Feb. 11, 1941. W. BUSCHBECK 2,231,152

ARRANGEMENT FOR RESISTANCE TRANSFORMATION

Filed June 14, 1939 2 Sheets-Sheet 1

Fig. 1

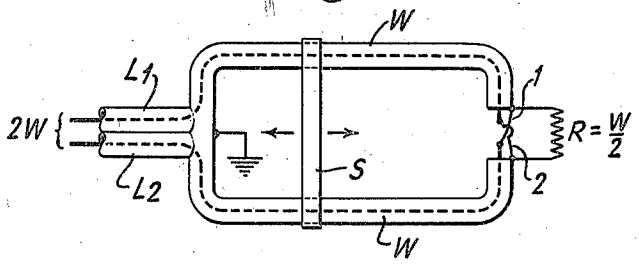


Fig. 1a

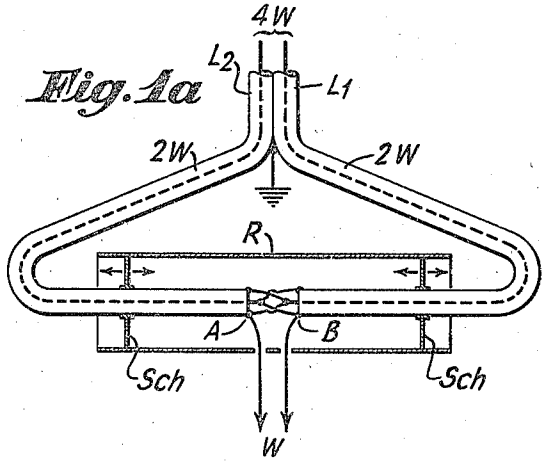
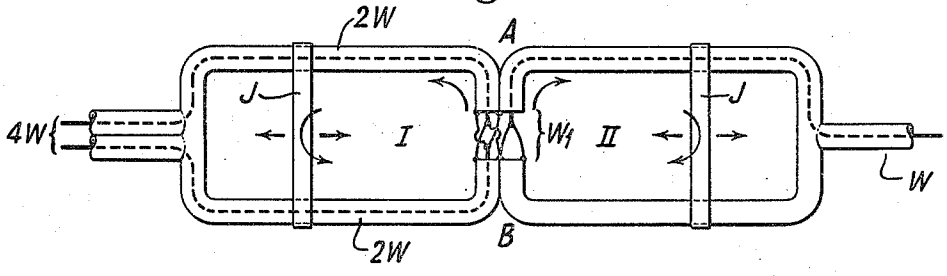


Fig. 2



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Fig. 2a

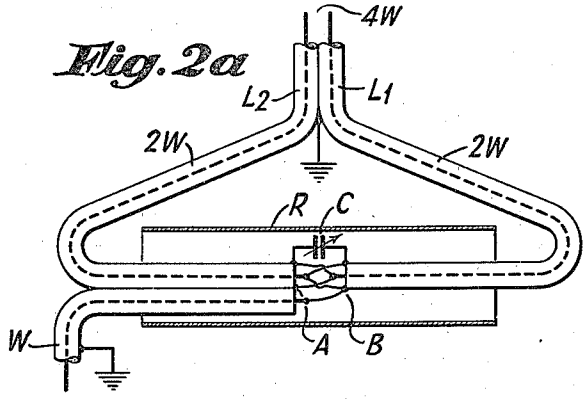


Fig. 3

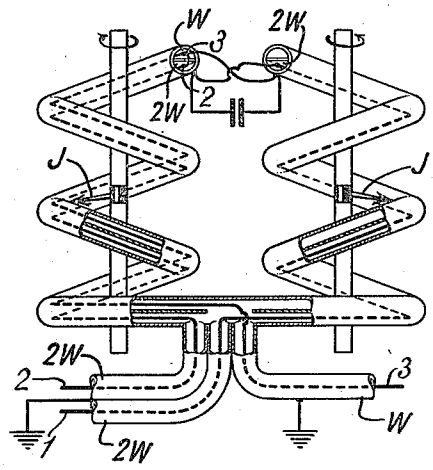
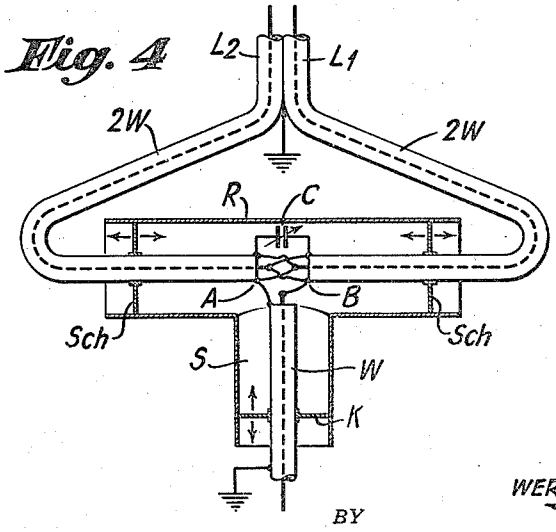


Fig. 4



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ARRANGEMENT FOR RESISTANCE TRANSFORMATION

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12 Claims. (Cl. 178—44)

In the high frequency field the problem often presents itself to transform to other values, resistances in a possibly simple manner whereby at the same time the requirement may have to be fulfilled to convert resistances symmetrical with respect to ground into those which are unsymmetrical with respect to ground, and vice versa; such as, for instance, at the symmetrical withdrawal of energy from a push-pull transmitter to be conducted on a grounded power cable, or at the passage from such a cable to an antenna arrangement which is symmetrical with respect to ground. To achieve these ends, various arrangements have already become known and have been proposed, such as with quasi-stationary means aside from simple transformer circuits, called the Boucherot bridge (German Patent 603,816), then the $\lambda/2$ reversing line with non-quasi stationary means (German Patent 568,559, corresponding to United States Patent No. 2,155,652, German Patent 620,001), the symmetry providing loop (British Patent 438,506, corresponding to United States No. 2,127,088) and the blocking tank (United States Patent 2,131,108, Fig. 12).

In accordance with the invention, an arrangement is proposed furnishing with simple means a transformation of 1:4 while retaining the symmetry between coupled circuits, and which renders possible a transfer of energy to the non-symmetrical line at the same time by utilizing an additional arrangement. The latter possibility offers the advantage over the said reversing line in that the tuning at wave change, etc., can be carried out in a much simpler way.

A more detailed description follows in conjunction with drawings, wherein Figs. 1, 1*a*, 2, 2*a*, 3 and 4 illustrate six different embodiments of the invention. All of these figures illustrate a system having an impedance transformation ratio of 1:4. Figs. 1 and 1*a* illustrate arrangements wherein there is effected a transformation of one symmetric or balanced potential into another symmetric or balanced potential, while Figs. 2, 2*a*, 3 and 4 illustrate arrangements wherein a symmetric or balanced potential is transformed into an unbalanced or asymmetric potential. In these figures similar elements are represented by similar reference characters.

In Fig. 1, two concentric lines L_1 and L_2, each having a wave resistance (i. e. surge impedance) equal to W ohms and having, for instance, an E. M. F. symmetrical with regard to ground are connected to a symmetry producing loop which contrary to the known construction has in both legs inner conductors having at the same time potentials applied thereto. At the open end of the loop the inner conductors thereof are criss-cross connected by means of wires 1 and 2 with the opposite outer conductors; a slide S movable over the outside of the conductors of the loop or a variable wattless resistance (i. e. reactance) at the open end of the loop permits of tuning for a blocking circuit. Since in this type of circuit each of the two concentric lines must be terminated by a resistance having the value W in order to obtain impedance matching, while the ends of the two lines are placed in parallel, however, there appears at the output a resultant resistance of the value

$$R=\frac{W}{2}$$

while at the input side the lines are in series and there is a resistance equal to 2W between the two inner conductors so that the entire arrangement will in fact be transformed in the proportion 4:1 while retaining the symmetry with respect to ground, whereby the absolute values of the wave resistances (surge impedances) can be chosen within wide limits by dimensioning the lines accordingly. One disadvantage of Fig. 1 is that radiation occurs from the external or outer conductors of the loop. This disadvantage is overcome in Fig. 1*a* wherein a surrounding tube R provides a high impedance to the flow of radio frequency energy over the outer conductors on both sides of A, B.

In Fig. 1*a* the reactance formed by the surrounding metallic tube R and the external conductors of cables L_1 and L_2 is tuned by suitable dimensioning of the length between the terminals of the conductor and the discs *Sch* connecting tube R to the external conductors. Said discs *Sch* are displaceable for enabling tuning variation. In effect, each half of the tube forms a blocking tank ($\lambda/4$ long as measured from disc *Sch* to A or B).

If it is desired to pass from the symmetrical state to the non-symmetrical state, a simple symmetry producing loop may be connected to the open end as shown in Fig. 2. It may hereby be suitable as actually shown in Fig. 2 to employ two separate loops I and II if these can be inserted in the line train between the source of E. M. F. and the load. But this is not necessary; since the compensation currents flow in fact through the two loops in the opposite directions, these loops can be placed above each other so that the tuning and the symmetrical condition can be ob-

tained at the same time with a single slide. Fig. 2 suffers from the same disadvantage as Fig. 1, in that radiation occurs from the outer conductors of the loop. It is clear that in actual constructions the loops should in general be of the shielded type, i. e., in case of longer waves the loops can be of the wound type (Fig. 3) whereby suitably each tube part can be wound as such into a convenient coil, while both coils are to be formed in the opposite sense in order to reduce the exterior stray field. The arrangement of Fig. 3 is described in more detail hereinafter. It is obvious that the E. M. F. and the load can be interchanged as in all such arrangements.

Fig. 4 shows another example of construction in accordance with the invention. In this figure, the arrangement of Fig. 1*a* is supplemented by a condenser C connected to the points A and B for tuning the reactance, and also supplemented by a concentric sleeve or blocking tank S. The two lines L_1, L_2 of the wave resistance 2W, forming in combination a line which is symmetrical with respect to ground, terminate into branches and are inserted in a surrounding tube R such that the ends thereof which are connected crosswise with one another are situated closely opposite each other. If the reactance formed by the surrounding tube R and the outer conductors of the power cable is tuned for a blocking circuit (either by a suitable dimensioning of the length between the ends of the line and the slidable discs Sch which connect the tube R with the outer conductors, or by the tuning of a parallel condenser C), a resistance placed between the points A, B and having the value W furnishes matching on the two cables passed around at the left side and right side, and the arrangement, therefore, furnishes a transformation of 4:1 while retaining symmetry with respect to ground. The transit to the unsymmetrical state can be realized by means of the blocking tank S already proposed whose inductance together with the already mentioned inductance can be tuned through short circuiting slider K and through condenser C which may also be represented suitably by a tubular parallel line with slidable short circuit bottom and whose length is above $\lambda/4$. The arrangement of Fig. 4 can be simplified by omitting the electrically decoupled blocking tank S and placing the asymmetric cable together with wave resistance W inside one arm of the surrounding tube R and connected to the power line of the wave resistance 2W which is passed towards the left side. Such an arrangement is shown in Fig. 2*a*. A similar thickening of the outer conductor of the cable extending towards the right side is hereby not required and not even appropriate, since with this measure only the inductance of the blocking part at the right would be reduced so that in this case the resultant wattless power of the entire blocking structure would be increased. It would be possible to pass outside the transformation structure by means of a tube surrounding the cable passing to the right side and which would then form the outer casing of the unsymmetrical line outside the blocking tube R, whereby the outer conductor of the cable having the wave resistance 2W and passing around at the right side would form inside the blocking tube R the inner conductor of the line having the wave resistance W and being unsymmetrical with respect to ground.

The arrangement according to Fig. 3 may be developed from the arrangement according to Fig. 2 with which it is electrically absolute equivalent by imagining that the right half of II of Fig. 2 is folded back to the left half I, so that in each branch two parallel energy lines exist. In order to place these two energy lines in a common tube, the tubes are parted in the center and one energy line runs in the upper external half of the tube while the other proceeds in the inner half of the tube. The symmetric line with wave resistance 4W beginning at the lower left-hand side proceeds in the two internal conductors 1 and 2, both of which then proceed in the lower sections of the two coiled loop branches. The symmetric conductor with wave resistance W beginning at the lower right-hand side, proceeds in conductor 3 which then runs in the upper section of the left loop path. Conductors 2 and 3 are connected to one another at the upper end of the left loop half and are connected in common to the end of the external conductor of the right loop half. Line 1 proceeding in the lower section of the right loop half is connected at its top end to the end of the external conductor of the left loop half. Short circuit bridge J of Fig. 2 is replaced in Fig. 3 by sliding contacts J which may be displaced in their position on the external conductors of the two loop halves by rotating the mounting axles H. This makes possible a tuning equivalent to the tuning of Fig. 2 where a portion of the coiled loop halves is short-circuited.

What is claimed is:

1. In a high frequency transmission system, a loop formed by a pair of coaxial lines, the correspondingly located ends of which are adjacent each other while the intermediate portions of said lines are spaced apart; a connection between the inner conductor of one line at one end and the adjacent outer conductor of the other line, and a connection between the inner conductor of said last line at said same end and the adjacent outer conductor of said first line; a transmission line coupled to said loop at said last end; and a circuit balanced with respect to ground connected to the coaxial lines at the other end.

2. In a high frequency transmission system, a loop formed by a pair of coaxial lines, the correspondingly located ends of which are adjacent each other while the intermediate portions of said lines are spaced apart; a connection between the inner conductor of one line at one end and the adjacent outer conductor of the other line, and a connection between the inner conductor of said last line at said same end and the adjacent outer conductor of said first line; a circuit balanced with respect to ground coupled to said coaxial lines at said last end; and a circuit balanced with respect to ground connected to the coaxial lines at the other end.

3. In a high frequency transmission system, a loop formed by a pair of coaxial lines, the correspondingly located ends of which are adjacent each other while the intermediate portions of said lines are spaced apart; a connection between the inner conductor of one line at one end and the adjacent outer conductor of the other line, and a connection between the inner conductor of said last line at said same end and the adjacent outer conductor of said first line; a circuit unbalanced with respect to ground coupled to said coaxial lines at said last end; and a circuit balanced with respect to ground connected to the coaxial lines at the other end.

4. In a high frequency transmission system, a loop formed by a pair of coaxial lines, the correspondingly located ends of which are adjacent

each other while the intermediate portions of said lines are spaced apart; a connection between the inner conductor of one line at one end and the adjacent outer conductor of the other line, and a connection between the inner conductor of said last line at said same end and the adjacent outer conductor of said first line; a variable condenser connected across said connections; a transmission line coupled to said loop at said last end; and a circuit balanced with respect to ground connected to the coaxial lines at the other end.

5. In a high frequency transmission system, a loop formed by a pair of coaxial lines, the correspondingly located ends of which are adjacent each other while the intermediate portions of said lines are spaced apart; a connection between the inner conductor of one line at one end and the adjacent outer conductor of the other line; and a connection between the inner conductor of said last line at said same end and the adjacent outer conductor of said first line; a transmission line directly connected to said loop at said last end; and a circuit balanced with respect to ground connected to the coaxial lines at the other end.

6. A system in accordance with claim 1, including a strap movable over the spaced apart outer conductors of the coaxial lines constituting the loop for tuning said loop.

7. In a high frequency transmission system, a loop formed by a pair of coaxial lines, the correspondingly located ends of which are adjacent each other while the intermediate portions of said lines are spaced apart; a connection between the inner conductor of one line at one end and the adjacent outer conductor of the other line, and a connection between the inner conductor of said last line at said same end and the adjacent outer conductor of said first line; another loop coupled to said first loop; a circuit balanced with respect to ground connected to the coaxial lines of said first loop at the end thereof removed from said connections; and a circuit unbalanced with respect to ground connected to said other loop.

8. In a high frequency transmission system, a tuned circiut formed by a pair of coaxial lines, the correspondingly located ends of which are adjacent each other while the intermediate portions of said lines are spaced apart; a connection between the inner conductor of one line at one end and the adjacent outer conductor of the other line, and a connection between the inner conductor of said last line at said same end and the adjacent outer conductor of said first line; a circuit balanced with respect to ground connected to said tuned circuit at the end thereof removed from said connections; and a transmission line also connected to said tuned circuit.

9. In a high frequency transmission system, a tuned circuit formed by a pair of coaxial lines, the correspondingly located ends of which are adjacent each other while the intermediate portions of said lines are spaced apart; a connection between the inner conductor of one line at one end and the adjacent outer conductor of the other line, and a connection between the inner conductor of said last line at said same end and the adjacent outer conductor of said first line; and a pair of circuits in energy transfer relation coupled to said tuned circuit.

10. A system in accordance with claim 8, characterized in this that the lines of said tuned circuit are coiled.

11. In a high frequency transmission system, a loop formed by a pair of coaxial lines, the correspondingly located ends of which are adjacent each other while the intermediate portions of said lines are spaced apart; a connection between the inner conductor of one line at one end and the adjacent outer conductor of the other line, and a connection between the inner conductor of said last line at said same end and the adjacent outer conductor of said first line, said coaxial lines at said end being arranged in substantially the same straight line; a tubular metallic surface surrounding said lines for a portion on both sides of said connections and tuned to provide a high impedance to currents tending to flow over the outer conductors of said coaxial lines; a two-conductor transmission line connected to said connections at said last end; and a circuit balanced relative to ground connected to the coaxial lines at the other end.

12. In a high frequency transmission system, a loop formed by a pair of coaxial lines, the correspondingly located ends of which are adjacent each other while the intermediate portions of said lines are spaced apart; a connection between the inner conductor of one line at one end and the adjacent outer conductor of the other line, and a connection between the inner conductor of said last line at said same end and the adjacent outer conductor of said first line, said coaxial lines at said end being arranged in substantially the same straight line; a tubular metallic surface surrounding said lines for a portion on both sides of said connections; slidable straps between said tubular surface and the outer conductors of said coaxial lines on both sides of said connections for tuning the effective length of said surface; a two-conductor transmission line connected to said connections at said last end; and a circuit balanced relative to ground connected to the coaxial lines at the other end.

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