Nov. 19, 1957 M. L. WATSON 2,814,039

MICROWAVE ANTENNA

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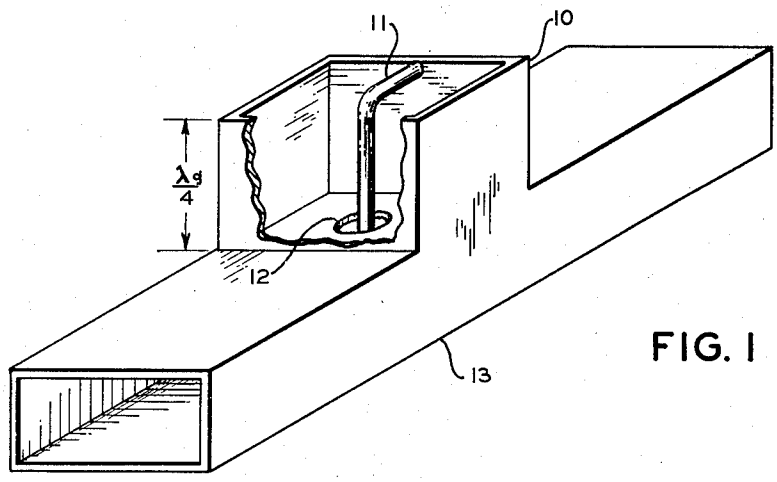
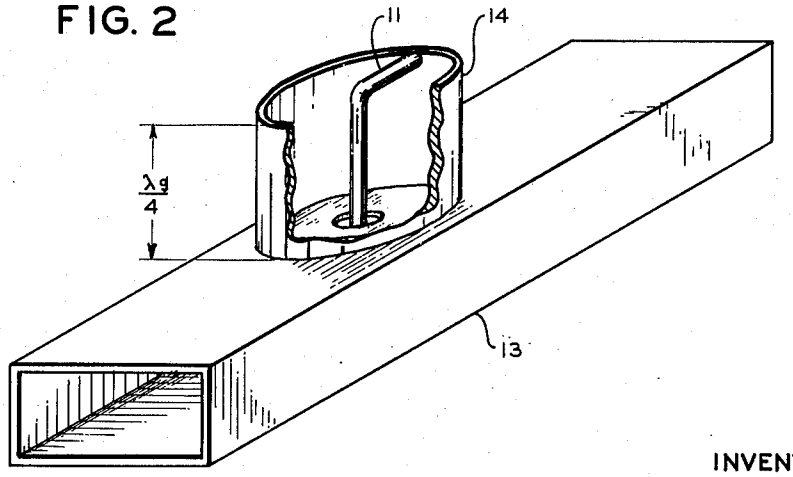


FIG. 1

FIG. 2



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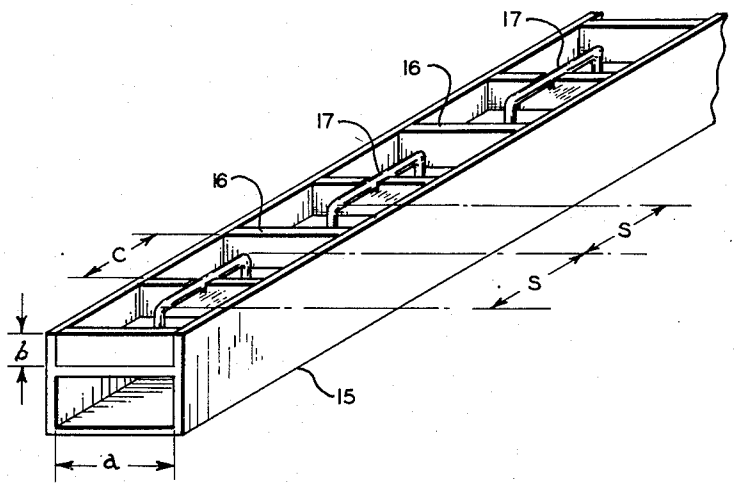
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FIG. 3



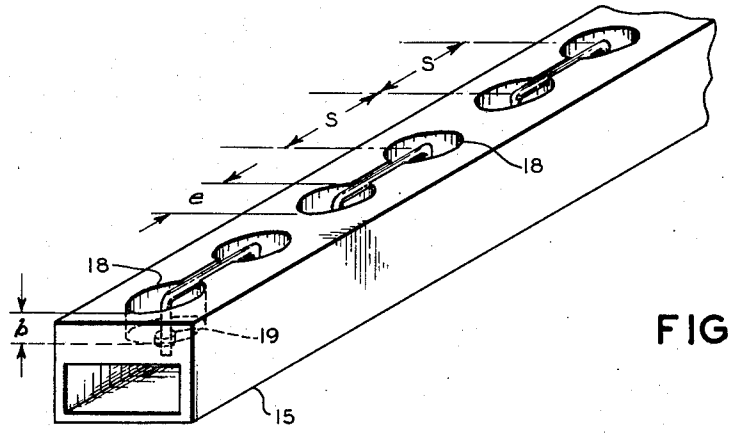


FIG. 4

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MICROWAVE ANTENNA

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11 Claims. (Cl. 343—844)

This invention relates in general to antennas and in particular to waveguide-type radiators for use in linear arrays.

This invention is applicable for use in linear antenna arrays where compact, light-weight equipment is desired and this invention provides easily adjustable coupling and simplicity of construction of the elements.

The primary object of this invention is to provide waveguide-type radiating elements for radiating electromagnetic energy which may be reversed in polarity and which may be fed from a waveguide or coaxial line to form a linear array.

Another object of this invention is to provide novel construction for linear arrays of the type described.

Other and further objects of this invention will be apparent from the following specifications when taken with the accompanying drawings in which:

Fig. 1 is a perspective view of one type of radiator of this invention;

Fig. 2 is a perspective view of another type of radiator of this invention;

Fig. 3 is a perspective view of one form of linear array embodying this invention; and

Fig. 4 is a perspective view of another form of linear array embodying this invention.

In Fig. 1 is shown one type of single radiator for use in the linear array shown in Fig. 3. The radiator consists of waveguide 10 which is one-quarter wavelength in length and is short circuited at one end as shown. This radiator is fed by probe 11 extending centrally along the length of the radiator and passing through aperture 12 in the wall of feed waveguide 13. At the open end of radiator 10, probe 11 is bent at right angles and attached to the center of one wide wall of radiator 10, thus placing the bent section of the probe parallel to the electric field. As is well known the phase of the electric field is determined by which wall probe 11 is attached to.

In Fig. 4 there is shown the same arrangement using a section of circular waveguide 14 as the radiator. All other elements of this structure are the same as explained above and are designated by the same numbers as the corresponding parts of the previous figure.

The linear array of Fig. 3 uses the rectangular radiators as previously described in connection with Fig. 1. One construction of this array utilizes a feed-guide 15 having one wide wall thicker than one-quarter wavelength. A channel is cut out of this wide wall with width a and depth b as shown, where width a is the internal dimension of the width of feed guide 15 and depth b is one-quarter wavelength. The dimension a will lie between one-half wavelength and one wavelength. At regular intervals partitions 16 are placed in the channel with distance c between adjacent surfaces equal to the narrow internal dimension of feed-guide 15. The dimension c will generally be somewhat less than one-half wavelength at the operating frequency. Each partition has a thickness which permits the desired radiator spacing s between centers of each radiator thus formed. In one typical

embodiment of the invention the spacing s may be one-half wavelength at the operating frequency but this spacing may be varied to vary the configuration of the directive pattern of the antenna array. Feed apertures are drilled in the center of each radiator and through the feed-guide. U-shaped probes 17 are supported in a groove cut in every other partition 16 and the ends of the probes project through the feed apertures into the main feed-guide 15. The U-shaped probes provide phase reversal at every other radiator to compensate for the increased distance from the feed end of guide 15. This phase reversal may be better understood by considering the U-shaped probe 17 as made up of two L-shaped probes as shown in Fig. 1. The fact that one of the L-shaped probes is bent in the direction of propagation of energy in feed-guide 15 while the other L-shaped probe is bent in a direction opposite the direction of propagation in feed-guide 15 will result in the phase reversal mentioned above. If the distance s is one-half a wavelength as suggested above, the ends of the probes extending into feed-guide 15 will be excited in phase opposition. The phase reversal of the U-shaped probes will compensate for the phase reversal within feed-guide 15 causing the rectangular radiators to be excited in phase. If it is desired to feed all of the rectangular radiators in phase opposition this may be accomplished by using individual L-shaped probes each bent in the same direction but spaced one-half wavelength apart along feed-guide 15. The rectangular radiators may be arrayed in many other and different combinations in accordance with well-known antenna theory.

The linear array shown in Fig. 4 is constructed from the same feed-guide 15 as is used for the construction of the array shown in Fig. 3. Instead of cutting a channel, however, cylindrical openings 18 are drilled in the thick wide wall of guide 15 having a diameter e, and a depth b, the depth being equal to one-quarter wavelength. The dimension e should be of sufficient size to support the dominant mode in a circular waveguide. The spacing s will depend on the manner in which the individual antennas are arrayed and on the shape of the field pattern to be achieved. Small feed apertures 19 are drilled completely through the wall in the center of openings 18 and U-shaped probes 20 are positioned as explained above.

The linear arrays of radiators described produce a narrow fan-shaped beam of electromagnetic energy. This beam may be scanned either mechanically or electrically using various well known scanning methods. This scanning may be accomplished by mechanically or electrically varying the wavelength in feed-guide 15 or by mechanically varying the position of the array in space.

This invention is not to be limited by the above described specifications but is to be limited only by the following claims.

What is claimed is:

1. Apparatus for radiating electromagnetic energy comprising a section of waveguide one-quarter wavelength long and short circuited at one end thereof, said section of waveguide having a small aperture positioned in the center of said short circuited end through which said section of waveguide is energized; and a feed probe extending centrally along the length of said section of waveguide, said feed probe having one end bent and fastened to a wall at the open end of said section of waveguide, said feed probe having its other end projecting through said aperture in said short circuited end of said section of waveguide whereby said feed probe when energized excites an electromagnetic field in said section of waveguide.

2. A linear array antenna having a plurality of elements as in claim 1, which antenna comprises a length

of waveguide having one thick wide wall with a channel cut therein, said wide wall having a thickness greater than one-quarter wavelength and said channel having a depth of one-quarter wavelength; a plurality of partitions at equally spaced intervals in said channel, the distance between adjacent surfaces of said partitions being equal to the narrow internal dimension of said waveguide and each of said partitions having a thickness to position the radiators thus formed a predetermined distance apart; an aperture in the center of each of said formed radiators; a groove in the upper center of alternate partitions; and a U-shaped probe, positioned in each of said grooves so that the ends of said probes project through said apertures.

3. A linear array antenna, of the type having a plurality of elements as in claim 1, said antenna comprising a length of waveguide having one thick wide wall, said wall having a plurality of cylindrical openings therein, said wide wall having a thickness greater than one-quarter wavelength and said cylindrical openings having a depth of one-quarter wavelength; an aperture in the center of each of said openings; a plurality of grooves in the upper center of said thick wall of said waveguide, each groove connecting alternate pairs of adjacent cylindrical openings; and a U-shaped probe positioned in each of said grooves so that the ends of said probes project through said apertures.

4. Apparatus for radiating electromagnetic energy comprising, a section of rectangular waveguide one-quarter wavelength long and short circuited at one end thereof, said waveguide being dimensioned in cross section to operate only in the dominant mode, said section of waveguide having a small aperture positioned in the center of said short circuited end through which said section of waveguide is energized; and a feed probe extending centrally along the length of said section of waveguide, said feed probe having one end bent and fastened to the center of one of the broader walls at the open end of said section of waveguide, said feed probe having its other end projecting through said aperture in said short circuited end of said section of waveguide whereby said feed probe when energized excites an electromagnetic field in said section of waveguide.

5. An antenna array comprising a length of rectangular waveguide, a plurality of one-quarter wavelength waveguide sections extending from a broad wall of said waveguide, said broad wall closing one end of each of said waveguide sections, said broad wall being formed with a plurality of openings therein, each of said openings being disposed at the center of a closed end of one of said waveguide sections, each of said waveguide sections being provided with a feed probe extending centrally along the length of said waveguide section, said feed probe having one end bent and fastened to a wall at the open end of said waveguide section, said feed probe having its other end projecting through said opening in said closed end and into said waveguide whereby electromagnetic energy in said waveguide energizes said feed probe.

6. An antenna array as in claim 5 wherein said one-quarter wavelength waveguide sections are rectangular in cross section.

7. An antenna array comprising, a length of rectangular waveguide, a plurality of one-quarter wavelength rectangular waveguide sections extending from a broad wall of said waveguide, said waveguide sections having their broader wall perpendicular to the longitudinal axis of said waveguide, said broad wall of said waveguide closing one end of each of said waveguide sections, said broad wall of said waveguide being formed with a plurality of openings therein, each of said openings being disposed at the center of a closed end of one of said waveguide sections, each of said waveguide sections being provided with a feed probe extending centrally along the length of said waveguide section, said feed probes having one end bent and fastened to a broad wall of said waveguide section at the open end thereof, said feed probe having its other end projected through said openings in said closed end and into said waveguide whereby electromagnetic energy in said waveguide energizes said feed probe.

8. Apparatus as in claim 7 wherein said waveguide sections have a cross section substantially identical to the cross section of said waveguide.

9. Apparatus as in claim 7 wherein the spacing between the centers of said waveguide sections measured along the longitudinal axis of said waveguide is greater than the narrower dimension of said waveguide sections.

10. Apparatus as in claim 7 wherein the spacing between the centers of said waveguide sections measured along the longitudinal axis of said waveguide is greater than the narrower dimension of said waveguide sections, said antenna array further comprising, conductive members disposed between adjacent waveguide sections and electrically connected to the broad walls thereof at said open end of said waveguide sections.

11. An antenna array comprising, a length of a rectangular waveguide, a plurality of one-quarter wavelength waveguide sections extending from a broad wall of said waveguide, said broad wall closing one end of each of said waveguide sections, said broad wall being formed at a plurality of openings therein, each of said openings being disposed at the center of a closed end of one of said waveguide sections, each of said waveguide sections being provided with a feed probe extending centrally along the length of said waveguide section, said feed probe having one end bent and fastened to a wall at the open end of said waveguide section, said feed probe having its other end projecting through said openings in said closed end and into said waveguide whereby electromagnetic energy in said waveguide energizes said feed probe, and a conductive member extending parallel to the said broad wall of said waveguide and spaced therefrom by substantially one-quarter wavelength, said conductive member being formed with openings therein coincident with the open ends of said waveguide sections.

References Cited in the file of this patent

UNITED STATES PATENTS

2,349,942	Dallenbach	May 30, 1944
2,402,622	Hansen	June 25, 1946
2,414,266	Lindenblad	Jan. 14, 1947
2,414,376	Heim	Jan. 14, 1947
2,425,716	Barrow	Aug. 19, 1947
2,427,693	Ryder	Sept. 23, 1947