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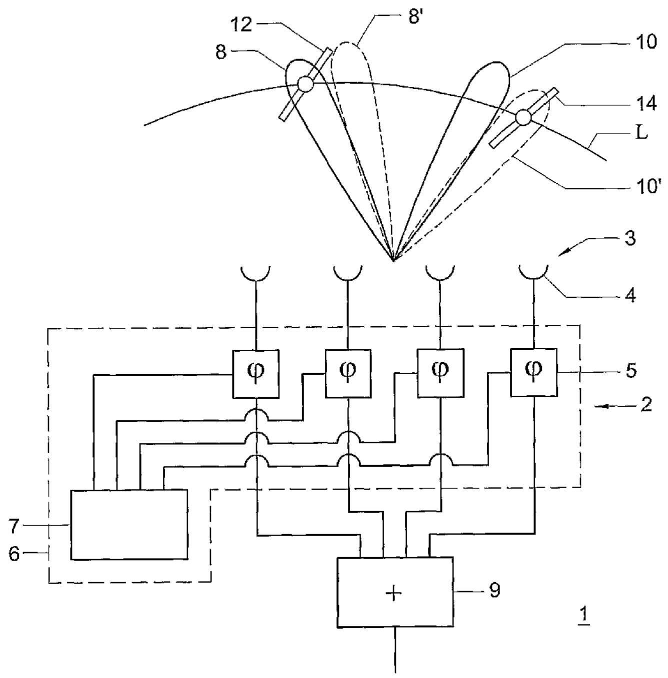
(54) Title: DEVICE AND METHOD FOR SENDING AND/OR RECEIVING SIGNALS TO/FROM AT LEAST TWO SATELLITES



(57) Abstract: Device for sending and/or receiving signals to/from at least two satellites. The device includes an antenna with at least two antenna beams, and a switching unit connected to the antenna and arranged for switching the at least two antenna beams between a first and second mode. In the first mode a first antenna beam is aimed at a first satellite for sending and/or receiving a first signal to/from the first satellite and a second antenna beam is aimed away from a second satellite. In the second mode, the second antenna beam is aimed at the second satellite for sending and/or receiving the second signal to/from the second satellite and the first antenna beam is aimed away from the first satellite

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Device and method for sending and/or receiving signals to/from at least two satellites

BACKGROUND OF THE INVENTION

The invention relates to a device for sending and/or receiving signals to/from at least two satellites. The invention further relates to a method for sending and/or receiving signals to/from at least two satellites, a satellite communications system including a device according to the invention, a switching unit for use in the device according to the invention, a computer program product for performing the method according to the invention and a receiver including the switching unit and/or the device according to the invention.

Satellite communications systems are generally known and used for receiving and/or transmitting signals, e.g. in the form of electro-magnetic radiation, between at least one satellite and at least one subscriber-unit. Satellite communications systems may, for example, be employed in telephone, internet, radio and television communication. Commonly, a satellite communications system includes a satellite in orbit around a celestial body, e.g. earth, and one or more receiving/transmitting units, positioned on the celestial body, which can receive signals from the satellite or transmit signals to the satellite. The receiving/transmitting units can also be positioned on vehicles, e.g. cars or aeroplanes, devices, e.g. computers, et cetera.

The receiving/transmitting units can, for example, be subscriber-units which provide a user with access to, e.g. internet, radio and/or television. Usually a receiving/transmitting unit includes an antenna, e.g. a dish antenna or a phased array antenna, for receiving and/or emitting the signals. Often it is desirable that a single receiving/transmitting unit can communicate with a plurality of satellites. For example, in the reception of television it can be desirable to be able to receive television signals from different satellites (e.g. the ASTRA1 and ASTRA2 satellites). These different satellites usually are located at different locations in the sky, so that it is desirable for a single subscriber-unit to be able to transmit/receive signals to/from different directions.

Different satellites, however, can transmit signals at a same frequency and with a same polarisation. It is not desired to receive signals having the same frequency and polarisation from two different satellites simultaneously with the same receiver, as discriminating between the signals coming from the different satellites is difficult. Both signals will be mixed, which will impede proper reception of either one of the signals.

Communications systems for receiving a signal from a selected satellite of a plurality of satellites are known. Such known communications systems, for instance, comprise a rotatable antenna which is mechanically rotated to aim a single antenna beam towards the selected satellite. The required rotation mechanism increases costs, is susceptible to malfunction and reduces user friendliness of the system, e.g. due to the relatively long time needed to switch from one satellite to another.

Also, communications systems are known, which include a reflector and multiple receiver systems, or a phased array antenna arranged to simultaneously create multiple independently steerable antenna beams to avoid the problem described above. In these known systems either the signals stemming from each beam are received by a separate receiver, or a desired beam is selected from the multiple beams for reception of the signals from the selected beam only. These known systems allow for fast switching from one satellite to another, but are relatively expensive due to the presence of multiple parallel feed networks and or multiple receiver systems.

For example, United States patent 6,034,634 discloses a satellite communications system comprising a phased array antenna with two sets of feed networks. Thereto, the phased array antenna includes a plurality of antenna units, each of which antenna units is connected to both feed networks. Each of the feed networks generates an independent, electrically controlled, antenna beam. Each beam is aimed at a (different) desired satellite from a plurality of satellites. Thereto, each feed network adjusts the phases of the antenna units of the antenna array with respect to each other, e.g. using time or phase shifter devices connected to the antenna units. The satellite communications system disclosed in United States patent 6,034,634 further comprises separate receivers for the signals stemming from each beam, for simultaneously communicating with the two satellites. In this system, therefore, the number of phase shifter devices and the number of receivers is doubled with respect to a satellite communications system arranged to communicate with a single satellite.

Thus, these communication systems require many expensive components, such as (electronically) adjustable time or phase shifter devices to control the multiple antenna beams. These known communications systems are, therefore, complex and expensive to manufacture.

SUMMARY OF THE INVENTION

An object of the invention is to provide a satellite communications system for sending and/or receiving signals to/from mutually different satellites, which system is of a less complex design. Accordingly, according to the invention, a satellite communications system according to claim 1 is provided.

Such a system is of a more simple design, because the system only has to select one of at least two operating modes. Thereto, the system has at least two coupled beams and at least two operating modes, wherein, in a first operating mode, a first antenna beam is aimed at a first satellite for sending and/or receiving a first signal to/from the first satellite while a second antenna beam is aimed away from a second satellite so as to avoid sending and/or receiving a second signal to/from the second satellite, and wherein, in a second operating mode, the second antenna beam is aimed at the second satellite for sending and/or receiving the second signal to/from the second satellite while the first antenna beam is aimed away from the first satellite so as to avoid sending and/or receiving the first signal to/from the first satellite. Accordingly, to switch between the first and second modes, only the pointing direction of the antenna beams has to be changed by a small amount. The change of direction can be generated with simple means, thereby reducing the cost of the satellite communications system.

In the first mode, the second antenna beam may be aimed adjacent the second satellite, and in the second mode, the first antenna beam may be aimed adjacent the first satellite. This provides the advantage that the antenna beam that is pointed away from, adjacent, the satellite can be pointed towards the satellite within a short time, with limited angular motion and/or with simple means.

The antenna may be a phased array antenna. This allows for simple changing of the pointing directions of the antenna beams by controlling the phase shift of the antenna elements in the array, and without mechanically moving parts, thus without friction and associated wear.

The system may include a single beam forming network for generating the at least two antenna beams. In this way the antenna beams are generated by a single beam forming network, thus reducing the number of adjustable time or phase shifter devices required, and therefore costs.

The system may include a single beam forming network comprising two sub beam forming networks each connected to a sub array of antenna elements with dedicated placement of the antenna elements such that each sub array forms at least first and second sub-beams substantially aimed at a first and second satellite, respectively. The combiner network for the two sub networks has two modes. The system may operate in different modes. In a first mode, the first sub-beams of the two sub arrays are aimed in the direction of the first satellite add constructively, while the second sub-beams are aimed away from second satellite, reducing the sensitivity in the direction of the second satellite to a level, which is sufficiently low to not receive the signals from the second satellite. In a second mode, the second sub-beams of the two sub arrays are aimed in the direction of the second satellite add constructively, while the first sub-beams are aimed away from first satellite, reducing the sensitivity in the direction of the first satellite to a level, which is sufficiently low to not receive the signals from the first satellite.

The at least one beam forming network may include fixed time or phase shifter devices for generating the first and second antenna beam with a fixed first and second pointing direction respectively. This provides the advantage that the at least one beam forming network is not provided with (electronically) adjustable time or phase shifter devices, thereby further reducing costs.

Specific embodiments of the invention are set forth in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is further elucidated with reference to the drawing, in which, by way of non-limiting example,

Fig. 1 shows a schematic view of a first example of an embodiment of a satellite communications system according to the invention,

Fig. 2a shows a schematic perspective view of an example of a device for transmitting and/or receiving a signal to/from satellites of a second example of an embodiment of a satellite communications system according to the invention,

Fig. 2b shows a schematic front view of the example of an second embodiment of a satellite communications system according to the invention,

Fig. 2c shows a schematic side view of the second example of an embodiment of a satellite communications system according to the invention,

Fig. 3 shows a schematic view of an example of an embodiment of a device for transmitting and/or receiving a signal to/from satellites of a third example of an embodiment of a satellite communications system according to the invention,

Fig. 4 shows a schematic view of a fourth example of an embodiment of a satellite communications system according to the invention,

Fig. 5 shows a schematic view of an example of a device for transmitting and/or receiving a signal to/from satellites of a fifth example of an embodiment of a satellite communications system according to the invention,

Fig. 6a shows a schematic view of a sixth example of an embodiment of a satellite communications system according to the invention in an inoperative mode, and

Fig. 6b shows an example of a schematic view of the sixth example of an embodiment of a satellite communications system according to the invention in a first operating mode.

In the Figures corresponding features are indicated with similar reference numerals.

DETAILED DESCRIPTION

Fig. 1 shows a first example of an embodiment of a satellite communications system 1 according to the invention. In this example the satellite communications system 1 comprises satellites 12, 14, each provided with a transmitter and/or receiver and an example of a device for transmitting and/or receiving a signal to/from the satellites. In this example, the device is a satellite receiver, which device, in this case, comprises a phased array antenna system 2. The satellite receiver can receive satellite signals from the satellites 12, 14. In the example of Fig. 1, the satellite receiver can receive a first signal from the first satellite 12, and a second signal from the second satellite 14. The satellite receiver is positioned on a celestial body, e.g. the earth, and the satellites 12, 14 are in orbit around the celestial body. However, the satellite receiver may likewise be in the air or in space and for example be in an airplane or be a part of a satellite.

In the example of Fig. 1, the satellite receiver comprises a phased array antenna system 2. Array antenna systems as well as phased array antenna systems are generally known in the art of antennas, for example from United States patent 6,232,919919 relevant parts incorporated herein by reference, and for the sake of brevity are not described in full detail.

In the example of Fig. 1, the phased array antenna system 2 comprises an antenna array 3 with at least two, in this example four, antenna units 4. The antenna units 4 are connected to a switching unit, which switching unit includes, in the example of Fig. 1, a single adjustable beam forming network 6. In the example of Fig. 1, the adjustable beam forming network comprises at least two, in this example four, time or phase shifter devices 5. In the example of Fig. 1, each time or phase shifter device 5 is connected to a separate antenna unit 4. In the example of Fig. 1, the adjustable beam forming network 6 further comprises a beam control unit 7, connected to the time or phase shifter devices 5. In the example of Fig. 1, the device 2 further comprises a combiner 9, connected to the time or phase shifting devices 5.

In use, the antenna units 4, shown in Fig. 1, receive radiation and each transform this radiation into a signal component. The signal components are fed, through the phase shifter devices 5, to the combiner 9. In the combiner 9, signal components received by the respective antenna units 4 are combined, in this example added, to yield an antenna signal received by the antenna array 3.

In general phased array antenna applications, a dense phased array is used. In the dense array the antenna units are arranged at a mutual distance which is less than half the wavelength of the signal to be transmitted and/or received. The time or phase shifter devices are usually arranged to provide a similar phase difference between each pair of adjacent antenna units. This causes that mainly signal components resulting from radiation impinging upon the individual antenna units from a certain direction arrive (through the time or phase shifter devices) at the combiner in phase, thus being combined, e.g. added, to yield the antenna signal. Signal components resulting from radiation impinging upon the antenna units from other directions arrive at the combiner substantially out of phase, thus being added to noise (or possibly being cancelled). The dense antenna array, therefore displays a radial sensitivity pattern which has a sensitivity peak in one pointing direction, in other words a single antenna beam.

In the example of Fig. 1, the antenna array 3 is sparse, i.e. the antenna units are spaced apart with a distance equal to or larger than half the wavelength of the signal to be transmitted and/or received. The sparse antenna array in Fig. 1 generates grating lobes 8, 10, i.e. the sparse antenna array displays a radial sensitivity pattern which has sensitivity peaks, of approximately equal sensitivity, in at least two pointing directions, and a reduced sensitivity in the remaining pointing directions. In this example the sparse antenna array 3 generates a first grating lobe 8 and a second grating lobe 10. In the example of Fig. 1, the grating lobes 8, 10 are spaced apart at a fixed angle, which angle depends on the spacing of the antenna units 4 within the antenna array 3. The first grating lobe forms a first antenna beam 8 and the second grating lobe forms a second antenna beam 10. The beam forming network 6 is arranged to steer the grating lobes in a manner known per se. In the example of Fig. 1, the beam control unit 7 controls the time or phase shifting devices 5 to generate a phase difference between the antenna units 4, e.g. a similar phase difference between each pair of adjacent time or phase shifter devices 5, to steer the antenna beams 8, 10. In this example the angle between the beams 8, 10 is constant while steering the beams. It should be noted, that antenna beam steering techniques are generally known in the art of phased antenna arrays, and any suitable steering technique may be used.

In the example of Fig. 1, the single beam forming network 6 steers both the first antenna beam 8 and the second antenna beam 10 simultaneously. More specific, the beam forming network can bring the antenna beams 8, 10 in a first operating mode and a second operating mode. In the first operating mode, the first antenna beam 8 is aimed at the first satellite 12, while the second antenna beam 10 is aimed away from the second satellite 14. In this example, in a second operating mode, the first antenna beam is aimed away from the first satellite 12, and the second antenna beam is aimed at the second satellite 14, as indicated by the dashed antenna beams 8',10'.

Accordingly, in the first operating mode, the phased array antenna system 2 is able to receive the first signal from the first satellite12, via the first antenna beam 8, while the second signal from the second satellite 14 will not be received by the phased array antenna system 2, since the second antenna beam 10 is not aimed at the second satellite 14. The second antenna beam 10 is considered not to receive the second signal if a signal strength of the second signal, received by the second antenna beam 10, is small enough not to interfere with reception of the first signal from the first satellite 12, by the first antenna beam 8, which first antenna beam 8 is aimed at the first satellite 12. On the other hand, in the second operating mode, the phased array antenna system 2 is able to receive signals from the second satellite 14, via the second antenna beam 10. In the second operating mode, signals from the first satellite 12 will not be received by the phased array antenna system 2, since the first antenna beam 8 is not aimed at the first satellite 12.

In this example, the phased array antenna system 2 is in the first operating mode during a first period. During this first period, the first antenna beam 8 is aimed at the first satellite 12 for receiving the first signal. In this example, the system is in the second operating mode during a second period, which, in this example, does not coincide with the first period. During this second period, the second antenna beam is aimed at the second satellite 14 for receiving the second signal. The system switches from the first mode to the second mode, hence from receiving the first signal to receiving the second signal, in order to consecutively communicate with the first and second satellite 12, 14. In this example, if the system is switched from the first operating mode to the second operating mode, the beam forming network 6 changes a phase of the antenna units 4 relative to each other. Due to the phase change, both antenna beams 8, 10 are moved in substantially a same moving direction, in this example in a clockwise direction. In the example of Fig. 1 the grating lobes 8, 10 are moved simultaneously, while maintaining the fixed angle between the grating lobes. In this example, both antenna beams 8, 10 are moved substantially in a moving direction along a virtual line L which connects the first and the second satellite 12, 14.

In order to avoid receiving the second signal in the first operating mode, but allowing fast or simple aiming of the second antenna beam 10 at the second satellite 14 when desired, the second antenna beam may be aimed adjacent to the second satellite, i.e. to a point close to, but not coinciding with, the position of the second satellite 14 in the first operating mode. If the second antenna beam 10 is aimed adjacent the second satellite 14, the second antenna beam is preferably aimed so close to the second satellite 14 that it can be aimed at the second satellite 14 within a short time period, for instance less than 1 ms, with an angular displacement of, preferably, less than 20°, more preferably less than 10°, or even less than 5°, and/or with simple controls. If the second antenna beam 10 is aimed adjacent the second satellite 14 it is preferably aimed sufficiently away from the second satellite 14 so as to avoid receiving the second signal from the second satellite. The second antenna beam is considered not to receive the second signal if a signal strength of the second signal received by the second antenna beam is small enough not to interfere with reception of the first signal from the first satellite by the first antenna beam, which first antenna beam is aimed at the first satellite. Therefore, the second antenna beam 10 is preferably aimed so far away from the second satellite 14, that the sensitivity of the second antenna beam 10 in the direction of the second satellite 14 is so small that the signal strength of the second signal, received by the second antenna beam 10, is small enough not to interfere with reception of the first signal from the first satellite 12, by the first antenna beam 8. The sensitivity of the second antenna beam 10 in the direction of the second satellite 14 may then for instance be at least 3dB, preferably at least 10dB or more, less than the maximum sensitivity of the second antenna beam, i.e. in the pointing direction of the second antenna beam. The above applies mutatis mutandis to the first antenna beam.

In the example of Fig. 1, the antenna array 2 is shown as a one-dimensional array, which will generate fan-shaped antenna beams 8, 10. The antenna array 2 can also be a two dimensional array, which can e.g. generate cone-shaped antenna beams. It will be appreciated that the first and second antenna beams 8, 10 can also be generated if the antenna units 4 are connected to two separate, adjustable beamforming networks, in which case the antenna array 3 may also be a dense array. This has the advantage that the beams can be generated and moved independently from each other. Since the beam forming networks only need to move the antenna beams over a limited angle, cheaper adjustable time or phase shifter devices with a more limited angular range can be used than when a single antenna beam has to be moved from pointing at the first satellite to pointing at the second satellite. Accordingly, a system according to the invention with two adjustable beamforming networks can still be less expensive than the prior art systems with two adjustable beam forming networks.

The satellite communications system 1 shown in Fig. 1, can for example be used to receive television signals transmitted by television satellites, e.g. by satellites broadcasting television signals over at least a part of the surface of the celestial body. In that case, signal processing circuitry may be connected to the antenna array which converts the signals received from the satellites into signals which can be processed by a television set. With the system shown in Fig. 1 it is, therefore, possible to consecutively watch a television channel from one satellite, e.g. in the ASTRA1 cluster, and than switch to a television channel from another satellite, e.g. in the ASTRA2 cluster.

Figs. 2a, 2b and 2c show a second example of an embodiment of a satellite communications system 1 according to the invention. Fig. 2a shows an example of a schematic perspective view of the device for transmitting and/or receiving a signal to/from the satellites, in this example a satellite receiver 20. In this example, the device 20 includes a phased array antenna system 2 comprising a first antenna array 22 of first antenna units 26 and a second antenna array 24 of second antenna units 28. In this example, the device 20 further includes a switching unit, which in the example of Figs. 2a-2c is a time or phase shifter device 30, e.g. a variable time or phase shifter device, connected to the first antenna array 22. In the example of Figs. 2a-2c the first antenna array 22 is connected to the combiner via a first combining network and the second antenna array 24 is connected to the combiner 9 via a second combiner network. Fig. 2b shows an example of a schematic front view of the system 1. In Fig. 2b only the first antenna array 22 is shown; the second antenna array 24 is positioned behind the first antenna array. In this example the antenna arrays 22, 24 are sparse antenna arrays, so that grating lobes 8, 10 are generated. In this example, the first grating lobe forms a first antenna beam 8 and the second grating lobe forms a second antenna beam 10. Fig, 2c shows an example of a schematic side view of the system 1. In the Fig. 2c only the first antenna beam 8 is shown; the antenna beams 8, 10 extend in a virtual plane 32 that is perpendicular to the drawing plane. The angle between the first and second antenna beam 8, 10 can be fixed and can, in this example, e.g. be determined by the spacing between the antenna units 26, 28 within the antenna arrays 22, 24. The direction in which the antenna beams 8, 10 are pointed within the virtual plane 32, can be adjusted by setting a phase difference between antenna units 26, 28 within the respective antenna arrays 22, 24. Said phase differences can be provided by a beam forming network with fixed time or phase shifter devices, which are cheaper than adjustable time or phase shifter devices.

In the example of Figs. 2a-2c, the time or phase shifter device 30 is arranged to introduce a phase difference between a first signal component received by the first array 22 and a second signal component received by the second array 24. The phase difference determines an angle α which the plane 32 in which both antenna beams 8, 10 extend, makes with a plane 34 in which the antenna arrays 22, 24 extend. It is, therefore, possible to control the angle α of the antenna beams 8, 10. In the example of Figs. 2a-2c, the angle α also determines an elevation of the antenna beams with respect to a plane on which the device 20 is placed (e.g. the ground on earth).

In the example of Figs. 2a-2c, the time or phase shifter device 30 controls the elevation of both the first and the second antenna beams 8, 10 simultaneously. More specific, the time or phase shifter device 30 can bring the antenna beams 8, 10 in the first operating mode and the second operating mode. In the first operating mode both antenna beams 8, 10 have a low elevation and the first beam 8 is aimed at the first satellite 12 and the second beam 10 is aimed to a point different from the position of the second satellite, in this example to a point below, the second satellite 14, as can be seen in Figs. 2b and 2c. Consecutively, in this example, in a second operating mode both beams 8', 10' have a high elevation and the first beam 8' is aimed to a point, above, the first satellite 12 and the second beam 10' is aimed at the second satellite 14. If both satellites have substantially the same elevation, the device 20 can be positioned tilted relative to the satellites 12, 14, such that from the viewing angle of the device 20 the first satellite 12 has a lower elevation than the second satellite 14. In this example, if the system 1 is switched from the first operating mode to the second operating mode, both antenna beams 8, 10 are moved in substantially a same direction. Both antenna beams are moved substantially in a moving direction which crosses a virtual line L which connects the first and the second satellite 12, 14.

In order to avoid receiving the second signal from the second satellite 14 in the first operating mode, but to allow a fast or simple aiming of the second antenna beam 10 at the second satellite 14 when desired, in the first operating mode the first beam 8 may be aimed at the first satellite 12 while the second beam 10 may be aimed adjacent, e.g. below, the second satellite 14. In the second operating mode the first beam 8' may then be aimed adjacent, e.g. above, the first satellite 12 while the second beam 10' may be aimed at the second satellite 14.

The satellite communications system 1 of Figs. 2a-2c requires no adjustable beam forming network but only a single time or phase shifter device 30, which gives the advantage that the system can be of simpler structure, and can be manufactured at reduced costs.

Fig. 3 shows a third example of an embodiment of a device 40 for transmitting and/or receiving a signal to/from the satellites for use in the satellite communications system according to the invention. In this example, the system includes a first two-dimensional antenna array 42 of first antenna units 46 and a second two-dimensional antenna array 44 of second antenna units 48. The antenna units 46, 48 are connected to a combiner 50. In the example of Fig. 3, the first antenna units 46 are connected to the combiner 50 via a switching unit, in this example a time or phase shifter device 30, e.g. a variable time or phase shifter device. The antenna units 46,48 can e.g. be patch antenna units. In this example, first and second signal components from the first and second arrays 42, 44, respectively, are fed to the combiner 50. A phase of the first signal component can be changed with respect to a phase of the second signal component by the time or phase shifter device 30.

The device 40 shown in Fig. 3 can be operated in a way similar to that described with respect to Figs. 2a-2c. The first antenna array 42 can be arranged to generate two first sub-beams, e.g. by generating grating lobes and/or by using (fixed) beam forming networks. The first antenna units 46 can, thereto, be positioned at a desired spacing with respect to each other, and/or can be connected to (fixed) time or phase shifter devices. The second antenna array 44 can, similarly, be arranged to generate two second sub-beams. In the far field (i.e. so far from the antenna arrays, that the plurality of antenna units 46, 48 is perceived as a single transmitting and/or receiving antenna) the first and second sub-beams are summed to yield the first and second antenna beams. The time or phase shifter device 30 can change the phase of the first signal component, hence the first sub-beams, with respect to the second signal component, hence the second sub-beams, thereby changing a pointing direction of the first and second antenna beams.

It is also possible that the first and second antenna arrays 42, 44 each include two antenna groups of antenna units. The antenna units of the first antenna group may be arranged to receive radiation with a first polarisation, e.g. left hand circular or horizontal linear polarisation, and the second antenna group may be arranged to receive radiation with a second polarisation. The second polarisation may be orthogonal to the first polarisation. The second polarisation may e.g. be right hand circular or vertical linear polarisation, respectively. Signals received by the first and second antenna group may be combined to make the antenna array sensitive to radiation with any desired polarisation, e.g. by varying a relative phase of the signal received by the first antenna group with respect to the signal received by the second antenna group, and/or e.g. by varying a relative amplitude of the signal received by the first antenna group with respect to the signal received by the second antenna group.

Fig. 4 shows a fourth example of an embodiment of a satellite communications system 1 according to the invention. In this example, the device 60 for transmitting and/or receiving a signal to/from the satellites, includes a first antenna array 22 of first antenna units 26 and a second antenna array 24 of second antenna units 28. In the example of Fig. 4, the antenna arrays 22, 24 may be dense arrays. In this example, the system further includes a combiner 64 and a switching unit, which switching unit in the example of Fig. 4 is a time or phase shifter device 62, e.g. a variable time or phase shifter device, connected to the first and second antenna array 22, 24. In the example of Fig. 4, the first antenna units 26 transmit a first signal component to the time or phase shifter device 62, and the second antenna units 28 transmit a second signal component to the time or phase shifter device 62.

In the example of Fig. 4, the time or phase shifter device 62 shifts the phase of the first and second signal components relative to each other. In this example, the time or phase shifter device 62 is provided with two output lines 66, 68. At the first output line 66, the time or phase shifter device 62 outputs a signal which results from having the first signal component lag behind the second signal component with a phase difference. At the second output line 68, the time or phase shifter device 62 outputs a signal which results from having the second signal component lag behind the first signal component with the phase difference. The signals on the first and second output lines 66 and 68 are combined, in this example added, in combiner 64. This results in two antenna beams 8, 10 being generated simultaneously. An angle β between the two antenna beams 8, 10 depends on the value of the, e.g. predetermined, phase difference by which the phase is shifted by the time or phase shifter device 62. If the phase difference is changed, the angle β between the antenna beams 8, 10 changes.

In the example of Fig. 4, the time or phase shifter device 62 controls the pointing direction of both the first and the second antenna beam 8, 10 simultaneously. More specific, the time or phase shifter device 62 can bring the antenna beams 8, 10 in a first operating mode and a second operating mode. In the first operating mode, the first beam 8 is aimed at the first satellite 12 while the second beam 10 is aimed away from, but next to, the second satellite 14, as can be seen in Fig. 4. In this example, in the second operating mode the first beam 8' is aimed away from, but next to, the first satellite 12 while the second beam 10' is aimed at the second satellite 14. If the system is switched from the first operating mode to the second operating mode, the angle β between both antenna beams 8, 10 is changed, so that both antenna beams 8, 10 are moved in substantially opposite moving directions, substantially along a virtual line L which connects the first and the second satellite 12, 14.

In order to avoid receiving the second signal in the first operating mode, but to allow a fast or simple aiming of the second antenna beam 10 at the second satellite 14 when desired, in the first operating mode, the first beam 8 is aimed at the first satellite 12 and the second beam 10 may be aimed adjacent, e.g. below, the second satellite 14. In the second operating mode the first beam 8' may be aimed adjacent, e.g. above, the first satellite 12 and the second beam 10' is aimed at the second satellite 14.

In the example of Fig. 4, the antenna arrays 22, 24 are schematically shown as one dimensional arrays that extend in a direction substantially parallel to the virtual line which connects the first and the second satellite. It is, of course, also possible that the arrays extend in a direction substantially at an angle, e.g. perpendicular, with respect to the line which connects the first and the second satellite. It is also possible that the first antenna array 22 extends substantially parallel to the second antenna array 24. It is also possible that the antenna arrays are two dimensional antenna arrays, e.g. as shown in the example of Fig. 3.

Fig. 5 shows a fifth example of an embodiment of a device 70 for transmitting and/or receiving a signal to/from the satellites of the satellite communications system 1 according to the invention. In this example, the system includes a first antenna array 22 of first antenna units 26 and a second antenna array 24 of second antenna units 28. In this example, the antenna arrays are arranged in an interleaved fashion. More specific the antenna units 26, 28 of the first and second antenna arrays 22, 24 are positioned in an alternating order. Each unit of the first array is positioned next to a unit of the second array and vice versa. In this example, the antenna units are positioned in a line-shaped arrangement. The system further comprises a switching unit, which switching unit in the example of Fig. 5 is a time or phase shifter device 62, e.g. a variable time or phase shifter device, connected to the first and second antenna array 22, 24, and a combiner 64.

The time or phase shifter device 62 can change the directions in which the antenna beams 8, 10 are pointed similar to the way explained with respect to Fig. 4. If, in this example, the phase difference is changed, the antenna beams 8, 10 move in substantially opposite moving directions.

Figs. 6a and 6b shows an example of a sixth embodiment of a satellite communications system 1 according to the invention. In this example, the device 70 for transmitting and/or receiving a signal to/from the satellites, includes a first antenna array 22 of first antenna units 26 and a second antenna array 24 of second antenna units 28. In the example of Figs. 6a and 6b, the antenna arrays 22, 24 are sparse arrays. In this example, the system further includes a switching unit, which switching unit in the example of Figs. 6a and 6b is a time or phase shifter device 62, e.g. a variable time or phase shifter device, connected to the first and second antenna array 22, 24. In the example of Figs. 6a and 6b, the first antenna units 26 transmit a first signal component to the time or phase shifter device 62, and the second antenna units 28 transmit a second signal component to the time or phase shifter device 62.

In the example of Figs. 6a and 6b, the antenna arrays 22, 24 are sparse arrays. The first antenna array 22 displays a first grating lobe 72 and a second grating lobe 74. The second antenna array 24 displays a first grating lobe 76 and a second grating lobe 78. In Figs. 6a and 6b the spacing of the antenna units 26, 28 in the first antenna array 22 is different from the spacing in the second antenna array 24. As a result, the angular distance between the grating lobes 72, 74 of the first antenna array 22 is different from the angular distance between the grating lobes 76, 78 of the second antenna array 24.

In Fig. 6a the situation is shown when no time or phase shift is introduced in the time or phase shifter device 62, i.e. in an inoperative mode. The first grating lobe 72 of the first antenna array 22 is aimed adjacent the first grating lobe 76 of the second antenna array 24. In this example the first grating lobes 72, 76 are spaced 3dB apart, i.e. the 3dB envelopes (that is the envelopes at which the receiving power is 3dB less than the maximum receiving power) of the grating lobes 72, 76 are contiguous. In Fig. 6a, also the second grating lobe 74 of the first antenna array 22 is aimed adjacent the second grating lobe 78 of the second antenna array 24. In this example the second grating lobes 74, 78 are spaced 3dB apart, i.e. the 3dB envelopes of the grating lobes are contiguous.

In the example of Figs. 6a and 6b, the time or phase shifter device 62 is arranged to shift the phase of the first and second signal components relative to each other. In this example, the time or phase shifter device 62 is provided with two output lines 66, 68. The first output line 66 receives a signal which results from having the first signal component lag behind the second signal component with a phase difference. The second output line 68 receives a signal which results from having the second signal component lag behind the first signal component with the phase difference.

In Fig. 6b, in a first operating mode, the phase difference is chosen such that when first signal component lags behind the second signal component with the phase difference, the pointing directions of the first grating lobes 72, 76 are rotated such that they substantially coincide in the direction of the first satellite 12. In Fig. 6b, the first grating lobes 72, 76 interfere constructively (i.e. the signals of the first grating lobes are in phase and are added, yielding a larger sensitivity or intensity). The second grating lobes, therefore, do not interfere constructively and form two sub-beams of a second antenna beam. Accordingly, a first antenna beam is generated which is more sensitive than the second antenna beam.

Due to the constructive interference of the first grating lobes 72, 76 a first antenna beam which is approximately 3dB more sensitive than the separate grating lobes 72-78 is generated. In Fig. 6b, the second grating lobes 74, 78 are effectively rotated away from each other. In this example, in the first operating mode, the 3dB envelopes of the second grating lobes are not contiguous. Thus, the second grating lobes 74, 78 are, effectively, aimed away from the second satellite 14. Thus, in the first operating mode, the first beam 8 is aimed at the first satellite 12 while the second beam 10 is aimed away from the second satellite 14, as can be seen in Fig. 6b.

In this example, in a (not shown) second operating mode, the phase difference is chosen such that when second signal component lags behind the first signal component with the phase difference, the pointing directions of the second grating lobes 74, 78 are rotated such that they substantially coincide in the direction of the second satellite 14. In this case, the second grating lobes interfere constructively, thus generating a second antenna beam which is approximately 3dB more sensitive than the separate grating lobes 72-78. In this case, the first grating lobes 72, 76 are rotated away from each other, so that they do not interfere constructively and form two sub-beams of a first antenna beam and are, effectively, aimed away from the first satellite. Thus, a second antenna beam is generated which is more sensitive than the first antenna beam.

In the example of Figs. 6a and 6b, the antenna arrays 22, 24 are schematically shown as one dimensional arrays that extend in a direction substantially parallel to the virtual line which connects the first and the second satellite. It is, of course, also possible that the arrays extend in a direction substantially at an angle, e.g. perpendicular, with respect to the line which connects the first and the second satellite. It is also possible that the first antenna array 22 extends substantially parallel to the second antenna array 24. It is also possible that the antenna arrays are two dimensional antenna arrays, e.g. as shown in the example of Fig. 3.

It will be appreciated that a second antenna beam can also be aimed away from a second satellite by reducing the intensity of the second antenna beam with respect to the first antenna beam that is aimed at the first satellite. The intensity of the second antenna beam may for instance be reduced relative to the intensity of the first antenna beam, by having a second grating lobe of a first antenna array and a second grating lobe of a second antenna array interfere destructively (i.e. the signals of the second grating lobes are substantially in counter-phase and cancel each other, yielding a low sensitivity or intensity).The second antenna beam can be considered to be aimed away from the second satellite if a signal strength of the second signal received by the second antenna beam is small enough not to interfere with reception of the first signal from the first satellite by the first antenna beam.

The device, antennas, communications systems and methods discussed in this publication are useable for sending and for receiving electromagnetic signals. It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design alternatives without departing from the scope of the appended claims. For example, the invention is not limited to sending or receiving only.

Also, in Fig. 5 the antenna units 26, 28 are provided in a line-shaped interleave arrangement but other interleave arrangements are also possible. However, other alternatives or modifications are also possible.

Furthermore in the shown examples, the communications system is arranged to switch between a first operating mode and a second operating mode for receiving a signal from either a first or a second satellite. It will be appreciated that, according to the invention, it is also possible to provide a communications system which is arranged to switch between a plurality, e.g. three or more, of operating modes for receiving a signal from any one satellite of a plurality of satellites, by aiming a desired antenna beam of a plurality, e.g. three or more, of antenna beams at a desired satellite of a plurality, e.g. three or more, of satellites, while any remaining antenna beams of the plurality of antenna beams are aimed away from, e.g. adjacent, the remaining satellites of the plurality of satellites.

In the shown examples, the communications system is arranged to receive a single signal from either the first or the second satellite. It will be appreciated that, according to the invention, it is also possible to provide a communications system which is arranged to simultaneously receive a plurality of signals from the first or second satellite. This can, for example, be achieved if the communications system can discriminate the individual signals of the plurality of signals, e.g. based on different frequencies and/or polarisations of the individual signals of the plurality of signals and/or other (multiple) access schemes like Time-Division Multiple Access (TDMA), Orthogonal Frequency Division Multiple Access (OFDMA), Code Division Multiple Access (CDMA), etc.

In the shown examples, a number of antenna elements in the first antenna array is equal to a number of antenna elements in the second antenna array. However, it will be appreciated that the number of antenna elements in the first antenna array may also be different from the number of antenna elements in the second antenna array.

It is also possible to provide a communications system which is arranged to simultaneously receive the plurality of signals from any one satellite of the plurality of satellites.

It will be appreciated that, according to the invention, it is also possible that at least two antenna beams of the plurality of antenna beams are each pointed at mutually different satellites, while any remaining antenna beams are pointed adjacent the remaining satellites of the plurality of satellites. This can for example be achieved if the at least two antenna beams point simultaneously at satellites which, transmit signals which can be received and/or processed separately, e.g. due to mutually different frequencies and/or polarisations.

Where in the description moving of an antenna beam is mentioned this also includes stopping to generate an antenna beam pointing in one direction followed by generating an antenna beam pointing in another direction.

It will be appreciated, that the signal received by the device for transmitting and/or receiving the signal can also be obtained by manipulating the signal components received by the respective antenna units in a computer with use of a program product for, for example, i.a. time or phase shifting and combining of the signal components. In this respect, the invention may also be implemented in a computer program for running on a computer system, at least including code portions for performing steps of a method according to the invention when run on a programmable apparatus, such as computer system or enabling a programmable apparatus to perform functions of a device or system according to the invention. Such a computer program may be provided on a data carrier, such as a CD-ROM or diskette, stored with data loadable in a memory of a computer system, the data representing the computer program. The data carrier may further be a data connection, such as a telephone cable or a wireless connection

The invention is not limited to implementation in the disclosed examples of devices, but can likewise be applied in other devices. In particular, the invention is not limited to physical devices or units implemented in non-programmable hardware but can also be applied in programmable devices or units able to perform the desired device functions by operating in accordance with suitable program code. Furthermore, the devices may be physically distributed over a number of apparatuses, while logically regarded as a single device. For example, the combiner 9 of the example of Fig. 1 may be implemented as a plurality of separate integrated circuit arranged to perform in combination the functions of the combiner. Also, devices logically regarded as separate devices may be integrated in a single physical device. For example, the phase shifters 5 of the example of Fig. 1 may be implemented as a single phase shifting circuit with multiple inputs and multiple outputs processor able to perform the functions of the respective switches.

Where in the description sending is mentioned, also receiving is meant and vice versa. The term communications system refers to both one-way and multi-way communications systems. The term antenna beam refers to both the pattern of transmitted radiation of a transmitting antenna as well as the pattern of radiation which can be received with a receiving antenna.

It will be appreciated that the device and method for sending and/or receiving signals to/from at least two satellites can also be used for sending and/or receiving signals to/from other signal senders and/or receivers, such as, but not limited to, stationary or quasi-stationary terrestrial or marine senders/receivers. The term satellite should, therefore, be understood to more generally denote any sender and/or receiver.

Claims

1. Device for sending and/or receiving signals to/from at least two satellites, including

an antenna with at least two antenna beams, and

a switching unit connected to the antenna and arranged for switching the at least two antenna beams between a first and second mode,

in which first mode a first antenna beam is aimed at a first satellite for sending and/or receiving a first signal to/from the first satellite and a second antenna beam is aimed away from a second satellite, and

in which second mode, the second antenna beam is aimed at the second satellite for sending and/or receiving the second signal to/from the second satellite and the first antenna beam is aimed away from the first satellite.

2. Device according to claim 1, wherein, in the first mode, the second antenna beam is aimed adjacent the second satellite, and wherein, in the second mode, the first antenna beam is aimed adjacent the first satellite

3. Device according to claim 1 or 2, wherein the antenna is a phased array antenna system.

4. Device according to claim 3, wherein the phased array antenna system comprises at least a first antenna array and a second antenna array.

5. Device according to claim 3 or 4, wherein the phased array antenna system comprises at least one sparse antenna array.

6. Device according to claim 4 and 5, wherein the first antenna array and the second antenna array are both sparse and wherein the sparseness of the first antenna array is different from the sparseness of the second antenna array.

7. Device according to any one of claims 4-6, wherein the first antenna array is connected to a first combining network, and the second antenna array is connected to a second combining network.

8. Device according to claim 4, and optionally any one of the preceding claims, wherein the antenna arrays are connected to each other via a combiner, for combining signal components, transmitted and/or received by the respective antenna

arrays, into the first signal to/from the first satellite or the second signal to/from the second satellite.

9. Device according to claim 8, wherein at least one of the antenna arrays is connected to the combiner via a time or phase shifter device.

10. device according to any one of claims 3-9, wherein the device includes at least one beam forming network for generating and aiming the first and/or second antenna beam.

11. Device according to claim 10, wherein the device includes a single beam forming network for generating the antenna beams.

12. Device according to any one of the preceding claims, wherein the switching unit comprises a variable phase shifter.

13. Device according to any one of claims 3-12, wherein the directions in which the antenna beams are pointing are coupled to each other, and wherein if a phase shift is applied to the antenna units in the phased array antenna system, the antenna beams are switched between said first and second mode.

14. Device according to any one of claims 4-12, wherein the directions in which the antenna beams are pointing are coupled to each other, and wherein if a phase shift is applied to the antenna units in at least one of the antenna arrays, the antenna beams are switched between said first and second mode.

15. Device according to claim 13 or 14, wherein if a same phase shift is applied to the antenna units, the antenna beams are switched between said first and second mode.

16. Device according to any one of claims 3-15, wherein the antenna beams are formed by grating lobes.

17. Device according to claims 6 and 16, wherein the first antenna array is arranged to generate a first and a second grating lobe and the second antenna array is arranged to generate a first and a second grating lobe, wherein the switching unit is arranged to, in the first mode, have the first grating lobes constructively interfere in a direction of the first satellite while the second grating lobes are aimed away from the second satellite, and to, in the second mode, have the second grating lobes constructively interfere in a direction of the second satellite while the first grating lobes are aimed away from the first satellite.

18. Device according to claims 12 and 17, wherein the variable phase shifter is arranged to, in the first mode, generate a first phase difference between the signals associated with the first antenna array and the second antenna array, which first phase difference is such that pointing directions of the first grating lobes are rotated such that they substantially coincide in the direction of the first satellite, and wherein the variable phase shifter is arranged to, in the second mode, generate a second phase difference between the signals associated with the first antenna array and the second antenna array, which second phase difference is such that pointing directions of the second grating lobes are rotated such that they substantially coincide in the direction of the second satellite.

19. Device according to any one of the claims 10-18, wherein the at least one beam forming network includes fixed time or phase shifter devices for generating the first and second antenna beam with a first and second direction respectively which are fixed relative to each other.

20. Device according to any one of the preceding claims, wherein, in use, the antenna beams are moved simultaneously when switching between modes.

21. Device according to any one of the preceding claims, wherein, in use, the antenna beams are moved in substantially the same direction when switching between modes.

22. Device according to any one of claims 1-20, wherein, in use, the antenna beams are moved in substantially opposite directions when switching between operating modes.

23. Device according to any one of the preceding claims, wherein the antenna beam that is aimed away from the satellite is aimed less than 20°, preferably less than 10°, more preferably less than 5° away from the satellite.

24. Device according to any one of the preceding claims, wherein the antenna beam that is aimed away from the satellite is aimed so far away from the satellite that the sensitivity of the aimed away antenna beam in the direction of the satellite is more than 3dB, preferably more than 10dB less than the maximum sensitivity of the aimed away antenna beam.

25. Device according to any one of the preceding claims, comprising

an array of antenna elements wherein said antenna elements are positioned such that at least a first and a second antenna arrays are formed each arranged for generating at least a first and a second grating lobe, wherein the first grating lobes in combination form the first antenna beam and the second grating lobes in combination form the second antenna beam,

at least two first combining networks, combining signals from the first or the second antenna array into a first signal component or a second signal component, respectively,

wherein the switching unit is connected to at least two of said first combining networks and wherein the switching unit comprises a time or phase shifter device arranged for adapting a phase of the first signal component relative to a phase of the second signal component such that the first and second signal components in combination yield the first signal in the first mode and the second signal in the second mode.

26. Device according to any one of the preceding claims, wherein the device comprises a control interface for accepting an external control signal for controlling the switching unit to switch to the first or the second mode.

27. Method for sending and/or receiving signals to/from at least two satellites, including:

- during a first period of time aiming a first antenna beam at a first satellite for sending and/or receiving a first signal to/from first satellite and aiming a second antenna beam away from a second satellite so as to avoid sending and/or receiving a second signal to/from the second satellite, and

- during a second period of time aiming a second antenna beam at a second satellite for sending and/or receiving the second signal to/from the second satellite and aiming the first antenna beam away from the first satellite so as to avoid sending and/or receiving the first signal to/from the first satellite.

28. Method according to claim 27, wherein, during the first period, the second antenna beam is aimed adjacent the second satellite, and wherein, during the second period, the first antenna beam is aimed adjacent the first satellite.

29. Method according to claim 27 or 28, wherein the first and second period are consecutive periods.

30. Method according to any one of claims 27-29, including simultaneously generating the first and second antenna beams.

31. Method according to any one of claims 27-30, including moving the antenna beams between the first and the second period.

32. Method according to any one of the claims 27-31, wherein the antenna beams are generated and/or moved using a phased array antenna system including antenna units.

33. Method according to claim 32, wherein the antenna beams are generated and/or moved using a phased array antenna system comprising at least one sparse antenna array.

34. Method according to claim 32 or 33, wherein the antenna beams are generated and/or moved using at least one beam forming network.

35. Method according to claim 34, wherein antenna beams are generated using a single beam forming network.

36. Method according to any one of claims 32-35, wherein the direction in which the antenna beams are pointing are coupled to each other, and wherein a phase shift is applied to the antenna units in the phased array antenna system for moving the antenna beams between said first and second period.

37. Method according to any one of claims 32-35, wherein the direction in which the antenna beams are pointing are coupled to each other, and wherein the phased array antenna system includes at least two antenna arrays, and wherein a phase shift is applied to the antenna units in at least one of the antenna arrays for moving the antenna beams between said first and second period.

38. Method according to claim 36 or 37, wherein a same phase shift is applied to the antenna units for moving the antenna beams between said first and second period.

39. Method according to any one of claims 32-38, wherein the antenna beams are formed by grating lobes.

40. Method according to claim 39, wherein a first and a second grating lobe are generated by a first antenna and a first and a second grating lobe are generated by a second antenna array, wherein during the first period the first grating lobes interfere constructively in a direction of the first satellite while the second grating lobes are aimed away from the second satellite, and wherein during the second period the second grating lobes interfere constructively in a direction of the second satellite while the first grating lobes are aimed away from the first satellite.

41. Method according to any one of claims 27-40, including moving the antenna beams simultaneously.

42. Method according to any one of claims 27-41, including moving the antenna beams in substantially the same direction.

43. Method according to any one of claims 27-41, including moving the antenna beams in substantially opposite directions.

44. Method according to any one of the claims 27-43, wherein the antenna beam that is aimed away from the satellite is aimed less than 20 degrees, preferably less than 10 degrees away from the satellite.

45. Method according to any one of the claims 27-44, wherein the antenna beam that is aimed away from the satellite is aimed so far away from the satellite that the sensitivity of the aimed away antenna beam in the direction of the satellite is more than 3dB, preferably more than 10dB less than the maximum sensitivity of the aimed away antenna beam.

46. Satellite communications system, including a device according to any one of claims 1-26 and at least two satellites in orbit around a celestial body, said device being positioned to received signals from said at least two satellites.

47. Switching unit for use in a device according to any one of claims 1-26.

48. Computer program product, loadable into the memory of a digital computer, comprising software code portions for performing the steps of the method according to any one of claims 27-45.

49. Receiver including a device according to any one of claims 1-26.

50. Receiver including a switching unit according to any one of claims 1-26.

51. Electronic apparatus, such as a television, including or connected to a receiver as claimed in claim 49 or 50.

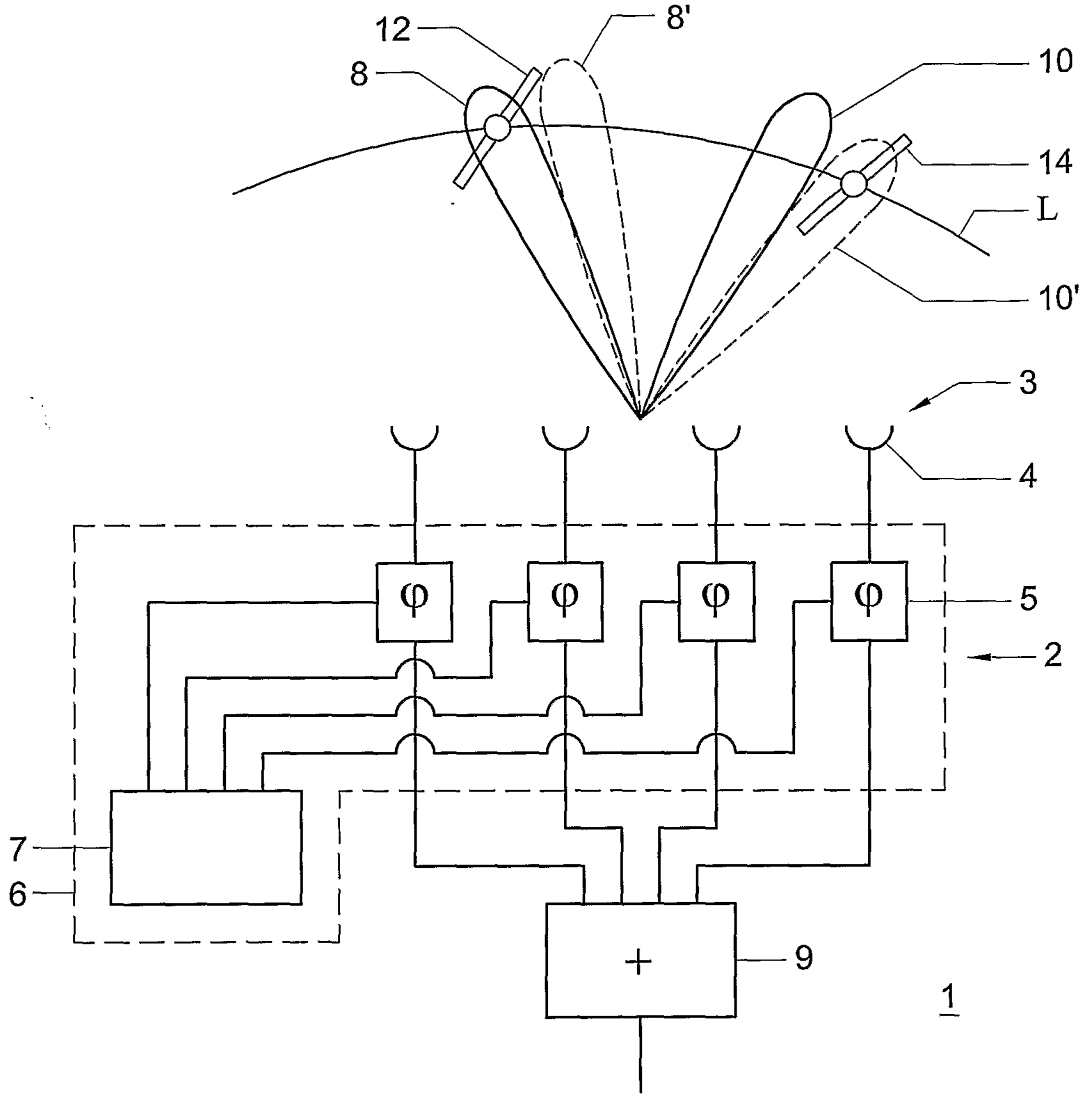

Fig. 1

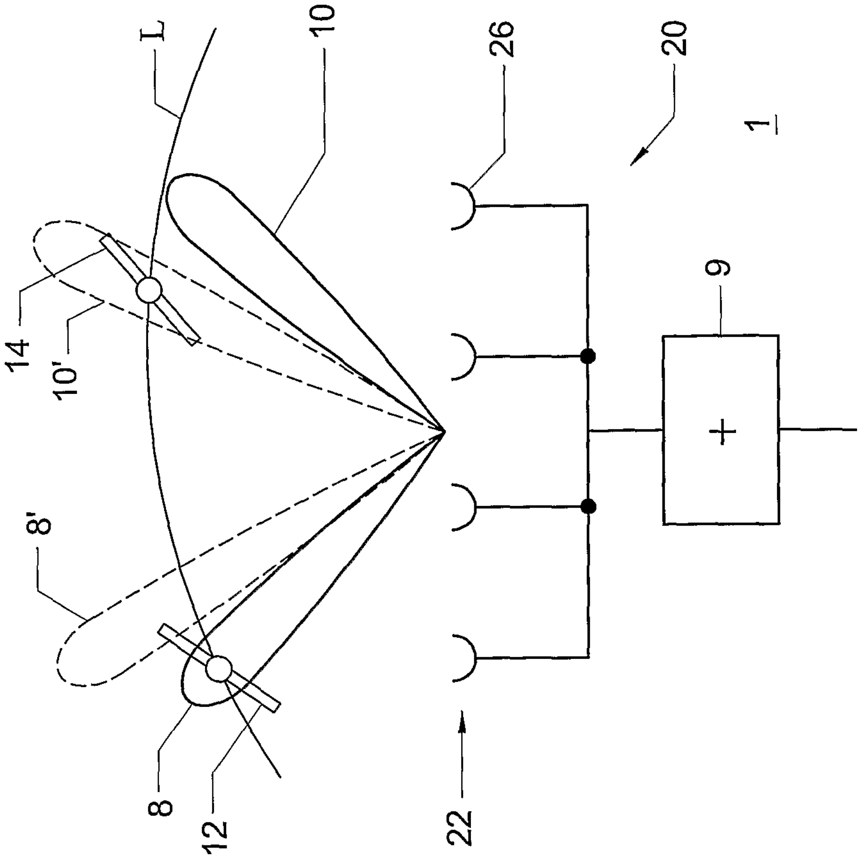

Fig. 2b

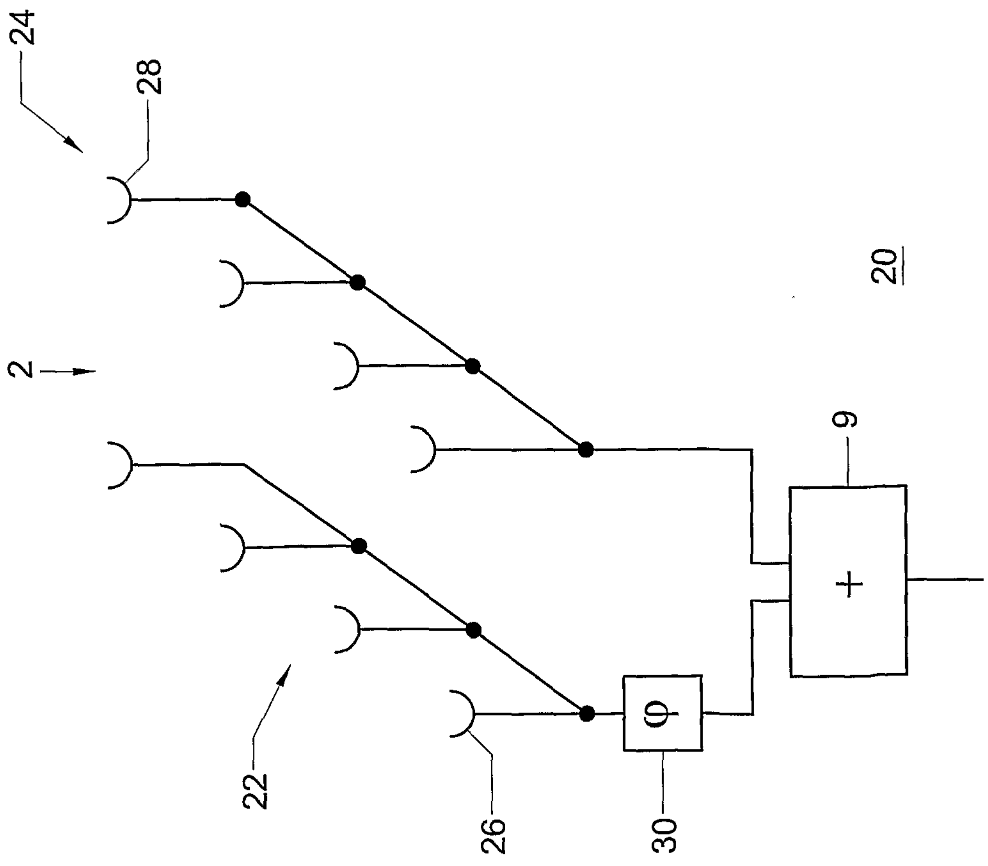

Fig. 2a

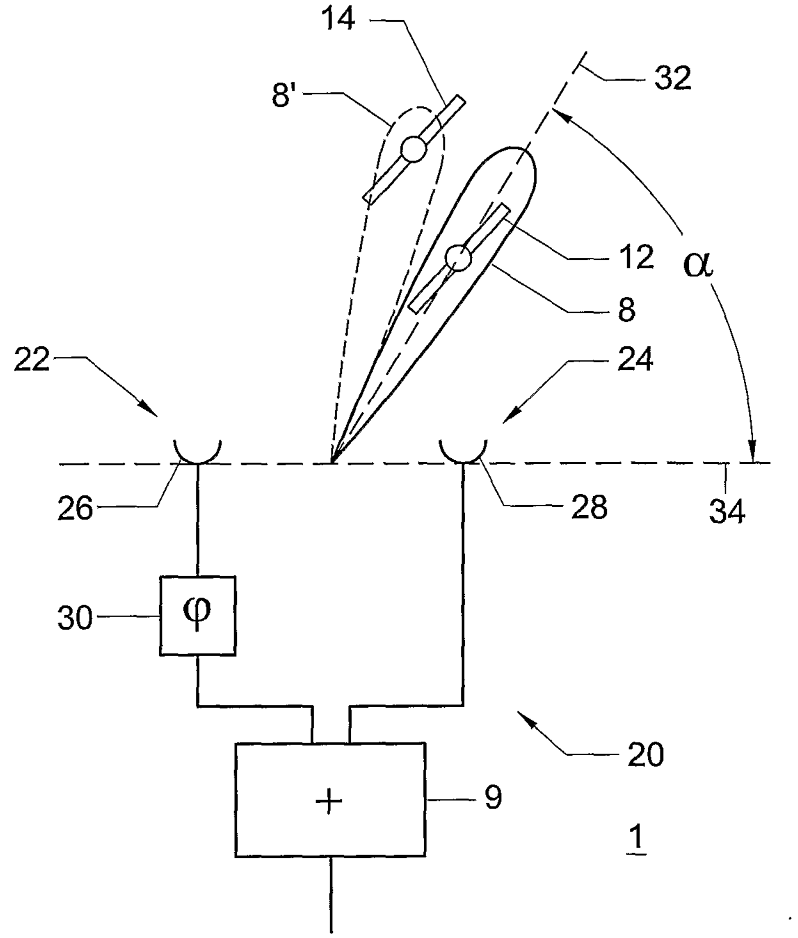

Fig. 2c

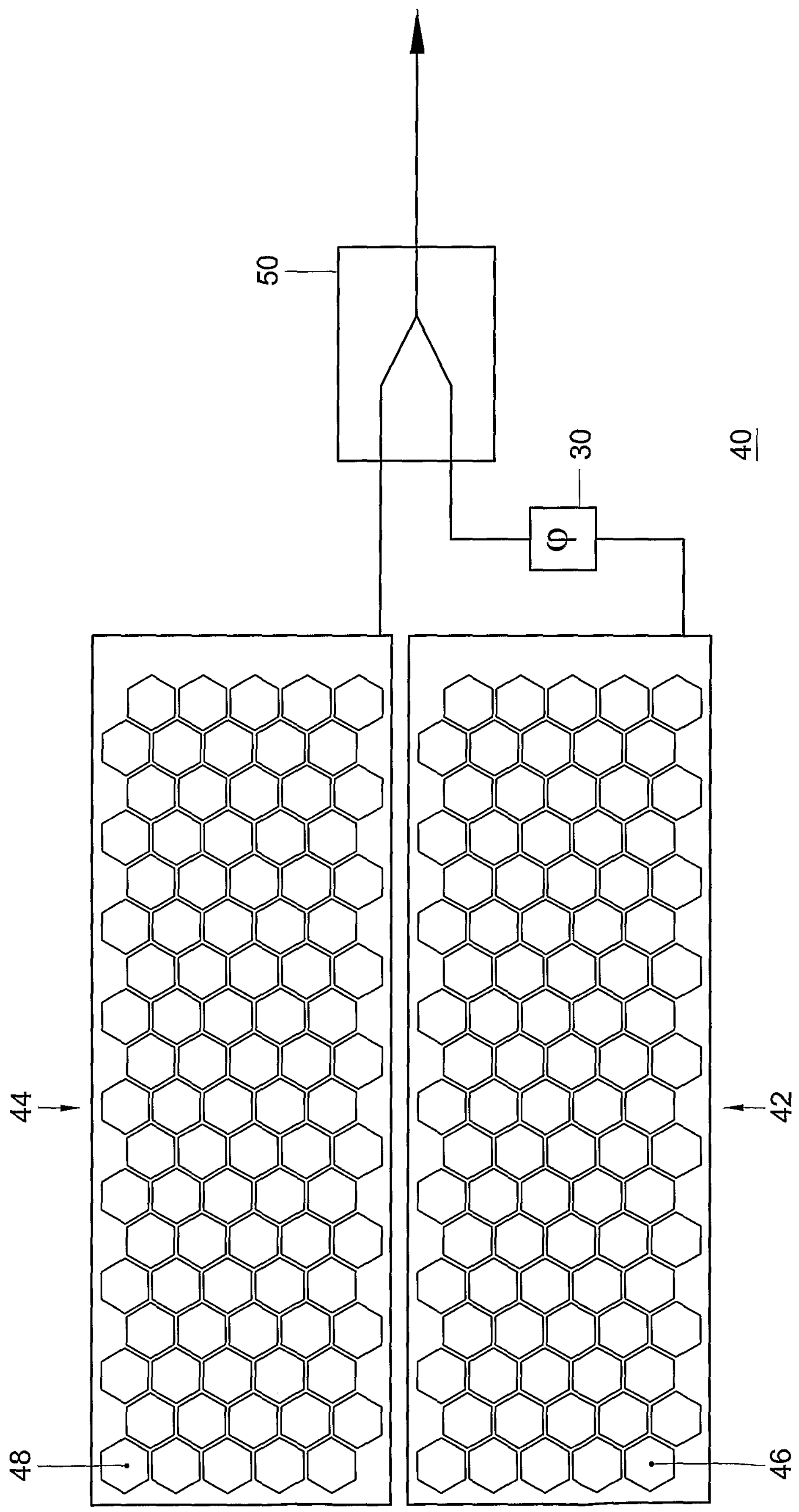

Fig. 3

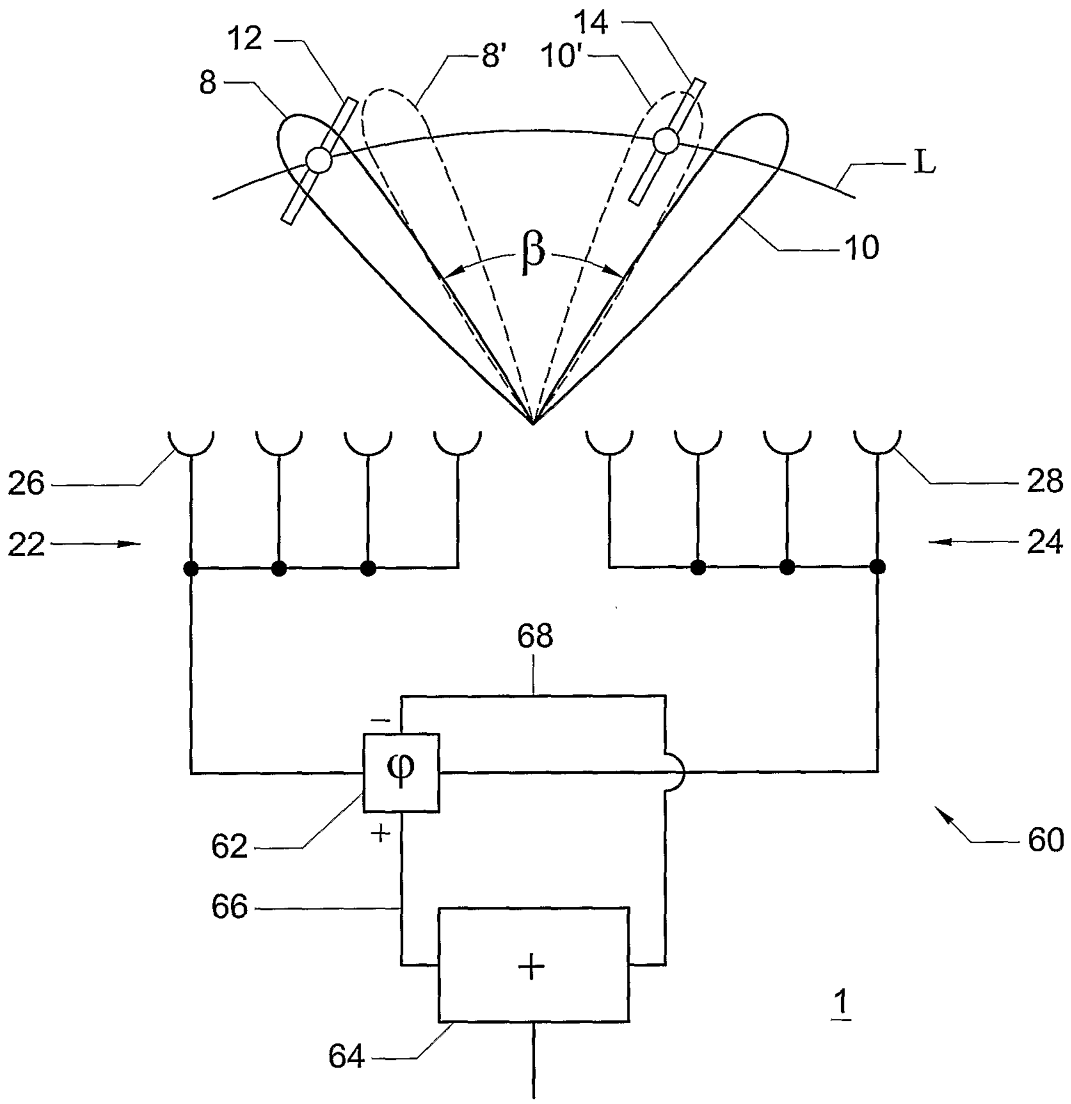

Fig. 4

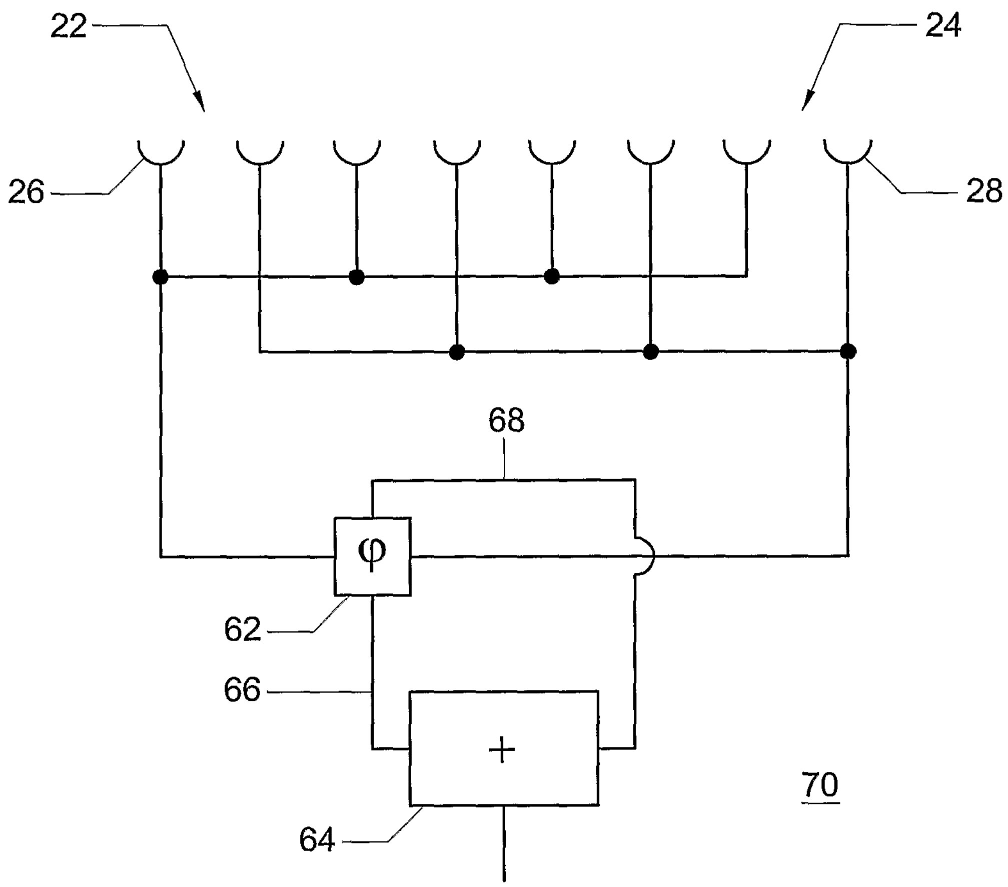

Fig. 5

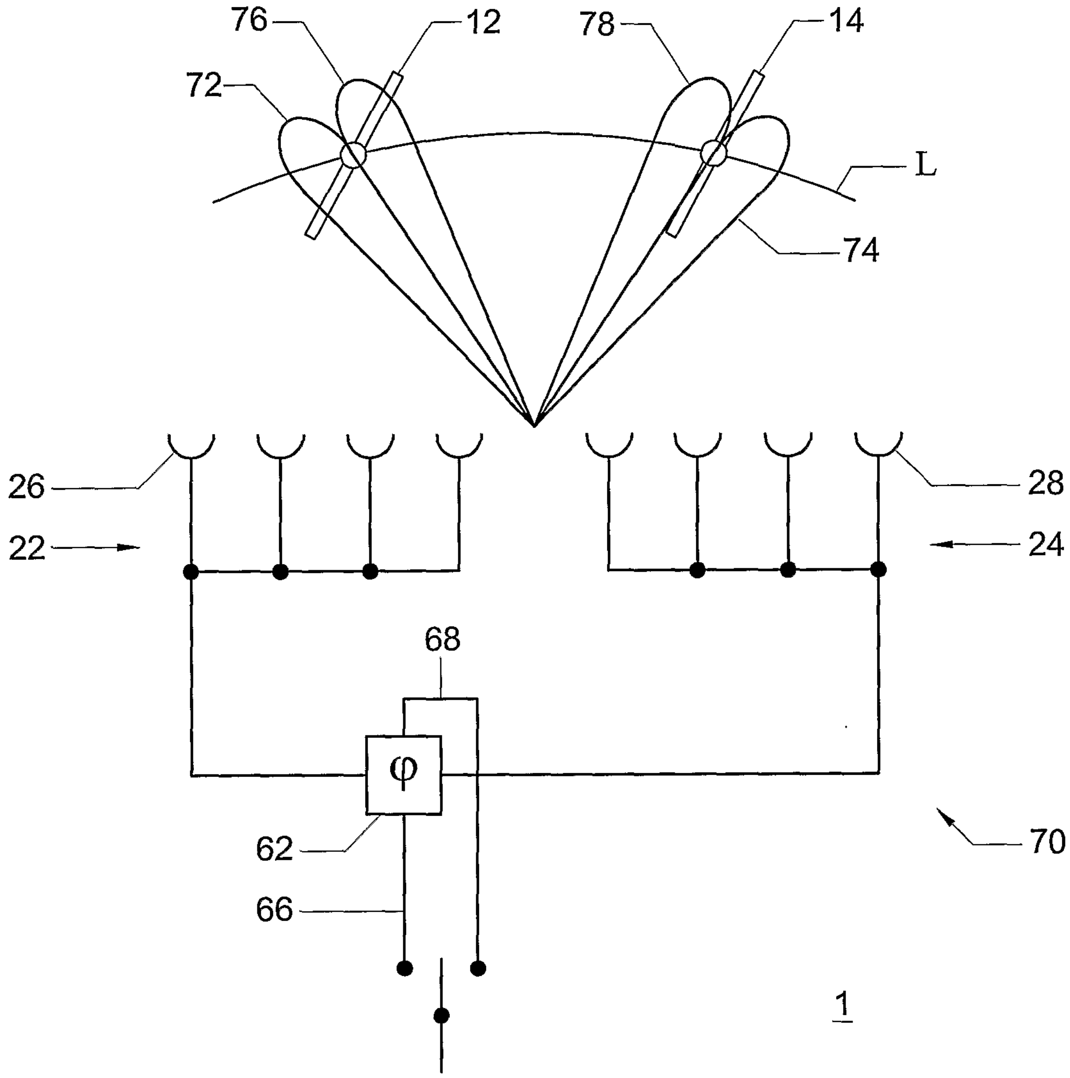

Fig. 6a

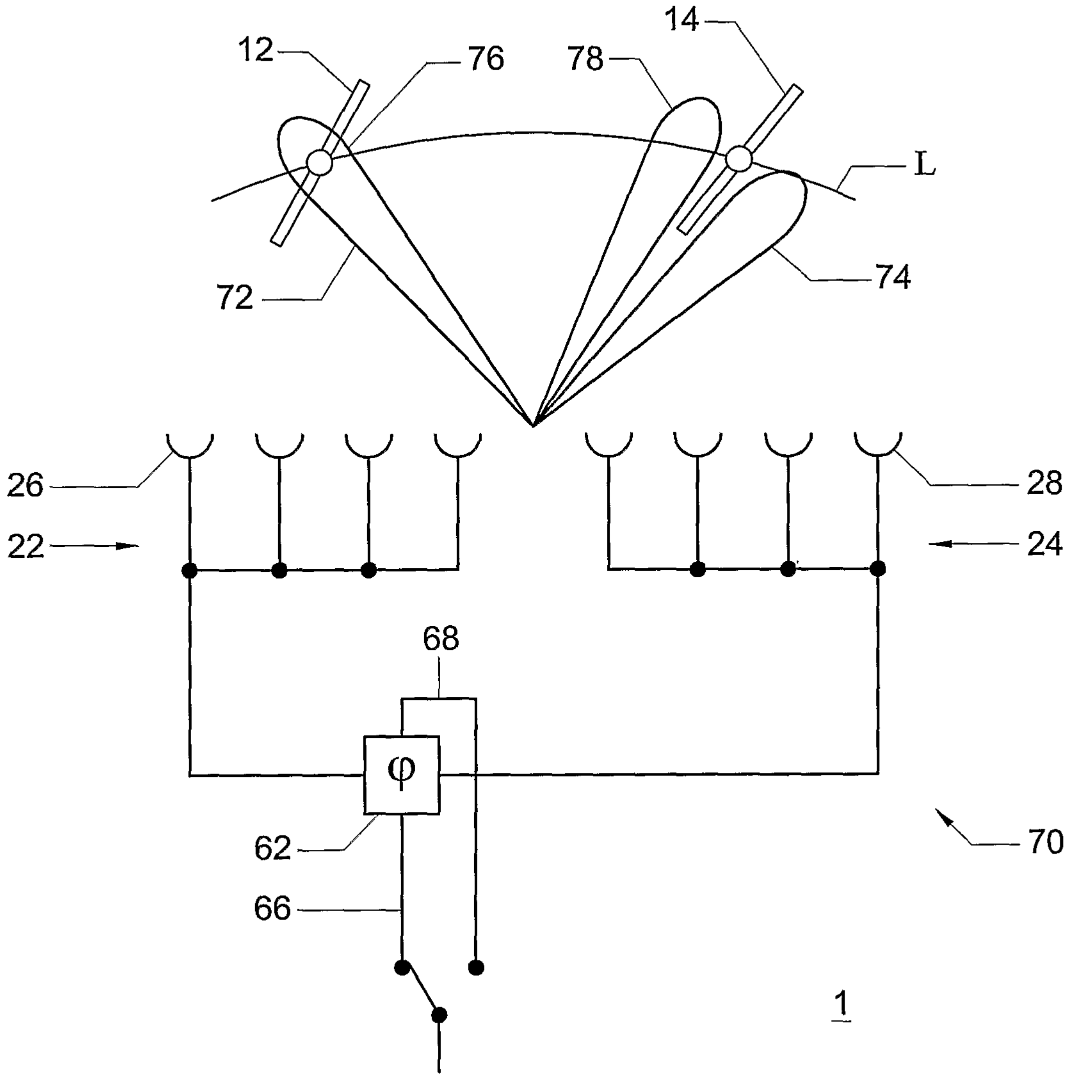

Fig. 6b

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2005/000700

A. CLASSIFICATION OF SUBJECT MATTER
H01Q25/00 H01Q3/26

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)
H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 043 788 A (SEAVEY ET AL) 28 March 2000 (2000-03-28) column 3, line 54 - column 4, line 39; figure 1 column 6, lines 41-50	1-51
X	US 6 751 801 B1 (FRISCO JEFFREY A ET AL) 15 June 2004 (2004-06-15) figure 8	1-51
X	PATENT ABSTRACTS OF JAPAN vol. 018, no. 223 (P-1729), 21 April 1994 (1994-04-21) -& JP 06 018647 A (MAZDA MOTOR CORP), 28 January 1994 (1994-01-28) abstract	1

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 February 2006	15/02/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Ribbe, J

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 034 634 A (KARLSSON ET AL) 7 March 2000 (2000-03-07) the whole document	1
X	US 3 836 970 A (REITZIG R,DT) 17 September 1974 (1974-09-17) the whole document	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2005/000700

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6043788	A	28-03-2000	NONE			
US 6751801	B1	15-06-2004	NONE			
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			BR	9813877	A	26-09-2000
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