343-756 CROSS REFERENCE SEARCH ROOM

July 7, 1959 N. YARU 2,894,261

ANTENNA ARRAY

Filed Nov. 1, 1957 2 Sheets-Sheet 1

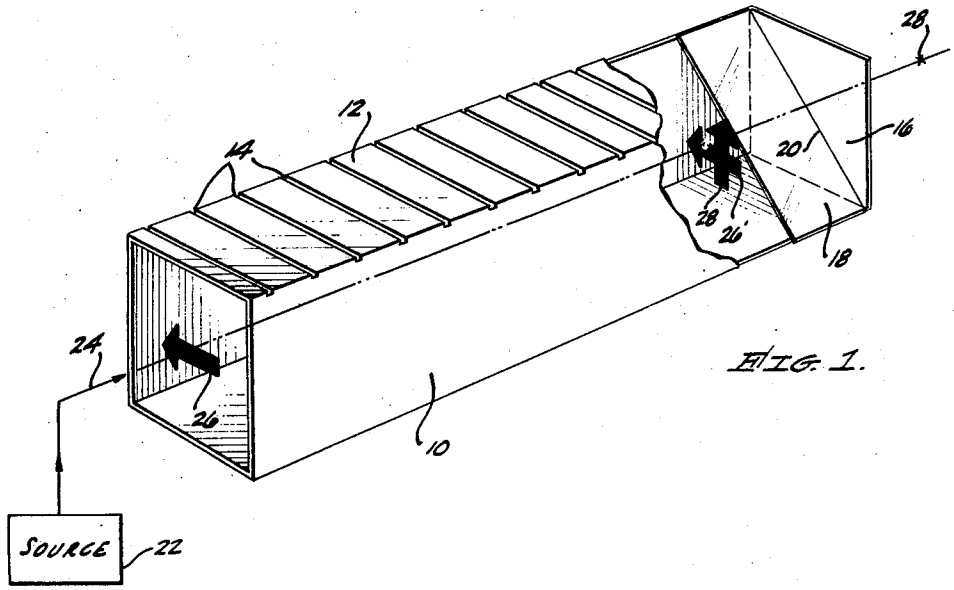


FIG. 1.

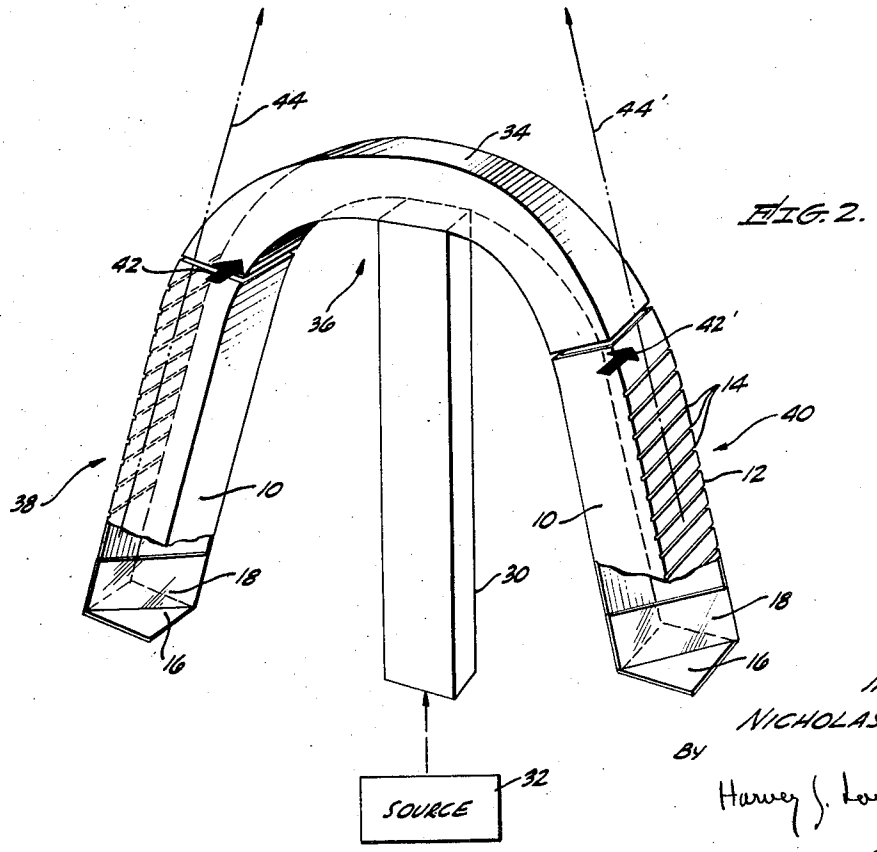


FIG. 2.

INVENTOR.
NICHOLAS YARU,
BY
Harvey J. Lombert
AGENT.

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ANTENNA ARRAY

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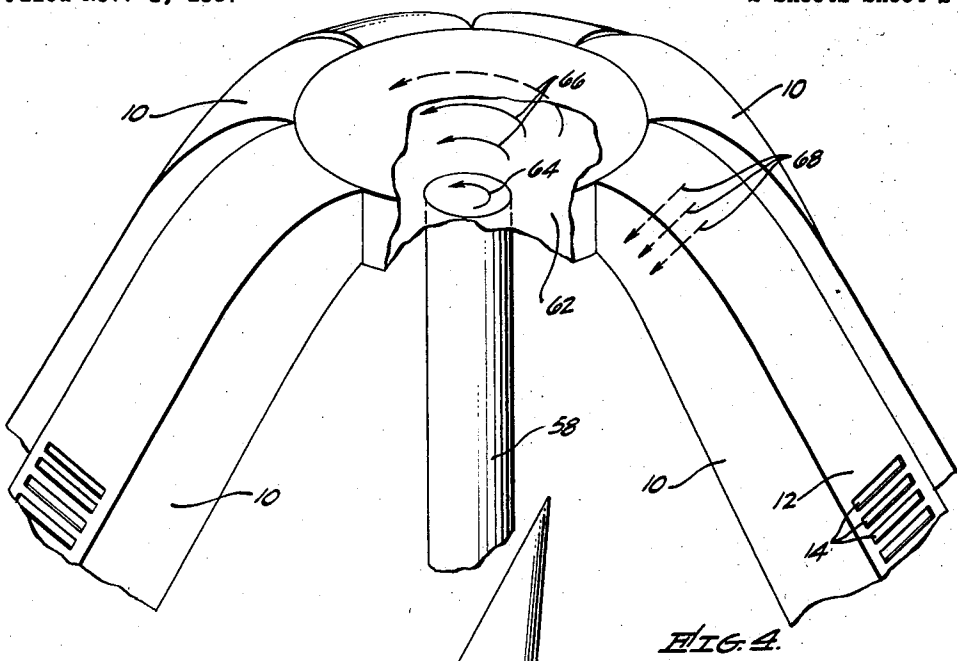


FIG. 4.

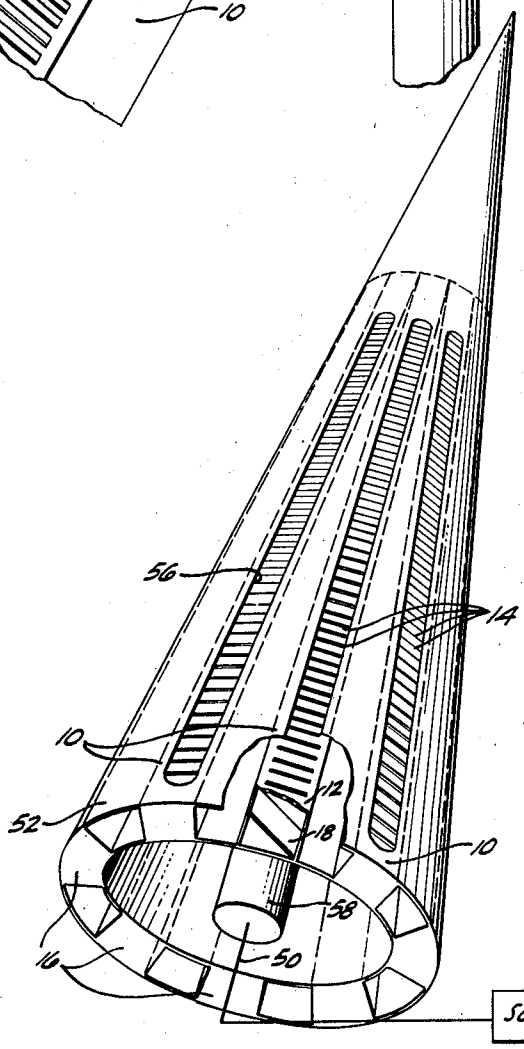


FIG. 3.

INVENTOR.
NICHOLAS YARU.
By
Harvey J. Lambert
AGENT

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2,894,261

ANTENNA ARRAY

Nicholas Yaru, Santa Monica, Calif., assignor to Hughes Aircraft Company, Culver City, Calif., a corporation of Delaware

Application November 1, 1957, Serial No. 695,185

11 Claims. (Cl. 343—771)

This invention relates to electromagnetic wave antennas and particularly to a reverse end-fire waveguide array.

Directive electromagnetic wave beams have been produced extensively by utilizing arrays such as wave conductors and associated radiators. These radiators may be suitably spaced along the wave conductor and driven by electromagnetic wave energy with appropriate relative amplitudes and phases. The most common configuration of arrays are radiators such as slots, probes or dipoles coupled directly to a waveguide. Such arrays are one-dimensional and often termed linear arrays.

Linear arrays in which a plurality of radiators are electromagnetically coupled to a waveguide are usually designated as either end-fire arrays or broadside arrays. End-fire arrays produce a beam directed along the axis of the array whereas the broadside array produces a beam whose maximum intensity has a direction normal to the axis of the array. End-fire arrays have become very useful where the cross-section of the antenna is to be kept at a minimum. Small mechanical cross-sections are important to reduce aerodynamic drag when the antenna is mounted upon a mobilized vehicle. Small electrical cross-sections are important to reduce radar detection. This invention is particularly suitable for end-fire arrays.

Two types of end-fire linear arrays are employed, one type being the ordinary or forward end-fire array and the other type being the reverse end-fire array. In the ordinary end-fire array the main lobe or beam lies along the array axis and has the same direction as the wave energy flow within the array waveguide. In the reverse end-fire arrays the main beam also lies along the array axis but has a direction exactly opposite to that of the wave energy flowing within the array waveguide.

The theories and techniques for feeding an array of radiators coupled to a waveguide to obtain the conventional forward end-fire pattern are well known in the art. See, for example, "Microwave Antenna Theory and Design," by Silver, volume 12, of the MIT Radiation Laboratory Series, chapter 9, page 257. The design of these end-fire linear arrays is relatively simple because the phase relation required between adjacent radiators is easily realizable without loading the waveguide to decrease the velocity of propagation. The phase excitation of each radiator must lag that of the preceding radiator in order to radiate a beam along the axis of the array in the same direction as the wave propagation within the waveguide.

These same techniques may likewise be employed to obtain the design parameters for reverse end-fire patterns but because a phase lead instead of a phase lag is required, such arrays are more complex. For the reverse end-fire arrays, the waveguide must be dielectrically loaded to lower the guide velocity below the free space velocity of propagation. This is necessary because the spacing between adjacent slots for a phase lead is large and second order beams arise from the slot positioning. By loading the waveguide with a dielectric, the guide wavelength is decreased. This in turn decreases the slot spacing

for the required phase lead to a distance which in free space will suppress these second order beams.

Because of the required critical slot spacing, such dielectrically loaded waveguides are extremely narrow banded and a small shift of frequency causes a large deterioration of the antenna pattern. In instances where the geometrical configuration of the array or the available space makes it impossible to move the feed point of a forward end-fire array from one end to the other, no satisfactory broad-banded reverse end-fire array is obtainable. Also, conical shaped antenna arrays to be broad-banded require feeding from the base of the cone which necessitates complex distribution networks.

It is therefore an object of this invention to provide a reverse end-fire linear array which requires no dielectric loading.

It is another object of this invention to provide a reverse end-fire linear array wherein the placement of the radiating element is the same as that of ordinary end-fire linear arrays.

It is another object of this invention to provide a new linear array of the reverse end-fire type.

It is another object of this invention to provide a conical array which may be fed from the vertex and which radiates a beam in the direction of the vertex.

It is still another object of this invention to provide a simplified broad-banded reverse end-fire type of linear array wherein the spacing of the radiators and the relative amplitudes and phases of the driving excitation are substantially the same as that employed for forward end-fire linear arrays.

In accordance with this invention an embodiment thereof may include a plurality of radiator elements, such as slots, coupled to a waveguide capable of propagating two orthogonal linearly polarized modes. The array is then fed with linearly polarized waves having a plane of polarization perpendicular to a selected plane. The radiator elements are, however, arranged so as to be excited only when the waveguide propagates linearly polarized waves having a plane of polarization parallel to the selected plane. Therefore the radiation elements are not excited and the array behaves like an ordinary waveguide in propagating the wave. When the electromagnetic wave reaches the end of the waveguide, its plane of polarization is turned through an angle of 90 degrees and the rotated wave is totally reflected back into the waveguide array. The reflected electromagnetic wave now being polarized normal to the selected plane excites the radiator elements to produce an end-fire beam. In this manner, a reverse end-fire linear array is obtained by utilizing a reflected wave for exciting the radiators. The spacing of the radiator elements and the driving excitation parameters are in all respects similar to the techniques heretofore employed with forward end-fire linear arrays.

Fig. 1 is a perspective cutaway view of a reverse end-fire waveguide array in accordance with this invention;

Fig. 2 is a perspective cutaway view of a reverse end-fire antenna including two waveguide arrays and a suitable feed waveguide;

Fig. 3 is a perspective view of a reverse end-fire conical antenna including a plurality of waveguide arrays; and

Fig. 4 is a detailed view in perspective of the feed means of the conical antenna shown in Fig. 3.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawings, in which several embodiments of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawings

are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

Referring now to the drawings, wherein like reference characters designate like parts, and particularly to Fig. 1, there is shown a square waveguide **10** dimensioned for propagating two orthogonal linearly polarized wave energy modes. A selected radiating wall **12** of the waveguide **10** includes a large number of thin, narrow, transverse radiating slots **14** excitable by polarized electric fields having a plane of polarization transverse to the radiating wall **12**. The slots **14** are shown as extending transversely to the longitudinal dimension of the waveguide **10** all the way across the waveguide **10**. Such slots are usually designated as nonresonant slots if its length differs from that of one-half of a guide wavelength. Actually, the slots **14** may be of any length but it has been found that slots extending all the way across the waveguide are very simple to cut. Furthermore, the spacing between slots is shown as being small (about one-twelfth of a guide wavelength) to obtain what is generally known as a leaky line. As mentioned above, the spacing of the slots, and the driving parameters determine the beam angle of the waves radiated and the slot dimension itself has been found to contribute to the shape of the beam radiated. Consequently, when a particular beam angle and beam cross-section is desired, the proper slot spacing and slot dimensions are selected from well known techniques described in the above-mentioned reference by Silver.

A conductive planar closure member **16** affixed to one end of waveguide **10** provides an electrical short. A conductive planar diagonal member **18** extends between diagonally opposite corners of the square waveguide **10** and abuts the planar closure member **16** along an edge **20** of the diagonal member. The conductive planar diagonal member **18** extends into the waveguide **10** a distance approximately equal to one-quarter of the guide wavelength (the wavelength of the waves within the waveguide at the operating frequency) and its thickness is selected such as to provide a mechanically rigid planar sheet.

A source **22** is connected to the square waveguide **10** to excite linearly polarized electric fields therewithin through path **24**. The arrow **26** of Fig. 1 indicates the spatial orientation of the plane of polarization of the linearly polarized waves excited within waveguide **10** which plane is parallel to the radiating wall **12** containing the radiating slots **14**.

The operation of the reverse end-fire waveguide array of Fig. 1 is as follows. Linearly polarized wave energy from the source **22** is propagated along path **24** and excites the lowest order TE-mode in waveguide **10**. The plane of polarization of these waves is parallel to wall **12** containing the slots **14**, as is shown by arrow **26** in Fig. 1. As previously stated, the radiating slots **14** in the radiating wall **12** are excitable only by linearly polarized waves having a plane of polarization orthogonal to wall **12**, or parallel to what will also be referred to as the selected plane. Therefore the wave energy mode excited by the source **22** is propagated along the waveguide without exciting slots **14** because none of the currents induced into the waveguide wall **12** have a component transverse to the direction of elongation of the slots **14**.

As the linearly polarized wave approaches the combination of the planar diagonal member **18** and the planar closure member **16**, a combination which is also termed as termination means, the plane of polarization is rotated through an angle of 90 degrees into parallelism with the selected plane as defined above. This rotation is illustrated by two arrows, the arrows **26'** representing the plane of polarization prior to reaching the diagonal **18**, and arrow **28** representing the plane of polarization after rotation. In addition to rotating the plane of polarization to become parallel to the selected plane, the combination of the closure member **16** and the diagonal member **18** causes a substantially complete reflection of the rotated linearly polarized wave. After reflection, the rotated wave is propagated back along the waveguide **10**, i.e., in the direction of source **22**. It is obvious that the reflection from the combination of the plate **16** and the diagonal **18** is accomplished substantially without losses because no dissipative elements are included into this termination.

The reflected linearly polarized wave having a plane of polarization parallel to the selected plane excites the slots **14** in much the same manner as a forward end-fire array is excited. In fact, the result obtained is the same as if the feed array had been shifted to point **28**. The excitation of the slot **14** in this manner will provide an end-fire beam which is reversed with respect to wave energy propagated from the source **22** but is forward with respect to the direction of the reflected electromagnetic wave.

The term end-fire, as used herein, designates an array giving rise to a beam whose axis is either parallel to the array axis or makes an angle with the array axis which is not 90 degrees. An end-fire array may be defined as an array which provides a beam which is not broadside. In practice, end-fire beams are those which are parallel to the array axis or make an angle therewith which is not greater than 60 degrees. This is, of course, arbitrary and the array of this invention may also be utilized for broad-fire beams.

It will be apparent to those skilled in the art that the teachings of the embodiment shown in Fig. 1 are likewise applicable to arrays which comprise waveguides of other than square cross-sections. For example, circular or ridge waveguides may be used in the same manner. The important characteristics of all waveguides which may be utilized for the linear array of this invention is that the waveguide can be excited by orthogonal linearly polarized modes. Likewise, the slot radiators **14** may be replaced by probes, dipoles or other well known types of radiation elements which in combination with the array waveguide are excitable by waves which are linearly polarized along a selected plane and which are not excited when the plane of polarization is orthogonal to the selected plane. In other words, the radiation elements must be polarization sensitive to one of the orthogonal modes.

The reverse end-fire linear array shown in Fig. 1 and described above may be utilized alone, or it may be combined with similar arrays to provide a multi-element antenna array. For instance, several arrays may be combined to form cone shaped antennas for the nose of a high speed aircraft. As is well known, plastic radomes or nose cover units, as they are sometimes referred to, for housing radar nose antennas become unsuitable when the temperatures due to atmospheric friction approaches the blistering point of the plastic material. One solution to this heat problem is a metallic radome comprising ordinary end-fire arrays which provides a forward end-fire beam. However, it has been found that the feed distribution system to feed a number of these arrays is very complicated.

Fig. 2 shows a two element reverse end-fire array comprising a standard rectangular feed waveguide **30** coupled to a source **32** which excites the feed waveguide **30** in the lowest TE-mode. The other end of the waveguide **20** is coupled to the central portion of a curved waveguide section **34**. A junction **36** formed by the rectangular waveguide **30** and the waveguide section **34** is an H-plane T-junction for the curved waveguide section **34** is of rectangular cross-section in the proximity of junction **34** and flares in width towards both ends to increase its narrow dimensions to that of its broad dimensions. In other words, the curved waveguide section **34** is of rectangular cross-section at its central portion and of square cross-section at both of its ends. Waveguide

section 34, feed waveguide 30 and source 32 provide a feed system.

Two substantially identical reverse end-fire linear arrays 38 and 40, similar to the array shown in Fig. 1, are coupled to the square ends of waveguide section 34. The arrays 38 and 40 comprise, just as explained in connection with Fig. 1, a square waveguide 10 which includes radiating slots 14 in a radiating wall 12. Each array is terminated at its free end by a closure member 16 and contains a conductive diagonal member 18 in engagement with the closure member 16.

The operation of the nose array of Fig. 2 is as follows. The source 32 excites the TE_{01}-rectangular waveguide mode within the feed waveguide 30. The junction 36 acts as a power divider and excites the TE_{10}-rectangular waveguide mode in the curved waveguide section 34. The planes of polarization of these modes are parallel respectively to arrows 42 and 42' and provide the orientation of the plane of polarization orthogonal to the selected plane. This mode, being polarized perpendicular to the selected plane, will not excite the radiators 14 in the coupled arrays 38 and 40. The mode in each array 38 or 40 is then rotated by the closure member 16 and the diagonal member 18 in the manner previously described. In other words, the plane of polarization of the energy is rotated through 90 degrees and completely reflected. Because the plane of polarization is now parallel to the selected plane, the reflected waves excite the radiators 14 to provide an end-fire beam from each array along beam axes 44 and 44'.

Fig. 3 shows an antenna array utilizing eight reverse end-fire array elements of the type shown in Fig. 1 and arranged about an antenna axis 50 to assume the geometrical configuration of a cone. More specifically, the waveguides define the frustum of a right circular hollow cone. Each array element comprises, just as the array shown in Fig. 1, a square waveguide 10 having a plurality of transverse slots 14 in waveguide wall 12. Each array is terminated, just as previously explained, by a closure member 16 with which a conductive diagonal member 18 is in contact.

A base structure comprising an outer skin 52 and an inner skin 54 may be utilized for supporting the individual waveguides 10 in the spatial relation shown and for providing an aerodynamically suitable structure. The outer skin 52 may be perforated by long narrow cutouts 56 to expose the radiating slots 14 of the waveguides 10. A cylindrical waveguide 58 located along the antenna axis 50 of the cone is part of the feed distribution system and is shown in Fig. 4. A source 60 is coupled to the cylindrical waveguide 58 and supplies the wave energy which is radiated by the slots 14.

The detailed manner in which the cylindrical waveguide 58 is coupled to the square waveguides 10 is shown in Fig. 4. The upper end (as seen in Fig. 4) of the cylindrical waveguide 58 is coupled to a radial waveguide 62. As is well known to those skilled in the art, the TE_{01}-circular waveguide mode indicated by the curved arrow 64 is electrically coupled to the TE_{01}-radial waveguide mode indicated by the arrows 66. The waveguides 10 are radially connected to the radial waveguide 62 which excites therein a linearly polarized mode, the plane of polarization of which is indicated by the arrows 68 in Fig. 4.

The conical array of Figs. 3 and 4 operates as follows. Wave energy from the source 60 is so coupled to the cylindrical waveguide 58 as to excite the TE_{01}-mode therewithin having electric field lines represented by arrow 64. The cylindrical waveguide 58 in turn excites the TE_{01}-radial waveguide mode in the radial waveguide 62 which gives rise to electric field lines represented by the arrows 66 in Fig. 4. As long as the waveguides 10 are symmetrically spaced, an even division of wave energy between them obtains.

The mode within the radial waveguide 62 excites the square waveguide 10 by setting up a linearly polarized mode having electric vectors where direction is indicated by the arrow 68 in Fig. 4. Because the direction of polarization of the electric field is parallel to the walls 12 containing the radiating slots 14, the currents induced into the radiating wall 12 do not have a component transverse to the direction of elongation of the slots 14. Consequently, the slots will not be excited and no radiation will take place.

As the linearly polarized waves are propagated through each square waveguide 10 they encounter the combination of the closure member 16 and the therewith abutting diagonal 18. As explained heretofore, this combination rotates the plane of polarization through an angle of 90 degrees and reflects the rotated waves back along the square waveguide 10. Because the electric vector is now perpendicular to the wall 12 of the waveguides 10 containing the slots 14 electric currents are induced into the radiating wall 12 which have component transverse to the direction of elongation of the radiating slots 14. The waveguides 10 with the slots 14 now operate like an ordinary end-fire linear array giving rise to an end-fire beam in the direction of propogation of the reflected waves.

The conical array of Fig. 3 has been explained in conjunction with a radial waveguide 62. It will be emmediately apparent to those skilled in the art that the radial waveguide serves as a distribution network for feeding the square waveguides 10. Obviously, the radial waveguide might be replaced by conical waveguides or other equivalent wave distributing networks which excite linearly polarized waves within the square waveguides having an electric field parallel to the wall containing the radiating slots. It is also apparent that the radiation slots 14 are merely shown by way of example and that equivalent radiators may be substituted therefor.

There has been described hereinabove a reverse end-fire linear array wherein reflected wave energy is utilized for obtaining an ordinary end-fire beam. The array usually, but not necessarily, comprises a waveguide conductor including radiation means associated therewith. This array is fed by electromagnetic waves which are oriented in such a way as not to excite the associated radiation means. In other words, the radiation means is disassociated from the electromagnetic waves excited within the waveguide. The waves are then operated upon by completely reversing its direction of propagation and rotating its plane of polarization through 90 degrees so as to completely excite the radiation means. There has also been described a conical array using reverse end-fire linear arrays.

What is claimed is:

1. A reverse end-fire waveguide array comprising: a waveguide section adapted to propagate orthogonal linearly polarized electromagnetic waves, one wall of said waveguide section including radiation means arranged to be excited by electromagnetic waves linearly polarized in a first plane; a source of electromagnetic waves for exciting linearly polarized waves in a second plane perpendicular to said first plane and coupled to one end of said waveguide section; and terminal means coupled to the other end of said waveguide section for rotating the linearly polarized waves excited by said source from parallelism with said second plane to parallelism with said first plane and totally reflecting said rotated waves.

2. A reverse end-fire linear array comprising: a hollow elongated conductor of substantially uniform cross-section having a central portion and a first and a second end portion, said conductor being excitable by orthogonal linearly polarized electromagnetic waves having a plane of polarization parallel to a first and a second plane; radiation means electrically associated with said central portion for providing an end-fire beam when said conductor is excited by electromagnetic waves linearly polar-

ized parallel to said first plane, said radiation means being electrically dissociated from said central portion when said conductor is excited by electromagnetic waves linearly polarized parallel to said second plane; a closure member electrically terminating said first end portion; a conductive planar diagonal member within said first end portion and abutting said closure member, said diagonal extending between diagonally opposed corners of said conductor and having a width substantially equal to one-quarter of the waveguide wavelength; and source means coupled to said second end portion for exciting within said conductor electromagnetic waves linearly polarized parallel to said second plane.

3. A reverse end-fire waveguide array comprising: a forward end-fire linear array including a waveguide and an associated radiation means, said array being excitable by electromagnetic wave energy linearly polarized parallel to a first plane to provide an end-fire beam, said array propating substantially all electromagnetic waves linearly polarized parallel to a second plane without exciting said radiation means, said second plane being perpendicular to said first plane; and wave reflecting means coupled to one end of said waveguide for rotating the plane of polarization of linearly polarized electromagnetic waves from said second plane to said first plane for exciting said radiation means with the waves reflected therefrom.

4. A reverse end-fire linear array comprising: a waveguide section dimensioned for propagating orthogonal linearly polarized electromagnetic waves, one wall of said waveguide section including radiation means excitable by electromagnetic waves linearly polarized along a first plane for radiating an end-fire beam extending in the direction of propagation of waves linearly polarized along said first plane; a source of electromagnetic waves linearly polarized along a second plane perpendicular to said first plane and coupled to one end of said waveguide section; a conductive closure member electrically terminating the other end of said waveguide section; and a conductive diagonal inside said waveguide section and abutting said closure member along one edge thereof, the combination of said closure member and said diagonal turning the plane of polarization of the electromagnetic waves from said second plane into said first plane and reflecting said waves towards said radiation means.

5. A reverse end-fire waveguide slot array comprising: a square waveguide section, one wall of said waveguide section including a plurality of transverse, narrow, closely spaced, nonresonant slots; a conductive planar closure member electrically closing one end of said waveguide section; a conductive planar diagonal abutting said closure member and extending between diagonally disposed corners of said waveguide section, said conductive diagonal extending into said waveguide section a distance equal to one-quarter of a waveguide wavelength; and a source of linearly polarized electromagnetic waves coupled to the other end of said waveguide section for exciting said waveguide section with waves linearly polarized parallel to said wall.

6. A reverse end-fire antenna array comprising: a plurality of waveguide sections, each waveguide section dimensioned for propagating orthogonal linearly polarized modes of electromagnetic waves; a source of linearly polarized electromagnetic waves, one end of each of said waveguide sections being coupled to said source for exciting each of said waveguide sections with electromagnetic waves having a plane of polarization orthogonal to a selected plane; radiation means included within each of said waveguide sections, said radiation means being excitable by electromagnetic waves having a plane of polarization parallel to said selected plane; and means coupled to the other end of each of said waveguide sections for rotating the plane of polarization of the electromagnetic waves from said source to become parallel to said selected plane and totally reflecting said rotated waves.

7. A reverse end-fire waveguide antenna comprising: a plurality of waveguide sections arranged symmetrically about an array axis; polarization selective radiation means associated with each of said waveguide sections, said radiation means radiating an end-fire beam when said waveguide section is excited with electromagnetic waves linearly polarized parallel to a selected plane; a source of electromagnetic waves, a like end of each of said waveguide sections being coupled to said source, said source exciting each of said waveguide sections with electromagnetic waves linearly polarized perpendicularly to said selected plane; and terminal means coupled to the other end of each of said waveguide sections, said terminal means operating upon said linearly polarized waves from said source by rotating the plane of polarization into parallelism with said selected plane and reflecting said rotated waves for exciting said radiation means.

8. A reverse end-fire waveguide antenna comprising: a plurality of waveguide sections arranged symmetrically about an array axis, each waveguide section dimensioned for propagating orthogonal linearly polarized modes of electromagnetic waves; a source of linearly polarized electromagnetic waves, one end of each of said waveguide sections coupled to said source for exciting said waveguide sections with electromagnetic waves having a plane of polarization perpendicular to a selected plane; radiation means included within each of said waveguide sections, said radiation means being excitable by electromagnetic waves having a plane of polarization parallel to said selected plane; a conductive planar member closing the other end of each of said waveguide sections; and a conductive planar diagonal inside each of said waveguide sections and abutting said conductive planar member, said planar diagonal having a width of one-quarter of the waveguide wavelength and extending between diagonally opposed corners of said waveguide sections.

9. A reverse end-fire waveguide antenna comprising: a plurality of waveguide sections arranged symmetrically about an array axis; polarization selective radiation means associated with each of said waveguide sections, said radiation means radiating an end-fire beam when said waveguide section is excited with electromagnetic waves linearly polarized parallel to a selected plane; a source of electromagnetic waves, one end of each of said waveguide sections being coupled to said source, said source exciting each of said waveguide sections with electromagnetic waves linearly polarized perpendicularly to said selected plane; a plurality of closure members each being coupled to the other end of a different one of each of said waveguide sections; and a plurality of diagonal members, each extending between diagonally opposed corners within a different one of each of said waveguide sections and abutting the associated closure member, the combination of a closure member and the associated diagonal member operating upon said linearly polarized waves from said source by rotating the plane of polarization into parallelism with said selected plane and reflecting said rotated waves for exciting said radiation means.

10. An end-fire waveguide antenna array comprising: two square waveguide sections arranged symmetrically about an array axis; an H-plane T-junction, said waveguide sections being respectively coupled to the symmetry arms of said junction; a source of linearly polarized electromagnetic waves coupled to the third arm of said junction, for exciting linearly polarized waves within said two square waveguides having a plane of polarization perpendicular to a selected plane; radiation slots included within a wall of each of said waveguide sections, said radiation means being excitable by electromagnetic waves having a plane of polarization parallel to said selected plane for radiating an end-fire beam in the direction of propagation of the exciting waves; two conductive planar members, each closing the other end of a different one of said two waveguide sections; and two conductive diagonal members each inside a different one of said two

waveguide sections and abutting the associated conductive planar member, said diagonal members having a width equal to one-quarter of the waveguide wavelength and extending between diagonally opposed corners of the associated waveguide sections, the combination of a closure member and the associated diagonal member operating upon said linearly polarized waves from said source by rotating the plane of polarization into parallelism with said selected plane and reflecting said rotated waves for exciting said radiation slots.

11. A conical waveguide antenna comprising: a plurality of square waveguide sections arranged about an array axis to define a hollow frustum of a right circular cone, the outer walls of said square waveguides each including a plurality of thin transverse nonresonant slots arranged to radiate an end-fire beam when said square waveguides are excited by linearly polarized waves having a plane of polarization perpendicular to said wall; a radial waveguide for exciting within said square waveguide linearly polarized electromagnetic waves having a plane of polarization perpendicular to said wall, the ends of said square waveguides defining the narrow portion of said cone being radially coupled to said radial waveguide; a cylindrical waveguide coupled to said radial waveguide for exciting the TE_{01}-radial waveguide mode therein; a source of electromagnetic waves coupled to said cylindrical waveguide for exciting the TE_{01}-circular waveguide mode therein; a plurality of conductive planar members, each closing the other end of a different one of said waveguide sections; and a plurality of conductive planar diagonal members, each inside a different one of each of said waveguide sections and abutting the associated conductive planar member, each of said planar diagonal members having a width of one-quarter of the waveguide wavelength and extending between diagonally opposed corners of said waveguide sections, the combination of a closure member and the associated diagonal operating upon said linearly polarized waves from said radial waveguide by rotating the plane of polarization through ninety degrees and reflecting said rotated waves for exciting said slots.

No references cited.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,894,261 July 7, 1959

Nicholas Yaru

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 71, for "arrows 26'" read -- arrow 26' --; column 4, line 14, for "feed array" read -- feed of the array --; column 5, line 13, for "TE_{01}- rectangular" read -- TE_{10}- rectangular --; column 6, line 19, for "have component" read -- have a component --; lines 26 and 27, for "emmediately" read -- immediately --; column 7, line 19, for "propating" read -- propagating --.

Signed and sealed this 17th day of November 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents