

Sept. 29, 1942.

L. WALTER

2,297,516

HIGH FREQUENCY TRANSLATING DEVICE

Filed Nov. 28, 1940

2 Sheets-Sheet 1

Fig. 1.

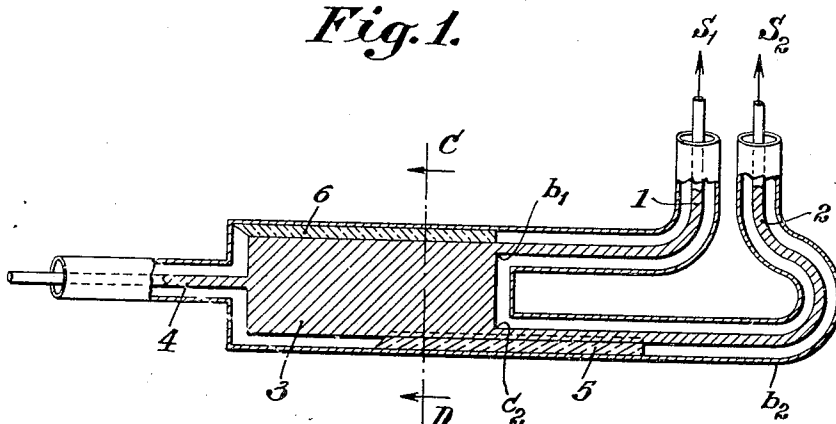


Fig. 1A.

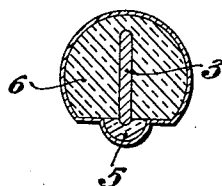


Fig. 2.

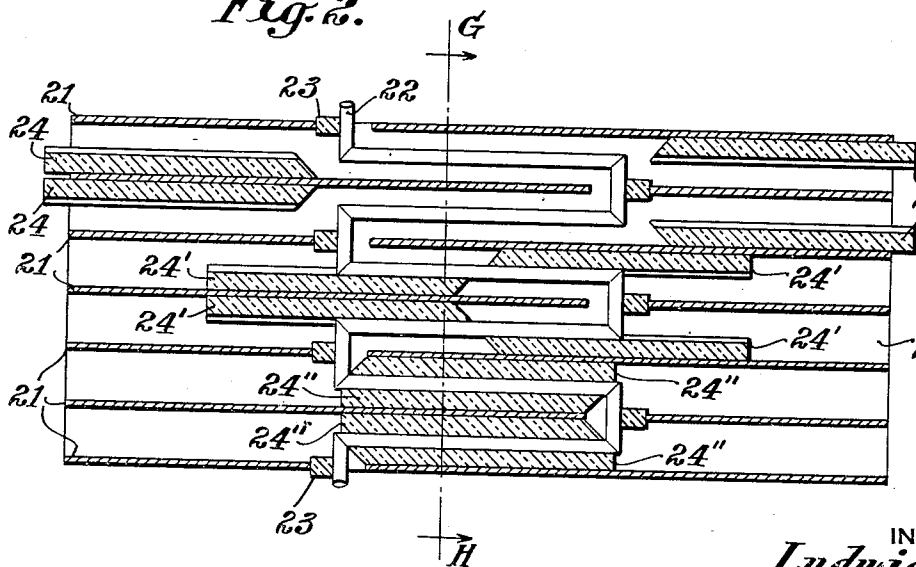
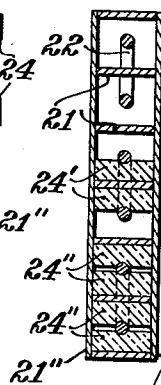


Fig. 2A.



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2 Sheets-Sheet 2

Fig. 3.

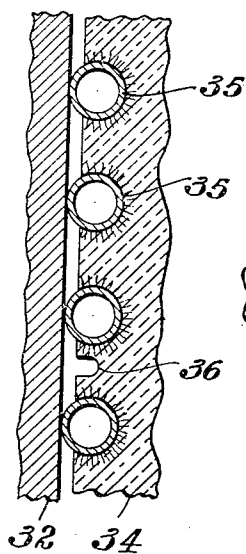


Fig. 4a.

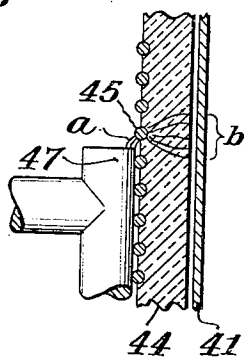


Fig. 4b.

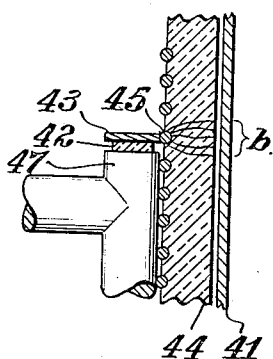


Fig. 4c.

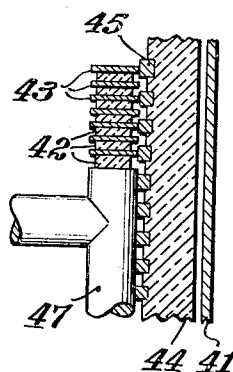


Fig. 5.

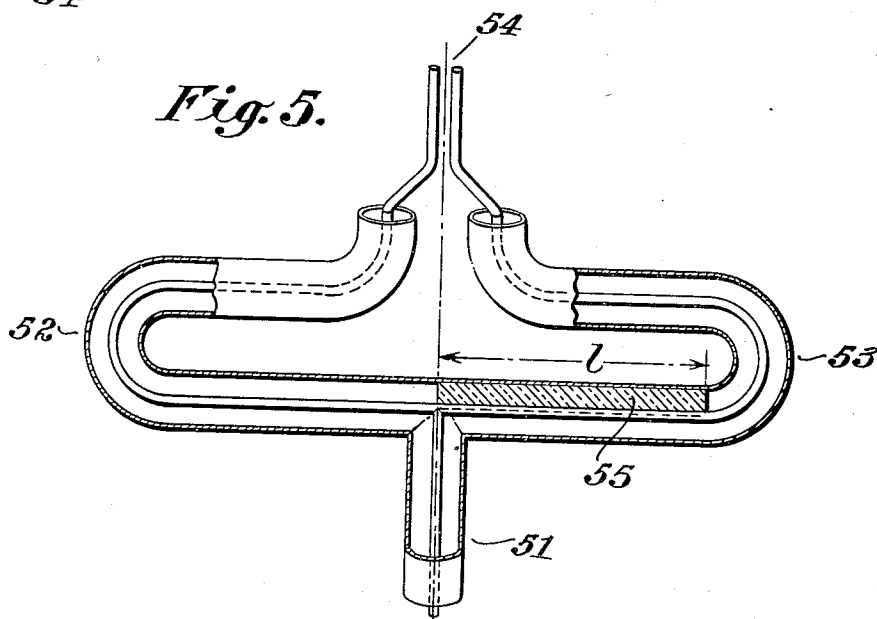
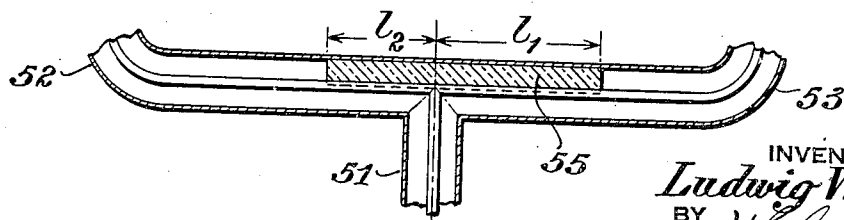


Fig. 5a.



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UNITED STATES PATENT OFFICE

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HIGH FREQUENCY TRANSLATING DEVICE

Ludwig Walter, Berlin, Germany; vested in the
Alien Property CustodianApplication November 28, 1940, Serial No. 367,554
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10 Claims. (Cl. 178—44)

The present invention relates to improvements in a device for coupling a high frequency arrangement being asymmetrical with respect to the ground potential with a symmetrical arrangement such as described, for example, in U. S. Patent #2,155,652. The device according to the said patent is characterized by the fact that the conductors having a potential which is symmetrical to ground are branched from a common point of the asymmetrical arrangement which point has a voltage and the branching is done across connection lines with correspondingly different electrical lengths. Where such an arrangement is to be adapted for varying wavelengths two different means were hitherto employed, namely concentric tubular pieces which can be straight telescoped into one another and through which a wave range of at the most 1:2 was covered, and secondly, the so-called phase changer as described in U. S. Patent #2,121,855, and in which the concentric tubular line which is wound into a screw line has a longitudinal slit in the outer tube and through which a sliding current tap means can be moved along the inner conductor. The latter arrangement involves considerable difficulties as to its construction in view of the fact that at the through place of the current tap means through the slit of the outer tube a flash-over gap exists whose breakdown strength is lower than that of the concentric line and whereby it is difficult to provide a sufficient insulation. Furthermore, in case of higher powers losses appear at the movable sliding contact.

In accordance with the present invention an arrangement of the type above described is rendered tunable to different wavelengths in that the electric length of one or of both connection lines is variable through variation of the dielectric constant of the dielectric of the line. This variation of the dielectric of the line is accomplished preferably by inserting a longer or shorter piece of a body having a high dielectric constant between the outer conductor and inner conductor of the connection line. In an example of construction the part of the dielectric body which is not utilized can be drawn into a part of the asymmetrical core line, and according to another form of construction it can be drawn out into the space outside the outer conductor while in a third mode of construction this unused part can be advanced from the one connection line into the other connection line.

Solid substances having a sufficiently high dielectric constant have been for years produced

by the ceramic industry. These substances also include some which have sufficiently low losses to be used in high-frequency fields.

The fundamental idea of the present invention resides in introducing a larger or smaller amount of substance of high dielectric constant into the one of the two concentric lines which join in a main line on leaving the transmitter terminals having identical and opposite potentials with respect to ground. The accompanying Figure 1 represents one of the many possibilities of putting the subject matter of the present invention into practice; Figure 1A shows a section of Figure 1 taken along line C—D; Figure 2 shows a modified form of the invention with Figure 2A showing a section of the structure of Figure 2 along line G—H; Figures 3, 4A, 4B and 4C show in enlarged detail modifications portions of the embodiment of Figure 2 and Figures 5 and 5A show further modifications of the invention.

Two concentric line pieces 1 and 2 coming, for instance, from the transmitter terminals S_1 and S_2 furnish equal potentials of opposite polarities; said line pieces have the same length and terminate in a conductor section 3 having an enlarged cross section. The one line piece terminates directly at said conductor section at the point b_1 , while the other one terminates across the "detour section" b_2, c_2 . The intermediate line section 3 having the cross section CD terminates at the concentric power line 4 having a conventional formation. Line 4 may, for instance, be coupled to an antenna or other load. In order to avoid reflections the intermediate piece 3 is given the wave resistance of the main line 4 while the two branches 1 and 2 have twice said wave resistance.

The straight part of the detour piece b_2, c_2 contains a semi-cylindrical body 5 made from a substance having a high dielectric constant. The faces with which said body rests on the conductors are metallized and joined with said conductors by means of gliding contact springs so as to avoid incandescence of the air in the gaps at these faces. The cross section of the intermediate line section 3 is such that the metallized faces of the body 5 can slide also along the conductors of the intermediate line section 3. This prevents the sliding contact springs from jumping from their seats. The body 5 has the effect that the electrical length of the detour section is longer by $\lambda/2$ than its geometrical length if the body is completely inserted into the detour section b_2, c_2 . If the said body is partly pulled out from said detour section and

into the intermediate piece 3, the detour section has a shorter electrical length while the wave resistance of the intermediate section has changed but slightly, or not at all. This is due to the fact that the line 3 is filled with a dielectric 6 of a high dielectric constant and preferably the same constant as that of the body 5. This dielectric fills out the entire cross section of the conductor except for the space left for the insertion of the body 5. It matters little as regards the slight influence upon the wave resistance of this conductor section whether this space is filled with air at the longest wave, or with the dielectric at the shortest wave so that there is realized always a favorable matching with the line 4 on the one hand and with the lines 1 and 2 on the other hand. The variation of the wave resistance of the detour piece which as such is very considerable is not detrimental because the electric length of this piece will be set always for $\lambda/2$. Therefore, at operation the resistance in b_2 is always equal to that in c_2 .

In order to be able to move as easily as possible the weight of the body 5 having a high dielectric constant, the entire arrangement is mounted so that its direction of movement is horizontal. In this case the body may move on rollers which protrude through the walls of the detour piece and of the intermediate piece.

A second example of construction is shown in Figure 2 in which only a single connection line is shown whose electric length is to be varied by inserting the ceramic body, while the other connection line as well as the symmetrical-to-asymmetrical connecting arrangement of Figure 1 are omitted for the sake of simplicity.

The line whose electric length is to be varied consists in this case of an inner conductor having a zig-zag form 22 which is surrounded by a casing forming the outer conductor and such that always the parts of the inner conductor which are parallel to one another are shielded against each other. In this way, by the individual walls 21, 21' and 21'' of the casing in conjunction with the inner conductor a coaxial line is formed which, as seen from section 2a, taken along line GH of Figure 2, has a quadratic cross section. Obviously, a corresponding arrangement may also be built with round cross sections which from an electrical point of view may be advantageous in various cases.

The inner conductor is held in place at the reversing places against the outer conductor casing, for instance, by means of insulators 23. For varying the electric length various insulating bodies 24, 24', 24'' are provided which can be inserted between the casing walls 21, 21', 21'' and the inner conductor in a manner such that they fill out more or less the space between the inner conductor and outer conductor. In the upper part of the drawing the insulating bodies 4 are completely pulled out so that in this case the electric length of the conductor loop is determined by the dielectric of the air. In the center of the drawing the insulating bodies 24' are inserted with the half into the line so that in this case the half of the intermediate space of the conductors is filled with air, while the other half is filled by the insulating body as dielectric. The electric length of this conductor piece hence is determined by an intermediate value of the dielectric constant of the two dielectrics, namely air and ceramic material for instance. In the lower part of the drawing the insulating bodies 24'' are completely inserted into the line so that

in this case the electric length of the line is determined substantially by the dielectric constant of the inserted dielectric.

The showing of the individual insulating bodies in the different positions pulled out from the line is only for a better understanding of the invention. In practice it will be of advantage so to adapt the arrangement that the insulating bodies to be pulled to the right as viewed from the drawing and, on the other hand, the bodies to be pulled to the left are rigidly connected with one another so that they may be pulled simultaneously to a greater or lesser extent out of the line.

In order to prevent corona effects the contact surfaces of the insulating bodies at the conductors must be metallized thus providing a favorable contact with the inner conductor and outer conductor. Now, the difficulty is hereby encountered that on pulling out the insulating bodies dead paths are caused by the metallized surface representing undesirable wattless resistance in parallel to the line. In order to avoid such a state it is of advantage to subdivide the metallized surface which faces the inner conductor. To render this possible without the appearance of corona effects to be avoided, suitable constructions are chosen such as are shown in Figure 3 for the straight parts and in the Figures 4A, 4B and 4C for the corners of the inner conductor sections. In Figure 3 the insulating body 34 has, for instance, sector-like grooves in the surface facing the one conductor 32 which grooves are covered with silver at the inside and whereby each of them has placed therein a respective contact spiral consisting of elastic conductor material 35. The surfaces between the grooves are not covered with metal. But at these places corona effects do not appear because these parts of the surface carry substantially reduced potentials by virtue of the deep engagement of the metallized grooves in the insulating body. The electric lines of force are concentrated upon the groove surface appearing only with the smallest part between the grooves. Through the contact spirals placed in the grooves there is attained a favorable electric connection of the metallized surfaces with the inner conductor. With the withdrawal of an insulating body thus designed no dead paths are encountered which could create undesirable wattless resistances since the various metallized parts of the body no longer form a coherent unit. Furthermore, grooves 36 which are not metallized at the inside and which are left empty may be provided between the individual grooves containing the contact spirals 35.

In Figure 4A the air gap a between the inner conductor corner 47 and the contact spring 45 which has just been lifted from the inner conductor at a movement of the insulating body 44 in the upward direction, would be under an excessive load since a very large part of the displacement flow b which must leave at this moment from the contact spring 45 and must pass to the outer conductor 41 through the insulating body 44 having a high dielectric constant, would have to pass from the corner of the inner conductor 47 through the air gap a to the contact spring 45.

In Figure 4B it is indicated how an air gap-free path for this displacement flow can be provided, namely by means of a plate 42 of insulating material is the same as that of the body 44 or similar thereto and whose surfaces are metallized while the remaining surfaces have a distance from the insulating body 44 which is

greater than the distance between the inner conductor and said body. Furthermore, a metal plate 43 is pressed upon said first plate and touches with its edge the contact spring 45.

In Figure 4C it is shown that a whole stack of such insulating plates and metal plates alternately placed one above the other one whereby the uppermost metal plate has the potential of the outer conductor 41, can prevent detrimental dielectric loads of air spaces between the individual metal plates 43 and contact springs 45 situated close by. To this end the thicknesses of the plates 42 and 43 on the one hand, and the thicknesses and distances of the contact springs on the other hand must be so matched that in all positions of the insulating body 44 each contact spring 45 touches at least one of the metal plates 43. Furthermore, the potential differences between adjacent metal plates must be maintained lower than the minimum potential required for the break down of shortest air distances. This can, however, be accomplished by choosing a sufficient number of plate pairs 42-43.

A third form of construction, according to the present invention, is shown in Figure 5. In this figure the asymmetrical line 51 is connected with the line loops 52 and 53 of equal length and pointing in different directions. The ends of said loops are again brought together with one opposite the other and are connected with the symmetrical line 54. Furthermore, an insulating body 55 is provided which can be moved in and out in the lower part of the two line loops 52 and 53. This insulating body fills out about the upper half of the conductor cross section of the lower part of the lines 52 and 53. In its position to the right as shown in Figure 5, the detour line is set for the longest wave. The right hand conductor loop 53 then has an electric length which exceeds that of the left hand conductor loop by a value corresponding with the length l of the insulating body multiplied by the square root of the ratio of the dielectric constants of the line section, covered by said insulating body, and of the air. If this electric length is exactly one half wavelength then for this wavelength the asymmetrical line 51 will have been connected in the correct phase with the symmetrical line 54.

In order to shorten the wave the body 55 is displaced further to the left as is shown in Figure 5A, whereby at the right side the line is rendered longer by the part section l_1 of the insulating body 55, while the left side is given a greater electric length by the part section l_2 of the insulating body. The total phase displacement attained is seen from the difference $l_1 - l_2$ multiplied by the square root of the ratio of the dielectric constants. In this way it is possible in principle to carry out a setting to the shortest waves.

The present invention has been elucidated in reference to several examples of construction but is not limited in any way to these examples, and can be adapted in accordance with many other modifications. The essential characteristic feature is that the electric length of a line is varied in respect to another line in that an insulator having a high dielectric constant is inserted into the line.

I claim:

1. In a radio frequency transmission line having a pair of elongated conductors insulated one from the other and energized by opposite instan-

taneous polarities, means for varying the electrical length of said line without changing the physical length thereof including a dielectric body having a different dielectric constant than that of the insulation between said conductors and means for varying the immersion of said body in the field between said conductors, said dielectric body having conductive coatings in contact with each of said conductors said coatings being so arranged as to be effective over only that portion of the dielectric which is in said field.

2. In a radio frequency transmission line having a pair of elongated conductors insulated one from the other and energized by opposite instantaneous polarities, means for varying the electrical length of said line without changing the physical length thereof including a dielectric body having a different dielectric constant than that of the insulation between said conductors and means for varying the immersion of said body in the field between said conductors, said dielectric body having conductive coatings in contact with each of said conductors, each of said coatings being discontinuous whereby the portions of said coating outside of the field between said conductors are isolated.

3. In a radio frequency transmission line having a pair of elongated conductors insulated one from the other and energized by opposite instantaneous polarities, means for varying the electrical length of said line without changing the physical length thereof including a dielectric body having a different dielectric constant than that of the insulation between said conductors and means for varying the immersion of said body in the field between said conductors, said dielectric body having conductive coatings in contact with each of said conductors, each of said coatings being discontinuous whereby the portions of said coating outside of the field between said conductors are isolated, and means for reducing the potential gradient between the portions of said coatings immediately adjacent said conductors but outside of said field.

4. In a radio frequency transmission line having a pair of elongated conductors insulated one from the other and energized by opposite instantaneous polarities, means for varying the electrical length of said line without changing the physical length thereof including a dielectric body having a different dielectric constant than that of the insulation between said conductors and means for varying the immersion of said body in the field between said conductors, said dielectric body having conductive coatings in contact with each of said conductors, each of said coatings being discontinuous whereby the portions of said coating outside of the field between said conductors are isolated, and means for reducing the potential gradient between the portions of said coatings immediately adjacent said conductors but outside of said field, including series capacity elements between said conductors and said portions.

5. In a radio frequency transmission line having an inner conductor and an outer shell insulated one from the other and energized by opposite instantaneous polarities, means for varying the electrical length of said line without changing the physical length thereof including a dielectric body having a different dielectric constant than that of the insulation between said inner conductor and outer shell and means for varying the immersion of said body in the field

between said conductor and said shell, said dielectric body having conductive coatings in contact with said conductor and said shell said coatings being so arranged as to be effective over only that portion of the dielectric which is in said field.

6. In a radio frequency transmission line having an inner conductor and an outer shell insulated one from the other and energized by opposite instantaneous polarities, means for varying the electrical length of said line without changing the physical length thereof including a dielectric body having a different dielectric constant than that of the insulation between said inner conductor and outer shell, and means for varying the immersion of said body in the field between said conductor and said shell, said dielectric body having conductive coatings in contact with said conductor and said shell, each of said coatings being discontinuous whereby the portions of said coating outside of the field between said conductor and said shell are isolated.

7. Means for coupling a symmetric translating element to an asymmetric transmission line having an outer shell and an inner conductor including a pair of coupling lines each having an outer shell and an inner conductor connected in a parallel relationship to said asymmetric line, a dielectric body adapted to be immersed in the field between the inner conductor and outer shell of one of said coupling lines a distance such that the electric length of said one line is increased relative to the other a half of the operating wavelength, the portion of said body which is not immersed in said field lying between the outer shell and the inner conductor of said asymmetric line.

8. Means for coupling a symmetric radio frequency translating element to a single asymmetric transmission line having an outer shell and an inner conductor including a pair of coupling lines each having an outer shell and an inner conductor connected in a parallel relationship to said asymmetric line, said coupling lines being arranged in an end-to-end relationship at their point of connection with said asymmetric line

and a dielectric body adapted to be moved along said coupling lines in the field between the inner conductor and outer shell thereof so that the length of one of said coupling lines is increased relative to the other in proportion to the amount of said body which is within said coupling line relative to the amount which is within the other of said coupling lines.

9. Means for coupling a symmetric translating element to an asymmetric transmission line having an outer shell and an inner conductor including a pair of coupling lines each having an outer shell and an inner conductor connected in a parallel relationship to said asymmetric line, a dielectric body adapted to be immersed in the field between the inner conductor and outer shell of one of said coupling lines a distance such that the electric length of said one line is increased relative to the other a half of the operating wavelength, the portion of said body which is not immersed in said field lying between the outer shell and the inner conductor of said asymmetric line, said dielectric body having conductive coatings in contact with said conductor and said shell.

10. Means for coupling a symmetric radio frequency translating element to a single asymmetric transmission line having an outer shell and an inner conductor including a pair of coupling lines each having an outer shell and an inner conductor connected in a parallel relationship to said asymmetric line, said coupling lines being arranged in an end-to-end relationship at their point of connection with said asymmetric line and a dielectric body adapted to be moved along said coupling lines in the field between the inner conductor and outer shell thereof so that the length of one of said coupling lines is increased relative to the other in proportion to the amount of said body which is within said coupling line relative to the amount which is within the other of said coupling lines, said dielectric body having conductive coatings in contact with said conductor and said shell.

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