

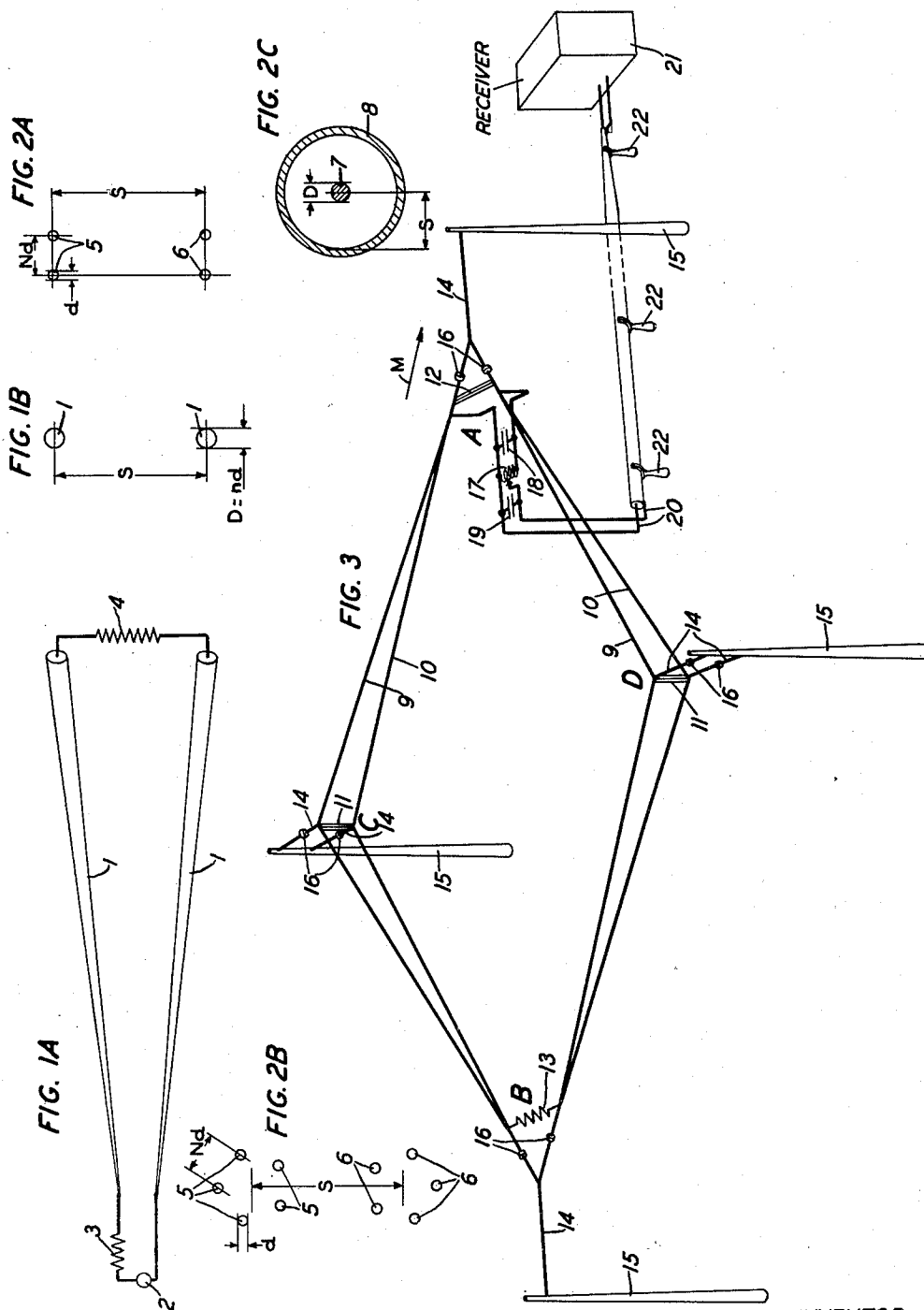
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TRANSMISSION SYSTEM

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TRANSMISSION SYSTEM

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12 Claims. (Cl. 250—33)

This invention relates to transmission systems and more particularly to aerial transmission systems designed to function at radio frequencies.

As is well known electrical transmission systems are usually designed so that the surge, or characteristic, impedance comprising unit linear inductance and unit linear capacitance is practically constant throughout the system, one reason being that standing waves may be eliminated by terminating a line so designed in such characteristic impedance. In systems having conductors of uniform diameter, the linear reactive values are usually rendered constant by positioning the conductors parallel with each other. In other systems, however, as for example, the diamond-shaped antenna disclosed in my co-pending application, Serial No. 513,063, filed February 3, 1931, in which the conductors are by design not parallel, this method of obtaining constant reactive values obviously cannot be employed.

Moreover, certain systems are designed to have a minimum or comparatively low impedance for the purpose of effecting a suitable impedance match between the system and another connected system. While a suitable low impedance may be obtained with comparative ease in the parallel-conductor system, the attainment of this result in systems having non-parallel conductors has not been satisfactorily achieved.

It is one object of this invention to obtain a constant characteristic impedance in a transmission system comprising non-parallel conductors.

It is another object of this invention to render the impedance of an electrical system a minimum.

It is a further object of this invention to increase the efficiency of a multi-wave directive antenna.

According to one feature of the invention at least one of two non-parallel conductors has a generally conical shape, the conductor diameter at any point in the system being proportional to the conductor spacing at that point.

According to another feature of the invention, the unequal spacing between non-parallel conductors of uniform diameter is, in a sense, compensated by substituting two or more wires in place of one or both conductors, and spacing said wires in accordance with the conductor spacing.

The invention will be more fully understood from the following description taken in connection with the drawing in which:

Fig. 1A represents a transmission system comprising two non-parallel conductors, each conductor being generally conical in shape;

Fig. 1B is an end view of the conductors shown in Fig. 1A with the significant dimensions indicated, these dimensions also occurring in Figs. 2A, 2B and 2C infra. Each of these figures, as

well as Fig. 3, represents, when correct dimensional relations are used, a transmission line of the invention;

Fig. 2A is a cross-sectional view of a transmission line, each conductor of which comprises two wires connected in parallel;

Fig. 2B is a cross-sectional view of a transmission line, each conductor of which comprises five wires connected in parallel;

Fig. 2C is a cross-sectional view of a concentric transmission line; and

Fig. 3 is a directive antenna system comprising V-shaped conductors, each conductor comprising two wires connected in parallel.

Referring to Figs. 1A and 1B, reference numerals 1 each designate a conical shaped conductor of a transmission line, each conductor having a variable diameter "D". The two conductors 1 are separated by a variable spacing "S". A source of energy 2 and an impedance 3 are connected to one end of the line and a terminating impedance 4 is connected to the other end of the line.

If the unit reactive values for the conductors of the system shown in Figs. 1A and 1B are large compared with the resistance

$$Z_0 = \sqrt{\frac{L}{C}} \quad (1)$$

where

Z_0 = the characteristic impedance;

L = the unit linear inductance;

C = the unit linear capacitance.

From the well known theorem that, regardless of the cross-sectional shape of the wires, the linear loop capacitance of the wires expressed in stat farads is the reciprocal of the external loop inductance expressed in abhenrys, it can be shown that

$$Z_0 = \frac{K}{C} \quad (2)$$

where K is a proportionality factor.

From (2) it is clear that any increase in C will be accompanied by a corresponding decrease in the characteristic impedance. The capacitance per unit length for a single wire to its return conductor is given by the relation

$$C_1 = \frac{.1208}{\log_{10} \frac{2S}{nd}} = \frac{.1208}{\log_{10} \frac{2S}{D}} \quad (3)$$

approximately, where

S = a variable representing the spacing between the centers of the conductors 1;

d = a constant and represents the diameter of an ordinary transmission conductor;

n = a variable factor;

$D = nd$ = a variable representing the diameter of the conductors shown in Figs. 1A and 1B.

The characteristic impedance of a small length

of the conductor in the system shown in Figs. 1A and 1B may be written;

$$Z_0 = 277 \log_{10} \frac{2S}{D} \quad (4)$$

In Fig. 2A the numeral 5 designates the two multiplied wires of a transmission line conductor and numeral 6 designates the two corresponding wires of the return conductor. The wires are of constant diameter "d" and the spacing "Nd" between the wire centers varies, "N" being a variable factor. The conductor spacing "S" also varies.

The system of Fig. 2B is similar to that of Fig. 2A, numerals 5 designating the five wires of a transmission conductor and numerals 6, the five wires of the associated return conductor.

For the general case of "w" wires connected in multiple, such as the two wires shown in Fig. 2A or the five wires shown in Fig. 2B the unit capacity may be written:

$$C_w = \frac{.1208w}{\log_{10} \frac{2S}{D} + \log_{10} \left(\frac{S}{Nd} \right)^{(w-1)}} \quad (5)$$

approximately, and the impedance

$$Z_{ow} = 277 \log_{10} \frac{2S}{d \sqrt[2N^{(w-1)}]{2N^{(w-1)}}} \quad (6)$$

approximately.

In Fig. 2C, reference numeral 7 designates the inner conductor and numeral 8 the outer conductor of a concentric transmission line. The variable spacing between the center of the inner conductor 7 and the inner surface of conductor 8 is denoted by the symbol "S"; and "D" represents the variable diameter of the inner conductor. The unit linear capacity is given by the relation

$$C_c = \frac{k}{\log_{10} \frac{2S}{D}} \quad (7)$$

where k is a constant.

The impedance is given by the relation

$$Z_c = 138 \log_{10} \frac{2S}{D} \quad (8)$$

It will be seen from Equation (4) that if the ratio

$$\frac{S}{D}$$

is maintained constant in the system shown in Figs. 1A and 1B, the characteristic impedance for a single wire will be constant. The variable diameters of both of the conductors are, therefore, chosen so that they each vary in proportion to the variable spacing. Hence, the characteristic impedance of both conductors remains constant. Similarly from Equation (6), if the spacing "S" and the spacing "Nd" are such that

$$\frac{2S}{d \sqrt[2N^{(w-1)}]{2N^{(w-1)}}}$$

is approximately constant, "w" and "d" being constant, the impedance throughout the transmission systems illustrated in Figs. 2A and 2B will remain constant. From Equation (8) if

$$\frac{S}{D}$$

is constant the characteristic impedance of the system shown in Fig. 2C will remain constant. Consequently, by properly choosing the spacing and effective conductor diameter, constancy in

characteristic impedance is obtained in the non-parallel conductor systems illustrated.

In addition to the above the characteristic impedance of a non-parallel conductor system embodying the invention is considerably lower, in a comparative sense, than the same system not modified in accordance with the invention. Thus, if the diameter "D" of a single-wire conductor in a transmission system not designed in accordance with the invention equals .2 cms. and the spacing "S" between the conductors equals 1000 cms., the impedance equals from Equation (4) 1100 ohms. If two wires, having a spacing such that "N" equals 500, or if a conical-shaped conductor having a diameter "D" equal to 500 "d", be employed in place of the single-wire conductor, the impedance will equal 360 ohms, assuming the conductor spacing "S" is the same in all three cases and that the diameter "d" of each wire remains constant.

It should be noted in this connection that, for a given result, the use of multiple wires in place of a solid conical conductor is more practical and economical. Thus, equating the corresponding terms of Equations (3) and (5), we find that the single-wire system illustrated in Figs. 1A and 1B and the multiple-wire systems in Figs. 2A and 2B will have equal capacities when $2N^{(w-1)} = n^w$. For the system of Fig. 2A the factor "n" equals

$$\sqrt[2N]{2N}$$

If N=500, the two-wire system of Fig. 2A is as effective in increasing the capacity as one wire whose diameter has been increased 31.6 times. The ratio of weights of copper in the two cases is 500:1. Hence, considerable economy may be effected by employing the multiple-wire system in place of the single-wire system.

Referring to Fig. 3, a unilateral receiving antenna is illustrated. Reference numeral 9 designates a horizontal diamond-shaped receiving antenna having end vertices A and B and side vertices C and D. This antenna comprises two V-shaped conductors oppositely positioned with respect to each other and is similar to the antenna described in my copending application, Serial No. 513,063, filed February 3, 1931. Reference numeral 10 designates a similar diamond-shaped antenna positioned immediately below antenna 9. The corresponding superimposed V-shaped conductors of the two antennas are electrically joined at vertices A and B, and separated at vertices C and D by spacers 11 which are constructed of insulating material and vertically positioned. The ratio of the spacing "Nd" between corresponding portions of the two antennas to the spacing "S" between corresponding points on the V conductors of antenna 9, or 10, is equal substantially to a constant. Spacer 12, also constructed of insulating material, is horizontally positioned and electrically separates the two V conductors of each antenna at vertex A. The V conductors of both antennas are connected at vertex B through a common terminating impedance 13. The antennas are supported by means of guy wires 14 attached to wooden poles 15. Insulators 16 serve to insulate the antennas from the supporting structure.

The antennas 9 and 10 are inductively connected through a coupling circuit comprising transformer 17 and condensers 18 and 19 to a low impedance concentric type transmission line 20 which is associated with a receiver 21. The line is supported above ground by means of supports 22. At a point near the receiver 21 both

conductors of the concentric line 20 are tapered for convenience but the ratio of the diameter of the inner conductor to the inner diameter of the outer conductor remains constant in accordance with this invention. Arrow M represents the desired direction of reception. As described in my copending application mentioned above the projection of each element on the vertical plane of the direction represented by arrow M is one-half a wave length less than the length of the element.

The operation of the receiving system is fully described in my copending application and will only be briefly outlined here. Energy is absorbed by the conductors of antennas 9 and 10 and transferred through the coupling circuit to the concentric line 20 and thence to the receiver 21. Because of the position of the V-shaped conductors and the value of the terminating impedance 13 maximum reception occurs in the direction M. The corresponding wires of the two antennas form a two-wire conductor and function in a manner explained in connection with Fig. 2A. The characteristic impedance is therefore substantially constant throughout the antenna system, and reflections are substantially eliminated at all frequencies. It should be noted here that if the V-shaped conductors were single-wire conductors of uniform section instead of two-wire conductors reflections would occur at all frequencies, the reflections at some frequencies being more pronounced than at other frequencies. The employment of multiple wire conductors in accordance with the invention, therefore, greatly increases the antenna operating efficiency at each frequency and also over a band of frequencies. Moreover, the antenna impedance of the system shown in Fig. 3 is considerably less than the impedance of either antenna 9 or 10 taken alone, and a more efficient transfer of energy between two antennas and the transmission line 20 is obtained inasmuch as the line 20 has a very low impedance. Instead of the multiple-wire conductors shown, generally conical conductors could be used, as in accordance with Fig. 1A, with like effect.

Although the invention has been described in connection with certain types of transmission systems, it is understood that it is not to be limited to any particular transmission system including transmitting and receiving antennas. Moreover, it is obvious that conductors of other than circular cross-section may be employed successfully in practicing the invention.

What is claimed is:

1. A transmission system comprising two conductors between which the spacing varies, at least one conductor having a varying effective unit capacity area, the ratio of the effective unit capacity area of a portion of the last mentioned conductor to the spacing between said portion and the other conductor being substantially equal to the corresponding ratio at another portion in said system, and means for energizing the two conductors in opposite phase.

2. A transmission system comprising two conductors between which the spacing varies, at least one conductor having a varying effective unit capacity area, the ratio of the effective unit capacity area of the last mentioned conductor at any given point to the spacing at said point being equal to a corresponding ratio at the point of minimum conductor spacing, and means for energizing the two conductors in opposite phase.

3. A transmission system comprising a plurality of conductors differently spaced at various points in said system, said system being energized, at least one conductor having a varying diameter, the ratio of the diameter of said conductor at any point thereof to the conductor spacing at said point being substantially constant.

4. A transmission system comprising a plurality of conductors differently spaced at various corresponding points thereof, said conductors each having a varying diameter, the ratio of the diameters of each of said conductors at any point to the conductor spacing at said point being constant, and means for energizing said system.

5. A V-shaped receiving antenna comprising two conductors positioned so that the bisector of the angle between said conductors and a distant transmitting station are included in the same plane, substantially, each conductor comprising a plurality of wires between which the spacing varies uniformly, the ratio of the wire spacing to the conductor spacing being the same at all points, substantially, in said antenna.

6. A transmission system comprising a plurality of non-uniformly spaced conductors at least one of which comprises a plurality of elements connected in parallel, the ratio of the spacing between said elements at any point in the system to the spacing between said conductors at said point being substantially equal to the similar ratios at other points in the system.

7. In combination, a transmission system comprising a plurality of transmitting conductors between which the spacing varies, means for energizing said conductors, said conductors each comprising a plurality of wires connected in parallel, the spacing between said wires varying in degree, and the ratio of the spacing between adjacent wires to the distance between the geometrical centers of said conductors being substantially constant.

8. In combination, a translation device, an antenna associated therewith, said antenna comprising V-shaped conductors oppositely positioned with respect to each other, each conductor comprising a plurality of wires connected in parallel, the ratio of the spacing between said wires to the spacing between said conductors being equal substantially to a constant.

9. In combination, an antenna having a plurality of conductors, the spacing between which varies, at least one conductor comprising a plurality of wires connected in parallel, the spacing between said wires at any point being proportional to the spacing between said conductors at that point.

10. In combination, a translation device, an antenna, an impedance, said antenna connected between said device and said impedance, said antenna comprising a diamond-shaped unit superimposed on another such suit, the ratio of the spacing between corresponding portions of said units at any point and the spacing at that point between corresponding portions of one unit being constant.

11. In combination, a substantially horizontal diamond-shaped antenna unit each element of which is one-half of an operating wave length longer than its projection on the path of the desired wave, a second diamond-shaped antenna unit having elements of similar length and positioned closely beneath the first mentioned unit, a receiver connected to one vertex, an impedance connected to the opposite vertex, the spacing be-

tween said antennas at the above mentioned vertices being negligible, said antennas being separated at the remaining vertices.

12. In combination, a substantially horizontal antenna comprising two V-shaped conductors having their vertices oppositely positioned, each half of the said conductors being equal substantially to one-half a wave length plus its projection on the path of the received waves, each con-

ductor comprising two wires connected in parallel, a receiver connected between one pair of corresponding terminals of said conductors, an impedance connected between the remaining pair of corresponding terminals, the spacing between said wires at any point and between said conductors at that point being equal substantially to a constant.

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10	85
15	90
20	95
25	100
30	105
35	110
40	115
45	120
50	125
55	130
60	135
65	140
70	145
75	150