May 26, 1953 C. E. LEWIS ET AL 2,640,095

COAXIAL CABLE SPLICES AND METHODS OF MAKING THEM

Filed Feb. 8, 1949 2 Sheets-Sheet 1

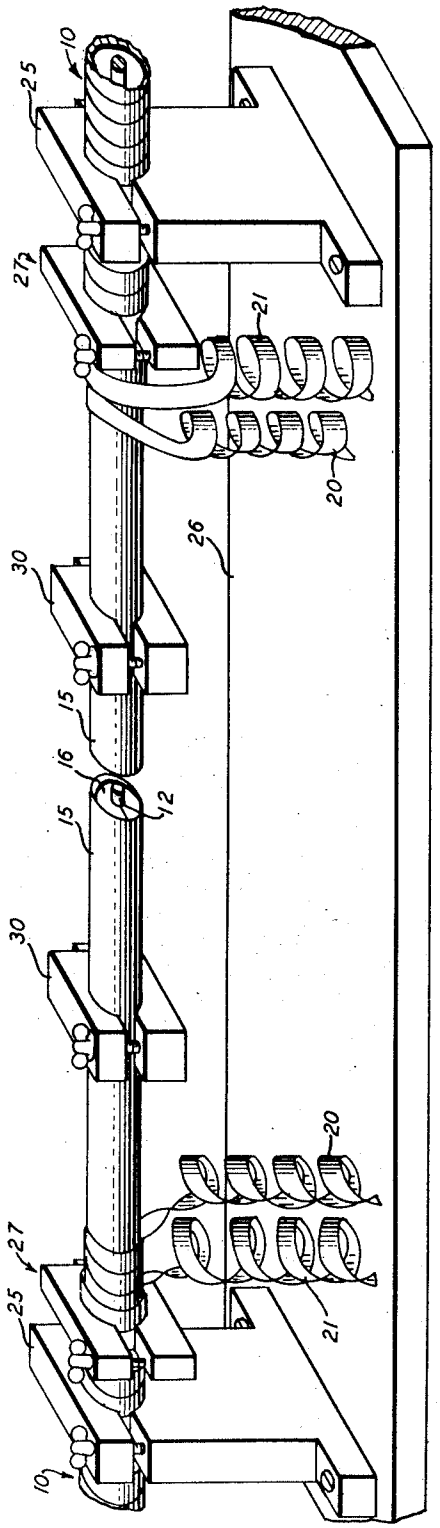


FIG. 2

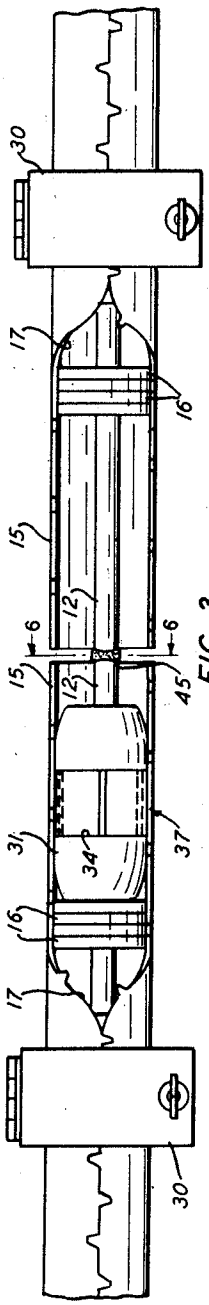


FIG. 3

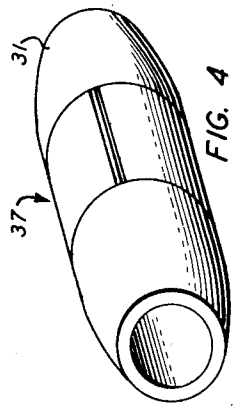


FIG. 4

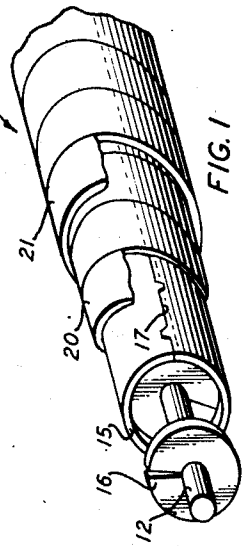


FIG. 1

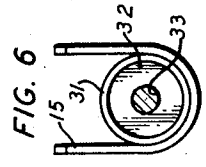


FIG. 6

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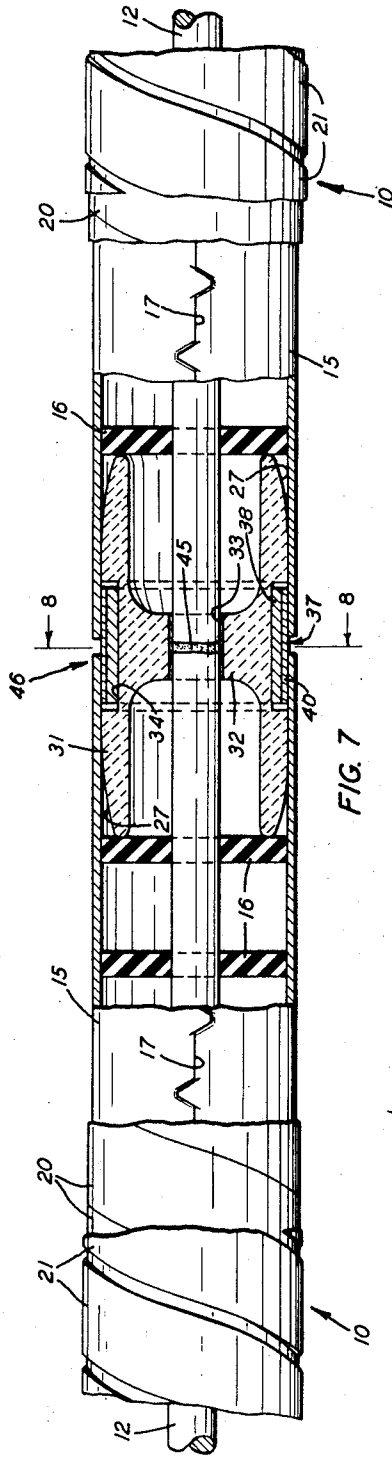


FIG. 7

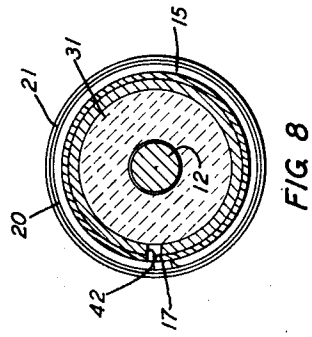


FIG 8

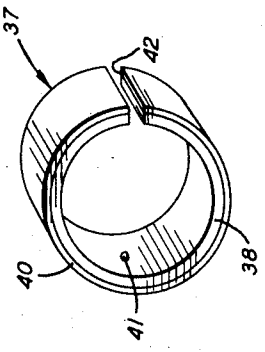


FIG. 5

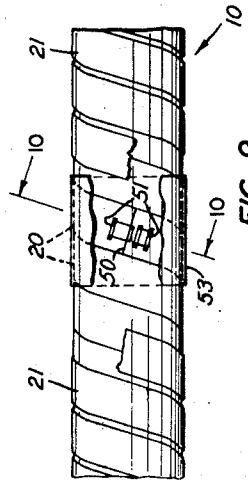


FIG. 9

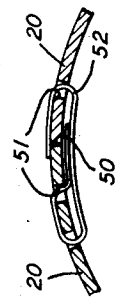


FIG. 10

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COAXIAL CABLE SPLICE AND METHODS OF MAKING IT

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Application February 8, 1949, Serial No. 75,228

8 Claims. (Cl. 174—88)

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This invention relates to cable splices and methods of making them, and more particularly to splices for coaxial cable units and method of making such splices.

Coaxial cables are used rather extensively in the transmission of intelligence electrically and as high frequency transmission lines. One type of coaxial cable comprises a plurality of coaxial units, which are twisted together and enclosed in a suitable insulating jacket, or metallic sheath, or both. The individual coaxial units employed in making such coaxial cables consist of a central conductor coaxially positioned within a tubular outer conductor having a longitudinal seam. Insulating discs spaced uniformly along the central conductor serve to separate and align the inner and outer coaxial conductors. A plurality of steel tapes are wound spirally around the tubular conductor, which tapes act as a shield for the unit and also prevent the tubular conductors from being crushed during the twisting operation employed in manufacturing coaxial cables.

Coaxial units are manufactured in lengths which will form coaxial cables having lengths required for installation in the field. It is often necessary to cut a manufactured length of coaxial unit to remove a mechanical or electrical defect therein, in which case it is necessary to splice the corresponding conductors of the two pieces of coaxial units together to obtain a coaxial unit which may be incorporated in a coaxial cable.

Due to the fact that the individual coaxial units have steel tapes wound around the tubular conductor and the fact that a plurality of the units are incorporated in a coaxial cable, the splice connecting the coaxial units together must be made inside the tubular conductor so as not to increase the diameter of the units at the splice. The splice also must not reduce materially the tensile strength of the coaxial unit.

In addition to these mechanical requirements, it is equally important that the physical structure of the splice must be such that it does not disturb the critical electrical characteristics of the coaxial unit. Therefore, the splice must be of such construction that it does not materially increase the capacitance of the coaxial unit at the point of the splice. Furthermore, the splice must not have a lower dielectric strength between the inner and outer conductors than in the balance of the unit.

An object of the invention is to provide new and improved cable splices and methods of making them.

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Another object of the invention is to provide new and improved splices for coaxial units and methods of making such splices.

A further object of the invention is to provide splices for coaxial units which do not produce any enlargement of the diameter of the outer conductors joined together by the splice, provide adequate strength for the spliced units, and provide good electrical continuity between the spliced conductors without materially increasing the capacitance of the coaxial unit or reducing the dielectric strength of the unit at the splice, and methods of making such splices.

One structure illustrating some of the features of the invention comprises a splice for coaxial units in which a butt-braze is formed between the center conductors of the coaxial unit to be spliced and a metallic band is brazed to the end portions of the tubular conductors in such a position that the band is brazed to a substantial area of the end portion of each tubular conductor.

One method of splicing such cables, which illustrates features of the invention, comprises butt-brazing the ends of the center conductors and brazing a metallic band to the end portions of the tubular conductors of the coaxial units in such a position that the band is brazed to a substantial area of the end portions of the tubular conductors.

A clear understanding of the invention will be had from the following detailed description of a specific structure embodying the invention and a method of making the same, which embodies the invention, and from the appended drawings, in which:

Fig. 1 is a perspective view of a portion of a typical coaxial unit which may be spliced by the use of apparatus and methods embodying the invention;

Fig. 2 is a front elevation of an apparatus in which the ends of two coaxial units may be secured during a splicing operation;

Fig. 3 is an enlarged, fragmentary, top plan view showing the end portions of two coaxial units during an early stage in the production of a splice between the coaxial units;

Fig. 4 is an enlarged, perspective view of an insert positioned in one of the coaxial units as shown in Fig. 3;

Fig. 5 is an enlarged, perspective view of a laminated ring used to splice the end portions of the tubular conductors of the coaxial units shown in Fig. 3;

Fig. 6 is an enlarged, vertical section taken along line 6—6 of Fig. 3;

Fig. 7 is an enlarged, fragmentary view of a completed splice between two coaxial units with a portion thereof broken away to show the internal structure of the splice;

Fig. 8 is an enlarged, vertical section taken along line 8—8 of Fig. 7;

Fig. 9 is a fragmentary view of the coaxial unit splice with portions thereof broken away to show the connection between the steel tapes of the spliced coaxial units, and

Fig. 10 is an enlarged, sectional view taken along line 10—10 of Fig. 9.

Referring now to the drawings and particularly to Fig. 1, there is shown a portion of one type of coaxial unit indicated generally by the numeral 10, which is used in the manufacture of coaxial cables. The coaxial unit 10 consists of a center conductor 12 coaxially positioned within a tubular outer conductor 15 by means of insulating discs 16—16 spaced uniformly along the center conductor. In the manufacture of the individual coaxial units, the tubular conductor 15 is formed longitudinally around the discs 16—16 from a thin copper tape, whereby the opposite sides of the tape form a longitudinal seam 17 along the tubular conductor. After the tubular conductor 15 is formed around the insulating discs 16—16, an inner layer of steel tape 20 and an outer layer of steel tape 21 are wound spirally around the tubular conductor 15 for the purpose of shielding and protecting it.

A plurality of coaxial units like the coaxial unit 10, are twisted together and enclosed in an insulating jacket and a lead sheath to form coaxial cables of specified lengths. To manufacture coaxial cables of specified length, it is often necessary to splice two lengths of coaxial units like the coaxial unit 10, to obtain a length of coaxial unit which may be incorporated in a coaxial cable.

Two coaxial units or portions of a coaxial unit, like the coaxial unit 10 (Fig. 1) may be spliced together in the following manner:

The end portions of two coaxial units 10—10 (Fig. 2) to be spliced, are secured in supports 25—25 provided on the top of a work bench 26 in such a position that the adjacent ends of the coaxial units do not contact each other. A detachable type of clamp, indicated generally at 27, is attached to each coaxial unit 10 at a point adjacent to its respective support 25 and the steel tapes 20 and 21 are unwound from the end of each tubular conductor of the coaxial units back to the clamp 27 and allowed to hang from the coaxial unit in the form of curls. The clamps 27—27 are attached to the coaxial units to prevent further unwinding of the steel tapes 20 and 21 from their respective tubular conductors.

After the steel tapes 20 and 21 have been removed to expose the ends of the tubular conductors, each coaxial unit is adjusted in its respective support 25 so that their respective longitudinal seams are aligned along the top side of the tubular conductors with respect to the work bench 26.

A small length is removed from the end of each tubular conductor 15 and a relatively smaller length is removed from each center conductor 12 so that the end of each center conductor 12 extends slightly beyond its respective tubular conductor as shown in Fig. 3. Care must be taken to insure that the end of each tubular conductor 15 and the end of each center conductor 12 is cut off square.

After the ends of the tubular conductors have been prepared in this manner, a split metal block 30 is clamped to each tubular conductor 15 a short distance from the end thereof for the purpose of absorbing the heat applied to the tubular conductors during the brazing operation hereinafter described. The longitudinal seam 17 of each tubular conductor is opened from the end thereof to its respective block 30 so that the end of each tubular conductor is substantially U-shaped, as shown in Figs. 3 and 6, and the end of its center conductor 12 and the insulating discs 16—16 are exposed. The exposed insulating discs then are slid toward the closed portion of the tubular conductors to clear the end portions of the center conductors, and a ceramic bushing 31 (Figs. 3 and 6) is positioned over the center conductor of one of the coaxial units and slid therealong until it engages a disc 16 at the inner end of the open portion of the tubular conductor.

The bushing 31 (Figs. 3, 4 and 7) is provided with a central hub 32 having a bore 33 therethrough for receiving the center conductor 12 of the coaxial unit and a peripheral groove 34 equidistant from the ends thereof. The central portion of the bushing is of such diameter that it fits snugly into the tubular conductors, whereas the end portions thereof are tapered to provide an annular clearance between the tubular conductor and the ends of the bushing. The bushing 31 is made of a ceramic material having a high dielectric strength, and capable of withstanding the heat encountered in brazing metals with silver solder or the like.

Before the bushing 31 is positioned in the end of one of the coaxial units as described, a split laminated ring 37 (Fig. 5) is positioned in the peripheral groove 34 of the bushing as shown in Fig. 4. The laminated ring 37 consists of a split copper band 38 surrounded by a split silver solder band 40, the two bands being spotwelded together at 41 so as to align the open ends of the bands to form a slit 42 in the laminated ring 37. The peripheral groove 34 is of such depth that the ring 37 may be positioned therein without any portion thereof extending beyond the periphery of the bushing 31.

After the ceramic bushing 31, having the laminated ring 37 assembled thereon, is positioned in the open end of one of the tubular conductors as shown in Fig. 3, a disc of silver solder is held against the center conductor 12 of the other coaxial unit. The coaxial unit having the bushing 37 positioned therein then is unclamped from its support 25, moved until its center conductor engages the silver solder disc and then is clamped to hold the disc between the center conductors. Suitable electrodes are attached to the ends of the center conductors and are connected electrically to a conventional micro-welder capable of passing sufficient current through the silver solder disc to melt it and form a brazed joint 45 (Fig. 3) between the center conductors. Any excess silver solder at the joint 45 is swaged down so that the diameter of the joint is equal to the diameter of the center conductors.

After the brazed joint 45 (Fig. 3) has been completed as described, the ceramic bushing 31 is moved along the center conductor 12 on which it is positioned until the hub portion 32 thereof is divided equally by the brazed joint as shown in Fig. 7. When the bushing 31 is positioned in

this manner, the laminated ring 37 positioned in the groove 34, extends an equal distance along each of the tubular conductors 15—15. The laminated ring 37 is so positioned on the bushing 25 that the slit 42 straddles the line of the longitudinal seams 17—17 (Fig. 8) of the tubular conductors. The insulating discs 16—16, which were slid away from the ends of the center conductors, are moved into equidistant positions on the center conductors with one of the discs of each coaxial unit positioned against an end of the bushing 31, as shown in Fig. 7. After the laminated ring 37 has been positioned in this manner, the opened ends of the tubular conductors are closed carefully so that the ends of the conductors are in substantially the same form as they were prior to being opened.

Brazing electrodes of standard design (not shown) are clamped around the periphery of the tubular conductors so that equal portions of the adjacent ends of the tubular conductors are engaged by the electrodes. The electrodes are connected electrically to a conventional welding transformer (not shown), and the electrodes and the end portions of the tubular conductors 15—15 clamped therein are heated sufficiently to melt the silver solder band 40 and braze the copper band 38 to the inside surfaces of the tubular conductors as shown in Fig. 7.

The ceramic bushing 31 serves to prevent the electrodes from crushing the tubular conductors and to hold the laminated ring 37 in place while the heat is being applied to cause the silver solder band to melt and braze the tubular conductors to the copper band. Excessive heat may dangerously affect the insulating quantity of the discs 16—16 and the structural quantity of the tubular conductors. To prevent damage to the unit by heat, the metallic blocks 30—30 are attached to the tubular conductors to absorb the heat applied to each tubular conductor and thereby prevent excessive heat from flowing along the tubular conductors beyond the point at which the braze is made.

When the end portions of the tubular conductors have been brazed to the copper band, a complete splice, indicated generally at 46 (Fig. 7), has been made between the center conductors 12—12 and the tubular conductors 15—15 of the coaxial units 10—10. After the splice 46 (Fig. 7) has been completed, the inner steel tape 20 of each coaxial unit is rewound around its respective tubular conductor and the excess portions of each tape are cut off square so that the ends of the corresponding tape abut as indicated by the numeral 50 in Fig. 9. The corresponding ends of each tape 20 then are perforated to provide slots 51—51, and a metal tape 52 is laced through the slots 51—51 in the manner shown in Fig. 10 to hold the tapes together. Several layers of pressure-sensitive tape 53, such as a cellulose strip covered on one side with a pressure sensitive adhesive, are wound around the laced joint of the tapes to hold it in place. One particular type of tape that has been found satisfactory for this purpose is a pressure sensitive tape manufactured by the Minnesota Mining & Mfg. Co., St. Paul, Minnesota, under the trade name of "Scotch Electrical Tape." After the ends of inner steel tape 20 are laced together in this manner, the outer steel tape 21 of each coaxial unit then is rewound so as to overlap the tape 20. The excess portions of the ends of each tape 21 are cut off square, and the ends of the tapes 21—21 are slotted and laced together in the same manner as that described for the tape 20. The laced joints between the tapes 20 and 21 are staggered along the coaxial unit so that they do not overlap and produce any enlargement of the coaxial units at the splice 46. Since material is cut from the end of each conductor 15 and from the end of each center conductor 12 after the steel tapes 20 and 21 have been removed to expose the ends of the tubular conductors, both tapes 20 and 21 contain excess lengths of tape when rewound about the tubular conductors 15—15. Hence, the staggering of the joints between the tapes 20 and 21 may be easily accomplished. The staggering of the joints between the tapes 20 and 21 may also be accomplished by cutting the tapes, prior to their removal, at staggered points along the length of the coaxial unit. Hence, when the tapes 20 and 21 are rewound, their joints necessarily will be staggered.

The bushing 31, forming part of the splice 46, is designed to maintain concentricity between the conductors of the coaxial unit at the splice and to support the end portions of the tubular conductors which are annealed by the heat applied to braze the conductors to the copper band. Since the end portions of the bushing are tapered, the splice may be flexed sufficiently to allow the coaxial unit containing the splice to be wrapped around a takeup reel, in which case, the body of the bushing prevents the end portions of the tubular conductors from buckling when the splice 46 is flexed.

Silver solder is used to form the brazed joint 45 and to braze the tubular conductors to the copper band in order to obtain good electrical conductivity at the brazed joints and at the same time produce a splice which does not reduce appreciably the tensile strength of the coaxial unit. The brazed joint between the tubular conductors and the copper band is not extended across their respective longitudinal seams because the opposite sides of the seams must be free to slide a certain amount with respect to each other when the spliced coaxial unit is twisted together with other coaxial units to form the core of a coaxial cable. Since the splice 46 introduces only a very small amount of material having a low dielectric constant between the center conductor and tubular outer conductor of a coaxial unit, the splice does not increase materially the capacitance of the coaxial unit at the splice and does not reduce the dielectric strength of the coaxial units at the splice.

The ceramic bushing is of such material and so designed that it prevents the reduction of the dielectric strength of the coaxial unit at the splice.

What is claimed is:

1. A splice for coaxial units each having an outer tubular conductor and an inner wire conductor disposed in concentric relation with respect to each other, which comprises a brazed joint between the wire conductors of two such coaxial units to be spliced, a non-conductive, annular member positioned over the brazed joint of the wire conductors so that it extends an equal distance into each tubular conductor, and a metallic band positioned around the annular member and brazed to the inner surface of the end portions of the tubular conductors, said annular member being of such dimensions to hold the metallic band in place against the inside surfaces of the tubular conductors while the band is brazed to the tubular conductors and for maintaining concentricity between the wire conductors and the tubular conductors so that the

splice does not reduce the dielectric strength of or increase materially the capacitance of the cables at the splice.

2. A splice for coaxial units each having a tubular conductor and an inner wire conductor disposed in concentric relation with each other, which comprises a butt-braze between the ends of the wire conductors of two such coaxial units to be spliced, a non-conductive bushing having tapered ends positioned over the brazed joint between the wire conductors so that it extends an equal distance into each tubular conductor, said bushing having a diameter substantially equal to the inside diameter of the tubular conductors of the said coaxial units and a peripheral groove around the central portion thereof, and a copper band positioned in the peripheral groove of the bushing and brazed to the tubular conductors in such a position that the band is brazed to a substantial area of the inner surface of each end portion of the tubular conductors, said peripheral groove of the bushing being of such depth that it holds the copper band against the tubular conductors and prevents them from being deformed when the band is brazed to the conductors.

3. A splice for coaxial units having an inner wire conductor concentrically disposed within an outer tubular conductor having a longitudinal seam, which comprises a brazed joint between the wire conductors of two such coaxial units to be spliced, a non-conductive annular member positioned over the brazed joint of the wire conductors so that it extends into each tubular conductor, and a split metallic band positioned around the annular member and brazed to the inner surfaces of the end portions of the tubular conductors in such a position that the brazed joint does not extend across the longitudinal seams of the tubular conductors, said annular member serving to hold the split metallic band in place against the inside surface of the tubular conductors while the band is brazed to the tubular conductors and for maintaining concentricity between the wire conductor and the tubular conductor at the splice.

4. A splice for coaxial units each comprising a center conductor concentrically disposed within a tubular conductor having a longitudinal seam, which comprises a butt-brazed joint between the wire conductors of two such coaxial units to be spliced, a ceramic tubular member having tapered ends positioned in the end portions of the tubular conductors so as to cover the brazed joint between the center conductors, said tubular member having a diameter substantially equal to the inside diameter of the tubular conductors of the coaxial units and a peripheral groove positioned centrally with respect to the ends of the tubular member, and a split copper band positioned in the peripheral groove and brazed to the inside surface of the end portions of the tubular conductors in such a position that the copper band does not extend across the longitudinal seam of the tubular conductors, said annular groove in the tubular member serving to hold the split copper band in position when the copper band is brazed to the tubular conductors, whereby the wire conductors and tubular conductors of the coaxial units are spliced together without enlarging the outside diameter of the coaxial units at the splice.

5. An insert for forming internal splices between metallic tubular members, which comprises an annular, ceramic member having a peripheral groove formed equidistant from the end thereof and having its ends tapered inwardly, and a split, laminated ring positioned in the peripheral groove and consisting of a split metallic band and a split silver solder band spot welded to each other, whereby when the insert is positioned within the end portions of two tubular members to be spliced the metallic band may be brazed to the inner surface of each tubular conductor by melting the silver solder band.

6. A splice for coaxial units having an outer tubular conductor and a center wire conductor disposed in concentric relation with respect to each other, which comprises a brazed joint between the ends of the wire conductors of two such coaxial units to be spliced, a nonconductive bushing positioned so that the ends thereof extend into the tubular conductors, said bushing having an outer diameter substantially equal to the inner diameter of the tubular conductors of said coaxial units and a peripheral groove around the central portion thereof, and a metallic band positioned in the peripheral groove of the bushing and brazed to the tubular conductors in such a position that the band is brazed to a substantial area of the inner surfaces of the adjacent end portions of the tubular conductors, said peripheral groove of the bushing being of such depth that it holds the metallic band against the tubular conductors and prevents the tubular conductors from being deformed during the brazing operation.

7. The method of splicing coaxial units each having a center conductor coaxially surrounded by a tubular conductor having a longitudinal seam and a plurality of steel tapes spirally wound around the tubular conductor, which comprises sliding the steel tapes back from the end of each coaxial unit a predetermined distance, squaring the ends of tubular conductors to be spliced, opening the end of the tubular conductor of each coaxial unit to permit access to the center conductors, positioning a ceramic bushing on the end of the center conductor of one of the coaxial units, said bushing having a peripheral groove spaced equidistant the ends of the bushing, and positioning a split laminated ring in the annular groove of the bushing, said laminated ring comprising a split copper band surrounded by a split silver solder band and spot welded thereto so as to align the open end of the bands with each other, brazing the ends of the center conductors, sliding the bushing over the brazed joint of the center conductors so that the open end of the laminated ring straddles the longitudinal seam of the tubular conductors, closing the ends of the tubular conductors around the bushing, and applying sufficient heat around the end portions of the tubular conductors in contact with the laminated ring to melt the silver solder band and braze the copper band to the inside surface of the tubular conductors so that the brazed joint does not extend across the longitudinal seam of the tubular conductors, said ceramic bushing being designed to prevent a reduction in the dielectric strength of the coaxial units at the splice.

8. The method of splicing cables having a center conductor positioned coaxially within an outer tubular conductor having a longitudinal seam, which comprises forming a butt-braze between the ends of the center conductors of two such cables to be spliced, positioning a non-conductive annular member over the brazed joint between the center conductors so that it extends a

substantial distance into each of the tubular conductors to be spliced, said annular member having a peripheral groove therein, positioning a split metallic band in the peripheral groove of the annular member, and brazing the metallic band to the inner surface of the end portion of each tubular conductor in such a position that the band does not extend across the longitudinal seam of the tubular conductors, said annular member being designed to support the metallic band when it is brazed to the end portions of the tubular conductors and to maintain concentricity between the center conductors and the tubular conductors at the splice.

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