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(56) Documents Cited
WO 2001/002874 A1 **WO 2000/052496 A1**
US 4644358 A **US 4599620 A**

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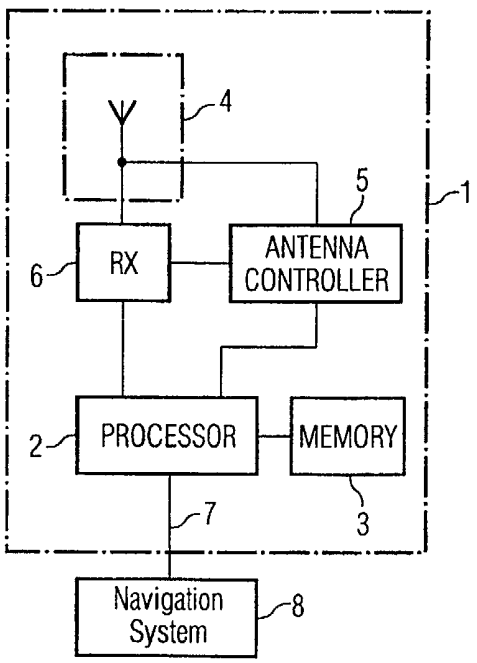
(54) Abstract Title
Determining orientation

(57) A body (eg an aircraft) whose attitude is to be determined carries a directional antenna. The beam of the antenna is scanned and is locked on to a RF source whose position is known. From the direction of the beam relative to the body, the body's attitude is determined. The RF source may be a GPS satellite. The antenna may be one or more phased arrays or a mechanically scanned antenna. If more than one antenna is used, their polar diagrams may point in different direction and the signals from them may be processed sequentially or selectively.

FIG 1



GB 2 379 110 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG 1

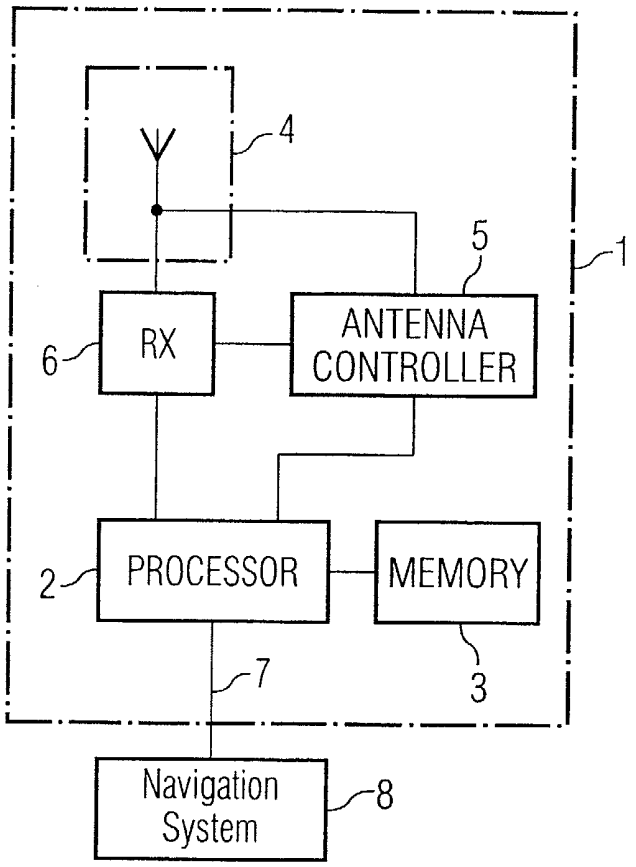

4
5
1
6
RX
ANTENNA CONTROLLER
2
PROCESSOR
MEMORY
3
7
Navigation System
8

FIG 2

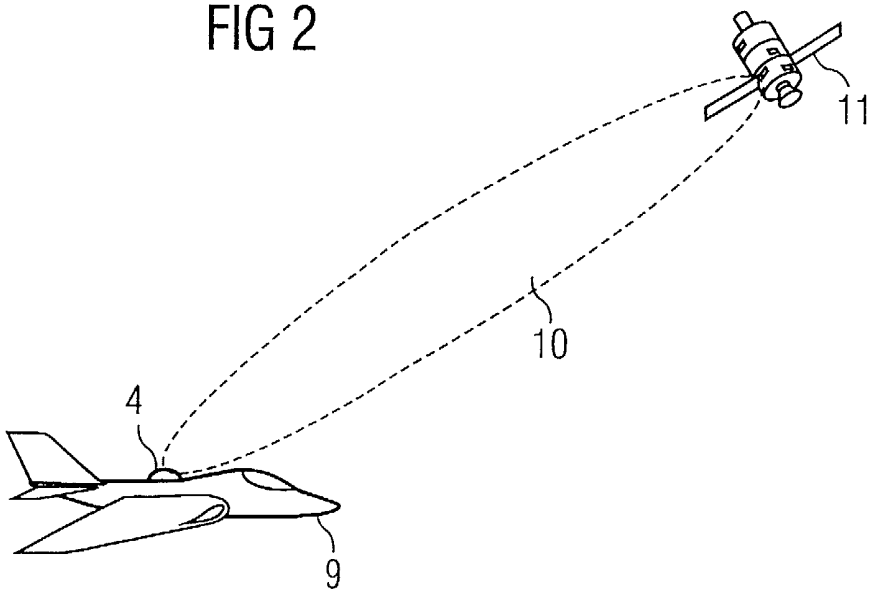

11
10
4
9

FIG 3

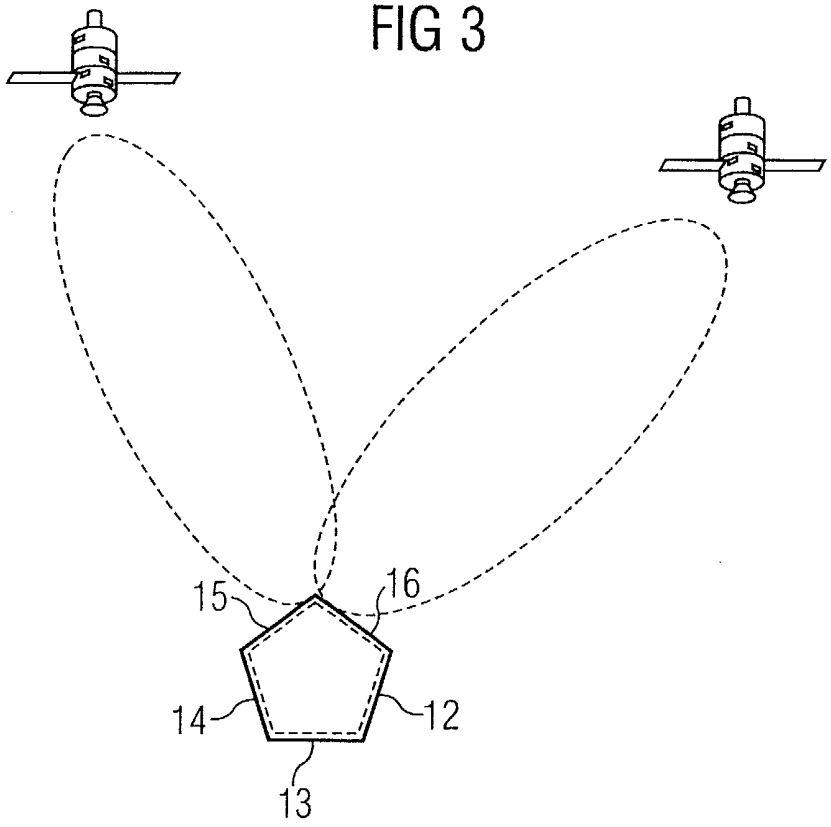
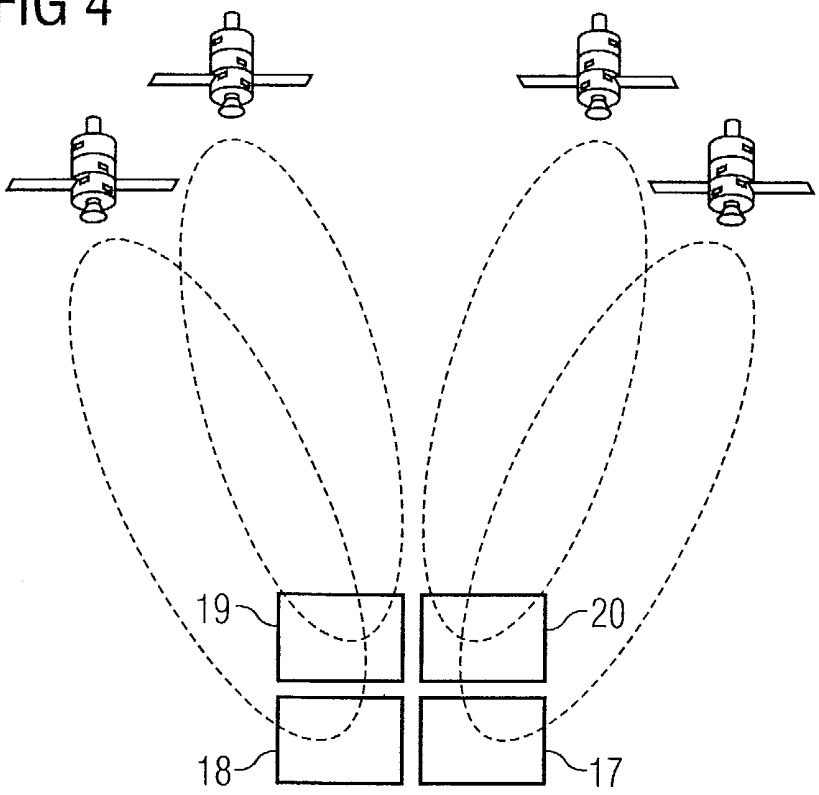


FIG 4



Apparatus To Determine The Orientation Of An Antenna Of A Radio Receiver

This invention relates to apparatus to determine the orientation of an antenna of a radio receiver, particularly, but not exclusively, for use in a satellite based system. The system may be concerned with communications or navigation.

It is known to provide aircraft with two antennas to enable reception of signals from Earth orbiting satellites. The difference in the signals provides an indication of the orientation of the antennas. These antennas are fixed to the structure of the aircraft and signals from the satellite are analysed to give an indication of the antenna orientation and hence the orientation of the aircraft. This information is passed to the aircraft systems relayed to the pilot via the usual cockpit instruments.

The present invention arose from a realisation by the inventor that with a knowledge of the gain characteristics of an antenna it is possible to determine orientation of the antenna relative to a radio source.

According to the invention there is provided apparatus to determine the orientation of an antenna comprising an antenna having variable gain characteristics, a controller for controlling the gain characteristics, a signal processor to process signals received from a radio source and to determine therefrom a direction from the antenna

to the radio source and hence from a knowledge of the location of the radio source to determine the orientation of the antenna.

Preferably, the antenna comprises a phased array antenna. This will enable the gain properties to be varied to move the preferred direction of the reception. In this manner, the antenna gain pattern representing the antenna properties can be made to "sweep" across the sky and where the radio source is a satellite the antenna properties can be changed to locate the satellite. When the received signal strength is at its greatest, the direction to the satellite will be known. With knowledge of the position of the satellite the orientation of the antenna can then be determined.

The position of geo-stationary satellites is fixed but it will be appreciated that other satellites move or "track" relative to the Earth. The satellite track is a predetermined orbit and typically this orbit is maintained, that is to say, it can be considered fixed. Depending on the time, the satellite will appear in different parts of the sky as it proceeds in its track. In the preferred embodiment, the satellite transmits information from which the current position in its orbit may be derived by the apparatus.

Alternatively, the information may be pre-stored in the apparatus and the satellite transmits an identification code that enables the appropriate pre-stored information to be accessed and the position derived. This may require a reference to be made to the current time. The time could be provided by a local clock at the apparatus or timing

information provided by a remote source, for example, the satellite itself. A yet further alternative could be for the satellite to transmit its current location as it progresses in its track. This will confer the advantage of reducing the processing time at the apparatus itself.

A specific embodiment of the invention will now be described by reference to the drawings in which:

Figure 1 shows in schematic block diagram form apparatus for determining the orientation of an antenna; and

Figure 2 shows the apparatus of figure 1 installed in an aircraft and receiving signals from a signal source in the form of a satellite; and

Figures 3 and 4 show alternative embodiments of antenna used in the apparatus shown in figure 1 and 2.

As is shown in figure 1, apparatus for determining the orientation of an antenna 1 comprises processor 2, memory 3, antenna 4, receiver 5 and antenna controller 5, receiver section 6 and an output 7 connected to a navigation system 8.

The processor 2 controls the functions carried out by the various sections, provides signal-processing capabilities and also performs the analysis required to determine the orientation of the antenna 4. The software and data required for this is held in the memory 3. The processor 2 is coupled to the memory 3 by a data-bus.

The receiver section 6 receives signals from the antenna 4 and places them in a form which enables decoding by the processor 2.

The antenna controller 5 controls variation in the antenna gain pattern and the resultant "sweeping" action of the antenna 4 under the control of the processor 2 in a manner to be later described.

The antenna 4, in this case, a phased array antenna comprising a number of antenna elements which are controlled to modify their individual gain characteristics and hence the overall gain pattern of the antenna 4.

As is shown in figure 2, the antenna 4 is fitted within a protective and aerodynamic dome fixed to an upper surface of a fuselage of an aircraft 9. It will be seen that the antenna 4 has a gain pattern 10 to receive signals from a satellite 11. (The relative dimensions of the satellite, aircraft and their separation are not to scale).

The processor 2 determines the antenna orientation and hence the orientation of the aircraft to which it is fixed. This orientation information is passed to the navigation system 8 by means of the output 7. The navigation system includes a set of displays for displaying the pitch, roll and yaw of the aircraft to a pilot.

The satellite 11 traverses the sky relative to the Earth in a predetermined orbit. This orbit is controlled by the satellite operator to avoid changes in position that would otherwise occur due to orbit "decay". Thus, the orbit may be regarded as controlled and fixed. As the satellite travels, it transmits a signal identifying itself and its position in its orbit at the time of transmission.

The phased array antenna 4 has its gain pattern varied under the control of the controller 5 and processor 2. The pattern is made to sweep the sky as the aircraft travels. If the antenna 4 receives the satellite transmissions it modifies its scan to "lock" its pattern onto the satellite 11 to give the greatest possible signal strength. The greatest received signal strength will be that achieved when the antenna gain pattern 10 is central on the satellite 11.

The transmission received when the pattern 10 is locked onto the satellite 11 provides information on the present location of the satellite 11 in its orbit. With knowledge of the position of the satellite 11 and the direction of the antenna gain pattern, the processor calculates the orientation of the antenna 4. Since the relationship of the antenna 4 relative to the aircraft 9 is known the orientation of the aircraft is also calculated by the processor 2 and this result is passed to the navigation system 8 for display to the pilot.

In alternative embodiments of the invention the antenna could be provided with a motor to facilitate the scanning operation. Or multiple antenna arrays could be provided. Figure 3 shows a multiple phased array antenna 4 having five phased antenna arrays 12 to 16 (although more than five arrays could be used). Each of the arrays 12 to 16 will form an antenna having a combined antenna gain. By switching between arrays 12 to 16 signals originating in different areas of the sky may be received. In addition the gain characteristics

of each array may be varied to narrow the characteristics or to perform a "sweep".

In the embodiment of figure 4, the antenna is formed by four generally planar phased arrays 17 to 20 (although again more arrays could be used). Each array has a gain pattern directed to different portions of the sky and thus able to receive signals from different satellites or indeed the same satellite as it tracks relative to the antenna. The processor 2 can then via the antenna controller 5 activate the arrays sequentially or selectively to receive signals from different portions of the sky. Again it will be possible to change the antenna characteristics if necessary to "steer" the gain pattern to different positions in the sky.

In this embodiment, the arrays have fixed characteristic but by selecting the arrays sequentially on selectively the overall antenna so provided is considered to have its gain pattern varied (its gain pattern being a result of the selected array or arrays).

Claims

1. Apparatus to determine the orientation of an antenna comprising an antenna having a controllable and variable gain characteristics, a controller for controlling the gain characteristics, a signal processor to process signals received from a radio source and to determine therefrom a direction from the antenna to the radio source and hence from a knowledge of the location of the radio source to determine the orientation of the antenna.

2. Apparatus as claimed in claim 1 wherein the antenna comprises a plurality of active antenna elements.

3. Apparatus as claimed in claim 2 wherein the antenna is a phased array antenna.

4. Apparatus as claimed in claim 3 wherein the antenna comprises a plurality of phased array antennas.

5. Apparatus as claimed in any one of claims 2, 3 or 4 wherein each respective antenna has a gain pattern directed in different respective directions.

6. Apparatus as claimed in claim 1 wherein the antenna is formed from an array of substantially fixed gain antennas.

7. Apparatus as claimed in claim 6 wherein the fixed gain antennas are activated sequentially or selectively to received signals.

8. Apparatus for determining an orientation of an antenna substantially as hereinbefore described with reference to, and as illustrated by, the figure 1, 2, 3 or 4 of the drawings.

Application No: GB 0120499.9
Claims searched: all

Examiner: Dr E.P. Plummer
Date of search: 28 May 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H4D

Int Cl (Ed.7): G01S 5/02

Other: Online: WPI, EPODOC, PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	WO01/02874A1	KVH INDUSTRIES whole document	1-7
X	WO00/52496A1	MOTOROLA whole document	1,2,5,6
X	US4644358	SEKINE whole document	1,2,6,7
X	US4599620	EVANS whole document	1-7

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.