May 24, 1932. H. O. PETERSON 1,860,052

TRANSMISSION LINE

Filed Dec. 8, 1928 2 Sheets-Sheet 1

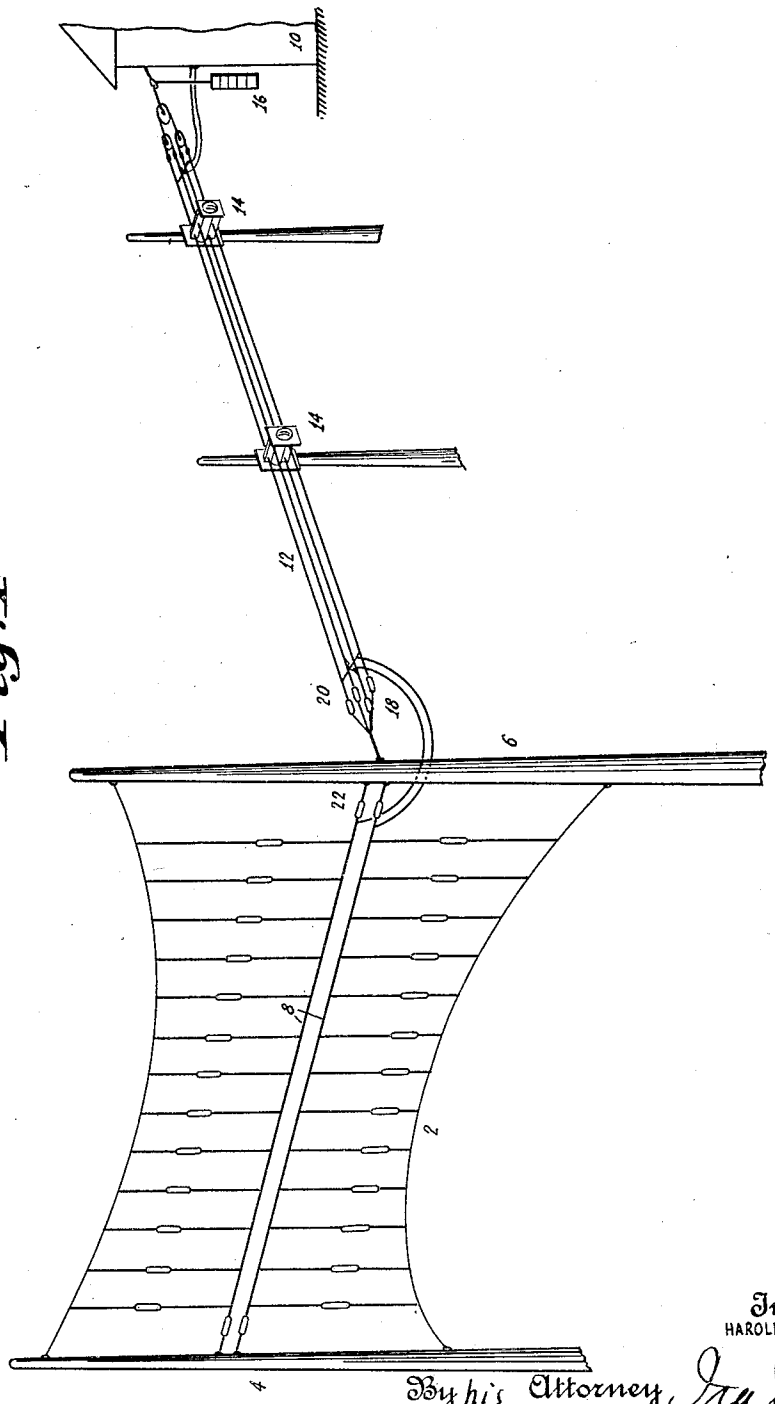


Fig. 1

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Fig. 2

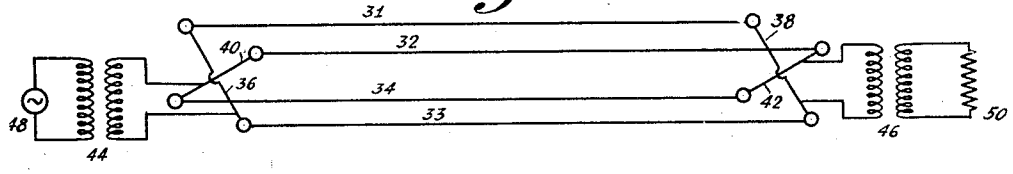


Fig. 3

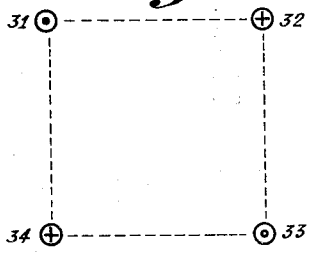


Fig. 4

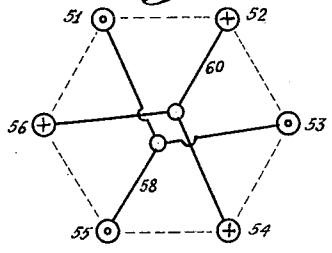


Fig. 5

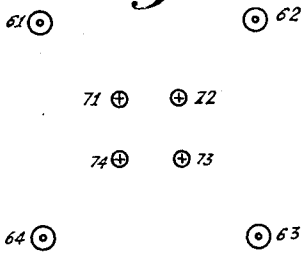


Fig. 6

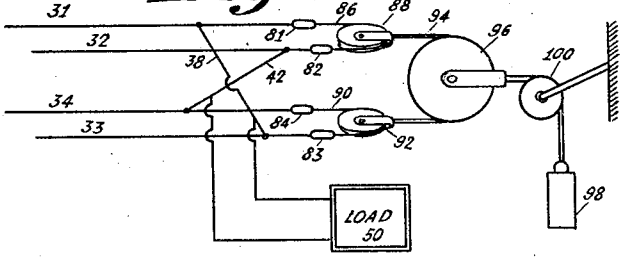


Fig. 7

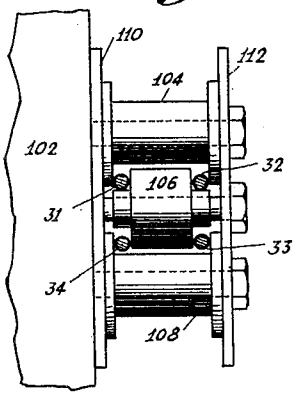


Fig. 8

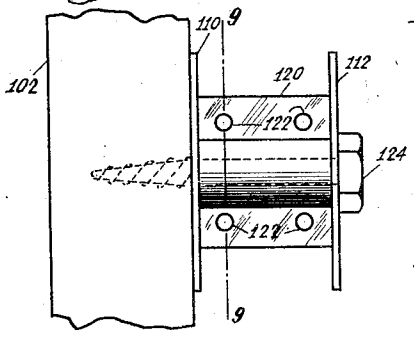
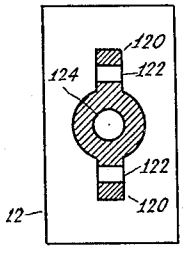


Fig. 9



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UNITED STATES PATENT OFFICE

HAROLD O. PETERSON, OF RIVERHEAD, NEW YORK, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

TRANSMISSION LINE

Application filed December 8, 1928. Serial No. 324,595.

This invention relates to transmission lines, and more particularly to a transmission line system for conducting high frequency energy without radiation and pick-up.

It is often necessary to transfer high frequency energy over a transmission line system, as for example from a transmitter to a remotely located antenna, or from a receiving antenna to a remotely located receiver, and in these cases it is respectively desirable to prevent radiation from or pick-up by the transmission line system. This is especially true in the case of directional antennas, for in such case the direction and directive properties of the line usually differ from those of the antenna, and serve to distort the directive pattern of the antenna system.

To provide a simple transmission line system for conducting high frequency energy without radiation or pick-up is the primary object of my invention, and to this end I provide a plurality of conductors connected electrically in parallel for conveying energy in one direction, and another plurality of conductors for returning the energy connected electrically in parallel and so located that the loci of the electrical centers of both sets of conductors coincide. Since alternating currents are being dealt with, the directions referred to are instantaneous only. With such an arrangement there is no physical displacement between the opposite electrical charges, and therefore neither radiation nor collection of energy. In a simple and preferred form of my invention I employ four parallel conductors arranged at the corners of a square, and at each end of the transmission line I electrically connect diagonally opposite conductors together.

With a transmission line system such as I have described it is exceedingly desirable to apply equal tension to each of the four conductors, in order that they may keep their relative spacing throughout their length. For this purpose I employ a differential supporting system at one end of the transmission line, comprising a pulley differentially supporting a pair of adjacent conductors, another pulley differentially supporting another pair of adjacent conductors, and a third pulley differentially supporting the blocks of these two pulleys, and tensioning means, preferably in the form of a large weight, connected to the block of the third pulley.

To prevent transverse displacement of the wires in order to preserve their formation, and to permit of changes of direction in the line, intermediate supports are often necessary. These should permit longitudinal movement of the conductors, in order to let the tensioning means function, and to provide suitable supports is a further object of my invention.

The supports unbalance the line when, as is desirable, a single post is used on one side of the line. To overcome this is a further object of my invention, and for this purpose I provide shielding plates positioned symmetrically at either side of the line.

My invention is described more in detail in the following specification, which is accompanied by drawings in which Figure 1 is an arrangement of an antenna and a transmission line, in a typical installation; Figure 2 is a wiring diagram for a four wire transmission line; Figure 3 is a section of the transmission line; Figure 4 is a section of a six wire transmission line; Figure 5 is a cross section of an eight wire transmission line arranged in a modified formation; Figure 6 is a detail of a differential tensioning means for a four wire transmission line; Figure 7 is an intermediate supporting means for the transmission line; Figure 8 is a modification; and Figure 9 is a section taken on the line 9—9 in Figure 8.

Referring to Figure 1 it will be seen that there is a directional antenna 2, supported between masts 4 and 6. The feeder members of the antenna, numbered 8, are connected to radio equipment in a remotely located building 10 by a transmission line 12. The transmission line and the antenna extend in differently related directions. The transmission line is supported at one or more intermediate points by supporting means 14, and is tensioned at one end by a tensioning weight 16. Jumpers 18 connect the transmission line 12 and the feeder members 8 before the insulators 20 and 22. The impedance

of the line is matched by that of the antenna.

The transmission line preferably consists of four conductors, and the electrical arrangement is shown more in detail in Figure 2, in which it is shown to consist of the conductors 31, 32, 33, and 34. Of these, conductors 31 and 33 are connected together at each end by leads 36 and 38, while conductors 32 and 34 are connected together at each end by leads 40 and 42. The leads 36 and 40 are connected to the terminals of a coupling coil 44, while the leads 38 and 42 are connected to the terminals of a coupling coil 46. A source of energy 48 is coupled to the coil 44, while a load 50 is coupled to the coil 46. In a transmitter system 48 is a transmitter, and 50 is an antenna, while in a receiving system 48 is an antenna, while 50 is a receiver, although in this case the connections would preferably be made without transformers, the line impedance being matched by proper design of the antenna. It will, of course, be appreciated that the transmission line is useful for carrying high frequency currents from any unit of high frequency equipment to any other, as well as to or from an antenna.

A cross section of the line shown in Figures 1 and 2 is given in Figure 3, from which it will be seen that the four conductors are located at the corners of a square, and that diagonally opposite pairs of conductors are connected electrically in parallel. The electrical center of the conductors 32 and 34 is at the geometrical center of the square, and the electrical center of the conductors 31 and 33 also is at the geometrical center of the square, so that the centers coincide. For the entire transmission line the loci of the centers coincide, and for this reason there is no effective displacement in space between the electrical charges of opposite polarity, and therefore neither radiation nor pick-up occur.

The invention is not restricted to four conductors, and to illustrate another number, reference may be made to Figure 4, in which six conductors 51, 52, 53, 54, 55, and 56 are employed. These conductors are located at the vertices of a regular hexagon, and alternate conductors, namely, 51, 53, 55, and 52, 54 and 56, are respectively connected electrically in parallel at each end of the line by conductors 58 and 60, as shown. In this case, as before, the loci of the electrical centers of the groups of parallel connected conductors coincide, thereby preventing radiation and pick-up.

I have indicated a preferred arrangement of eight conductors in Figure 5. Referring to this figure it will be seen that the four conductors, 61, 62, 63, and 64 are arranged at the corners of a square, and connected electrically in parallel, while the four conductors 71, 72, 73, and 74 are arranged at the corners of a square of different size, and also connected electrically in parallel. With an arrangement of this nature, if one side of the transmission line is to be kept at ground potential it is preferable to ground the outer conductors, that is, the conductors 61, 62, 63, and 64.

In order to keep the spacing of the conductors uniform it is desirable to tension each of the conductors equally, and for this purpose a differential tensioning means may be provided. Such an arrangement, as applied to a transmission line of four conductors, is indicated in Figure 6, in which, incidentally, each of the conductors 31, 32, 33, and 34 is provided with an insulator 81, 82, 83 and 84, before which the connecting links 38 and 42 are provided. Leads from the links 38 and 42 run to a supply source or load 50. A loop of flexible cord or wire 86 connects the insulators 81 and 82, and passes around the periphery of a pulley wheel 88, so that the conductors 31 and 32 are differentially supported thereby. A loop of flexible wire 90 is connected to the insulators 83 and 84, and passes around the periphery of a pulley wheel 92, so that the conductors 33 and 34 are differentially supported thereby. A loop of flexible wire 94 is connected to the blocks of the pulleys 88 and 92, and passes over the periphery of the pulley wheel 96, so that the pulley blocks are differentially supported thereby. Tensioning means, preferably in the form of a large weight 98, is applied, by way of a fixed pulley 100, to the block of the pulley 96. In this manner equal tension is applied to each of the four conductors. By making the diameters of the pulleys equal to the length of a side of the square at the corners of which the transmission line conductors are located, the spacing of the conductors will not be disturbed.

In a long line it may be desirable to provide intermediate supports to properly space the conductors, and this is especially necessary if the line is to be given horizontal or vertical changes in direction between its terminals. Vertical changes in direction are sometimes desirable in order to keep the line reasonably parallel to the surface of the ground over which it extends, though sudden changes in direction should be avoided to prevent reflections. The intermediate supporting means should preferably permit longitudinal movement of the conductors, to allow for the action of the differential tensioning means already described. One suitable arrangement is indicated in Figure 7, in which there are attached to a supporting post 102 a plurality of insulation rollers 104, 106 and 108. These so fit together, as shown, as to provide spaces in which the conductors 31, 32, 33, and 34 are confined, as regards transverse displacement, though longitudinal displacement is readily possible.

The post 102, being situated at one side of

the line, is nearer to the conductors 31 and 34 than to the conductors 32 and 33, and therefore is apt to cause unbalance. That is, when dealing with radio frequency energies a ground may be established by a wooden pole; for, there is sufficient leakage for the surface of a wooden pole to constitute an appreciable absorption of energy. To overcome this difficulty metallic plates 110 and 112 are provided, and these are positioned symmetrically either side of the transmission line, and are grounded to the post 102 by the regular fastening bolts.

The arrangement shown in Figure 7, employing rollers, is more complicated than is actually necessary when dealing with a portion of the transmission line which is straight. In such case a modified form illustrated in Figures 8 and 9, is employed. Referring to these figures it will be seen that a single insulation block 120, preferably isolantite, is used, and is provided with four holes 122, for supporting the conductors against transverse displacement. At either side of the insulator 120 metallic plates 110 and 112 are provided, and the entire structure is held together and affixed to the post 102 by a single bolt 124. The insulator 122 is enlarged to accommodate the bolt 124, as is illustrated by the cross section of the insulator shown in Figure 9.

I claim:

1. The method of transferring radio frequency energy without radiation or pick-up which includes conveying the energy in one direction along a plurality of paths located on the apices of a polygon, and returning the energy in the opposite direction along a different plurality of paths located on the apices of a similar polygon the locus of the electrical centers of which coincides with the locus of the electrical centers of the aforesaid paths.

2. A transmission line system for conducting high frequency energy without radiation or pick-up comprising a plurality of conductors connected in parallel and located on the apices of a regular polygon for conveying energy in one direction, and a plurality of return conductors connected in parallel similarly situated on a similar polygon with apices alternating with the first polygon and so located that the loci of the electrical centers of both sets of conductors coincide.

3. An open air transmission line system for conducting high frequency energy without radiation or pick-up comprising an even numbered plurality of conductors arranged in open air at the vertices of a regular polygon, and means at each end of the transmission line for connecting alternate conductors together.

4. A transmission line system for conducting high frequency energy without radiation and pick-up comprising an even numbered plurality of conductors arranged at the vertices of a regular polygon, means at each end of the transmission line for electrically connecting alternate conductors together, and tensioning means arranged to apply equal tension to each of the conductors.

5. A transmission line system comprising four conductors arranged at the corners of a square, insulators at each end of the transmission line, means at each end of the transmission line for electrically connecting diagonally opposite conductors together before the insulators, means to support one end of the transmission line, and means to support the other end of the transmission line including a differentially yieldable member connected between a pair of adjacent conductors, another differentially yieldable member connected between the other pair of adjacent conductors, a third differentially yieldable member connected to the said other two members, and tensioning means connected to the third member.

6. A transmission line system comprising four conductors arranged at the corners of a square, insulators at each end of the transmission line, means at each end of the transmission line for electrically connecting diagonally opposite conductors together before the insulators, means to support one end of the transmission line, and means to support the other end of the transmission line including a pulley differentially supporting a pair of adjacent conductors, another pulley differentially supporting the other pair of adjacent conductors, a third pulley differentially supporting the blocks of the said two pulleys, and tensioning means connected to the block of the third pulley.

7. In combination, a directional antenna, remotely located radio apparatus, and a transmission line system therebetween comprising an even numbered plurality of conductors arranged at the corners of a regular polygon and means at each end of the transmission line for connecting alternate conductors together, whereby said transmission line system experiences neither radiation nor pick-up which might affect the directive pattern of the antenna.

8. In combination, a directional antenna, remotely located radio apparatus, and a transmission line system therebetween comprising four conductors arranged at the corners of a square, with means at each end for electrically connecting diagonally opposite conductors together, whereby said transmission line system experiences neither radiation nor pick-up.

9. In combination, a transmission line comprising a plurality of conductors, arranged in open air at the corners of a square, a single source of supporting tension to be applied thereto, and differential tensioning means therebetween for applying tension

from the source equally to each of the plurality of conductors.

10. In combination, a transmission line comprising a plurality of conductors, arranged in open air at the corners of a regular polygon, means for supporting one end of the line, a single source of supporting tension to be applied to the other end of the line, differential tensioning means between the source and the line for applying tension from the source equally to each of the plurality of conductors, and intermediate supporting means for supporting the conductors against transverse displacement, while permitting longitudinal displacement.

11. In combination, a transmission line comprising a plurality of conductors, arranged in open air at the corners of a regular polygon, means for supporting one end of the line, a single source of supporting tension to be applied to the other end of the line, differential tensioning means between the source and the line for applying tension from the source equally to each of the plurality of conductors, and intermediate supporting means at substantially uniform heights above ground for supporting the conductors against transverse displacement, while permitting longitudinal displacement.

12. In combination, a transmission line system comprising four conductors arranged at the corners of a square, means at each end for electrically connecting diagonally opposite conductors together, means for supporting one end of the line, a single source of supporting tension to be applied to the other end of the line, differential tensioning means between the source and the line for applying equal tension to each of the four conductors, and intermediate supporting means for maintaining the four conductors in square formation, while permitting longitudinal displacement.

13. The combination with a transmission line comprising a plurality of conductors arranged in desired formation, and a supporting means for keeping the conductors in that formation, of shielding means located symmetrically with respect to the transmission line at the supporting means only and not intermediate the supporting means in order to prevent unbalance of the line by the supporting means.

14. In combination, a transmission line system comprising four conductors arranged at the corners of a square, means at each end for electrically connected diagonally opposite conductors together, intermediate supporting means for said transmission line, and conductive shielding means positioned symmetrically with respect to the transmission line at the supporting means only and not intermediate the supporting means in order to prevent the latter from unbalancing the transmission line.

15. In combination, a transmission line system comprising four conductors arranged at the corners of a square, means at each end for electrically connecting diagonally opposite conductors together, means for supporting one end of the line, a single source of supporting tension to be applied to the other end of the line, differential tensioning means between the source and the line for applying equal tension to each of the four conductors, intermediate supporting means for maintaining the four conductors in square formation while permitting longitudinal displacement, and conductive shielding means positioned symmetrically with respect to the transmission line at each of the intermediate supporting means in order to prevent the latter from unbalancing the line.

HAROLD O. PETERSON.