

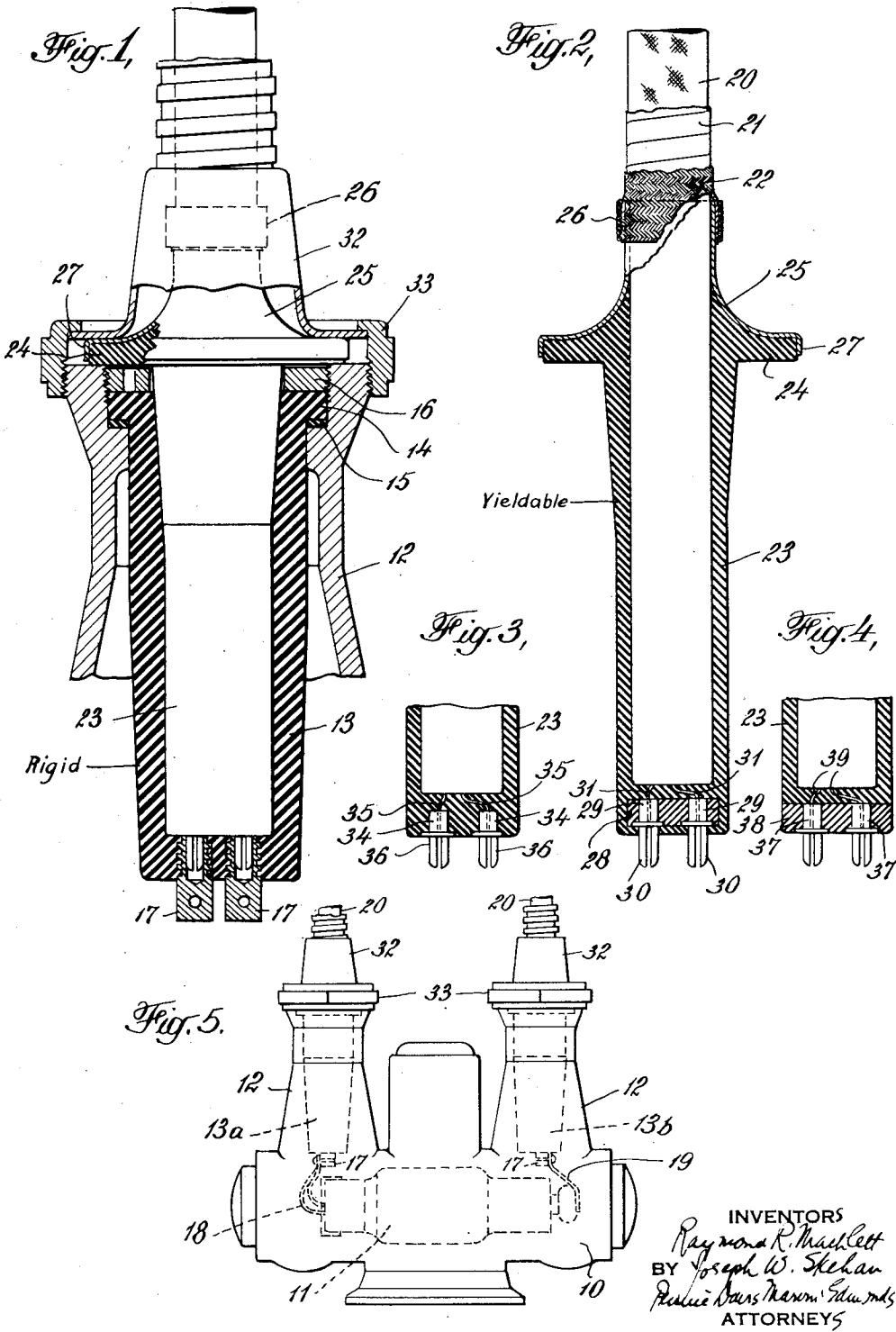
April 21, 1942.

R. R. MACHLETT ET AL

2,280,711

HIGH TENSION APPARATUS

Filed April 25, 1941



INVENTORS
 Raymond R. Machlett
 BY Joseph W. Sheehan
 Arthur Davis, Maxine E. Edwards
 ATTORNEYS

UNITED STATES PATENT OFFICE

2,280,711

HIGH TENSION APPARATUS

Raymond E. Machlett, New Canaan, and Joseph W. Skehan, Stamford, Conn., assignors to Machlett Laboratories Incorporated, Springdale, Conn., a corporation of Connecticut

Application April 25, 1941, Serial No. 390,310

14 Claims. (Cl. 174-75)

This invention relates to high tension electrical apparatus and is concerned more particularly with a novel detachable coupling which may be employed for a wide variety of purposes in making connections in shockproof high tension systems. The new coupling may be advantageously used in systems of numerous kinds, but since it affords special advantage in the X-ray field, an adaptation of the invention suitable for use with X-ray apparatus will be illustrated and described in detail for purposes of explanation.

In modern shockproof X-ray equipment, the tube is usually mounted in a metallic housing filled with an insulating liquid, such as oil, and high tension 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 connections may be employed for the purpose. Heretofore, the connection employed commonly included a sleeve of rigid insulating material, such as porcelain or that known commercially as "Bakelite," mounted on and enclosing one end of the cable, and a socket of similar insulating material mounted on or within the housing. The sleeve and socket were provided with terminals connected, respectively, to the cable conductor and the tube terminal and, to establish a connection from the tube to the source through the cable, the sleeve was inserted in the socket to bring the sleeve and socket terminals into contact, after which, the sleeve was secured in place by suitable clamping means.

In such an installation, 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 commercially 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 this air insulation is the weak spot in the system.

X-ray apparatus frequently operates at voltages of at least 50 PKV between the terminals and ground and, since the tube housing is grounded through the grounded metallic sheathing on the cables, the air path between the socket and sleeve from the terminals to the grounded housing must be very long in order to prevent sparkover. This requires that the sleeve and socket be long and usually necessitates the provision of long necks

on the housing to enclose the sockets. The practical limitations are such that the sleeve and socket combination ordinarily has a breakdown voltage under normal atmospheric conditions which is not greatly in excess of the voltage rating of the tube and the use of the air insulation, therefore, represents a potential hazard.

When X-ray equipment having detachable cable connections of the type above described and now in common use is employed at high altitudes, the breakdown voltage of the connections is reduced and a similar effect results from excess humidity in the atmosphere. A flashover for any reason not only destroys the insulating members of the connection but may also produce other serious results, as, for example, if the equipment, as is frequently the case, is used in operating rooms where ether vapor may be present, a breakdown may ignite fumes.

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 not only give rise to high-frequency oscillations in the circuit involving the cable capacitance, which reduce the life of the cable, but also result in the formation of nitrous oxide, which is likely to cause injury to the cable insulation and also tends to corrode the contacting terminals and may result in sufficiently poor contact to detrimentally affect the filament circuit.

Another practical difficulty encountered in the construction of the terminals above described is that the sleeve, which is mounted on the cable, cannot be made to fit the latter in such a way as to exclude air. Also, it is necessary to provide insulation within the sleeve for the connection between the conductors in the cable and the sleeve terminals. The upper end of the sleeve is ordinarily received within a metallic bell-shaped element, known as a stress flare, which is electrically connected to the metallic sheathing on the cable and, in the assembled equipment, is also connected electrically to the metallic housing of the tube. The spaces within the sleeve around the cable and between the cable and the flare must, accordingly, be filled with insulation and, for this purpose, an insulating compound capable of withstanding high operating temperatures is used. As the compound must be introduced into the spaces between the cable and the sleeve and flare while it is heated to a high temperature, it is extremely difficult to fill those spaces with the hot compound in such a way as to prevent the formation of air holes and, if such

air holes are present, breakdown is likely to occur.

The present invention is, accordingly, directed to the provision of a novel detachable coupling for use in shockproof high tension electrical equipment, such as X-ray apparatus, which does not involve the use of air as an insulator, is of long life, and can be constructed and used with facility. The new coupling comprises a pair of interfitting parts, such as a sleeve and a socket, and one of the parts is made preferably of rigid insulating material and the other of yielding insulating material. The parts are provided with terminals which are engaged when one part is fully inserted into the other and in fitting the parts together, the surface of the yielding part conforms to that of the rigid part and there is complete contact of the parts over their opposed surfaces.

When the coupling is used, for example, in X-ray apparatus for connecting a cable to a shockproof tube immersed in oil within a housing, the rigid part may be a socket mounted within the housing with its terminal connected to the terminal of the tube. The yielding part then takes the form of a sleeve mounted on the end of the cable and is preferably so applied thereto as to be united to the insulation thereon. The terminal of the yielding sleeve is connected to a conductor within the cable and when the yielding sleeve is inserted in the rigid socket, the two are forced together by suitable clamping means, so that the opposed surfaces of the sleeve and socket are forced into and maintained in contact and there is no air serving as insulation between them.

The rigid part of the new coupling may be made of various insulating materials, such as porcelain, or any suitable synthetic material, such as that known as "Bakelite," and the yielding part may be made of a suitable synthetic rubbery material, such as that known commercially as "Neoprene." In the application of the yielding part to the cable, the latter is preferably provided with the usual stress cone and the rubbery material is subjected to heat and pressure and molded in position, so that the material flows and fills the entire space within the cone. Since a connection made with the new coupling contains no air, difficulties arising from corona and sparkover are avoided and the coupling members may be made shorter and more compact than those previously used for the purpose.

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

Fig. 1 is a view, partly in section and partly in elevation, with parts broken away, illustrating one form of the new coupling employed in a shockproof X-ray apparatus;

Fig. 2 is a view, partly in section and partly in elevation, through one of the parts of the coupling applied to a cable;

Figs. 3 and 4 are sectional views illustrating modified forms of one end of the part of the coupling applied to the cable; and

Fig. 5 is a view in side elevation illustrating the use of the new coupling as a cable termination with a shockproof X-ray unit.

The drawing illustrates the use of the coupling as a cable termination on cables for supplying current to an X-ray apparatus which includes a housing 10 containing a tube 11 and provided with a pair of necks 12, in each of which is mounted a socket insulator 13, which may be

made of any suitable material, such as porcelain or that known commercially as "Bakelite." The socket, which forms one of the interfitting parts of the coupling, has a circumferential flange 14 at its open end and it is mounted within its neck 12 with its flange resting upon a gasket 15 lying on a shoulder formed around the opening into the neck. The inner wall of the opening is threaded and the socket is held in place by a ring 16 which is screwed into the opening and compresses the flange 14 against gasket 15. This makes an oil-tight seal between the socket and the inner wall of the neck, so that escape of the insulating fluid within which the tube 11 is immersed within the housing is prevented.

Embedded in the socket at its lower end are one or more terminals 17 which are connected to the terminals at one end of the tube. In the apparatus shown in Fig. 5, the socket 13a has two terminals connected by leads 18 to terminals at one end of the tube, while the socket 13b has a single terminal connected by a lead 19 to the terminal at the other end of the tube. The inner ends of the terminals 17 are exposed within the socket and each terminal has a recess in its inner end.

High tension energy is supplied to the tube through a cable 20, which includes one or more conductors. In the construction shown in Fig. 2, the cable contains two conductors (not shown) which extend concentrically through the cable and the conductors are contained within a body of insulation which is enclosed within a wrapping 21 of tape. Overlying the tape is a metallic sheathing 22 and over the sheathing is a decorative outer layer (not shown) which may be of silk or the like.

The free end of the cable is encased within a sleeve 23, which forms the other of the interfitting parts of the new coupling and is made of a corona-resistant rubbery compound, which is preferably a synthetic rubber, such as that commercially known as "Neoprene." Before applying the sleeve to the cable, the metallic sheathing 22 and the tape 21 are removed for a considerable distance back from the end and the surface of the rubber insulation on the cable is cleaned. The sleeve is provided with a circumferential flange 24, which is of greater diameter than the opening into the neck 12, and, above the flange, the cable carries a stress flare 25, which is made of metal and has its small end connected to the end of the metallic sheathing 22. For this purpose, the small end of the flare is inserted beneath the sheathing, a wire wrapping 26 is applied, and the parts are then soldered together. The large end of the flare terminates in a cylindrical flange 27 and the sleeve is so formed as to fit within the flange and fill the space between the interior of the flare and the outer surface of the cable. The provision of solid insulation filling this entire space is of extreme importance and, with the previous constructions, it was difficult to introduce the hot insulating compound within the flare in such manner as to avoid the presence of air holes. No such difficulty is encountered when the space is filled by a portion of the sleeve. The flange 24 projects outward past the free edge of flange 27, as shown.

At the closed end of the sleeve, a disc 28 of rigid insulating material is embedded in the material of the sleeve and mounted within the disc are one or more terminals 29 having split ends

30 which project through the end of the sleeve. The terminals 29 are connected to the conductors in the cable by leads 31 which are embedded in the sleeve material above the disc. The sleeve material thus insulates the leads and terminals and holds them properly in position.

In the use of the new coupling, the sleeve 23 is inserted within the socket 13 with the projecting portions 30 of the sleeve terminals 29 entering the recesses in the socket terminals 17. The lower face of the flange 24 of the sleeve then rests on the upper end of the neck 12 and overlies the upper face of ring 16. With the parts in this position, a bell-shaped clamping member 32 and its locking ring 33, which have previously been slipped on the cable, are moved down until member 32 rests upon the upper surface of the flare 25. The ring 33, which is internally threaded, is then screwed on the end of the neck and turned down until the force thereby applied to the sleeve 23 causes the material thereof to be distorted and make tight contact with the inner surface of the socket from end to end thereof. The sleeve material also makes tight contact with inner surface and the top of ring 16 and with the parts in this condition, the rubbery corona-resistant material of the sleeve completely fills the space between the cable and the interior of the socket 13 and flare 25.

Instead of mounting the terminals 29 in a disc 28, which is thereafter embedded in the end of the sleeve, the disc may be omitted and the terminals 34 embedded in the sleeve material. The terminals are connected as before by leads 35 to the cable conductors. The terminals have the split ends 36 receivable in the recesses in the socket terminals 17.

In another modified form illustrated in Fig. 4, terminals 37 are mounted in a disc 38, which may be of rigid insulating material, the disc having a diameter substantially the same as the outer diameter of sleeve 23. The disc is affixed to the end of the sleeve and the terminals are connected to the cable conductors by leads 39 which pass through the body of the sleeve material.

The sleeve may be formed and applied to the end of the cable in various ways, as, for example, by molding. In this operation, the cable is stripped of the metallic sheathing and tape back from its free end, the flare is applied, and the sleeve terminals are connected by their leads to the cable conductors, the terminals being mounted in discs of insulation or not, as may be desired. Thereafter, the rubbery material, which has been roughly shaped to the desired form, is applied to the surface of the cable and inserted within the flare. The material is also applied over the proper portions of the sleeve terminals and their leads, cement being preferably applied previously to the metal parts, such as the terminals and leads and the internal surfaces of the flare.

The assembly is then placed in a mold and heat and pressure are applied until the rubbery material is softened and rendered fluent, so that it not only adheres to the previously cleaned surface of the insulation and the metal parts but also flows into and completely fills the space within the flare. The result is that the sleeve is united to the insulation and the metal parts and, as it flows into the flare, it forces out the air between the latter and the cable. As previously pointed out, it is of utmost importance that no air be present between the flare and the cable

insulation and by molding the rubbery material under heat and pressure, as described, the elimination of air from within the flare is relatively easy.

After the molding operation described has been completed, the assembly is subjected to a curing operation of the usual type. The sleeve portion of the coupling is then ready for use.

In the foregoing, the new coupling has been described in the form of a cable termination employed for connecting a cable to a tube within a shockproof housing. It will be apparent that the coupling may similarly be employed as a termination for connecting the cables to the transformer and it may also be used in a modified form for connecting together two lengths of cable for connecting a switch in the high voltage circuit to either the tube or the transformer. Various other uses for the coupling will be readily apparent. In all forms, the terminals through which the high tension energy passes are completely insulated by solid insulation and there is no air present in the coupling, so that by the use of the new coupling, a high tension system may be rendered completely shockproof without air employed as an insulator at any point.

We claim:

1. A detachable coupling for use in high tension apparatus which comprises a socket of rigid insulating material, a terminal mounted in the wall of the socket and exposed within the latter, a sleeve of yielding insulating material having a closed end, said sleeve being receivable within the socket with the opposed surfaces of the socket and sleeve lying in full contact with no air between, a terminal embedded in the closed end of the sleeve in position to engage the socket terminal when the sleeve is fully inserted into the socket, and means for holding the sleeve within the socket and applying force to the sleeve to cause the opposed surfaces of the sleeve and socket to make full contact.

2. In high tension apparatus, such as X-ray equipment, which includes a housing containing a device to be supplied with high tension energy, the combination of a socket of rigid insulating material adapted to be mounted in an opening in the wall of the housing and having at least one terminal mounted in its wall and having portions exposed both inside and outside the socket wall, a high tension cable containing at least one conductor, said cable being provided with a layer of insulating material enclosing the conductor, a sleeve of yielding insulating material enclosing the end of the cable and adhering to the insulation thereon, at least one terminal mounted at the end of the sleeve connected to the conductor within the cable, the sleeve being shaped to permit its insertion into the socket to bring the terminals into contact and to force the opposed surfaces of the sleeve and socket into tight contact, and a grounded flare enclosing the end of the sleeve remote from the terminal.

3. In high tension apparatus, such as X-ray equipment, which includes a housing containing a device to be supplied with high tension energy, the combination of a socket of insulating material adapted to be mounted in an opening in the wall of the housing and having at least one terminal mounted in its wall, the terminal having portions exposed both inside and outside said socket wall, a high tension cable containing at least one conductor, said cable being provided with a layer of insulating material en-

closing the conductor and a metallic wrapping over the insulating material and stopping short of the end of the cable, a flare mounted on the cable remote from the end and electrically connected to the metallic wrapping, a sleeve of yielding insulating material enclosing the end of the cable and adhering to the insulation thereon, said sleeve having a portion extending into and making tight contact with the interior of the flare, at least one terminal mounted in the sleeve and having a portion exposed outside said sleeve, and a connection between the conductor and the sleeve terminal and lying within the body of the sleeve material, the sleeve being adapted to be inserted into the socket with the outer surface of the sleeve in tight contact with the inner surface of the socket and the sleeve terminal in electrical contact with the socket terminal.

4. In high tension apparatus, such as X-ray equipment, which includes a housing containing a device to be supplied with high tension energy, the combination of a socket of insulating material adapted to be mounted in an opening in the wall of the housing and having at least one terminal mounted in its wall, the terminal having portions exposed both inside and outside said socket wall, a high tension cable containing at least one conductor, said cable being provided with a layer of insulating material enclosing the conductor, a grounded flare mounted on the cable remote from the end, a sleeve of yielding insulating material enclosing the end of the cable and adhering to the insulation thereon, said sleeve having a portion extending into and making tight contact with the interior of the flare, a disc of insulating material mounted on and closing the free end of the sleeve, at least one terminal mounted in the disc and having portions exposed on opposite sides of the disc, and a connection between the conductor and the disc terminal and lying within the body of the sleeve material, the sleeve being adapted to be inserted into the socket with the outer surface of the sleeve in tight contact with the inner surface of the socket and the disc terminal in electrical contact with the socket terminal.

5. In high tension apparatus, such as X-ray equipment, which includes a housing containing a device to be supplied with high tension energy, the combination of a socket of insulating material adapted to be mounted in an opening in the wall of the housing and having at least one terminal mounted in its wall, the terminal having portions exposed both inside and outside said socket wall, a high tension cable containing at least one conductor, said cable being provided with a layer of insulating material enclosing the conductor, a grounded flare mounted on the cable remote from the end, a sleeve of yielding insulating material enclosing the end of the cable and adhering to the insulation thereon, said sleeve having a portion extending into and making tight contact with the interior of the flare, a disc of insulating material embedded in the sleeve material at the free end of the sleeve, at least one terminal mounted in the disc and having portions exposed on opposite faces of said disc, and a connection between the conductor and the disc terminal and lying within the body of the sleeve material, the sleeve being adapted to be inserted into the socket with the outer surface of the sleeve in tight contact with the inner surface

of the socket and the two terminals in electrical contact.

6. In high tension apparatus, such as X-ray equipment, which includes a housing and a device within the housing to be supplied with high tension energy, the combination of a socket of insulating material mounted in an opening in the wall of the housing and having at least one terminal mounted in its wall, a connection within the housing between the socket terminal and a terminal of the device, a cable connected at one end to a source of energy, a sleeve of yielding insulating material having a closed end, said sleeve enclosing and adhering to the end of the cable and provided with at least one terminal embedded in the closed end of the sleeve and connected to a conductor within the cable, the sleeve being mounted in the socket with the sleeve and socket terminals in contact, and means engaging a portion of the housing and operable on a portion of the sleeve to cause the sleeve to make tight contact with the entire inner surface of the socket.

7. In high tension apparatus, such as X-ray equipment, which includes a housing and a device within the housing to be supplied with high tension energy, the combination of a socket of insulating material mounted in an opening in the wall of the housing and having at least one terminal mounted in its wall, a connection within the housing between the socket terminal and a terminal of the device, a cable connected at one end to a source of energy and containing at least one conductor, said cable being provided with a layer of insulating material enclosing the conductor, a grounded flare mounted on the cable remote from the end, a sleeve of yielding insulating material enclosing the end of the cable and adhering to the insulation thereon, said sleeve having a portion completely filling the space within the flare around the cable, and at least one terminal mounted in the sleeve and having a portion exposed outside said sleeve, a connection between the conductor and the sleeve terminal and lying within the body of the sleeve material, the sleeve being mounted in the socket with the terminals in contact, and means for applying force to the sleeve to cause it to make contact with the entire inner surface of the socket.

8. In high tension apparatus, such as X-ray equipment, which includes a housing and a device within the housing to be supplied with high tension energy, the combination of a socket of insulating material mounted in an opening in the wall of the housing and having at least one terminal mounted in its wall, a connection within the housing between the socket terminal and a terminal of the device, a cable connected at one end to a source of energy, a grounded flare encircling the cable near the other end thereof, a sleeve of yielding insulating material enclosing and adhering to the end of the cable and having a circumferential flange overlying the end of the socket and having a portion filling the space around the cable within the flare, at least one terminal mounted in the sleeve and having a portion exposed outside said sleeve, a connection between the conductor and the sleeve terminal and lying within the body of the sleeve material, the sleeve lying within the socket with the terminals in contact, and means engageable with the flare and operable to apply force to the sleeve to cause it to make tight contact with the entire inner surface of the socket.

9. In high tension apparatus, such as X-ray

equipment, which includes a housing and a device within the housing to be supplied with high tension energy, the combination of a socket of insulating material mounted in an opening in the wall of the housing and having at least one terminal mounted in its wall, a connection within the housing between the socket terminal and a terminal of the device, a cable connected at one end to a source of energy, a grounded metallic flare encircling the cable near the other end thereof, a sleeve of yielding insulating material enclosing and adhering to the end of the cable and having a circumferential flange overlying the end of the socket and having a portion filling the space around the cable within the flare, at least one terminal mounted in the sleeve and having a portion exposed outside said sleeve, a connection between the conductor and the sleeve terminal and lying within the body of the sleeve material, the sleeve lying within the socket with the terminals in contact, a clamping collar outside the flare, and means engaging the housing and collar and operable to apply force to the sleeve to cause it to make tight contact with the entire inner surface of the socket.

10. In high tension apparatus, a cable which includes a conductor enclosed within a layer of a rubber compound acting as insulation, a sleeve of yielding insulating material mounted to enclose one end of the cable, the sleeve adhering to the surface of the layer, a grounded flare encircling the cable, said sleeve extending into and making tight contact with the interior of the flare, and a terminal mounted in the end of the sleeve and connected within the sleeve material to the conductor in the cable.

11. In high tension apparatus, a cable which includes a conductor enclosed within a layer of a rubber compound acting as insulation, a sleeve of yielding insulating material mounted to enclose one end of the cable, the sleeve adhering to the surface of the layer, a terminal mounted in the end of the sleeve and connected within the sleeve material to the conductor in the cable, and a grounded metallic flare mounted on the cable, the sleeve having a portion completely filling the space within the flare between the latter and the surface of the cable.

12. A detachable coupling for use on high tension apparatus which comprises an elongated socket of rigid insulating material having a circumferential flange around its open end and having at least one terminal mounted in its closed end, a high tension cable containing at least one conductor, said cable having a layer of insulating material enclosing the conductor, a sleeve of

yielding insulating material having a closed end and enclosing the end of the cable and adhering to the outer surface of said layer of insulating material, said sleeve having a circumferential flange remote from the end of the cable, at least one terminal mounted in the closed end of the sleeve and connected to the conductor, said sleeve terminal being engageable with the socket terminal when the sleeve is inserted in the socket, and means for clamping the sleeve and socket flanges together to hold the sleeve securely in the socket with their respective terminals in engagement.

13. A detachable coupling for use on high tension apparatus which comprises an elongated socket of rigid insulating material having at least one terminal mounted in its closed end, a high tension cable containing at least one conductor, said cable having a layer of insulating material enclosing the conductor, a sleeve of yielding insulating material having a closed end and enclosing the end of the cable and adhering to the outer surface of said layer of insulating material, a grounded metallic flare encircling the sleeve at a place remote from its closed end, the sleeve making tight contact with the interior of the flare, and at least one terminal mounted in the closed end of the sleeve and connected to the conductor, said sleeve terminal being engageable with the socket terminal when the sleeve is inserted in the socket.

14. A detachable coupling for use on high tension apparatus which comprises an elongated socket of rigid insulating material having a circumferential flange around its open end and having at least one terminal mounted in its closed end, a high tension cable containing at least one conductor, said cable having a layer of insulating material enclosing the conductor, a sleeve of yielding insulating material having a closed end and enclosing the end of the cable and adhering to the outer surface of said layer of insulating material, said sleeve having a circumferential flange remote from the end of the cable, a grounded metallic flare encircling the sleeve adjacent the flange, the sleeve making tight contact with the interior of the flare, at least one terminal mounted in the closed end of the sleeve and connected to the conductor, said sleeve terminal being engageable with the socket terminal when the sleeve is inserted in the socket, and means for clamping the sleeve and socket flanges together to hold the sleeve securely in the socket with their respective terminals in engagement.

RAYMOND R. MACHLETT.
JOSEPH W. SKEHAN.