Nov. 7, 1933. G. W. GILMAN 1,933,668

ARRANGEMENT FOR ANTENNA TRANSMISSION LINES

Original Filed Sept. 6, 1930

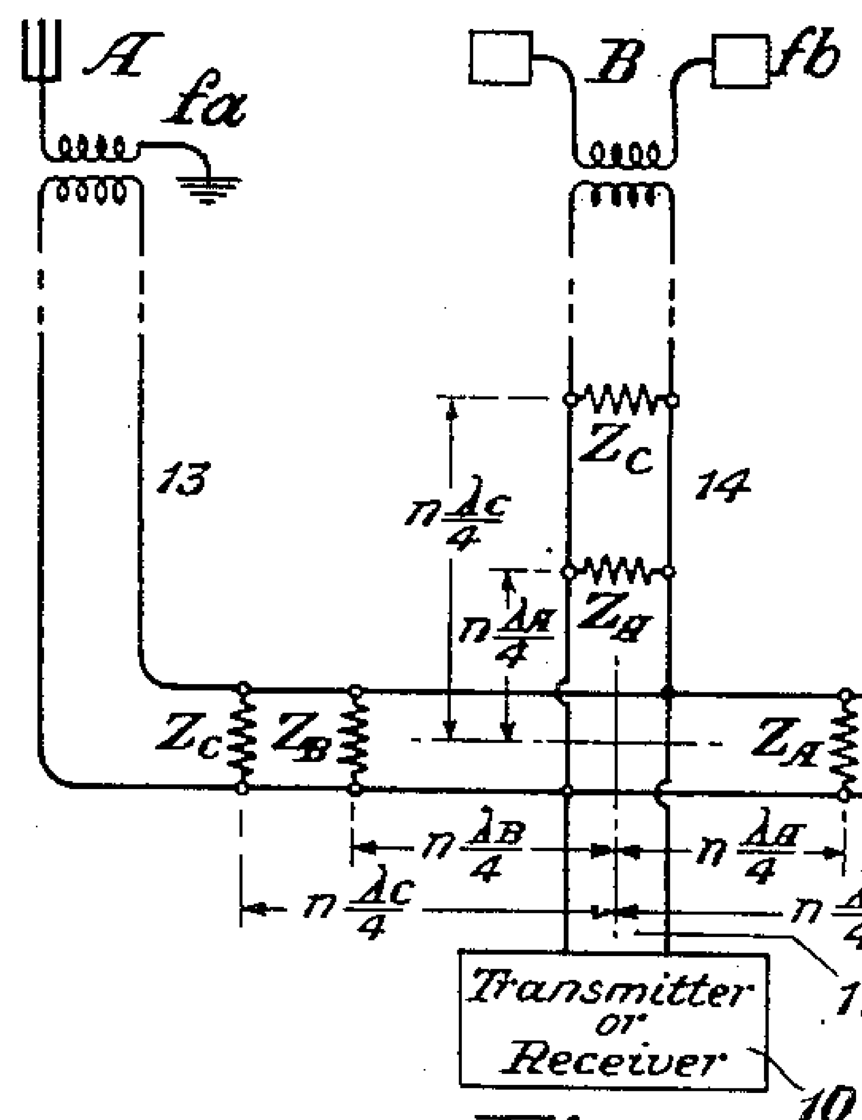

Fig. 1

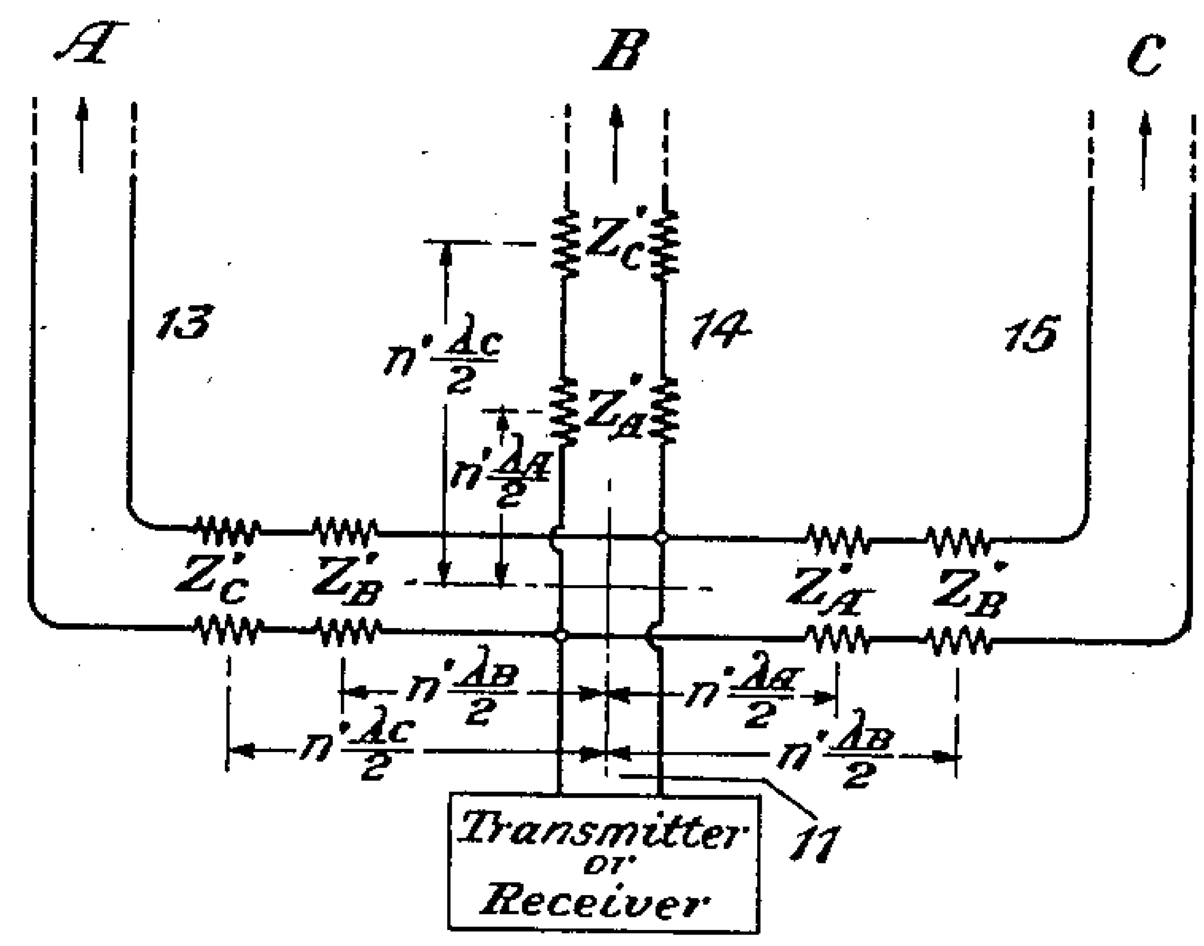

Fig. 2

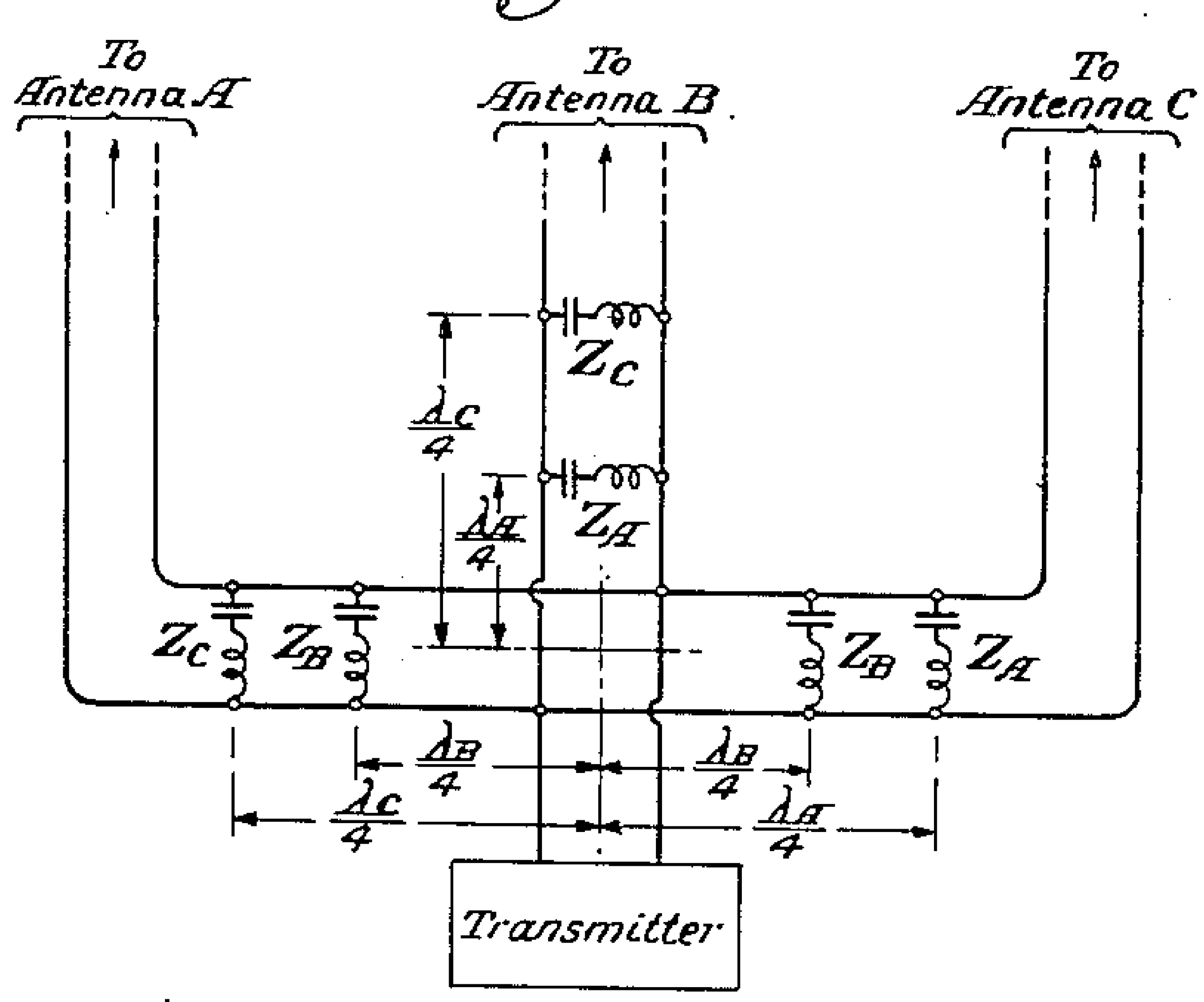

Fig. 3

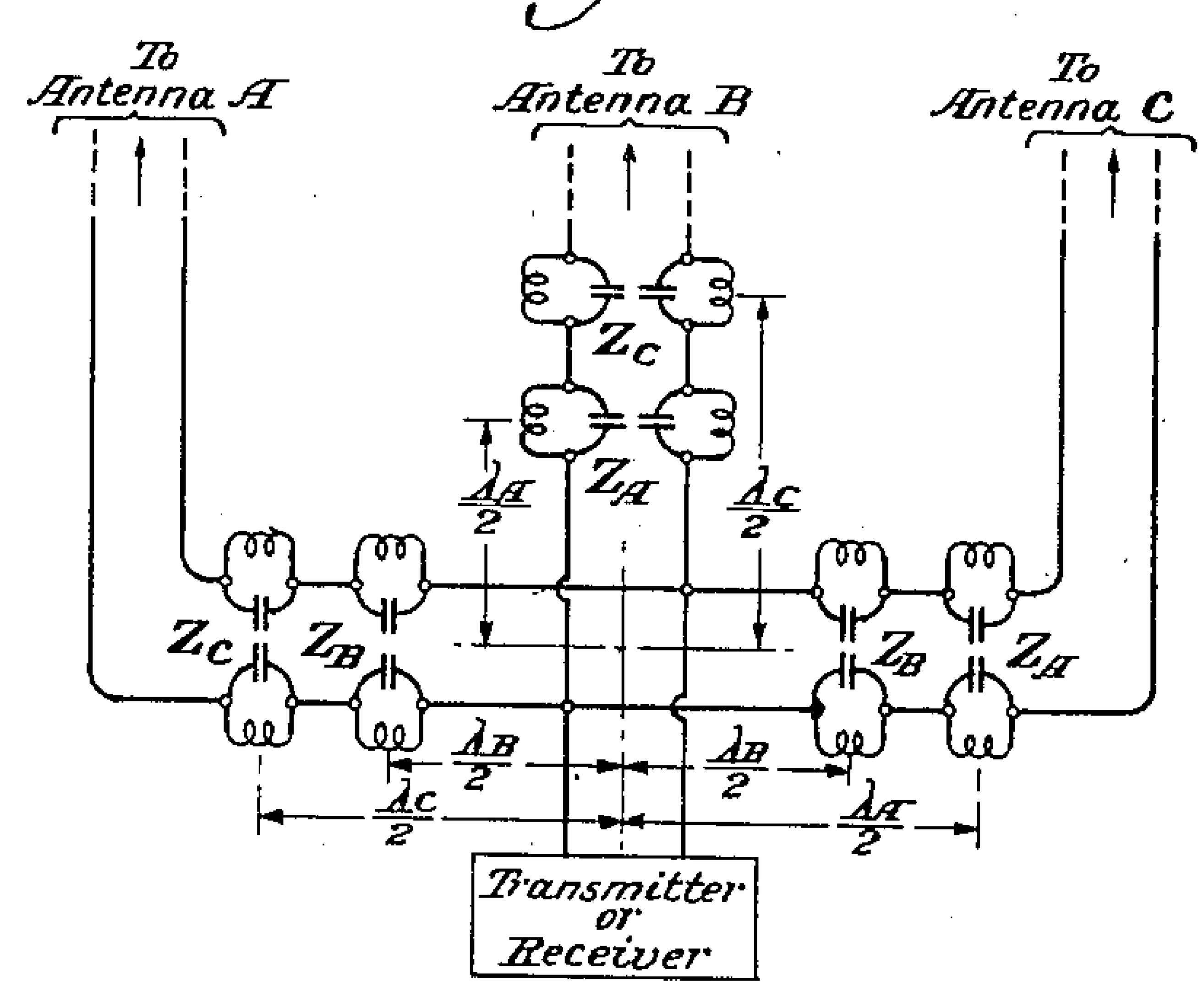

Fig. 4

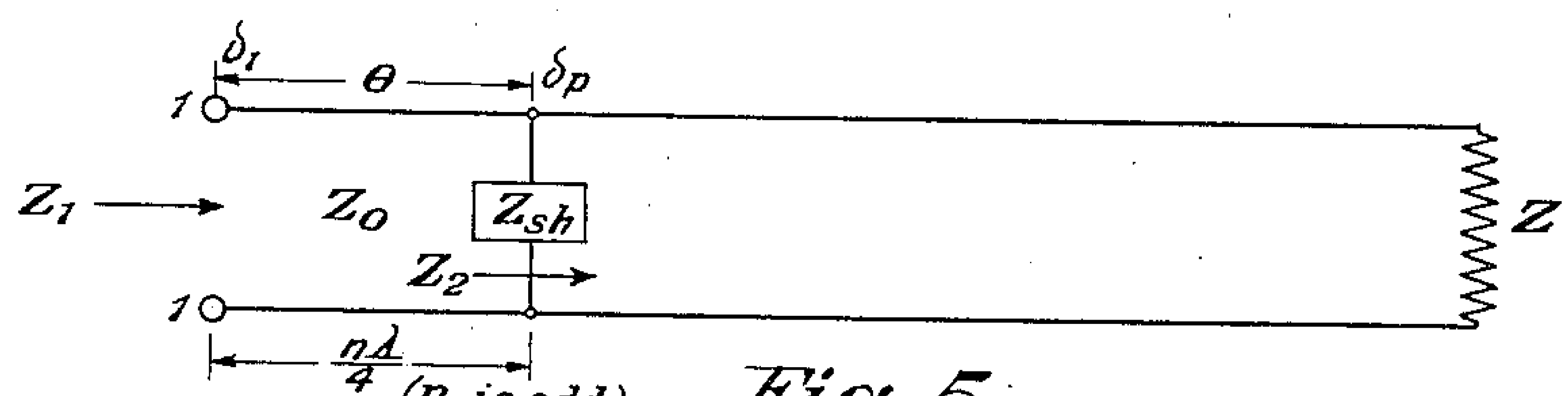

Fig. 5

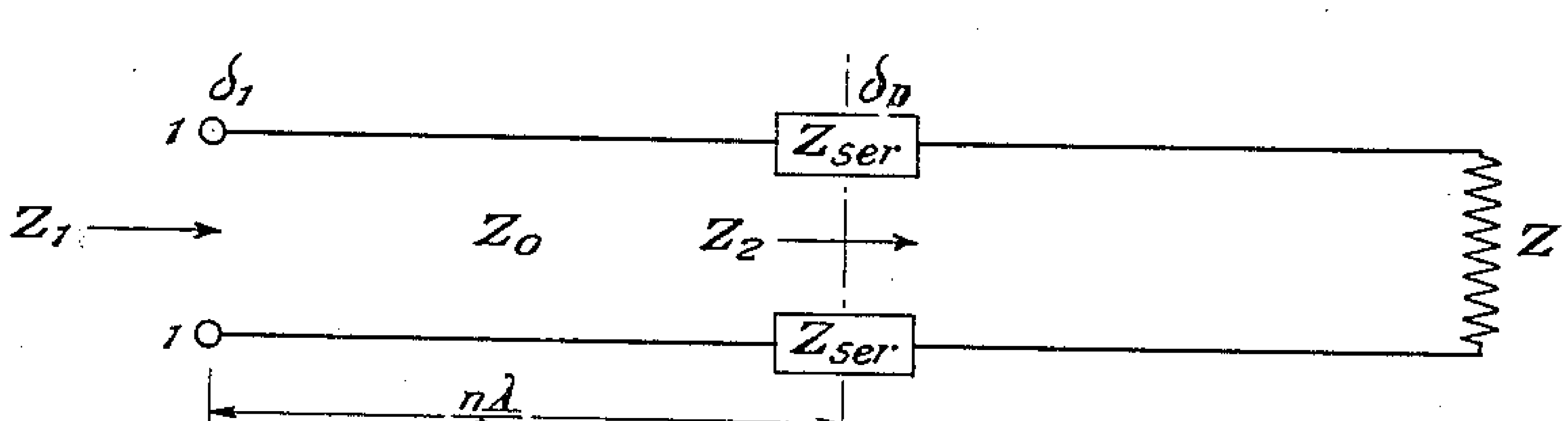

Fig. 6

INVENTOR
G. W. Gilman
BY
ATTORNEY

Patented Nov. 7, 1933

1,933,668

UNITED STATES PATENT OFFICE

1,933,668

ARRANGEMENT FOR ANTENNA TRANSMISSION LINES

George W. Gilman, Lawrenceville, N. J., assignor to American Telephone and Telegraph Company, a corporation of New York

Application September 6, 1930, Serial No. 480,246
Renewed July 6, 1933

13 Claims. (Cl. 178—44)

This invention relates to arrangements for antenna transmission lines, especially such as are used at stations where a plurality of antennæ adjusted for different frequencies are present, and is applicable to both transmitting and receiving stations.

Its purpose is that of enabling a number of such antennæ systems designed for different frequencies to be connected so that the frequency of the entire station may be changed simply by changing the frequency of the wave used. Another purpose is to accomplish this without the use of mechanical or electrical switching means calling for any moving parts. A further purpose is to devise an arrangement of this kind which shall be equally applicable to transmitting and to receiving stations or to combined transmitting and receiving stations.

The invention will be better understood by reference to the following specification and accompanying drawing, in which Fig. 1 shows one generalized method of accomplishing the results; Fig. 2 shows another method; Figs. 3 and 4 show specific ways in which the arrangements of Figs. 1 and 2 may be carried out; and Figs. 5 and 6 are diagrammatic sketches to be used in the theoretical considerations of my invention.

Referring more particularly to Fig. 1, there is shown at 10 a source of radio frequency power to be transmitted or a circuit for receiving radio frequency signals. In the immediate description to follow, however, the portion 10 will be treated as a transmitter. Running out from this transmitter 10 is a transmission line 11 which fans out to a number of branches 13, 14 and 15, each of these branches going to an antenna system of a particular frequency. Thus, for instance, the branch 13 supplies power to an antenna system A. Similarly, the branches 14 and 15 supply power to antennæ systems B and C. These antennæ systems are shown schematically only and are shown each as of a different form solely to point out that this invention may be applicable to any type of antenna system, suitable provision being made as by means of transformers to establish the proper relationship between the impedance of the transmission lines and the antenna systems.

Lacking any provision to the contrary, currents of a given frequency emanating from the transmitter 10 would travel out on each of the branch transmission lines and would tend to set up currents of greater or less magnitude in each and all of the antennæ systems. This would give rise to certain losses of energy and certain irregularities, such as interference from the waves sent out from the different antennæ. To avoid such effects it has been common practice to use separate transmission lines going to the antenna system to be used with suitable selective switching mechanism. In this invention, however, I propose to avoid such steps by arranging or modifying the characteristics of the transmission line, and in particular the branches to the antennæ systems, in such a manner that when the transmitter is tuned for the frequency corresponding to one particular antenna, no radio frequency power will be transmitted to any antennæ by the branch transmission lines except the one going to the antenna to be used.

One method of accomplishing this result is shown in Fig. 1 and consists in bridging across each branch line an impedance of a character which will prevent the transfer to the antenna of power of all operating frequencies except the one for which its antenna is tuned. Thus, in branch 13 there are shown bridged across the line two impedances Z_b and Z_c which will prevent power transfer over the branch 13 of waves of the frequencies corresponding to antennæ B and C. Similarly, in branch 14 there are bridged impedances Z_a and Z_c which will prevent transfer of the frequencies corresponding to antennæ A and C, and finally, in the branch 15 there are bridged the impedances Z_a and Z_b acting to prevent transfer of the frequencies appropriate to antenna A and B. The physical characteristics of these bridged impedances or networks may vary considerably but in general will be of such a character that in order to perform their function to the best advantage they should each be placed at a distance from the common junction point of the branches equal to ¼ wave length or an odd number of ¼ wave lengths of the wave which they are intended to suppress. This disposition of the impedances has been shown in Fig. 1 and the theoretical basis for this relationship will be shown hereinafter.

Instead of using bridged or shunted networks it is possible to use series networks in an analogous manner and performing the same function. Such an arrangement is shown in Fig. 2 where in branch 13 there are included in series the impedances Z_b' and Z_c' acting to prevent transfer of power of the frequencies appropriate to the antennæ B and C. Similarly, impedances are connected in series in the branch lines 14 and 15. In this case, for the most effective functioning of these impedances it is desirable that they should be placed at a distance from the common junction point of approximately ½ wave length or a whole number of ½ wave lengths of the wave which is not to be transmitted over any one branch.

As stated above, the particular form which the impedances or networks may take on varies considerably, but the simplest form which may be used for a shunt arrangement is that shown in Fig. 3 in which each shunt consists of a series inductance and capacity of such values as to be tuned to the particular frequency of one of the other antennæ. Similarly, in the series impedance the simplest network is that shown in Fig. 4, where each network consists of a so-called anti-resonant tuned circuit or a parallel tuned circuit. Such a circuit, as is well known, has the property of offering a very high impedance to a series E. M. F. of frequency equal to that for which the parallel circuit is tuned and a relatively small impedance for all other frequencies.

The theoretical considerations on which my circuit depends can be briefly given by reference to Fig. 5 in which there is shown a smooth transmission line whose characteristic or iterative impedance is Z_o, and which is terminated at some point in that impedance. Across this line at some point P there is shunted the impedance Z_{sh}. Under these circumstances the input impedance as measured from the point 1 is $Z_1 = Z_o \tan h\delta_1$ where δ_1 is the "position angle" at the input of the line. The position angle δ_1 is related to the position angle at any point P by

$$\delta_1 = \delta_p + \theta$$

where θ is the angle of the line between point P and the sending end of the line.

But

$$\delta_p = \tanh^{-1}\frac{Z_2}{Z_0}$$

where Z_2 is the combined impedance of the shunt Z_{sh} and the impedance of the line as measured from the shunt towards the line termination. If at a certain frequency Z_{sh} is zero, then $Z_2 = 0$ and $\delta_p = 0$, so that

$$Z_1 = Z_0 \tanh \theta$$

If now the distance from the input terminals of the line to the shunt is an odd multiple of ¼ wave lengths for this particular frequency, then

$$Z_1 = Z_0 \tanh\frac{jn\pi}{2} = \pm j\infty$$

where

$$j = \sqrt{-1}.$$

Thus it is apparent that at this particular frequency the impedance of this branch is infinitely large and the branch may therefore be bridged across other circuits without loss and without absorbing energy from these circuits. A shunt which will offer zero impedance at a particular frequency is that of a series tuned circuit comprising an inductance and capacity of suitable magnitudes, as shown in Fig. 3. At a frequency appreciably removed from its tuning frequency Z_{sh} will be far from zero in value and Z_1 will therefore be far from infinity. The effect of the shunt at such other frequencies is therefore negligible. Additional shunts may be placed across the line L, each tuned to the frequency for which it is to act as a suppressor, it being understood that each bridge should be placed at a distance from the common junction point of an odd number of ¼ wave lengths of the wave to which the particular shunt applies.

A similar treatment may be given for the case of a series network by reference to Fig. 6 in which again the line L is taken to represent a smooth transmission line smoothly terminated. Here again Z_o is the characteristic impedance of the line and its input impedance as measured from 1 is again

$$Z_1 = Z_0 \tanh \delta_1.$$

If in this case the series impedance Z_{ser} is made infinite at a particular frequency, then

$$\delta_p = \tanh^{-1}\frac{\infty}{Z_o} = \infty$$

and

$$Z_1 = Z_0 \coth \theta$$

If the distance from the input terminals of the line to the series impedance is any whole multiple of ½ wave length, then

$$Z_1 = Z_0 \coth jn\pi = \pm j\infty$$

and thus it is seen that the same results are obtained as for the shunt.

While the bridge or series impedances have been shown as of a very simple form, it is to be understood that these may become more complex networks to yield similar results. Also it is to be understood that the resistance in these impedances should be preferably as low as possible in order the more closely to conform to the conditions specified in the treatment above. It should also be pointed out that while the positions for these impedances have been definitely specified, such positions are not extremely critical and a reasonable variation from the best theoretical position is permissible without serious effects.

Although in Fig. 1 the antennæ are shown as operating on the frequencies f_a, f_b and f_c, it is to be understood that they are not necessarily tuned to these frequencies, respectively. They may be so tuned or they may be otherwise adjusted to operate favorably at these frequencies, and then again, they may be aperiodic, the prime condition for the system being that the power which is intended for radiation on one antenna shall not be able to get out to the other antennæ. This is made possible by the networks connected to the respective branch transmission lines.

While in Figs. 1 to 4 three branch lines have been shown, it is to be understood that additional lines may be used according to the number of additional antennæ, in which case it would be necessary to introduce additional shunt or series impedances. In general each branch would have an impedance for each of the other branches. While the invention may find its chief usefulness at a transmitter station, where it enables a change in sending frequency to be made, with the appropriate antenna alone coming into action and without any special switching mechanism, the invention will apply equally well to a receiving station, that particular branch transmission line alone coming into action which is appropriate for the wave which is being received.

What is claimed is:

1. In radio transmission a plurality of antennæ, a transmission line comprising a pair of conductors, a branch therefrom to each antenna, and means in each branch to prevent transfer of power at the frequencies for which the antennæ associated with the other branches are to be operated, the branches being connected in parallel.

2. In a radio station comprising a plurality of antennæ each to operate at its own frequency,

a transmission line comprising a pair of conductors and a branch therefrom to each antenna, and networks in one branch to prevent power transfer thereover of those frequencies for which the antennæ of the other branches are to operate.

3. In a radio station comprising a plurality of antennæ each to operate at its own frequency, a transmission line comprising a pair of conductors and a branch therefrom to each antenna, and networks in each branch to prevent power transfer thereover of those frequencies for which the antennæ of the other branches are to operate.

4. In a radio station comprising a plurality of antennæ each adapted to operate at its own frequency, a transmission line comprising a pair of conductors and a branch therefrom to each antenna, and means for excluding from each branch the frequencies of the antennæ associated with the other branches, said means comprising a plurality of networks each tuned to one of the frequencies to be excluded.

5. In a radio station comprising a plurality of antennæ each adapted to operate at its own frequency, a transmission line comprising a pair of conductors and a branch therefrom to each antenna, and means associated with each branch for excluding from each branch the frequencies of the antennæ associated with the other branches, said means comprising a plurality of networks each tuned to one of the frequencies to be excluded.

6. In a radio station comprising a plurality of antennæ each adapted to operate at its own frequency, a transmission line and a branch therefrom to each antenna, and means associated with each branch for excluding from each branch the frequencies of the antennæ associated with the other branches, said means comprising a plurality of networks each tuned to one of the frequencies to be excluded, and each network being placed at a definite portion of a wave length from the junction point of the branch with the main transmission line.

7. In a radio station comprising a plurality of antennæ each adapted to operate at its own frequency, a transmission line and a branch transmission line comprising a pair of conductors therefrom to each antenna, and a series tuned circuit bridged across one branch and tuned to the frequency at which another antenna is to operate.

8. In a radio station comprising a plurality of antennæ each tuned to its own frequency, a transmission line and a branch therefrom to each antenna, and a series tuned circuit bridged across one branch and tuned to the frequency of another antenna and placed at an odd number of ¼ wave lengths at this frequency from the junction point of the branch to the main transmission line.

9. In a radio station comprising a plurality of antennæ each tuned to its own frequency, a transmission line and a branch transmission line comprising a pair of conductors therefrom to each antenna, a plurality of series tuned circuits bridged across each branch and each tuned to the frequency of the antenna of another branch.

10. In a radio station comprising a plurality of antennæ each adapted to operate at a different assigned frequency, a transmission line and a branch transmission line comprising a pair of conductors therefrom to each antenna, a plurality of parallel tuned circuits connected in series with each branch, each parallel tuned circuit in each branch being tuned to the frequency corresponding to the antenna of another branch.

11. The combination of claim 5 characterized by the fact that the plurality of networks are so positioned with respect to the junction point of the transmission line and the branches as to make any one branch offer a high impedance, as seen from the junction point, to frequencies to be excluded.

12. The combination of claim 5 characterized by the fact that each network is placed at a distance from the junction point of the transmission line and the branches equal to a whole number of quarter waves of the frequency it is designed to exclude.

13. The combination of claim 10 characterized by the fact that each parallel tuned circuit is placed at a distance from the junction point of the transmission line and the branches equal to a whole number of half waves of the frequency it is designed to exclude.

GEORGE W. GILMAN.