MULTI-CHANNEL SLOT ANTENNA FOR ULTRA HIGH FREQUENCIES

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This invention relates to radio antennas for ultra high frequencies, particularly antennas intended for radio and television broadcasting.

One object of the present invention is to provide a new and improved array of antennas capable of simultaneously serving several television or radio stations operating on different frequency channels.

A further object is to provide such a new and improved antenna array in which the radiation patterns for all of the frequency channels are substantially the same, and in which all of the radiation patterns are nearly circular with only minor variations, so that power is effectively radiated in all directions.

Another object is to provide such a new and improved antenna array in which there is only a negligible amount of interference or cross-talk between the various channels.

A further object is to provide such a new and improved antenna array which is structurally sound and is well adapted for erection on a high tower or on top of a high building.

A further object is to provide such a new and improved antenna array which has a configuration and overall dimensions such as to present no serious structural problems.

Another object is to provide such a new and improved antenna array which is reasonably easy to construct and low in cost.

Further objects and advantages of the present invention will appear from the following description, taken with the accompanying drawings, in which:

FIG. 1 is a perspective view of an antenna array to be described as an illustrative embodiment of the present invention.

FIG. 2 is a fragmentary enlarged elevational view of a portion of the array of FIG. 1.

FIG. 3 is a longitudinal section taken generally along the line 4—4 in FIG. 2.

FIG. 4 is a horizontal section, taken generally along the line 5—5 in FIG. 1.

FIG. 5 is a perspective view of an antenna array 10 capable of serving several ultra-high frequency television stations simultaneously. The array may be mounted in the highest and best available location. For example, the antenna array may be mounted on a high tower on top of the highest available building in a metropolitan area. In this way, all of the television stations may benefit from the advantageous location of the antenna array. Moreover, substantial economies may be effected by servicing several television stations simultaneously.

The illustrated antenna array 10 comprises a plurality of antennas in the form of parallel elongated wave guides 12 which are vertically disposed. Virtually any reasonable number of wave guides may be employed so as to service any desired number of television stations. By way of example, the illustrated antenna array 10 comprises six parallel wave guides 12, capable of serving six television stations on different ultra-high frequency channels. Energy is fed to each of the wave guides 12 by an individual transmission facility 14, whereby the transmitter of each television station is connected to the associated wave guide. As shown, the transmission facilities 14 are in the form of coaxial transmission lines or cables connected to the respective wave guides 12.

Each of the illustrated wave guides 12 is in the form of a hollow vertical duct, made of metal so as to be electrically conductive. The cross-sectional shape of the wave guides may be varied, but it is advantageous to employ a rectangular cross section, as illustrated to best advantage in FIGS. 1 and 4. Thus, each of the illustrated wave guides 12 has a pair of opposite parallel sides 16 which are relatively wide or broad, and relatively narrow sides 18 extending between the broader sides 16.

As shown, all of the wave guides 12 are mounted in a single horizontal row, edge to edge, with the narrow sides or edges 18 adjacent each other. The broader sides 16 extend in the direction of the row. On each side of the array, the broader sides 16 of the wave guides 12 are substantially coplanar. As shown, the adjacent narrow sides 18 are secured directly together, but in some cases it may be desirable to space them apart and to interpose structural stiffening or reinforcing members therebetween.

Rounded vertical members 20 may be mounted at both ends of the row of wave guides 12 to reinforce the antenna array and to improve the aerodynamic characteristics of the array so that it will withstand even the strongest winds. The members 20 may be made adequately stiff and strong structurally. Moreover, it will be understood that cables, struts and other structural reinforcing members may be employed within, between or adjacent the wave guides 12 as needed.

In order to provide for radiation of energy at ultra high frequencies, each of the wave guides 12 is provided with a plurality of radiating slots 22 which are formed in both of the broader sides 16. The slots extend longitudinally along the wave guide and are longitudinally spaced in a row along the length thereof. By varying the shape, size and spacing of the slots 22, each wave guide 12 is tuned to a different frequency channel. As shown by way of example in FIGS. 1 and 4, a set of the various wave guides 12 are of different lengths. A high Q or factor of merit is readily obtained, so that the tuning may be quite sharp. In this way each wave guide rejects or sharply attenuates the signals received from the other wave guides so that the cross-talk or interference between the various wave guides is negligible.

Another factor which effectively suppresses cross-talk between the various wave guides 12 resides in the substantially different spacings of the radiating slots 22 from antenna to antenna. Since no two of the wave guide antennas will have anywhere near the same effective phase progression rate along their axial apertures in any of their operating bands, the antennas will be inherently too far out of step phasewise with respect to one another to function to any significant extent as wave couplers in the fields of the adjacent antennas. This is especially true for electrically long antennas. Thus, the illustrated antennas have several radiating slots and are several wave lengths long. The frequencies of the wave guide antennas should be staggered with respect to antenna location in the array so that the various adjacent antennas are as widely separated as possible in frequency. Such staggering effectively reduces the coupling between the antennas. To achieve the ultimate suppression of cross-talk, rejection filters may be employed at the antenna inputs but it is believed that such rejection filters will seldom be necessary in actual practice.

As shown, each of the slots 22 has a shape resembling a dumbbell. Thus, each slot has a relatively narrow parallel sided main portion 24 which connects with enlarged generally circular end portions 26. Various other shapes...
may be employed, but the illustrated shape is particularly advantageous because it provides a higher Q than normally exhibited by a simple parallel sided slot of resonant length.

The illustrated slots 22 are located centrally on the wave guides 12 so that the slots extend along the center lines of the broader sides 16. This construction is advantageous to provide desirable radiation patterns which are nearly circular. However, the central location of the slots 22 mitigates against radiation of energy from the slots. To insure effective radiation of the ultra high frequency energy from the wave guides, each slot 22 should be provided with a probe or coupler 28, whereby the slot is coupled to the fields within the wave guides. As shown in FIGS. 3 and 4, each of the illustrated couplers 28 is in the form of an adjustable conductive probe extending into the wave guide from the wall 16. The probe 28 is located on one side of the slot 22 adjacent the center thereof. Each of the illustrated probes 28 is in the form of an adjusting screw which is tapped into the wall 16 of the wave guide so that the probe may readily be adjusted. Each of the coupling screws or probes 28 may be adjusted by turning the screw so as to vary the extent to which the screw projects into the wave guide. Each of the opposite slots 22 in the wave guides should have its own coupling screw or probe 28. The probes 28 for the opposite slots 22 should normally be opposite each other, as shown in FIGS. 3 and 4. The probes for the various wave guides may be on either side of the slots 22, as required to obtain the desired radiation patterns.

The slots 22 on both sides of each wave guide 12 produce a radiation pattern which is very nearly circular, with only very minor lobes or variations. Thus, for example, the deviation from a circular pattern may be as low as 1.5 decibels. It will be evident that each wave guide provides effective radiation of energy in all directions. Moreover, there is no overshadowing of one antenna by another, so that all of the wave guides produce radiation patterns which are substantially the same, with only minor variations. Accordingly, all of the stations using the antenna array will be effectively served on a virtually equal basis.

The antenna array is readily constructed on a sound structural basis and is well suited for erection on a high tower or other high place. Although the array is relatively long and thin, it may readily be constructed to withstand the highest winds. The array is reasonably compact and of modest overall dimensions so that the erection of the array does not present serious structural problems. For example, the illustrated array for six stations may be 50 feet long, 6 feet wide and 6 inches thick, to cite only one possible example.

In short, the antenna array of the present invention will serve quite a number of ultra high frequency television or radio stations simultaneously on an efficient, economical and practical basis. All of the stations will be given good radiation patterns which are substantially the same, so that substantially equal treatment is accorded to the stations. The array may be erected at the highest and best available location, to the mutual benefit of all of the television stations.

Various other modifications, alternative constructions and equivalents may be employed without departing from the true spirit and scope of the invention, as exemplified in the foregoing description and defined in the following claims.

I claim:

1. In a multi-channel antenna array for ultra high frequencies, the combination comprising a plurality of wave guides in the form of metal ducts of generally rectangular cross section, each of said wave guides having a pair of oppositely disposed wider sides and a pair of oppositely narrower sides extending therebetween, said wave guides being disposed side by side in a row with said narrower sides of the successive wave guides adjacent each other, said wave guides being disposed with said wider sides of said wave guides in co-planar relation to one another, each of said wave guides being formed with a series of longitudinal radiating slots in both of said wider sides thereof, each of said wave guides being tuned to a different frequency channel, and means for feeding ultra high frequency energy to said wave guides, said wave guides being effective to radiate ultra high frequency energy in the different frequency channels without interference with each other.

2. In a multi-channel antenna for ultra high frequencies, the combination comprising a plurality of elongated parallel wave guides in the form of hollow ducts having a pair of oppositely disposed wide sides and a pair of relatively narrow edges extending therebetween, said wave guides being disposed edge to edge in a row with said relatively wide sides extending along the row, each of said wave guides having a series of spaced longitudinal slots formed in both of said relatively wide sides, each of said wave guides being tuned to a different frequency channel, and energy transmission means connected to each of said wave guides, said wave guides being effective as antennas at the different frequency channels without interference with one another.

3. In a multi-channel antenna for ultra high frequencies, the combination comprising a plurality of hollow elongated wave guides, each of said wave guides being generally rectangular in cross section and having a pair of relatively broad sides opposite each other and a pair of relatively narrow sides extending between said broad sides, said wave guides being arranged parallel to one another and in a single linear row, said narrow sides of adjacent wave guides being together while said broad sides of said wave guides extend along said row, each of said wave guides having a series of radiating slots formed in both of said broad sides thereof for radiating ultra high frequency energy, said slots extending longitudinally and being spaced apart longitudinally, each of said wave guides being tuned to a different frequency channel, and a plurality of means connected to said wave guides for transmitting ultra high frequency energy thereinto, said wave guides being effective to radiate energy at the different frequency channels without interference with one another.

4. In a multi-channel antenna for ultra high frequencies, the combination comprising a plurality of parallel elongated wave guides of generally rectangular cross section, each of said wave guides having a pair of oppositely disposed wide sides and a pair of relatively narrow sides extending therebetween, said wave guides being disposed in a linear row with said broad sides extending along the row, the adjacent wave guides in said row being secured together with the narrow sides thereof adjacent each other, each of said wave guides having a plurality of longitudinal slots formed in both of said broad sides for radiating ultra high frequency energy,
said slots being centrally disposed and spaced longitudinally, each of said wave guides being tuned to a different frequency channel, and means for supplying ultra high frequency energy at different frequencies to said wave guides, said wave guides being effective to radiate the ultra high frequency energy without interference with one another.

5. In an antenna array for a plurality of ultra high frequency channels, the combination comprising a plurality of hollow elongated wave guides disposed parallel to one another and in a row, each of said wave guides having a pair of broad sides opposite each other and extending along the row, each of said wave guides having a series of longitudinally spaced radiating slots formed in both of said broad sides, each of said wave guides being tuned to a different frequency channel, and energy transmission means connected to each of said wave guides, said wave guides being effective as antennas at the different frequency channels without interference with one another.

6. In an antenna array for a plurality of ultra high frequency channels, the combination comprising a plurality of hollow elongated wave guides disposed parallel to one another and in a row, each of said wave guides having a pair of broad sides opposite each other and extending along the row, each of said wave guides having a series of centrally disposed longitudinally spaced radiating slots formed in both of said broad sides, each of said wave guides being tuned to a different frequency channel, each wave guide having a coupling device adjacent each slot for coupling the slot to the fields within the wave guide so that energy will be radiated by the slot, and energy transmission means connected to each of said wave guides to supply ultra high frequency energy therein, said wave guides being effective as antennas at the different frequency channels without interference with one another.

7. In an antenna array for a plurality of ultra high frequency channels, the combination comprising a plurality of hollow elongated wave guides disposed parallel to one another and in a row, each of said wave guides having a pair of broad sides opposite each other and extending along the row, each of said wave guides having a series of centrally disposed longitudinally spaced radiating slots formed in both of said broad sides, each of said wave guides being tuned to a different frequency channel, each wave guide having a coupling probe projecting into the wave guide adjacent each slot for coupling the slot to the fields within the guide so that the slot will radiate energy from the guide, and energy transmission means connected to each of said wave guides to supply ultra high frequency energy thereto, said wave guides being effective as antennas at the different frequency channels without interference with one another.

8. In an antenna array for a plurality of ultra high frequency channels, the combination comprising a plurality of hollow elongated wave guides disposed parallel to one another and in a row, each of said wave guides having a pair of broad sides opposite each other and extending along the row, each of said wave guides having a series of centrally disposed longitudinally spaced radiating slots formed in both of said broad sides, each of said wave guides being tuned to a different frequency channel, each wave guide having a coupling probe projecting into the wave guide adjacent each slot for coupling the slot to the fields within the guide so that the slot will radiate energy from the guide, said probe having means for adjusting the extent to which the probe projects into the guide, and energy transmission means connected to each of said wave guides to supply ultra high frequency energy thereto, said wave guides being effective as antennas at the different frequency channels without interference with one another.

No references cited.

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