June 9, 1942. N. E. LINDENBLAD 2,286,179

WIDE BAND ANTENNA

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Fig. 1

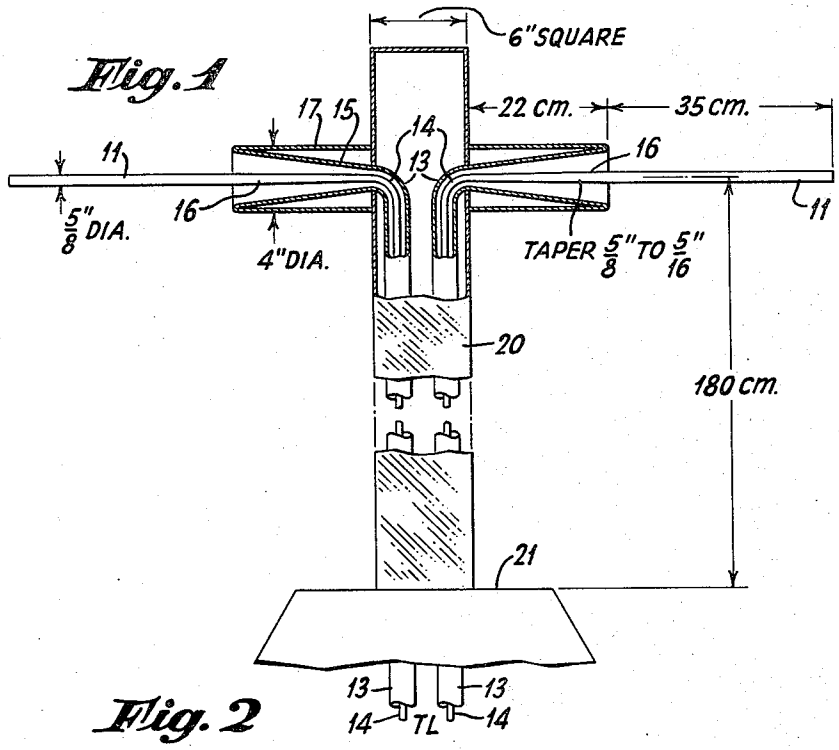


Fig. 2

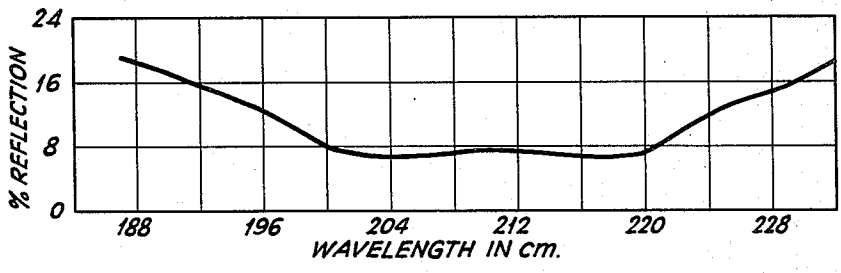
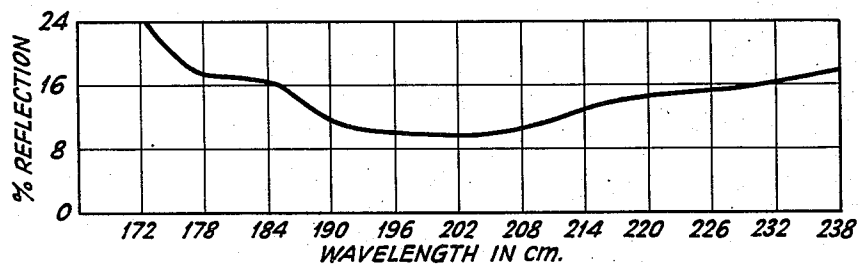


Fig. 3



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WIDE BAND ANTENNA

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Fig. 4

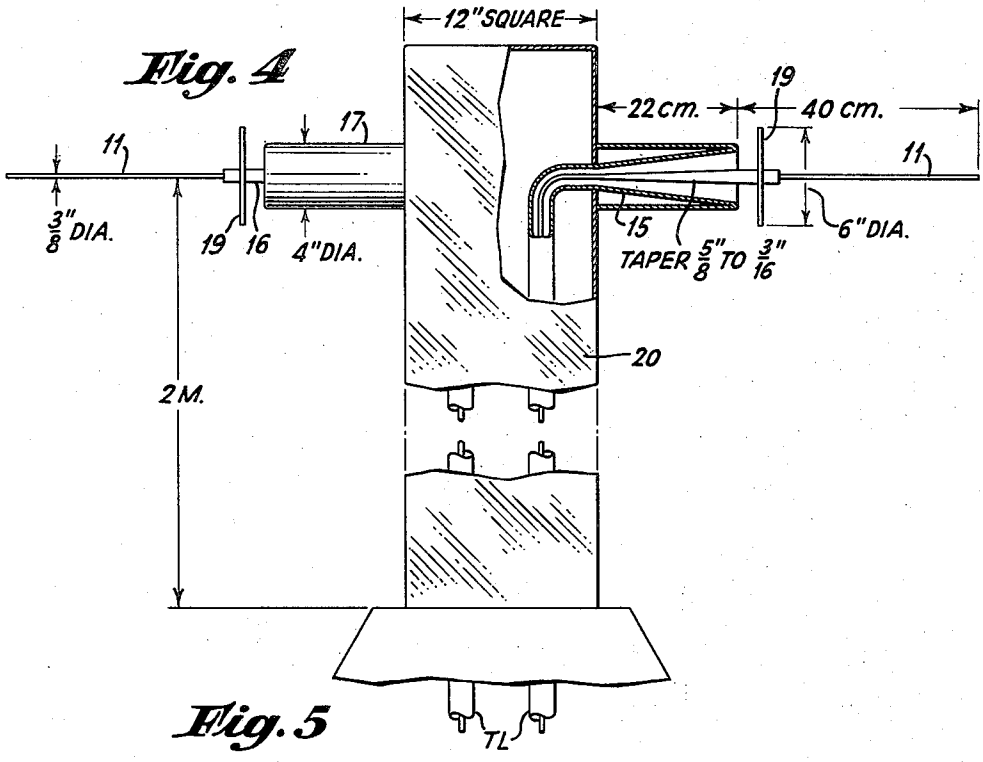


Fig. 5

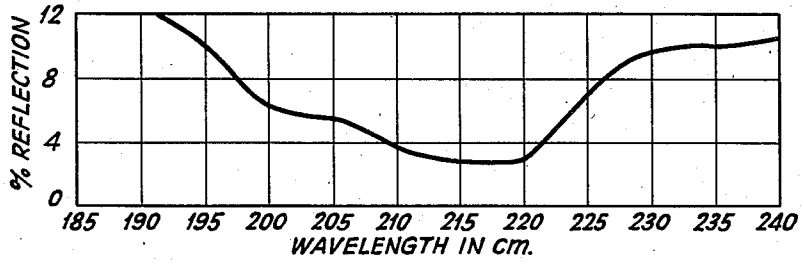
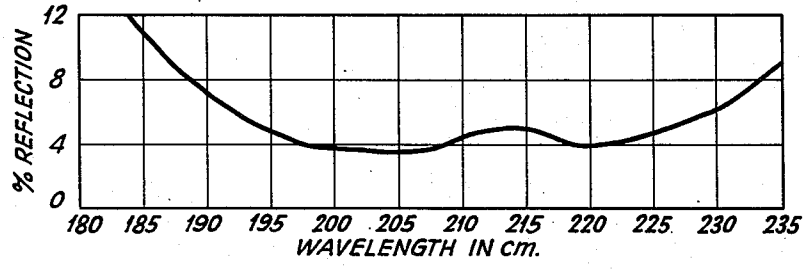


Fig. 7



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June 9, 1942. N. E. LINDENBLAD 2,286,179

WIDE BAND ANTENNA

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Fig. 6

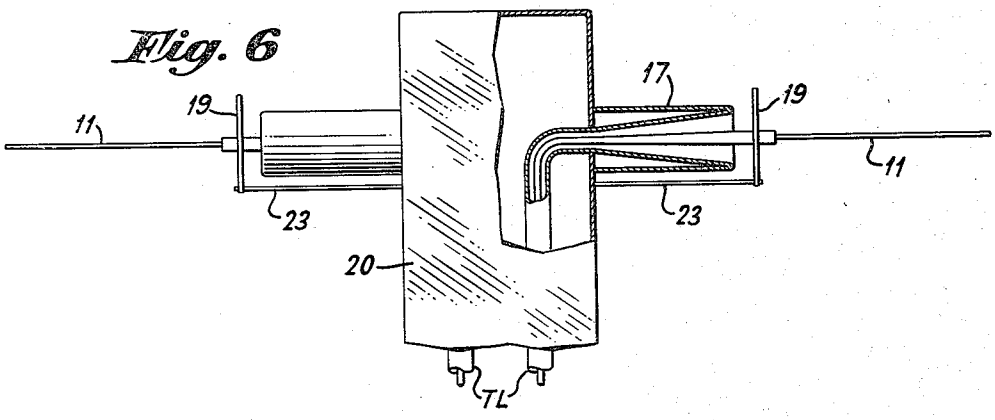
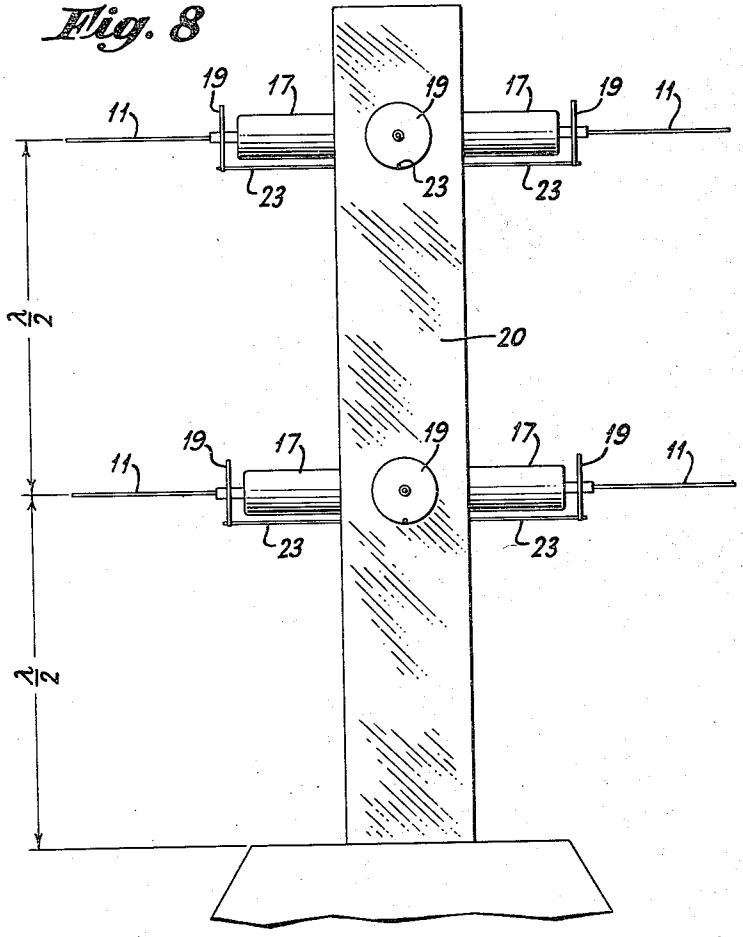


Fig. 8



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Fig. 9

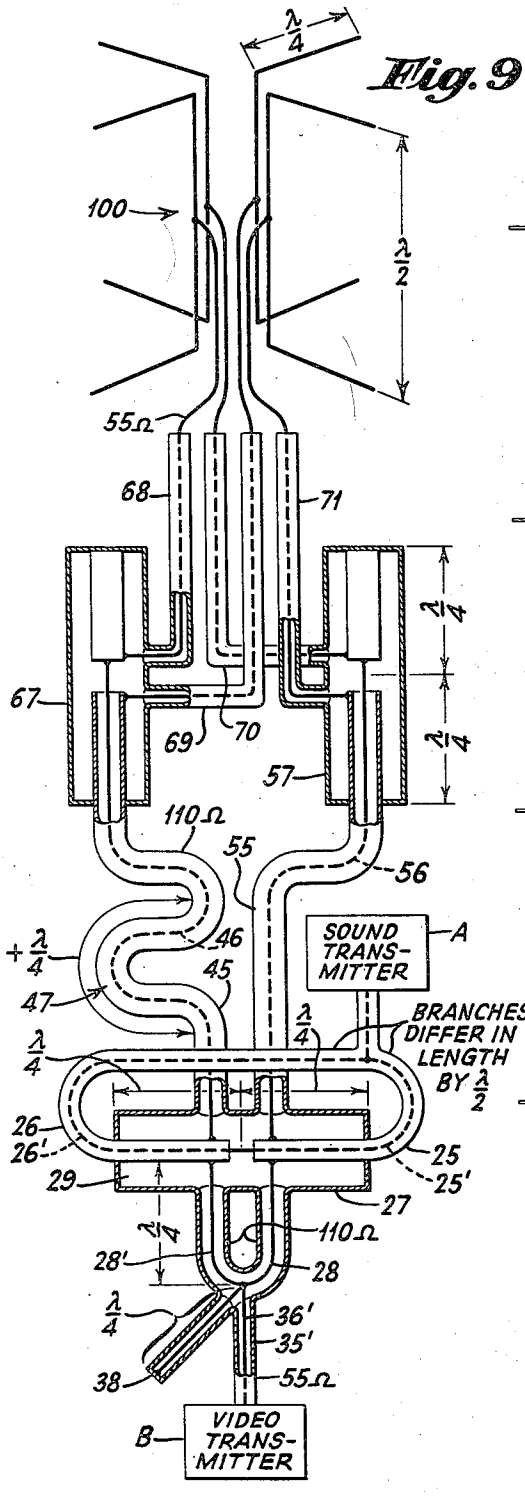
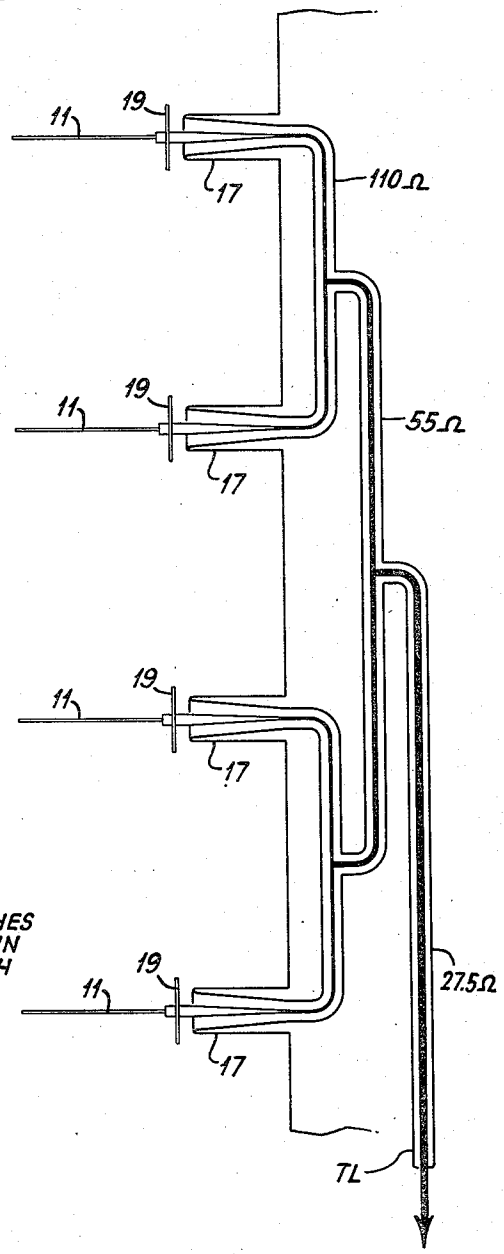


Fig. 12



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Fig. 10

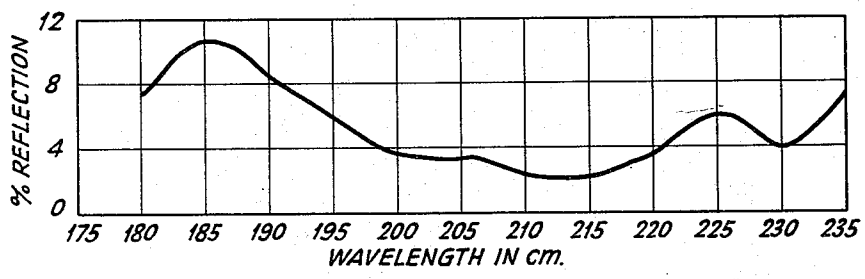
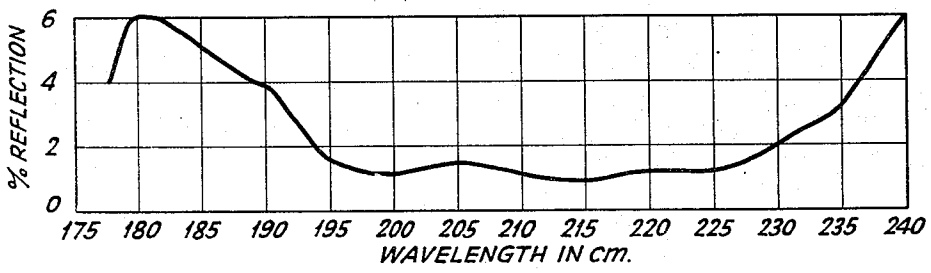


Fig. 11



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Patented June 9, 1942 2,286,179

UNITED STATES PATENT OFFICE

2,286,179

WIDE BAND ANTENNA

Nils E. Lindenblad, Rocky Point, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application July 10, 1940, Serial No. 344,683

21 Claims. (Cl. 250—33)

The present invention relates to a short wave antenna and, more particularly, to a short wave antenna adapted to radiate a wide band of frequencies.

An object of the present invention is to provide an antenna suitable for the transmission of a wide band of frequencies which may be constructed at a moderate cost.

A further object of the present invention is to provide an antenna structure capable of radiating television signals and the accompanying audio signals from the same radiating elements.

Another object of the present invention is to provide an antenna adapted to transmit horizontally polarized waves with a relatively low and a relatively constant circuit loss over a range of frequencies covering at least one television channel including both video and audio signals.

A further object of the present invention is to provide a single antenna structure which will radiate signals from both vision and sound transmitters of a television station without requiring frequency selective filters for preventing coupling between the transmitters.

Still another object of the present invention is to provide an antenna having means included therein for adjusting the input impedance of the radiator elements to compensate for variations in impedance due to the effect of surrounding objects.

Still a further object of the present invention is to provide an antenna having the above characteristics and which, in addition, shall be mechanically safe when used on tall buildings and towers.

A further object is to provide an antenna which will be simple, mechanically strong and substantially entirely metallic in construction.

Still another object of the present invention is to provide an antenna in which otherwise insulated portions are provided with conductive mechanical supports by which the antenna will be entirely electrically grounded for protection against lightning and which, though grounded, will not have its operation as an effective and efficient high frequency antenna impaired or otherwise affected.

The present antenna is a further development of the antenna disclosed in my copending application, Serial No. 208,573, filed May 18, 1938.

The above mentioned objects of the present invention, and others which may appear from the following detailed description, are attained by a modification and reconstruction of the radiating elements forming the antenna shown in my prior application and by utilizing a common antenna system for both video and audio signals.

The present invention features an antenna comprising one or more fairly large diameter radiators having mounted thereon discs which have a diameter which is a large fraction of the length of the operating wave. As an example, I have used, in accordance with the principles of the present invention, discs having a diameter of 6 inches (15 centimeters) when operating at a mean wavelength of 210 centimeters. The radiators of an antenna constructed according to the present invention are connected to the associated apparatus by means of a concentric transmission line, the transmission line being gradually expanded to make a smooth transition between a comparatively small diameter transmission line and the larger effective diameter of the radiator. The ratio between the diameters of the inner and outer conductors of the transmission line is kept constant in the transition section in order to prevent any material change in the characteristic line surge impedance. In order to maintain a constant ratio of resistance to low reactance in one modification of the present invention, the antenna is so arranged that a shell surrounding the tapered outer conductor of the transition section and connected thereto comprises a portion of the radiator with the protruding central conductor as the other portion. The integrated length of the combination is substantially of the order of a quarter of the operating wavelength. Each radiator as a whole is effectively energized at the transition point between the sleeve and the central extention portion of the quarter wave radiating system. This makes the sleeve portion of the antenna a parallel reactance of predominant inductive value and the center conductor extension with its loading disc a series reactance of predominant capacitive value. The diameter of the loading disc heretofore mentioned is so chosen as to obtain an increase in the capacitive reactance of the radiator to the desired extent, to correct the impedance characteristics of the radiator element of which it is a component and also to compensate for the inductance of the grounding shunt which will be mentioned forthwith. By electrically connecting a portion near the edge of the disc to the shell portion of the transmission line or to the supporting grounded column, any possible fluctuation in phase relationship between the different portions of the antenna are avoided and metallic ground-

ing of the entire antenna is permissible. In order to compensate for the shunting inductance caused by this connection, a compensating shunt capacity may be provided. This may be done by increasing the ratio between the diameters of the outer and inner conductors of the transmission line along the length of the tapered transitional portion between the transmission line proper and the antenna, the diameter of the disc may be increased, or its spacing from the end of the tapered section decreased.

The foregoing principles of the present invention may be applied to a turnstile antenna having a plurality of horizontal substantially quarter wave sections arranged around the central supporting tower and mechanically and electrically connected at the center. These radiators may be energized in the proper phase relationship to generate a rotating electrical field as disclosed in Patent #2,086,976, issued to G. H. Brown, July 15, 1937. Also, a plurality of turnstiles may be arranged one above the other and energized by the desired signals.

According to one aspect of the present invention wherein a plurality of signals are applied to the same radiators, opposite relative phase rotation for the signals may be provided in order to reduce the coupling between the sources of the signals.

Further objects, features and advantages of the present invention may be more fully understood by reference to the following detailed description, which is accompanied by a drawing in which Figure 1 illustrates one form of the present invention, while Figures 2 and 3 are curves illustrative of the effects of variation in dimensions in the antenna shown in Figure 1; Figure 4 illustrates a modification of the invention and Figure 5 is a curve showing the improved characteristics obtained by the antenna as constructed according to Figure 4; Figure 6 illustrates a further modification of the form of the invention shown in Figure 4 and Figure 7 illustrates the effect of the modifications of Figure 6; Figure 8 shows a further modification of the present invention in which a plurality of radiators constructed as shown in Figure 6 are combined to make a turnstile antenna; Figure 9 illustrates a transmission line circuit for energizing an antenna as shown in Figure 8 from a plurality of transmitters; Figures 10 and 11 illustrate the effect of the addition of various features of the transmission line circuit shown in Figure 9 while Figure 12 illustrates in partial section one way in which a four-tiered turnstile antenna may be energized.

Referring, now, to Figure 1 it will be seen that the antenna constructed according to one aspect of the present invention consists of a pair of coaxially arranged radiator elements 11 supported on opposite sides of a supporting column 20 at a distance approximately equal to one wavelength above a roof 21 of a building. The radiating elements 11 are energized from a transmitter (not shown) through the medium of a pair of transmission lines TL. The transmission lines TL each comprise an outer shell 13 and an inner conductor 14. The inner conductor 14 is connected to one end of the radiator 11 by a tapering transition section 16. The outer shell 13 of the transmission line is continued over the tapering section 16 as a shell portion 15 which is also tapered. The tapers of the transition section 16 and the shell section 15 are so related that the ratio of the diameter of 16 with respect to the inside diameter of shell section 15 is constant throughout the length of the transition section. The tapered portion of the transmission line is covered by an outer shell 17 which is connected thereto at its outer end and acts in conjunction with element 11 to form substantially a quarter wavelength radiator.

In order to determine the performance of the antenna shown in Figure 1, signals of various frequencies were applied to the transmission line and the percentage of reflection on the transmission lines were measured.

Plotting the percentage of reflection as ordinates against wavelengths as abscissa, the curve of Figure 2 is obtained. The amount of reflection obtained was derived from the ratio between the maximum and minimum current values appearing at different points along the transmission line. The reflection may be caused in several ways. First, the loading resistance may not correspond to the line feeding it; second, the loading impedance may be correct, but a reactive component may be present; third, both of these causes may be combined. The quantity and kind of reflection present is determined from the position of current or voltage maxima or minima of the standing wave component on the line. If it is desired to obtain an expression of the reflection in percentage terms, as has been done for the curve of Figures 2, 3, 5, 7, 10, 11, and taking a specific example where the ratio of maximum voltage E_{max} to minimum voltage E_{min} is 1.1 to 1 the percentage reflection is obtained from the following expression:

$$\text{Per cent reflection} = \frac{E_{max}-E_{min}}{E_{max}+E_{min}} = \frac{1.1-1}{1.1+1} = \frac{0.1}{2.1} = 4.75\%$$

It will be seen that the antenna as first constructed had a percentage of reflection of 16 or less for a band of wavelengths varying from 192 to 230 centimeters. As shown in the curve in Figure 3, the band of wavelengths at which the reflection was 16% or less was increased to from 184 centimeters to 232 centimeters by increasing the size of the supporting column from 6 inches to 12 inches square and making adjustments of the ratio of diameters in the transition section. These changes are shown in Figure 4.

The antenna of Figure 1 was further modified in the form shown in Figure 4 by the addition of loading discs 19. The addition of discs 19 caused an increase in the capacitive reactance of the radiating elements of the antenna and thus compensated for a previous excess inductive reactance. It will be noted also that radiators 11 were decreased in diameter for a portion of their length. The improvement due to these changes is shown in Figure 5.

The curve of Figure 5 has a vertical scale of twice that used in Figures 2 and 3 and it will be noted that the percentage of reflection is now 8 or less over a band of wavelengths ranging from 197 to 227. For a considerable portion of this band of wavelengths the reflection is less than 4%. It will thus be seen that the addition of the capacitive loading discs resulted in a substantial improvement. In accordance with my invention, the loading discs 19 may be slidably mounted on the transition section 16 so that corrections may readily be made for local conditions arising after the antenna has been installed. Furthermore, the radiating elements 11 may be arranged to telescope within the element 16 so that the length may be finally adjusted after the installation of the antenna is com-

pleted. After the desired adjustment is obtained the parts may be fastened rigidly together by means of set screws or they may be soldered or brazed into position. In adjusting the position of discs 19 the aim is to approach a combination of the capacitive effect of the discs 19 and the inductive effect of shell 17 such that the square root of the inductance-capacity quotient is equal to the radiation resistance of each radiator component for as wide a frequency band as possible.

The radiation resistance R of each component of the antenna is largely determined by the relative length of the radiating elements 11. The impedance of the component elements also depends upon their diameter. It is, of course, desirable that the total resultant impedance, which happens to approach the radiation resistance of each component, be substantially equal to the surge impedance of the transmission line by which it is energized. The line surge impedance is obtained by the use of the formula

$$Z = 138 \log \frac{(D)}{d}$$

where D is the inner diameter of the outer tube 13 and d is the outer diameter of inner conductor 14 of the concentric line.

A further modification of the invention shown in Figure 4 is shown in Figure 6 wherein grounding shunts 23 have been connected between discs 19 and the supporting tower 20. The grounding shunts are highly desirable since they not only aid in supporting the radiating portion of the antenna but they also positively ground the radiators as a protection against lighting strokes and, furthermore, an aid in preventing fluctuations of the impedance within the desired operating frequency band. The introduction of the grounding shunts 23 has another effect which will also be noticed. They constitute a shunt or parallel current path from the center conductor 14 of the transmission line to the shell 15 and thus increase the impedance of the antenna looking into the transmission line TL. This shunt is predominantly inductive. The increase in the shunt inductance may be compensated for by decreasing the ratio of the inner diameter of the outer conductor 15 to the outer diameter of inner conductor 16 along the length of the transitional portion or tapered section. This results in a decrease of the surge impedance along the length of the expanding portion and the resultant capacity compensates for the increase in inductance caused by the shunt 23. The shunt inductance may be also compensated for by either increasing the diameter of discs 19 or by decreasing the spacing from the end of shell portion 17. With the grounding shunts 23 in place the improvement of band width of the antenna obtained is shown by the curve in Figure 7. It will be noted that now the reflection is 4% or less for wavelengths varying from 197 centimeters to 223 centimeters. This is a substantial improvement not only in the percentage of reflection but, also, the width of the band obtained.

It will be noted from the results shown in the curve of Figure 7 that it is possible by utilizing my invention, as far as it has now been described, to provide a radiator without curved surfaces and without phase quadrature combinations which has a band width of 17 percent. However, an antenna such as just described has disadvantages for broadcast transmission since it is somewhat directional in the horizontal plane. Furthermore, its vertical directivity is not as high as desired. Therefore, the principles of the present invention, discussed above, may be applied to a double layer turnstile antenna as shown in Figure 8. Since each turnstile, in effect, comprises two dipoles at right angles there is no directivity in the horizontal plane. The stacking of two turnstiles one above the other spaced apart substantially a half wavelength, for example, introduces a desirable vertical directivity. It is believed that the construction will be evident from Figure 8 without further description, especially when the foregoing description of the more elementary embodiments is considered.

The radiators of the antenna shown in Figure 8 may be energized by a transmission line system such as shown in Figure 9. In Figure 9 I have shown a sound transmitter A and a video transmitter B arranged to feed a single antenna of the type shown in Figure 8 and in this figure denoted generally by the reference character 100. The sound transmitter A is connected to a pair of transmission lines 25, 25' and 26, 26', said lines differing in length by a half wavelength. The load ends of the pair of transmission lines are turned to face each other in an end to end relationship and surrounded by a shell 27. The shell 27 has a length equal to a half wavelength and is connected at its ends to the outer sheaths 25 and 26.

Due to the half wavelength difference in lengths of lines 25, 25' and 26, 26', the inner conductors may be directly connected as shown and a pair of balanced output lines composed of outer sheaths 45, 55 and inner conductors 46, 56, connected adjacent ends of sheaths 25 and 26. Energy from transmitter A thus is supplied by conductors 46, 56 in a push-pull relationship. The converter for joining the single-sided circuit to the pairs of balanced lines 46, 56 is generally denoted by reference numeral 29. Shell 27 surrounding the last quarter wave sections of sheaths 25, 26 prevents the flow of current along the outside of the sheaths and since the structure within the shell is symmetrical any reactive components introduced due to the junction 29 are balanced with respect to conductors 46, 56. The construction and theory of the operation of the converter 29, as thus far described, is more fully disclosed in copending application #275,193, filed May 27, 1939 (RCA D. #17322) to which reference may be made for further details.

The video transmitter B energizes a single-sided transmission line 35', 36' which is connected to the pair of balanced lines 46, 56, through conductors 28, 28', each having a length equal to a quarter of the mean operating wavelength. Thus energy is introduced into conductors 46, 56 in a push-push or in-phase relationship from transmitter B. Since the sum of the lengths of conductors 28, 28' is a half wavelength, no adverse effect on signals from transmitter A on conductors 45, 46 is introduced. By inserting a loop 47 having a length equal to a quarter of the mean wavelength in one of the balanced lines, energy in phase quadrature is obtained at their far ends, the phase rotation being in opposite directions for the signals from the two transmitters. The opertaion of the complete converter for supplying energy in phase quadrature in opposite rotation from a pair of separate signal sources is more fully described in copending application #338,177, filed May 31, 1940,

(RCA D. #15391), to which reference may be made for further details.

As pointed out in my prior copending application #338,177 (RCA D. #15391), through circuit symmetry the two inputs to the converter **29** are entirely uncoupled from each other for all frequencies as long as there are no returning waves due to reflection from the antenna. In order to compensate for any slight remaining reactance in the lines due to the converter **29** a quarter wave stub **38** is inserted at the junction of conductors **28, 28'** and **36**. The quarter wave stub **38** being spaced a quarter wavelength from the quarter wavelength shell portions of transmission lines **25, 26** within converter **29** compensates for any reactance due to that cause. The theory of operation of the quarter wave spacing between similar reactance whereby they mutually compensate for each other is more fully set forth in a prior patent to E. C. Cork, et al., #2,165,961, issued July 11, 1939. Four phase energy for the antenna **100** is supplied from transmission lines **45, 55** through the medium of a pair of single to push-pull converters **57, 67** which feeds transmission lines **68, 69, 70** and **71**. The operation of these converters is generally the same as that of converter **29**, except that the single lines enter only one end of the converter as in the case of the converters described in copending application #276,193.

The transmission lines **68, 69, 70** and **71** are so connected that opposite radiations of antenna **100** are energized in phase opposition or push-pull. The adjacent radiators are energized in phase quadrature. Rotating fields due to the energy from two transmitters are thus simultaneously radiated from a single antenna structure. The rotation of one field is opposite to that of the other.

By using the transmission line as shown in Figure 9 it will be thus seen that it is possible to utilize a common antenna for audio and video signals without requiring resonant filters for preventing interaction between the transmitters. The curves in Figures 10 and 11 show the amount of reflection obtained in an antenna constructed as shown in Figure 8 energized by a transmission line system as shown in Figure 9 with and without the quarter wave compensating stub **38** of Figure 9.

It will be noted from Figure 11 that the compensating stub causes a substantial improvement since the vertical scale of Figure 11 is twice that of Figure 10. A band width of over 27 percent is readily obtained as shown in Figure 11.

In Figure 9 I have considered the radiation resistance of each element of the antenna **100** as 110 ohms. Transmission lines **68, 69, 70** and **71** thus have a surge impedance of 55 ohms since each feeds two radiators in parallel. Lines **45, 55**, therefore, have an impedance of 110 ohms and lines **25, 26** and **35**,' 55 ohms each.

If it is desired to obtain a greater amount of vertical directivity the antenna may be constructed as shown in part section in Figure 12. Only a portion of the antenna has been shown here since the antenna structure is entirely symmetrical about its vertical axis. In this figure there is shown a four layer vertical turnstile. Each of the radiating elements as shown in Figure 12 has a radiation resistance of approximately 110 ohms so they are connected in pairs through 110. ohm lines to a 55 ohm cross connecting line and the center point of the 55 ohm line is then connected to a 27.5 ohm line identified by the reference character **TL**. There are, of course, in the completed antenna four such transmission lines **68, 69, 70, 71** to an energizing system such as shown in Figure 9. Due to the use of four levels of the turnstile the line impedance of all the converter connections is cut in half and any adverse effects due to reactance effects of the quarter wave liberator sleeves within the converters correspondingly reduced. In some cases where a four layer turnstile is used, it may not be necessary to use the quarter wave compensating stub identified by numeral **38** of Figure 9, due to the lower impedance of all of the lines.

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

I claim:

1. An antenna comprising a radiating conductor element having a length of the order of a quarter of the operating wavelength and having conductively mounted transversely thereon at a point intermediate ends a conductor disc and means for energizing said element connected to one end thereof.

2. An antenna comprising an elongated radiating conductor element having conductively mounted transversely thereof at a point intermediate its ends a conductor disc having a diameter which is large in terms of the operating wavelength, a transmission line and means for coupling said transmission line to said conductor element comprising a tapered concentric conductor section naving a central conductor and an outer shell surrounding said conductor, the ratio of the diameter of said conductor and shell being constant through the length of said tapered section whereby a gradual transition between said transmission line and said antenna is attained without material change in the line surge impedance.

3. An antenna comprising a radiating conductor element having conductively mounted thereon at a point intermediate its ends a conductor disc having a diameter which is large in terms of the operating wavelength, a transmission line, and means for coupling said transmission line to said conductor element comprising a tapered conductor section connected between said line and said radiating element.

4. An antenna comprising a linear aerial conductor element having mounted transversely thereof at a point intermediate its ends a conducting disc having a diameter which is a large fraction of the length of the operating wave, a concentric conductor transmission line having an outer sheath and an inner conductor and means for coupling said line to said conductor element comprising a tapered concentric conductor section having a central conductor connected to said aerial and said inner conductor, and an outer shell surrounding said central conductor and connected to said outer sheath, the ratio of the diameter of said central conductor and shell being constant through the length of said tapered section whereby a gradual transition between said transmission line and said antenna is attained without material change in the line surge impedance.

5. An antenna system comprising a number N of linear aerial conductor elements each having mounted transversely thereof at a point intermediate its ends a conducting disc having a

diameter which is a large fraction of the length of the operating wave, said elements being disposed radially about a central point and in a common horizontal plane, each conductor spaced substantially 360/N degrees from adjacent conductors and means for maintaining radio frequency voltages on said conductors, the phase relation between the voltages on adjacent conductors being 360/N electrical degrees, said means comprising a concentric conductor transmission line and means for coupling said line to each of said conductor elements comprising a number of tapered concentric conductor sections, each having a central conductor and an outer shell surrounding said conductor, the ratio of the diameter of said conductor and shell being constant through the length of said tapered section whereby a gradual transition between said transmission line and said antenna is attained without material change in the line surge impedance.

6. An antenna system comprising a central conductor and an outer shell surrounding said conductor, said central conductor extending beyond the end of said outer shell, a conductive disc mounted on said central conductor beyond the end of said outer shell, a concentric cable transmission line connected to said conductor and shell and forming a continuation thereof, and a conductive support connected between the edge of said disc and said outer shell, said connection acting as an inductance connected between said conductor and said shell.

7. An antenna system comprising a central conductor and an outer shell surrounding said conductor, said central conductor extending beyond the end of said outer shell, a conductive disc mounted on said central conductor beyond the end of said outer shell, a concentric cable transmission line connected to said conductor and shell and forming a continuation thereof, and a conductive support connected between the edge of said disc and said outer shell, said connection acting as an inductance connected between said conductor and said shell, the space between said disc and the end of said outer shell being so adjusted that the capacity therebetween compensates for the inductance of said conductive support.

8. An antenna system comprising a plurality of radiating elements disposed radially in a common plane about a central neutral point, each of said elements formed of a central conductor having mounted transversely thereof at a point intermediate its ends a disc having a diameter which is large in terms of the operating wave, and an outer shell surrounding said conductor, said central conductor extending beyond the end of said shell, a concentric cable transmission line and means within said outer shell for coupling said line at said central point to each of said elements, said means comprising a tapered conductor connected to said central conductor, the ratio of the diameters of said tapered conductor and the interior of said shell being constant through their length whereby a gradual transition between said transmission line and said antenna is attained without material change in the line surge impedance, and a conductive support connected between the edge of the disc and the shell of each of said radiating elements, said connection acting as an inductance connected therebetween.

9. An antenna system comprising a plurality of radiating elements disposed radially in a common plane about a central neutral point, each of said elements formed of a central conductor having mounted transversely thereof at a point intermediate its ends a disc having a diameter which is large in terms of the operating wave, and an outer shell surrounding said conductor, said central conductor extending beyond the end of said shell, a concentric cable transmission line and means within said outer shell for coupling said line at said central point to each of said elements, said means comprising a tapered conductor connected to said central conductor, the ratio of the diameters of said tapered conductor and the interior of said shell being constant through their length whereby a gradual transition between said transmission line and said antenna is attained without material change in the line surge impedance, and a conductive support connected between the edge of the disc and the shell of each of said radiating elements, said connection acting as an inductance connected therebetween, the space between said disc and the end of said outer shell being so adjusted that the capacity therebetween compensates for the inductance of said conductive support.

10. An antenna comprising a radiating conductor element, having mounted transversely thereof at a point intermediate its ends a conductor disc having a diameter which is large in terms of the operating wavelength, a concentric conductor transmission line having an inner conductor and an outer sheath, and means for coupling said transmission line to said conductor element comprising a tapered concentric conductor section having a central conductor and an outer shell surrounding said conductor, the ratio of the diameter of said conductor and shell being constant through the length of said tapered section whereby a gradual transition between said transmission line and said antenna is attained without material change in the line surge impedance.

11. An antenna comprising a radiator conductor element, having a length of the order of a quarter of the operating wavelength and having conductively mounted thereon at a point intermediate its ends a conductor disc having a diameter which is large in terms of the operating wavelength and means for energizing said element connected to one end thereof.

12. An antenna system comprising four linear aerial conductor elements each having mounted transversely thereof at a point intermediate its ends a conducting disc having a diameter which is a large fraction of the length of the operating wave, said elements being disposed radially about a central point and in a common horizontal plane, each conductor spaced substantially 90 degrees from adjacent conductors, a pair of transmitters and means for energizing each of said aerial conductor elements from both of said transmitters, the phase relation between the voltages on adjacent conductors being 90 electrical degrees, the relative phase displacement of energy from said two transmitters on said conductor elements being in opposite directions.

13. An antenna system comprising four linear aerial conductor elements each having mounted transversely thereof at a point intermediate its ends a conducting disc having a diameter which is a large fraction of the length of the operating wave, said elements being disposed radially about a central point and in a common horizontal plane, each conductor spaced substantially 90 degrees from adjacent conductors, a pair of transmitters and means for energizing each of

said aerial conductor elements from both of said transmitters, the phase relation between the voltages on adjacent conductors being 90 electrical degrees, the relative phase displacement of energy from said two transmitters on said conductor elements being in opposite directions, each of said means comprising a concentric conductor transmission line and means for coupling said line to each of said conductor elements comprising a number of tapered concentric conductor sections, each having a central conductor and an outer shell surrouding said conductor, the ratio of the diameter of said conductor and shell being constant through the length of said tapered section whereby a gradual transition between said transmission line and said antenna is attained without material change in the line surge impedance.

14. A turnstile antenna comprising at least one pair of crossed horizontal dipoles, a pair of sources of high frequency oscillations, means for energizing the dipoles of said antenna from both of said sources in a phase quadrature relationship whereby energy from each of said sources establishes a rotating field, the phase quadrature relationship of energy in said dipoles from said sources progressing in opposite directions whereby said fields rotate in opposite directions around said antenna.

15. A turnstile antenna comprising a plurality of pairs of crossed horizontal dipoles arranged about a common vertical axis, a pair of sources of high frequency oscillations, means for energizing each of the crossed dipoles of said antenna from both of said sources in a phase quadrature relationship, the phase quadrature relationship of energy in said dipoles from said sources progressing in opposite directions around said antenna.

16. An antenna as set forth in claim 14 in which each of said dipoles comprises a pair of coaxial substantially quarter wave linear conductors, each of said conductors having conductively mounted thereon at a point intermediate its ends a conductive disc having a diameter which is large in terms of the operating wavelength.

17. An antenna as set forth in claim 15 in which each of said dipoles comprises a pair of coaxial substantially quarter wave linear conductors, each of said conductors having conductively mounted thereon at a point intermediate its ends a conductive disc having a diameter which is large in terms of the operating wavelength.

18. An antenna as set forth in claim 14 in which each of said dipoles comprises a pair of coaxial substantially quarter wave linear conductors having conductively mounted transversely thereof at a point intermediate its ends a conducting disc having a diameter which is a large fraction of the length of the operating wave, a concentric conductor transmission line for each linear conductor and means for coupling said line to said linear conductor comprising a tapered concentric conductor section having a central conductor connected to said aerial and said transmission line, and an outer shell surrounding said conductor, the ratio of the diameter of said conductor and shell being constant through the length of said tapered section whereby a gradual transition between said transmission line and said antenna is attained without material change in the line surge impedance.

19. An antenna system comprising a central conductor and an outer shell surrounding said conductor, said central conductor extending beyond the end of said outer shell, a conductive disc mounted on said central conductor beyond the end of said outer shell, said central conductor extending beyond said disc, a concentric cable transmission line connected to said conductor and shell and forming a continuation thereof.

20. An antenna comprising a plurality of radiating elements radially arranged about a common center, means for so energizing said elements from a first source of high frequency energy that a radiant energy field rotating in one predetermined direction is established and means for simultaneously so energizing said elements from a second source of high frequency energy that a second radiant energy field rotating in a direction opposite to said predetermined direction is established.

21. An antenna comprising a plurality of radiating elements radially arranged about a common vertical axis, means for so energizing the said elements from a first source of high frequency energy that a field of horizontally polarized energy rotating in one predetermined direction is established and means for simultaneously so energizing said elements from a second source that a field of horizontally polarized energy rotating in a direction opposite to said predetermined direction is established.

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