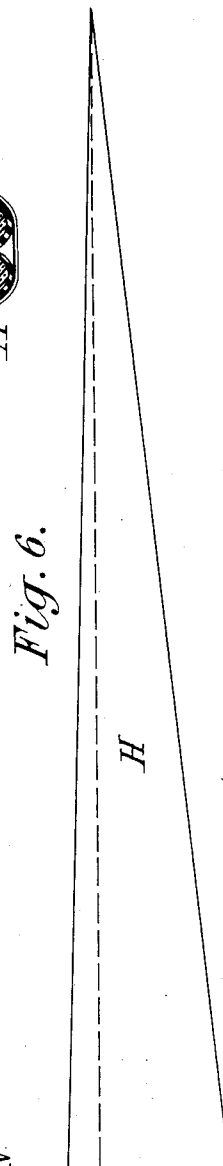
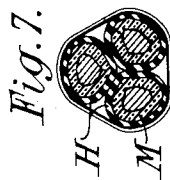
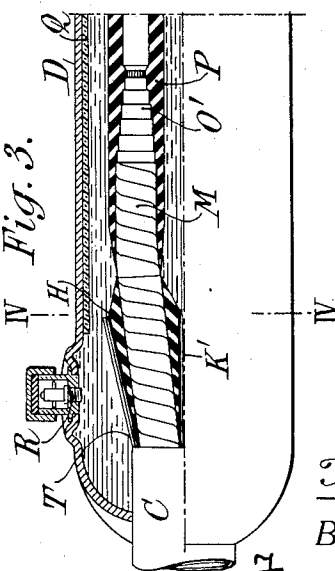
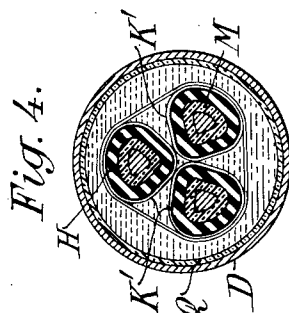
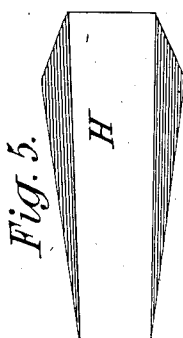
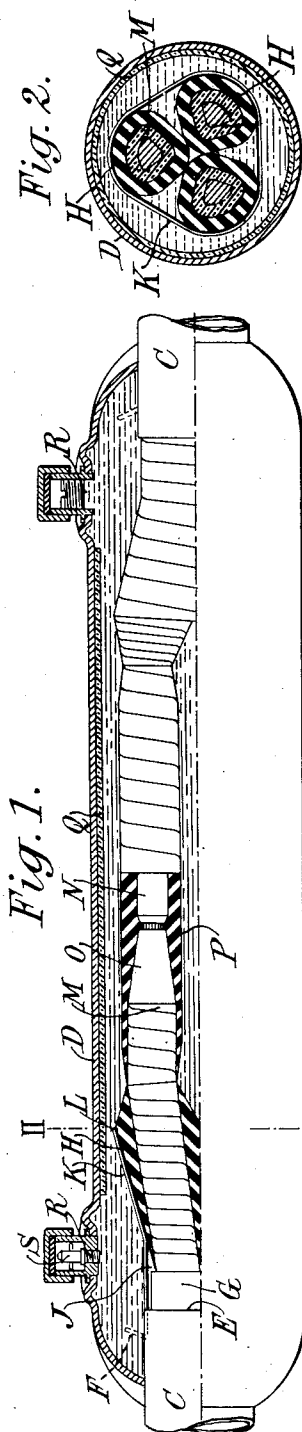


Jan. 15, 1935.

T. F. PETERSON
ELECTRIC CABLE JOINT
Filed April 5, 1929

1,987,971



INVENTOR :
Thomas F. Peterson,
By Attorneys,
Fraser, Myers & Manley

UNITED STATES PATENT OFFICE

1,987,971

ELECTRICAL CABLE JOINT

Thomas F. Peterson, Brooklyn, N. Y.

Application April 5, 1929, Serial No. 352,877

5 Claims. (Cl. 173-268)

The present invention relates to the method of forming, and the construction of, joints or connections between the ends of cables employed in the transmission of electrical energy at high potential. The invention is applicable to the forming of joints in standard types of insulated multiple conductor cable.

The object of the invention is to provide an improved cable joint which is electrically as strong or stronger than the original cable and which consequently will not break down under any usual service conditions.

Special features of the invention reside in an improved crotch construction whereby the separate insulated conductors are mechanically supported in fanned out position at the joint, the nature of this crotch support being such as to prevent mechanical injury to the insulation of the individual conductors and also to prevent the development of electrical stresses tending to destroy the insulating mediums employed in the joint.

A further object of the invention is to provide a grounded metallic or metalized shield around at least a section of the insulated conductors where they are fanned out, this shield flaring out gradually from the end of the lead or other metal sheath which normally surrounds the cable and which in the usual construction of joints is cut away near the end of the cable. The provision of this shield avoids the abrupt discontinuity of the conducting sheath which closely surrounds the cable and thus prevents the development of electrical strains which in hitherto known constructions have been found to be a source of joint failure.

If the joint is to be made in what is known as shielded cable, wherein each of the insulated conductors is provided individually with a continuous metallic shield, then the flared shields, according to the present invention, are applied to each insulated conductor. In such manner there is provided a conductive flared extension of the shielding of each conductor, by means of which a zero potential surface is maintained around each of the insulated conductors, whereby the development of concentrated electrical stresses in the insulation, due to the abrupt termination of grounded metallic shielding in close proximity to the conductor, is largely avoided; and this shielding extension is continued to a point where, through the flaring out of the shields, the physical separation thereof from the conductor is in itself sufficient to prevent excessive electrical stresses in the insulation. At such point the shielding extension is terminated in order to

avoid contiguity of the shielding with respect to the cleavage surface between the factory-applied insulation and the insulation which must necessarily be applied on the job at the time of making up the joint. Such cleavage surface is especially subject to electrical weakness because of the unfavorable conditions under which the joints are ordinarily made up in underground installation work. The presence of the zero potential shielding contiguous to such cleavage surface would throw an increased electrical stress upon this surface and thus increase the likelihood of failure at this part of the joint. Shielded joints have heretofore been made in which the conductive shielding is carried continuously throughout the length of the joint.

Unlike joint constructions hitherto employed with belted cable, the disposition of the entire insulation according to my invention is such as to provide a substantially uniform dielectric path radially of each conductor and symmetrical with respect to the axis of each. In three-conductor three-phase cables, the central axis of the cable is at zero potential. According to my invention the zero potential shield extension for belted cable and the insulation within such shield, flares at such an angle as to preserve radially outward from each conductor a zero potential zone at a distance from each conductor which is substantially equal to the distance of each conductor from the zero potential central axis of the cable; and because of the special arrangement of the insulating elements at the crotch, the dielectric paths from each conductor outward or inward to the zones of zero potential are substantially alike. This eliminates the dangerous circumferential electrical stresses which are necessarily present in joints where unsymmetrical dielectric paths to the zones of zero potential are present. At the point where the conductors have been fanned out so as to provide adequate separation between them, it is unnecessary to closely preserve the symmetry of the dielectric paths as above described, and consequently the special insulating cones which are employed to act as spreaders for the cable crotch, need extend only to the point where the conductors are adequately separated; and the same is true of the zero potential shield extension which, in the case of belted cable, surrounds the group of three insulating cones.

A further object of the invention is to provide a joint surrounded by oil or insulating compound, and in which wrapped insulation is relied upon

at the connectors and adjacent parts instead of integral insulating barriers which are commonly employed in conjunction with such oil or compound insulation to separate and insulate the fanned out conductors at the joint. This construction avoids the excessive electrical stresses which are thrown on the insulating compound or oil where in constructions hitherto known the presence of thick barriers having a high dielectric constant with respect to the oil or compound, subjects the electric path through such oil or compound, to an excessive proportion of the total stress. This represents a distinct improvement over other constructions in that the electrical stresses due to the difference in dielectric constants of the solid and fluid insulating mediums are more evenly distributed so that the insulating compound or oil is not subject to electrical failure because of having imposed upon it excessive electrical stresses.

The invention further contemplates a novel method of applying wrapped insulation so as to build up a conical protection for the conductors where they are fanned out at the joint, and by this means afford a mechanical spreader for the conductors whereby they are supported in fanned out position.

The invention further provides an elongated spreader, the bearing surface of which against the insulated cable which it supports in fanned-out position, is so extensive as to eliminate any concentrated mechanical stress upon such insulation. It has been found that the elimination of such concentrated mechanical stress as is ordinarily imposed upon insulation where a comparatively short porcelain spreader, for example, is inserted between the insulated conductors, materially increases the electrical strength of the joint. My spreader reduces to a minimum the mechanical stress necessary to support the conductors in their flared-out position.

The invention further aims to provide a joint in which the twist or lay of cable conductors may be carried through the joint and in which much greater facility for connecting conductors, which may arrive at the joint ends in any random relationship, in a predetermined order so that the connection of the conductor at a remote terminal point need not be disturbed. This bringing of the conductors into proper conjunction at the joint is usually termed "phasing out". The joint is applicable to belted or shielded cable, and may be used to join cables of each type together. The construction at either end of the joint according to the present invention may be used in the formation of cable terminals, pot-heads or test ends.

The usual types of cable dealt with in practice consist of solid or stranded copper conductors insulated with rubber compound, many layers of varnished cloth tape or oil saturated paper tape, these insulated conductors being cabled together with suitable fillers in interstices and bound by means of tape, thin metal strips or additional insulation which constitutes the so called belt. Various outside coverings are used. In the case of the impregnated paper insulated cable, this is practically always a lead sheath.

Though multiple conductor cable has, in the past, generally been made up in the usual belted form in which ratio of belt thickness to conductor insulation thickness has varied from 0 to 1, there is now coming into fairly widespread use the so called Hochstadter or shielded conductor cable in which the individual conductors, after

insulating, are wrapped with a thin metal tape and instead of the belt insulation a metal binder is used.

Generally accepted installation methods give rise to the need for making joints between sections of cable. A very usual jointing method has consisted in removing lead sheaths and belt insulation from ends of cable, then fanning the conductors and inserting a porcelain spreader in the crotch so formed. After removing some two or three inches of the insulation surrounding the individual conductors, metallic connectors are sweated to the copper conductors, the factory insulation being then "pencilled" or tapered down to the conductors and the joint completely covered with wrapped insulation. Barrier tubes are then introduced between conductors and a lead sleeve housing is wiped to cable sheaths. The joint is then filled with a suitable insulating compound.

I have found from long observation in operation and numerous laboratory tests of completed joints and prepared crotches used in testing cable samples that such methods are not altogether satisfactory. In the first place, crotches are weak electrically because of their liability to mechanical injury incidental to bending conductors into shape. Crotch spreaders may result in mechanical injury to insulation and may weaken same by pressure and by abrupt changes in dielectric constants. In the case of three phase operation of multiple conductor cable the abrupt discontinuity of the lead sheath gives rise to conditions which facilitate development of circumferential electrical stresses around conductors. These are very ruinous to insulation. Short paths of oil between conductors, the oil having a low dielectric constant with respect to the solid insulation of the conductors, are liable to electrical breakdown which eventually may result in complete failure of insulation.

Aside from the forementioned the cleavage surface between hand applied and factory insulation is a source of weakness. Barriers do not materially strengthen these and may actually weaken the joint. They are invariably of high dielectric constant and usually of such shapes that the electric field will traverse a long length of solid insulation and short path of oil or compound. The latter then has a great burden of stress thrown upon it which may precipitate a failure.

The present invention has for its object the elimination of these difficulties.

Further objects of the invention will be apparent from the following detailed description, wherein reference is had to the accompanying drawing, and in which—

Figure 1 is a partial axial longitudinal section of a joint made up of belted cable;

Fig. 2 is a transverse cross section of the same taken along the line II—II of Fig. 1.

Fig. 3 is a similar section of a joint made up of shielded conductor cable. It will be apparent that a joint may be formed between belted cable and shielded cable, in which case half of the joint would be illustrated in Fig. 1 and the other half in Fig. 3.

Fig. 4 is a transverse cross section of the same taken along the line IV—IV of Fig. 3.

Fig. 5 is an axial cross section of a tapered, wrapped insulator which may be pre-formed according to the present invention and subsequently secured around each of the insulated conductors where they are flared out from the cable. This tapered, wrapped insulator takes the place of the

porcelain or other mechanical spreader ordinarily employed to fan out the conductors.

Fig. 6 is a plan view showing the shape of the sheet of insulating material which is employed to form the wrapped insulator illustrated in Fig. 5.

Fig. 7 is a transverse cross section on somewhat reduced scale taken along the line II—II of Fig. 1, and illustrates a form of cable which is preferred because of the conductor contour being such as to permit of more effective distribution of the insulation.

In making up a joint in belted cable (Fig. 1), after cutting off ends of cable C squarely and arranging for butting them properly in the usual manner, a lead sleeve or housing D is slipped back over one end of cable and the lead sheath E of cable removed for a foot or so. The edge of this lead sheath is temporarily belled as indicated in dotted lines at F, and the belt insulation G is then removed to a point an inch or so away from the end of the lead sheath when the latter is in normal position against the cable.

The factory insulated conductors are then fanned out and built up with cones H of high dielectric constant material, using tape which is hand applied, or pre-wrapped cones as in Fig. 5. Varnished cambric or other fabric is preferred for this use. The space J near the small ends of the cones is then filled by wrapping thin strips of tape around all three conductors. One or two layers of tape are applied around three conductors to hold them together. Metal shielding K is then applied, beginning under belled lead (lead is then beaten down) and extending around the built up insulation of all conductors to the point L at the maximum thickness of built up cone. The shielding may be metal foil, metallized paper or conducting tape or gauze or other equivalent conducting material and should be positively connected to lead sheath E of the cable in such manner as to afford a good electrical connection therewith.

When the crotch at each cable end has been formed and reinforced in the manner above described, the conductors are bent into position shown in drawing, the insulation M is removed for a few inches from ends of conductors and connectors N are sweated to them. Beginning at a point close to the end of each connector, the factory insulation is then "pencilled" by tapering as shown at O in Fig. 1, or it may be stepped, as shown at O' in Fig. 3, prior to applying hand wrapping P. The material applied will be dependent on type of insulation of cable. Low loss varnished cambric will be found very satisfactory for most uses and such wrapping is particularly suitable with paper insulated cable.

Following the completion of the insulation of the joint, the lead sleeve D which preferably is mechanically reinforced by an insulating tube Q centered between filling holes R is slipped over the joint, the ends of the sleeve being then beaten down and wiped to the lead sheath E of cable C.

The joint is then flushed and filled with oil or suitable compound. Check valves S for pressure filling and for use in connection with oil reservoir systems described in my paper, Electrical World, November 19, 1927, are also provided.

The method of making up of crotch with metal shielded cable, as illustrated in Figs. 3 and 4, is similar to the above except that instead of removing belt, both metal binder tape overall and the metallic shielding tape T on the individual conductors is removed to within $\frac{1}{2}$ " of belled lead. Built up cones H are put in place and metallic shields K' applied over the cone of each individual

conductor to point of maximum thickness of cone. This shielding is electrically connected to the conductor shielding tape and constitutes a conductive extension thereof by which each of the conductors is shielded, while in the belted cable joint hereinbefore described, the metallic shield K surrounding all three of the insulated conductors, constitutes an extension of the lead sheath E. The conductors of shielded cable may be bound together at crotch by means of tape, wire or the like.

Fig. 6 shows diagrammatically a long strip of insulating material, cut in such a way, that, when wrapped on a suitable mandrel, yields a cone H (Fig. 5) of desired proportions. The mandrel should be slightly greater in diameter than the diameter of the insulated conductors to which the cone is to be applied. When removed it may be slipped over conductors and tightened up much the same way as a shade on a roller. This method of pre-forming the cones on a mandrel instead of building them up by hand wrapping in the position which they will ultimately occupy in the finished joint, effects a great saving of labor.

In the preparation of cable terminals, potheads, test ends or the like, the steps necessary for making one end of joint are taken. Obvious modification of the proportions of the various parts may be necessary in adapting this invention to these devices.

In the complete joint according to my invention, the built-up conical insulators H take the place of the usual crotch spreaders and afford an effective reinforcement for the insulated conductors at points where insulation failure has heretofore been found to be most prevalent. Circumferential electrical stresses are reduced to a negligible quantity by maintaining a zero potential conductive shield at a distance outward from each conductor substantially equal to the distance from the conductors to the zero potential axis of the cable and joint. The insulating wrapping according to my invention eliminates the necessity of additional high dielectric insulating barriers which are, in various forms, ordinarily employed in electrical joints, and thus relieves the oil or insulating compound from bearing an excessive proportion of the electrical stress.

In some joints hitherto employed the metallic shielding tape of the cable has been carried completely across the connectors so as to form a continuous metallic shield for the joint. This subjects the necessary cleavage surface between factory insulation and that applied by hand to full electrical stress. This difficulty is avoided in the present construction.

The theory and development of this joint are covered fully in a paper presented by me before the American Institute of Electrical Engineers, June 1927, and printed in the transactions for that year.

While two embodiments of my invention have been hereinbefore described, it will be understood that the invention is not limited thereto but may be otherwise embodied and modified without departing from the spirit of the invention as set forth in the following claims.

What I claim is:

1. In a multiple conductor high voltage cable joint, a tapered insulating spreader surrounding each of the conductors, said spreaders supporting the conductors in a fanned-out position by mutual bearing and engagement of a tapered surface of one spreader with a corresponding surface of the spreader of another conductor.

2. In a multiple conductor high-voltage cable joint, a pre-formed insulating spreader surrounding each of the conductors, said spreaders having tapered surfaces adapted, when mutually engaged, to support the conductors in mutually divergent attitudes whereby to provide the requisite separation of the conductors at the crotches of the joint.
3. The method of obtaining a tightly wound insulation about a member to be insulated, consisting in rolling up a multiplicity of turns of sheet insulating material to form a tubular insulator, subsequently placing said tubular insulator on the member which is to be insulated so as to surround such member at a desired location, and thereafter tightening said tubular insulator against the surface of the member by rotating the outer turns of the pre-wound insulator relative to the inner turns.
4. In a three-conductor high-voltage joint for shielded cable, tapered insulating spreaders surrounding the conductors from the seat of the cable crotch to a point at which the conductors are effectively separated by said spreaders, and

grounded conductive shields individually surrounding each of said tapered spreaders.

5. In a cable joint for three-phase, three-conductor shielded cable in which each insulated conductor is normally provided with its individual metal shield, a joint comprising fanned-out conductors, metallic connectors connecting abutting ends of conductors, insulation applied over said connectors and replacing the factory insulation of the conductors where such insulation has been removed to permit of joining the conductor ends, and tubular flaring metallic shields conductively connected at their small ends to the individual conductor shields, and extending therefrom along and around each conductor to a point where the internal surface of each of the said flaring shields is at a maximum distance from the conductor which it surrounds, the said shields being shorter than the distance between the cable crotch and the line of cleavage between the said applied insulation and factory applied insulation.

THOMAS F. PETERSON.