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(54) Directivity varying type diversity antenna apparatus

(57) A directivity varying type diversity antenna apparatus of the present invention includes a plurality of nondirectional antenna elements (11 to 1n) arranged at regular intervals, a receiving antenna determination means (20) for determining a diversity receiving antenna (A1 to A4) by selecting antenna elements (11 to 1n), arranged in specific positions, from among the plurality of nondirectional antenna elements and combining the selected antenna elements, a phase control means (30) for controlling a relationship in phase between RF signals of radio waves received by the diversity receiving antenna (A1 to A4) determined by the receiving antenna determination means (20), a diversity processing means (50) for diversity-processing the RF signals whose phases are controlled and supplying the diversity-processed RF signals to a tuner (60), and a directivity varying control means (70) for properly performing an operation of directivity based on information indicative of receiving conditions, supplying a first instruction signal (S2) for changing an antenna element to the receiving antenna determination means (20) and supplying a second instruction signal (S3) for changing the relationship in phase between the RF signals to the phase control means (30) in accordance with a result of the operation.

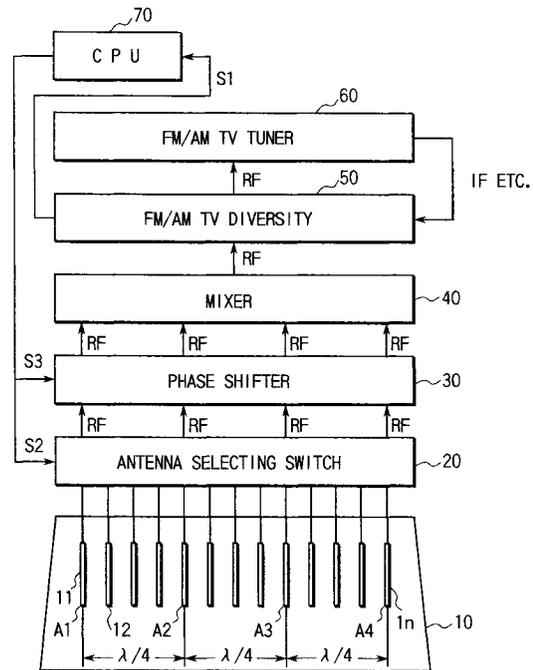


FIG. 1

## Description

The present invention relates to a directivity varying type diversity antenna apparatus favorably used as an antenna apparatus which is to be mounted on an automobile and the like.

FIG. 14 is a view of the constitution of a prior art diversity reception type antenna apparatus which is mounted on the window of an automobile. In FIG. 14, two antenna elements 101 and 102, which are constituted of copper-made strips, are meanderingly formed on the rear window 10 of the automobile. These two antenna elements are capable of receiving a radio wave of frequency bands adapted to an FM/AM and TV tuner 104 for receiving FM (frequency-modulated), AM (amplitude-modulated) and TV waves, and also receiving an antenna signal necessary for diversity reception.

The antenna elements 101 and 102 are connected to an FM/AM and TV diversity processing circuit 103. An RF signal is supplied from the circuit 103 to the tuner 104. The tuner 104 sends out a signal such as an IF (intermediate frequency) signal for monitoring the receiving conditions, which is fed back to the diversity processing circuit 103.

The antenna elements of the above prior art antenna apparatus do not change the directivity of an antenna. The tuner monitors the receiving conditions such as interference noise, receiving level, and vertical/horizontal synchronizing state (TV). When the tuner detects radio disturbance or abnormal electric field strength, its information is fed back to the diversity processing circuit 103, and one of the antenna elements is switched to the other whose receiving level is higher. In other words, in the prior art antenna apparatus, the antenna elements 101 and 102 are simply switched to each other, and each of the antenna elements does not execute any specific processing or control in accordance with the receiving conditions.

Consequently, since a large variety of antenna elements are arranged on the rear window 10 of the automobile in order to receive FM/AM and TV waves, there is strong possibility that even when one of the antenna elements is switched to the other, the latter antenna element will undergo a radio disturbance.

It is accordingly an object of the present invention to provide a directivity varying type diversity antenna apparatus whose directivity is varied with the receiving conditions of FM/AM and TV waves and which is adapted to the strength of an electric field in the receiving area and reduced in noise thereby to always receive the waves satisfactorily.

To attain the above object, according to one aspect of the present invention, there is provided a directivity varying type diversity antenna apparatus comprising a means for selectively combining a plurality of elements and controlling phases of the plurality of elements in order to vary a directivity of an antenna in accordance with a receiving condition when an FM/AM wave and a TV

wave is received.

According to another aspect of the present invention, there is provided a directivity varying type diversity antenna apparatus comprising:

- a plurality of nondirectional antenna elements arranged at regular intervals;
- receiving antenna determination means for determining a diversity receiving antenna by selecting antenna elements, arranged in specific positions, from among the plurality of nondirectional antenna elements and combining the selected antenna elements;
- phase control means for controlling a relationship in phase between RF signals of radio waves received by the diversity receiving antenna determined by the receiving antenna determination means;
- diversity processing means for diversity-processing the RF signals whose phases are controlled by the phase control means and supplying the diversity-processed RF signals to a tuner; and
- directivity varying control means for properly performing an operation of directivity based on information indicative of receiving conditions, which is output from the diversity processing means, supplying a first instruction signal for changing an antenna element to the receiving antenna determination means and supplying a second instruction signal for changing the relationship in phase between the RF signals to the phase control means in accordance with a result of the operation.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram showing the constitution of a directivity varying type diversity antenna apparatus according to an embodiment of the present invention;

FIG. 2 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into a first state under the specific conditions;

FIG. 3 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into a second state under the specific conditions;

FIG. 4 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into a third state under the specific conditions;

FIG. 5 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase

of each antenna element of the apparatus is changed into a fourth state under the specific conditions;

FIG. 6 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into a fifth state under the specific conditions;

FIG. 7 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into a sixth state under the specific conditions;

FIG. 8 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into a seventh state under the specific conditions;

FIG. 9 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into an eighth state under the specific conditions;

FIG. 10 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into a ninth state under the specific conditions;

FIG. 11 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into a tenth state under the specific conditions;

FIG. 12 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into an eleventh state under the specific conditions;

FIG. 13 is a pattern view of the directivity of the antenna apparatus shown in FIG. 1, when the phase of each antenna element of the apparatus is changed into a twelfth state under the specific conditions; and

FIG. 14 is a view of the constitution of a prior art diversity reception type antenna apparatus which is mounted on the window of an automobile.

(Embodiment)

FIG. 1 is a block diagram of the constitution of a directivity varying type diversity antenna apparatus according to an embodiment of the present invention. As illustrated in FIG. 1, a plurality of nondirectional (vertically polarized plane wave) antenna elements 11 and 12 to 1n, which are constituted of copper-made strips, are arranged at regular intervals horizontally on a rear window 10 of an automobile.

These antenna elements 11 and 12 to 1n are con-

nected to a plurality of branch terminals of an antenna selecting switch 20.

The switch 20 includes a reception antenna selecting means for selecting a diversity reception antenna by selectively combining the specifically-positioned ones of the nondirectional antenna elements. Thus, two or more antenna elements (four in this embodiment) per one system, are selected as antenna elements required for reception, and thus the diversity reception antenna is selected. The antenna elements A1 to A4 are selected such that when the wavelength of their received wave is  $\lambda$ , an interval between the antenna elements is  $\lambda/4$ . Since the wavelength varies from received wave to received wave, a large number of antenna elements are provided in advance so as to be selected without any trouble.

Four RF signals are taken out by the antenna selecting switch 20 and supplied to a phase shifter 30. The phase shifter 30 is a phase control means for controlling the phases of RF signals of radio waves received by the antenna elements A1 to A4 so as to have a predetermined relationship in the phases. If the relationship in phase between the RF signals is varied, desired directivity is obtained, resulting in better receiving condition than that of normal diversity receiving condition.

The RF signals the phases of which are varied by the phase shifter 30, are mixed by a mixer 40 and the mixed signal is supplied to an FM/AM and TV diversity processing circuit 50. The RF signal output from the circuit 50, is supplied to an FM/AM and TV tuner 60. The tuner 60 sends a signal such as an IF (intermediate frequency) signal for monitoring the receiving condition, and this signal is fed back to the diversity processing circuit 50.

The diversity processing of the diversity processing circuit 50 is substantially the same as that of the prior art circuit. However, the circuit 50 outputs an information signal S1 indicative of the receiving condition, and the information signal S1 is supplied to a CPU 70.

The CPU 70 includes a directivity varying control means. The CPU 70 performs an operation to obtain the optimum directivity based on the information signal S1. In accordance with the result of the operation, an instruction signal S2 for selecting an antenna element is supplied to the antenna selecting switch 20. Further, another instruction signal S3 for changing a phase relationship between the RF signals is supplied to the phase shifter 30.

Thus, the directivity of a selected diversity reception antenna can be varied. The factors in varying the directivity are intervals between the selected antenna elements and the phase relationship between RF signals generated from the antenna elements.

FIGS. 2 to 13 are pattern views illustrating the directivity on the horizontal plane when the phase relationship between the first to fourth antenna elements is variably set in a predetermined state under the following specific conditions:

- 1) Received frequency 98MHz
- 2) Antenna elements in use four nondirectional antenna elements A1 to A4
- 3) Interval between antenna elements  $\lambda/4$  (= about 750 mm)
- 4) Directions corresponding to the front and rear of an automobile  $0^\circ$  to  $180^\circ$  of the pattern views

The phases of antenna elements A1 to A4 in each of FIGS. 2 to 13 are as follows:

FIG. 2	Phase of antenna element A1	0.00
	Phase of antenna element A2	0.00
	Phase of antenna element A3	0.00
	Phase of antenna element A4	0.00
FIG. 3	Phase of antenna element A1	180.00
	Phase of antenna element A2	0.00
	Phase of antenna element A3	0.00
	Phase of antenna element A4	180.00
FIG. 4	Phase of antenna element A1	0.00
	Phase of antenna element A2	180.00
	Phase of antenna element A3	0.00
	Phase of antenna element A4	180.00
FIG. 5	Phase of antenna element A1	0.00
	Phase of antenna element A2	90.00
	Phase of antenna element A3	270.00
	Phase of antenna element A4	0.00
FIG. 6	Phase of antenna element A1	0.00
	Phase of antenna element A2	270.00
	Phase of antenna element A3	90.00
	Phase of antenna element A4	0.00
FIG. 7	Phase of antenna element A1	0.00
	Phase of antenna element A2	270.00
	Phase of antenna element A3	180.00
	Phase of antenna element A4	0.00
FIG. 8	Phase of antenna element A1	0.00
	Phase of antenna element A2	180.00
	Phase of antenna element A3	270.00
	Phase of antenna element A4	0.00
FIG. 9	Phase of antenna element A1	270.00
	Phase of antenna element A2	180.00
	Phase of antenna element A3	90.00
	Phase of antenna element A4	0.00
FIG. 10	Phase of antenna element A1	0.00
	Phase of antenna element A2	90.00
	Phase of antenna element A3	180.00
	Phase of antenna element A4	270.00
FIG. 11	Phase of antenna element A1	180.00
	Phase of antenna element A2	180.00
	Phase of antenna element A3	0.00
	Phase of antenna element A4	180.00
FIG. 12	Phase of antenna element A1	0.00
	Phase of antenna element A2	180.00

(continued)

5 FIG. 13	Phase of antenna element A3	180.00
	Phase of antenna element A4	180.00
	Phase of antenna element A1	0.00
	Phase of antenna element A2	0.00
	Phase of antenna element A3	180.00
	Phase of antenna element A4	180.00

10 In the directivity varying type diversity antenna apparatus of the above embodiment, the directivity of the antenna can be varied in accordance with the receiving conditions so as to prevent a radio disturbance. That is, the antenna apparatus of the present invention is of an active type. Since the directivity is automatically selected in accordance with the receiving conditions, the reception most suitable for the conditions of the receiving area can be achieved. Consequently, a radio disturbance can be avoided with a considerably higher probability than that in the prior art diversity reception, and good reception can always be performed.

15 In the directivity varying type diversity antenna apparatus of the present invention, the directivity diversity receiving function is added to the current diversity receiving function. Thus, the antenna apparatus has a double diversity function.

(Modifications)

20 The directivity varying type diversity antenna apparatus according to the embodiment of the present invention can be modified as follows:

- 25 i) A diversity receiving antenna is selected using nondirectional antenna elements arranged at an interval shifted from  $\lambda/4$ .
- ii) The antenna apparatus is mounted everywhere except the window of an automobile.

Claims

- 30 1. A directivity varying type diversity antenna apparatus characterized by comprising a means (20, 30) for selectively combining a plurality of elements (A1 to A4) and controlling phases of the plurality of elements (A1 to A4) in order to vary a directivity of an antenna in accordance with a receiving condition when an FM/AM wave and a TV wave is received.
- 35 2. A directivity varying type diversity antenna apparatus characterized by comprising:
  - 40 a plurality of nondirectional antenna elements (11 to 1n) arranged at regular intervals;
  - 45 receiving antenna determination means (20) for determining a diversity receiving antenna

(A1 to A4) by selecting antenna elements, arranged in specific positions, from among the plurality of nondirectional antenna elements (11 to 1n) and combining the selected antenna elements (A1 to A4);  
 5  
 phase control means (30) for controlling a relationship in phase between RF signals of radio waves received by the diversity receiving antenna (A1 to A4) determined by the receiving antenna determination means (20);  
 10  
 diversity processing means (50) for diversity-processing the RF signals whose phases are controlled by the phase control means (30) and supplying the diversity-processed RF signals to a tuner (60); and  
 15  
 directivity varying control means (70) for properly performing an operation of directivity based on information indicative of receiving conditions, which is output from the diversity processing means (50), supplying a first instruction signal (S2) for changing an antenna element to the receiving antenna determination means (20) and supplying a second instruction signal (53) for changing the relationship in phase between the RF signals to the phase control means (30) in accordance with a result of the operation.  
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- 3. The directivity varying type diversity antenna apparatus according to claim 2, characterized in that the plurality of nondirectional antenna elements (11 to 1n) are a plurality of copper-made strip conductors and arranged at regular intervals horizontally on a rear window (10) of an automobile.  
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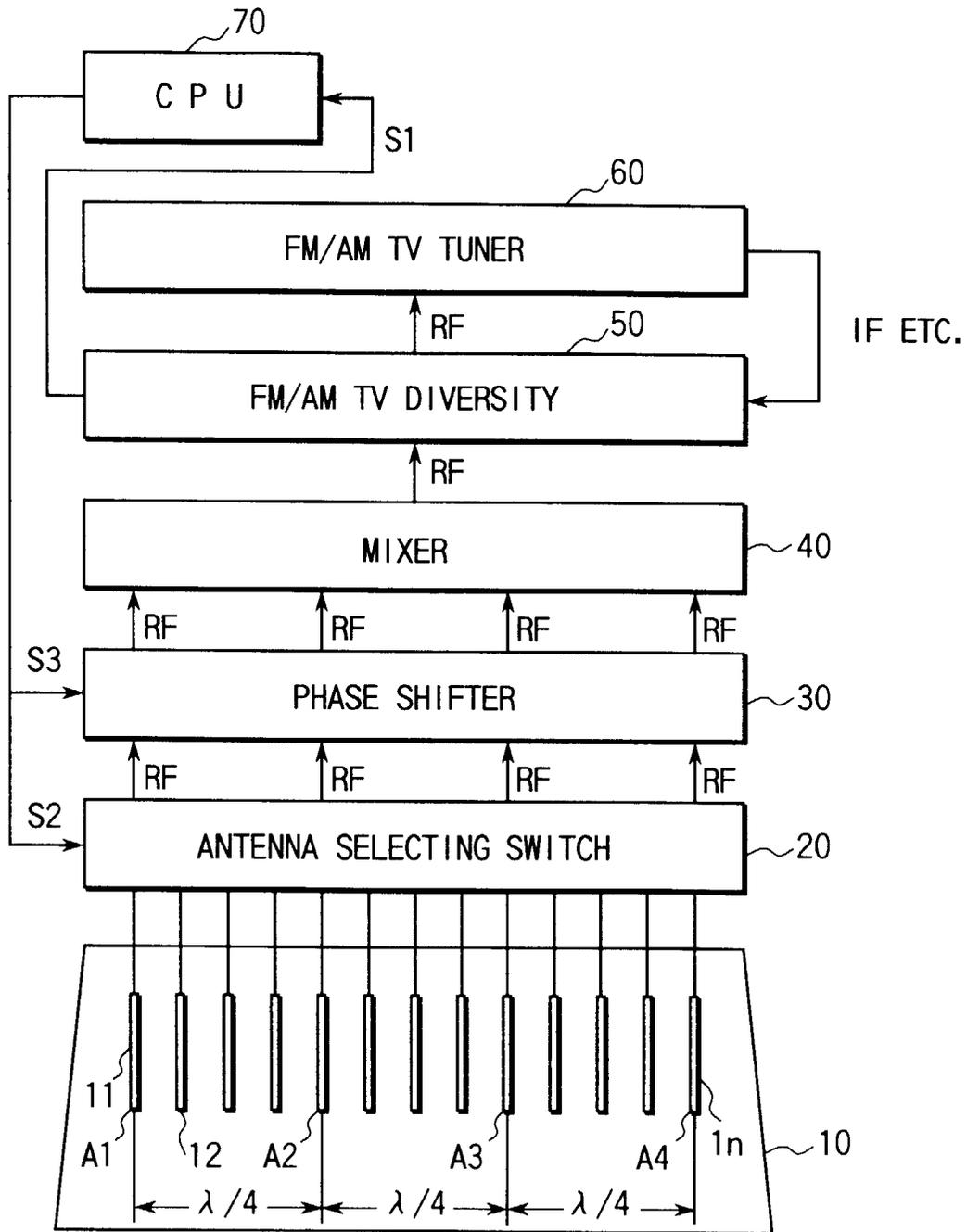


FIG. 1

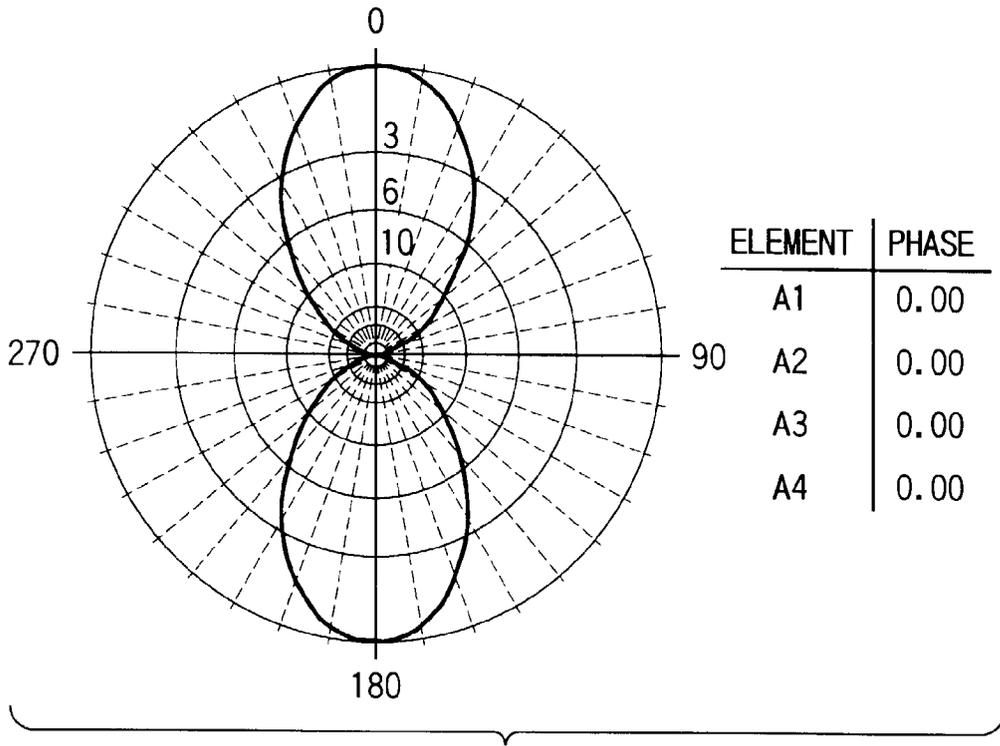


FIG. 2

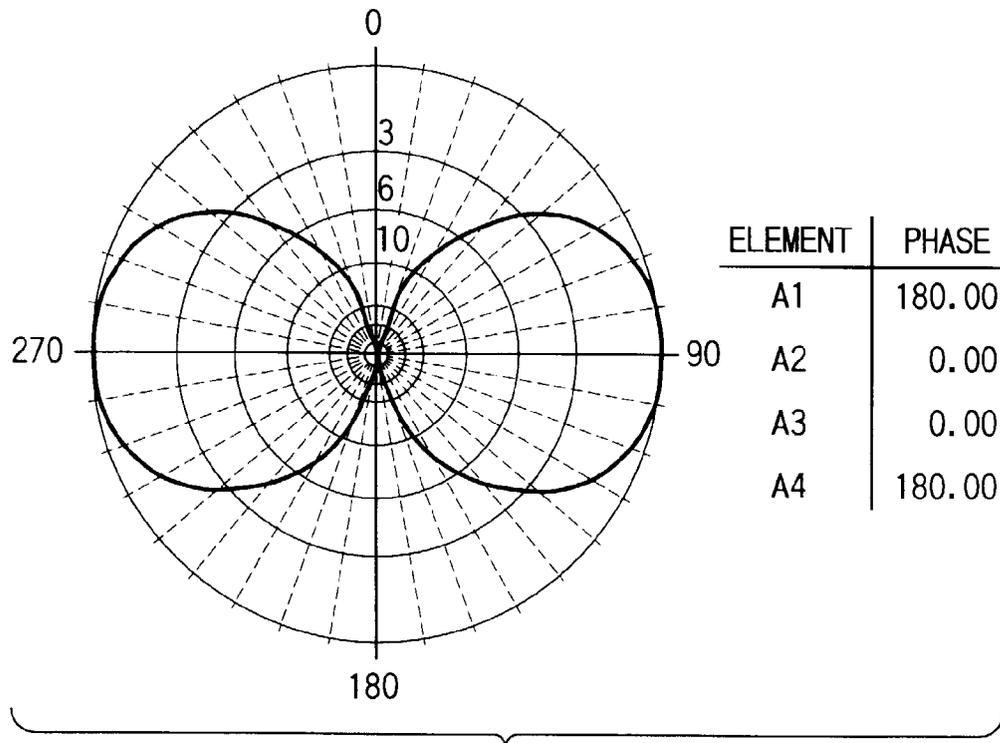


FIG. 3

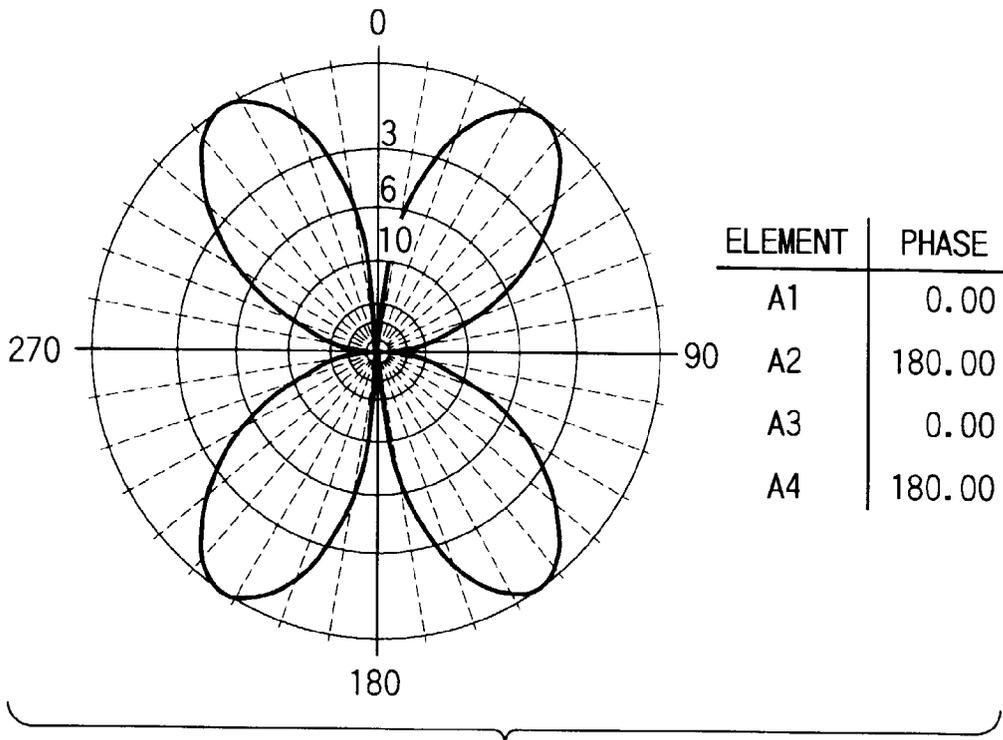


FIG. 4

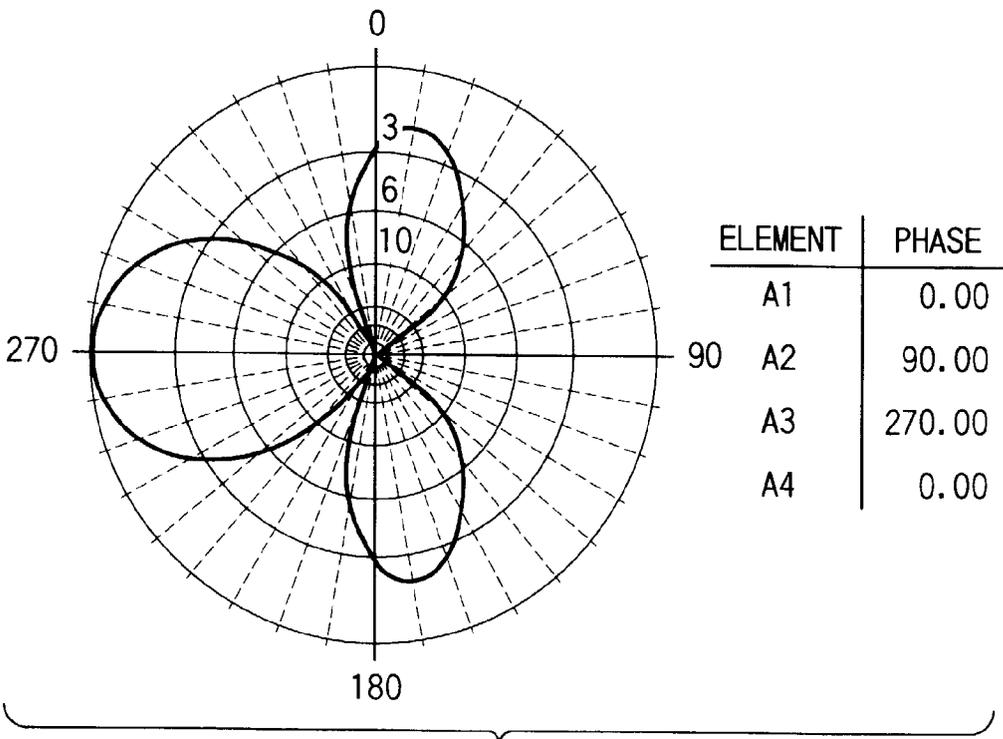


FIG. 5

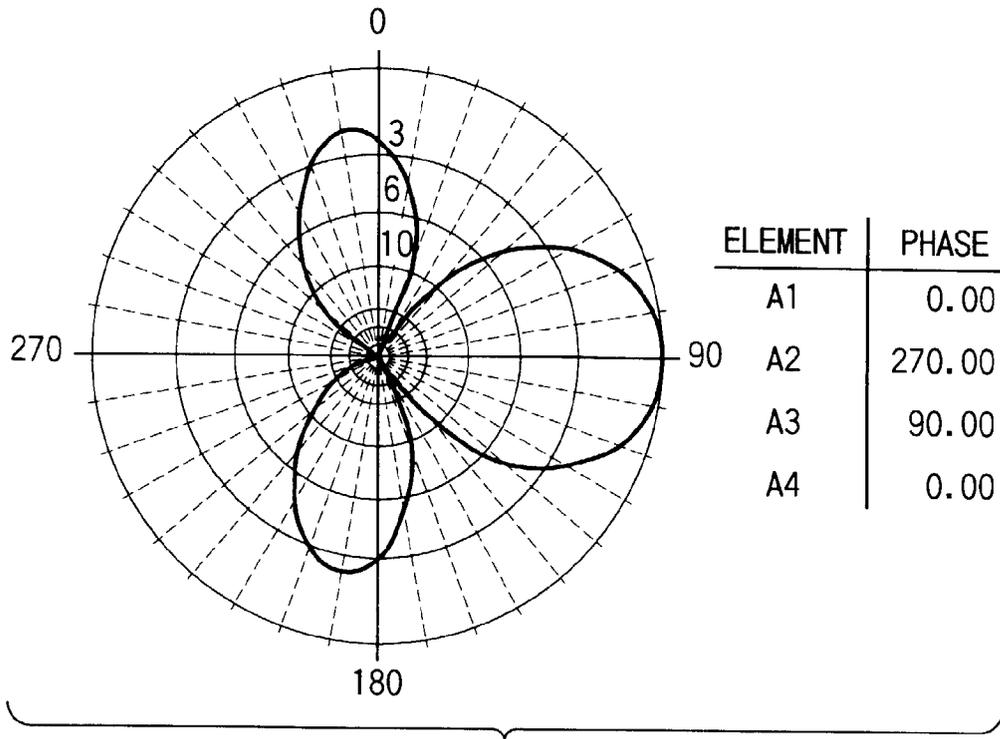


FIG. 6

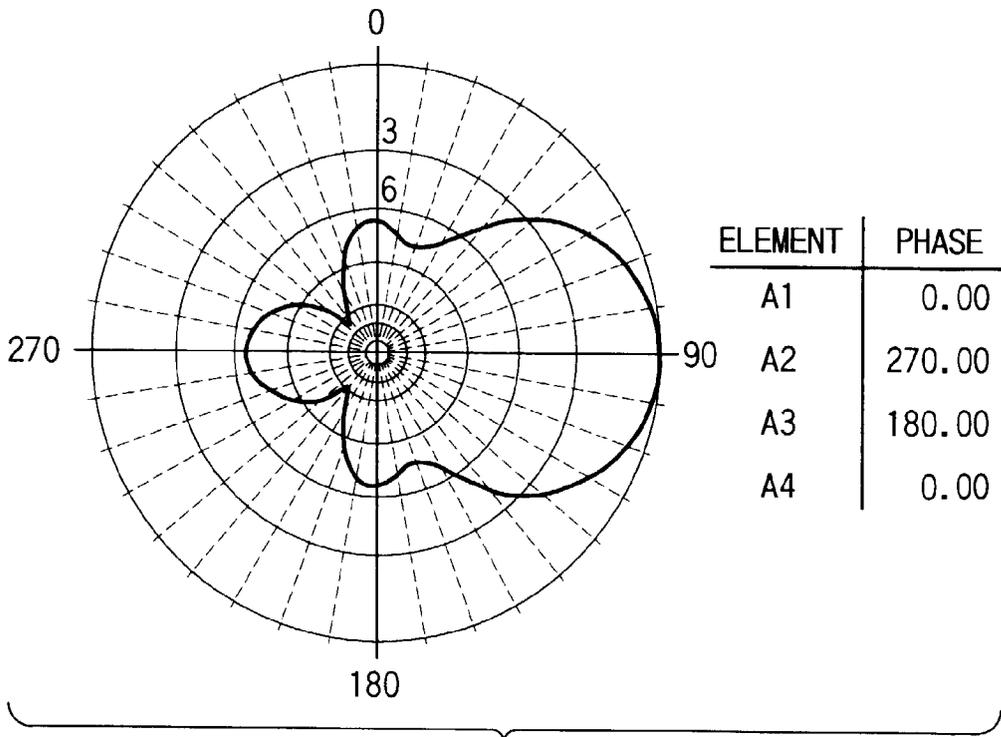


FIG. 7

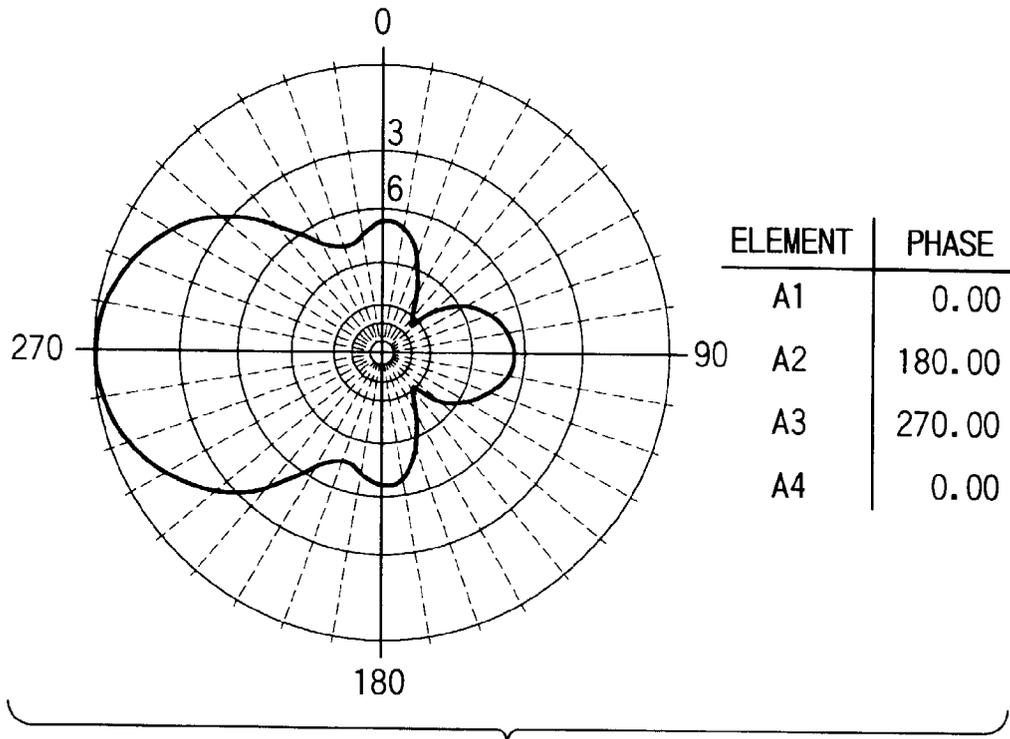


FIG. 8

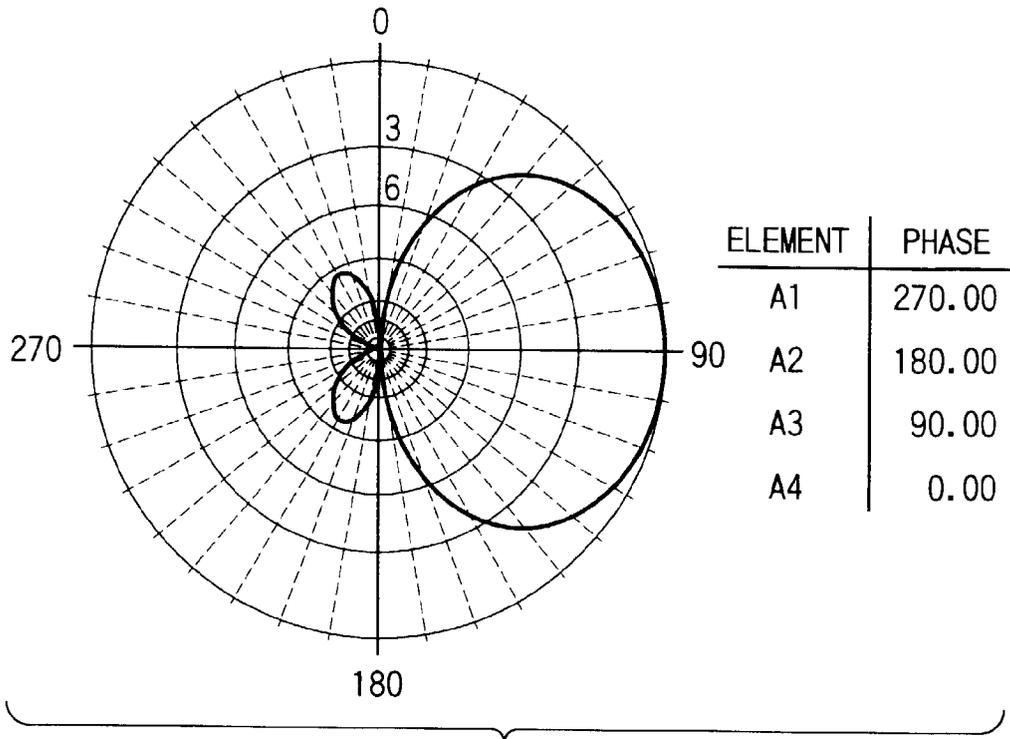


FIG. 9

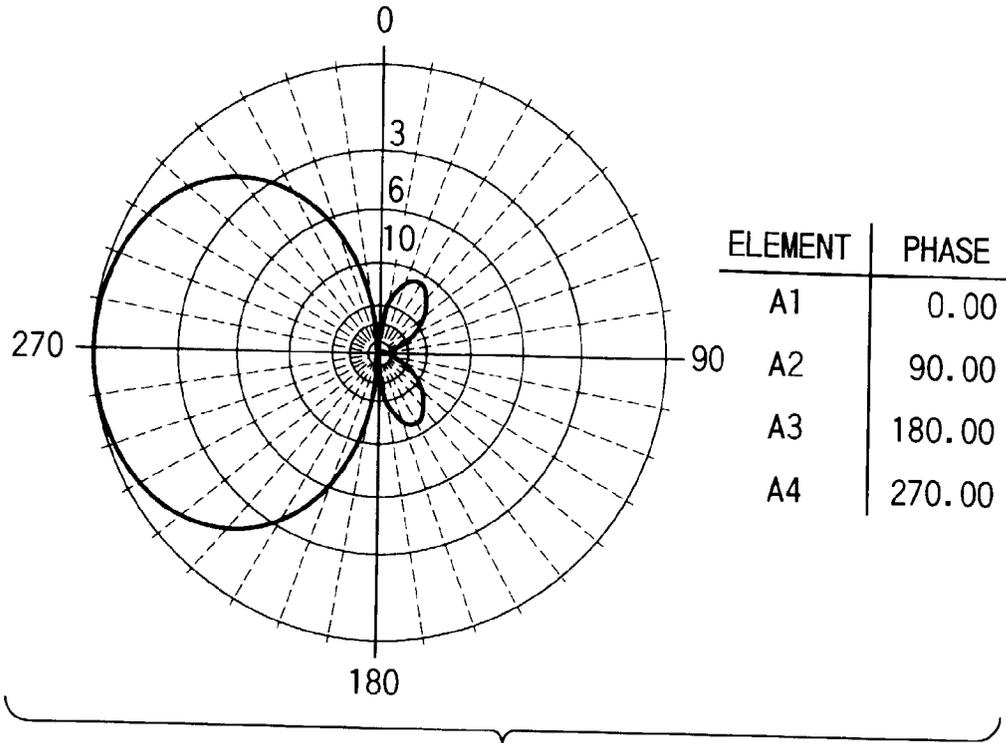


FIG. 10

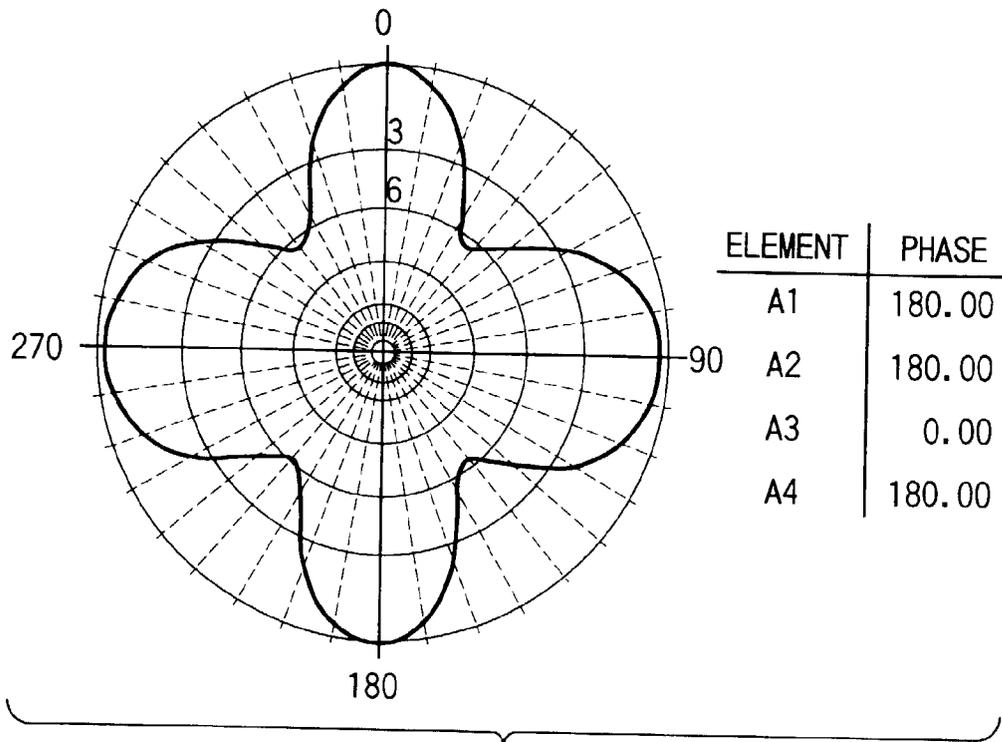


FIG. 11

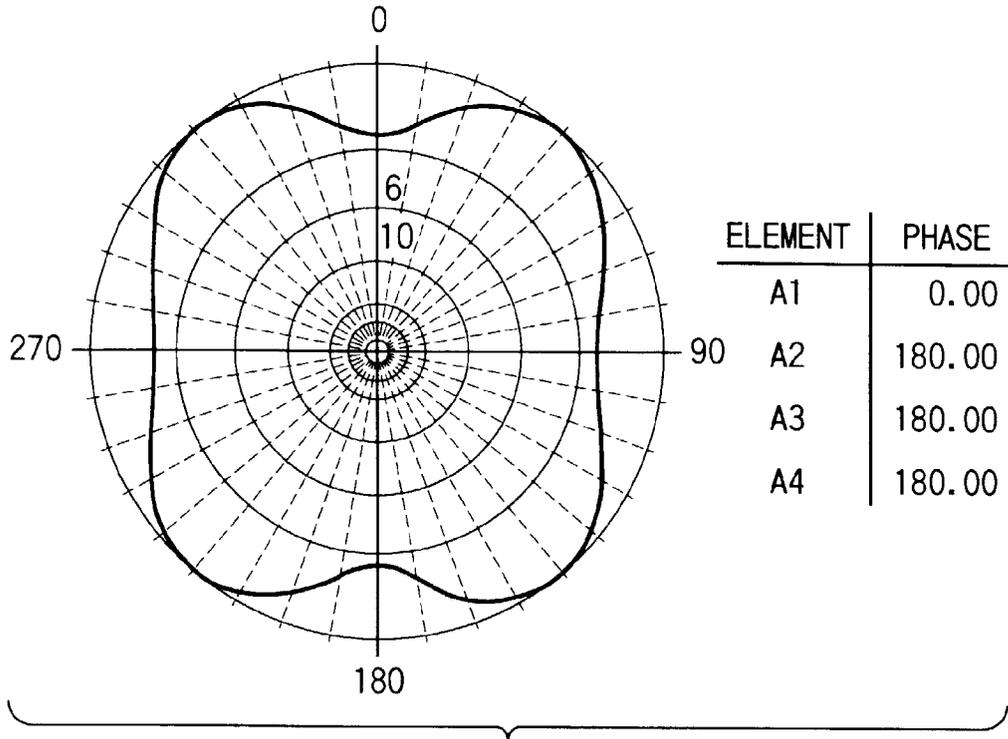


FIG. 12

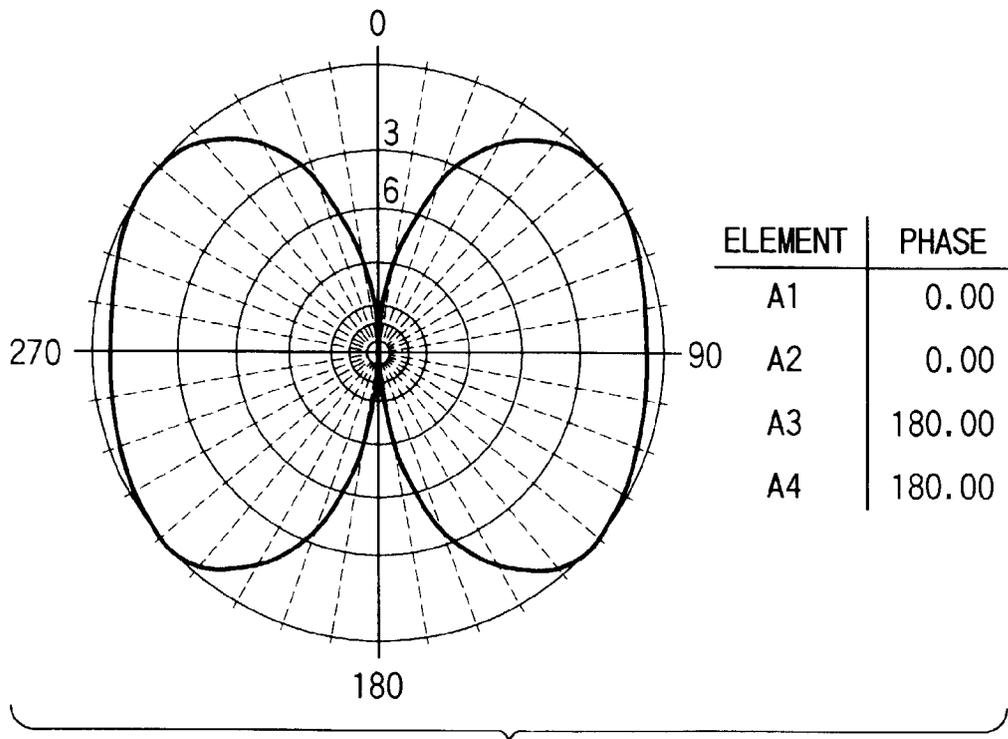


FIG. 13

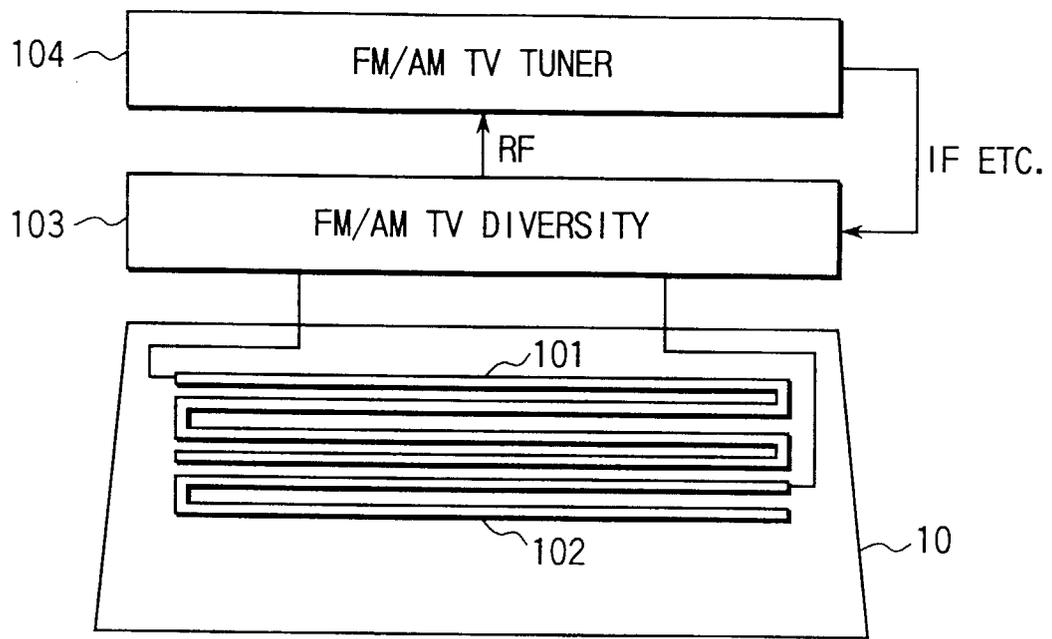


FIG. 14



European Patent Office

EUROPEAN SEARCH REPORT

Application Number  
EP 98 30 3451

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	DE 43 21 805 A (NIPPON SHEET GLASS) 27 January 1994 * column 2, line 41 - column 4, line 66 *	1,2	H01Q1/12 H01Q1/32 H01Q3/26 H04B7/08
Y	* column 6, line 7 - column 18, line 8; figures 3,10,12,18,19 * ---	3	
Y	DE 35 21 732 A (ASAHI GLASS) 2 January 1986 * abstract; figures 5-12 * ---	3	
A	BOCHMANN H: "VIER ANTENNEN AN EINEM EMPFAENGER" FUNKSCHAU, vol. 64, no. 1, 27 December 1991, pages 66-70, XP000279000 * the whole document * ---	1-3	
A	LINDENMEIER H K ET AL: "ANTENNA AND DIVERSITY TECHNIQUES FOR BROADCAST RECEPTION IN VEHICLES" PROCEEDINGS OF THE ANTENNAS AND PROPAGATION SOCIETY INTERNATIONAL SYMPOSIUM (APIS), CHICAGO, JULY 20 - 24, 1992, vol. VOL. 2, no. -, 20 July 1992, pages 1097-1100, XP000342287 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS * the whole document * -----	1-3	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H01Q H04B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 13 August 1998	Examiner Angrabeit, F
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X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

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