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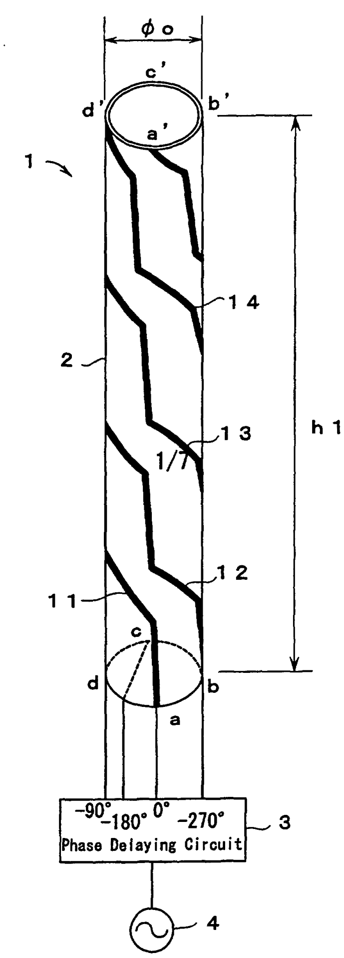
(54) **HELICAL ANTENNA**

(57) The object being to achieve a smaller size for the sake of portability, a plurality of helical elements 11-14 is formed helically on the outer surface of an insulative antenna main body 2 constituting a tube shape. Each of the above-mentioned plurality of helical elements 11-14, which is a helix of a predetermined winding angle, is formed by being bent in a periodic waveform shape, in which the winding angle line Lα is regarded as the center line. Thus, the overall length h1 of the helical antenna 1 can be shortened.

Fig. 1



EP 1 150 382 A1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a helical antenna suitable for mounting on satellite communications apparatus.

2. Description of the Related Art

[0002] A variety of satellite communications systems have been proposed for the purpose of mobile communications, and as satellite communications systems, there are geostationary mobile satellite communications systems, which utilize geostationary satellites, and non-geostationary mobile satellite communications systems, which utilize non-geostationary satellites.

[0003] Non-geostationary mobile satellite communications systems comprise systems that utilize satellites in low-to-intermediate altitude orbits, systems that utilize satellites in long elliptical orbits, and systems that make use of inclined synchronous orbits. Among these, systems that utilize non-geostationary satellites in low-to-intermediate altitude orbits are LEO (Low Earth Orbit) communications systems. Because this LEO communications system constitutes a system having a small propagation delay time, and propagation loss is also reduced, it has the advantages of enabling terminal transmission power to be reduced, and of making it possible to facilitate the making of small, lightweight terminals.

[0004] Furthermore, as LEO communications systems, there are Little LEO [systems], which only handle data transmissions, and Big LEO [systems] capable of voice transmissions. Among the Big LEO [systems], there are the Iridium System and the ICO (Intermediate Circular Orbit) System (Project 21). As for the Iridium System, the communications system is a TDMA (Time Division Multiple Access) system, which utilizes frequencies in the 1.6GHz band, and is constituted such that communications are performed using (66 + 6) non-geostationary satellites launched to an altitude of 780 km so as to cover the entire globe. These non-geostationary satellites orbit [the Earth] at intervals of 30 degrees longitude. Further, the ICO system places each of 6 orbiting satellites in orthogonal inclined orbits of 10,390 km, and the portable terminals are dual terminals capable of being used in common with a satellite network, which makes use of satellites, and an existing ground-based portable telephone system.

[0005] In a satellite mobile communications system like this, since communication delay times can be ignored even though a lot of satellites are required, voice and data communications can be carried out in real-time. Furthermore, because terminal transmission power can be reduced, it is possible to make the terminals portable. Therefore, if a portable radio for a satellite mobile communications system is carried around, it will be possible to conduct telephone conversations and data transmissions in real-time with telephones and portable telephones worldwide. Furthermore, in a satellite mobile communications system, circularly polarized waves are used so as to be suitable for portable radios.

[0006] Now then, in a portable radio for a satellite mobile communications system, because of the need to receive circularly polarized waves, a helical antenna or a microstrip antenna, which is capable of transmitting and receiving circularly polarized waves, is used.

[0007] Here, the constitution of a conventional helical antenna capable of transceiving circularly polarized waves is shown in Fig. 6 and Fig. 7. Fig. 6 is a diagram showing the constitution of a helical antenna 100, and Fig. 7 is an development view of an developed antenna main body 102.

[0008] As shown in Fig. 6, a helical antenna 100 is constituted from an insulative antenna main body 102 constituting a cylindrical shape, a phase delaying circuit 103, comprising a matching circuit for delaying and feeding phases to helical elements 111, 112, 113, 114 disposed on the outer surface of the antenna main body 102, and a feeding portion 104.

[0009] When an antenna main body 102 comprising 4 helical elements 111-114 is developed, it becomes as shown in Fig. 7, and it is clear that the 4 helical elements 111-114 are each wound onto the antenna main body 102 at winding angle α. The wind-start ends of the 4 helical elements 111-114 are regarded as a, b, c, d, respectively, and the wind-terminate ends are regarded as a', b', c', d'. These wind-start ends a, b, c, d are positioned at equal intervals (roughly 90°), and signals are supplied to the wind-start ends a, b, c, d from the feeding portion 104 which delay a predetermined amount of phase via the phase delaying circuit 103 comprising a matching circuit. For example, a signal, which is delayed 0° is supplied to wind-start end a, a signal, which is delayed 270° is supplied to wind-start end b, a signal, which is delayed 180° is supplied to wind-start end c, and a signal, which is delayed 90° is supplied to wind-start end d. Thus, by supplying to the 4 helical elements 111-114 signals, which delay phase approximately 90° each in the counterclockwise direction, right-handed circularly polarized waves are emitted from the antenna main body 102. Further, it is also possible to emit left-handed circularly polarized waves by reversing the relationship between the winding direction of the helical elements and the phase of a phase delaying circuit.

[0010] There were problems with the conventional helical antenna shown in Fig. 6 and Fig. 7 from the standpoint of the constitution thereof in that the overall length ho of the antenna main body 102 was long, and when used on portable apparatus of a satellite mobile communications system, the overall constitution [of the portable apparatus] became larger.

SUMMARY OF THE INVENTION

[0011] For portable apparatus, because the size thereof is required to be as small as possible, an object of the present invention is to provide a small-sized helical antenna having outstanding portability when mounted to a portable apparatus of a satellite mobile communications system.

[0012] In order to realize the above-mentioned object, a helical antenna of the present invention is a helical antenna comprising a plurality of helical elements wound helically on the outer surface of the insulative antenna main body constituting a tube shape, and each of the above-mentioned plurality of helical elements, which is a helix of a predetermined winding angle, is formed by being bent in a periodic waveform shape in which the winding angle line, which constitutes the above-mentioned winding angle, is regarded as the center line.

[0013] Further, in a helical antenna of the above-mentioned present invention, the shape of each abovementioned helical element can constitute a triangular wave shape.

[0014] Furthermore, in a helical antenna of the above-mentioned present invention, the shape of each above-mentioned helical element can constitute a sine wave shape.

[0015] And furthermore, in a helical antenna of the above-mentioned present invention, when the angle formed by the tangential line of each abovementioned helical element and the normal line of the above-mentioned center line at the point of intersection of each abovementioned helical element and the above-mentioned center line is regarded as β, [the helical antenna] can be constituted such that $0° < \beta < 90°$.

[0016] By means of this present invention, since the constitution is such that each helical element of a plurality of helical elements is formed by being bent into the shape of a periodic waveform shape in which the winding angle line, which constitutes the winding angle, is regarded as the center line, the overall length of the antenna main body can be made shorter. Thus, the helical antenna can be made smaller, enabling the realization of a helical antenna, which is well suited to being mounted on a portable apparatus of a satellite mobile communications system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a diagram showing a first example of a constitution of an aspect of the embodiment of a helical antenna of the present invention;

Fig. 2 is an development view of an antenna main body in a first helical antenna of the present invention;

Fig. 3 is a diagram showing a second example of a constitution of an aspect of the embodiment of a helical antenna of the present invention;

Fig. 4 is an development view of an antenna main body in a second helical antenna of the present invention;

Fig. 5 is a diagram showing the directivity within the vertical plane in a first helical antenna of the present invention;

Fig. 6 is a diagram showing an example of the constitution of a conventional helical antenna; and

Fig. 7 is an development view of an antenna main body in a conventional helical antenna.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] A first constitution of an aspect of the embodiment of a helical antenna of the present invention is shown in Fig. 1. Further, an development view of the antenna main body in the helical antenna shown in Fig. 1 is shown in Fig. 2.

[0019] As shown in Fig. 1, a helical antenna 1 is constituted from an insulative antenna main body 2 constituting a ϕo outer diameter cylindrical shape; a phase delaying circuit 3 for delaying and feeding a phase to a helical element 11, 12, 13, 14 disposed on the outer surface of the antenna main body 2; and a feeding portion 4. Furthermore, the phase delaying circuit 3 can also comprise a matching circuit for matching the helical elements 11, 12, 13, 14 and the feeding portion 4.

[0020] If an antenna main body 2 comprising 4 helical elements 11-14 is developed, it will become as shown in Fig. 2, making it clear that the 4 helical elements 11-14 are each wound onto the antenna main body 2 by being bent in a triangular wave shape, which is a periodic waveform in which the winding angle line $L\alpha$, which constitutes the winding angle α, is regarded as the center line.

[0021] The 4 helical elements 11-14 are the same shape, and if helical element 11 is taken as an example, when the angle formed by the tangential line of helical element 11 and the normal line of the winding angle line $L\alpha$ (center line) at the point of intersection of the winding angle line $L\alpha$ of the winding angle α, which is the center line, is regarded as β as shown in the figure, β constitutes $0° < \beta < 90°$. Furthermore, the angle of the apex of the triangular wave shape of helical element 11 constitutes 2β. The 4 helical elements 11-14 are either formed by applying a conductive thin film to the outer surface of a cylindrical antenna main body 2, or are formed by etching a conductive thin film, which is formed over the entire outer surface of an antenna main body 2.

[0022] Thus, since a first helical antenna 1 of the present invention is constituted such that the 4 helical elements 11-14 are formed by being bent in a triangular wave shape, it becomes possible to make the overall length h1 of the helical antenna 1 shorter than that of a conventional helical antenna. Furthermore, instead of bending [a helical element] into a triangular wave shape, it can be bent into a trapezoidal shape, which cuts off the apex of the triangular wave.

[0023] The wind-start ends of the 4 helical elements 11-14 are regarded as a, b, c, d, respectively, and the wind-terminate ends thereof are regarded as a'. b', c', d'. The wind-start ends a, b, c, d thereof are positioned at roughly equal intervals (approximately 90°), and signals from a feeding portion 4, which delay a predetermined phase amount via the phase delaying circuit 3, are supplied to the wind-start ends a, b, c, d. For example, a signal, which is delayed 0° is supplied to wind-start end a, a signal, which is delayed 270° is supplied to wind-start end b, a signal, which is delayed 180° is supplied to wind-start end c, and a signal, which is delayed 90° is supplied to wind-start end d. Thus, by supplying to the 4 helical elements 11-14 signals, which delay the phase approximately 90° each in the counter-clockwise direction, right-handed circularly polarized waves are emitted from the antenna main body 2. Further, it is also possible to emit left-handed circularly polarized waves by reversing the relationship between the winding direction of the helical elements 11-14 and the phase of the phase delaying circuit 3.

[0024] Thus, a first helical antenna of the present invention can be regarded as an antenna suitable for being used on portable apparatus of a satellite mobile communications system.

[0025] Next, a second constitution of an aspect of the embodiment of a helical antenna of the present invention is shown in Fig. 3. Further, an development view of the antenna main body in the helical antenna shown in Fig. 3 is shown in Fig. 4.

[0026] As shown in Fig. 3, helical antenna 31 is constituted from an insulative antenna main body 32 constituting a ϕo outer diameter cylindrical shape; a phase delaying circuit 33 for delaying and feeding a phase to a helical element 41, 42, 43, 44 disposed on the outer surface of the antenna main body 32; and a feeding portion 34. Furthermore, the phase delaying circuit 33 can comprise a matching circuit for matching the helical elements 41, 42, 43, 44 and the feeding portion 34.

[0027] If an antenna main body 32 comprising 4 helical elements 41-44 is developed, it will become as shown in Fig. 4, making it clear that the 4 helical elements 41-44 are each wound onto the antenna main body 32 by being bent in a sine wave shape, which is a periodic waveform in which the winding angle line $L\alpha$ of the winding angle α is regarded as the center line.

[0028] The 4 helical elements 41-44 are the same shape, and if helical element 41 is taken as an example, when the angle formed by the tangential line of helical element 41 and the normal line of the winding angle line $L\alpha$ (center line) at the point of intersection of the winding angle line $L\alpha$ of the winding angle α, which is the center line, is regarded as β as shown in the figure, β constitutes $0° < \beta < 90°$. The 4 helical elements 41-44 are either formed by applying a conductive thin film to the outer surface of a cylindrical antenna main body 32, or are formed by etching a conductive thin film, which is formed over the entire outer surface of an antenna main body 32. Furthermore, the 4 helical elements 41-44 are bent in the shape of a sine wave, but [the shape of the helical elements 41-44] is not limited thereto, and can be bent into a periodic curved line shape.

[0029] Thus, since a second helical antenna 31 of the present invention is constituted such that the 4 helical elements 41-44 are formed by being bent in a sine wave shape, it becomes possible to make the overall length h2 of the helical antenna 31 shorter than that of a conventional helical antenna.

[0030] The wind-start ends of the 4 helical elements 41-44 are regarded as a, b, c, d, respectively, and the wind-terminate ends thereof are regarded as a'. b', c', d'. The wind-start ends a, b, c, d thereof are positioned at roughly equal intervals (approximately 90°), and signals from a feeding portion 34, which delay a predetermined phase amount via the phase delaying circuit 33, are supplied to the wind-start ends a, b, c, d. For example, a signal, which is delayed approximately 0° is supplied to wind-start end a, a signal, which is delayed approximately 270° is supplied to wind-start end b, a signal, which is delayed approximately 180° is supplied to wind-start end c, and a signal, which is delayed approximately 90° is supplied to wind-start end d. Thus, by supplying to the 4 helical elements 41-44 signals, which delay the phase approximately 90° each in the counter-clockwise direction, right-handed circularly polarized waves are emitted from the antenna main body 32. Further, it is also possible to emit left-handed circularly polarized waves by reversing the relationship between the winding direction of the helical elements 41-44 and the phase of the phase delaying circuit 33.

[0031] Thus, a second helical antenna of the present invention can also be regarded as an antenna suitable for being used on portable apparatus of a satellite mobile communications system.

[0032] Next, directivity within the vertical plane of the first helical antenna 1 of the present invention shown in Fig. 1 is shown in Fig. 5. However, it is the directivity within the vertical plane when the winding angle α of the helical antenna 1 is roughly 65° and β is roughly 60°. Looking at the directivity shown in Fig. 5, it is clear that, despite being able to shorten the overall length of the conventional helical antenna 100 shown in Fig. 6, the directivity thereof remains practically unchanged.

[0033] The above-mentioned helical antennas of the present invention are not only for right-hand and left-hand circularly polarized waves, but can also be utilized for linearly polarized waves.

[0034] Furthermore, in the explanation hereinabove, the antenna main body 2 (32) was a cylindrical shape, but the antenna main body 2 (32) is not limited to a cylindrical shape, and can also be a polygonal shape, such as a hexagon or octagon. This antenna main body 2 (32) can be formed using an insulating material, such as ABS resin (Acrylonitrile Butadiene Styrene Copolymer), polycarbonate, polyacetal, polypropylene, or polytetrafluoroethylene, or a flexible base material, such as polyimide.

[0035] Further, the wind-terminate ends a', b', c', d' of the 4 helical elements 11-14 (41-44) were constituted such that all were open as shown in the figures, but wind-terminate end a' and wind-terminate end c' can be constituted so as to be short-circuited, and, in addition, wind-terminate end b' and wind-terminate end d' can be constituted so as to be short-circuited.

[0036] Furthermore, the number of helical elements is not limited to 4, but can also be 1 or 2.

[0037] Furthermore, the helical antenna 1 (31) of the present invention is not limited to an antenna for a portable terminal for a satellite mobile communications system, but rather can be used as an antenna for mounting to an automobile and as an antenna for a ship.

[0038] As explained hereinabove, because the present invention is constituted such that a helical antenna is formed by bending each helical element of a plurality of helical elements into a shape of a periodic wave shape in which the winding angle line, which constitutes the winding angle, is regarded as the center line, it is possible to shorten the overall length of the antenna main body. Thus, it is possible to make a helical antenna smaller, enabling the realization of a helical antenna well suited for mounting on satellite communications apparatus.

Claims

1. A helical antenna, comprising a plurality of helical elements, which are wound helically on the outer surface of an insulative antenna main body constituting a tube shape,

wherein each of said plurality of helical elements, which is a helix of a predetermined winding angle, is formed by being bent in a periodic waveform shape in which the winding angle line, which constitutes said winding angle, is regarded as the center line.

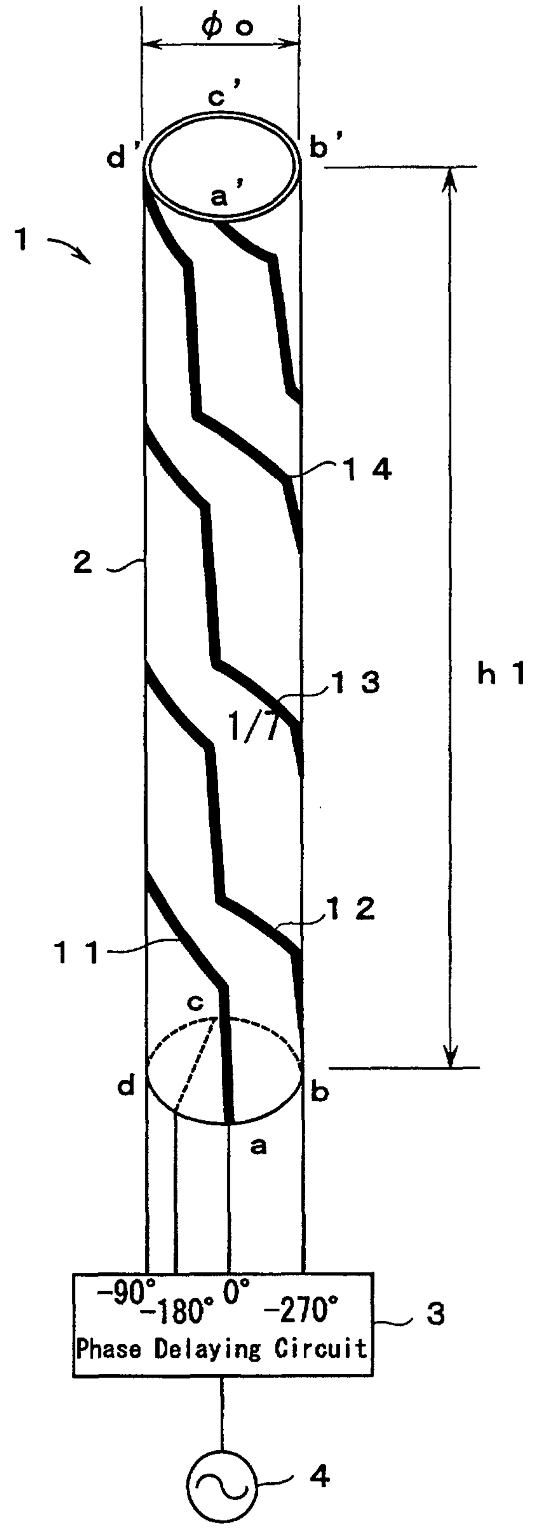
2. The helical antenna according to claim 1, wherein the shape of each said helical element constitutes a triangular wave shape.

3. The helical antenna according to claim 2, wherein $0° < \beta < 90°$ when the angle formed by the tangential line of each said helical element and the normal line of said center line at the point of intersection of each said helical element and said center line is regarded as β.

4. The helical antenna according to claim 1, wherein the shape of each said helical element constitutes a sine wave shape.

5. The helical antenna according to claim 4, wherein $0° < \beta < 90°$ when the angle formed by the tangential line of each said helical element and the normal line of said center line at the point of intersection of each said helical element and said center line is regarded as β.

Fig. 1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Phase Delaying Circuit
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4

Fig. 2

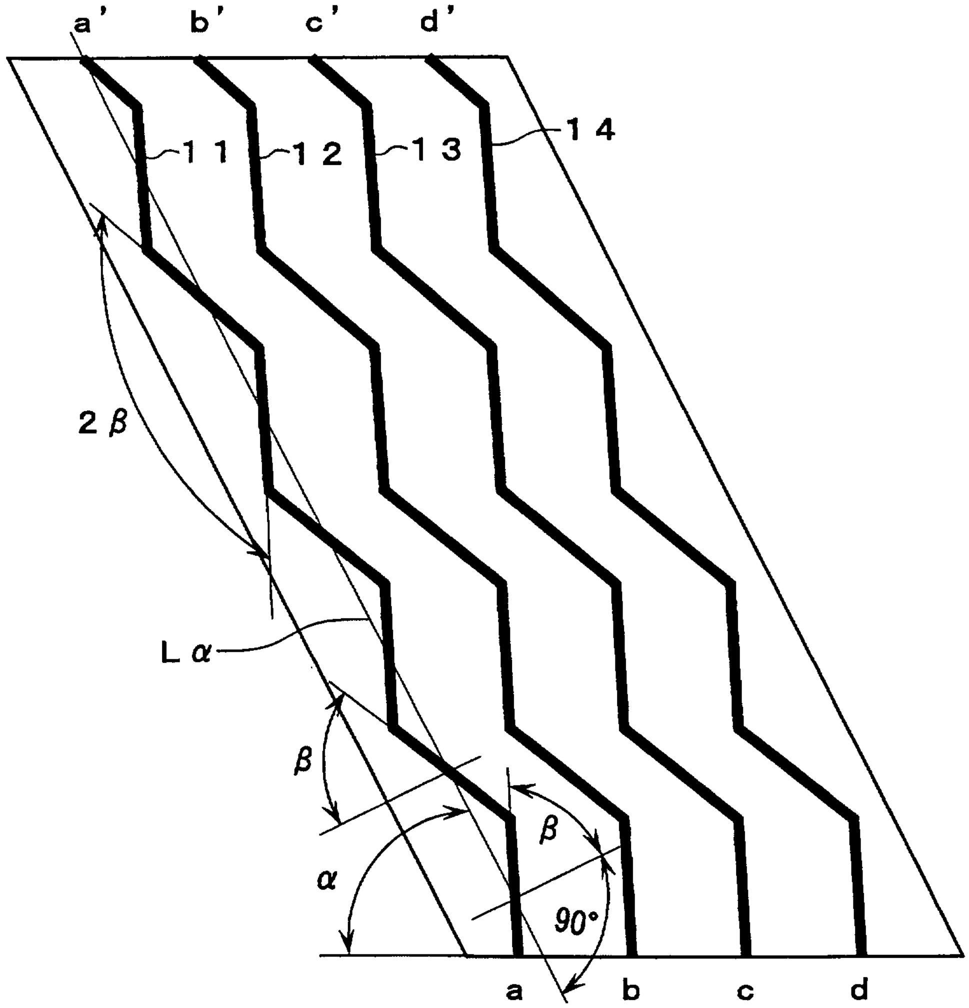
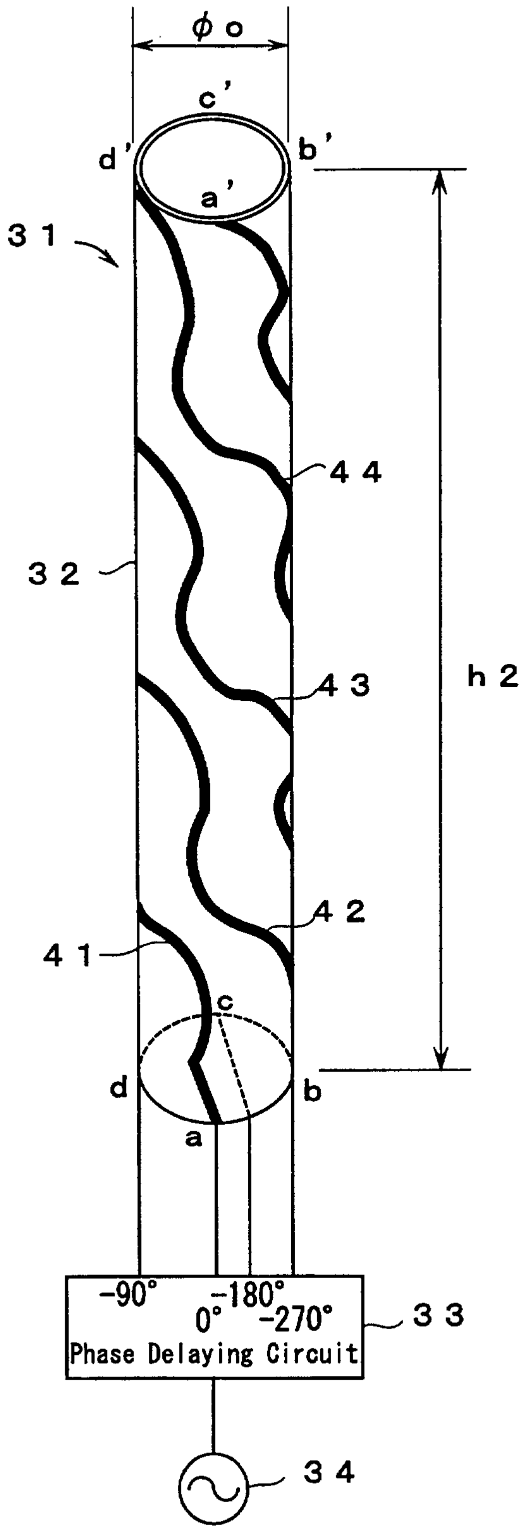


Fig. 3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Phase Delaying Circuit
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Fig. 4

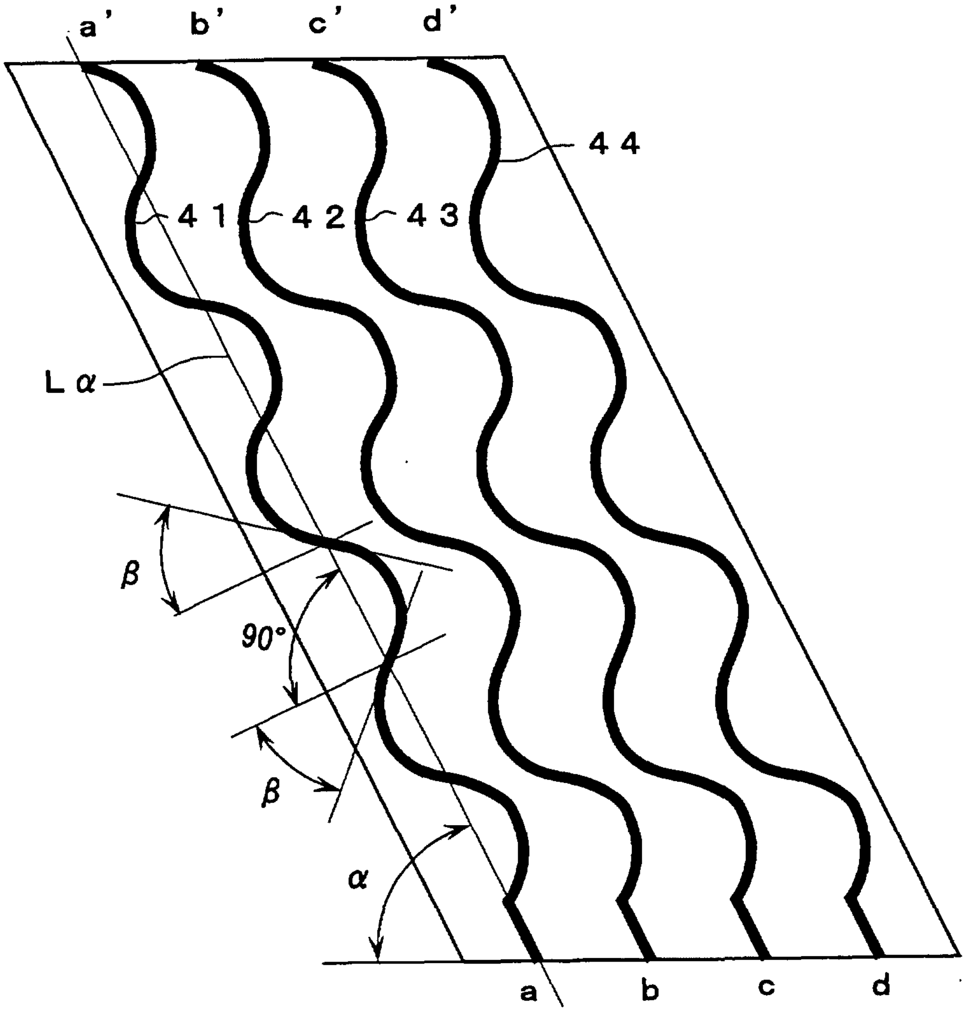


Fig. 5

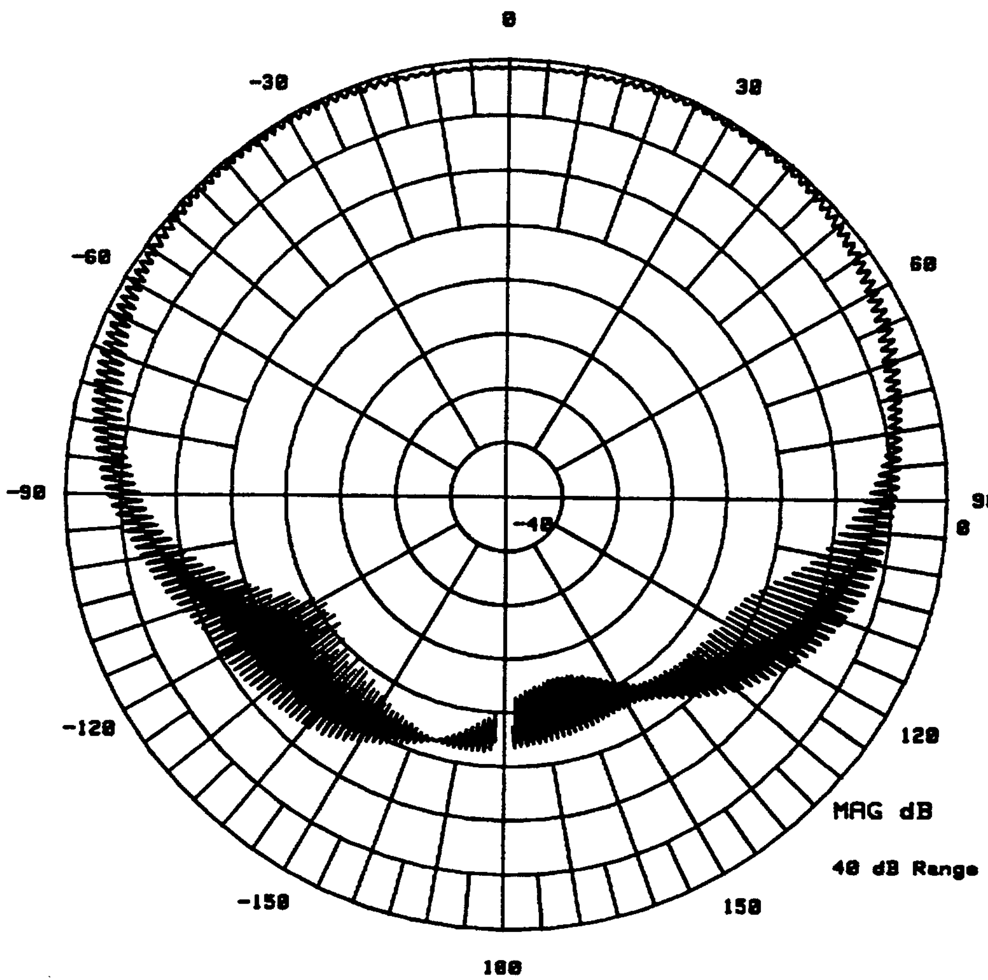
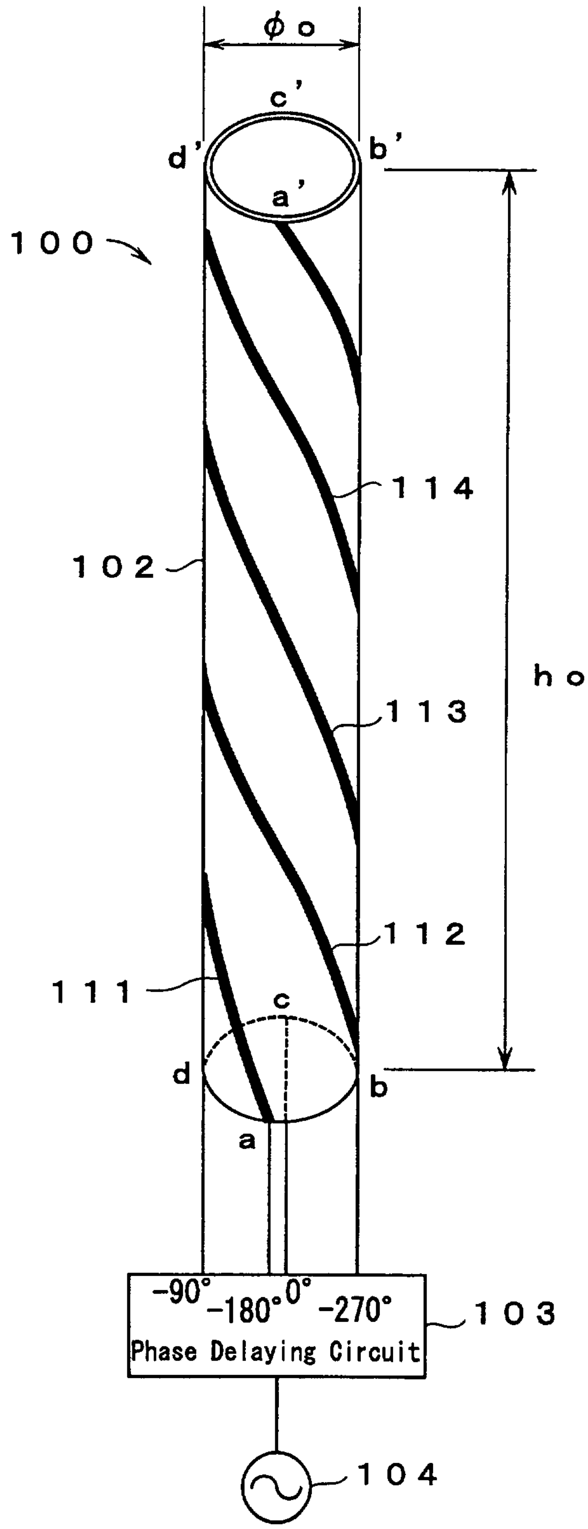


Fig. 6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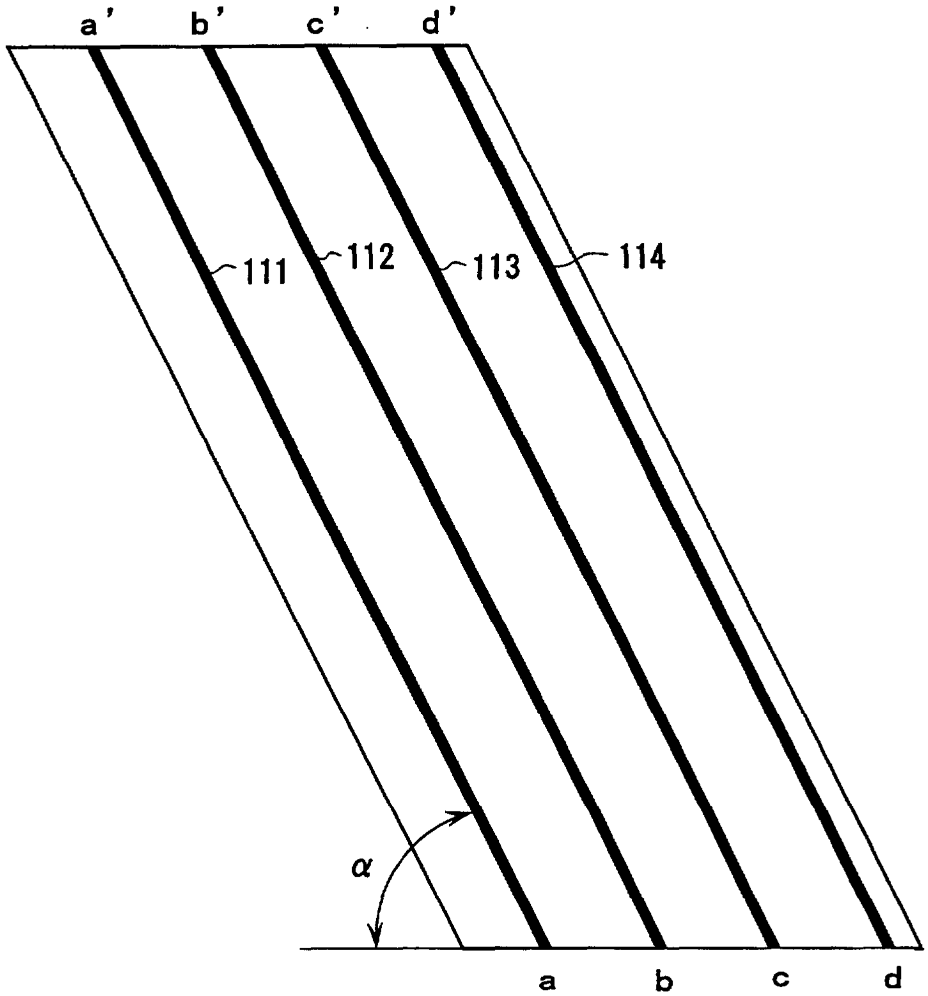
Phase Delaying Circuit
103
104

Fig. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/06410

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^7 H01Q11/08, H01Q1/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^7 H01Q11/08, H01Q1/00-1/10, H01Q1/27-1/52

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2000
Kokai Jitsuyo Shinan Koho 1971-2000 Jitsuyo Shinan Toroku Koho 1996-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP, 000320404, A1 (CENTRE NATIONAL D'ETUDES SPATIALES), 14 June, 1989 (14.06.89) & FR, 002624656, A & JP, 01-264003, A Full text; all drawings	1-5
A	US, 005198831, A1 (501 Pronav International, Inc.), 30 March, 1993 (30.03.93) (Family: none) Full text; all drawings	1-5
A	US, 005581268, A1 (Globalstar L.P.), 03 December, 1996 (03.12.96) & FI, 000002543, U & FI, 000757406, A & JP, 09-051227, A & WO, 097006577, A1 Full text; all drawings	1-5
A	JP, 09-260915, A (Murata MFG. Co., Ltd.), 03 October, 1997 (03.10.97) (Family: none) Full text; all drawings	1-5
A	JP, 51-035099, B (Matsushita Electric Ind. Co., Ltd.), 30 September, 1976 (30.09.76) (Family: none) Full text; all drawings	1-5

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December, 2000 (14.12.00)	26 December, 2000 (26.12.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)