in the apparatus of the patent, air serves as the insulating medium between the terminals and the grounded housing 49 and sleeve 57. In the modified construction shown, the use of air as an insulator is avoided and for this purpose, the space between the interfitting parts of the insulators is filled with plastic insulating material 59. In order that this material may be prevented from escaping, a ring 60 of a deformable material, such as synthetic rubber, is mounted between the insulators at a suitable place and, in the apparatus illustrated, the outer groove in the insulator 54 is slightly enlarged so that the ring may be inserted therein.

When the insulators with the ring in place are to be assembled, a layer of the plastic insulating medium is applied to the face of the insulators to fill the spaces surrounding the contacts and to coat the flanges and the grooves between them. The insulators are then moved together and excess medium present is removed. Upon tightening of the clamping ring, the deformable ring 60 is engaged by the outer flange on insulator 50 and deformed so that it contacts with the surfaces of both insulators. The ring thus acts as a seal for the body of insulating medium lying between the surfaces of the insulators and in the space surrounding the contacts 52, 56.

The term "high-dielectric deformable medium" or similar terms, when used in the appended claims, refers to a deformable insulating medium having a dielectric value greater than the dielectric value of air.

I claim:

1. In X-ray apparatus which includes a housing and an X-ray tube immersed in an insulating liquid within the housing, means for supplying high potential energy to the tube which comprises a socket of insulating material mounted in an opening in the wall of the housing and provided near its closed end with at least one terminal having portions exposed both inside and outside the socket, a connection inside the housing between the socket terminal and a terminal on the tube, a cable connected at one end to a source of energy, an insulating sleeve mounted on the other end of the cable and provided with at least one terminal connected to a conductor within the cable, the sleeve being mounted in the socket with the sleeve and socket terminals in contact, a body of high dielectric deformable medium within the socket filling the space between the opposed surfaces of the socket and sleeve, deformable insulating means contacting with the sleeve and socket and closing the outer end of the space between them for sealing the body of insulating medium in place, and means for holding the sleeve within the socket.

2. In X-ray apparatus which includes a housing and an X-ray tube immersed in an insulating liquid within the housing, means for supply-

ing high potential energy to the tube which comprises a socket of insulating material mounted in an opening in the wall of the housing and provided near its closed end with at least one terminal having portions exposed both inside and outside the socket, means for holding the socket in place, a connection inside the housing between the socket terminal and a terminal on the tube, a cable connected at one end to a source of energy, an insulating sleeve enclosing the other end of the cable and provided with at least one terminal connected to a conductor within the cable, the sleeve being mounted in the socket with the terminals of the sleeve and socket in contact, a body of high dielectric deformable medium filling the space between the opposed surfaces of the socket and sleeve, a ring of deformable insulating material contacting with the sleeve and socket and closing the outer end of the space between them for sealing the body of insulating medium in place, and means for holding the sleeve within the socket.

3. In X-ray apparatus which includes a housing and an X-ray tube immersed in an insulating liquid within the housing, means for supplying high potential energy to the tube which comprises a socket of insulating material mounted in an opening in the wall of the housing and provided near its closed end with at least one terminal having portions exposed both inside and outside the socket, means for holding the socket in place, a connection inside the housing between the socket terminal and a terminal on the tube, a cable connected at one end to a source of energy, an insulating sleeve enclosing the other end of the cable and provided with at least one terminal connected to a conductor within the cable, the sleeve being mounted in the socket with the terminals of the sleeve and socket in contact, a body of a high dielectric deformable medium filling the space between the opposed surfaces of the socket and sleeve, a ring of deformable insulating material contacting with the sleeve and socket and closing the outer end of the space between them for sealing the body of insulating medium in place, and means for holding the sleeve within the socket and compressing the ring to make it effective as a seal.

4. In high tension apparatus, such as X-ray equipment, a housing having an opening in a wall thereof, a socket of insulating material mounted in the opening and extending into the housing, a terminal mounted in the wall of the socket near the closed end thereof and having portions exposed at the inner and outer surfaces of said wall, a high tension cable, an insulating sleeve enclosing one end of the cable, a terminal mounted in the wall of the sleeve near the end thereof and connected to a conductor within the cable, the sleeve being mounted in the socket with the terminals of the socket and sleeve in contact, a body of high dielectric deformable medium filling the space between the opposed surfaces of the socket and sleeve, a deformable insulating member surrounding the sleeve and contacting with the socket near the open end thereof, the member overlying the body of insulating medium, and means for compressing the member to force it into close contact with the sleeve and socket and cause it to seal the body of insulating medium in place.

5. In high tension apparatus, such as X-ray equipment, a housing having an opening in a wall thereof, a socket of insulating material mounted in the opening and extending into the housing, a terminal mounted in the wall of the socket near the closed end thereof and having portions exposed at the inner and outer surfaces of said wall, a high tension cable, an insulating sleeve enclosing one end of the cable, a terminal mounted in the wall of the sleeve near the end thereof and connected to a conductor within the cable, the sleeve being mounted in the socket with the terminals of the socket and sleeve in contact, a body of high dielectric deformable medium filling the space between the opposed surfaces of the socket and sleeve, a ring of deformable insulating material closing the outer end of the space between the socket and sleeve, and means for compressing the ring to force it into close contact with the sleeve and socket and cause it to seal the insulating medium in place.

6. In X-ray apparatus, the combination of a high potential transformer having a pair of terminals, an X-ray tube having a pair of terminals, connections between the transformer and tube terminals, and means entirely insulating said connections including housings within which the transformer and tube are respectively immersed in an insulating liquid, each housing having a pair of openings in a wall thereof, a socket of insulating material mounted in each opening, the socket having a terminal near its closed end having portions exposed on the inside of the socket and within the housing, respectively, the terminals of the sockets being connected respectively to the terminals of the tube and transformer, a pair of cables, an insulating sleeve enclosing each end of each cable, each sleeve having a terminal which is connected to a conductor within its cable and has a portion exposed on the outside of its insulator, each sleeve being mounted in a socket with the terminals of the insulator and socket in contact, a body of high dielectric deformable medium filling the space in each socket between the opposed surfaces of the socket and sleeve, a deformable member of insulating material closing the open end of each space between a sleeve and its socket, and means for holding the individual members in firm contact with their respective sleeves and sockets to seal their associated bodies of insulating medium in position.

7. In high tension electrical apparatus, such as X-ray equipment, the combination of a housing having an opening in its wall, a device to be supplied with high tension energy mounted within the housing, a member of insulating material closing the opening in the housing wall, the member having a terminal embedded therein and exposed on opposite faces thereof, a connection within the housing between the terminal and the device, a cable connected to a source of high tension energy and containing a conductor, a second member of insulating material having a terminal embedded therein and exposed on opposite faces thereof, the second member enclosing a portion of the cable at the end thereof and having its terminal connected to the conductor, the insulating members having interfitting parts, a body of high dielectric deformable medium interposed between the interfitting parts of the members, deformable means engaging both members for sealing the insulating medium in place, and means for securing th members together with their parts interfitted and their terminals in contact.

8. In high tension electrical apparatus, the combination of a conductor, a member of insulating material surrounding a portion of the con-

ductor, a second member of insulating material, said members having interfitting parts, a terminal mounted in the wall of the second member and connected electrically to the conductor when the members have their parts interfitted, and a member of high dielectric material between said first two members, said member of high dielectric material being elastic and deformable under pressure, and means for maintaining said member of high dielectric material in tight contact with the opposed surfaces of said first two members, said member of high dielectric material affording a dielectric path between said first two members sufficiently great to prevent electrical breakdown at potentials normally applied to the apparatus.

9. In high tension electrical apparatus, the combination of a conductor, a member of insulating material surrounding a portion of the conductor, a second member of insulating material, said members having interfitting parts and said second member being made of rigid material, a terminal mounted in the wall of the second member and connected electrically to the conductor when the members have their parts interfitted, and a member of high dielectric material between said first two members, said member of high dielectric material being elastic and deformable under pressure, and means for maintaining said member of high dielectric material in tight contact with the opposed surfaces of said first two members, said member of high dielectric material affording a dielectric path between said first two members sufficiently great to prevent electrical breakdown at potentials normally applied to the apparatus.

10. In high tension electrical apparatus, the combination of a conductor, a member of insulating material surrounding a portion of the conductor, a second member of insulating material, said members having interfitting parts, a terminal mounted in the wall of the second member and connected electrically to the conductor when the members have their parts interfitted, a member of high dielectric material between said first two members, said member of high dielectric material being elastic and deformable under pressure, and means for maintaining said member of high dielectric material under a pressure sufficient to cause it to be deformed and to maintain a tight contact with the opposed surfaces of said first two members, said member of high dielectric material affording a dielectric path between said first two members sufficiently great to prevent electrical breakdown at potentials normally applied to the apparatus.

11. In high tension electrical apparatus, the combination of a conductor, a member of insulating material surrounding a portion of the conductor, a member of high dielectric material of annular section encircling the first member, the annular member being made of a material which is elastic and deformable under pressure, a socket of insulating material into which the first member may be inserted, a terminal carried by the socket and in position to be connected electrically to the conductor when the first member is inserted into the socket, and means for holding the first member in the socket with the annular member tightly engaging opposed surfaces of the socket and first member, said member of high dielectric material affording a dielectric path between the socket and first member sufficiently great to prevent electrical breakdown at potentials normally applied to the apparatus.

12. In high tension electrical apparatus, the combination of a conductor, a member of insulating material surrounding a portion of the conductor adjacent one end, a member of high dielectric material of annular section encircling the first member, the annular member being made of a material which is elastic and deformable under pressure, a socket of rigid insulating material into which the first member may be inserted, a terminal connected to the conductor, a terminal carried by the socket and engaged by the first terminal when the first member is fully inserted into the socket, and means for holding the first member within the socket and applying force to the annular member to cause it to engage opposed surfaces of the socket and first member, said member of high dielectric material affording a dielectric path between the socket and first member sufficiently great to prevent electrical breakdown at potentials normally applied to the apparatus.

13. In high tension electrical apparatus, the combination of a conductor, a member of insulating material surrounding a portion of the conductor adjacent one end, a member of high dielectric material of annular section encircling the first member, the annular member being made of a material which is elastic and deformable under pressure, a socket of rigid insulating material into which the first member may be inserted, a terminal carried by the socket and electrically connected to the conductor when the first member is fully inserted into the socket, the annular member engaging opposed surfaces of the socket and first member between the terminal and the atmosphere when the first member is fully inserted within the socket, and means for holding the first member within the socket and forcing the annular member into tight engagement with the opposed surfaces of the socket and first member, said member of high dielectric material affording a dielectric path between the socket and first member sufficiently great to prevent electrical breakdown at potentials normally applied to the apparatus.

14. In high tension apparatus, the combination of a conductor, a member of insulating material surrounding a portion of the conductor adjacent one end, a second member of insulating material, said members having interfitting parts, a terminal mounted in the wall of the second member and connected electrically to the conductor when the members and their parts are interfitted, and a member of high dielectric material between said first two members, said member of high dielectric material being elastic and deformable under pressure, and means for maintaining said member of high dielectric material under a pressure sufficient to cause it to be deformed and to maintain a tight contact with the opposed surfaces of said first two members, said member of high dielectric material affording a dielectric path between said first two members sufficiently great to prevent electrical breakdown at potentials normally applied to the apparatus, said deformable member completely preventing access of the atmosphere to the terminal between the first two members.

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