

May 22, 1945.

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2,376,725

END SEAL FOR TRANSMISSION LINES

Filed Feb. 28, 1942

Fig. 1.

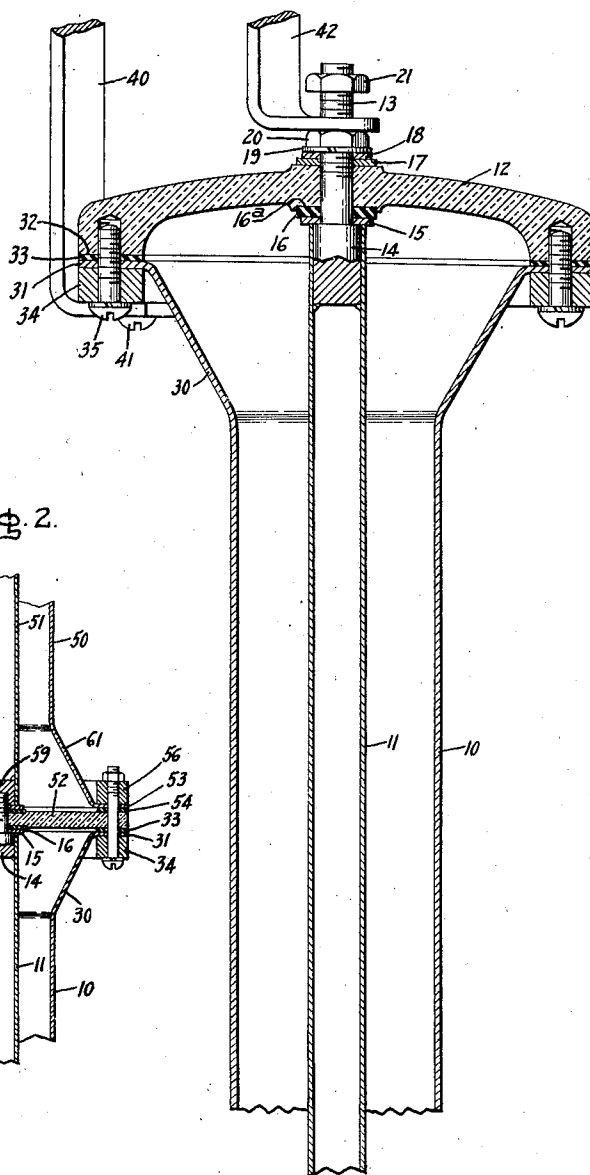
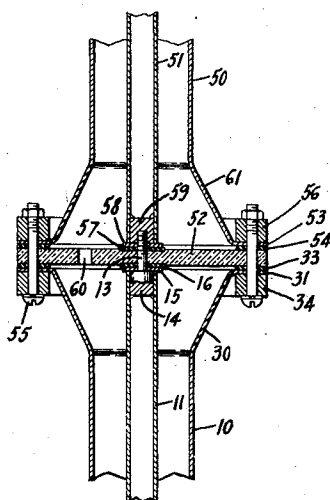


Fig. 2.



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UNITED STATES PATENT OFFICE

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END SEAL FOR TRANSMISSION LINES

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Application February 28, 1942, Serial No. 432,844

2 Claims. (Cl. 174-19)

This invention relates to transmission lines, and more particularly to mechanical connections between the two conductors thereof.

Conductors which are utilized for the transmission of high frequency waves are generally used in pairs spaced relatively closely to minimize radiation therefrom. Spacing between such pairs of conductors, and the sizes of the individual conductors, determine certain transmission characteristics of the transmission line, one of which is known as the surge impedance, or characteristic impedance. Abrupt changes in such impedance along a transmission line generally produce deleterious effects, as is well known in the art. When two such conductors are spaced closely together, it is therefore necessary to use insulating means between the conductors to maintain proper spacing therebetween under the effect of external forces.

It is an object of the invention to provide new and improved means whereby the two conductors of such a transmission line may be maintained in proper spaced relation with minimum variation in impedance along the line.

It is a further object of the invention to provide such means which is especially useful for maintaining the proper spacing between two such conductors at the ends thereof.

It is an additional object of the invention to provide such spacing means which are rugged and highly resistant to the effect of external forces and the elements, and which is at the same time simple and easily constructed and assembled.

The invention is particularly useful with coaxial transmission lines, in which the spacing means may be utilized for closing the passage between conductors against the passage of gas under pressure, used for insulation purposes, and against moisture and the like. It is accordingly also an object of the invention to provide such insulating means, particularly useful in coaxial transmission lines, whose configuration is such, in conjunction with the coaxial lines, as to make the total length of each line, including its end connections to associated apparatus, substantially equal to the total length of the other line.

The features of the invention which are believed to be novel are set forth with particularity in the appended claims. The invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing, in which

Fig. 1 of the drawing is a sectional view along the axis of a transmission line embodying the invention, and Fig. 2 is a modification thereof.

In Fig. 1 a coaxial transmission line including an outer cylindrical conductor 10 and an inner cylindrical conductor 11 is terminated near a generally disc-shaped insulator 12. A threaded member 13 extends through the insulator 12 and has a plug-shaped end 14 soldered or brazed with- in the end of the inner conductor 11. A metal washer 15 is placed over the threaded member 13 adjacent the plug 14 and firmly holds a disc 16 of packing material within the recess 16a in the insulator 12. The disc 16 is preferably made of synthetic rubber, as for example, polyisobutylene compound, which is soft enough to spread and make a gas-tight seal between the center conductor 11 and the insulator 12. At the same time such material has long life when subjected to high frequency currents, light, oil, heat and most gases.

On the outside of the insulator 12 a disc 17, of some soft material such as pure aluminum or annealed copper, is placed over the threaded member 13, followed by a metal washer 18, a lock washer 19, and a nut 20 which is screwed on the threaded member 13 to compress the insulator 12 and the discs 16 and 17 tightly between the plug 14 and the nut 20. Due to their softness, the discs 16 and 17 distribute pressure uniformly over the central surface of the insulator 12, and minimize the chances of breakage. A second nut 21 is provided for convenience in making electric connection through the threaded member 13 to the center conductor 11.

The insulator 12, as is clearly shown in the cross-sectional view thereof is made somewhat dome-shaped, the under side of the dome facing the interior of the transmission line. The outer part of the under face of the domed insulator is made flat in a plane perpendicular to the conductor 10 to form a circular sealing surface 32.

The cylindrical outer conductor 10 is spun at its end portion near the insulator 12 into a conical configuration 30 and the extreme end of the coned portion 30 so formed is further spun into a flange 31 in a plane substantially perpendicular to the conductors 10 and 11. The flange 31 is shaped thus parallel to surface 32 to conform thereto and provide good gas sealing therebetween. This flange 31 and surface 32 may, if desired, take other mutually conforming shapes. A ring 33 of synthetic rubber, or other suitable material, is placed between the flange 31 and the sealing surface 32 of the insulator 12, and a

metal clamping ring 34 is pressed toward the insulator 12 by screws 35 suitably spaced there-around and extending through the ring 34, the flange 31, the ring 33, and into threaded holes in the insulator 12.

The dome shape of the insulator 12 provides sufficient mechanical strength so that gas under pressure may be confined between the conductors 10 and 11 to increase the breakdown voltage therebetween, and also to prevent "breaking" of the line with the consequent introduction of moisture.

Furthermore, the rubber sealing ring 33 and the rubber disc 16 provide sufficient sealing between the insulator 12 and the conductors 10 and 11 so that such gas under pressure suffers no leakage.

The use of the insulator 12 provides a dielectric path between the screw member 13 and the flange 31, which path is sufficiently long to withstand the voltage between conductors 10 and 11 without breakdown, and due to the shape of the insulator 12 there is less capacity between the conductors 10 and 11 at the insulator than would be the case if the usual type of insulator were provided between the conductors 10 and 11 without altering their sizes. Although the use of this long ceramic path between the flange 31 and the screw member 13 tends to minimize this capacity, yet this capacity is still larger than the capacity existing in a similar length of the transmission line between the conductors 10 and 11 where no insulator is present. If suitable provision were not made for counteracting the effect of this added capacity between the conductors 10 and 11, there would be a discontinuity in the transmission line, with consequent deleterious effects.

In the section of the transmission line including the coned portion 30 of the outer conductor 10, the two conductors 10 and 11 are spaced farther apart than at other sections of the transmission line. Due to the fact that they are so spaced, there is less capacity between the coned portion 30 of the outer conductor 10 and the inner conductor 11 than there is between other portions of the outer conductor 10 and the inner conductor 11. At the same time, the space enclosed by the conductors 10 and 11 in that section of the transmission line including the conical section 30 is greater than the space enclosed by a similar length of the transmission line in which the conductor 10 is uniform in diameter. Due to the fact that the conductors 10 and 11 enclose such additional space at the conical portion 30, the inductance of the transmission line is greater at this conical portion 30 than at other portions of the line.

At each incremental section of the coned portion 30 of the transmission line there is a particular characteristic impedance, which varies from a value equal to that of the transmission line where the coned portion 30 is joined to the uniform portion of the transmission line to a higher surge impedance at the open end of the coned portion 30. Due to the fact that this coned portion 30 thus has a smoothly varying characteristic impedance, it tends to act as an impedance transformer.

When a particular material is used for the insulator 12 and a particular shape therefor is utilized, the amount of capacitance introduced between the flange 31 of the outer conductor 10 and the threaded member 13 is fixed. This does not mean that the capacity between the coned portion 30 and the inner conductor 11 is fixed,

for that capacity depends upon the angle to which the coned portion 30 is flared. If this angle, formed by the inner surface of the coned portion 30 with the axis of the transmission line is too great, there is increased capacity between the coned portion 30 through the insulator 12 and the threaded member 13. If this angle be too small, the inductance added by the flaring of the coned portion 30 may be more than enough to compensate for capacity effect caused by the insulator 12. Furthermore, if this angle is too small, the coned portion 30 becomes very long, and may approach a length equal to a substantial portion of a wave length of a wave transmitted through the transmission line. It is not desirable that the length of the coned portion 30 should be so great.

In any particular situation, where the dimensions of the inner and outer conductors 11 and 10, and the shape and material of the insulator 12 are chosen, a suitable choice of the angle made by the coned section 30 with the axis of the transmission line may be made, so that the progressive simultaneous decrease in capacity and increase in inductance of the coned portion 30, progressing from the transmission line toward the insulator 12, may be made effective just to counteract the change in surge impedance of the transmission line at the insulator 12 due to the increased capacity between the conductors 10 and 11 through the insulator 12.

Although the optimum angle between the inner surface of the conical portion 30 and the axis of the transmission line generally lies somewhere between 20 and 60 degrees in any particular case, this angle depends entirely on the particular structure utilized for the insulator 12 and the transmission line 10, 11. The dimensions of the transmission line 10, 11 are generally fixed by considerations not mentioned herein, such as the characteristic impedance of the source of oscillations, or the load therefor. It is generally desirable to make the insulator 12 as thin as possible to reduce capacitance therethrough, and yet thick enough to have sufficient strength to maintain proper spacing between the conductors 10 and 11 and to resist the pressure of gas in the transmission line.

It is generally desirable that the overall length of the conical portion 30 and the insulator 12 be a small portion of a wave length of a wave transmitted through the transmission line 10, 11. If the particular structure chosen for the insulator 12 be such as to require a very small angle between the inner surface of the coned portion 30 and the axis of the transmission line, thereby making the coned portion 30 of considerable length with respect to a wave length, it is generally desirable to change the formation, and possibly the material, of the insulator 12 in such fashion that the angle between the inner surface of the coned portion 30 and the axis of the transmission line may be increased substantially.

When the invention is used in an end connection for a coaxial transmission line, as illustrated in Fig. 1, especially advantageous connections may be made to desired apparatus. Such connections are made by means of a short transmission line comprising two parallel conductors without introducing large amounts of inductance, and consequent discontinuity, at any part of the coaxial transmission line or of the parallel conductor connections. In Fig. 1 a wide flat conductor 40 is fastened to the conducting ring 34 by means of a screw 41, and a parallel wide, flat conductor 42

is fastened upon the threaded member 13 by means of the nut 21. If desired, the characteristic impedance between the wide flat conductors 40 and 42 may be made the same as the characteristic impedance between the conductors 10 and 11. To this end, the spacing between the conductors 40 and 42, and the width of these conductors, may be given such values that there is any desired characteristic impedance therebetween. It should be noted particularly that the conductor 40 extends only a small distance beyond the end of the conductor 42, so that no substantial extra inductance is introduced between the conductors 40 and 42, as is the case in connections made with end terminals provided previously for coaxial transmission lines.

In Fig. 2 a connecting arrangement is shown in which a connection is made between a coaxial transmission line including the conductors 10 and 11 and a second similar coaxial transmission line including an outer conductor 50 and an inner conductor 51. Certain elements of the device of Fig. 2 are like those of the arrangement illustrated in Fig. 1, and are designated by like reference numerals. A flat insulating disc 52 is interposed between the two coaxial transmission lines, the flat flanged portion 31 of the outer conductor 10 bearing through washer 33 on one side of the disc 52, and a similar flat flanged portion 53 of the outer conductor 50 bearing through a washer 54 against the other side of the insulating disc 52.

The outer conductors 10 and 50 of the two transmission lines are held together by bolts 55 extending through the conducting ring 34, flange 31, washer 33, insulating disc 52, washer 54, flange 53, and another conducting ring 56 similar to conducting ring 34.

The threaded member 13 at the end of the inner conductor 11 extends through the center of the insulating disc 52 and through washers 57 and 58, respectively, similar to washers 16 and 15, into a metal plug 59 fastened into the end of the inner conductor 51. The threaded member 13 is screwed tightly into the plug 59 to maintain a firm electrical connection between the inner conductors 11 and 51.

A hole 60 is provided through the insulating disc 52 to allow for the passage of fluid therethrough. Where gas under pressure is maintained between the inner conductors 11 and 51 and the outer conductors 10 and 50, the pressure of the gas in various sections of the line is equalized through the hole 60. There may, if desired, be more than one of the holes 60, as for example, three such holes.

The electrical structure of the joint including the insulating disc 52 between the two coaxial transmission lines in Fig. 2 is similar to that of the arrangement of Fig. 1. The disc 52 is of larger diameter than the outer conductors 10 and 50, thereby minimizing the capacitance added between the inner and outer conductors of the two transmission lines. This added capacitance is compensated by the inductance added between the inner and outer conductors of the two transmission lines by the conical portion 30 of the outer conductor 10 and by a similar conical portion 61 of the outer conductor 50.

Where, as in the arrangement of Fig. 2, there are two conical portions 30 and 61, each of which

introduces added inductance into its coaxial transmission line, the inductance added by each of these conical portions 30 and 61 need not be so great as the inductance added by the single conical portion 30 in the arrangement of Fig. 1. Generally, therefore, the conical portion 30 in the arrangement of Fig. 2 need not be as long as the conical portion 30 in the arrangement of Fig. 1.

While we have shown and described a particular embodiment of the invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and we, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent in the United States is:

1. An end seal for a high frequency transmission line of the type having a tubular outer conductor and a coaxially disposed inner conductor comprising, a disc of insulating material affixed centrally to one end of said inner conductor and having a diameter larger than the diameter of said outer conductor, a section of said outer conductor at the end thereof adjacent said one end of said inner conductor being flared outwardly at an angle to the periphery of said disc and being affixed thereto, said flared section of said outer conductor having a length substantially smaller than the length of a wave transmitted by said transmission line, the angle of said flared section being such that the increased inductance introduced between said conductors by said flared section is sufficient to compensate substantially completely for the increased capacity introduced therebetween by said insulating disc, said disc being of a thin domelike shape to afford maximum mechanical strength to resist mechanical forces between said conductors.

2. An end seal for a gas filled high frequency transmission line of the type having a tubular outer conductor and a coaxially disposed inner conductor comprising, a disc of insulating material affixed centrally to one end of said inner conductor and having a diameter larger than the diameter of said outer conductor, a section of said outer conductor at the end thereof adjacent said one end of said inner conductor being flared outwardly at an angle between 20° and 60° to the periphery of said disc and being affixed thereto, said flared section of said outer conductor having a length substantially smaller than the length of a wave transmitted by said transmission line, the angle of said flared section being such that the increased inductance introduced between said conductors by said flared section is sufficient to compensate substantially completely for the increased capacity introduced therebetween by said insulating disc, and fluid sealing means interposed between said flared section and said disc and between said inner conductor and said disc, said disc being of a thin domelike shape to afford maximum mechanical strength to resist mechanical forces between said conductors and the pressure of said gas within said line.

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