

Oct. 22, 1957

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2,810,907

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Filed Dec. 22, 1954

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SLOTTED WAVEGUIDE ANTENNA

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Application December 22, 1954, Serial No. 476,932

8 Claims. (Cl. 343-767)

This invention relates to a slotted waveguide antenna, and more particularly, to an omni-directional antenna including a plurality of slotted longitudinally extending ridge waveguides disposed around, and coupled to, a central hollow pipe input waveguide.

The antenna of this invention is especially useful for ultra-high frequency television broadcasting where a long array of radiating elements is required to provide the desired field pattern, and where high power handling capacity is of great importance.

It is an object of this invention to provide an improved high power relatively tall antenna array combining great mechanical strength with simplicity of construction and adjustment.

It is another object to provide an improved antenna array so constructed as to facilitate independent adjustment of the amplitude and phase of the energy coupled to the individual radiating elements.

It is a further object to provide an improved antenna array so constructed as to be readily adjustable for use at any one of a number of frequency ranges.

It is a still further object to provide a novel slotted ridge waveguide for transfer of energy to free space.

In one aspect the invention comprises a vertically mounted central cylindrical hollow pipe waveguide of steel having a wall thickness sufficient to provide the necessary mechanical strength. A plurality of longitudinally extending slotted ridge waveguides is mounted on the exterior of the hollow pipe. Energy to be transmitted is propagated thru the hollow pipe waveguide to a point intermediate the ends in the array where it is coupled to the surrounding ridge waveguides. The energy is propagated in both directions thru the ridge waveguides, and is coupled to the radiating slots therein from which the energy is radiated into free space. The ridge waveguides are formed on the exterior of the hollow pipe waveguide by means of vanes extending radially from the hollow pipe waveguide and extending the entire length of the aperture of the antenna array. The vanes constitute the narrow sidewalls of the waveguides. The exterior of the hollow pipe waveguide forms one of the wide sidewalls of the ridge waveguides. The other wide sidewalls of the ridge waveguides are formed by longitudinally extending formed sheets each connected to the outer edge of one of the vanes. The edge portions of adjacent sheets are formed so that adjacent edges together define a ridge in the wide sidewall of the ridge waveguide, the edges of the adjacent sheets being spaced at the center of the ridge to provide a slot in the ridge extending the length of the ridge waveguide. A plurality of longitudinally spaced clamps connecting the edges of the sheets divide the long slots into radiating slots having an appropriate length in terms of wavelengths at the mean operating frequency.

These and other objects and aspects of the invention will be apparent to those skilled in the art from the following more detailed description taken in conjunction with the appended drawings wherein:

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Figure 1 is an elevation of an antenna constructed according to the teachings of this invention and showing the general appearance thereof;

Figure 2 is an enlarged fragmentary elevation of the antenna of Figure 1;

Figure 3 is a partial sectional view taken transversely thru the antenna of Figure 1;

Figure 4 is a partial sectional view taken on the line 4-4 of Figure 2;

Figure 5 is a partial sectional view taken on the line 5-5 of Figure 2;

Figure 6 is a partial sectional view taken on the line 6-6 of Figure 2;

Figure 7 is a partial sectional view taken on the line 7-7 of Figure 2;

Figure 8 is a fragmentary elevation of an antenna similar to that shown in Figures 1 thru 7 but including coupling loops in place of coupling probes; and

Figure 9 is a partial sectional view taken on the line 9-9 of Figure 8.

Figures 1 thru 7 show an omni-directional slotted waveguide antenna including a central cylindrical hollow pipe waveguide 10 thru which the antenna is fed with radio frequency energy to be radiated, and a plurality of longitudinally arranged slotted ridge waveguides mounted on the exterior of the hollow pipe waveguide 10. The slotted ridge waveguides have narrow sidewalls defined by vanes 12 extending longitudinally throughout the length of the antenna aperture and extending radially outward from the exterior wall of the hollow pipe waveguide 10. In the example shown in the drawings, there are eight equally circumferentially spaced vanes 12 to provide eight longitudinally extending ridge waveguides therebetween. A different number of ridge waveguides may be employed, the number eight being selected for illustration because it is large enough to provide a substantially omni-directional pattern from the antenna in the horizontal plane.

One of the broad sidewalls of each of the ridge waveguides is defined by the outer wall of the hollow pipe waveguide 10. The other broad sidewall of each of the ridge waveguides is defined by longitudinally extending formed sheets 15, each of which is connected along a longitudinal center line to the outer edge of a vane 12. The longitudinal formed sheets 15 fastened to adjacent vanes 12 have side edges formed so that together they define a ridge 16, and are spaced apart to provide a slot 17 in the ridge, the slot extending the entire length of the antenna array. As thus far described, the antenna consists of a central hollow pipe waveguide 10 surrounded by longitudinally extending ridge waveguides having longitudinal slots in the centers of the ridges of the respective waveguides, as shown more clearly in Figure 3.

The top and bottom ends of each of the eight ridge waveguides are short-circuited electrically by means of a conductive short-circuiting element 20 clamped between the hollow pipe waveguide 10 and the adjacent edges of the slot 17 formed between longitudinal sheets 15, as shown in Figures 2 and 4. The shorting member 20 electrically short-circuits the ridge waveguide near the top end of the antenna array as effectively as though the entire end of the waveguide were sealed by a metallic cover. The top of the antenna array is preferably sealed against the weather by means of a top cap 22 which may be made of insulating materials such as fiberglass reinforced polyester resin. The slots may also be covered against the weather.

The slot 17 in the ridge 16 of each ridge waveguide extending from the top shorting member 20 to the bottom shorting member (not shown) is divided into a plurality of radiating slots 17' by means of bridging clamps 23 connected across the slots 17. The bridging clamps

23 are spaced apart by an appropriate distance in terms of wavelengths at the operating frequency of the antenna to provide radiating slots 17' which will radiate radio frequency energy into free space when properly excited.

The radiating slots 17' formed between two spaced bridging clamps 23 are excited from the interior of the ridge waveguide by means of probes 26 connected by means of clamps 27 to one edge of the slots 17'. The probes 26 are preferably in the form of a screw which may be adjusted lengthwise to provide the desired degree of coupling. Energy is propagated thru the ridge waveguides in the TE₁₀ mode and is coupled by the probes 26 to the radiating slots 17' from which the energy is radiated into free space.

It will be noted that in the antenna shown by way of example in the drawings, the radiating slots 17' have a length of approximately a half-wavelength in free space at the mean operating frequency of the antenna, and that the centers of the radiating slots 17' are spaced a half-wavelength apart in the ridge waveguide at the mean operating frequency. It will also be noted that the coupling probes 26 of the successive radiating slots 17' are connected alternately to one side of the slot and then to the other side. This reversal of the position of the coupling probes 26 is for the purpose of reversing the polarity of the energy coupled from the waveguide at points 180 degrees displaced, so that the slots are all excited in phase with each other. It will be noted that there are spaces or slots 17'' between the radiating slots 17'. Energy in the ridge waveguides does not couple to any portion of the slot 17 not having a coupling probe. These portions may be left open or they may be closed without any effect on the operation of the antenna.

Energy applied to the antenna thru the central cylindrical waveguide 10 is coupled to the several ridge waveguides by means of coupling probes 30 extending thru apertures 31 in the cylindrical hollow pipe 10 and fastened by means of clamps 33 to the edges of the formed sheets 15, as shown in Figures 2 and 7. All of the ridge waveguides are thus excited from the central hollow pipe waveguide at a longitudinally intermediate point (for example at a central point) along the length of the antenna array. The energy divides, half of the energy in each ridge wavegoing up, and the other half going down. As the energy passes thru the ridge waveguides, the energy is coupled to the radiating slots 17' from which the energy is radiated into free space.

Figures 8 and 9 show an alternative arrangement wherein the probes 26 are replaced by coupling loops 35 extending into the ridge waveguide and having ends connected to opposite edges of the radiating slots. When coupling loops as shown in Figures 8 and 9 are employed, the lengths of the radiating slots 17' are preferably adjusted to approximately one full wavelength in free space at the operating frequency, and the coupling loops 35 at the centers of adjacent radiating slots are spaced apart a full wavelength in the ridge waveguide at the operating frequency. Because of the difference between a wavelength distance in the waveguide and in free space, there is a space 17'' between adjacent layers of radiating slots 17'.

It will be noted that according to the construction shown and described, a strong cylindrical hollow pipe waveguide 10 is employed to convey the energy to be radiated up to the center point of the antenna array, and to provide the structural strength necessary to hold the entire antenna array in a vertical position without the use of electrically disturbing guy wires or braces. The hollow pipe waveguide 10 is preferably made of steel and provided with a wall thickness sufficient to give the required mechanical strength under all expected conditions of wind and ice loading.

The vanes 12 are preferably welded on the exterior of the hollow pipe waveguide 10 to define the narrow

sidewalls of a plurality of longitudinally extending ridge waveguides. Longitudinally extending formed sheets 15 are fastened along a longitudinal center line to the outer edge of each of the vanes 12. The adjacent longitudinal sheets 15 are formed and spaced so as to provide a ridge 16 in the ridge waveguide, the ridge being provided with a continuous longitudinal slot 17. The continuous slot 17 is divided up into a plurality of radiating slots 17' by means of bridging clamps 23, and energy is coupled to the radiating slots 17' by means of probes or loops extending into the ridge waveguides.

It is apparent that an antenna constructed according to the teachings of the invention is easily adjusted after construction to operate at any desired frequency within a wide range of values, and that the amplitude and phase of the energy coupled to the radiating slots 17' is also easily adjustable. The main strength of the antenna is provided by the central hollow pipe waveguide 10, and the elements affecting the electrical characteristics of the antenna are mounted on the exterior of the hollow pipe waveguide 10 in such a way as to facilitate adjustment and application of an antenna to any special circumstance as may be required.

What is claimed is:

1. A slotted waveguide antenna comprising, a central hollow pipe waveguide, a plurality of longitudinally extending ridge waveguides mounted on the outside of said hollow pipe waveguide, the outer walls of said ridge waveguides being inwardly formed to define ridges, said ridges being provided with longitudinal radiating slots, and means to couple energy from said hollow pipe waveguide to said ridge waveguides.

2. A slotted waveguide antenna as defined in claim 1, and in addition, means to couple energy from said ridge waveguides to said slots therein.

3. An omni-directional slotted waveguide antenna comprising, a central hollow pipe waveguide, a plurality of longitudinal vanes extending radially from the exterior wall of said hollow pipe waveguide, longitudinal formed sheets each connected to the outer edge of one of said vanes, said sheets forming slotted ridged wide sidewalls of ridge waveguides including the wall of said hollow pipe waveguide as the other wide sidewalls, and said vanes as the narrow sidewalls, means to couple energy from said hollow pipe waveguide to said ridge waveguides, and a plurality of spaced short-circuiting clamps connecting adjacent edges of said sheets together to form a plurality of radiating slots.

4. An omni-directional slotted waveguide antenna comprising, a central hollow pipe waveguide, a plurality of longitudinal vanes extending radially outwardly from the wall of said hollow pipe waveguide, longitudinal formed sheets each connected on a central longitudinal line to the outer edge of one of said vanes, the adjacent longitudinal edges of said sheets being formed to provide an inwardly extending longitudinal ridge with a longitudinal slot therein, said hollow pipe waveguide, said vanes, and said formed sheets defining a plurality of slotted ridge waveguides, means to couple energy from said hollow pipe waveguide to said ridge waveguides, and a plurality of short-circuiting clamps connecting adjacent edges of the sheets forming said longitudinal slots to longitudinally divide each of said slots into a plurality of radiating slots.

5. An omni-directional slotted waveguide antenna comprising, a central hollow pipe waveguide, a plurality of longitudinal vanes extending radially outwardly from the wall of said hollow pipe waveguide, longitudinal formed sheets each connected on a central longitudinal line to the outer edge of one of said vanes, the adjacent longitudinal edges of said sheets being formed to provide an inwardly extending longitudinal ridge with a longitudinal slot therein, said hollow pipe waveguide, said vanes, and said formed sheets defining a plurality of slotted ridge waveguides, a plurality of clamps connecting adjacent

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edges of the sheets forming said longitudinal slots to longitudinally divide each of said slots into a plurality of radiating slots, means to couple radio frequency energy from said hollow pipe waveguide to said ridge waveguides, and means to couple radio frequency energy from said ridge waveguides to said radiating slots in the ridges thereof.

6. An antenna element comprising a generally rectangular waveguide having an inwardly extending ridge in a broad sidewall thereof, said ridge being provided with a longitudinally extending radiating slot therein.

7. An antenna element as defined in claim 6, and in addition, coupling means extending into said waveguide for coupling energy therefrom to said radiating slot.

8. An antenna element comprising a ridge waveguide having two narrow sidewalls, a first broad sidewall, and a second broad sidewall including an inwardly extending ridge having a wall portion in relatively close parallel spaced relation with said first broad sidewall, a longitudi-

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nally extending radiating slot in said wall portion of said ridge, means to propagate radio frequency energy thru said waveguide, and means to couple energy from said waveguide to said radiating slot.

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