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SLOTTED WAVEGUIDE ANTENNA ARRAY

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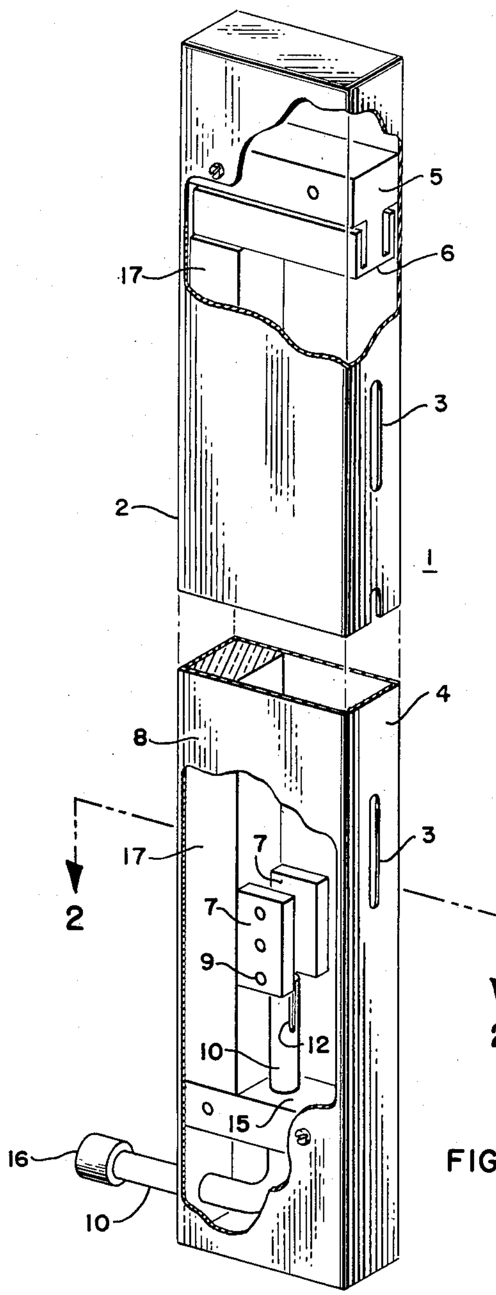

FIG. 1

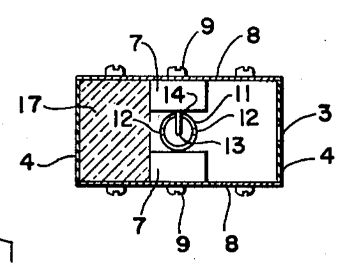

FIG. 2

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SLOTTED WAVEGUIDE ANTENNA ARRAY

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This invention relates to an improved slotted waveguide antenna array, particularly adapted for use where it is necessary to limit the lateral width of the array.

It is frequently desirable, especially in military aircraft, to locate an antenna within the confines of the fin or rudder thereof. Where a high-speed aircraft is involved, the lateral thickness of the fin or rudder is extremely limited and, as a result, if an antenna is to be constructed therein, it must likewise be of relatively narrow dimensions.

It is an object of this invention to provide a slotted waveguide antenna array wherein the slots are located in the narrow wall of a rectangular waveguide section thereby producing an antenna which meets the above requirement.

Another object of this invention is to provide an antenna array of relatively narrow width which will have a relatively broad pattern in a plane perpendicular to the axis of the wave guide, while at the same time having a narrow radiation pattern in a plane passing through the axis of the wave guide.

It is a further object to provide a slotted wave guide antenna array wherein the slots are in the narrow face of the wave guide and yet may be excited in the proper in-phase relationship so as to give the desired pattern.

Further and other objects will appear from the following description and claims when taken in view of the accompanying drawings.

In the drawing:

Figure 1 is a fragmentary perspective view of the complete antenna unit.

Figure 2 is a transverse sectional view through the antenna.

The antenna array 1 comprises an elongated section of rectangular waveguide 2 having a plurality of radiating slots 3 formed in one of the narrow walls 4 thereof. The particular antenna shown has five such slots, although to better show the construction, only three of them appear in the drawing. The number of slots will of course depend upon the radiation patterns desired in any particular case. As shown in Figure 1, the slots are arranged along the center line of the narrow wall and each has an effective length equal to one-half of the wave length in space at the design frequency. The center-to-center spacing of the slots is equal to a full wave length in space. Secured within the waveguide adjacent its upper end is a non-contacting shorting element 5 which forms an effective short circuit across the waveguide 2 in the plane of its lower face 6. This face of the shorting member is located three-quarters of a wave length above the center of the uppermost slot 3.

Spaced one-half wave length below the center of the lowest slot 3 are a pair of metal blocks 7 firmly secured to the broad walls 8 of the waveguide as at 9. As is clear from the drawing, blocks 7 are located along the median plane of the waveguide and together with the walls 4 and 8 of the guide, form a ridge waveguide section which serves as an impedance matching transformer

section between the radiating portion of the array and a coaxial feed line 10.

In order to symmetrically excite the waveguide from the un-symmetrical conductors of the coaxial cable, opposed portions of the outer conductor 11 are cut away to provide a pair of slits 12, each having a length equal to one-quarter wave length at the design frequency, which slits divide the end portion of the outer conductor into two symmetrical halves, each half being electrically connected to the adjacent block 7. The center conductor 13 is then bridged across to the junction of one-half of the outer conductor with its associated block as indicated at 14. This forms what is known in the art as a "balun" connection. The coaxial line 10 extends downwardly from the blocks 7 through the metal end wall 15 of the impedance matching section and then laterally outwardly through one of the walls of the waveguide to a suitable coaxial connector 16.

As previously set forth, the slots 3 have a center-to-center spacing equal to one wave length in space. This spacing is essential in order to obtain the desired narrow beam width in the vertical plane without the production of undesired side lobes. However, it is a well known characteristic of air-filled waveguide that the apparent wave length within the guide is greater than that in free space. Yet, to excite the slots 3 in the desired in-phase relationship, the fields within the waveguide must be the same at each of the slots. In order to overcome this difficulty, applicants have partially filled the wave guide with an elongated block 17 of suitable dielectric material of such dimensions as to make the effective wave length within the guide equal to that in free space. In the particular antenna shown, the dielectric material consists of a block of polystyrene which extends between the shorting member 5 and the element 15 along the side of the waveguide opposite from the slots 3. The thickness of the block required to bring about the desired correction in wave length will depend upon the dimensions of the guide, the frequency for which the array is designed, the material used and its relative location within the guide. In the instant case, using polystyrene and locating it as shown in the drawing, the proper thickness was determined to be approximately one-third of the wider dimension of the guide.

The operation of the antenna is believed to be apparent from the above description. It may, of course, be used with equal effectiveness either for transmitting or receiving. Assuming that the antenna is to be used for transmitting, radio energy at the desired frequency will be conducted to the antenna by means of the coaxial cable 10 and will excite the waveguide so as to produce standing waves therein. The matching transformer formed by the blocks 7 and end wall 15 will serve to match the impedance of the transmission line 10 to that of the wave guide 2 so as to prevent standing waves occurring on the line 10. Due to the presence of the dielectric block 17 within the waveguide, the apparent wave length of the standing waves within the waveguide, when measured along the slotted wall, will be exactly equal to that in free space and will, as a result, cause the excitation of the radiating slots 3 in the desired in-phase relationship. The radiation pattern in the vertical plane is relatively narrow while that in the horizontal plane is quite broad. Field strength measurements of a 5-slot array, constructed as described above, showed a half power beam width of only about 11° in the vertical plane, and of about 130° in the horizontal plane.

Since the radiation is from the narrow wall of the guide, the antenna may be located within a thin airfoil or control surface so that its major axis of propagation is in the plane of the airfoil as is frequently required.

Obviously, as is well understood in the art, the dimensions of the matching transformer section **7** will depend upon the number of slots and the resulting impedance of the array as well as upon the type of feed line employed. While but one form of the invention has been shown, many changes can be made without departing from the basic concept of the invention. Thus, dielectric block **17** could be made of other materials than polystyrene and could be located in other portions of the waveguide so long as it is designed to bring about the desired correction of wave length therein. The dielectric block need extend only throughout the slotted portion of the waveguide since the apparent wave length in the other portions of the guide will not adversely affect the radiation characteristics of the antenna so long as the slots are excited in the desired in-phase relationship. Other known types of feed could obviously also be provided without affecting the operation.

We claim as our invention:

1. An antenna array for electromagnetic waves of predetermined frequency comprising an elongated rectangular tube having one internal dimension of said tube substantially narrower than the other dimension of the rectangle, one of the narrower walls of said tube having formed therein a plurality of elongated collinear slots spaced longitudinally along said wall, the center-to-center spacing of said slots being substantially equal to a wavelength in space at said frequency, an assembly adapted to be placed within said tube consisting of a strip of dielectric material of a width substantially equal to the narrower dimension of said tube, a metal end wall transverse of said tube, a non-contacting shorting element spaced from said end wall in said tube by the longitudinal extent of said dielectric strip, the face of said shorting element being located approximately three-quarters wavelength from the center of the nearest of said slots, an impedance matching transformer positioned between the end slot and said metal end wall, said transformer being positioned approximately one-half wavelength from the center of the nearest slot, a coaxial feed line extending through said end wall to a point adjacent said transformer, means providing a connection between the said coaxial feed line and the said transformer such that electromagnetic energy applied thereto in an unbalanced line sense is transformed to a balanced line sense, said dielectric strip material extending between said end wall and said shorting element and partially filling said tube, whereby the apparent wavelength of said standing waves as measured longitudinally along said tube at the narrow edge thereof coincides with that of the wavelength in space at said frequency.

2. An antenna array for electromagnetic waves of predetermined frequency comprising an elongated rectangular tube having one internal dimension of said tube substantially narrower than the other dimension of the rectangle, one of the narrower walls of said tube having formed therein a plurality of elongated collinear slots spaced longitudinally along said wall, the center-to-center spacing of said slots being substantially equal to a wavelength in space at said frequency, a metal end wall extending transverse of one end of said tube, a non-contacting shorting element at the other end of said tube, the face of said shorting element being located approximately three-quarters wavelength from the center of the nearest of said slots, an impedance matching transformer positioned between an end slot and said metal end wall, said transformer being positioned approximately one-half wavelength from the center of the nearest slot, a coaxial feed line extending through said end wall to a point adjacent said transformer, means providing a connection between the said coaxial feed line and the said transformer such that electromagnetic energy applied thereto in an unbalanced sense is transformed to a balanced line sense, including a strip of dielectric material extending between said end wall and said shorting element and partially filling said tube, whereby the apparent wavelength of said standing waves as measured longitudinally along said tube at the narrow edge thereof coincides with that of the wavelength in space at said frequency.

3. An antenna array for electromagnetic waves of predetermined frequency comprising an elongated rectangular tube having one internal dimension of said tube substantially narrower than the other dimension of the rectangle, one of the narrower walls of said tube having formed therein a plurality of elongated collinear slots spaced longitudinally along said wall, the center-to-center spacing of said slots being substantially equal to a wavelength in space at said frequency, an assembly adapted to be placed within said tube consisting of a longitudinal spacer strip of dielectric material of a width substantially equal to the narrower dimension of said tube, a metal end wall transverse of said tube at one end of said strip, and a non-contacting shorting element in said tube at the other end of said dielectric strip, the face of said shorting element being located approximately three-quarters wavelength from the center of the nearest of said slots, an impedance matching transformer positioned between the end slot and said metal end wall, said transformer being positioned approximately one-half wavelength from the center of the nearest slot, a coaxial feed line extending through said end wall to a point adjacent said transformer, means joining the said coaxial feed line to the said transformer such that electromagnetic energy applied thereto in an unbalanced line sense is transformed to a balanced line sense, said dielectric strip material partially filling said tube, whereby the apparent wavelength of said standing waves as measured longitudinally along said tube at the narrow edge thereof coincides with that of the wavelength in space at said frequency.

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