Dec. 1, 1942. P. S. CARTER 2,303,610

REVERSIBLE UNIDIRECTIONAL ANTENNA

Filed May 16, 1941

Fig. 1

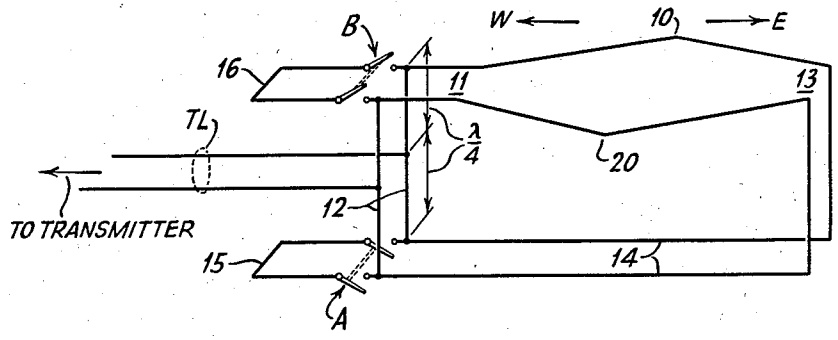
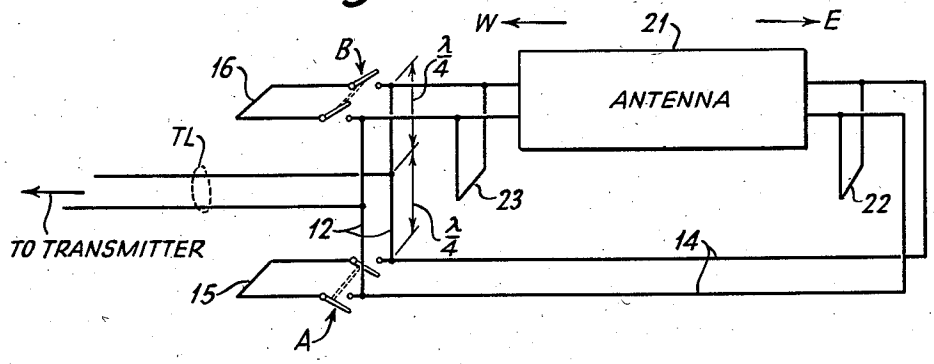


Fig. 2



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REVERSIBLE UNIDIRECTIONAL ANTENNA

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7 Claims. (Cl. 250—33)

The present invention relates to traveling wave antennae and, more particularly, to such antennae which are designed to be unidirectional in either of two desired opposite directions.

An object of the present invention is the elimination of termination losses in reversible traveling wave antennae.

Another object of the present invention is to provide a reversible traveling wave antenna which does not waste power through the use of terminating resistors.

Still another object is to provide an elongated traveling wave antenna in which energy arriving at the end remote from the input end is reapplied to the input and reradiated and which antenna may have the direction of radiation reversed if desired.

The present invention contemplates the coupling, through impedance matching networks, if necessary, of a transmission line to each end of a traveling wave antenna. Then to this transmission line at a predetermined point is connected another transmission line by means of which the antenna is energized or by means of which the antenna is connected to a receiving apparatus. The first-mentioned transmission line has connected thereto at each side of the connection of the second transmission line switches by means of which shunt reactances may be selectively connected thereto in such location that energy from the transmitter is applied to one end of the traveling wave antenna and the major portion of the energy is radiated throughout the length of the antenna. Such energy as is not radiated by the time the traveling wave reaches the other end of the antenna is picked up by the transmission line and reapplied to the originating end in a proper amplitude and phase relationship with respect to the energy therein to be in an additive relationship thereto. The shunt reactances are arranged to be selectively switched into and out of circuit with the transmission line in order that the antenna may be made unidirectional in either of two opposite directions along the axes of the antenna.

Further objects and features of the present invention will be more fully understood from the following detailed description, which is accompanied by a drawing in which Figure 1 illustrates the application of the principles of the present invention to a rhombic antenna and Figure 2 illustrates the application to a generalized traveling wave antenna.

Referring, now, to Figure 1, 10 and 20 denote a pair of conductors disposed in a generally rhombic configuration on a horizontal plane. At end 11 of the antenna is connected a short section of transmission line 12, while at the other end 13 of the traveling wave antenna is connected another transmission line 14 which is directly connected to the transmission line section 12. At substantially the midpoint of the transmission line section 12 is connected a second transmission line TL by means of which the antenna is energized from a transmitter (not shown). At each side of the point of connection of transmission line TL to transmission line section 12, at a distance therefrom of a quarter wavelength, are connected shunt reactances 15 and 16. The reactances are so related to the total conductor length through the antenna and transmission lines 14 and 12 that the energy reapplied to the feed end of the antenna is in phase with energy originally applied. The shunt reactances 15 and 16 are arranged to be selectively connected and disconnected from transmission line section 12 by means of switches A and B. By switching in either shunt and disconnecting the other the antenna may be made unidirectional in its characteristics in either of two desired opposite directions. For example, if it is desired to radiate energy in the direction indicated by arrow E, switch A is closed and switch B is open. Under these circumstances energy arriving along transmission line TL from the transmitter is applied to the traveling wave antenna at end 11 and progresses along the traveling wave antenna in the direction of arrow F. As it travels along the antenna a large portion of the energy is radiated and that which arrives at end 13 is applied to transmission line 14 and thus conducted back to end 11, where it again enters the antenna and has a second opportunity of radiation. The shunt reactance 15, together with the $\lambda/4$ line section 12, transforms the voltage of the energy arriving along transmission line 14 to such value that it combines directly with energy arriving at end 11 directly from the transmitter by way of transmission line TL. The shunt reactance 15, together with the $\lambda/4$ line section 12, acts as a transformer, having such proportions that the voltage is stepped up in a ratio of $\epsilon^{-\alpha L}$ to 1, where αL is the total attenuation over the antenna and return line, in proceeding from the feedback line 14 to the input end of the antenna and the energy arriving by way of transmission line 14 is in phase with the energy arriving by way of transmission line TL. If it is desired to transmit energy in the direction indicated by arrow W, switch A is open and switch B closed. In this case energy is directly applied to end 13 of the traveling wave antenna and travels through the antenna in the direction indicated by arrow W. That which arrives at end 11 is transformed by shunt reactance 16 to proper voltage value to combine directly with energy arriving from the transmitter by way of transmission line TL.

It will thus be seen that I have perfected a traveling wave antenna which may be made selec-

tively unidirectional in either of two desired opposite directions. No energy is wasted in terminating resistance since all energy not radiated is returned to whichever end of the system is at any given instant being used as the input end. The laws determining the length and position of shunt reactances **15** and **16** have been illustrated in great detail in my prior copending application, Serial #358,059, filed September 24, 1940, (RCA D. #19,285), to which reference may be made for a more complete disclosure thereof. It is believed sufficient for the present case to merely indicate that reactances **15** and **16** are so located and of such length as to transform the voltage arriving from the far end of the antenna to such value that it may be reapplied to the input end of the antenna.

In Figure 2 I have shown a modification of my invention as applied to any antenna of the traveling wave type. The antenna is indicated generally by a box **21**. Since the impedance of the antenna may not in all cases be the same as the impedance of the transmission line **14**, impedance matching shunt circuits **22** and **23** may be connected at each end of the antenna. These shunt circuits must be included in case the impedance of the antenna is substantially different from that of the feeder lines, since in such case reflection would otherwise occur at each end of the antenna and a pure traveling wave would not therefore be obtained. I have heretofore more fully described the theory of operation of the impedance matching shunts such as those indicated by reference characters **22** and **23** in my prior Patents #1,909,610, granted May 16, 1933, and #2,109,801, granted November 5, 1935, to which patents reference may be made for a more complete description. However, for present purposes, it is believed sufficient to know that they match the impedance of the antenna and transmission line connected thereto whereby reflection is prevented. The direction of radiation of antenna **21** of Figure 2 may be reversed in the same way as described above with reference to the rhombic antenna shown in Figure 1. That is, by closing switch B the antenna will radiate in the direction W and by closing switch A the antenna will radiate in the direction E.

While I have particularly shown and described several modifications of my invention, I wish it to be clearly understood that my invention is not limited thereto but that modifications and improvements within the scope of the invention may be made.

I claim:

1. In combination, a traveling wave antenna having a pair of ends, a transmission line connecting said ends, a pair of shunt reactances arranged to be selectively connected to said transmission line adjacent one of said ends, the points of connection of said reactances being spaced along said transmission line a predetermined distance, and means for energizing said antenna connected to said transmission line midway between said points of connection.

2. In combination, a traveling wave antenna having a pair of ends, a transmission line connecting said ends, a pair of shunt reactances arranged to be selectively connected to said transmission line adjacent one of said ends, the points of connection of said reactances being spaced along said transmission line a distance equal to a half wavelength to the operating frequency of said antenna, and means for energizing said antenna connected to said transmission line midway between said points of connection.

3. In combination, a traveling wave antenna having a pair of ends, a transmission line connecting said ends, a pair of shunt reactances arranged to be selectively connected to said transmission line adjacent one of said ends, the points of connection of said reactances being spaced along said transmission line a distance equal to a half wavelength to the operating frequency of said antenna, and a second transmission line connecting said antenna to a high frequency transducer connected to said first transmission line midway between the points of connection of said shunt reactances.

4. In combination, a traveling wave antenna having a pair of separated ends, a transmission line connecting said ends, means for energizing said antenna connected to said transmission line at a predetermined distance from its connection to one of said ends, and a pair of shunt reactances arranged to be selectively connected to said transmission line whereby the direction of radiation from said antenna may be reversed, one of said reactances being disposed at the junction of said transmission line and the separately mentioned one of said ends and the other at said predetermined distance from the connection of said energizing means to said transmission line.

5. In combination, a traveling wave antenna having a pair of ends, a transmission line connecting said ends, means for energizing said antenna connected to said transmission line at a distance equal to one-quarter of the operating wavelength from its connection to one of said ends and a pair of shunt reactances arranged to be selectively connected to said transmission line whereby the direction of radiation from said antenna may be reversed, one of said reactances being disposed at the junction of said transmission line and the separately mentioned one of said ends and the other at a distance equal to one-quarter of the operating wavelength from the connection of said energizing means to said transmission line.

6. A rhombic antenna comprising a pair of conductors having their ends adjacent and their midpoints separated, a transmission line connecting one pair of adjacent ends to the other pair of adjacent ends, a pair of shunt reactances arranged to be selectively connected to said transmission line adjacent one pair of adjacent ends, the point of connection of said reactances being spaced along said transmission line a distance equal to one-half the operating wavelength, and means for energizing said antenna connected to said transmission line between said points of connection of said reactances.

7. A rhombic antenna comprising a pair of conductors having their ends adjacent and their midpoints separated, a transmission line connecting one pair of adjacent ends to the other pair of adjacent ends, a pair of shunt reactances arranged to be selectively connected to said transmission line adjacent one pair of adjacent ends, the points of connection of said reactances being spaced along said transmission line, and means for energizing said antenna connected to said transmission line between said points of connection of said reactances.

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