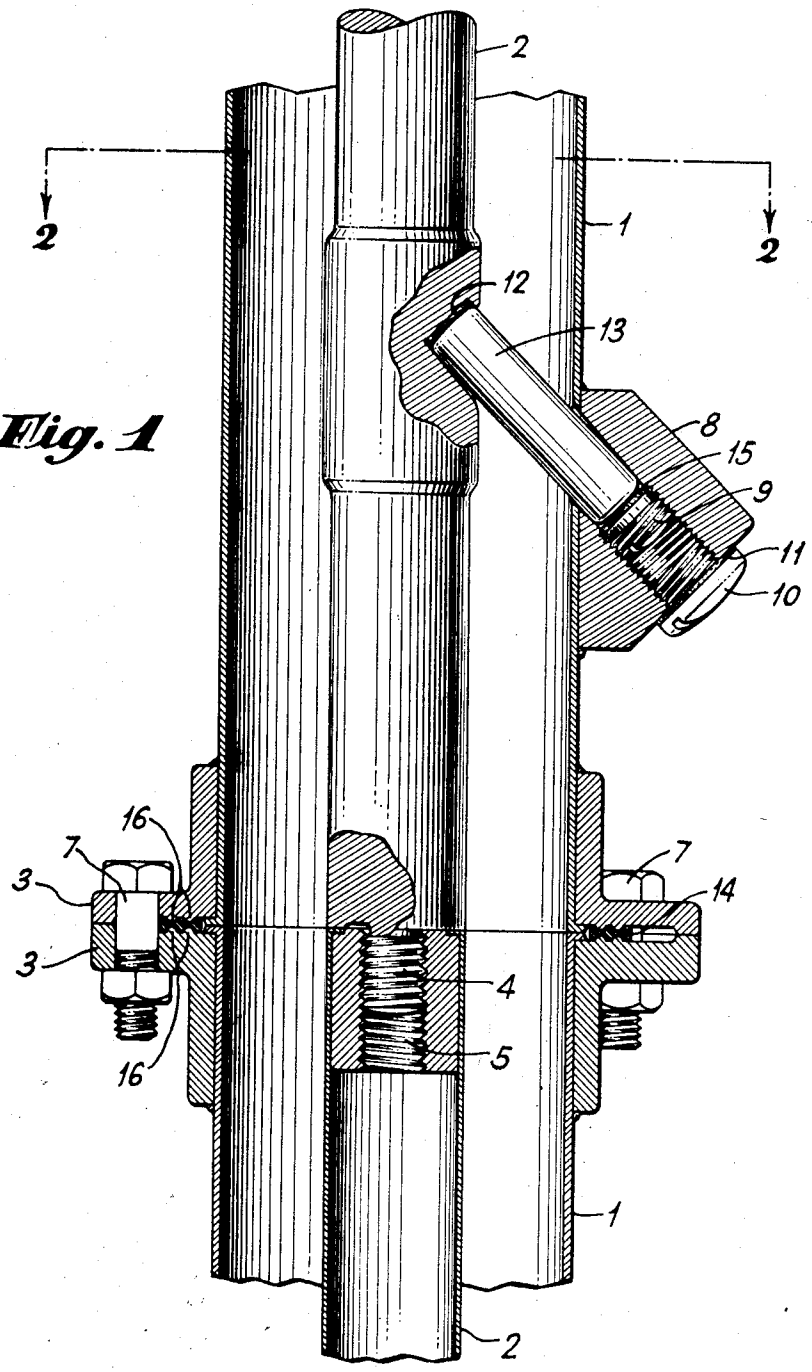
Sept. 16, 1941. G. L. USSELMAN 2,256,066

COAXIAL CONDUCTOR SYSTEM

Filed June 25, 1938 4 Sheets-Sheet 1

Fig. 1



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COAXIAL CONDUCTOR SYSTEM

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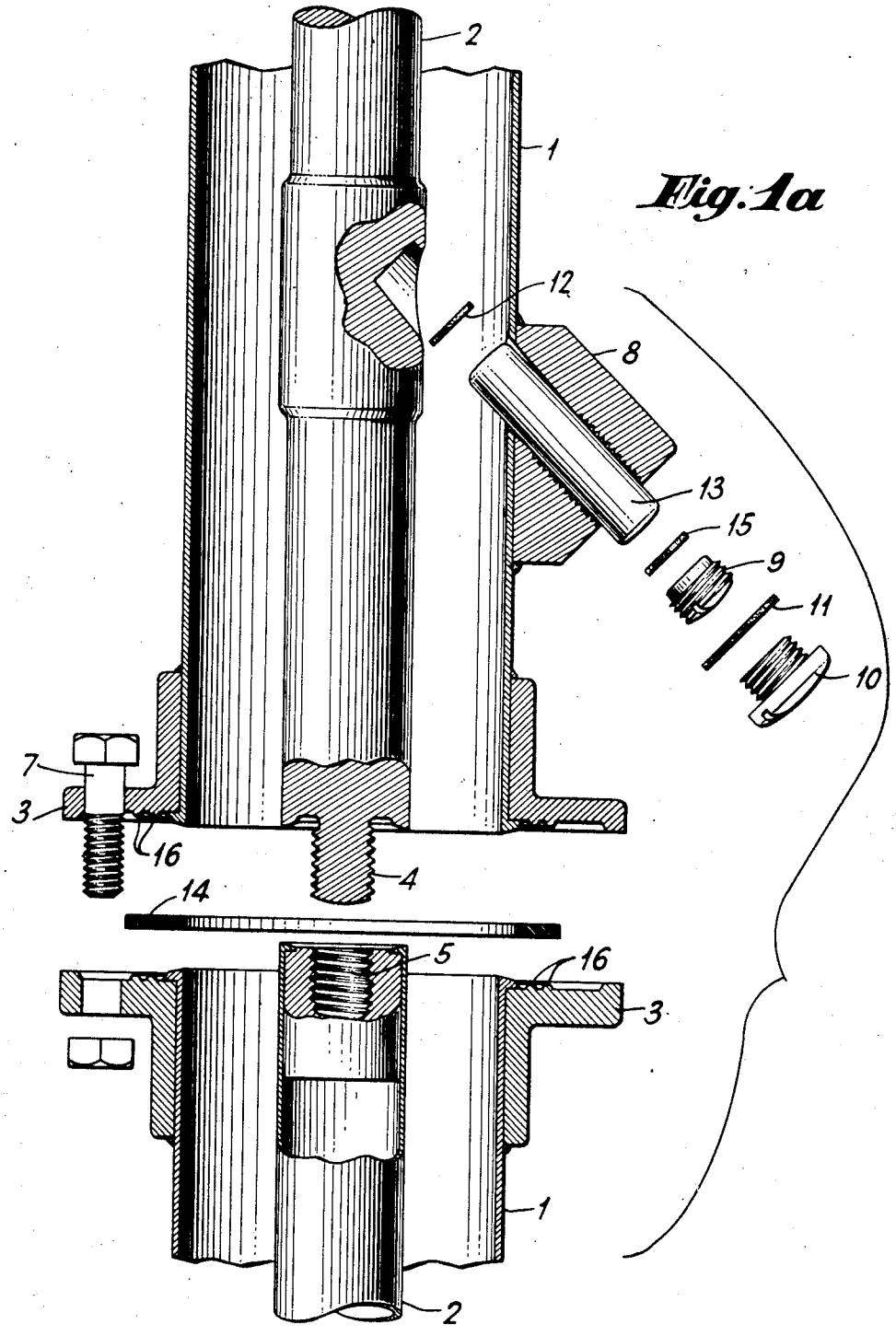


Fig. 1a

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COAXIAL CONDUCTOR SYSTEM

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Fig. 2

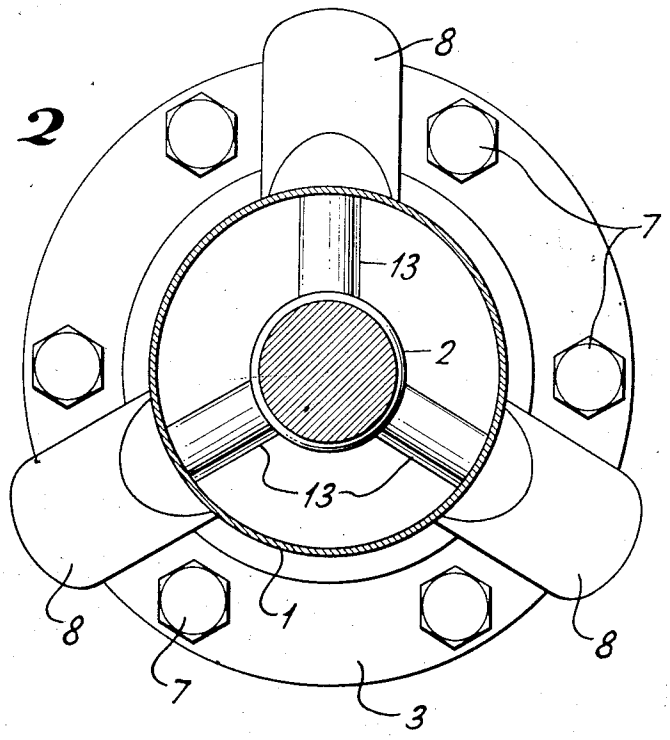
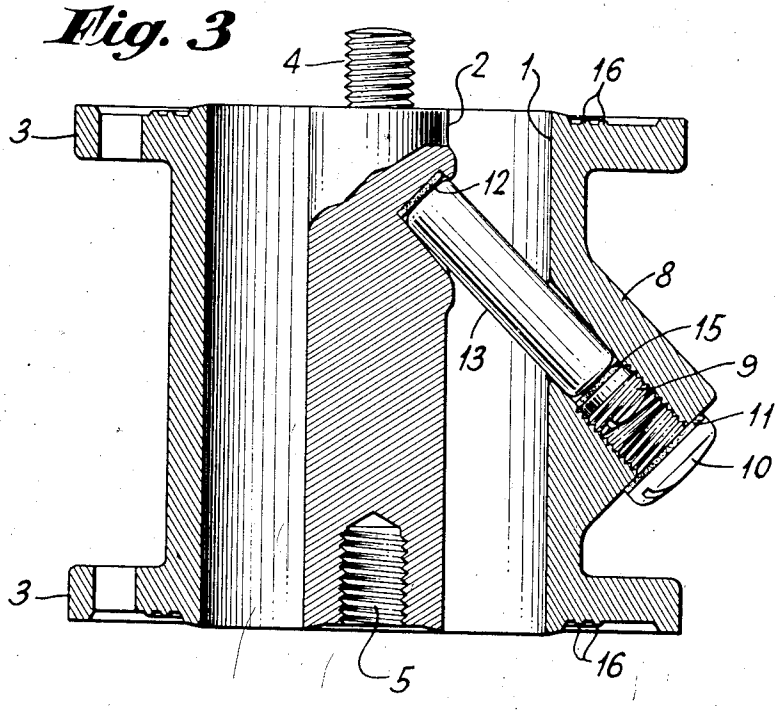


Fig. 3



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COAXIAL CONDUCTOR SYSTEM

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Fig. 4

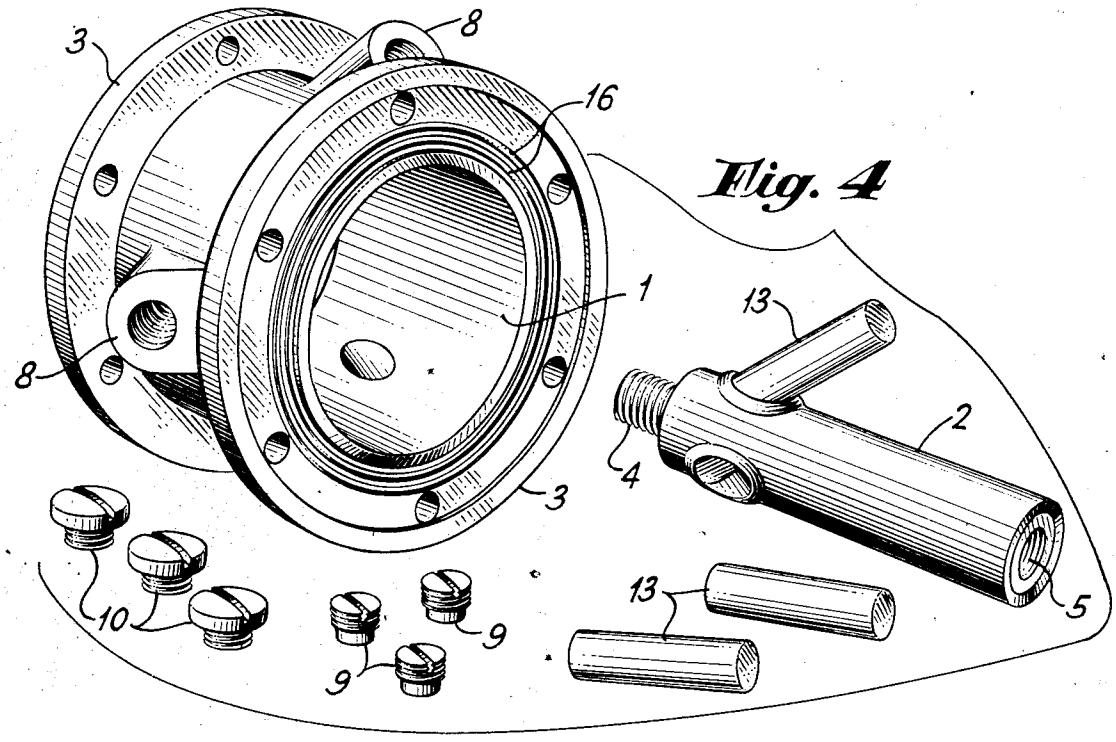
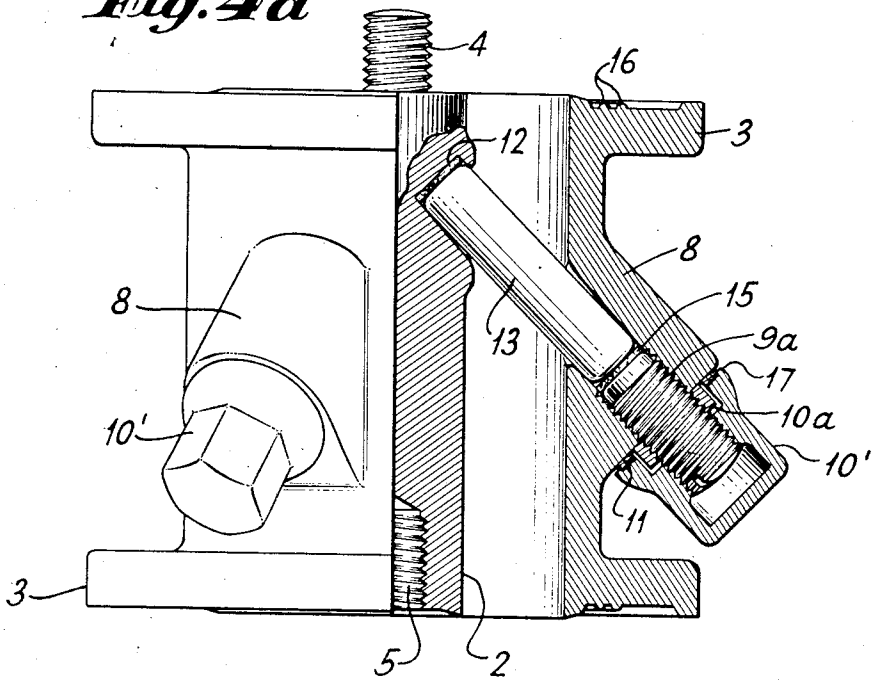


Fig. 4a



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Patented Sept. 16, 1941

2,256,066

UNITED STATES PATENT OFFICE

2,256,066

COAXIAL CONDUCTOR SYSTEM

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Application June 25, 1938, Serial No. 215,743

20 Claims. (Cl. 174—28)

This invention relates generally to coaxial, sometimes called concentric, conductor systems, and more particularly (1) to insulating spacers to be used in separating the coaxial conductors, and (2) to means for connecting together sections of conductors in end-to-end fashion, whereby the outer conductor is rendered air-tight and provides a relatively smooth, continuous inner surface for the flow of electrical currents.

It is known to use coaxial conductor lines for the transmission of radio frequency energy, wherein various types of insulators are spaced along the length of the line for insulating the two conductors of the coaxial line from each other, and for spacing the inner conductor in proper relation with respect to the outer conductor. The outer conductor of the line is usually maintained at ground potential, and supported by grounded clamps, especially where a vertical length of line is employed. On high-power high-frequency circuits, the inner conductor may carry currents of the order of fifty million to one hundred million cycles per second, and be maintained at a high frequency potential of the order of one thousand volts, more or less, above ground. It will therefore be evident that in the interest of efficiency of the electrical circuit, the inner conductor must be well insulated from the outer conductor, and where the coaxial line is vertically arranged, also strongly supported against an end thrust produced by the force of gravity. Heretofore, it has been customary to employ either tension type insulators or bowl type compression insulators for this purpose. Difficulties with these known insulators are that the tension insulators are not very strong, and the bowl shaped insulators have a large dielectric capacity which is objectionable for high frequency circuits.

The present invention overcomes the foregoing difficulties and provides, among other things, an insulating arrangement which has small dielectric capacity and which offers strong support for the inner conductor of a coaxial line. Specifically, the insulating arrangement of the invention comprises a plurality of quartz insulators in the form of rods symmetrically positioned around the inner conductor. It has been found that a quartz insulator is very strong in compression and has a low dielectric constant which makes for low capacity and minimizes the chances of corona forming on the inner conductor. Since quartz has the lowest (power factor) loss of any strong insulator, the use of this material in high frequency and high voltage lines or cables is very desirable.

An important advantage of the insulating arrangement of the present invention is that it firmly and insulatingly supports the inner conductor of the concentric transmission line against an end thrust such as is created by the force of gravity on a vertical section of line.

Another trouble experienced with coaxial conductor lines has existed at the junction points of sections of these lines when placed end-to-end. In the past, it has been difficult to make the joints between adjacent sections of line air-tight, and almost impossible to produce a relatively smooth continuous inner surface for the high frequency currents at the points of contact between the outer conductors of the adjacent sections.

The present invention, by means of a novel flange arrangement, enables the joints between the outer conductors of adjacent sections of line to become air-tight, and by a tapering operation on these same outer conductors at the line of contact, produces a firm continuous surface for the flow of high frequency currents.

A better understanding of the invention may be had by referring to the following description which is accompanied by drawings, wherein like parts are represented by like reference numerals throughout the figures.

In the drawings:

Fig. 1 shows in cross-section a coaxial conductor system utilizing an insulating arrangement between the conductors, and a novel flange arrangement for connecting together two sections of coaxial line, in accordance with the principles of the present invention;

Fig. 1*a* is an exploded view of the coaxial conductor system of Fig. 1 showing, in detail, the various elements constituting the insulator arrangement and the flange arrangement of the invention;

Fig. 2 is a plan view of Fig. 1, taken along the lines 2—2;

Fig. 3 is a view of one section of coaxial line embodying the features of the invention, which can be used in conjunction with similar sections to constitute a transmission line;

Fig. 4 shows, in perspective, the disassembled elements of the section of coaxial line of Fig. 3; and

Fig. 4*a* shows a section of coaxial line, partly in perspective and partly in cross-section, of an arrangement similar to that of Fig. 3, with means for adjusting the positions of the insulator rods and for locking the adjusting means.

Referring to Fig. 1 in more detail, there is shown a coaxial conductor system comprising

an outer conductor 1 and an inner conductor 2, both preferably made of or coated with excellent electrically conductive material, such as copper. The inner conductor 2 is supported against and insulated from the outer conductor by a plurality of rod insulators 13 made of good insulating material, preferably quartz. These rod insulators 13 may be of any shape but are preferably round, any desired number of which may be used. It is preferred that three of these rods be used spaced symmetrically around the inner conductor 120° apart. The rods 13 are shown set at equal angles of 45° with respect to the vertical, although it will be appreciated that any desired angle may be used.

The inner conductor 2 is notched or provided with holes to receive the ends of the several insulator rods 13 which, in turn, extend through the outer conductor 1 where their lower ends rest in sockets in individual metal shoulders 8. The edges of these holes are slightly rounded to prevent corona and danger of arc-over. The shoulders are soldered, brazed, or riveted to the outer surface of conductor 1, and if desired may be continuously arranged to form a single collar, or this may all be combined into a single casting. The sockets or holes in collars 8, 8 are each fitted with a screw 9 for supporting and adjusting the position of the insulator 13 against which it rests. A lead or asbestos cushion 15 is placed between each screw 9 and the adjacent end of its associated insulator rod 13. On the ends of insulators 13 which set into the notches of conductor 2 are asbestos or lead cushions 12. The edges and ends of each insulator 13, 13 are slightly rounded to prevent chipping and undue strain if the angle of the insulators with respect to the conductors should change. In order to give the insulators 13 room for movement, thus preventing insulator breakage due to slight movements thereof, the notches or holes in inner conductor 2 and the holes in outer conductor 1 and in collars 8, 8 are tapered and made slightly larger than the insulators.

If desired, that part of inner conductor 2 into which the insulators 13, 13 set may be made larger than the other parts of the inner conductor, for strengthening purposes, as shown, and to compensate for any slight change in line characteristics (inductance and capacity) due to the holes or notches cut in them for the insulators.

The holes in shoulder 8, 8 are also each fitted with a cap screw 10 and a gasket 11 to make the coaxial transmission line air-tight at these points.

The lower part of Fig. 1 also shows a novel flange arrangement for connecting together sections of coaxial conductors in end-to-end fashion. This novel flange arrangement produces good electrical contact between the outer conductors of adjacent sections and enables the coaxial line to be air-tight at the points of junction. The desirability of an air-tight joint will be appreciated from the fact that when compressed air is employed within the coaxial conductor system, the transmission line will operate at higher voltages without corona formation and arc-over between conductors. When compressed air is thus employed, such air should be kept free from dust and excessive moisture.

To achieve the result of air-tightness, among others, the adjacent sections of the coaxial conductor systems to be joined together are each provided with a flange 3, preferably in the form of a ring, mounted externally of the outer conductor 1 and soldered, brazed, or otherwise secured thereto. Adjacent surfaces of the flanges 3, 3 confronting each other are provided with annular, ring-like teeth 16 which are arranged to bite into a rubber ring gasket 14 of such thickness that the latter will be compressed into the position shown when the flanges are firmly pressed together by bolts 7, thus ensuring an air-tight joint. The outer edges of the flanges are made to be close together, so that if more than normal pressure is produced by the tightening of bolts 7, these edges will meet and act as a fulcrum, thus forcing the inner edges of the flanges more firmly together, rather than loosening them, as might otherwise occur.

In order to provide a smooth continuous, and firm line of contact directly between the inner surfaces of the outer conductors 1, 1 of adjacent sections of coaxial line, the outer conductors are tapered at the line of contact, as shown more clearly in Fig. 1*a*, so that they wedge together upon the application of pressure to the flanges 3, 3 by the bolts 7, 7.

The inner conductors of adjacent sections of coaxial line are connected together, however, by screwing the end of one inner conductor into the adjacent end of the other inner conductor. For this purpose, there is provided a threaded male coupling element 4 at one end of one inner conductor, and a cooperating threaded female coupling element 5 at the adjacent end of the other inner conductor, both being threaded. The end joints of the inner conductor also have the edges tapered so that the outside surface are sure to make good electrical contact.

It is believed that a clearer picture of the arrangement may be had by referring to the exploded view of Fig. 1, illustrated in Fig. 1*a*, wherein the elements are shown disassembled.

Fig. 2 shows a plan view of Fig. 1, along the lines 2—2, looking down in the direction of the arrows.

Fig. 3 is another modification of the invention, showing how a section of coaxial line may be designed for convenient fitting into other similarly designed sections to provide a long string of sections mounted end-to-end. Each section is here provided with flanges at both ends of the outer conductor. It should be noted in this figure that the flanges 3 and shoulder 8 are made integral with the outer conductor 1 so that all these parts can be manufactured by one operation in casting. Since the parts of this section are similar in arrangement to those shown in Figs. 1 and 1*a* and the same parts similarly labeled, it is believed that the manner in which they cooperate is obvious.

Fig. 4 shows, in perspective, the disassembled elements of Fig. 3. It should be noted that the inner conductor is provided with a rim or lip around each notch into which the insulator rod sets. However this lip may be left off without vitally affecting the usefulness of the invention, provided that the insulators are set deeper into the inner line.

Fig. 4*a* illustrates a modified arrangement of coaxial line similar to that shown in Fig. 4. This new figure shows the details for only one insulating rod, it being understood that the same features are also used for the other insulating rods. For adjusting the position of each insulating rod 13, there is provided a screw 9*a* which is given an appreciable length, as shown, to accommodate a locking ring 10*a* which is adapted

to be threaded and screwed over the element 9a. Locking ring 10a serves to lock screw 9a in position, thus preventing screw 9a from working itself loose due to possible vibration. Element 10' is a sealing nut which is screwed on to the end of screw 9a, as shown, after rubber ring washer or gasket 11 has been put in place. This entire insulating assembly is made air-tight by tightening sealing nut 10' which has a lip 17 on its outer edge, thus preventing the rubber washer 11 from squeezing or blowing out from under it to form an air leak. This lip 17 is slightly less than the thickness of the rubber washer 11 and consequently allows proper compression of the rubber ring and yet prevents its escape.

It should be understood, of course, that various changes in size and arrangements of the parts can be made without departing from the spirit and scope of the invention.

What is claimed is:

1. In a coaxial conductor system, an inner conductor having a plurality of notches symmetrically arranged around the circumference thereof, and means for insulating the inner conductor from the outer conductor of said system comprising insulating rods, each rod having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, said rods being each arranged at an acute angle with respect to both said inner and outer conductors.

2. In a coaxial conductor system, an inner conductor having a plurality of notches symmetrically arranged around the circumference thereof, and means for insulating the inner conductor from the outer conductor of said system, comprising quartz insulating rods each having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, said rods being each arranged at an acute angle with respect to both said inner and outer conductors.

3. In a coaxial conductor system, an inner conductor having a plurality of notches symmetrically arranged around the circumference thereof, and means for insulating the inner conductor from the outer conductor of said system comprising quartz insulating rods, each rod having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, and means individual to each quartz rod for maintaining the same under compression, said rods being each arranged at an acute angle with respect to both said inner and outer conductors.

4. In a coaxial conductor system, an inner conductor having three notches therein positioned substantially at 120° with respect to each other around the circumference thereof, an insulating rod for each notch having one end inserted therein and its other end protruding through the outer conductor of said system, and means located externally of said outer conductor for maintaining each of said rods under compression, each of said rods being arranged at an acute angle with respect to both said inner and outer conductors.

5. In a coaxial conductor system, an inner conductor having three notches therein positioned substantially at 120° with respect to each other around the circumference thereof, a quartz insulating rod for each notch having one end inserted therein and its other end protruding through the outer conductor of said system, said rods being set at substantially equal acute angles with respect to the axis of said inner conductor, and means located externally of said outer conductor for maintaining each of said rods under compression.

6. In a coaxial conductor system, an inner conductor having a plurality of notches symmetrically arranged around the circumference thereof, and means for insulating the inner conductor from the outer conductor of said system comprising quartz insulating rods, each having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, and means individual to each quartz rod and located externally of said outer conductor for maintaining the same under compression, said rods being set at approximately equal acute angles with respect to said inner conductor.

7. A section of a coaxial conductor transmission line comprising an inner conductor having a plurality of notches symmetrically positioned around the circumference thereof, an insulator rod individual to each notch and having one end inserted therein and its other end passing through the outer conductor and maintained in fixed relation thereto, said rods being set at acute angles with respect to the axis of said inner conductor, and a flange for each end of said section for securing said section to its next adjacent section.

8. A section of a coaxial conductor transmission line comprising an inner conductor having a plurality of notches symmetrically positioned around the circumference thereof, an insulator rod individual to each notch and having one end inserted therein and its other end passing through the outer conductor and maintained in fixed relation thereto, said rods being set at acute angles with respect to the axis of said inner conductor, said inner conductor of said section having male and female coupling elements at opposite ends thereof for joining with opposite coupling elements of the inner conductors of adjacent sections, and a flange for each end of said section, at least one of said flanges having one or more annular ring-like teeth for compressing a gasket adapted to be placed between said flange and the flange of an adjacent section of line.

9. In combination, a pair of sections of high frequency coaxial transmission line placed end-to-end, said sections comprising hollow outer conductors having integral therewith external flanges near adjacent ends surrounding the circumferences thereof, the hollow conductors of said sections being tapered at the line of contact therebetween, and means located externally of said hollow conductors for forcing said flanges directly together into contact with each other, whereby said tapered ends are wedged together at the current carrying surfaces, the inner conductors of said line having a plurality of notches symmetrically positioned around the circumference thereof, an insulator rod individual to each notch and having one end inserted therein and its other end passing through the outer conductor and maintained in fixed relation thereto, said rods being set at acute angles with respect to the axis of said inner conductor.

10. In combination, a pair of sections of high frequency coaxial transmission line placed end-to end, said sections comprising hollow outer conductors, having integral therewith external flanges near adjacent ends surrounding the circumferences thereof, said flanges having teeth-

like rings therein, the hollow outer conductors of said sections being tapered at the line of contact therebetween, a ring gasket located between the teeth-like rings of adjacent flanges, and means located externally of said hollow conductors for forcing said flanges directly together into contact with each other, whereby said gasket is compressed to provide an air-tight joint between said sections and said tapered ends are wedged together at the current carrying surfaces, the inner conductors of said line having a plurality of notches symmetrically positioned around the circumference thereof, an insulator rod individual to each notch and having one end inserted therein and its other end passing through the outer conductor and maintained in fixed relation thereto, said rods being set at acute angles with respect to the axis of said inner conductor.

11. In a vertical coaxial conductor system, an inner conductor having a plurality of notches symmetrically arranged around the circumference thereof, and means for insulating the inner conductor from the outer conductor of said system and for supporting said inner conductor, said means comprising a plurality of insulating rods, each having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, and means individual to each rod and attached to said outer conductor for maintaining each of said rods under compression, said rods being positioned at angles with respect to said inner conductor, the ends of said rods resting in said notches being higher in location than the other ends of said rods.

12. In a coaxial conductor system, an inner conductor having three notches therein positioned substantially at 120° with respect to each other around the circumference thereof, a quartz insulating rod for each notch having one end inserted therein and its other end protruding through the outer conductor of said system, said rods being set at substantially equal 45° angles with respect to the axis of said inner conductor, and means located externally of said outer conductor for maintaining each of said rods under compression.

13. In a vertically arranged coaxial conductor system, an inner conductor having a plurality of notches symmetrically arranged around the circumference thereof, and means for insulating the inner conductor from the outer conductor of said system comprising insulating rods, each rod having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, said rods being each arranged at an acute angle with respect to both said inner and outer conductors, the ends of said rods resting in said notches being higher in location than the other ends of said rods, whereby the inner conductor of said coaxial conductor is firmly and insulatingly supported against the end thrust created by the force of gravity.

14. In a coaxial conductor system, an inner conductor having a plurality of notches symmetrically arranged around the circumference thereof, said notches having rounded rims, and means for insulating the inner conductor from the outer conductor of said system comprising insulating rods, each rod having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, said rods being each arranged at an acute angle with respect to both said inner and outer conductors.

15. In a coaxial conductor system, an inner conductor having a plurality of notches symmetrically arranged around the circumference thereof but spaced from one another along the length of said inner conductor, and means for insulating the inner conductor from the outer conductor of said system comprising insulating rods, each rod having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, said rods being each arranged at an acute angle with respect to both said inner and outer conductors.

16. In a coaxial conductor system having an outer conductor and an inner conductor, said inner conductor having a plurality of notches arranged around the circumference thereof, and means for insulating the inner conductor from the outer conductor of said system comprising insulating rods, each rod having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, said rods being each arranged at an acute angle with respect to both said inner and outer conductors, and means attached to and controllable from the outside of said coaxial conductor and bearing upon the last end of each of said insulators for maintaining the position thereof.

17. In a coaxial conductor system having an outer conductor and an inner conductor, said inner conductor having a plurality of notches arranged around the circumference thereof, and means for insulating the inner conductor from the outer conductor of said system comprising insulating rods, each rod having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, collars attached to said outer conductor for accommodating the ends of said insulators passing through said outer conductor, said collars each having a threaded interior and a screw cooperating therewith and bearing upon said last end of said insulator.

18. In a coaxial conductor system having an outer conductor and an inner conductor, said inner conductor having a plurality of notches arranged around the circumference thereof, and means for insulating the inner conductor from the outer conductor of said system comprising insulating rods, each rod having one end inserted into one of said notches and the other end passing through said outer conductor and maintained in fixed relation thereto, a collar for each insulator attached to said outer conductor for accommodating the end of the insulator passing through said outer conductor, said collar having a threaded interior and a screw cooperating with said threaded interior and bearing upon the end of said insulator accommodated in said collar, said screw having an end protruding beyond said collar, and a cap adapted to threadedly engage said screw for rendering said collar air-tight.

19. In a coaxial conductor system having an outer conductor and an inner conductor, means for insulating the inner conductor from the outer conductor of said system comprising insulating rods, each rod having one end bearing on said inner conductor and the other end passing through an aperture in said outer conductor and maintained in fixed relation thereto, a col-

lar for each insulator attached to the outer conductor, externally thereof, for accommodating the end of the insulator passing through its associated aperture, a cap for each collar, and a gasket located between each cap and its collar and adapted to be held firmly in position, whereby said apertures are rendered air tight.

20. A coaxial system as defined in claim 19, characterized in this that said cap exerts pressure against its gasket and has a lip on its lower edge for preventing escape of said gasket under pressure from the inside of said line.

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