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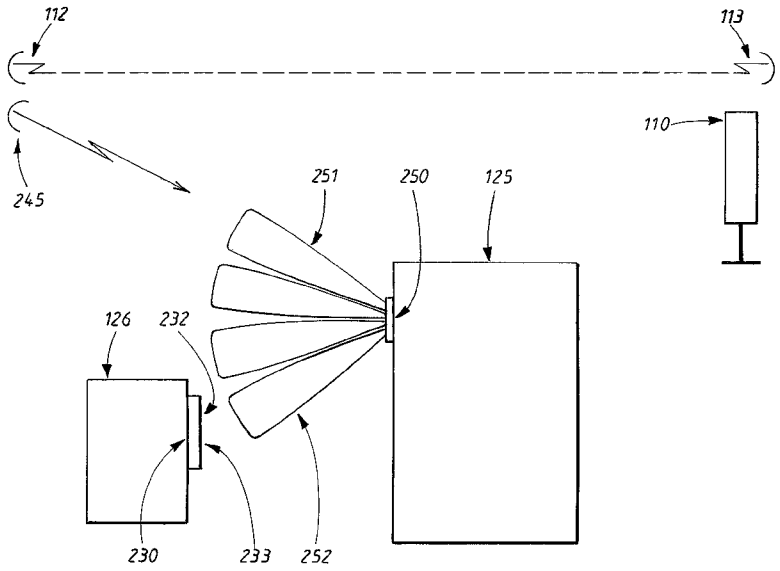
(54) **Title:** AN IMPROVED REPEATER ANTENNA FOR USE IN POINT-TO-POINT APPLICATIONS



(57) **Abstract:** The invention discloses a repeater antenna (250) for use in point-to-point applications in telecommunications systems on the microwave range, and is intended for connecting transmissions from a first radio unit (245) at a first site to a second radio unit (230) at a second site. The repeater antenna is essentially plane, and has at least a first and a second antenna element and a feed network for said antenna elements. The antenna elements give rise to a first (251) and a second (252) antenna beam, so that the first beam can be used for reception of the signals from said first radio unit and the second beam can be used for transmitting the received signals to said second radio unit.

WO 2007/004930 A1

TITLE

An improved repeater antenna for use in point-to-point applications.

TECHNICAL FIELD

The present invention discloses a repeater antenna for use in point-to-point applications in telecommunications systems n the microwave range, and is intended for connecting transmissions from a first radio unit at a first site to a second radio unit at a second site.

BACKGROUND ART

In telecommunications systems such as, for example, cellular telephony systems in the microwave range, there can be a number of problems for a base station when trying to communicate with the users located in the area covered by the base station. In urban areas, examples of such problems can be high rise building which obstruct the line of sight to certain sub-areas, or that in certain sub-areas the concentration of users can exceed that which can be handled by the base station.

One way of handling these problems is to install other base stations which can cover the sub-areas in question, usually base stations with smaller capacity, so called “micro” or “pico-stations”. These “pico-stations” then need to be connected to the network in some way, suitably with the pico-station as one of the points in a point-to-point connection. Said point-to-point connection could be made by means of a repeater station, which would be directed at the “pico-station” from the base station, or from a higher level in the network.

Conventional repeater antennas are usually designed by means of two reflector antennas, often parabolic dishes, connected by means of a waveguide and pointed in different directions. Installing such repeaters, especially in urban areas, is becoming increasingly difficult, due to a number of factors

such as aesthetic considerations and difficulties in finding sufficient space for a repeater site.

Another kind of previously known repeater is merely a large sheet of reflective material, such as metal. Such a repeater would suffer from a number of drawbacks, for example high losses due to low directivity, and would generally not be suitable for use in urban areas.

DISCLOSURE OF THE INVENTION

As described above, there is thus a need for a repeater antenna in a point-to-point telecommunications system which would overcome the previously described drawbacks of known repeater antennas.

This need is addressed by the invention in that it discloses a repeater antenna for use in point-to-point applications in telecommunications systems on the microwave range, intended for connecting transmissions from a first radio unit at a first site to a second radio unit at a second site.

The repeater antenna of the invention is essentially plane, and has at least a first and a second antenna element, as well as a feed network for the antenna elements. The antenna elements give rise to a first and a second antenna beam, so that the first beam can be used for reception of the signals from the first radio unit, and the second beam can be used for transmitting the received signals from the first radio unit to said second radio unit.

In one embodiment, the antenna elements are created on a sheet of electrically conducting material, and the antenna additionally comprises a ground plane spaced apart from the antenna elements by means of a dielectric material.

The repeater antenna is thus essentially plane, and can be bent if this is suitable, but it can also be essentially flat in addition to being plane.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in more detail in the following description, with reference to the appended drawings, in which

Fig 1 shows a basic view of a system in which the repeater antenna of the invention can be applied, and

Fig 2 shows a basic view of the system of fig 1 in which the repeater antenna of the invention is used, and

Fig 3 shows a top view of the system of fig 2, and

Fig 4 shows an embodiment of the repeater antenna.

EMBODIMENTS OF THE INVENTION

Fig 1 shows an example of a telecommunications system 100 in which the invention may be used. The system 100 shown in this example is a cellular telephony system in the microwave range, i.e. from 1GHz and upwards, but another example of a possible system is a fixed wireless access system in the same frequency range.

In the system 100, there is a base station 110 which is connected to higher levels in the system via a radio link connection 112-113. The radio base station uses one or several antennas 120 in order to cover a certain area, a so called cell, within which the base station handles communication to and from users of the cellular systems, as well as all control of the telephones of said users.

There can be a number of factors which would make it difficult or impossible for the base station 110 to service users in an area A within the cell, one such reason being that the number of user in that particular area is so high that the total number of users in the entire cell exceeds the base station's capacity.

Another reason which could make it difficult for the base station to service users in area A is that the cell of the system 100 is located in an urban area with one or several high-rise buildings 125, 126, which block the communications from the base station antenna 120. Thus, there will be areas such as the shaded area A within the cell which cannot be serviced by the base station 110, since they cannot be reached in Line of Sight (LOS) by the radio transmissions from the base station.

Fig 2 shows the system of fig 1, with some additional equipment, which will be described below. In order to increase service to users in area A, in which there is a high concentration of users, or which is blocked from the transmissions from the base station, an additional base station 230 has been added to the system. This base station can be one which is similar to the base station 110, or it can be a so called "pico" base-station, i.e. a base station which has a smaller capacity than the base station 110, the pico station being one which is specifically intended to aid larger base stations. In order to handle the communication to and from users, the pico station is equipped with a first antenna 233, and in order to communicate with higher levels in the system, the pico station is also equipped with a second antenna 232. Naturally, these two antennas can also be combined into one antenna.

The communication between the pico station and the higher levels in the system is in the example shown handled by a dedicated antenna or radio link 245 at the same site that handles the communication with the base station 110. This should be seen as an example only, other solutions to this could, for example, be that one and the same antenna or radio link 112, 245, is used for both purposes at the "higher level site".

In order for the radio link 245 to be able to transmit to and receive transmissions from the pico station, a repeater antenna 250 of the invention has been deployed, in this case on an outside wall of the building 125.

The repeater antenna 250 is essentially plane, and comprises a plurality of antenna elements, i.e. it has at least a first and a second antenna element, and is also equipped with a feeder network for said antenna elements.

The antenna elements cause the repeater antenna to have a plurality of antenna beams, at least a first 251 and a second antenna 252 beam. Thus, as shown in fig 2, the first antenna beam 251 can be used for reception of the signals from the radio link 245.

Although the repeater antenna 250 is essentially plane, the fact that it has at least two antenna beams makes it possible to use the second antenna beam 252 for transmitting the signals received by the repeater antenna 250 from the radio link 245 to the pico base station 230.

In this particular application, there is also a need for transmissions from the pico base station to the radio link 245, for which the same antenna beams are used as for receiving from the radio link at he pico station. Thus, the pico base station 230 transmits to the repeater antenna 250 in the second antenna beam 252, and the repeater antenna then transits those signals to the radio link 245 via the first antenna beam 251.

The antenna beams 251, 252, of the repeater antenna, as shown in fig 2, are in different elevational planes. However, in the azimuth plane, i.e. in the direction into and out form the paper in fig 2, the antenna beams can be in one and the same plane, or in different planes, according to what is necessary in the particular application. In order to clarify this, fig 3 shows a top view of the system 200 of fig 2, in which the antenna beams 251, 252, of the repeater antenna 230 point in different directions in azimuth. The direction of the antenna beams will normally be decided when manufacturing the antenna. However, if the antenna has more beams than are needed by the system, so that a choice can be made as to which beams that should be used, this can be accomplished by, for example, setting a switch in the antenna. Thus, if, as

shown in the drawings, the antenna has four beams, of which only two are used, the choice as to which two beams that are used in a particular application or system can be decided by such a switch.

The repeater antenna 250 is essentially plane, which means that it can easily be installed on, for example, the walls of buildings etc. However, if it is desired, the antenna can be bent slightly, meaning that it is still plane, but that the plane of the antenna isn't flat, which may be an advantage when installing the antenna, or if it is desired to bend the repeater antenna into a curved shape in order to influence the antenna diagram, i.e. the antenna beams. However, in the system shown in fig 2, the repeater antenna is both essentially plane and essentially flat.

Before the design of the repeater antenna is described in more detail, one more aspect of the repeater antenna should be mentioned: the repeater antenna can be either an active or a passive antenna. In other words, the repeater antenna can either passively relay signals which have been received in one beam to be transmitted by another of the antenna beams, or the received signals can be amplified before they are re-transmitted. One and the same repeater antenna could in fact be used for both applications: if the repeater is to be used in a passive mode, the input/output ports to the respective beams would simply be connected to each other, and if the repeater is to be used in an active mode, the same ports could be connected to each other via an external amplifying equipment.

Naturally, the repeater antenna could also be designed as an active or passive repeater from the beginning.

Turning now to some examples of the more exact design of the repeater antenna, the antenna is suitably but not necessarily designed as a so called "patch antenna". Such an antenna comprises as radiation elements patches of an electrically conducting material, which have usually been created on a

non-conducting layer or substrate, in a manner which as such is well known within the art. The "patch" type of antenna will also comprise a ground plane, i.e. another plane of electrically conducting material, which is spaced apart from the radiation elements by means of a dielectric material, usually in the form of a separate physical layer of, but said layer of dielectric material may also be no more than a layer of air.

The patch antenna also comprises a feeder network, by means of which the radiation elements are connected to input/output ports of the antenna, and also possibly to each other, and, where applicable, to other components of the antenna, such as, for example, phase shifters.

The feed network can be created in the same conducting layer as the radiation elements, or as a separate network which would then, for example, be connected to the radiation elements by means of through-holes in the ground plane.

The design of the feed network for the radiation elements can be chosen from a large number of principles, such as, for example, travelling wave antennas, butler matrix antennas or even individual antenna patches. An example of a travelling wave antenna 400 is shown in fig 4: the antenna 400 comprises at least a first 411 and a second 412 radiation element, which are arranged in series at a centre distance D from each other.

Since the radiation elements are connected serially to each other there will be a first and a second "end element" to which are attached input/output ports 422, 423, of the antenna 400.

As shown in fig 4, the antenna 400 has a first and a second antenna beam 432, 433, each of which is associated with one of the antenna ports 422, 423. This means that the first beam 432 may be used by accessing the first port 422, and in a similar way the second beam 433 is associated with the second

port 423. The angle between the beams is determined by the centre distance D between the antenna elements of the antenna.

As can also be seen in fig 4, the two antenna beams of the travelling wave antenna are each other's "mirror image" with respect to an imagined line 440 which extends in a direction perpendicular to the antenna. Thus, the two beams are sometimes referred to as the "plus" or the "minus"-directions.

The Butler matrix antenna will only be commented upon briefly here, since it is also quite well known within the art. A Butler matrix antenna comprises N input/output ports, and produces M antenna beams, where N=M. By means of a network internal to the Butler matrix, a signal input at any one of the input/output ports produces equal amplitudes at all of the antenna ports, and a linear phase progression from (antenna) port to port. If the antenna ports are connected in sequence to an equally spaced linear antenna array, one antenna beam is formed for each input/output port.

The internal network may comprise phase shifters and hybrids, and by externally combining two or more of the input/output ports, the antenna diagram can be moved, broadened or be given altered side lobe levels.

The invention is not limited to the examples of embodiments shown above, but may be freely varied within the scope of the appended claims. For example, different polarizations maybe used in different antenna beams, or one or more of the antenna elements may be dual polarized. It should be pointed out that any number of antenna beams can, in principle, be used. Also, more than one beam can be used for transmitting the signals received from the first radio unit 245, so that the repeater antenna could cover more than one area at a time.

CLAIMS

1. A repeater antenna (230) for use in point-to-point applications in telecommunications systems in the microwave range, the repeater antenna (250) being intended for connecting transmissions from a first radio unit (245) at a first site to a second radio unit (230) at a second site, said repeater antenna being characterized in that it is essentially plane and has at least a first and a second antenna element and a feed network for said antenna elements, the antenna elements giving rise to a first (251) and a second (252) antenna beam, so that the first beam can be used for reception of the signals from said first radio unit and the second beam can be used for transmitting the received signals to said second radio unit.

2. The repeater antenna of claim 1, characterized in that the antenna elements are created on a sheet of electrically conducting material, and in that the antenna additionally comprises a ground plane spaced apart from the antenna elements by means of a dielectric material.

3. The repeater antenna of claim 1 or 2, in which the design of the feed network for the antenna elements is chosen from at least one of the following: travelling wave antennas, butler matrix antennas or individual antenna patches.

4. The repeater antenna of any of claims 1 - 3, characterized in that the antenna in addition to being essentially plane also is essentially flat.

5. The repeater antenna of any of claims 1-4, which is a passive repeater antenna.

6. The repeater antenna of any of claims 1-4, which is an active repeater antenna.

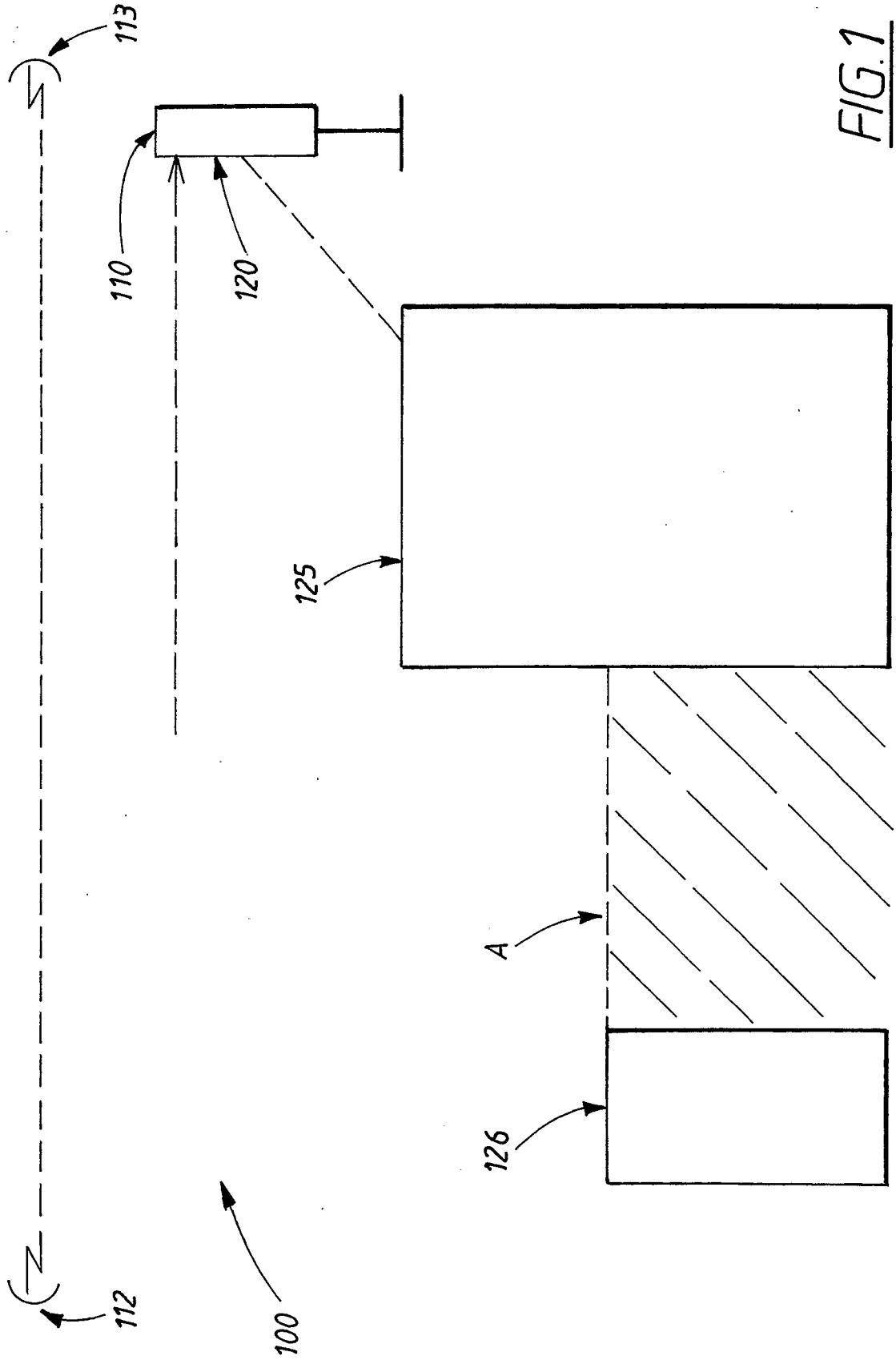


FIG.1

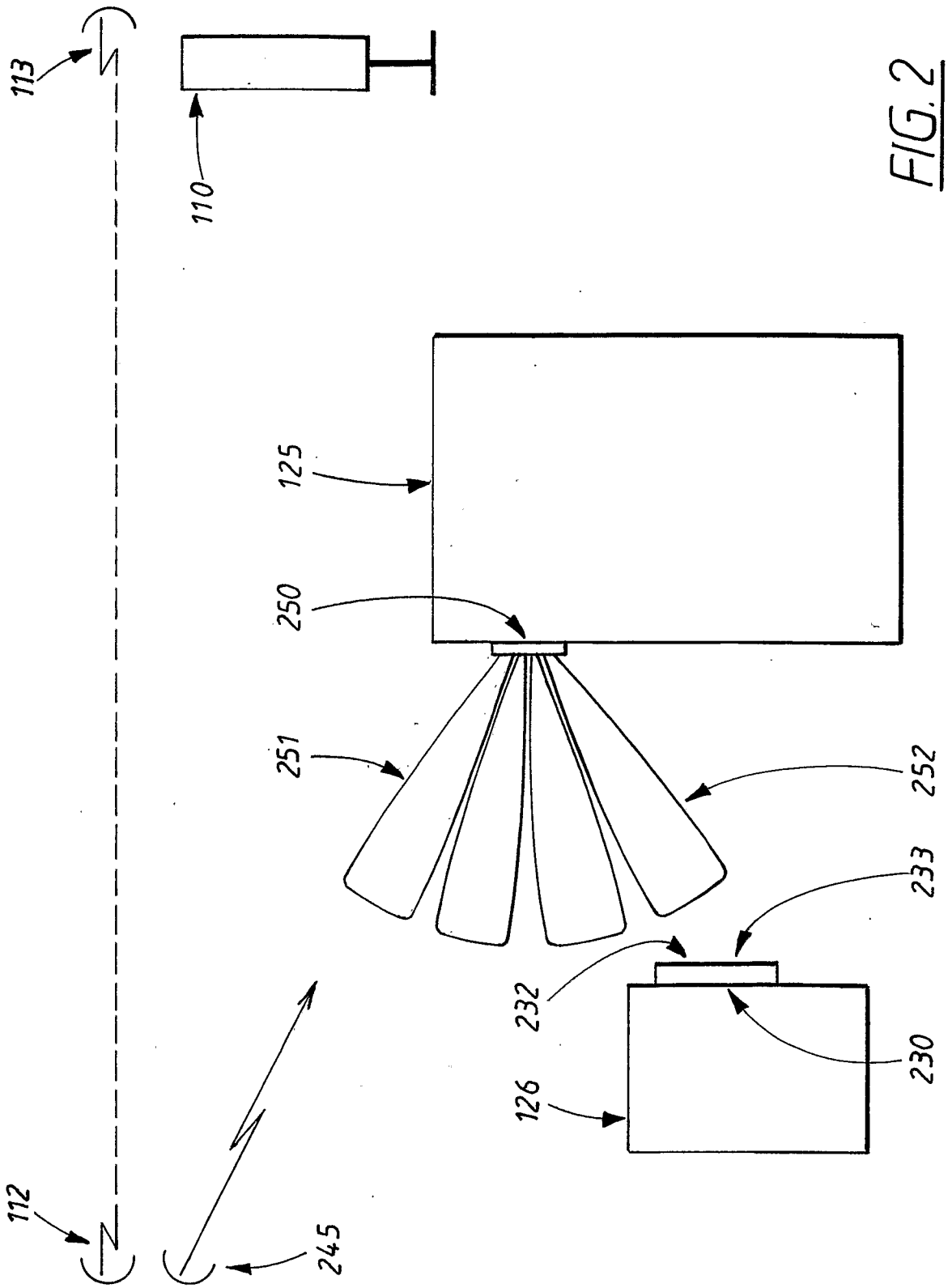


FIG. 2

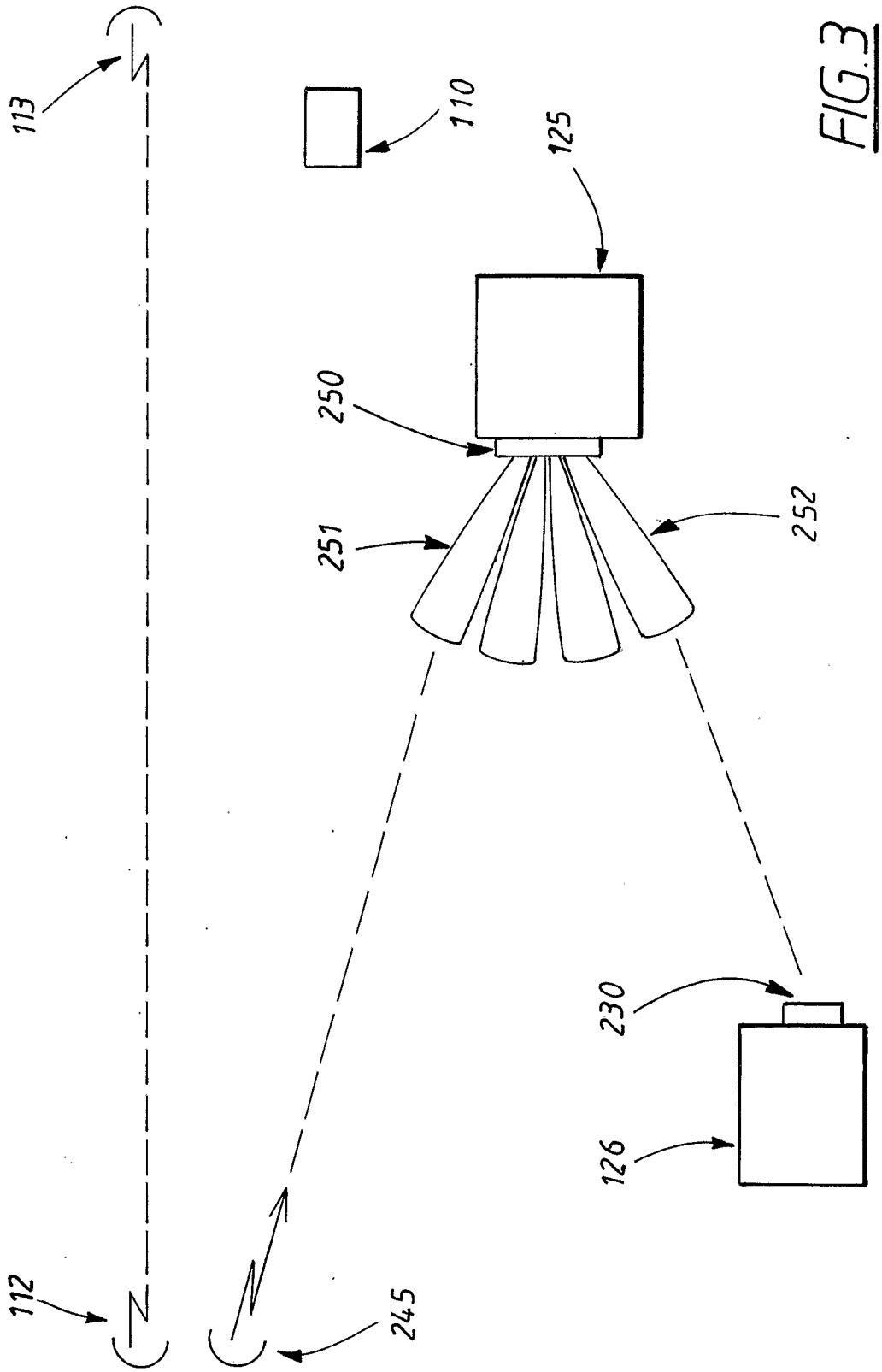


FIG.3

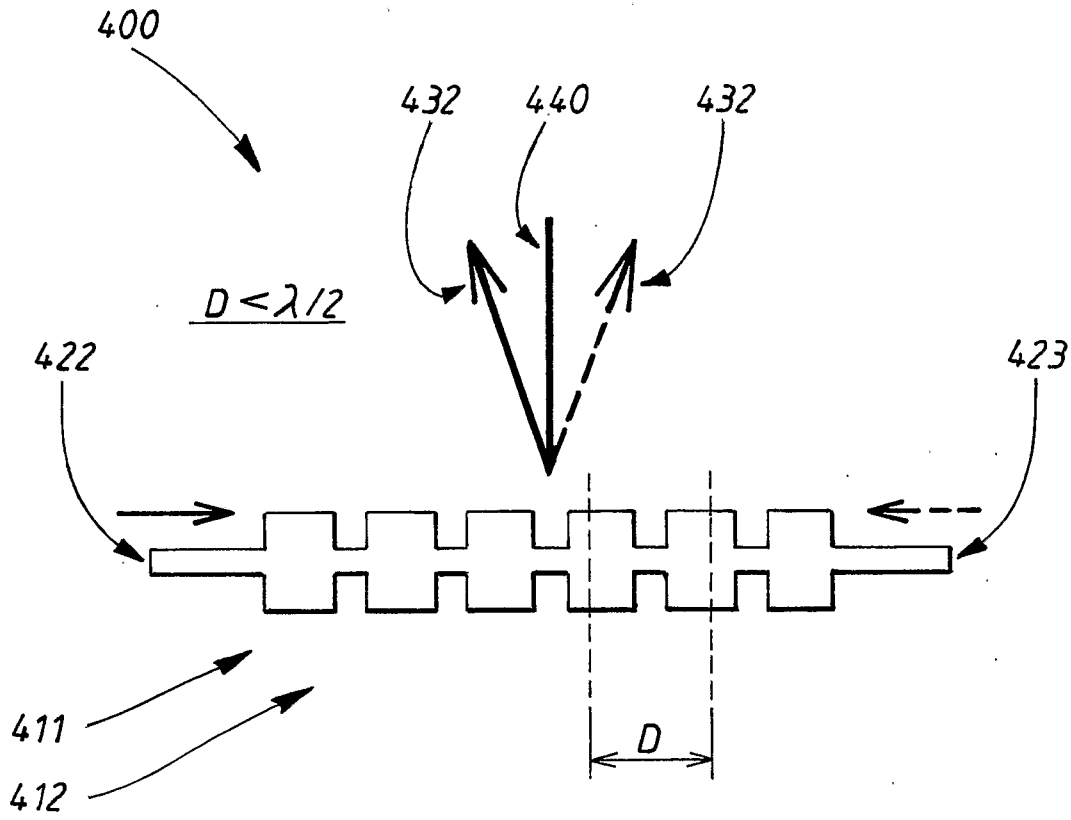


FIG.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 2005/001081

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: H01Q, H04B

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20050057421 A1 (MOHAMADI), 17 March 2005 (17.03.2005), figure 9, claim 9, abstract, paragraph (0045)	1-6
A	US 20050059342 A1 (ENGELS ET AL), 17 March 2005 (17.03.2005), claim 1, abstract	1-6
A	US 30050057394 A1 (LEE), 17 March 2005 (17.03.2005), abstract	1-6
A	WO 2004025321 A1 (LOCKHEED MARTIN CORPORATION), 25 March 2004 (25.03.2004), abstract	1-6

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

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
15 February 2006	14 -02- 2006
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Rune Bengtsson / JA A Telephone No. +46 8 782 25 00

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US	20050057421	A1	17/03/2005	NONE		
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