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DIRECTIONAL AERIAL

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Fig. 1.

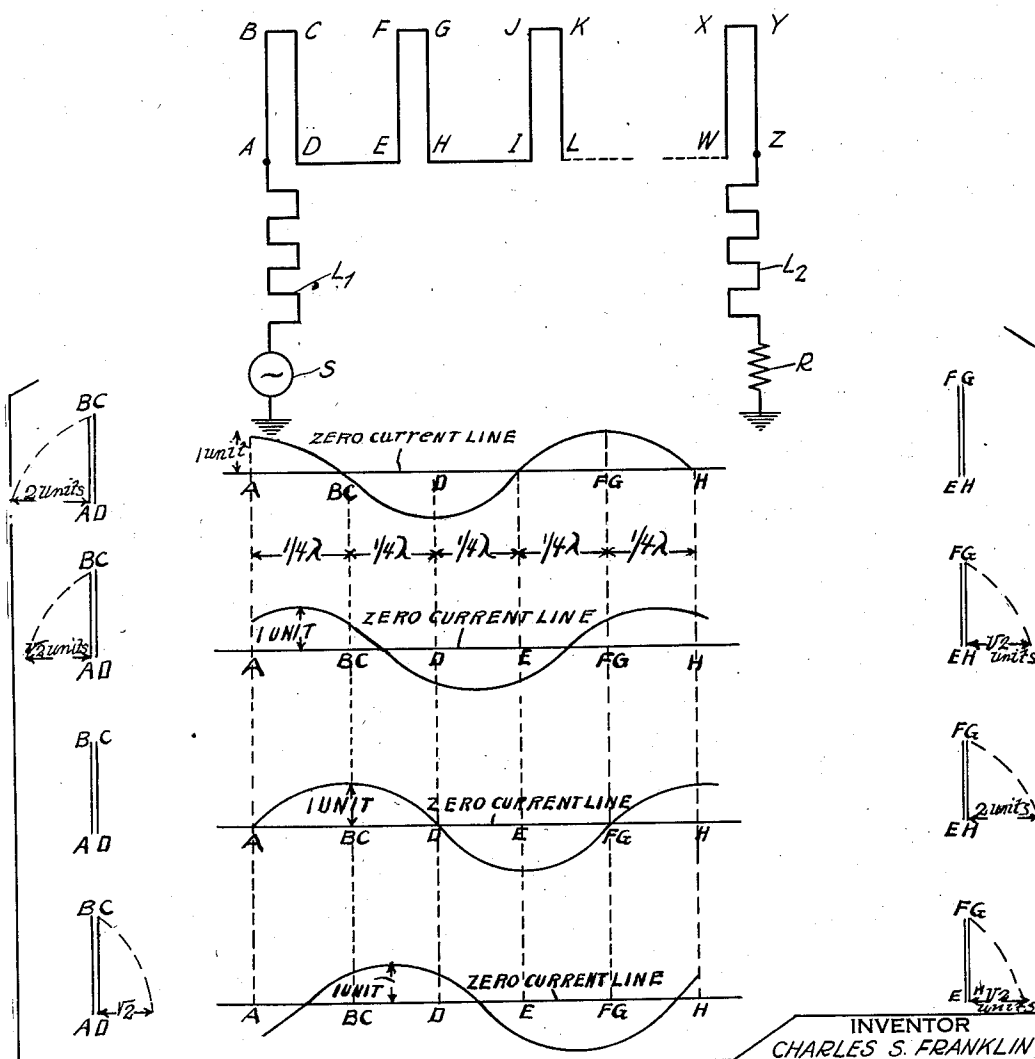


Fig. 2.

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DIRECTIONAL AERIAL

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This invention relates to directional aeralis and more particularly to directional aeralis suitable for use on short waves. The invention has for its object to provide a relatively simple directional aeral system whereby sharp concentration of energy may be obtained in a desired direction with substantially no radiation in the opposite direction.

In a preferred construction in accordance with the invention the direction of radiation is endwise of the aeral, i. e. in the general direction in which the aeral extends.

According to this invention an aeral which is long relative to the working wave length is extended in a desired line of direction and consists of lengths of conductor arranged substantially in that line, said lengths alternating with and connecting in series lengths of conductor making an angle to the said line, the lengths relative to the working wave length and the positions of the said lengths of conductor being such that the radiation from those lengths which are at an angle to the general line of extension of the aeral is additive in one direction and substantially mutually cancelling in the opposite, while the total radiation from the remaining lengths is equal to or approximates to zero.

The invention is illustrated in the accompanying drawing. Figure 1 shows, diagrammatically, one arrangement in accordance therewith, and Figure 2 shows the current distribution in two loops of the aeral of Figure 1.

Referring to the drawing A, B, C, D . . . W, X, Y, Z is a directional aeral adapted to give concentrated radiation endwise and suitable for use on short waves. This aeral has an over-all physical length (measured in its general line of extension) of any desired plurality of wave lengths, for example, four wave lengths. The aeral is energized at one end from a suitable transmitter S which is earthed at one terminal and connected at the other to one end of a feed line L₁. The other end of the feed line L₁ is connected to the end A of the aeral and the far end Z of the aeral is preferably earthed as shown through a second line L₂ in series with a resistance R of value substantially equal to the surge impedance of the said aeral. Waves will travel along the aeral from A to Z, but owing to the termination of the said aeral by an impedance equal to its surge impedance, there will be no reflection of energy back from Z to A. Starting from the transmitter end of the aeral (the end A) the said aeral comprises a portion AB extending at right angles to the general line of

extension of the aeral (indicated by the double headed arrow) this portion being one quarter of a wave length long and being succeeded by another portion BC at right angles to the first portion, the second portion being a small fraction of a wave length long, for example, 1/20th of a wave length. The second portion is succeeded by a third portion CD which is parallel to the first and of similar length and this in turn is succeeded by a fourth portion DE which extends in the general line of extension of the aeral and is one-quarter of a wave length long less the length of the second portion, i. e., the portion DE will be 1/5th of a wave length long if BC is 1/20th of a wave length. The fifth portion EF of the aeral is parallel and similar to the first portion AB; the sixth portion FG corresponds to the second portion BC; the seventh portion GH to the third portion CD and the eighth portion HI to the fourth portion DE and so on. It will thus be seen that the length ABCD forms a first loop extending at right angles to the general line of aeral extension, the length EFGH forms a second loop, the length IJKL a third loop, and so on these loops being connected in series by the portions DE, HI and LW which are in the same straight line and extend in the general line of aeral extension. Further, it will be observed that each loop consists approximately of one half wave length of wire bent back upon itself the loops being spaced substantially one quarter of a wave length apart.

Consider the loop ABCD. The phase of the current at A is some 180° in advance of the current at D, but since the direction of the wire CD is reversed relative to AB the currents at A and D are substantially in phase at this end of the loop. At BC the currents are in opposite phase owing to the reversal of the direction of the wires and the shortness of the connecting wire BC. Thus each loop ABCD, EFGH, and so on, acts like a quarter wave aeral. The phase at the point A is some 270° in advance of that at the point E so that the phase of radiation from the successive loops ABCD, EFGH will differ by 270°. Hence the radiation from the loops is additive in the general direction ZA and mutually cancelling in the opposite direction AZ. The radiation from the wires DE, HI, and so on will have the same phase relationships and add in the direction ZA and cancel in the direction AZ. As, however, the radiation in the directions of these wires is zero or substantially so, the total radiation from the wires DE, HI, and so forth, will

be negligibly small as compared to that from the loops A B C D, E F G H, etc.

For the sake of convenience let the dimensions A B in the accompanying drawing be termed the depth of a loop, the dimension B C plus D E the spacing between loops, and the dimension B C the width of a loop. Preferably the wires A B and C D are straight so that if the length measured along the wire A B is a quarter of a wave length the depth of the loop is physically a quarter of a wave length. If desired, however, the wires A B and C D may be folded so that the physical depth of the loop will be less than the length measured along the wires A B or C D. The width of the loop is not critical and need only be sufficient to ensure that the wires A B and C D do not make contact; in fact the wire B C can be dispensed with altogether and the points B and C united into one point if the loop be made in the form of a V having its apex at the common point B C.

It is found that with quarter wave length loops and spaces, as described, the polar curve of radiation is a somewhat flat nosed unidirectional curve point in the direction Z A. By reducing the depth of the loops or the spaces between them, or both, by a small percentage, the sharpness of the polar curve may be increased. The current decreases along the aerial principally due to radiation and if the physical length A to Z is some four wave lengths, then the current at Z is, in practice, generally less than one-tenth the current at A and in these circumstances, therefore, the terminating line L₂ and surge resistance R may be dispensed with without appreciably affecting the polar curve.

If the depths of the loops and if the spacings be reduced somewhat the radiation per loop and consequently the decrement of current decreases and this assists in sharpening the polar curve of radiation, but also results in some loss as the current through the terminating resistance R will be increased unless, of course, the number of loops is increased. It has been found in practice that an aerial having loops and spaces of quarter wave length, less 5% and approximately four wave lengths long (this length is the physical length from end to end) gives a fairly sharp radiation diagram and may be regarded for all practical purposes as being effectively uni-directional, even if no terminating surge impedance be employed over a band of 10% wide frequencies.

Although the above described dimensions of quarter wave length less a few per cent (say 5%) for the loops and spaces are preferred, other proportions may be used and good results obtained provided that the depth of a loop plus the spacing between consecutive loops is made substantially equal to half a wave length. Thus A B and C D may be made equal to one-sixth of a wave length and B C plus D E equal to one-third of a wave length. In this case although the radiation from two adjacent loops adds in the direction Z A it does not, of course, cancel in the direction A Z. Nevertheless the radiation of a number of such loops is additive in the direction Z A and is not additive in the direction A Z and for a number of loops the combined radiation in the direction A Z is very small so that the aerial remains practically or approximately uni-directional.

Figure 2 illustrates the current distribution in two loops of the aerial, in four relative phases differing successively by 45 degrees.

The current distribution is shown with loops

A B C D and E F G H pulled out straight. Attenuation is neglected and it is assumed that the wave travels from A to H and passes on. On each side are shown the effective currents in the loops A B C D and E F G H when folded up, these currents being obtained by summing up the currents in A B C D and E F G H at that instant, remembering that C D and G H are reversed by the change of direction of the wire. It will be seen that the effective currents in the loops A B C D and E F G H are identical with the current distribution in a one-quarter wave earthed aerial and that they act as such. Also that as the phase in E F G H is 270 degrees behind A B C D the effective currents combine in the direction H A.

It has been found that by progressively changing along the aerial the proportions of the loops and spaces relative to the working wave length the rate of decrement of current can be brought to a desired value and in this way the aerial may be made effective for a relatively wide band of working wave lengths. Aerials in accordance with this invention may generally be employed for harmonics of a fundamental frequency wave, but in general the directional characteristics are different for different harmonics.

It will be appreciated that the present invention provides a comparatively simple and efficient uni-directional aerial giving a high degree of concentration and not requiring a reflector. The degree of concentration is, of course, a function of the aerial length (measured in the direction of extension) in terms of the wave length.

By adding one half wave length of wire to the fourth, eighth and twelfth portions, and so on of the illustrated aerial while maintaining the same physical distance between the end of one loop and the beginning of the next the relative phases of the successive loops will be changed by 180° and the result will therefore be that the direction of concentration will be reversed, i. e., the aerial will radiate in the general direction of its extension, but towards instead of away from the transmitter end. Where such half wave length portions are added the now extended fourth, eighth and twelfth (and so on) portions should be arranged in zigzag form or in any other convenient manner so as to prevent radiation therefrom.

If the illustrated construction be modified by adding a complete wave length of wire to the total length of wire in the first four portions and a complete wave length to the total length in the second four portions and so on, still maintaining the physical distance between the beginning of the first portion and the end of the fourth, the beginning of the fifth and the end of the eighth and so on, at one quarter of the working wave length, concentrated radiation will again be obtained in the general direction of extension and away from the transmitter end. This addition of one wave length of wire to each group of four consecutive portions presents, however, the advantage that as the length of each loop may be made longer, stronger radiation per loop may be obtained if desired. There is, however, the disadvantage that the decrement along the wire will be greater and the useful effective length of the aerial (measured in the general direction of extension) will be reduced so that the concentration will not be so great.

If desired the loops may be arranged at some angle other than 90° to the general direction of extension, for example at 60° thereto and if this

be done then, by suitably adjusting the length of the fourth, eighth, twelfth portions of the aerial (and so on) concentration can be obtained along a line making a desired angle with the general direction of extension. This effect enables the unit aerial to be constructed in such manner that it may be readily supported from a single mast and, if desired, a plurality of such unidirectional aeral's may be accommodated from a single mast.

A plurality of aeral's in accordance with the present invention may be employed in combination to obtain improved concentration if desired. What is claimed is:

1. An endwise aerial which is, from end to end, at least approximately four times the length of the working wave length and which consists of a continuous conductor bent to form loops at intervals along the conductor, said loops being at an angle to the direction of radiation which is the general direction of extension of the aerial, said loops having an overall length approximately equal to a one-half wave length and being separated from one another by lengths of conductor approximately equal to one-quarter of a wave length.

2. An endwise extended aerial consisting of a plurality of conductive portions in the same straight line and in the line of extension of the aerial, each of said conductive portions being substantially one-quarter of a wave length less 5% measured along the conductor, said portions being connected in series by loops at an angle to the line of extension, each of said loops being substantially half a wave length long less 5% measured along the conductor, the physical length of said aerial from end to end being at least approximately four wave lengths.

3. An endwise extended aerial consisting of a plurality of conductive portions in the same straight line and in the line of extension of the aerial, each of said conductive portions being substantially one-quarter of a wave length less 5% measured along the conductor, said portions being connected in series by loops at an angle to the line of extension, each of said loops being

substantially half a wave length long less 5% measured along the conductor, a terminating resistance connected to one end of the aerial and a source of radio frequency energy connected to the other end of the aerial.

4. An endwise aerial which is long relative to the working wave length and which consists of a continuous conductor bent to form loops at intervals along the conductor, said loops being at an angle to the direction of radiation which is the general direction of extension of the aerial, said loops having an overall length approximately equal to a one-half wave length and being separated from one another by lengths of conductor approximately equal to one-quarter of a wave length, and an impedance connecting one end of said aerial to ground, said impedance being of a value substantially equal to the surge impedance of said aerial for preventing reflection of energy over said aerial.

5. An end-wise aerial which is long relative to the working wave length and which consists of a continuous conductor bent to form loops at intervals along the conductor, said loops being at an angle to the direction of radiation which is the general direction of extension of the aerial, the depth of said loops plus the length of the spacing between adjacent loops being substantially equal to one-half the length of a working wave, and high frequency apparatus connected to one end of the aerial and a terminating surge impedance connected to the other end of the aerial.

6. An end-wise uni-directional aerial system which is at least four times the length of the operating wave, comprising a continuous conductor bent to form loops at intervals along conductor, said loops having closely spaced legs and being at an angle to the direction of radiation which is the general direction of extension of the aerial, the depth of said loops plus the length of the spacing between adjacent loops being substantially equal to one-half the length of the operating wave, and high frequency apparatus connected to one end of said conductor.

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