Aug. 23, 1966 TAIICHIRO NOGUCHI ETAL 3,268,904

MULTICONDUCTOR TYPE BROAD BAND ANTENNA

Filed April 3, 1964

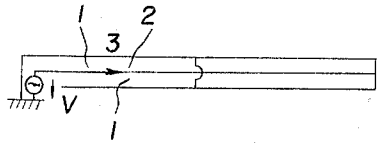


FIG. 1

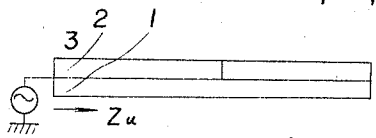


FIG. 2(A)

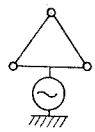


FIG. 2(B)

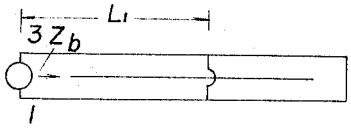


FIG. 3(A)

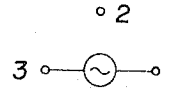


FIG. 3(B)

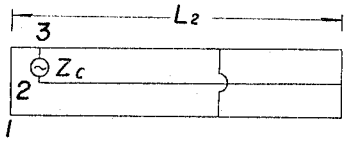


FIG. 4(A)

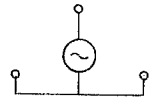


FIG. 4(B)

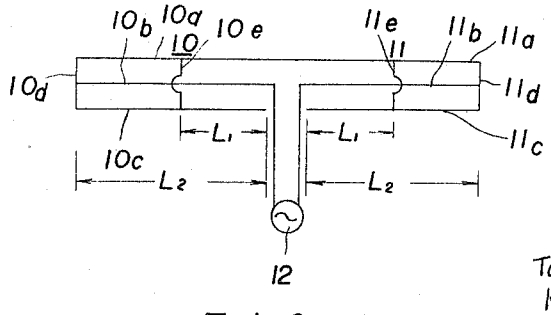


FIG. 5

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MULTICONDUCTOR TYPE BROAD BAND ANTENNA

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This invention relates to a multiconductor type broad band antenna which can effectively operate over an extremely broad frequency band.

When a plurality of parallel conductors are suitably combined a current component serving as radiation and a current component acting as a reactance element are produced. We have found that the input impedance, directivity and other characteristics of an antenna can be improved over a wide frequency band because of the difference in frequencies between low frequency band and high frequency band used in television by suitably combining said current components.

The present invention is based on the above described discovery and contemplates a multiconductor type broad band antenna characterized in that symmetrically disposed component sections of the antenna are short circuited by short circuiting elements at points other than their ends and that said component sections are respectively connected to feeder elements.

Accordingly it is the principal object of this invention to provide a novel antenna which can effectively operate over a broad frequency band.

Another object of this invention is to provide a novel television antenna of simple construction but can operate over a very wide frequency band.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which we regard as our invention, it is believed that the invention will be better understood from the following description taken in connection with the accompanying drawing, in which

FIG. 1 shows a diagram for explaining a multiconductor type circuit;

FIGS. 2(A), 3(A) and 4(A) show the component circuits of the circuit shown in FIG. 1;

FIGS. 2(B), 3(B) and 4(B) show the respective cross sections of the circuit components shown in FIGS. 2(A), 3(A) and 4(A) and

FIG. 5 represents a diagrammatic elevational view of an antenna embodying the principle of this invention.

Referring now to the accompanying drawing FIG. 1 thereof shows a circuit comprising three parallel conductors **1**, **2** and **3** with conductors **1** and **3** short circuited at an intermediate point. When it is assumed that a voltage is applied to one end, i.e. the lefthand end, of the conductor **2** and that the opposite ends of the conductors **1**, **2** and **3** are short circuited as shown in FIG. 1, then it is able to consider that the circuit shown in FIG. 1 is constituted by three component circuits as shown in FIGS. 2(A) to 4(A). Impedances Z_u, Z_b and Z_c of these component circuits are given respectively by

$$Z_u=R_u+jX_u$$
$$Z_b=jW_b\tan 2\pi/\lambda$$
$$Z_c=jW_c\tan 2\pi/\lambda$$

where Z_u, Z_b and Z_c represent respectively the impedance of the component circuits, R_u resistance component, X_u reactance component, W_b the characteristic impedance of the component circuit shown in FIG. 3(A), λ wave length,

W_c the characteristic impedance of the component circuit shown in FIG. 4(A), L_1 the distance between the lefthand end or the supply end of conductors **1**, **2** and **3** and short circuiting point along conductors **1** and **3** and L_2 represents the total length of the circuit.

In order to fulfil these three critical transmission conditions the input impedance Z_{in} should be represented by:

$$Z_{in}=\frac{Z_u\cdot\frac{1}{4}Z_b+Z_uZ_c+(\frac{3}{8})^2\frac{1}{4}Z_bZ_c}{\frac{1}{4}Z_b+Z_u+(1-(\frac{3}{8}))^2Z_c} \quad (1)$$

For the purpose of giving those skilled in the art, a better understanding of the invention, the derivation of Equation 1 is given below:

By representing the current distribution factor as "*a*," and the voltage drop across and currents through the individual conductors in the transmission lines of FIG. 1 by V_1, V_2, V_3, and I_1, I_2, I_3, and, the supply voltages and currents through the individual conductors in transmission lines of FIGS. 2(A) to 4(A) by V_u, V_b, V_c, and I_u, I_b, I_c, the relationship among these values can be represented by the formula:

$$\begin{pmatrix}V^1\\V_2\\V_3\end{pmatrix}=\begin{pmatrix}1 & \frac{1}{2} & 1-2a\\1 & 0 & -2a\\1 & -\frac{1}{2} & 1-2a\end{pmatrix}\begin{pmatrix}V_u\\V_b\\V_c\end{pmatrix} \quad (1\text{-}1)$$

and

$$\begin{pmatrix}I_1\\I_2\\I_3\end{pmatrix}=\begin{pmatrix}a & 1 & \frac{1}{2}\\1-2a & 0 & -1\\a & -1 & \frac{1}{2}\end{pmatrix}\begin{pmatrix}I_u\\I_b\\I_c\end{pmatrix} \quad (1\text{-}2)$$

and from these equations balanced and unbalanced voltages and currents can be obtained as

$$\begin{pmatrix}V_u\\V_b\\V_c\end{pmatrix}=\begin{pmatrix}a & 1-2a & a\\1 & 0 & -1\\\frac{1}{2} & -1 & \frac{1}{2}\end{pmatrix}\begin{pmatrix}V_1\\V_2\\V_3\end{pmatrix} \quad (1\text{-}3)$$

and

$$\begin{pmatrix}I_u\\I_b\\I_c\end{pmatrix}=\begin{pmatrix}1 & 1 & 1\\\frac{1}{2} & 0 & -\frac{1}{2}\\1-2a & -2a & 1-2a\end{pmatrix}\begin{pmatrix}I_1\\I_2\\I^3\end{pmatrix} \quad (1\text{-}4)$$

Since the second wire of the array of FIG. 1 is considered as being open-circuited at an intermediate part,

$$I_1=0$$

and since the third wire is short-circuited,

$$V_3=0$$

Hence, impedances Z_u, Z_b and Z_c of respective transmission line components can be given as

$$Z_u=\frac{V_u}{I_u}=\frac{aV_1+(1-2a)V_2}{I_2+I_3} \quad (1\text{-}5)$$

$$Z_b=\frac{V_b}{I_b}=\frac{V_1}{-\frac{1}{2}I_3} \quad (1\text{-}6)$$

and

$$Z_c=\frac{V_c}{I_c}=\frac{\frac{1}{2}V_1-V_2}{-2aI_2+(1-2a)I_3} \quad (1\text{-}7)$$

These values leads to the equation:

$$\begin{pmatrix}1-2a\\0\\-1\end{pmatrix}^{(V_2)}=\begin{pmatrix}Z_u & Z_u & -a\\0 & \frac{1}{2}Z_b & -1\\-2aZ_c & (1-2a)Z_c & -\frac{1}{2}\end{pmatrix}\begin{pmatrix}I_2\\I_3\\V_1\end{pmatrix} \quad (1\text{-}8)$$

From this equation it follows:

$$\begin{pmatrix} I_1 \\ I_2 \\ V_1 \end{pmatrix} = \frac{1}{D} \begin{pmatrix} \frac{1}{4}Z_b + (1-2a)Z_c & \frac{1}{2}Z_u + a(1-2a)Z_c & -Z_u - \frac{1}{2}aZ_b \\ 2aZ_c & -\frac{1}{2}Z_u - 2a^2Z_c & Z_u \\ -aZ_bZ_c & -Z_uZ_c & -\frac{1}{2}Z_uZ_b \end{pmatrix} \begin{pmatrix} 1-2a \\ 0 \\ -1 \end{pmatrix}^{(V_2)} \quad (1\text{-}9)$$

where

$$D = \frac{1}{4}Z_uZ_b + Z_uZ_c = a^2Z_bZ_c \quad (1\text{-}10)$$

From the above, the relation desired between voltage V_2 and current I_2 can be expressed by

$$I_2 = \frac{V_2}{D}\left(\frac{1}{4}Z_b + Z_u + (1-2a)^2Z_c\right) \quad (1\text{-}11)$$

thus, the desired input impedance Z_{in} is:

$$Z_{in} = \frac{V_2}{I_2} = \frac{\frac{1}{4}Z_uZ_b + Z_uZ_c + (2a)^2\frac{1}{4}Z_bZ_c}{\frac{1}{4}Z_b + Z_u + (1-2a)^2\frac{1}{4}Z_c} \quad (1\text{-}12)$$

FIG. 5 shows our novel antenna having such an input impedance.

More particularly, where Z_c approaches infinity, the Equation 1 becomes:

$$Z_{in} = (\tfrac{3}{1})^2Z_u + \frac{(\frac{2}{3})^2}{(\frac{1}{3})^2}\cdot\tfrac{1}{4}\cdot Z_b = 9Z_u + Z_b \quad (2)$$

On the other hand if the impedance Z_b approaches to infinity, the Equation 1 becomes:

$$Z_{in} = Z_u + (\tfrac{2}{3})^2\cdot Z_c \quad (3)$$

Referring now to FIG. 5 of the accompanying drawing there is shown an antenna according to this invention. The antenna comprises a pair of symmetrically disposed component sections **10** and **11** each including three parallel conductors $\mathbf{10}_a$, $\mathbf{10}_b$ and $\mathbf{10}_c$ and $\mathbf{11}_a$, $\mathbf{11}_b$ and $\mathbf{11}_c$ which are interconnected by conductors $\mathbf{10}_d$ and $\mathbf{11}_d$ at their outer ends. A suitable source of high frequency energy **12** is connected across the inner terminals of the second conductors $\mathbf{10}_b$ and $\mathbf{11}_b$ of each section and the first and third conductors $\mathbf{10}_a$ and $\mathbf{10}_c$ and $\mathbf{11}_a$ and $\mathbf{11}_c$ of each of said component sections are interconnected or short circuited by conductors $\mathbf{10}_e$ and $\mathbf{11}_e$, respectively, at points intermediate the opposite ends of each section.

In order to provide the desired characteristics, in accordance with this invention the length L_1, FIG. 5 or the distance between the short circuiting conductor $\mathbf{10}_e$ or $\mathbf{11}_e$ and the inner end of the component section is selected to be equal to ¼ of the wave length at a suitable frequency in a higher frequency band and the length L_2 of each section to ¼ of the wave length at a suitable frequency in a lower frequency band. By this design it is possible to provide an improved antenna which can satisfy the Equation 2 in a lower frequency band while the Equation 3 in a higher frequency band, thus operating effectively over a very wide band.

While the invention has been explained by describing particular embodiments thereof, it will be apparent that improvements and modifications may be made without departing from the scope of the invention as defined in the appended claim.

What we claim as new and desire to secure by Letters Patent of the United States is:

A multiconductor type broad band antenna comprising a pair of symmetrically disposed component sections, each including three parallel conductors, means to interconnect the outer ends of said conductors of each of said component sections, means to interconnect the inner ends of the first conductors of each of said component sections, means to feed an electric energy across inner ends of the second conductors of each of said component sections and means to short circuit the first and the third conductors of each of said component sections at a point intermediate the opposite ends thereof, the length of each of said component sections being selected to be equal to ¼ of the wave length at a frequency in a lower frequency band and the length of the conductor between said short circuiting means and said feeding means of each of said component sections being selected to be equal to ¼ of the wave length at a frequency in a higher frequency band.

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