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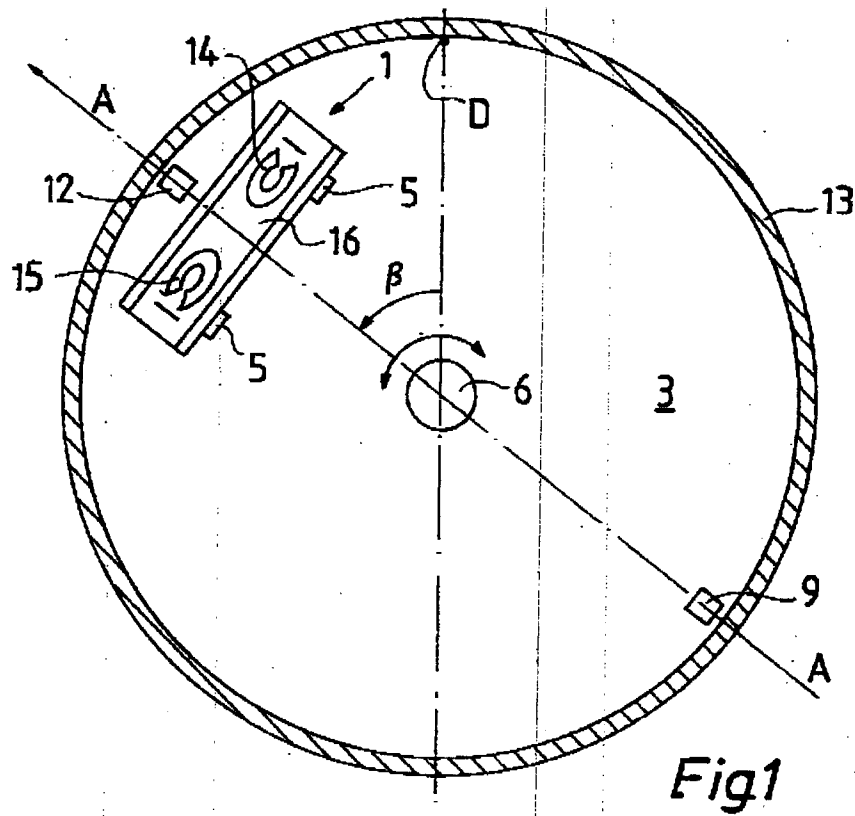
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(54) **Satellite antenna system.**

(57) The invention relates to a satellite antenna system, particularly for land mobile voice communications, provided with a radiator unit (1), which is steerable to the satellite in the azimuth plane. According to the invention, the radiator unit (1) comprises two antenna elements (14, 15) and a ground plane (16); the said elements are formed of circular,

planar, conductive plates and terminated to a load; they are turned at an angle of 180° with respect to each other and evenly spaced at a standard distance from the ground plate. The radiator unit is used for receiving and transmitting circularly polarized electromagnetic radiation.

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The invention relates to a satellite antenna system defined in the introductory section of patent claim 1, particularly for a land terminal for voice communications.

New satellite systems are under development, especially for land mobile communications. Data transmission and localisation services, such as Inmarsat C, PRODAT, Euteltracks and Lockstar, have already been demonstrated and are gradually coming into operational use. Market surveys also show, that there is a demand for voice communications. Two systems, EMS (European Mobile System) and Inmarsat M, are under development for L-band land mobile voice communications. These systems complement particularly terrestrial mobile services by providing flexible closed networks having a European wide coverage area. One of the most promising applications is private networks for truck communications.

Omnidirectional antennas can be used with low rate data transmission. The gain with these antennas is of the order 3...5 dBi, which is generally sufficient. However, voice communications need a better signal to noise ratio than the one offered by omnidirectional antennas. This leads to an antenna gain requirement of the order 10...12 dBi. In the prior art there are known several antenna systems where the antenna element is steerable. Such antennas are, among others, certain slot and horn antennas, as well as dipole antennas. A drawback with these antenna units is the complexity of feed network applications, and their unsuitability for tracking systems. Moreover, the mechanical properties of these antennas are often unsuitable particularly with respect to land mobile terminals.

The object of the invention is to provide a new antenna system, whereby the above mentioned drawbacks can be eliminated. Another object of the invention is to achieve an antenna system which is economical in production costs and suitable for mass production.

The antenna system of the invention is characterized by the features enlisted in the patent claim 1.

According to the invention, the satellite antenna system particularly for terrestrial voice communications includes a radiator unit, comprising two antenna elements and a common ground plane, both of the two antenna elements being made of a thin plate of some conductive material, advantageously metal; each antenna element comprises a planar or platelike, circular part, i.e. curved part, which advantageously has a standard width and is arranged at a standard distance from the ground plane, and narrowing, advantageously triangular points, which are located at both ends of the curved part and are arranged at an angle with respect to the plane of the curved part, and ori-

ented towards the ground plane; the tips of the said points are formed to be blunt, advantageously straight cut, and in the vicinity of these blunt tips there are located the poles in an unsymmetrical fashion, one of the poles being coupled to the feed/reception circuit and the second to the load; the said antenna elements are turned to an angle of 180° with respect to each other, at an equal distance from the ground plane; and by means of this radiator unit there is received and transmitted circularly polarized electromagnetic radiation. The shape and measures of the ground plane, as well as the distance of the antenna elements from each other and from the ground plane are optimized with respect to maximum antenna gain and minimum size for the ground plane.

In a preferred embodiment of the satellite antenna system, the ground plane is formed as a trough-like part, wherein the antenna elements are arranged. The mechanical structure of such ground plane is stiff. Moreover, such ground plane has a stabilizing effect on the feed point impedance.

In another preferred embodiment of the satellite antenna system, in connection with the ground plane and in the vicinity of both antenna elements, there is arranged a conductive strip, which is essentially perpendicular to the ground plane and extends, in the direction of the outer edges of the points of the antenna element, over the wide of the said points. These strips improve the signal transmission properties of the antenna element and stabilize the matching from the feed/reception circuit to the antenna elements.

In another preferred embodiment of the satellite antenna system, the radiator unit comprises a power divider and phase shifter unit, with two phase shifters and a 180° hybrid.

In another preferred embodiment of the satellite antenna system, the power divider and phase shifter unit are installed on the backside of the ground plane, together with the antenna element loads.

In another preferred embodiment of the satellite antenna system, each phase shifter is of the loaded line type, comprising two parallel transmission lines, connected at one end to the input and output ports, and transmission lines arranged in between these and the input and output ports, and switch members, arranged at the ends of the matched lines connected to the input and output ports, in order to realize the phase shift. Three beams with different orientations can be produced for the radiator unit by means of the phase shifters, depending on the states of the switches, of the phase shifters.

In another preferred embodiment of the satellite antenna system, the system comprises a first base element on which the radiator unit is installed,

and support members whereby the radiator unit is installed on the first base element, at a suitable elevation angle with respect to the azimuth plane.

In another preferred embodiment of the satellite antenna system, the support members are adjustable members for adjusting the elevation angle. By means of the support members, the elevation angle of the radiator unit is set in the azimuth plane, so that the beam of the antenna is steered towards the satellite. The elevation angle varies between 10° - 50° , and is advantageously adjustable for instance at 10° intervals.

In another preferred embodiment of the satellite antenna system, the system comprises a second base element and a turning motor, and the first base element is installed movably to the second base element, so that the first base element and the radiator unit are turnable, by means of the turning motor, in the azimuth plane with respect to the second stationary base element. Thus the stationary base element can be attached on a suitable moving platform, for instance a vehicle.

In another preferred embodiment of the satellite antenna system, the turning motor is a step motor. By using a step motor, the installation of the gearbox in connection with the turning motor can be avoided.

In another preferred embodiment of the satellite antenna system, the system includes a steering unit, which comprises a control unit for realizing the acquisition and tracking of the satellite, a detecting and measuring unit for measuring the rf-level, means for defining the angular position of the radiator unit in the azimuth plane, and the control of the turning motor. By means of the steering unit, when starting the operation of the antenna system, the satellite is searched by measuring the strength of the radio frequency signal in different directions and by thus defining the direction to which the radiator unit is oriented. Thus the connection between the land terminal and the satellite is created, and while the land terminal moves, attention is paid to that the radiator always is steered towards the satellite. By means of suitable sensors, the steering angle of the radiator unit in the azimuth plane is controlled, and the turning motor in turn is controlled by means of the control, so that first the satellite is localized and then the radiator unit is kept focused towards the satellite.

In another preferred embodiment of the satellite antenna system, the system includes a flexible cable, whereby the radiator unit is connected to the steering unit and to the transmitter-receiver, and a limit switch for limiting the rotation angle of the radiator unit. By means of the limit switch, the radiator unit can be rotated to one direction 360° at the most; thus the flexible cable does not have to turn to one direction more than one full turn, and

the mechanical strain for the cable does not become too heavy.

In another preferred embodiment of the satellite antenna system, the system is covered by a radome. Thus the antenna system is protected for instance against wind load in a vehicle environment, and against other possible environmental changes, too.

An advantage of the invention is that the radiator unit is a simple unit fitting in a relatively small space; it is economical in production costs and thus suitable for mass production. The radiator unit is particularly suitable to a mobile land terminal for voice communication. It is easily integrated for instance to a truck terminal.

Another advantage of the invention is that a relatively high antenna gain is achieved by using the radiator unit.

Another advantage of the invention is that by means of the radiator unit, there is created a radiation pattern with a wide coverage area. The satellite antenna system is suitable for small elevation angles, starting from about 10° , which are particularly important in northern latitudes, bearing in mind the use of the antenna system. A particular factor affecting the achievement of a small elevation angle is the ground plane of the radiator unit.

As for the further advantages of the invention, the following can be stated. The satellite acquisition routines function rapidly after switching the system on. The system also takes into account a fairly large pointing error of the radiator unit, with respect to the band width and gain loss of the radiator unit. Moreover, an advantage of the system is that it operates with a low signal to noise ratio. Further, the antenna system functions reliably irrespective of changes in short and long term signal levels. Yet another advantage of the antenna system is its rapid recovery from disturbance situations. In addition, the antenna system causes a minimal amount of distortions to communication channels. For instance, a coupling between different beams of the radiator unit causes a maximum difference of ± 0.5 db or $\pm 10^\circ$ in the amplitude and phase of the rf-signal respectively.

A general advantage of the invention is, that in an extremely demanding propagation environment of rf-radiation, it functions reliably and well.

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 radiator unit seen from the top, and figure 3b 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 unit;
 figure 8 illustrates the beams of the radiator unit; and
 figure 9 is a block diagram of the steering unit.

Figures 1 and 2 are schematical illustrations of a satellite antenna system of the invention. The antenna system comprises a radiator unit 1 and a power divider and phase shifter unit 2. Also the satellite antenna system comprises a first base element 3 and a second base element 4. The radiator unit 1 is installed in the support of the first base element 3. The antenna system is further provided with support member 5, whereby the radiator unit 1 is adjusted in the first base element 3 at a suitable elevation angle α with aspect to the azimuth plane B - B. The support members 5 are for instance support bars, which are adjustable in length, either at certain intervals or continuously, either manually or with a suitable actuator, in order to set the elevation angle α .

In the satellite antenna system, the first base element 3 is movably installed in connection to the second base element 4. This is realized so that the first base element 3 is attached with bearings by a turning axis 6 to the second base element 4. Thus the first base element complete with the radiator unit 1 can be turned with respect to the axis C - C in the azimuth plane B - B. The turning is carried out by means of the step motor 7 arranged in connection with the axis 6.

The radiator unit 1 of the satellite antenna system is steered to the satellite by means of a particular steering unit 8. This steering unit comprises at least a control unit 33 (cf. figure 9) for realizing the acquisition and tracking of the satellite, means for defining the angular position B of the radiator unit in the azimuth Plane B - B, a control 39 of the stepping motor and means for defining the signal level of the received rf-radiation, i.e., a detecting and measuring unit 34. The steering unit 8 will be explained in more detail below.

In this embodiment, the means for defining the angular position of the radiator unit include a location sensor 9, such as a Hall sensor, which is connected to the first 3 and second 4 base elements. The mutual position of the base elements in the rotatory plane B - B, and the angular position β of the radiator unit 1 with respect to a predetermined stationary orbit point, for example D, can then be defined on the basis of the rotatory posi-

tion value of the axis of the step motor 7, and the calibration reading of the step motor obtained from the location sensor 9.

The satellite antenna system further comprises a flexible connecting cable 11 and a limit switch 12. By means of the cable 11, the radiator unit 1 is connected to the steering unit 8 and to the transmitter-receiver (not illustrated in the drawing). By means of the limit switch 12, the rotation angle β of the radiator unit 1 is limited, so that the first base element 3 of the radiator unit 1 cannot be rotated to one direction, seen from the switch, more than 360° , i.e. for one full turn at the most.

The limit switch 12 and the location sensor 9 are advantageously integrated to one single switch for checking the angular position β of the step motor 7 and for limiting the turning of the step motor 7 and the first base element 3 to 360° .

In addition to this, the antenna system is covered with a radome 13. It is advantageously attached to the second base element 4. Thus the base element 3 and the radiator unit 1 are located inside the radome 13, protected from the surroundings.

The radiator unit 1 of the satellite antenna system is illustrated in figure 3a and 3b. The radiator unit 1 comprises two antenna elements 14, 15, which are similar in structure. The antenna elements 14, 15 are arranged at a distance a from each other. They are attached near the ground plane 16, in parallel thereto and at a small distance therefrom. The antenna elements 14, 15 are turned to an angle of 180° with respect to each other.

The antenna elements 14, 15 are discrete travelling-wave type air dielectric antenna elements. The antenna element 14, 15 is formed of a thin plate 17 made of some conductive material, preferably metal such as copper or brass. The antenna element 14, 15 includes a planar curved part with a standard width and an essentially circular form i.e. a curved part 17a. The curved part 17a fills a 270° sector of a circle. The nominal electric length of the curved part is near to the employed wavelength. The curved part 17b is arranged at a standard distance h from the ground plane 16.

At both ends of the curved part 17a, there are provided narrowing, advantageously triangular points 17b, 17c. The points 17b, 17c are arranged, with respect to the plane 17a of the curved part, at an angle towards the ground plane 16. They are advantageously made of the same uniform plate material as the curved part 17a and bent thereof. In between the points 17b, 17c there is a slot 17f. The tips of the points 17b, 17c are formed to be blunt, and are advantageously cut as straight blunt tips, as is illustrated in figure 3a. In the vicinity of the straight-cut blunt tips 17d, 17e, unsymmetrically with respect to the medium lines D - D, E - E of the

points 17b, 17c, i.e. at the sides of the blunt tips, there are arranged the poles 18; 18a, 18b and 19; 19a, 19b. One pole serves as the feed pole, and the second as the load. By forming the points 17b, 17c as blunt tips, particularly as straight-cut blunt tips 17d, 17e, and by placing the poles 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 14, 15 is symmetrical with respect to the straight line F-F running in the middle of the slot 17f and parallelly thereto. Depending on the employed direction of circular polarization, both poles 18, 19 can serve either as feed or load poles.

Coupling pins lead from the poles 18, 19 through the ground plane 16, electrically insulated therefrom, to the other side of the ground plane, where they are connected to the power divider and phase shifter unit 2 and to the matched loads 20a, 20b (cf. figure 4). At the blunt tips of the points 17b, 17c, such as at the straight cut blunt tips 17d, 17e, the antenna element is attached, by means of coupling pins, to the ground plane 16 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 14, 15 is supported, most advantageously in the middle of the curved part 17a, by an electrically insulating support 17g against the ground plane 16.

The radiation power of the antenna element 14, 15 can be adjusted by adjusting the width b of the curved part 17a of the plate 17 and its distance h from the ground plane 16. An optimal antenna gain is achieved when roughly 90% of the fed power produces radiation, and 10% is absorbed in the matched load.

It is found out that the optimal gain value of one antenna element 14, 15, and the width of the beam depend on the shape and size of the ground plane. The direction of the maximum main beam is to some extent dependent on the employed frequency, and deviates about 5 - 15° of the normal of the ground plane. This deviation angle also depends on the shape of the ground plane. By using two co-operating antenna elements 14, 15, which elements are turned 180° with respect to each other and arranged at a distance a from each other in the vicinity of the ground plane, and which elements are fed parallelly with a suitable phase difference, the angular dependence of the main beam on the frequency can practically be eliminated. Thus the fitting of the antenna elements 14, 15 on the ground plane 16 at a distance a from each other particularly reduces the tilting of the beam with respect to the employed frequency. The dimensions and shape of the ground plane, and the

distance a between the antenna elements 14, 15 and the ground plane can be optimized so, that a maximum antenna gain is achieved with a smallest possible size of the ground plane.

It is pointed out that when using two antenna elements 14, 15 in the radiator unit 1, the ground plane 16 does not necessarily have to be a straight plane, but it may contain a fold 16e (dotted line in figure 3a) in between the antenna elements 14, 15. Most advantageously, the fold 16e is located at an equal distance from both of the antenna elements 14, 15. Thus, in between the sections of the ground plane 16 divided by, the fold 16e and the antenna elements 14, 15, there can be an angle of even 20° without any serious detectable changes in the radiation distribution, such as extra side lobes. Thus the antenna elements 14, 15 together with the ground plane 16 can be bent at a small angle with respect to each other. Most advantageously, however, the ground plane 16 is a straight plane.

The ground plane 16 is a rectangular plane, with its edges 16a, 16b, 16c and 16d, turned upwards, so that the plane forms a shallow trough. The width 1 of the ground plane 16 is of the same order as the distance a between the antenna elements 14, 15, and the length k of the ground plane in turn is of the order $1.7 - 2 \times a$. The depth s of the trough-like ground plane is of the order 0.1 a. In a preferred embodiment, the dimensions of the ground plane 16 are 325 x 175 mm², and the depth of the ground plane is 20 mm. The ground plane is made of some suitable thin, conductive material, advantageously metal such as aluminum. Apart from the facts already mentioned, the trough-like ground plane 16 of two antenna elements is that it increases antenna gain and stabilizes the shape of the main beam, particularly with different elevation angles.

In connection to the ground plane 16, in an essentially perpendicular position in the vicinity of the poles 18; 18a, 18b and 19; 19a, 19b of both antenna elements 14, 15, there is arranged a thin, conductive strip 10; 10a, 10b, advantageously made of some metal such as aluminum. This strip is an essentially straight and narrow plate, with a maximum width as wide as the distance of the curved part 17a from the ground plane, extending in the direction of the outer edges of the triangular points 17b, 17c roughly as wide as the points 17b, 17c, i.e. as far as the edges of the curved part 17a, as is seen in figure 3a. These strips 10; 10a, 10b, improve the transmission capacities of the rf-signal and stabilize the matching from the feed, circuit to the antenna elements.

Figure 4 is a block diagram of the satellite antenna system of the present invention. The feed poles 18; 18a, 18b of the antenna elements 14, 15 of the radiator unit 1 are connected to the power

divider and phase shifter unit 2, and respectively the second poles 19; 19a, 19b are connected to the matched loads 20; 20a, 20b. The power divider and phase shifter unit 2 comprises two phase shifters, i.e. the first phase shifter 21 and the second phase shifter 22, as well as a 180° hybrid 23. The first input 23a of the hybrid 23 is the input of the power divider and phase shifter unit 2, and it is connected, with a flexible cable 24, to the steering unit 8 and to the receiver-transmitter unit (not illustrated in the drawing). The second of the inputs of the hybrid 23 is grounded through the load 25. The outputs 23c, 23d of the hybrid 23 are respectively connected to the input of the first phase shifter 21 and to the input of the second phase shifter 22.

The hybrid 23 is schematically illustrated in figure 5. The input and output ports are denoted with same reference numbers as in figure 3. The input port 23a is a difference, i.e. D-port, and the input port 23b is a sum, i.e. S-port. When a signal is fed in through the D-port, the signals from the output ports are in a 180° phase shift. When again a signal is fed to the hybrid through the S-port, the signals from the output ports are in phase.

The phase shifters 21, 22 are realized by using transmission cables and switch members, as is seen in figure 6. The phase shifter 21, 22 comprises two parallel transmission cables 26a, 26b and 27a, 27b connected at one end to both input and output ports P1, P2, as well as transmission cables 28a, 28b connected in between the ports. In addition to this, the phase shifter comprises switch members 31 and 32 installed at each port P1, P2, at the ends of the matched cables 29a, 29b. The switch members 31, 32 are realized by means of suitable diodes, and they can be switched to on and off positions. Both switch members 31, 32 are simultaneously in the same state, so that the phase shifter 21, 22 is symmetrical in structure. The transmission properties of the phase shifter 21, 22 from the port P1 to the port P2 or vice versa are thus the same. Such a loaded line type phase shifter 21, 22 has low losses and a wide frequency band. Moreover, the phase shifter has good input matching.

A layout of a preferred embodiment of the power divider and phase shifter unit 2 is illustrated in figure 7. The hybrid 23 and the phase shifters 21, 22 are produced on the same substrate by using the microstrip method. The load 20a, 20b of the radiator unit 1 are also integrated on the same substrate. The power divider and phase shifter unit 2 is advantageously located behind the radiator unit 1, and connected with transmission cables to the feed poles 18a, 18b of the antenna elements 14, 15. The ground pole is connected to the ground plane 16. Now the power divider and phase shifter unit 2 only has one input/output port 23a, which is

provided with a suitable connector, such as a SMA connector. The steering unit 8 is connected by a flexible cable 24 (cf. figure 3) to this connector of the power divider and phase shifter unit 2.

In this embodiment, the phase shifters 21, 22 are optimized to give a 23° phase shift. This means an angle difference of about 8° ($\pm 4^\circ$ from straight direction) for the beams obtained from the radiator unit 1 (cf. figure 8). A larger angle difference is obtained with a larger phase shift. This means that by changing the states of the phase shifters 21, 22, and particularly the states of their switch members 31, 32, the direction of the beam from the radiator unit 1 can be changed in between the middle position and these extreme positions, as will be explained below.

In steering the radiator unit 1 by means of the steering unit 8, the phase shifters 21, 22 are used for orienting the new during the tracking of the satellite. By suitably manipulating the switches 31, 32 of the phase shifter 21, 22, it is possible to shift from the "Right" beam to the "Left" beam, or to the middle beam "Mid", as is illustrated in figure 8. The width of the beams is somewhat affected by the elevation angle α , but also the employed reception and transmission band. The above described power divider and phase shifter unit 2 is mainly desired for the frequency band 1.5 - 1.7 GHz.

The switch from the "right" beam to the "left" or vice versa is realized by changing the state of the switch members 31, 32 of both phase shifters 21, 22. Now the phase shifters become each other's mirror images in relation to their properties. Respectively, if the state of only one switch member 31 or 32 is changed, the beam is shifted from the middle beam "mid" either to the "right" or "left" beam.

Figure 9 is a block diagram of the steering unit 8 and the connected units and devices of the antenna system. The steering unit comprises a control unit 33, as well as a detecting and measuring unit 34. Advantageously the control unit is composed of a data processing unit 33a and of a connected memory unit 33b. To the control unit 33, there is further connected, by means of a suitable bus 44, a number of connector units, such as the connector unit 35 of the angle detector, the connector unit 36 of the elevation angle detector, an A/D converter 37 for transmitting the measured rf-level from the detecting and measuring unit 34 to the control unit 33, the phase shifter switching unit 38, the step motor control 39 and the supporting member control 40. Moreover, the steering unit 8 comprises connector units for feeding programs of the control unit 33 and other information to the steering unit 8, and a connector unit 43 for connecting the steering unit 8 to external systems. In

addition to this, the steering unit may include a compass connection unit 41 in order to connect an electric compass unit 47 to the steering unit.

The connector unit 35 of the angle detector is connected to a limit switch 12, or alternatively to an angular sensor 9, in order to define the angular position of the radiator unit 1 in the azimuth plane. The Connector unit 36 of the elevation angle detector is in turn connected to the elevation angle detector 45, which is arranged in between the first base element 3 and the radiator unit 1 (cf. figure 2). The detecting and measuring unit 34 includes an intermediate frequency unit and a rf-detector, as well as a measuring unit for measuring the rf-level. This is fed to the steering unit through the A/D converter 37. The switching unit 38 is connected to the switch members 31, 32, such as diodes, of the phase shifters 21 and 22 of the power divider and phase shifter unit 2. The control 39 of the step motor is connected to the step motor 7. In this case the support members 5 are provided with an actuator 46 (cf. figure 2), such as an electric motor, for lengthening and shortening the support members 5. The actuator 46 at the support members is connected to the control 40 of the support members.

The acquisition and tracking of the satellite is realized by means of the steering unit 8 as follows. When starting the satellite antenna system, the elevation angle α of the radiator unit 1 is checked. If the elevation angle α does not correspond to the location of the land terminal with respect to the latitude and the satellite, it is corrected for instance at 10° intervals between $10 - 50^\circ$. The shape and width of the beam are such, that adjusting steps of 10° are sufficient for achieving 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 5, by means of the actuator 46 of the support members, to be suitable, so that the desired elevation angle α is achieved. Information of the elevation angle α is sent to the steering unit 8 through the elevation angle detector 45.

If the satellite antenna system is used within a relatively small geographical area, the elevation angle α is adjusted for example manually to be suitable, and is kept permanently in this value.

After setting the elevation angle α , the radiator unit 1 is turned, supported by the first base element 3, around the axis C - C by using the step motor 7 to a predetermined direction, such as counter-clockwise, until the limit switch 12 is reached. The azimuth angle β is checked. Thereafter the first, or the coarse acquisition program, is started. The level of the radio frequency signal of the satellite, i.e. its rf-level, is measured with the detecting and measuring unit 34 at suitable angle

intervals, for instance at 18° intervals, so that a 360° circle sector has 20 measuring points altogether. The rf-level readings obtained at these points are recorded in the memory 33b. During this measurement, either the right or the left beam can be used (cf. figure 8).

When the first series of measurements is carried out, the radiator unit 1 is turned towards the periphery of the angular range where the maximum rf-level signal was measured. Thereafter the second, or the fine acquisition sub-program is started. The angular sector of this acquisition window is for instance $\pm 27^\circ$, and the measurements are carried out at smaller angle intervals than in the coarse acquisition; for instance at 9° or smaller intervals. The measurements are carried out in the said area, whereafter the radiator unit 1 is turned towards the point where the maximum rf-signal level was detected. Now the system proceeds to the tracking phase.

The tracking phase is based on the measurement of the level difference of the received satellite signal from two beams, i.e. from the left and the right beam, as was explained earlier in connection with the power divider and phase shifter unit. The level difference is measured for instance by measuring first the rf-signal level from the first beam, for instance the "left", beam, and then the second rf-signal from the "right" beam, by changing the state of the switch elements 31, 32 of the phase shifters 21, 22, as was explained above. The directional adjustment of the radiator unit 1 corresponding to the level difference is advantageously registered in tabular form in the memory 33b of the data processing unit 33a of the tracking control unit 33. On the basis of the measured level difference, the directional adjustment is obtained directly from the memory, which adjustment is then fed to the control unit 39 of the step motor 7. On the basis of the directional adjustment, the step motor 7 is turned a suitable number of steps to a given direction, whereafter the radiator unit 1 is steered to the satellite with sufficient accuracy. By following this procedure, it is attempted to keep the radiator unit 1 continuously steered to the target satellite, in order to maintain the communication connection irrespective of the movements of the land terminal.

The beams "right" and "left" are located so near to each other, that a sufficiently strong satellite signal is continuously received from both. The symmetrical phase shifters 21, 22 of the power divider and phase shifter unit 2 do not cause phase leaps in the received signal during the shifts from the left beam to the right and vice versa. The phase leap is 2 degrees at the most. It is pointed out that the deviating of the beam, i.e. changing over from one beam to another, as well as the

measurement of the satellite signal level are carried out electrically, whereas the directional adjustments of the radiator unit 1 are carried out mechanically by turning the radiator unit.

The steering unit 8 can be provided with a digital compass unit 47 or with some other detector whereby the turning of the vehicle can be observed, which provides an effective help for the steering unit 8 in keeping the radiator unit focused to the satellite.

In the above specification, the invention is explained with reference to one preferred embodiment only, but many modifications are possible within the scope of the inventional idea defined in the appended patent claims.

Claims

1. A satellite antenna system particularly for a land terminal for voice communications **characterized** in that the satellite antenna system comprises a radiator unit (1) provided with two antenna elements (14, 15) and a common ground plane (16), both of which antenna elements (14, 15) are formed of a thin plate (17) made of some conductive material, advantageously metal; that both of the antenna elements (14, 15) comprise a platelike circular part, i.e. curved part (17a), which advantageously has a standard width (b) and is arranged at a standard distance (h) from the ground plane (16), and narrowing, advantageously triangular points (17b, 17c), located at both ends of the curved part (17a) and arranged at an angle with respect to the plane of the curved part (17a) and oriented towards the ground plane (16); that the tips of the said points (17b, 17c) are formed as blunt tips, advantageously as straight cut blunt tips (17d, 17e) and that in the vicinity of these blunt tips, there are located the poles (18; 18a, 18b; 19; 19a, 19b) in an unsymmetrical fashion and one of these poles is coupled to the feed/reception circuit, and the other to the load (20; 20a, 20b); that the said antenna elements (14, 15) are turned to an angle of 180° with respect to each other and arranged at a standard distance (a) from each other and from the ground plane (16), and that by means of the said radiator unit (1) there is received and transmitted circularly polarized electromagnetic radiation.
2. The satellite antenna system of claim 1, **characterized** in that the ground plane (16) is formed as a trough-like member, wherein the antenna elements (14, 15) are installed.
3. The satellite antenna system of claim 1 or 2, **characterized** in that in connection with the ground plane (16), in the vicinity of both antenna elements (14, 15), there is arranged a conductive strip (10; 10a, 10b) which is essentially perpendicular to the ground plane and extends, in the direction of the outer edges of the points (17b, 17c) of the antenna element, over the width of the said points.
4. The satellite antenna system of claim 1, 2 or 3, **characterized** in that the radiator unit comprises a power divider and phase shifter unit (2), with two phase shifters (21, 22) and a 180° hybrid (23).
5. The satellite antenna system of claim 4, **characterized** in that the power divider and phase shifter unit (2) is installed on the backside of the ground plane (16), together with the loads (20; 20a, 20b) of the antenna elements (14, 15).
6. The satellite antenna system of claim 4 or 5, **characterized** in that each phase shifter (21, 22) comprises two parallel transmission cables (26a, 26b; 27a, 27b) connected at one end to the input and output ports (P1, P2); transmission cables (28a, 28b) arranged in between the input and output ports (P1, P2); and switching members (31, 32), installed at the ends of matched cables (29, 29b; 30a, 30b) 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 satellite antenna system comprises a first base element (3), on which the radiator unit (1) is installed, and support members (5), whereby the radiator unit (1) is installed on the first base element (3) at a suitable elevation angle (α) with respect to the azimuth plane (B - B);
 - the satellite antenna system comprises a second base element (4) and a turning motor, advantageously a step motor (7), and the first base element (3) is movably installed in the second base element (4), so that the first base element (3) and the radiator unit (1) are in the azimuth plane turnable by the turning motor with respect to the second stations base element (4); and that
 - the antenna system is most advantageously covered with a radome (13).

8. The satellite antenna system of claim 7, **characterized** in that the support members (5) are adjustable members for adjusting the elevation angle (α). 5
9. The satellite antenna system of claim 7 or 8, **characterized** in that the antenna system is provided with a flexible cable (11) whereby the radiator unit (1) is connected to the steering unit and to the transmitter-receiver, and a limit switch (12) for limiting the rotation angle (β) of the radiator unit. 10
10. The satellite antenna system of claim 7, 8 or 9, **characterized** in that the satellite antenna system comprises a steering unit (8), provided with a control unit (33), a detecting and measuring unit (34) for measuring the level of a rf-signal, means (9) for defining the angular position of the radiator unit in the azimuth plane, and a control (39) of the step motor. 15 20 25 30 35 40 45 50 55 10

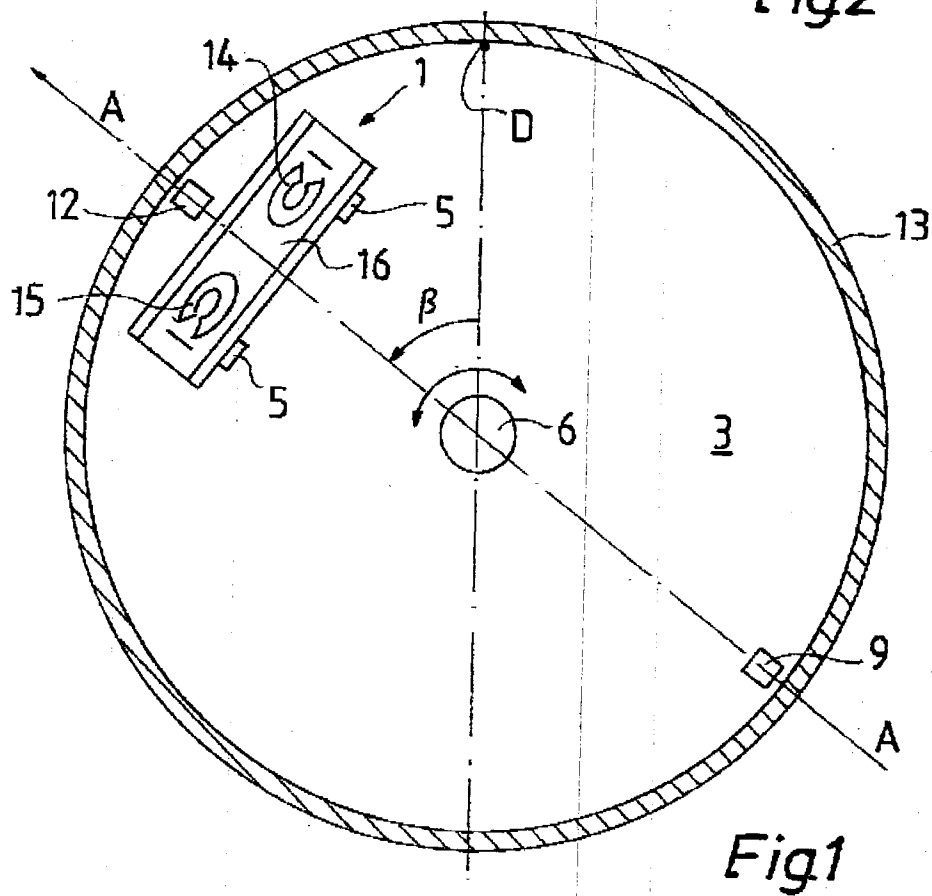
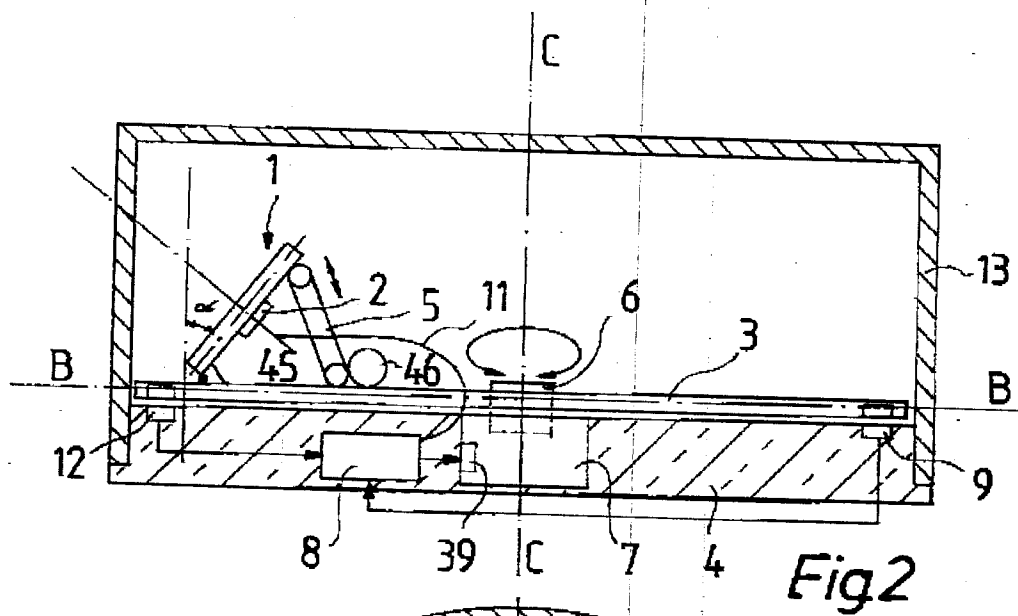


Fig. 3a

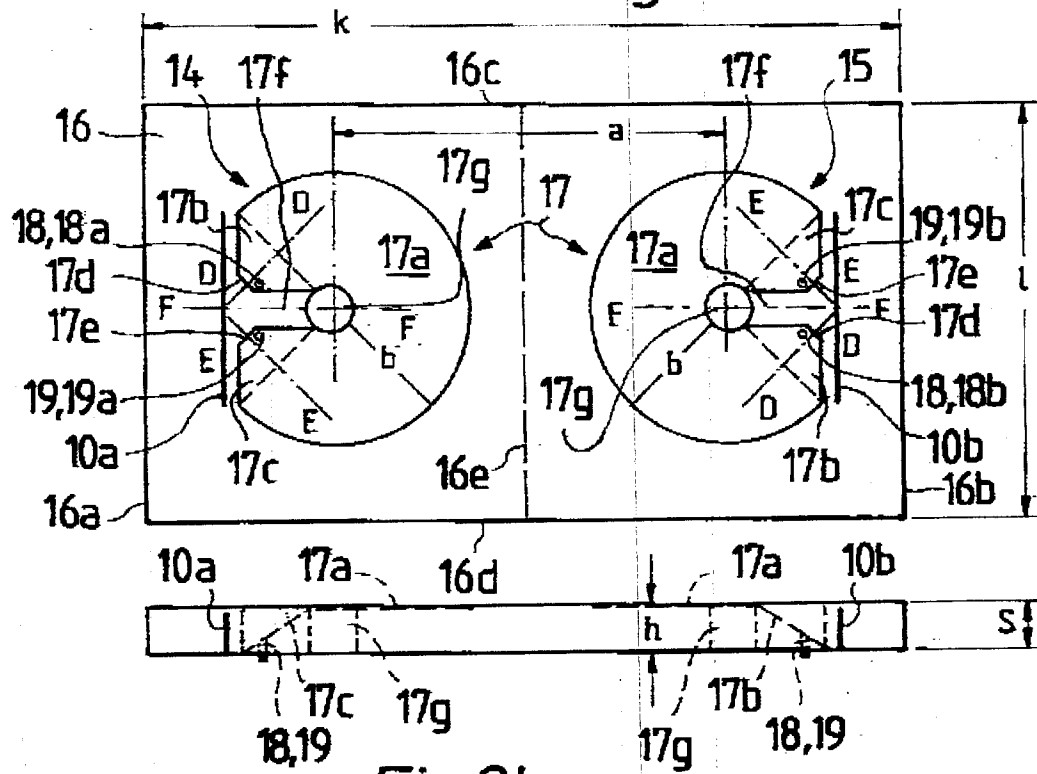


Fig. 3b

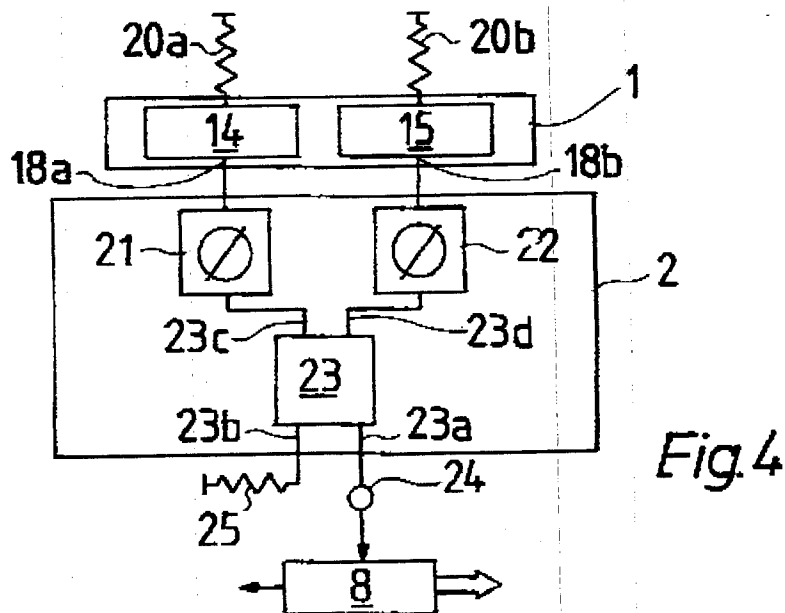
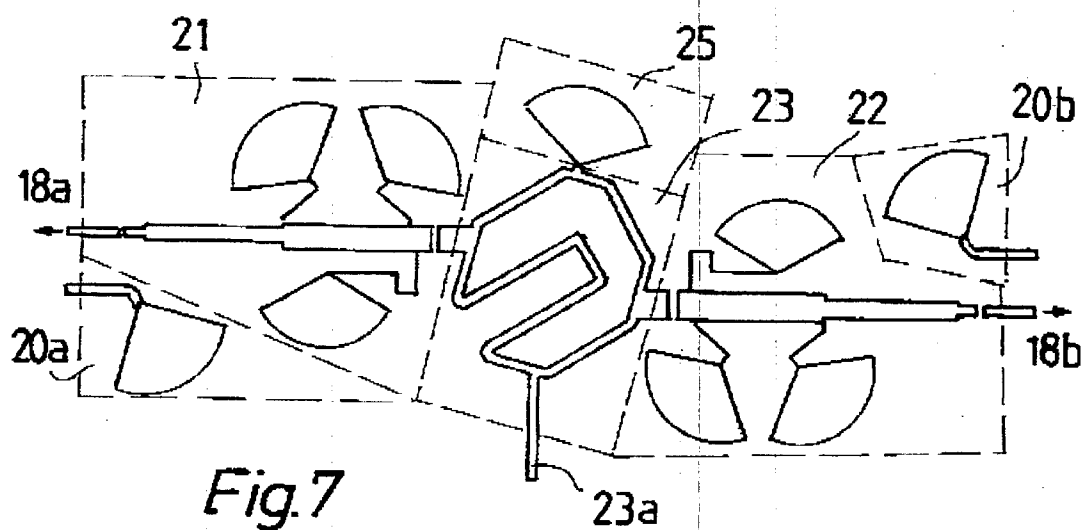
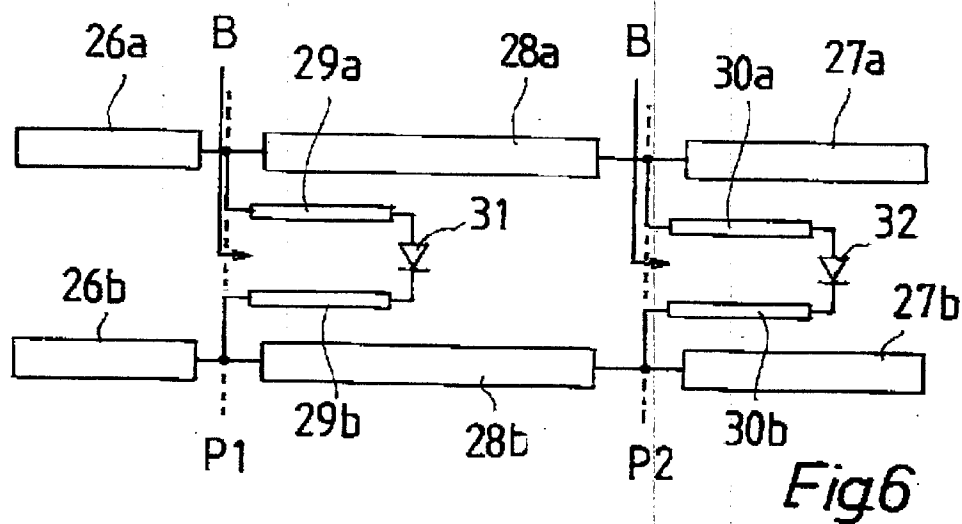
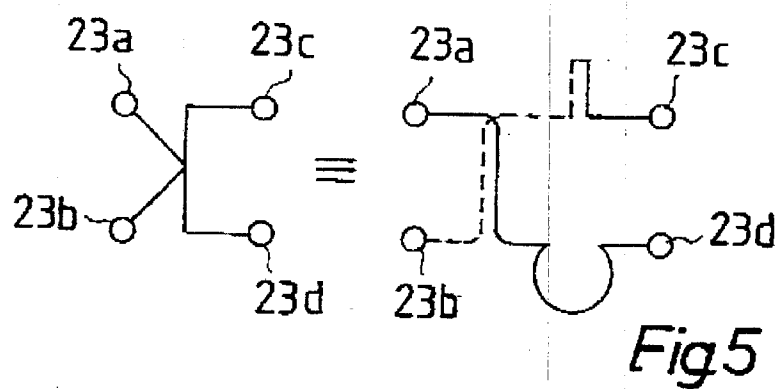


Fig. 4



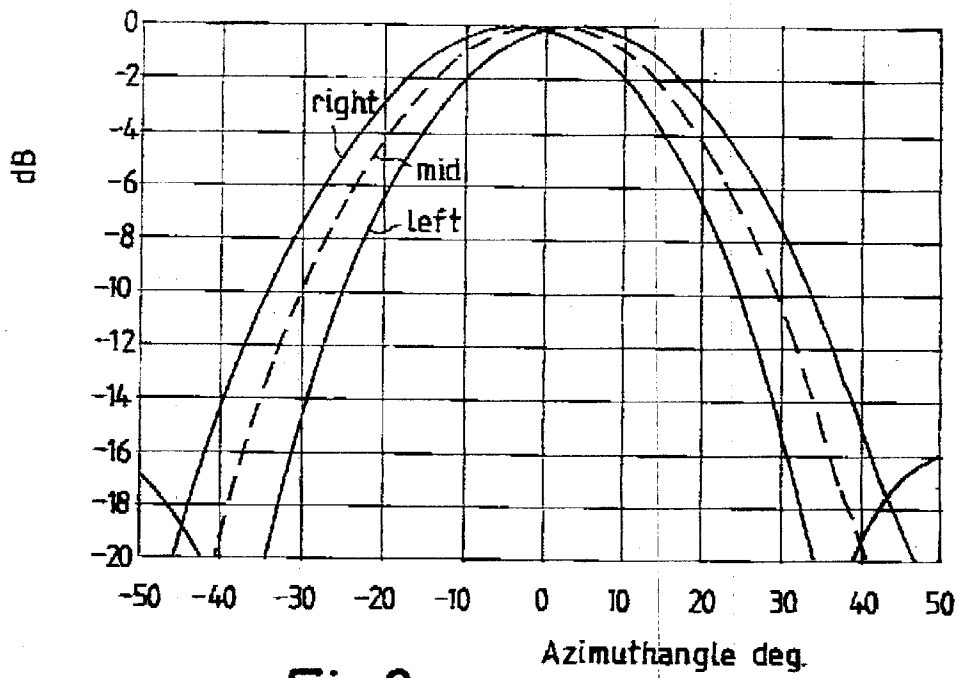
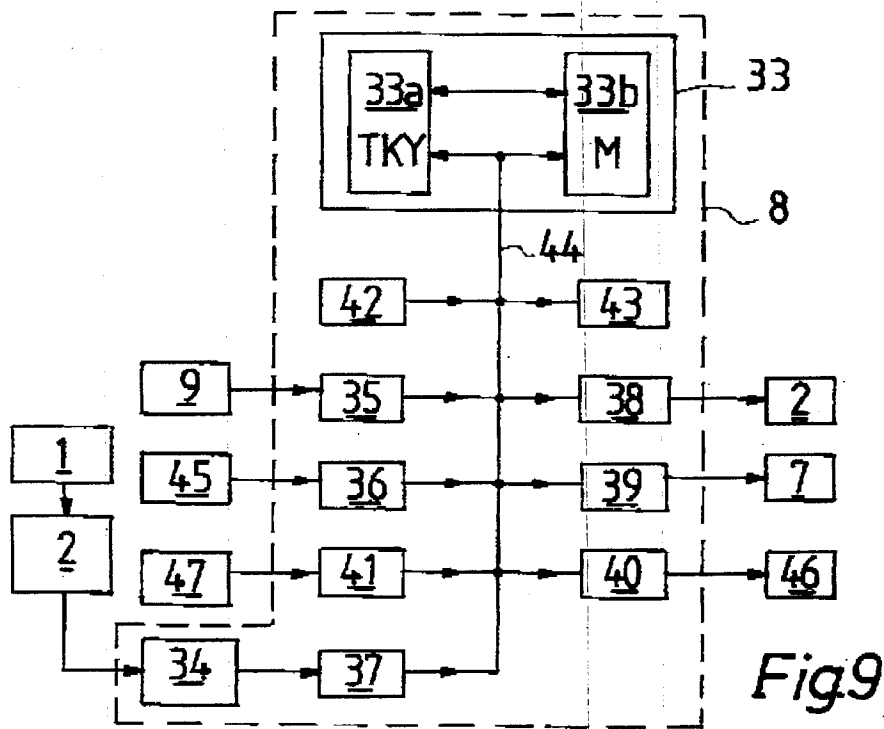


Fig 8





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Y	US-A-4 881 078 (YAMANE ET AL.) * column 1, line 50 - column 3, line 2; figures 1-10 * ---	1,7-10	H01Q1/32 H01Q3/08 H01Q9/04
Y	IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION vol. 37, no. 3, March 1989, NEW YORK US pages 281 - 288 DREWNIK ET AL. 'ANSERLIN:A Broad-Band,Low_Profile,Circularly Polarized Antenna' * page 281 - page 282; figure 1 * ---	1,7-10	
A	NTIS TECH NOTES May 1990, SPRINGFIELD, VA US pages 394 - 395 BELL ET AL. 'Mechanically-Steered,Mobile Satellite-Tracking Antenna' * the whole document * ---	1,7-10	
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A	37TH IEEE VEHICULAR TECHNOLOGY CONFERENCE June 1987, TAMPA, FLORIDA pages 113 - 117 HUANG 'L-BAND PHASED ARRAY ANTENNAS FOR MOBILE SATELLITE COMMUNICATIONS' * page 113 - page 116; figure 5 * --- -/--	1-6	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 FEBRUARY 1993	Examiner ANGRAEIT F.F.K.
CATEGORY OF CITED DOCUMENTS 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 T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			



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A	THE RECORD OF THE IEEE 1990 INTERNATIONAL RADAR CONFERENCE May 1990, ARLINGTON, VIRGINIA pages 496 - 500 WATKINS ET AL. 'EXPERIMENTAL INVESTIGATION OF BROAD-BAND MICROSTRIP ANTENNAS' * the whole document *	1,2	
A	1987 INTERNATIONAL SYMPOSIUM DIGEST ANTENNAS AND PROPAGATION vol. II, June 1987, BLACKSBURG, USA pages 798 - 801 DREWNIK ET AL. 'POWER DIVISION BY ELEMENT DESIGN IN A CIRCULARLY POLARIZED, SERIES-FED ARRAY' * page 798 - page 799 *	1,2	
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 FEBRUARY 1993	Examiner ANGRABEIT F.F.K.
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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		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	