Feb. 9, 1943. N. E. LINDENBLAD 2,310,853

ANTENNA

Filed Dec. 20, 1941

Fig.3

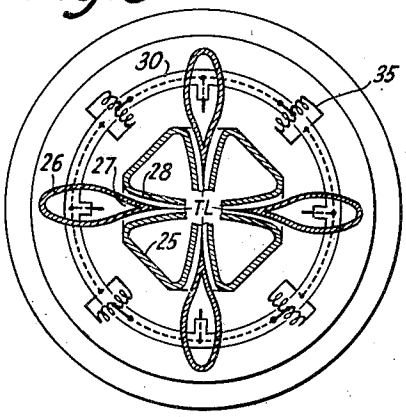


Fig.2

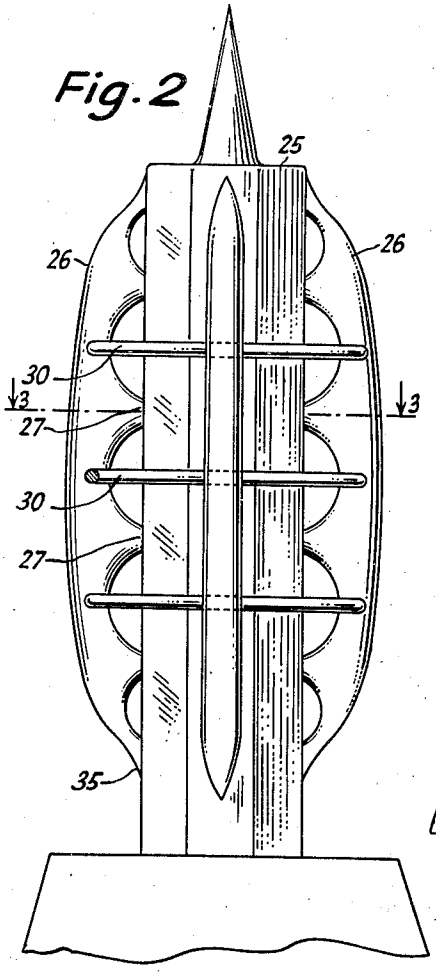
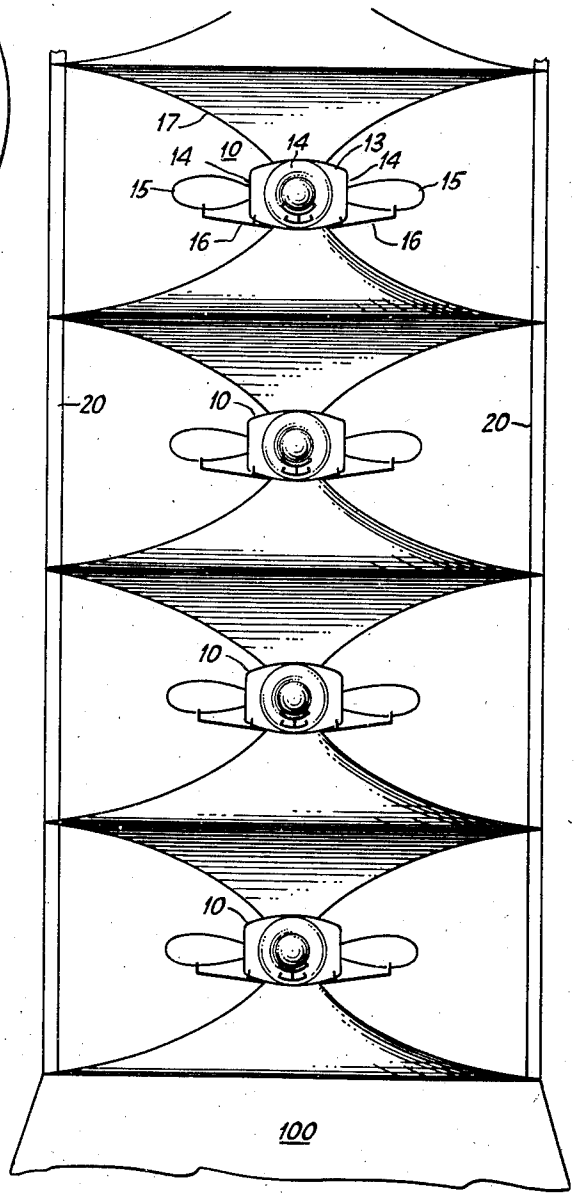


Fig.1



INVENTOR
NILS E. LINDENBLAD
BY H. G. Grover
ATTORNEY

Patented Feb. 9, 1943 2,310,853

UNITED STATES PATENT OFFICE

2,310,853

ANTENNA

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

Application December 20, 1941, Serial No. 423,748

15 Claims. (Cl. 250—11)

The present invention relates to ultra short wave antennae and, more particularly, to such antennae for operation over an extremely broad band of frequencies.

The present invention is a modification of the antenna disclosed in my prior Patent #2,239,724, granted April 29, 1941.

An object of the present invention is the provision of an antenna suitable for radiating horizontally polarized waves covering an extremely wide band of frequencies without substantial frequency discrimination.

A further object of the present invention is the provision of an antenna for broadcasting a wide range of frequencies substantially uniformly in all horizontal directions.

Another object of the present invention is to improve the vertical directivity of ultra short wave broadcast antennae.

Still another object of the present invention is the provision of a single antenna structure for radiating a plurality of separate high frequency waves without interaction therebetween.

Still a further object of the present invention is the provision of a single mechanically strong antenna which is entirely electrically grounded as a protection against lightning without, at the same time, effecting its efficiency as a radiator of high frequency waves.

Still another object is the provision of an antenna structure which does not depend for structural stability upon the mechanical strength of insulating materials in its assembly.

The present antenna includes a plurality of vertically stacked horizontal turnstile antennae with wave directive structure associated with each turnstile and its supporting structure for increasing the directivity of each turnstile in the vertical plane. The wave directive structure also acts to prevent random phase combination of energy radiated by each of the turnstiles and thus increases the vertical directivity of the array beyond that which would normally result from the vertical stacking of the antennae.

In a modified form of the invention each of the radiating arms of the turnstiles in vertical alignment are electrically joined at their outer ends to form vertical fins. Horizontally disposed conductive rings are used to connect oppositely disposed fins at a plurality of vertically spaced points. While each ring is in electrical contact with each fin the diameter of the ring is so chosen that adjacent fins are effectively isolated one from the other, the length of the conductor from one fin to the next being such that a high impedance is presented to the operating frequency. At the same time the conductive length between alternate fins is such as to present a much lower impedance at the operating frequency. Furthermore, the rings may at the same time act as a vertically stacked array of ring antennae by being energized at a different frequency through the intermediary of toroidal coupling coils surrounding the rings at spaced points.

The present invention will be more fully understood by reference to the following detailed description, which is accompanied by a drawing in which Figure 1 shows an embodiment of the present invention, while Figure 2 shows a modification thereof and Figure 3 shows a horizontal section of the antenna shown in Figure 2 taken along lines 3, 3 of Figure 2 and in which a further modification has been illustrated.

In Figure 1, the antenna array comprises a plurality of broad band turnstile type antennae, each of which is identified by reference numeral 10. Each of the turnstile antenna 10 is constructed according to the principles set forth in my prior Patent #2,239,724, granted April 29, 1941, and includes a cross shaped hub 13 having radially extending arms 14. From each of the arms 14 of the hub extend radiating elements 15. Elements 15 are of generally ellipsoidal form with their inner ends tapered gradually down to the diameter of the inner conductor of the transmission line by means of which they are energized. The tapering portion may be continuously curved, as in a horn, following an exponential, ellipsoid or other curved line. The radiating elements 15 extend a considerable distance into arms 14 of hub 13 and are therein surrounded by a gradually expanding horn shaped portion connected at its inner end to the outer shell of the energizing transmission line and at the outer end to the end of the arms 14. The portions of radiating elements 15 which extend beyond the ends of arms 14 have a predominantly capacitive reactance while the arms 14 have a parallel reactance characteristic which is predominantly inductive. These elements are conductively in series across the transmission line and form a series tuned circuit having a wide band width characteristic. Generally, the inductance L of arm portion 14 and the capacity C of the extending radiating elements 15 are proportioned with respect to the radiation resistance R of each component of the antenna that the following relationship is attained:

$$\sqrt{\frac{L}{C}}=R$$

A conductive supporting arm 16 is provided between each of the radiating elements 15 and the immediately adjacent arm portion 14. In addition to supporting the ellipsoidal members 15, the connection between these two elements has a further beneficial effect. Without the connection, the phase relationship between the extending portion 15 and the arm 14 has sometimes too much freedom so that some irregularities in the impedance may occur within the desired operating frequency band. The connection avoids these irregularities. The connection also is of great importance in that it permits a metallic grounding of all parts of the antenna as regards direct current voltages, lightning strokes, etc.

Each complete turnstile element of the array as so far described is arranged within a reflector 17. The reflector is preferably in the form of a surface of revolutions formed by a parabola revolved about its directrix or about a line parallel to the directrix. It thus acts to concentrate in the vertical plane energy radiated from each turnstile 10. Since the reflector 17 is symmetrical with respect to the horizontal plane and since the turnstile element 10 is also symmetrical with respect to the horizontal plane there is no discrimination in any horizontal direction, that is, the radiated energy is substanitally uniformly distributed in all horizontal directions.

The complete antenna array in Figure 1 comprises a plurality of turnstile elements 10, each within its parabolic reflecting structure 17 stacked vertically along a common vertical axis. If desired, in order to increase the mechanical strength of this structure supporting posts 20 may be provided at uniformly spaced points around the periphery of reflectors 17.

The whole antenna may be mounted on the top of a tower or tall building such as that indicated by reference character 100. The top of the structure may be terminated by any symmetrical spire arrangement which may seem desirable from an architectural standpoint. Due to the symmetrical form of the complete antenna it presents an attractive appearance in addition to being an efficient broad band radiator.

The modification shown in Figure 2, likewise, involves a plurality of turnstile radiating elements vertically stacked along a common vertical axis. However, in this form the hub elements, separately shown as elements 13 in Figure 1, are all merged into an octagonal supporting column 25. The radiating elements, shown as supporting ellipsoids 15 in Figure 1, are all merged together at their outer ends to form a comblike structure 26 in which the widely spaced teeth are connected to energizing structure within column 25. A horizontal cross section of member 26, as shown in Figure 3, is substantially ellipsoidal in form having tapering sections 27 extending into the column 25.

As previously described, the tapering portions are surrounded by tapering horns 28, Figure 3, to provide a smooth impedance transformation from the transmission line to the radiating elements per se. In the modification shown in Figure 2 the supporting and impedance restraining functions of arms 16 of Figure 1 are fulfilled by horizontal rings 30. It will be seen that ring 30 connects one member 26, energized in one phase, with a diametrically opposite member energized in opposing phase relationship. The diameter of ring 30 is so chosen that the length of the conductor path between adjacent members 26 is of the order of a quarter wavelength whereby a high impedance is presented. Therefore, it may be considered that each pair of opposing radiators is directly connected while adjacent radiators are electrically isolated one from the other. The point of connection between members 26 and ring 30 must, of course, be so chosen as not to directly short circuit all of the energy fed to the antenna. It will be noted that the antenna of Figure 2, though its conductive members 26 have their length vertical, the effective radiation is horizontally polarized and rotary in character.

If it is desired to radiate a pair of independent but fairly closely adjacent frequencies from the antenna shown in Figure 2, cross coupling networks may be utilized between the transmission lines TL connected to radiators 26 and the necessary transmitters. Alternatively as shown in Figure 3, the rings 30 themselves may be utilized for radiating one signal while the members 26 radiate another signal. This may be accomplished by energizing rings 30 by toroidal coupling coils 35 uniformly distributed around the ring. Energy is fed from one transmitter to the toroidal coupling coils 35 by conductors passing through the ring and down through the length of member 26 and into the supporting column 25 at point 36 where it is electrically connected to the supporting column.

The details of the operation of the toroidal coupling coils do not form a part of the present invention but are completely disclosed and are claimed in my copending application, Serial #403,123, filed July 19, 1941, now Patent #2,296,356, issued September 22, 1942.

It should be noted that in the modification of Figure 2, all of the effective turnstile antennae may be considered to have their top portions, of like polarity, directly connected together. They, therefore, combine their radiation directly and random phase combination of the radiated energy is prevented. The vertical directivity is therefore improved over that which would be expected from a vertical array of a similar number of separate turnstiles.

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

I claim:

1. An antenna array including a plurality of turnstile antennas arranged along a common vertical axis, means for energizing said antennas in the same phase relationship from a source of high frequency energy and means associated with said antennas for preventing the energy radiated thereby from combining in an out of phase relationship within a narrow angle including a line normal to said axis.

2. An antenna array including a plurality of turnstile antennas arranged along a common vertical axis, means for energizing said antennas in the same phase relationship from a source of high frequency energy and means associated with said antennas for causing the energy radiated thereby to combine in an in-phase relationship in directions normal to said axis.

3. An antenna array including a plurality of turnstile antennas arranged along a common vertical axis, means for energizing said antennas in the same phase relationship from a source of high frequency energy and means associated with said antennas for preventing the energy radiated

thereby from combining in an out of phase relationship within a narrow angle including a line normal to said axis, said last means including a reflector surrounding each of said antennas in the form of a surface of revolution generated by revolving a parabola about its directrix, said directrix being coincident with said axis.

4. An antenna array including a plurality of turnstile antennas arranged along a common vertical axis, means for energizing said antennas in the same phase relationship from a source of high frequency energy and means associated with said antennas for causing the energy radiated thereby to combine in an in-phase relationship in directions normal to said axis, said last means including a reflector surrounding each of said antennas in the form of a surface of revolution generated by revolving a parabola about its directrix, said directrix being coincident with said axis.

5. An antenna array including a plurality of turnstile antennas arranged along a common vertical axis, means for energizing said antennas in the same phase relationship from a source of high frequency energy and means associated with said antennas for preventing the energy radiated thereby from combining in an out of phase relationship within a narrow angle including a line normal to said axis, said last means including a reflector surrounding each of said antennas in the form of a surface of revolution generated by revolving a parabola about a line parallel to its directrix, said line being coincident with said axis.

6. An antenna array including a plurality of turnstile antennas arranged along a common vertical axis, means for energizing said antenna in the same phase relationship from a source of high frequency energy and means associated with said antennas for preventing the energy radiated thereby from combining in an out of phase relationship within a narrow angle including a line normal to said axis, said last means including connections from points on one antenna to points on each other antenna carrying the same potential.

7. A antenna array including a plurality of turnstile antennas arranged along a common vertical axis, means for energizing said antenna in the same phase relationship from a source of high frequency energy and means associated with said antennas for preventing the energy radiated thereby from combining in an out of phase relationship within a narrow angle including a line normal to said axis, said last means including connections from points on one antenna to points on each other antenna carrying the same potential, said connections being in the form of vertical fins.

8. An antenna array including a plurality of turnstile antennas arranged along a common vertical axis, means for energizing said antenna in the same phase relationship from a source of high frequency energy, means associated with said antennas for preventing the energy radiated thereby from combining in an out of phase relationship within a narrow angle including a line normal to said axis, including connections from points on one antenna to points on each other antenna carrying the same potential, said connections being in the form of vertical fins and a plurality of conductive rings concentric with said axis and spaced vertically one from the other, each of said rings being connected to each of said fins.

9. An antenna array including a plurality of turnstile antennas arranged along a common vertical axis, means for energizing said antennas in the same phase relationship from a source of high frequency energy, means associated with said antennas for preventing the energy radiated thereby from combining in an out of phase relationship within a narrow angle including a line normal to said axis, including connections from points on one antenna to points on each other antenna carrying the same potential, said connections being in the form of vertical fins and a plurality of conductive rings concentric with said axis and spaced vertically one from the other, each of said rings being connected to each of said fins and means for energizing said rings from a separate source of high frequency energy.

10. An antenna array including a plurality of turnstile antennas, each of said antennas comprising a plurality of radiators arranged radially in a common horizontal plane, said antennas being arranged along a common vertical axis, means for energizing said antennas in the same phase relationship from a source of high frequency energy and means associated with said antennas for preventing the energy radiated thereby from combining in an out of phase relationship within a narrow angle including a line normal to said axis.

11. An antenna array including a plurality of turnstile antennas, each of said antennas comprising a plurality of radiators arranged radially in a common horizontal plane, said radiators being ellipsoidal in longitudinal section, said antennas being arranged along a common vertical axis, means for energizing each of said antennas from a source of high frequency energy to radiate a horizontally polarized rotating field of energy and means associated with said antennas for causing the energy radiated thereby to combine in an in-phase relationship in directions normal to said axis.

12. An antenna array including a plurality of turnstile antennas, each of said antennas comprising a plurality of radiators arranged radially in a common horizontal plane, said antennas being arranged along a common vertical axis, means for energizing said antennas in the same phase relationship from a source of high frequency energy and means associated with said antennas for preventing the energy radiated thereby from combining in an out of phase relationship within a narrow angle including a line normal to said axis, said last means including connections from points on one antenna to points on each other antenna carrying the same potential.

13. An antenna array including a plurality of turnstile antennas, each of said antennas comprising a plurality of radiators arranged radially in a common horizontal plane, said antennas being arranged along a common vertical axis with the radiators thereof in vertical alignment, means for energizing said antennas in the same phase relationship from a source of high frequency energy and means associated with said antennas for causing the energy radiated thereby to combine in an in-phase relationship in directions normal to said axis and including vertical connecting strips connecting the outer ends of each radiator with corresponding radiators in vertical alignment therewith.

14. An antenna array including a plurality of turnstile antennas, each of said antennas comprising a plurality of radiators arranged radially in a common horizontal plane, said antennas being arranged along a common vertical axis with the radiators thereof in vertical alignment, means for energizing said antennas in the same phase

relationship from a source of high frequency energy and means associated with said antennas for causing the energy radiated thereby to combine in an in-phase relationship in directions normal to said axis and including vertical connecting strips connecting the outer ends of each radiator with corresponding radiators in vertical alignment therewith, and a plurality of conductive rings concentric with said axis and spaced vertically one from the other, each of said rings being connected to each of said fins and means for energizing said rings from a separate source of high frequency energy.

15. An antenna array including a plurality of turnstile antennas, each of said antennas comprising a plurality of radiators arranged radially in a common horizontal plurality of radiators arranged radially in a common horizontal plane, said antennas being arranged along a common vertical axis with the radiators thereof in vertical alignment, means for energizing said antennas in the same phase relationship from a source of high frequency energy and means associated with said antennas for causing the energy radiated thereby to combine in an in-phase relationship in directions normal to said axis and including vertical connecting strips connecting the outer ends of each radiator with corresponding radiators in vertical alignment therewith, and a plurality of conductive rings concentric with said axis and spaced vertically one from the other, each of said rings being connected to each of said fins.

NILS E. LINDENBLAD.