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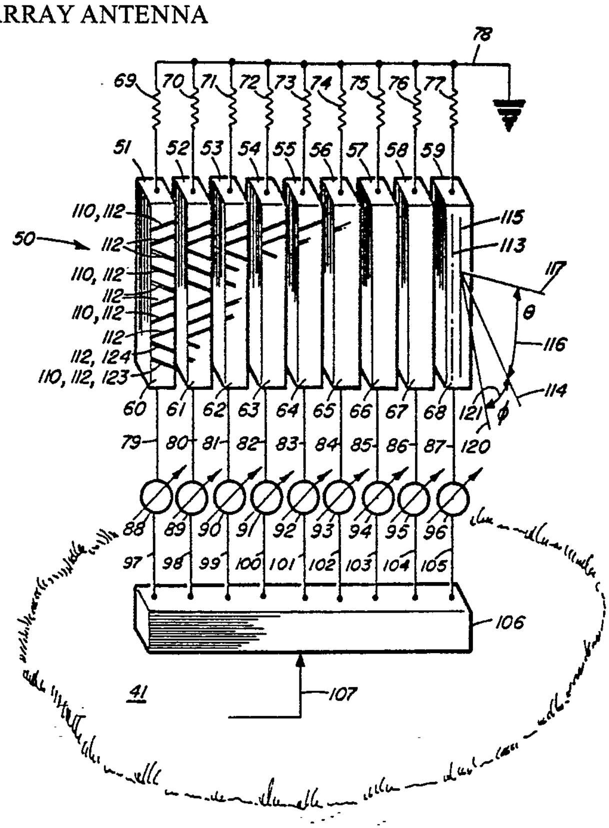
(54) Title: WAVEGUIDE SLOT ARRAY ANTENNA



(57) Abstract

A waveguide slot array antenna for radiating electromagnetic energy in a single beam comprising a plurality of waveguides (51-59), each waveguide (51-59) having slots (110 and 112) spaced at first and second spacings to provide a single beam. The invention overcomes the problem of grating lobes occurring at certain angles for the main beam.

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WAVEGUIDE SLOT ARRAY ANTENNA

Technical Field of the Invention

This invention relates to antennas and more particularly to a waveguide slot array antenna.

Background of the Invention

A waveguide slot array antenna may comprise a number of waveguide elements which are fed with R.F. energy from one end and terminated at the other end of the waveguide. Slots are formed in the waveguide to radiate or leak R.F. energy. The amount of energy coupled out of a slot in a waveguide is determined by the slot size and angle. The antenna pattern from the antenna aperture of the slot array antenna is determined by the amplitude and phase distribution of the R.F. energy radiating from the slots in the waveguides. The angle, orientation and location of the slots along the waveguides provides the amplitude and phase distribution from each slot.

Each waveguide element may be rectangular in cross section having a broadside and a narrow side or edge. For obtaining R.F. energy from a waveguide which is polarized in the direction of the longitudinal axis of the waveguide, slots are formed in the narrow side or edge of the waveguide element. The antenna pattern from an array antenna may be electronically scanned for example ± 60° in azimuth by controlling the phase and amount of radio frequency energy coupled to each waveguide element. A power divider and phase shifters are normally used to control the phase and amplitude of the R.F. energy at the input of each waveguide element.

Waveguide slot array antennas may form a pencil beam with low side lobes which radiates broadside to the slot array antenna. When the pencil beam is directed at 90° to the antenna aperture or waveguide longitudinal axis or at an acute angle with respect to the the waveguide longitudinal axis at the end fed by R.F. energy, a single pencil beam with low side lobes may be generated. When the pencil beam is directed at an angle greater than 90° with respect to the antenna aperture and away from the waveguide end fed by R.F. energy, multiple beams are formed, for example, the desired pencil beam and a grating lobe. In many applications the presence of a grating lobe is unacceptable.

Presently for a particular application, a waveguide slot array antenna is positioned near the surface of the ground for radiating a pencil beam at ground level and extending up to an elevation of 20°. The waveguide slot array antenna is positioned vertical to the ground with the waveguide elements positioned parallel to one another and vertical to the ground with the R.F. energy fed at the upper end of each waveguide with the lower end of each waveguide terminated. The -6 db point of the underside of the pencil beam pattern is positioned at the horizon, thereby reducing undesirable ground reflections.

A general discussion of waveguide slot array antennas is provided in a book by H. Jasik entitled "Antenna Engineering Handbook" McGraw-Hill Book Company, Inc. 1961, pgs. 9-1 thru 9-18 which shows an edge slot in a rectangular wave guide in Fig. 9-11.

It is therefore desirable to provide a waveguide slot array antenna that may radiate a single pencil beam from the antenna aperture at angles greater than 90° with respect to the waveguide longitudinal axis at the end fed by R.F. energy.

It is further desirable to provide a waveguide slot array antenna having additional slots to provide R.F. energy to cancel a grating lobe.

It is further desirable to provide a waveguide slot array antenna which may be positioned above the ground with a plurality of vertical waveguide elements having the end nearest the ground fed with R.F. energy and the upper end of each waveguide element terminated.

Summary of the Invention

An apparatus is described for radiating electromagnetic energy in substantially a single beam comprising a plurality of waveguides spaced apart from one another, each waveguide having a first wall facing in a first direction, each waveguide having a plurality of first slots in the first wall having a first spacing along the waveguide for generating a first beam and an undesired second beam, each waveguide having a plurality of second slots in the first wall having a second spacing along the waveguide less than the first spacing for generating a third beam to substantially cancel the second beam, and each waveguide adapted for coupling electromagnetic energy thereto having a predetermined amplitude and phase, respectively.

Description of the Drawing

Fig. 1 is a schematic and pictorial view of a waveguide array antenna of the prior art.

Fig. 2 is a graph showing a typical radiation pattern from the antenna Fig. 1.

Fig. 3 is a schematic and pictorial view of one embodiment of the invention.

Fig. 4A is a front view of a portion of one waveguide element in Fig. 3.

Fig. 4B is an enlarged view of a portion of Fig. 4A.

Figs. 5 and 6 are front views of a portion of a waveguide element.

Figs. 7A and 7B are graphs of the radiation pattern from an array of waveguide elements where one is shown in Fig. 5.

Figs. 8A and 8B are graphs of the radiation pattern from an array of waveguide elements where one is shown in Fig. 6.

Fig. 9A and 9B are graphs of the radiation pattern from an array of waveguide elements shown in Fig. 3.

Detailed Description

Referring to Fig. 1, a waveguide slot array antenna 10 of the prior art is shown. A plurality of waveguide elements 11-19 are positioned side-by-side and spaced apart from one another. The lower end of waveguide elements 11-19 are terminated by resistors 20-28. The upper end of waveguide elements 11-19 are coupled through phase shifters 29-37, respectively, to a respective input of power divider 39. Waveguide elements 11-19 have one edge wall which may be co-planar to one another with slots 42 formed therein to provide a radiating aperture 43. Radio frequency (R.F.) power or microwave power is coupled to power divider 39 over line 40. Below waveguide elements 11-19 is shown the earth's surface or ground 41.

Fig. 2 is a graph showing a typical radiation pattern from waveguide slot array antenna 10 of Fig. 1. In Fig. 2 the radius ρ represents amplitude and the polar angle θ represents elevation angle with 90° at the horizon. As shown in Fig. 2 a single lobe or beam is radiated extending from the horizon upwards in elevation to an angle of 20° shown by arrow 45. Curve 46 shows the elevation direction and amplitude of the main beam. Curve 47 shows the amplitude and direction of the upper side lobe adjacent the main beam 46 and curve 48 shows the amplitude and direction of the lower side lobe adjacent the main beam 46.

Fig. 3 is a schematic and pictorial view of a waveguide slot array antenna 50 for radiating electromagnetic energy in substantially a single beam. Waveguides 51-59 are shown spaced apart from one another. Waveguides 51-59 have a wall 60-68, respectively, which may have a surface facing in the same direction. Walls 60-68 may be, for example, co-planar. Waveguides 51-59 are terminated by resistors 69-77, respectively, to ground potential, for example, by line 78. The lower end of waveguides 51-59 are coupled over lines 79-87, respectively, through phase shifters 88-96, respectively, and over lines 97-105, respectively, to respective inputs of power divider 106. Power divider 106 receives electromagnetic energy such as in the form of radio frequency or microwave energy or power over line 107. The microwave power received on lead 107 is divided by power divider 106 and distributed over lines 97-105.

Walls 60-68 have a plurality of first slots 110 cut therein for radiating R.F. power in a first beam. In addition to slots 110, slots 112 are cut in walls 60-68 to radiate R.F. power to cancel out a grating lobe which is also formed at the time the first beam of R.F. power is formed. For example, the desired beam of R.F. power may radiate at an angle of θ measured from the normal to the respective wall of the waveguide and away from the input end of waveguides 51-59. Reference line 114 is normal to wall 68 and to reference line 115 which is then lying on the surface of wall 68 and parallel to the longitudinal axis 113 of waveguide 59. Angle θ as shown by arrow 116 is formed between reference line 114 and reference line 117 and is in the plane formed by reference lines 114 and 115. Angle θ which may be, for example, 10° may be the peak of a beam radiated from aperture 118 formed by slots 110 in walls 60-68. Angle $\emptyset$ which may be, for example, -57.11° is formed between reference line 114 and reference line 120 as shown by arrow 121. Reference line 120 is in the plane formed by reference lines 114 and 115. Angle $\emptyset$ may be the peak amplitude in a grating lobe or beam radiated from slots 110 formed in walls 60-68.

Slots 112 formed in walls 60-68 may also form a beam having a peak at angle $\emptyset$ and having a phase opposite to the grating lobe radiated by slots 110. Slots 110 and 112 form radiating aperture 118.

Referring to Figs. 4A and 4B, wall 60 of waveguide 51 is shown. Slots cut in wall 60 are spaced apart at their centers by the dimension d/3 which may be, for example, .8356 cm (.329"). Slot 123 may be cut at an angle $\emptyset_1$ as shown by arrow 124 with respect to reference line 125. Reference line 125 is on the surface of wall 60 and is orthogonal to the longitudinal axis 128 of waveguide 51. Slot 124 may likewise be cut at an angle $\emptyset_2$ with respect to reference line 126 shown by arrow 127. Reference line 126 is on the surface of wall 60 and is orthogonal to the longitudinal axis 128 of waveguide 51. Waveguide 51 may be, for example, rectangular in cross section with respect to the longitudinal axis 128. The position of the center of a slot shown, for example, by reference point 130 on slot 123 and the orientation of the slot with respect to reference line 125, determines the phase of the R.F. energy coupled out. For positive angles of $\emptyset_1$ the R.F. energy coupled out of slot 123 will be at one phase angle and for negative angles of $\emptyset_1$ the R.F. energy coupled out of slot 123 will be shifted by 180°. The angle $\emptyset_1$ of the slot determines the amount of R.F. energy coupled out of the slot. For example, when $\emptyset_1$ is 0° no energy is coupled out of slot 123. When $\emptyset_1$ is 90° the maximum energy is coupled out of slot 123. The polarization of the R.F. energy coupled out of slots 110 and 112 is aligned with reference axis 128.

Fig. 5 shows waveguide 51' with slots 110' cut in wall 60'. Slots 110' are spaced at distance d which corresponds to 2.507 cm (.987"). Slots 110' are selected to provide the desired main beam at an angle θ having a peak amplitude along reference line 117 shown in Fig. 3. An undesired grating lobe may also be formed.

Fig. 6 shows a waveguide 51" having slots 112" formed in wall 60". Slots 112" are spaced apart by distance d/3 which corresponds to .836 cm (.329"). Slots 112" are selected to provide a single beam at an angle $\emptyset$ having a peak amplitude along reference line 120 in Fig. 3 and shifted 180° in phase to cancel out a grating lobe formed by slots 110' shown in Fig. 5.

Fig. 4A is a combination or summation of slots 110' and 112" shown in Figs. 5 and 6, respectively, to provide a single main beam having a peak amplitude along reference line 117 shown in Fig. 3 with the undesired grating lobe cancelled out.

The angle Θ of the peak radiation from a beam of R.F. energy radiated from a waveguide array having equally spaced anti-phased slots is given by equation (1).

$$\sin \Theta = \frac{\lambda_o}{\lambda_g} + \frac{\lambda_o}{d} (n - 1/2) \qquad (1)$$

In equation (1), Θ is the angle at which the beam is formed, λ_0 is the free space wavelength, λ_g is the waveguide wavelength, d is the slot spacing, and n is an integer value of zero, ± 1, ± 2, ... The value selected for d, λ_0 and λ_g determine what interger values n can have for real values of Θ, that is, for sin Θ less than or equal to one. If in equation (1), angle Θ is real only for the value of n equals zero, then only a single beam (main beam) is formed. If angle Θ is real for more than one value of n, then the main beam plus other beams called grating lobes are formed. One grating lobe is formed for each non-zero value of n. Using the values of 0.68 for λ_0/λ_g, 0.987 for d/λ_0 and with n equal to zero in equation (1) yields Θ equal to +10°, which corresponds to a single main beam. Using the same values except for n equal to minus one in equation (1) yields Θ equal to -57.11°, which is a grating lobe. The above values would be generated from a waveguide slot antenna fabricated with waveguides 51' shown in Fig. 5.

Fig. 7A shows a graph of the radiation pattern from a waveguide slot array antenna fabricated with waveguides 51' shown in Fig. 5. In Fig. 7A the ordinate represents power in decibels and the abscissa represents elevation angle in degrees. Curve 130 shows the main beam and curve 131 shows the grating lobe. Fig. 7B shows in polar coordinates the information shown in Fig. 7A. In Fig. 7B the radius represents power in decibels and the angle represents elevation angle in degrees. An angle of 90° as shown in Figs. 7A and 7B corresponds to the broadside direction from aperture 118 shown, for example, by reference line 114.

Using the value of 0.329 for d/λ_0 and the value of 0.68 for λ_0/λ_g in equation (1) with n equal to zero yields θ equal to -57.11°. Further, the beam at -57.11° is the only beam formed. A waveguide slot array antenna using waveguides 51", as shown in Fig. 6, would provide a single beam at -57.11°. The radiation pattern is shown in Figs. 8A and 8B. In Fig. 8A the ordinate represents power in decibels and the abscissa represents elevation angle in degrees. Curve 134 shows a single beam and curve portion 135 shows the radiation of side lobes. Referring to Fig. 8B the radius represents power in decibels and the polar angle represents elevation angle in degrees. Curves 134' and 135' in Fig. 8B correspond to the information shown in Fig. 8A. In Figs. 7A and 8A, the amplitude distributions of curves 131 and 134, respectively, are substantially the same. The amplitude distributions shown in Figs. 7A and 8A can be weighted appropriately and combined out of phase to yield an amplitude distribution having the desired main beam and no grating lobe as shown in Figs. 9A and 9B.

In Fig. 9A the ordinate represents power in decibels and the abscissa represents elevation angle in degrees. Curve portions 137 and 138 represent low side lobes, while curve portion 139 represents the single main beam. In Fig. 9B the radius represents power in decibels and the polar angle represents the elevation angle in degrees. Curve 139' corresponds to curve 139 in Fig. 9A and curves 137' and 138' correspond to curves 137 and 138 in Fig. 9A.

By combining the slots 110' shown in Fig. 5 with slots 112" shown in Fig. 6 with slots 112" reoriented to provide an additional 180° phase shift, a waveguide 51 shown in Fig. 4A will result. In Fig. 4A every third slot 112" overlaps slot 110' to provide a combined slot 110, 112 as shown in Fig. 4A.

Table I provides the necessary data for a 63 slot waveguide for use in a waveguide slot array antenna to provide the radiation pattern shown in Figs. 9A and 9B. The synthesis technique used to determine the amplitude distribution for the main beam with a flat top pulse was to equate the coefficients of the antenna array factor given by equation (2) to the coefficients of the Fourier series expansion of a rectangular pulse.

$$s(\theta) = a_o + 2\sum_{m=1}^{\frac{n-1}{2}} a_m \cos(m2\pi d/\lambda \sin\theta) \qquad (2)$$

In equation (2), a_o is the amplitude of the center element and a_m equals a_{-m} for a symmetric amplitude distribution. d represents the spacing between waveguide elements and θ represents the angle of radiation with respect to a reference line normal to the plane of the radiating surface of the waveguide elements.

Table I

Slot #	$\frac{d}{\lambda_o}$	d Centimeters	d Inches	Amplitude (dB)	Phase (deg)		Slot Orientation
1	-10.199	0.000	(0.000)	-27.034	0.000	/	0.
2	-9.870	1.948	(0.767)	-20.869	-80.542	/	0.
3	-9.541	3.896	(1.534)	-27.962	-161.084	/	0.
4	-9.212	5.845	(2.301)	-30.716	-61.626	\	180.
5	-8.883	7.793	(3.068)	-31.296	-142.168	\	180.
6	-8.554	9.741	(3.835)	-46.189	-42.710	/	0.
7	-8.225	11.692	(4.603)	-32.307	56.748	\	180.
8	-7.896	13.640	(5.370)	-21.510	-23.794	\	180.
9	-7.567	15.588	(6.137)	-25.088	-104.336	\	180.
10	-7.238	17.536	(6.904)	-23.987	-4.878	/	0.
11	-6.909	19.484	(7.671)	-17.987	-85.420	/	0.
12	-6.580	21.433	(8.438)	-25.300	-145.962	/	0.
13	-6.251	23.381	(9.205)	-28.527	-66.504	\	180.
14	-5.922	25.329	(9.972)	-31.239	-147.047	\	180.
15	-5.593	27.277	(10.739)	-36.642	-47.589	/	0.

16	-5.264	29.225	(11.506)	-26.995	51.869	\	180.
17	-4.935	31.176	(12.274)	-16.753	-28.673	\	180.
18	-4.606	33.124	(13.041)	-20.406	-109.215	\	180.
19	-4.277	35.072	(13.808)	-19.419	-9.757	/	0.
20	-3,948	37.021	(14.575)	-13.418	-90.299	/	0.
21	-3.619	38.969	(15.342)	-20.786	-170.841	/	0.
22	-3.290	40.917	(16.109)	-24.397	-71.303	\	180.
23	-2.961	42.865	(16.876)	-31.204	-151.925	\	180.
24	-2.632	44.813	(17.643	-26.674	-52.467	/	0
25	-2.303	46.761	(18.410)	-18.642	46.991	\	180.
26	-1.974	48.710	(19.177)	-8.233	-33.552	\	180.
27	-1.645	50.660	(19.945)	-11.330	-114.094	\	180.
28	-1.316	52.608	(20.712)	-9.251	-14.636	/	0.
29	-0.987	54.557	(21.479)	-1.750	-95.178	/	0.
30	0.658	56.505	(22.246)	-6.789	-175.720	/	0.
31	-0.329	58.453	(23.013)	-6.217	-76.262	\	180.
32	0.000	60.401	(23.780)	0.000	-156.804	\	180.
33	0.329	62.349	(24.547)	-6.217	122.654	\	180.
34	0.658	64.298	(25.314)	-6.789	-137.888	/	0.
35	0.987	66.246	(26.081)	-1.750	141.570	/	0.
36	1.316	68.194	(26.848)	-9.251	61.028	/	0.
37	1.645	70.142	(27.615)	-11.330	160.486	\	180.
38	1.974	72.093	(28.383)	-8.233	79.944	\	180.
39	2.303	74.041	(29.150)	-18.642	-0.599	\	180.
40	2.632	75.989	(29.917)	-26.674	98.859	/	0.
41	2.961	77.937	(30.684)	-31.204	-161.683	\	180.
42	3.290	79.886	(31.451)	-24.397	117.775	\	180.
43	3.619	81.834	(32.218)	-20.786	-142.767	/	0.
44	3.948	83.782	(32.985)	-13.418	136.691	/	0.
45	4.277	85.730	(33.752)	-19.419	56.149	/	0.
46	4.606	87.678	(34.519)	-20.486	155.607	\	180.
47	4.935	89.626	(35.286)	-16.753	75.065	\	180.
48	5.264	91.577	(35.054)	-26.995	-5.477	\	180.
49	5,593	93.525	(36.821)	-36.642	93.981	/	0.
50	5.922	95.474	(37.588)	-31.239	-166.561	\	180.
51	6.251	97.422	(38.355)	-28.527	112.896	\	180.
52	6.580	99.370	(39.122)	-25.300	-147.646	/	0.

53	6.909	101.318	(39.889)	-17.987	131.812	/	0.
54	7.238	103.266	(40.656)	-23.987	51.270	/	0.
55	7.567	105.214	(41.423)	-25.088	150.728	\	180.
56	7.896	107.163	(42.190)	-21.510	70.186	\	180.
57	8.225	109.111	(42.957)	-32.307	-10.356	\	180.
58	8.554	111.059	(43.724)	-46.189	89.102	/	0.
59	8.883	113.010	(44.492)	-31.296	-171.440	\	180.
60	9.212	114.958	(45.259)	-30.716	118.018	\	180.
61	9.541	116.906	(46.026)	-27.962	-152.524	/	0.
62	9.870	118.854	(46.793)	-20.869	126.934	/	0.
63	10.199	120.802	(47.560)	-27.034	46.392	/	0.

In Table I the waveguide element is WR159, the center frequency is 5060.7 MHz, d/λ_0 equals 3.29 and d/λ_g equals 0.223 with all slots equally spaced and formed on the narrow wall or edge of the waveguide.

The invention describes an apparatus for radiating electromagnetic energy in substantially a single beam comprising a plurality of waveguides spaced apart from one another and having a wall or surface facing in a first direction, each waveguide having a plurality of slots in the wall having a first spacing along the waveguide for generating a main beam and a grating lobe, each waveguide having additional slots in the wall of the waveguide having a second spacing along the waveguide less than the first spacing for generating a third beam to substantially cancel the second beam, and each waveguide adapted for coupling electromagnetic energy at one end having a predetermined amplitude and phase, respectively. The invention further provides utilizing slots at first and second spacings with overlapping slots being combined as a single slot on the waveguide.

We Claim:

1. Apparatus for radiating electromagnetic energy in substantially a single beam comprising:

a plurality of waveguides (51-59) spaced apart from one another,

each said waveguide (51-59) having a first wall (60-68) facing in a first direction (114),

each said waveguide (51-59) having a plurality of first slots (110) in said first wall (60-68) having a first spacing along said waveguide (51-59) for generating a first beam and an undesired second beam,

each said waveguide (51-59) having a plurality of second slots (112) in said first wall (60-68) having a second spacing along said waveguide (51-59) less than said first spacing for generating a third beam to substantially cancel said second beam, and

each said waveguide (51-59) adapted for coupling electromagnetic energy thereto having a predetermined amplitude and phase respectively.

2. The apparatus of claim 1 wherein said plurality of waveguides (51-59) are positioned transverse to and above the surface of the ground (41).

3. The apparatus of claim 2 wherein each said waveguide is terminated by a resistive load (69-71) at an end furthest above said ground (41).

4. The apparatus of claim 1 wherein each said waveguide (51-59) includes a rectangular waveguide having a straight longitudinal axis (113) and wherein said first wall (60-68) has a lesser width than a second wall.

5. The apparatus of claim 1 wherein each said waveguide (51-59) includes first means (79-87) for coupling electromagnetic energy to an end closest to said ground.

6. The apparatus of claim 1 wherein said first slots (110) are evenly spaced apart by a distance d.

7. The apparatus of claim 6 wherein said second slots (112) are evenly spaced apart by one third said distance d.

8. The apparatus of claim 6 wherein at least one of said first slots (110) and one of said second slots (112) are combined into one slot (110, 112).

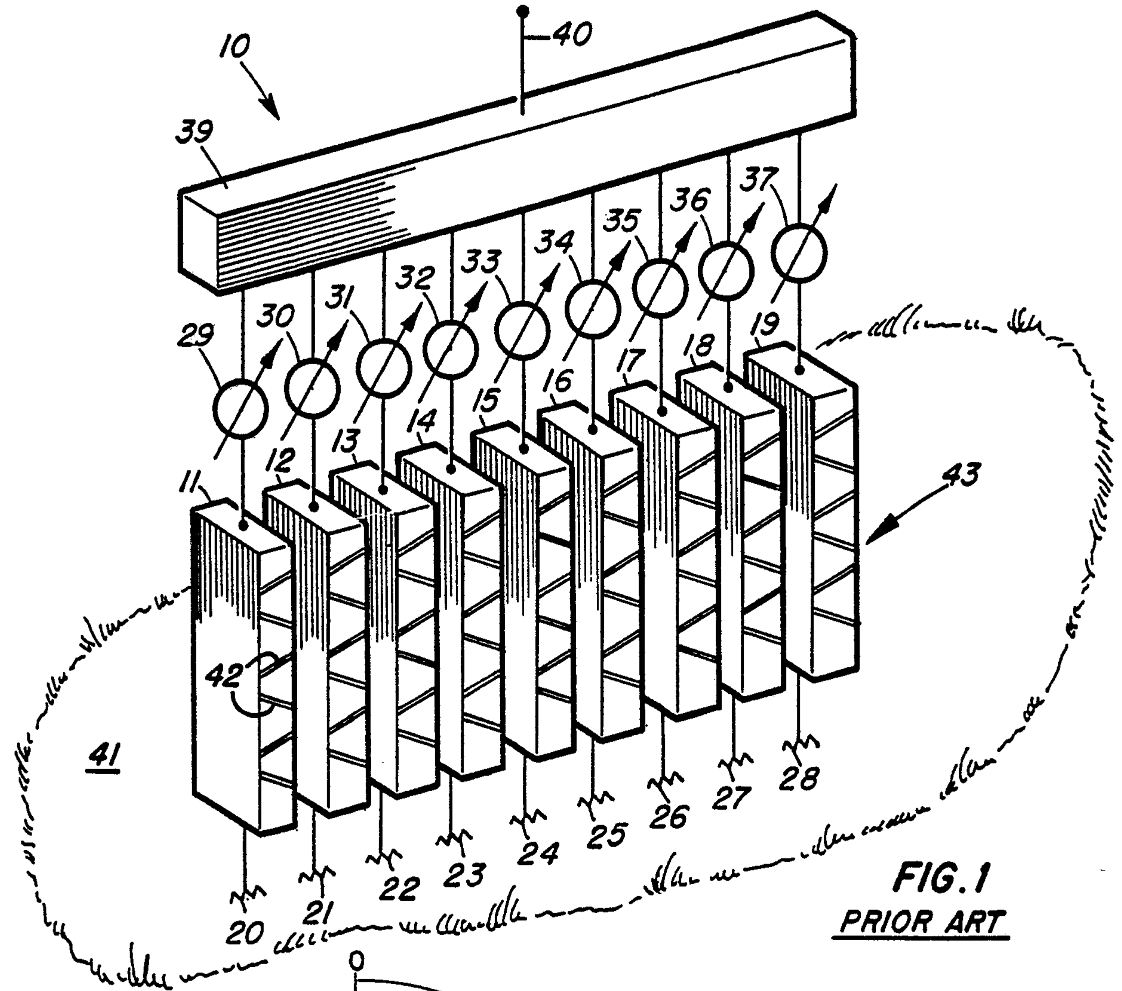


FIG. 1
PRIOR ART

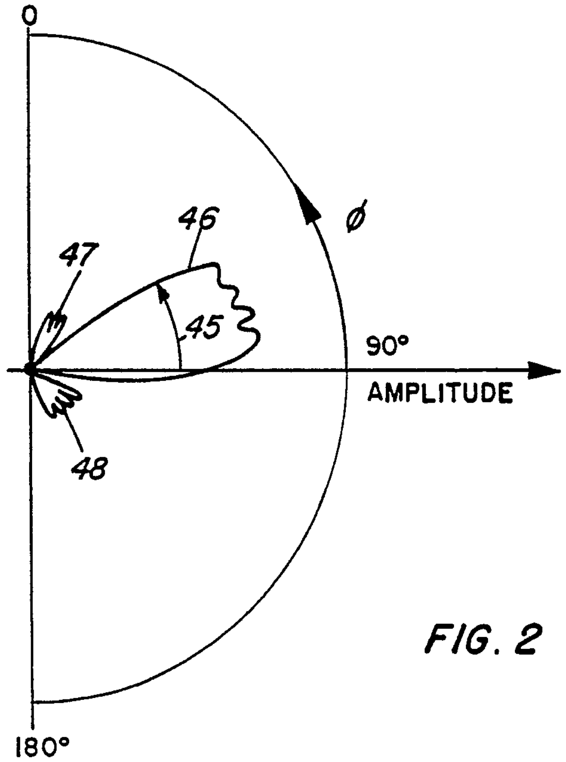
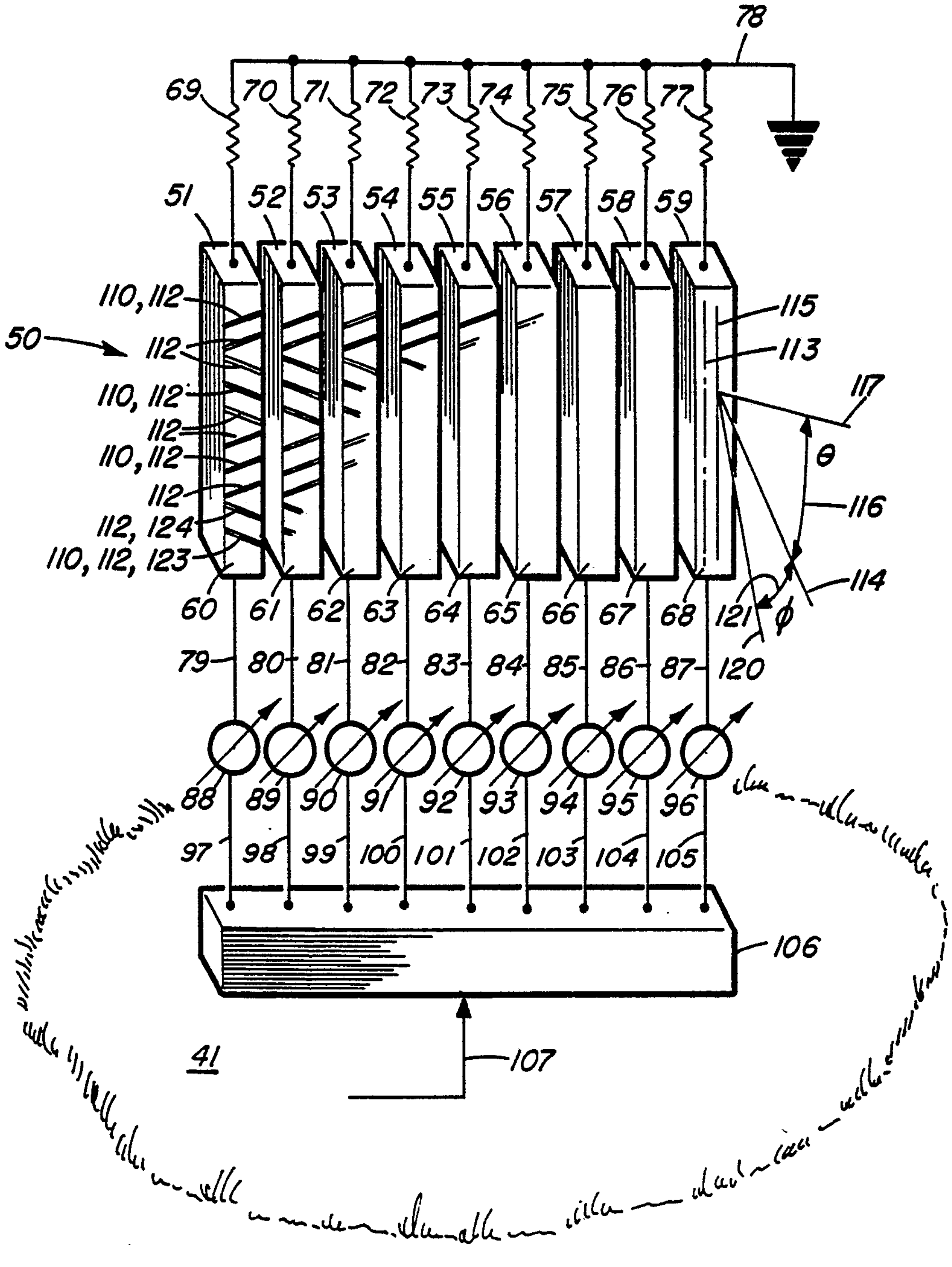


FIG. 2

SUBSTITUTE SHEET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θ
116
114
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106
41
107

FIG. 3

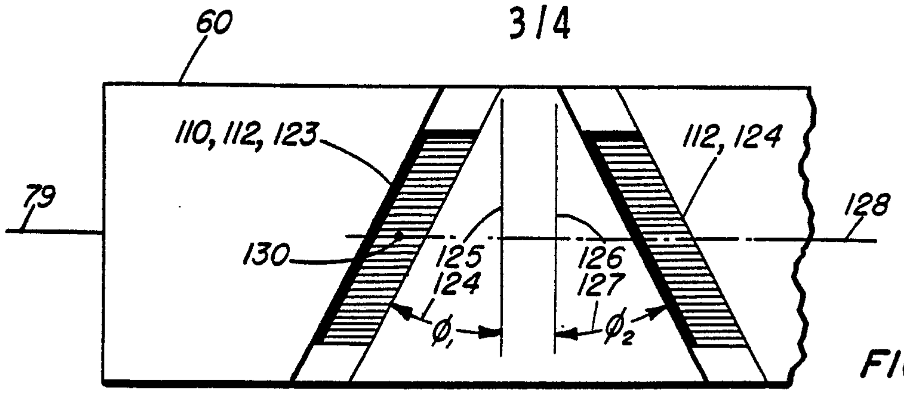

FIG. 4B

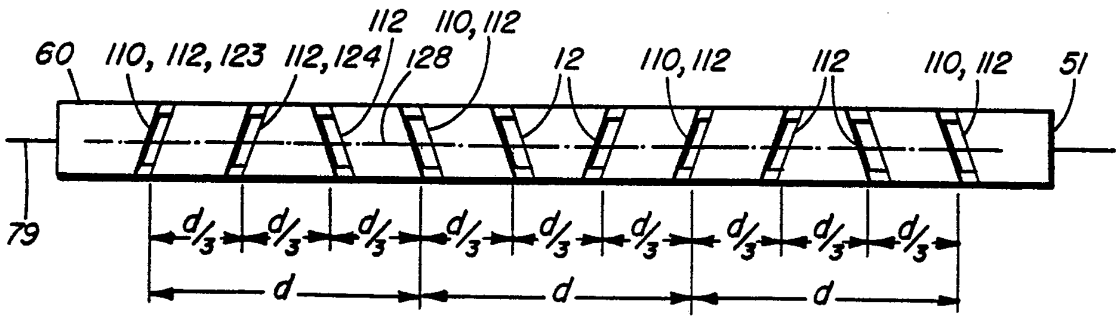

FIG. 4A

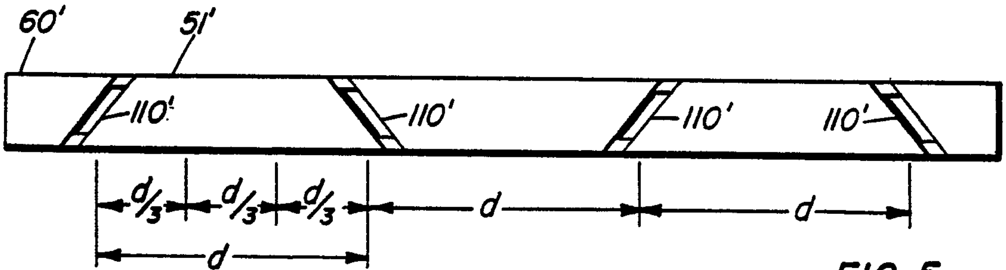

FIG. 5

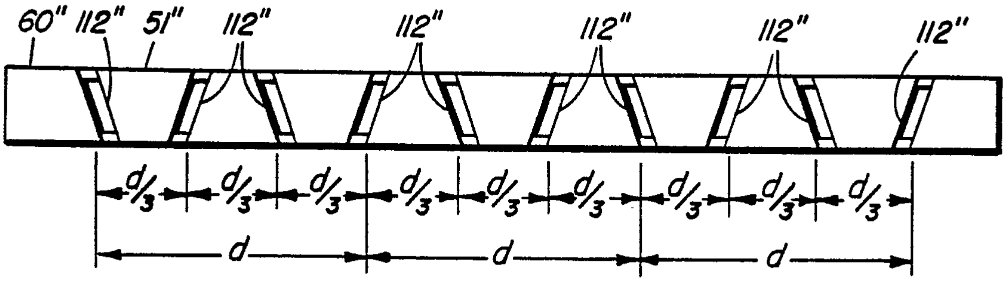

FIG. 6

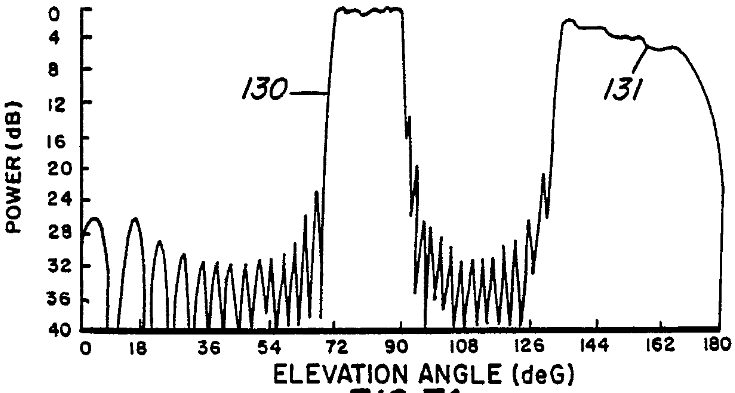

FIG 7A

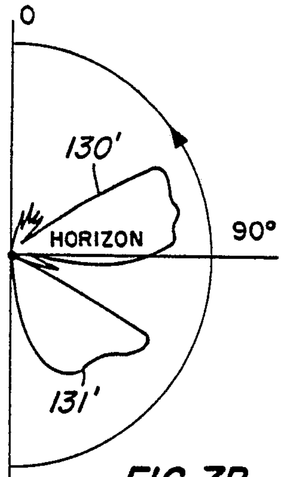

FIG. 7B

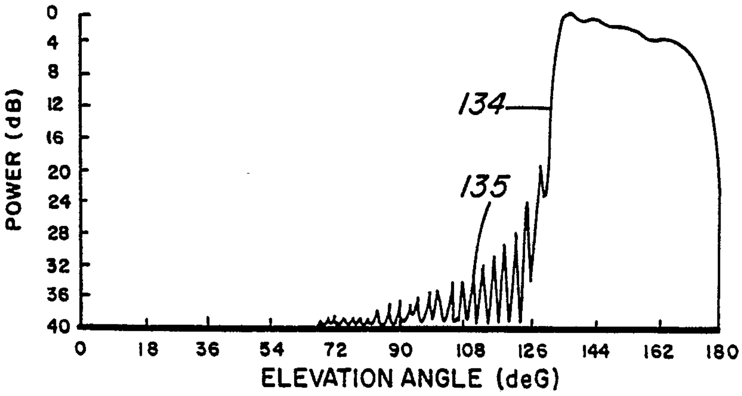

FIG. 8A

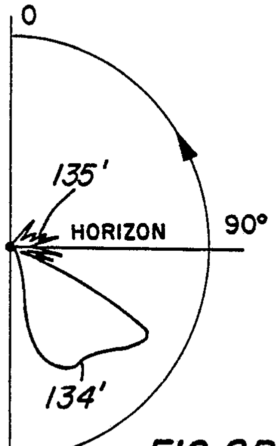

FIG. 8B

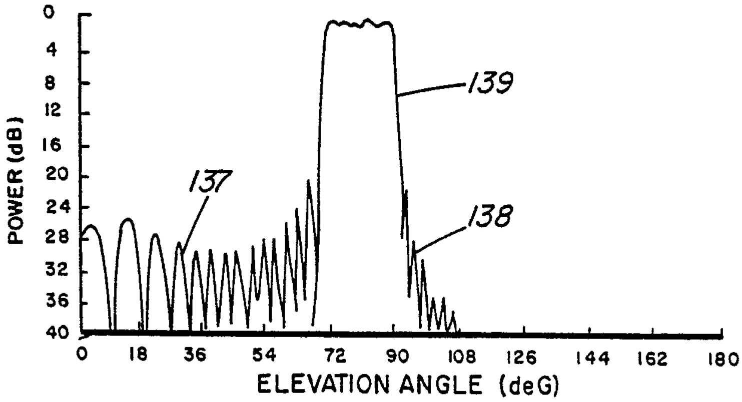

FIG. 9A

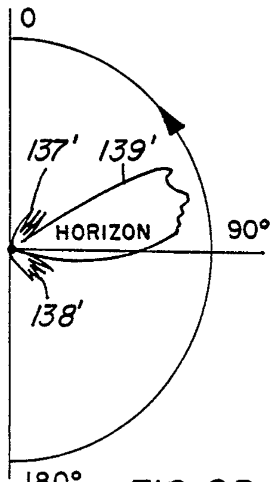

FIG. 9B

INTERNATIONAL SEARCH REPORT

International Application No PCT/US86/00603

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC. (4): H01Q 13/10
U.S. CL. 343/771

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	343/767-771, 371, 372

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	US, A, 3, 740, 751 (NEMIT) 19 JUNE 1973, See col. 2, lines 45-63.	1-8
Y	US, A, 3, 259, 898 (TOBER) 05 JULY 1966, See Figure 7.	1-8
A	US, A, 3, 135, 959 (MORAN) 02 JUNE 1964, See the entire document.	1-4
A	US, A, 3, 963, 999 (NAKAJIMA et al.) 15 JUNE 1976, See col. 4, lines 61-68.	1
A	GB, A, 706, 301 (THOMSON-HOUSTON) 24 MARCH 1954 See the entire document.	1

* Special categories of cited documents: [15]
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
02 JUNE 1986	20 JUN 1986
International Searching Authority [1]	**Signature of Authorized Officer** [20]
ISA/US	Michael Wimer MICHAEL WIMER

Form PCT/ISA/210 (second sheet) (October 1981)