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(54) **Satellite antenna system**

Antennensystem für Satelliten-Kommunikation

Système d'antenne pour communication d'un satellite

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Description

The invention relates to a satellite antenna system defined in the preamble of claim 1.

Such an antenna system is known in itself from the publication "Electronics & Communications in Japan", Part 1 - Communications, Vol. 71, No. 4, 1988, New York (US), pages 117-124, T. Hori et al. "Switched-Element Spherical Array and Antenna for Wide Scan Angle".

This known steerable antenna system is suitable to be used for mobile communications.

Although this publication describes the principle of the set-up of a spherical array antenna with a wide scan angle it does not give any information about the practical structure of such an antenna system.

The invention aims to propose an antenna system of the above-mentioned kind which is economical in production costs and does suitable for mass production, can be fitted in a small space and retains the advantages obtained by the configuration as proposed in the above-mentioned publication.

These aims are achieved by the measures as described in the characterizing clause of claim 1.

Preferred embodiments are described in the subclaims. The configuration as proposed in claim 2 results in an excellent matching between the antenna element, its feed/reception circuit and the load.

The specific structure as described in claim 3 not only has the advantage of being stiff, but also provides a good isolation between neighbouring antenna elements. Furthermore, there is a stabilizing effect on the impedance of the feedpoint.

The measures of claims 4-6 result in that the beam of each active antenna unit, composed of two antenna elements, can be adjusted at, for instance, $\pm 7°$ with respect to the average normal direction of the antenna elements, so that flexible and reliable tracking of a satellite is possible. Moreover, with a relatively small number of antenna elements (for instance 12) in the circular configuration at least twice the number (thus 24) of beams can be produced, which cover the azimuth plane without any gaps.

When using the measure of claim 7 the elevation angles of all antenna elements are set to the same position in the azimuth plane, so that the elevation angles of all the beams of the antenna elements are correct with respect to the location of the satellite.

As for the further advantages of the invention, the following can be maintained: the satellite acquisition routines function rapidly after switching the system on. The system also takes into account a fairly large steering error of the radiator unit, with respect to the band width and gain loss of the antenna element. Moreover, an advantage of the system is that the signal to noise ratio is small. Further, the antenna system functions reliably irrespective of changes in short and long term signal levels. Yet another advantage of the antenna system is that it is rapidly recovered from disturbance situations. In addition, the antenna system causes a minimal amount of distortion to communication channels.

The invention is explained in more detail below, with reference to the appended drawings where

figure 1 is a top-view illustration of a satellite antenna system of the invention;
figure 2 gives a cross-section A - A of the satellite antenna system of figure 1;
figure 3a illustrates the antenna element seen from the top, and figure 3b the same antenna element seen from the side;
figure 4 is a block diagram of the main parts of the satellite antenna system of the invention;
figure 5 is a schematical illustration of the hybrid;
figure 6 is a schematical illustration of the phase shifter;
figure 7 is a layout of the power divider and phase shifter units;
figure 8 illustrates the beams; figure 8a illustrates the beams of the active pair of antenna elements, and
figure 8b illustrates the realizable beams of a radiator unit with 12 antenna elements; and
figure 9 is a block diagram of the steering unit, together with connected units and devices.

Figures 1 and 2 are schematical illustrations of a satellite antenna system of the invention. The antenna system comprises a radiator unit 1', with a number of identical antenna elements 1; 1^1 - 1^{12} and their ground planes 9; 9^1 - 9^{12}, which are arranged on a disc-like base element 2. They are installed adjacently in a circular configuration, on the periphery of the base element 2. They are arranged at regular intervals from each other, so that they cover the whole circumference sector by sector. In this preferred embodiment, the radiator unit 1' is formed of twelve antenna elements 1^1 - 1^{12} and twelve ground planes 9^1 - 9^{12}.

The antenna system also includes support members 3, whereby the elements 1^1 - 1^{12} and their ground planes 9^1 - 9^{12} of the radiator unit 1' are arranged at a suitable elevation angle α with respect to the base element 2. The support members 3 are for instance support bars, which are adjustable in length, either stepwise or continuously, manually or by means of a suitable actuator, in order to adjust the elevation angle α.

The antenna system also includes the control unit 4 and the switching unit 5. Among the antenna elements 1^1 - 1^{12}, to one and the same active antenna unit, for instance 6, there belong simultaneously two antenna elements 1^7, 1^8, which are chosen by means of the control unit 4 and the switching unit 5 to receive circularly polarized electromagnetic radiation from a desired direction, and to transmit the same to essentially the same direction.

The satellite antenna system is provided with a radome 7 in order to protect the antenna elements 1^1 - 1^{12}

and other equipment pertaining to the antenna system.

The antenna elements 1; 1^1 - 1^{12} are identical, discrete travelling-wave type air dielectric elements, as is illustrated in figures 3a and 3b. Each antenna element 1 is formed of a thin plate 8 made of some conductive material, advantageously metal such as copper or brass. The antenna element 1 includes a platelike part, i.e. curved part 8a, which has a standard width and is essentially circular in shape. This curved part 8a fills a 270° sector of the circle. The nominal electric length of the curved part 8a is near the employed wavelength. The curved part 8a is fitted at a standard distance h from the ground plane 9.

At both ends of the curved part 8a, there are provided narrowing points 8b, 8c, advantageously having the shape of an isosceles triangle. The points 8b, 8c are arranged, with respect to the plane of the curved part 8a, at an angle towards the ground plane 9. They are advantageously made of the same uniform plate material as the curved part 8a and bent thereof. In between the points 8b, 8c there is a slot 10. The tips of the points 8b, 8c are formed to be blunt, and are advantageously cut as straight blunt tips 8d, 8e, as is illustrated in figure 3a. In the vicinity of the straight-cut tips 8d, 8e, unsymmetrically with respect to the medium lines D-D, E-E of the points 8b, 8c, i.e. at the sides of the blunt tips, there are arranged the poles 11, 12. One pole serves as the feed pole, and the other as the load. By forming the points 8b, 8c as blunt points, particularly as straight-cut blunt tips 8d, 8e, and by placing the poles 11, 12 in an unsymmetrical fashion, there is achieved an optimal matching (roughly 50 ohm) in between the antenna elements 14, 15 and the feed/reception circuit. The antenna element is symmetrical with respect to the straight line F-F running in the middle of the slot 10 and parallelly thereto. Depending on the employed direction of circular polarization, both poles 11, 12 can serve either as feed or load poles.

Coupling pins lead from the poles 11, 12 through the ground plane 9, electrically insulated therefrom, to the other side of the ground plane, where they are connected to the switching unit 5 and to the matched loads 15 (cf. figure 4). At the blunt tips of the points 8b, 8c, such as the straight-cut tips 8d, 8e, the antenna element 1 is attached, by means of coupling pins, to the ground plane 9 serving as the base, but in such a fashion that an electrical connection is not created, i.e. an insulating plate or film is left in the coupling. Moreover, the antenna element 1 is supported, most advantageously in the middle of the curved part 8a, by an electrically insulating support 10a against the ground plane 9.

The radiation power of the antenna element 1; 1^1 - 1^{12} can be adjusted by adjusting the width b of the curved part 8a of the plate 8, as well as its distance h from the ground plane 9. An optimal antenna gain is achieved, when roughly 90% of the power fed in the antenna element produces radiation and 10% is absorbed in the matched load.

The active antenna unit, for instance 6 in figure 1, is formed electrically by choosing two adjacent antenna elements, such as 1^7, 1^8 from among the antenna elements 1^1 - 1^{12}. Thus remarkable advantages are gained as compared to only one chosen antenna element. It has been found out that an optimal gain value and optimal width of the beam depend on the shape and size of the ground plane 9; 9^1 - 9^{12}. The direction of the main beam maximum is somewhat dependent on the used frequency, and deviates from the ground plane normal for about 5 - 15°. This angle deviation is also dependent on the shape of the ground plane. By means of two cooperating adjacent antenna elements 1^1 - 1^{12}, which elements are evenly spaced and fed parallelly with a suitable phase difference, the angular dependence of the main beam on the frequency can be practically eliminated.

The ground plane 9 is a trapezoid plane, the edges 9a, 9b, 9c and 9d whereof are turned upwards, so that the ground plane forms a shallow trough (note: in figure 3a, the edges are turned to horizontal plane for illustrative purposes). The central width 1 of the ground plane 9 is of the same order as the total width of the plate 8 and the distance a between the antenna elements, and the length k of the ground plane in turn is of the order 1.5 - 2.0 x a. The depth s of the trough-like ground plane is of the order 0.1a. In a preferred embodiment the dimensions of the ground plane are: height k = 150 mm, width on the wide side 11 = 150 mm, width on the narrow side 12 = 90 mm, and depth h of the ground plane = 20 mm. The ground plane 9 is made of some suitable conductive material, such as aluminium.

Figure 4 is a block diagram of the satellite antenna system of the invention. The feed points 11; 11^1 - 11^{12} of the antenna elements 1; 1^1 - 1^{12} of the radiator unit 1' are connected to the two switch groups 13, 14 of the switching unit 5, and respectively the second points 12; 12^1 - 12^{12} are connected to the matched loads 15; 15^1 - 15^{12}. The antenna elements 1^1 - 1^{12} are grouped so that adjacent elements 1^1, 1^2; 1^2, 1^3; 1^3, 1^4, ... are connected to different switch groups 13, 14. Thus the antenna elements 1^1 - 1^{12} are connected alternately to the first switch group 13 or to the second switch group 14. In this case each switch group 13, 14, has six outputs 13; 13^1 - 13^6 and 14; 14^1 - 14^6. By means of the control unit 4, the switch groups are controlled so that two adjacent elements 1^1, 1^2; 1^2, 1^3; ... can always be chosen to function simultaneously as an active antenna unit.

The inputs 16, 17 of the switch groups 13, 14 are connected to the power divider and phase shifter unit 18. The power divider and phase shifter unit 18 comprises two phase shifters, i.e. the first phase shifter 19 and the second phase shifter 20, and a 180° hybrid 21. The first input 21a of the hybrid 21 is the input of the power divider and phase shifter unit 18, and it is connected to the detecting and measuring unit 29, as well as to the receiver-transmitter unit (not illustrated in the drawing). The second of the inputs of the hybrid 21 is grounded through the load 22. The outputs 21c, 21d of the hybrid 21 are respectively connected to the input of the first phase shifter 19 and to the input of the second phase shifter 20.

The hybrid 21 is schematically illustrated in figure 5. The input and output ports are denoted with the same reference numbers as in figure 4. The input port 21a is a difference or D-port, and the input port 21b is a sum or S-port. When a signal is fed in through the D-port, from the output ports 21c, 21d there are received output signals, which are in a 180° phase difference. When again a signal is fed from the S-port to the hybrid, the signals received from the output ports are in phase.

The phase shifters 19, 20 are realized by means of transmission cables and switch members, as is seen in figure 6. The phase shifter 19, 20 includes two parallel transmission cables 23a, 23b and 24a, 24b connected at one end to both the input and output port P1, P2, and transmission cables 25a, 25b connected in between the ports. In addition, the phase shifter 19, 20 comprises switch members 28a and 28b installed at both ports P1, P2, at the ends of the matching cables 26a, 26b; 27a, 27b. The switch members 28a, 28b are realized by means of suitable diodes, and they can be switched to on and off positions. Both switch members 28a, 28b are simultaneously in the same state, so that the phase shifter 19, 20 is symmetrical in structure. The shifting properties of the phase shifter 19, 20 from the port P1 to the port P2 or vice versa are thus similar. Such a loaded line type phase shifter 19, 20 has small losses and a wide frequency band. Moreover, the phase shifter has good matching properties.

A preferred embodiment of the power divider and phase shifter unit 18 is illustrated as a layout in figure 7. The hybrid 21 and the phase shifters 19, 20 are produced on the same substrate by using the microslip method.

In this embodiment, the phase shifters 19, 20 are optimized to create a 33° phase shift. This means a roughly 14° (± 7° from straight middle line) angle difference for the beams obtained from the active antenna unit. By changing the states of the phase shifters 19, 20, and particularly the states of their switch members 31, 32, the direction of the beam of the active antenna unit can be shifted in between the normal, i.e. middle direction, and extreme positions of the ground plane 9, as is explained below.

The phase shifters 19, 20 are utilized in steering the beam while performing the satellite tracking. By suitably manipulating the switches 28a, 28b of the phase shifter 19, 20, it is possible to move from the "right" beam to the "left" beam or to the middle beam "mid", which beams are illustrated in figure 8a. The switching from the "right" beam to the "left" beam of vice versa is realized so, that the states of both switch members 28a, 28b of the phase shifters 19, 20 are changed. Thus the phase shifters become mirror images as regards their properties. Correspondingly, if the state of only one switch member, either 28a or 28b, is changed, the beam is shifted from the middle beam "mid" either to the "right" or "left" beam. The width of the beams is somewhat affected by the elevation angle α, and also the employed reception and transmission band. The above explained power divider and phase shifter unit 18 is mainly designed for the frequency band 1,5 - 1,7 GHz.

An active antenna unit is formed of two adjacent antenna elements 1^1, 1^2; 1^2, 1^3, ... For the active antenna unit, there can be arranged two beams as was explained above, the said beams deviating up to even 15°. By means of the radiator unit 1, a twofold number of beams is produced on the circle as compared to the number of the antenna elements 1^1 - 1^{12}. Thus 24 beams can be produced with 12 antenna elements, the said beams being spaced essentially evenly in a circular configuration in the azimuth plane. This is illustrated in figure 8b.

Figure 9 illustrates, in the form of a block diagram, the steering unit 30 together with the connector and peripheral devices. The steering unit 30 comprises a data processing unit 31a and a connected memory unit 31b. To the data processing unit 31a, there is further connected, by a suitable bus 32, a number of peripheral devices through the intermediation of the connector units, for instance the elevation angle detector 33 by intermediation of its connector unit 34, the A/D converter 35 of the detecting and measuring unit 29, the phase shifter switching unit 36 and the control 37 of the support members. The control unit 4 of the switching unit 5 also is connected to the bus 32 of the steering unit 30. In addition to this, the steering unit 30 includes a connector unit 38 for feeding information, such as programming and other information for the steering device, and a connector unit 39 for connecting the steering unit to external systems. Moreover, the steering unit 30 advantageously comprises a compass connector unit 40 in order to connect a compass 41 to the system.

The connector unit 34 of the elevation angle detector is connected to the elevation angle detector 33 measuring the elevation angle a of the antenna elements 1, and the said detector 33 is arranged in between the base element 3 and the antenna elements 1; 1^1 - 1^{12} (cf. figure 2). The detecting and measuring unit 29 contains an intermediate frequency unit and a rf-detector, as well as a measuring unit for measuring the rf-level. This measuring signal is fed to the steering unit via the A/D converter 35. The switching unit 36 is connected to the switch members 28a, 28b of the phase shifters 19 and 20 of the power divider and phase shifter unit 18. In this case the support members 3 are provided with an actuator 42 (cf. figure 2), such as electric motor, in order to lengthen and shorten the support members 3. The control 37 of the support members is connected to the actuator 42 of the support members.

By means of the steering unit 30, the acquisition and tracking of the satellite is carried out as follows. When starting the satellite antenna system, the elevation angle a of the elements 1^1 - 1^{12} of the radiator unit 1 is checked. If the elevation angle a does not correspond the location of the land terminal with respect to the latitude and the satellite, it is adjusted for instance at 10° intervals between 10 - 50°. The form and width of the beam is such, that the 10° adjusting steps are sufficient for a good antenna gain and signal to noise ratio. The correcting of the elevation angle α is carried out by adjusting the length of the support members 3 to be suitable by means of the actuator 42 of the support members, so that the desired elevation angle α is achieved. The information of the elevation angle α is sent to the steering unit 30 through the elevation angle detector 33.

After setting the elevation angle α, the acquisition of the satellite is started. The radio frequency level, i.e. rf-level of the satellite is measured by means of the detecting and measuring unit 29, by activating a pair of antenna elements 1^1, 1^2; 1^2, 1^3; 1^3, 1^4; etc, one pair at a time, so that all of the antenna elements 1^1 - 1^{12} are checked. The measured rf-level values, obtained from the said antenna units activated in succession, are recorded in the memory 31b. During this measurement, the beams of each pair of antenna elements are observed, both the right and the left beam, so that the azimuth plane will be scanned throughout by the beams illustrated in figure 8b.

When the first series of measurements is made, in the radiator unit 1' there is activated that pair of antenna elements which gave the maximum rf-level signal. Thereafter the system proceeds to tracking.

The tracking phase is based on the tracking of the rf-signal level by means of two beams, i.e. the left and the right beam, as was explaned above in connection with the devider and phase shifter unit. By following this procedure, it is attempted to keep the active antenna unit continuously electrically steered to the target satellite, in order to maintain the communication connection irrespective of the movements of the land terminal.

The steering unit can be provided with an electric compass 41 or other such detector, so that the turning of the vehicle can be observed, and the steering unit 30 can be effectively helped in maintaining the radiator unit steered to the satellite.

Claims

1. A satellite antenna system particularly for land mobile voice communications, comprising a radiator unit (1') which is steerable to the satellite in the azimuth plane, and is formed of a number of antenna elements (1; 1^1 - 1^{12}) and their ground planes (9; 9^1 - 9^{12}), a control unit (4) and a switching unit (5); the antenna elements (1^1 - 1^{12}) of the radiator unit (1'), together with their ground planes (9^1 - 9^{12}) being adjacently arranged in a circular configuration, so that among the said antenna elements (1^1 - 1^{12}), to one active antenna unit (6) there belong simultaneously two adjacent antenna elements (1^7, 1^8), and the said two elements are chosen, by means of the control unit (4) and the switching unit (5), to receive circularly polarized electromagnetic radiation from a desired direction and to further transmit the same to essentially the same direction.
characterized in that each antenna element (1; 1^1 - 1^{12}) is formed of a thin plate (8) made of conductive material, and that each antenna element (1; 1^1 - 1^{12}) comprises a platelike, circular part, i.e. curved part (8a), which has a standard width (b) and is arranged at a standard distance (h) from the ground plane (9; 9^1 - 9^{12}), and narrowing, pointed end parts' (8b, 8c), which are located at both ends of the curved part (8a) and arranged at an angle with respect to the plane of the curved part (8a) and towards the ground plane (9); with at the tips of these points (8b, 8c) poles (11, 12), of which the first is coupled to the feed/reception circuit and the second to the load (15).

2. The satellite antenna system of claim 1, **characterized** in that the points (8b, 8c) of each antenna element are formed as blunt tips, (8d, 8e), and that the poles (11, 12) are located, in the vicinity of these blunt tips, an unsymmetrically with respect to the shape of the tips.

3. The satellite antenna system of claim 1-2, **characterized** in that the ground plane (9; 9^1 9^{12}) of each antenna element (1; 1^1 - 1^{12}) is formed as a troughlike element, wherein the antenna element (1; 1^1 - 1^{12}) is installed.

4. The satellite antenna system of claim 1-3, **characterized** in that the switching unit (5) comprises two switch groups (13, 14), whereby two adjacent antenna elements (1^1, 1^2; 1^2, 1^3; 1^3, 1^4; ...) can be chosen from a desired spot on the circular configuration.

5. The satellite antenna system of claim 4, **characterized** in that the antenna system comprises a power divider and phase shifter unit (18), provided with two phase shifters (19, 20) and a 180° hybrid (21), which power divider and phase shifter unit (18) is coupled to the switching unit (5).

6. The satellite antenna system of claim 5, **characterized** in that each phase shifter (19, 20) comprises two parallel transmission cables (23a, 23b; 24a, 24b) connected at one end to the input and output ports (P1, P2); transmission cables (25a, 25b) provided in betweeen the input and output ports (P1, P2); and switch members (28a, 28b), installed at the ends of the matched cables (26, 26b; 27a, 27b) connected to the input and output ports (P1, P2), in order to realize the phase shift.

7. The satellite antenna system of any of the preceding claims, **characterized** in that the antenna elements (1; 1^1 - 1^{12}) are provided with suppbrt members (3), whereby the antenna elements are arranged on a base element (2) at a suitable elevation angle (a) with respect to the azimuth plane (B - B), and that the said support members (3) are advantageously adjustable members for adjusting the elevation angle (α).

8. The satellite antenna system of any of the preceding claims, **characterized** in that the antenna system is covered with a radome (7).

9. The satellite antenna system of any of the preceding claims, **characterized** in that the antenna system is provided with a steering unit (30) for the acquisition and tracking of the satellite, the said steering unit comprising a detecting and measuring unit (29) for measuring the rf-signal level; and that the said steering unit is connected to a control unit (4) and switching unit (5) for choosing two co-operating antenna elements (e.g. 6) among the antenna elements (1; 1^1 - 1^{12}), which two chosen antenna elements give the best signal level in data communication with the satellite.

Patentansprüche

1. Ein Satelliten-Antennensystem, insbesondere für bewegliche Landfunk-Sprechverbindungen, umfassend eine Strahlereinheit (1'), die zu den Satelliten in der Azimut-Ebene verstellbar und aus einer Anzahl Antennenelemente (1; 1^1 - 1^{12}) und ihren Bodenflächen (9; 9^1 - 9^{12}) gebildet ist, eine Regel- und Steuereinheit (4) und eine Schalteinheit (5), wobei die Antennenelemente (1^1 - 1^{12}) der Strahlereinheit (1') zusammen mit ihren Bodenflächen (9^1 - 9^{12}) zueinander benachbart in einer kreisförmigen Anordnung angeordnet sind, so daß unter den Antennenelementen (1^1 - 1^{12}) gleichzeitig zwei benachbarte Antennenelemente (1^7, 1^8) zu einer aktiven Antenneneinheit (6) gehören und die zwei Elemente durch die Steuer- und Regeleinheit (4) und die Schalteinheit (5) ausgewählt sind, um zirkular polarisierte elektromagnetische Strahlung aus einer gewünschten Richtung zu empfangen und in der im wesentlichen gleichen Richtung weiter zu übertragen, **dadurch gekennzeichnet**, daß jedes der Antennenelemente (1; 1^1 - 1^{12}) aus einer dünnen Platte (8) aus leitendem Material gebildet ist und daß jedes Antennenelement (1; 1^1 - 1^{12}) ein plattenähnliches, kreisförmiges Teil, z.B. ein gekrümmtes Teil (8a), das eine genormte (Richt-)Weite (b) hat und in einem genormten Abstand (h) von den Bodenflächen (9; 9^1 - 9^{12}) angeordnet ist, und sich verengende, zugespitze Endteile (8b, 8c) umfaßt, die sich an beiden Enden des gekrümmten Teiles (8a) befinden und unter einem Winkel mit Bezug zu der Ebene des gekrümmten Teiles (8a) und zur Bodenfläche (99) hin angeordnet sind, und zwar mit an den Spitzen dieser zugespitzten Enden (8b, 8c) angeordneten Polen (11, 12), von denen der erste mit der Zuführ-/Empfangsschaltung verbunden ist und der zweite mit der Last (15).

2. Das Satelliten-Antennensystem nach Anspruch 1, **dadurch gekennzeichnet**, daß die zugespitzten Enden (8b, 8c) jedes Antennenelementes als stumpfe Spitzen (8d, 8e) ausgebildet sind und daß die Pole (11, 12) in der Nachbarschaft dieser stumpfen Spitzen und unsymmetrisch mit Bezug zu der Form der Spitzen angeordnet sind.

3. Das Satelliten-Antennensystem nach Anspruch 1 bis 2, **dadurch gekennzeichnet**, daß die Bodenflächen (9; 9^1 - 9^{12}) jedes Antennenelementes (1; 1^1 - 1^{12}) als ein wannen- bzw. muldenförmiges Element ausgebildet sind, worin das Antennenelement (1; 1^1 - 1^{12}) installiert ist.

4. Das Satelliten-Antennensystem nach Anspruch 1 bis 3, **dadurch gekennzeichnet**, daß die Schalteinheit (5) zwei Schaltergruppen (13, 14) umfaßt, wodurch zwei benachbarte Antennenelemente (1^1, 1^2; 1^2, 1^3; 1^3, 1^4; ...) aus einer gewünschten Stelle auf der kreisförmigen Anordnung ausgewählt werden können.

5. Das Satelliten-Antennensystem nach Anspruch 4, **dadurch gekennzeichnet**, daß das Antennensystem einen Leistungsteiler- und eine Phasenschieber-Einheit (18) umfaßt, versehen mit zwei Phasenschiebern (19, 20) und einer 180° Hybrid-Schaltung (21), wobei die Leistungsteiler- und Phasenschieber-Einheit (18) mit der Schalt-Einheit (5) geschaltet ist.

6. Das Satelliten-Antennensystem nach Anspruch 5, **dadurch gekennzeichnet**, daß jeder Phasenschieber (19, 20) zwei parallele Übertragungskabel (23a, 23b; 24a, 24b), die an einem Ende mit den Eingangs-und Ausgangs-Anschlüssen (P1, P2) verbunden sind; Übertragungskabel (25a, 25b), die zwischen den Eingangs- und Ausgangs-Anschlüssen (P1, P2) vorgesehen sind; und Schaltelemente (28a, 28b), die an den Enden der Anpassungskabel (26, 26b; 27a, 27b) installiert sind, die mit den Eingangs- und Ausgangs-Anschlüssen (P1, P2) verbunden sind, umfaßt, um die Phasenverschiebung zu realisieren.

7. Das Satelliten-Antennensystem nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet**, daß die Antennenelemente (1; 1^1 - 1^{12})

mit Stützelementen (3) versehen sind, wodurch die Antennenelemente unter einem geeigneten Steigungs- bzw. Neigungswinkel (a) mit Bezug zu der Azimut-Ebene (B-B) auf einem Basiselement (2) angeordnet sind, und daß die Stützelemente (3) vorzugsweise Justierelemente zum Justieren des Steigungs-bzw. Neigungswinkels (α) sind.

8. Das Satelliten-Antennensystem nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet**, daß das Antennensystem mit einem Radom (Antennenkuppel) (7) abgedeckt ist.

9. Das Satelliten-Antennensystem nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet**, daß das Antennensystem mit einer Steuer- bzw. Verstelleinheit (30) zum Bereitstellen und Verfolgen des Satelliten ausgestattet ist, wobei die Steuereinheit eine Ermittlungs- und Meßeinheit (29) zum Messen des RF-Signalpegels umfaßt, und daß die Steuer-/Verstelleinheit mit einer Steuer- und Regeleinheit (4) und einer Schalteinheit (5) verbunden ist, zum Auswählen von zwei zusammenarbeitenden Antennenelementen (z.B. 6) unter den Antennenelementen (1; 1^1 - 1^{12}), wobei die zwei gewählten Antennenelemente den besten Signalpegel der Datenverbindung mit dem Satelliten aufweisen.

Revendications

1. Système d'antenne satellite, en particulier pour communications vocales entre des mobiles terrestres, comprenant une unité de rayonnement (1') orientable vers le plan azimutal du satellite et composé d'un certain nombre d'éléments d'antenne (1 ; 1^1-1^{12}) et de leurs plans de sol (9 ; 9^1-9^{12}), d'une unité de commande (4) et d'une unité de commutation (5) ; les éléments d'antenne (1^1-1^{12}) de l'unité de rayonnement (1'), ainsi que leurs plans de sol (9^1-9^{12}) , étant agencés de façon adjacente, selon une configuration circulaire, de sorte que, parmi lesdits éléments d'antenne (1^1-1^{12}), deux éléments d'antenne adjacents (1^7, 1^8) appartiennent simultanément à une unité d'antenne active (6) et lesdits deux éléments d'antenne sont choisis, au moyen de l'unité de commande (4) et de l'unité de commutation (5) pour recevoir un rayonnement électromagnétique de polarisation circulaire depuis une direction souhaitée et pour le transmettre ensuite essentiellement dans la même direction, caractérisé en ce que chaque élément d'antenne (1 ; 1^1-1^{12}) est composé d'une plaque mince (8) en matériau conducteur et en ce que chaque élément d'antenne (1 ; 1^1-1^{12}) comprend une partie circulaire en forme de plaque, c'est-à-dire une partie incurvée (8a), qui présente une largeur standard (b) et qui est placée à une distance standard (h) du plan de sol (9 ; 9^1-9^{12}) et des parties d'extrémité effilées se rétrécissant (8b, 8c) et qui sont situées aux deux extrémités de la partie incurvée (8a) et placées selon un angle par rapport au plan de la partie incurvée (8a) et vers le plan de sol (9) ; au bout de ces points (8b, 8c) se trouvant des pôles (11, 12), le premier étant couplé au circuit de réception/alimentation et le deuxième à la charge (15).

2. Système d'antenne satellite selon la revendication 1, caractérisé en ce que les points (8b, 8c) de chaque élément d'antenne sont constitués par des bouts pointus (8d, 8e) et en ce que les pôles (11, 12) sont situés au voisinage de ces bouts pointus, de façon asymétrique par rapport à la forme des bouts.

3. Système d'antenne satellite selon les revendication 1 et 2, caractérisé en ce que le plan de sol (9 ; 9^1-9^{12}) de chaque élément d'antenne (1 ; 1^1-1^{12}) se présente sous la forme d'un élément en auge, dans lequel est installé l'élément d'antenne (1 ; 1^1-1^{12}).

4. Système d'antenne satellite selon les revendications 1 à 3, caractérisé en ce que l'unité de commutation (5) comprend deux groupes de commutateurs (13, 14), grâce auxquels il est possible de choisir entre deux éléments d'antenne adjacents (1^1, 1^2 ; 1^2, 1^3 ; 1^3, 1^4 ; ...) à partir d'un endroit souhaité de la configuration circulaire.

5. Système d'antenne satellite selon la revendication 4, caractérisé en ce que le système d'antenne comprend une unité formée d'un diviseur de puissance et d'un déphaseur (18), dotée de deux déphaseurs (19, 20) et d'un hybride à 180° (21), l'unité formant le diviseur de puissance et le déphaseur (18) étant couplée à l'unité de commutation (5).

6. Système d'antenne satellite selon la revendication 5, caractérisé en ce que chaque déphaseur (19, 20) comprend deux câbles de transmission parallèles (23a, 23b ; 24a, 24b) connectés à une extrémité des ports d'entrée et de sortie (P1, P2) ; des câbles de transmission (25a, 25b) disposés entre les ports d'entrée et de sortie (P1, P2) ; et des éléments de commutation (28a, 28b) installés aux extrémités des câbles appairés (26, 26b ; 27a, 27b) connectés aux ports d'entrée et de sortie (P1, P2) afin d'obtenir le déphasage.

7. Système d'antenne satellite selon l'une quelconque des revendications précédentes, caractérisé en ce que les éléments d'antenne (1 ; 1^1-1^{12}) sont dotés d'éléments de support (3), les éléments d'antenne étant disposés sur un élément de base (2) à un angle d'élévation approprié (α) par rapport au plan azimutal (B-B), et en ce que lesdits éléments de support (3) sont, de façon avantageuse, des éléments réglables permettant de régler l'angle d'élévation (a).

8. Système d'antenne satellite selon l'une quelconque des revendications précédentes, caractérisé en ce que le système d'antenne est recouvert d'un radôme (7).

9. Système d'antenne satellite selon l'une quelconque des revendications précédentes, caractérisé en ce que le système d'antenne est doté d'une unité d'orientation (30) permettant l'acquisition et la poursuite du satellite, ladite unité d'orientation comprenant une unité de détection et de mesure (29) pour mesurer le niveau de signal RF ; et en ce que ladite unité d'orientation est connectée à une unité de commande (4) et une unité de commutation (5) pour choisir deux éléments d'antenne en coopération (par exemple 6) parmi les éléments d'antenne (1 ; 1^1-1^{12}), deux éléments d'antenne choisis donnant le meilleur niveau de signal pour la communication de données avec le satellite.

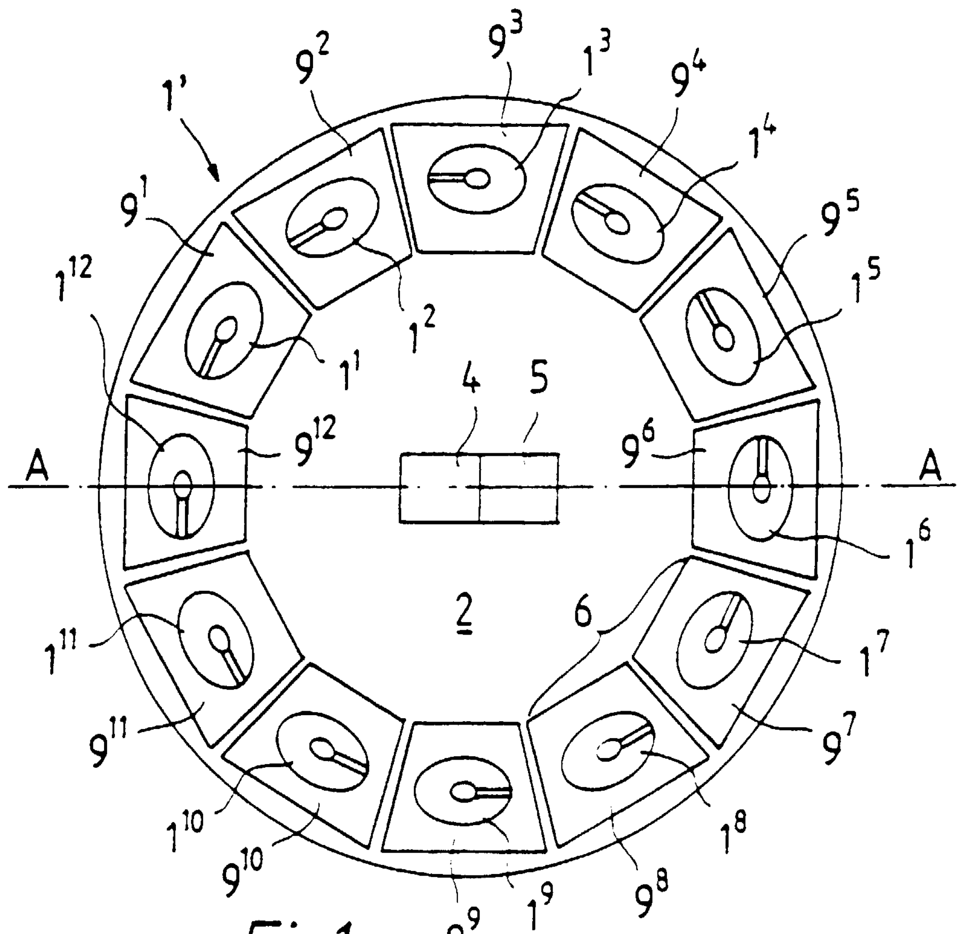
1'
9^2
9^3
1^3
9^4
1^4
9^1
9^5
1^12
1^2
1^5
1^1
4
5
A
9^12
9^6
A
1^6
2
6
1^11
1^7
9^11
9^7
1^10
1^8
9^10
9^8
9^9
1^9

Fig.1

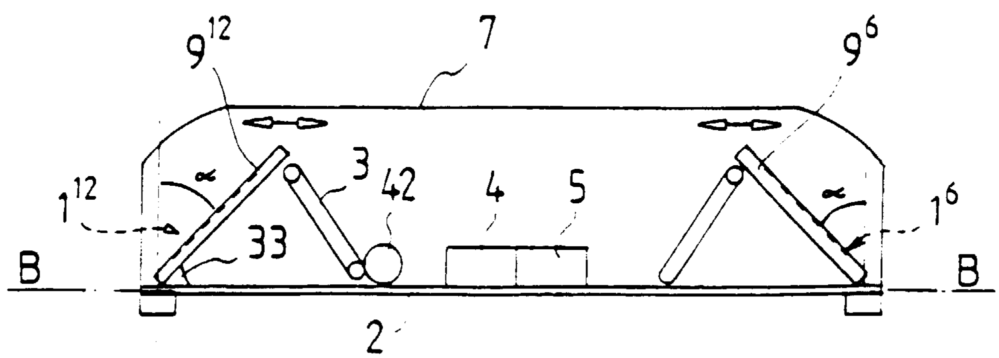
9^12
7
9^6
3
42
4
5
1^12
1^6
33
B
B
2

Fig.2

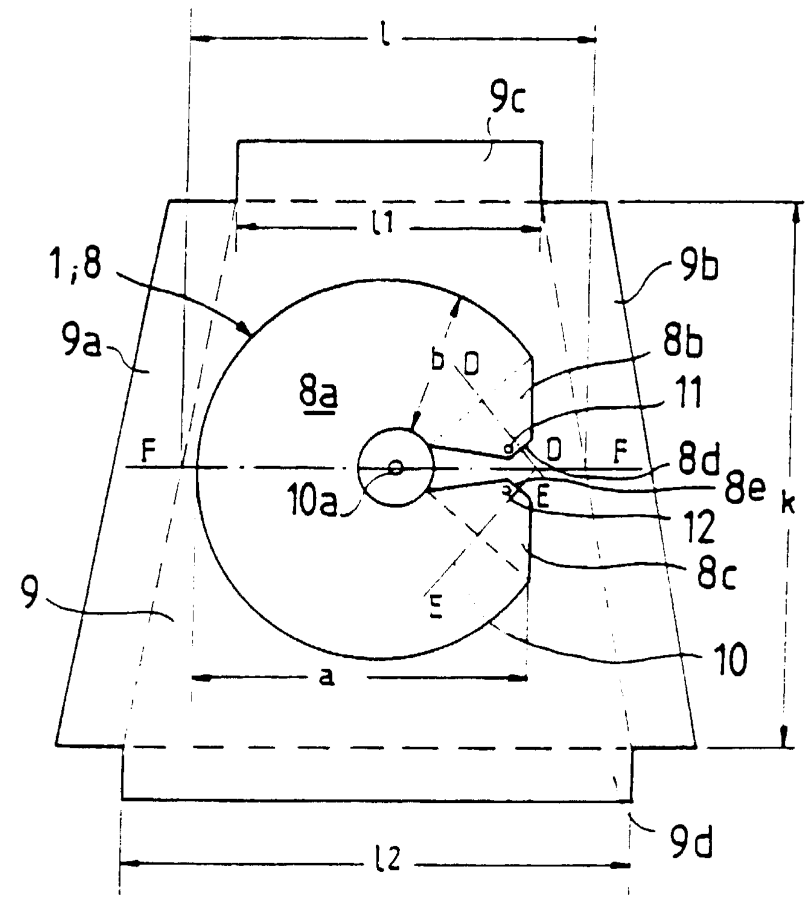
l
9c
l1
1;8
9b
9a
8b
b
D
8a
11
F
D
F
8d
8e
10a
E
k
12
8c
9
E
10
a
9d
l2

Fig.3a

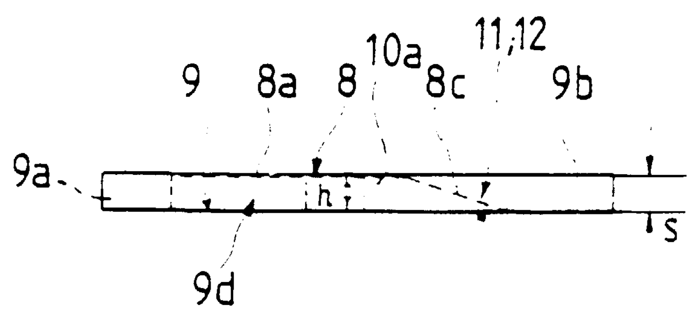
11;12
10a
9
8a
8
8c
9b
9a
h
s
9d

Fig.3b

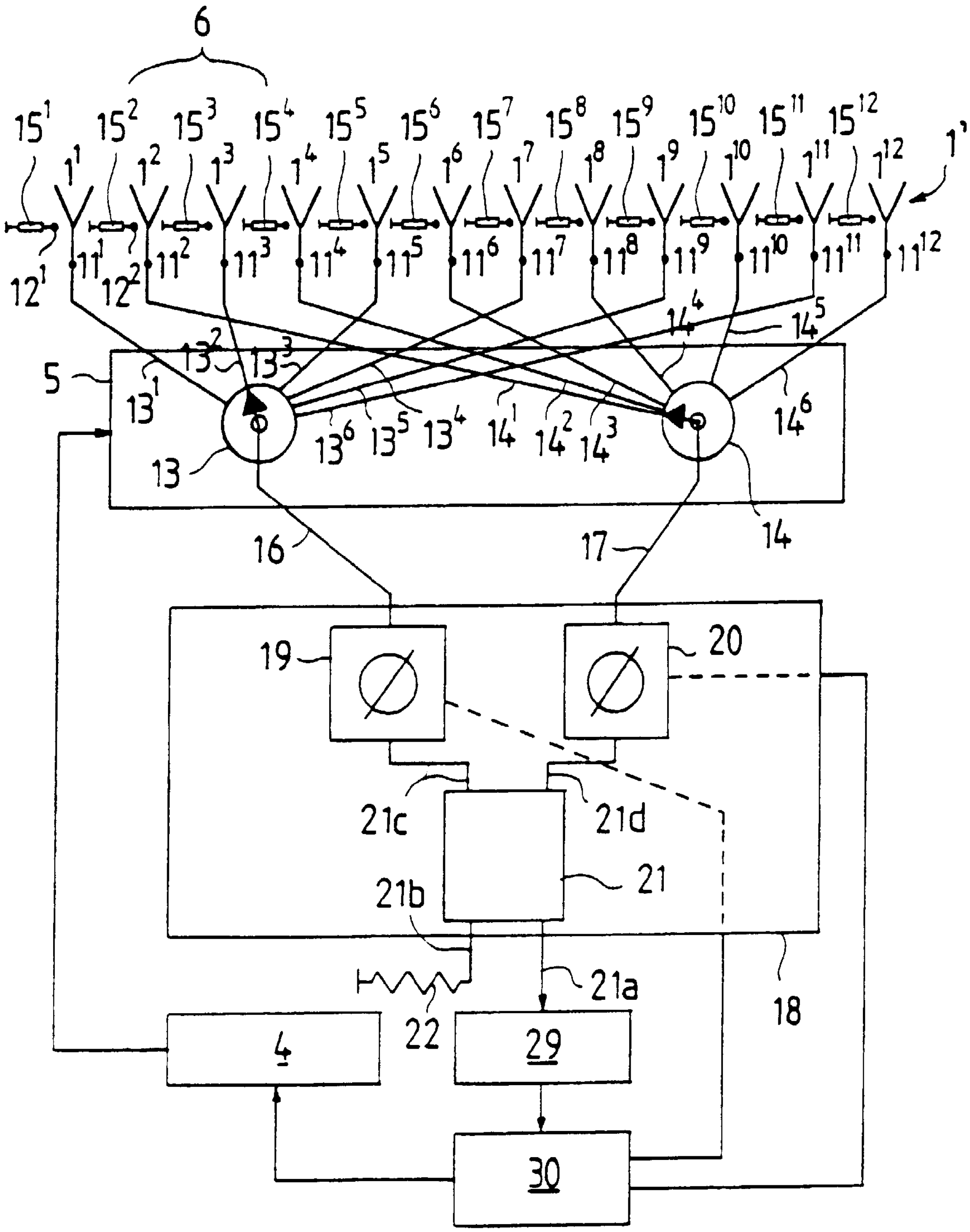
6
15¹ 15² 15³ 15⁴ 15⁵ 15⁶ 15⁷ 15⁸ 15⁹ 15¹⁰ 15¹¹ 15¹²
1¹ 1² 1³ 1⁴ 1⁵ 1⁶ 1⁷ 1⁸ 1⁹ 1¹⁰ 1¹¹ 1¹² 1'
12¹ 12² 11¹ 11² 11³ 11⁴ 11⁵ 11⁶ 11⁷ 11⁸ 11⁹ 11¹⁰ 11¹¹ 11¹²
5
13¹ 13² 13³ 13⁴ 13⁵ 13⁶ 13
14¹ 14² 14³ 14⁴ 14⁵ 14⁶ 14
16
17
19
20
21c
21d
21
21b
21a
22
18
4
29
30

Fig.4

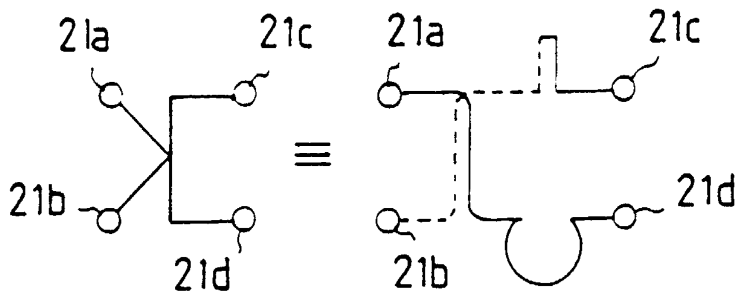

Fig.5

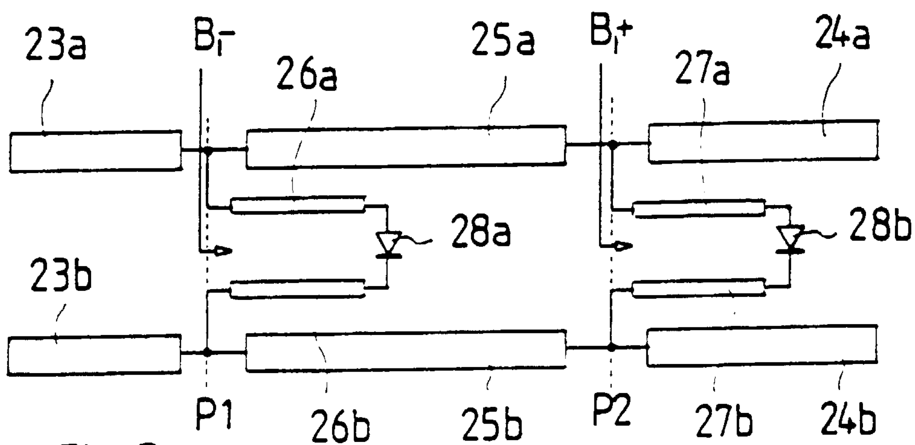

Fig.6

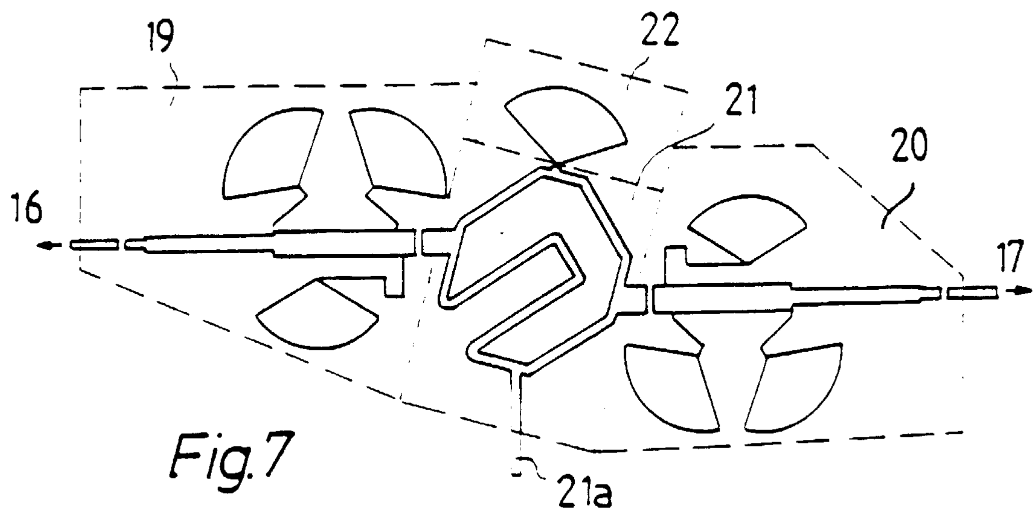

Fig.7

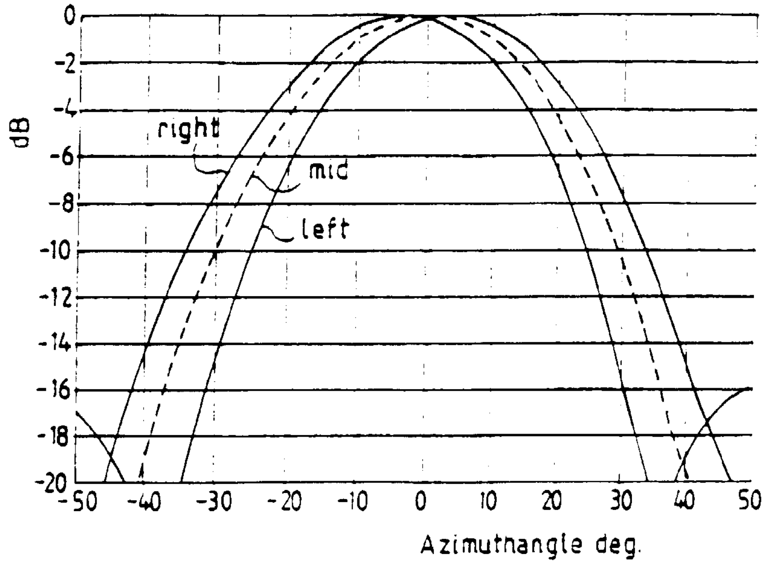
dB
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
right
mid
left
-50 -40 -30 -20 -10 0 10 20 30 40 50
Azimuthangle deg.

Fig.8a

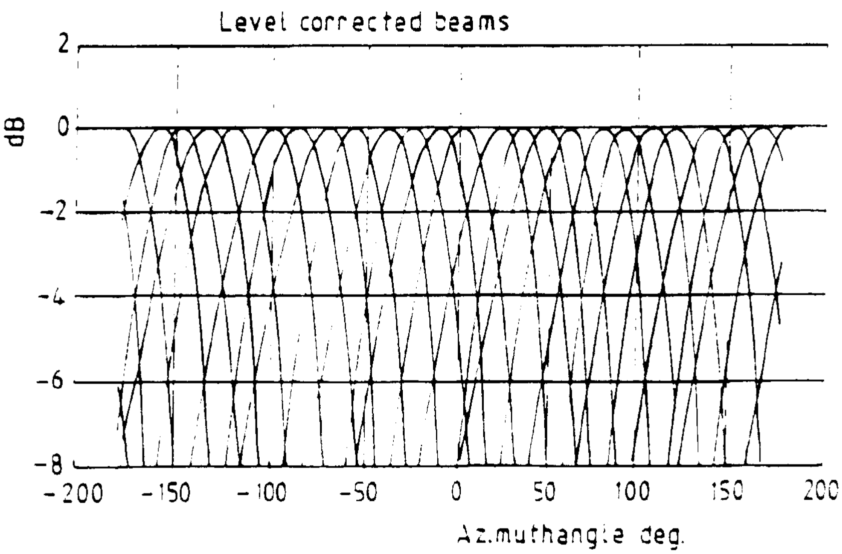
Level corrected beams
dB
2
0
-2
-4
-6
-8
-200 -150 -100 -50 0 50 100 150 200
Azimuthangle deg.

Fig.8b

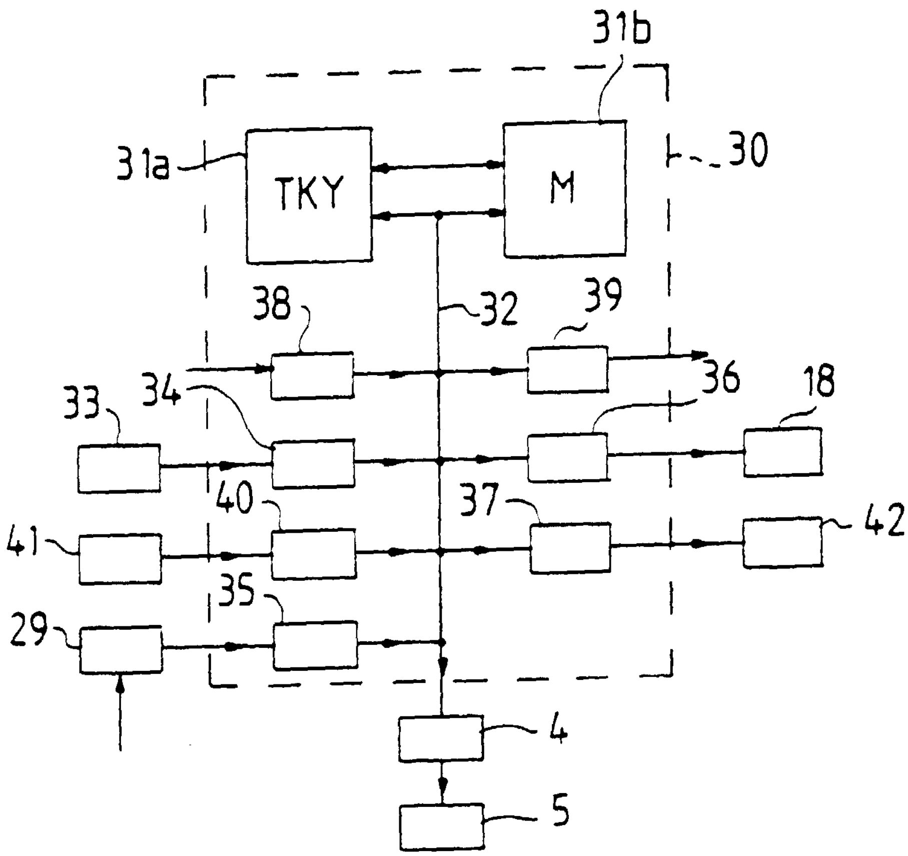

Fig.9