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54 An earth terminal for satellite communication systems.

57 An earth terminal for a geostationary satellite communication system incorporates an oval or elliptical shaped antenna 1 whose horizontal dimension d_1 is greater than its vertical dimension d_2 . The relatively small dimension d_2 facilitates transportation of the antenna whilst giving a beam shape which is broader in a direction perpendicular to the

geostationary orbit of the satellite than in a direction parallel thereto. This special beam shape accommodates small movements of the satellite perpendicular to the orbit whilst giving the necessary angular resolution in the direction of the orbit to avoid interference with other satellites in the geostationary orbit.

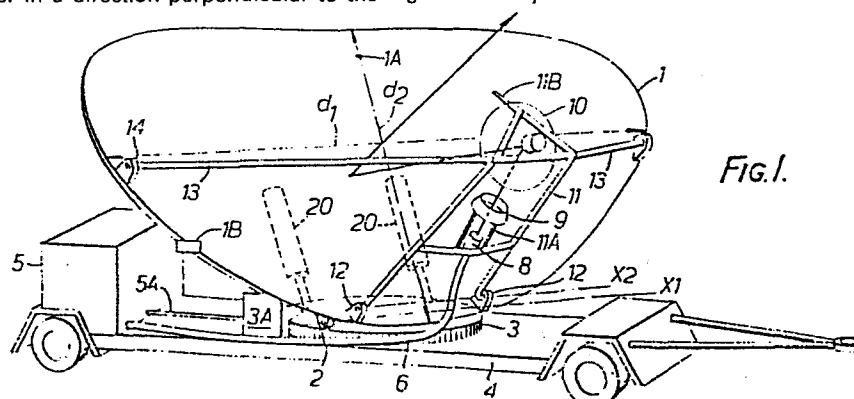


Fig. 1.

AN EARTH TERMINAL FOR SATELLITE COMMUNICATION SYSTEMS

This invention relates to an earth terminal for satellite communication systems.

The invention arose in the design of a road transportable terminal. A previous design had incorporated a circular antenna reflector of three metres diameter which, whilst large for the purposes of road transport, presented no insurmountable problems in this respect. However, with the increasing number of communication satellites it has now become necessary to use more highly directional antennas to prevent interference between different satellite communication systems.

In order to meet the requirement for improved directionality a four metre diameter reflector was initially considered necessary but it soon became apparent that this could not be transported by road because of height limitations imposed by bridges and other overhead obstructions. Similar difficulties arise with air transport where a height limitation is imposed by the shape of the aircraft fuselage.

This invention provides an earth terminal for a satellite communication system comprising an antenna system designed and arranged so that the main lobe of its gain characteristics is broader in a direction perpendicular to the orbit of the satellite than in the direction of the orbit of the satellite. For this

reason the idea of having one dimension of the reflector (the horizontal dimension) greater than the other was proposed. Surprisingly it was found that the limitation on the second dimension does not present a
5 problem. This is because many communication satellites are arranged in geostationary orbits which all lie on a common equatorial great circle and will thus be seen to lie in a continuous line when viewed from any part of the earth's surface, this line extending for
10 practical purposes in the azimuth direction. Lack of directionality in a direction perpendicular to this line (i.e., in elevation) and due to the relatively small "second" dimension of the antenna reflector therefore does not cause interference with neighbouring
15 satellites.

Accordingly the invention provides an earth terminal for a satellite communication system comprising an antenna system designed and arranged so that the main lobe of its gain characteristics is
20 broader in a direction perpendicular to the orbit of the satellite than in the direction of the orbit of the satellite.

Because of inaccuracies in positioning geostationary satellites they do not appear, to an
25 observer on the ground, to be truly stationary but rather move about in a region extending both in the direction of the geostationary orbit and perpendicular thereto. For this reason an earth terminal, in

accordance with the invention, preferably includes means for tracking the satellite in the direction of the orbit: which will normally call for adjustment of the antenna in azimuth. This is desirable because the
5 highly directional characteristics of the antenna in the direction of the geostationary orbit mean that the beamwidth does not simultaneously illuminate the whole of the area of movement of the satellite. The azimuth tracking facility also greatly facilitates setting up
10 of the system when it arrives at it's destination since it eliminates the need to set the azimuth of the boresight of the antenna accurately to the known centre of movement of the satellite. This has previously been a problem in transportable satellite communication
15 systems because of the difficulty in obtaining an accurate azimuth reference. It would also be a problem in domestic, community and like terminals designed just to receive and not to transmit where speed and ease of installation is important for cost reasons. The
20 invention, whilst particularly applicable to transportable systems can thus be usefully applied to some fixed systems. Also, it is apparent from the foregoing that, whilst the invention is particularly applicable to the type of antenna which incorporates a
25 reflector dish, the invention would also be applicable to phased array antennas.

The earth terminal of this invention preferably does not include means for tracking the satellite in a direction perpendicular to the orbit, which will normally be in elevation. The cost of including an
5 elevation tracking system is not considered necessary firstly because the relatively short "second" dimension of the reflector can give a beamwidth in elevation sufficiently wide to embrace the whole area of movement of the satellite; and secondly because accurate
10 inclination measuring devices are available. This means that the previously mentioned difficulty of correctly setting the azimuth of the antenna does not apply to setting the elevation.

In order to improve further the ease with which
15 the antenna can be transported the sub-reflector and preferably also the feed are mounted on a pivotted supporting frame which can be folded away to a position close to the main reflector. This makes a compact arrangement either for transportation by road if the
20 whole assembly is formed as part of a road trailer or vehicle, or for storage in a standard container, or for fitting into an aircraft fuselage.

Thus, according to another aspect of the invention there is provided a transportable antenna comprising a
25 supporting structure, a main antenna pivotted relative to the supporting structure about orthogonal axes, a sub-reflector, a feed, and a supporting frame carrying

the sub-reflector and pivotted relative to the reflector so as to enable the sub-reflector to be pivotted from an operational position where it is spaced from the main reflector to a position for transportation where it is located relatively close to the main reflector.

To avoid inteference with other communication systems employing for example an adjacent satellite in the geostationary orbit it may be required that the earth terminal transmit a very low amount of radiation in directions other than the specified main lobe of the antenna. Another aspect of the invention aims to meet this requirement and provides a dual-reflector antenna comprising a feed, a sub-reflector arranged to be illuminated by the feed and a main reflector arranged to receive the radiation after reflection from the sub-reflector, characterised by a shielding device defining an annular region of shielding between the feed and the sub-reflector so as to obstruct radiation from the feed which would otherwise miss the sub-reflector.

This technique is applicable to any dual-reflector antenna (i.e., Cassegrain or Gregorian) whether or not forming part of a satellite communications sytem. The technique can achieve a substantial reduction in "spillover" i.e., radiation missing the sub-reflector, thereby reducing the amount of radiation emitted in directions other than that required. The shield also

preferably has the effect of reducing the intensity of radiation in the edge regions of the main reflector thus reducing the amount of radiation which misses the latter.

5 One way in which the invention may be performed will now be described with reference to the accompanying illustrations in which:

10 Figure 1 is a schematic perspective view of a road transportable antenna forming part of a satellite communication system for any form of satellite communication;

and

15 Figure 2 illustrates schematically the relationship of the beam shape of the antenna shown in Figure 1 with the locus of movement of the satellite.

Referring to Figure 1 of the drawings there is illustrated a road-trailer-mounted offset Gregorian antenna with an elliptical main reflector 1 having a
20 first maximum dimension d_1 in the horizontal plane and a second minimum dimension d_2 in an orthogonal plane. The reflector 1 has lugs one of which is shown at 2 by which it is pivotted about a horizontal axis on a turntable 3 which can be rotated about an orthogonal
25 vertical axis on a frame 4 which forms part of a road trailer. The trailer carries a television transceiver 5 from which energy to be transmitted is fed along a

flexible waveguide 6 to a feed horn 8. From the horn 8 the energy is directed through a shielding device 9 onto an offset concave sub-reflector 10 and then to the main reflector 1. The feed horn 8, shielding device 9 and sub-reflector 10 are mounted on a framework 11 which is pivotted, about a horizontal axis, on lugs 12 fixed to the reflector 1. The framework is held at the illustrated position by removable stays 13 each secured at one end to framework 11 and at the other end to a lug 14 also fixed to the reflector. The feed horn 8, shielding device 9 and sub-reflector 10 are designed so as to illuminate substantially the whole of the main reflector 1. The larger diameter d_1 results in a narrower beamwidth in azimuth than is achieved in elevation by the smaller diameter d_2 . The sub-reflector 10 is designed to spread the energy arriving from the horn 8 across the axes d_1 and d_2 of the reflector 1 in such a way that the energy is tapered from the centre of the reflector to the edges to a greater extent in the dimension d_1 than in the dimension d_2 . It is desirable to accomplish this because the greater taper in direction d_1 will result in a relatively lower level of sidelobes, while the lesser taper in d_2 , whilst resulting in higher sidelobes, assists in maintaining the highest possible directionality from the complete aperture.

The purpose of the shielding device 9, supported

between the horn 8 and reflector 10 on struts 11A forming part of the framework 11, is to act as an obstruction to radiation from the horn which would otherwise miss the sub-reflector 10. It also reduces
5 the radiation intensity at the edges of the sub-reflector and therefore in the region of the edges of the main reflector, thus reducing the amount of radiation from the sub-reflector which misses the main reflector. The radiation which misses the two
10 reflectors is called "spill-over" and it is desirable to reduce this as much as possible to minimise interference e.g., with other satellite communication systems. The shielding device 9 is, as shown on Figure 1 formed by a frusto-conical metal surface tapering
15 towards the sub-reflector. This is preferable to an annular surface since it enables a shielding effect to be obtained over a considerable angle without obstructing radiation passing from the sub-reflector to the main reflector.

20 The main lobe of the transmitted beam is shown schematically by the shaded area 15 on Figure 2. It's boresight 16 is shown aligned with a satellite 17 which moves within a roughly square region 18 centred on a geostationary orbit 19 of the satellite 17.

25 Before deployment, the reflector 1 lies substantially horizontally on the frame 4, the stays 13 are stowed away, and the framework 11 is folded so as

to lie against the reflector. An extension 11B of the framework 11 extends through a hole 1A of the reflector 1 and is secured thereto by a catch mechanism (not shown) behind the reflector.

5 When the illustrated transmitter is to be deployed the reflector 1 is tilted in elevation on its lugs 2 by manually operated jacks shown schematically at 20 and is rotated in azimuth using the turntable 3 and a servo mechanism 3A which engages teeth on the edge of the
10 turntable. An accurate inclination sensing instrument 1B is used to enable the boresight 16 to be set at the elevation of the satellite which will usually be as illustrated at approximately the highest point of the orbit 19. The azimuth is then set roughly to the
15 direction of the satellite using a relatively inaccurate compass. Fine adjustment is then effected by an operator until the satellite has been acquired. Following this the satellite is automatically tracked in azimuth during movements from one side to another of
20 the square 18. The tracking is effected by automatic rotation of turntable 3 by the servo mechanism 3A under the control of the transceiver 5 via line 5A.

Because of the highly directional nature of the transmitted beam in azimuth coupled with the lower
25 sidelobes in this plane, interference with other communication systems using other satellites such as that shown at 21 on Figure 2 is avoided. Deployment of

the system is facilitated because of the provision of the azimuth tracking system which provides the necessary mechanical means for the operator to effect the fine adjustment referred to previously and ensures
5 that the beam is correctly aligned in azimuth with the satellite. Finally of course the shape of the antenna enables it, and it's transporter, to travel under most road bridges and overhead obstacles or, in a slightly modified version to be carried by air.

10 In practice it is envisaged that the antenna will be needed in circumstances when the geostationary orbit
19 makes an angle of no more than 45° with the horizontal in the region 7. In such circumstances little penalty is paid in using an antenna with its
15 major axis permanently horizontal as in the illustrated example. There may however be circumstances where it is desired to communicate with a satellite in a part of the orbit which appears inclined to the horizontal. In such circumstances the antenna can take advantage of
20 the features already described if the axis d_1 is inclined so that it lies effectively tangential to the position of the satellite in the geostationary arc as viewed from the antenna. Such an inclined mounting arrangement can be achieved on a mobile installation:
25 but is more readily achieved on a permanent stationary installation.

CLAIMS

1. An earth terminal for a satellite communication system comprising an antenna system designed and arranged so that the main lobe of it's gain characteristics is broader in a direction perpendicular to the orbit of the satellite than in the direction of the orbit of the satellite.
2. An earth terminal according to Claim 1 including a main reflector which is broader in a first dimension than in a second orthogonal dimension.
3. An earth terminal according to Claim 2 in which the first dimension is horizontal.
4. An earth terminal according to Claim 2 or 3 including means for transporting the reflector.
5. An earth terminal according to any preceding claim designed so that in use it's main lobe, or a principle part thereof, embraces the whole of the range of movements of the satellite perpendicular to its orbit but only part of the range of movements of the satellite parallel to its orbit, the earth terminal including means for tracking the satellite in the direction parallel to the orbit but not in the direction perpendicular to its orbit.
6. A transportable antenna comprising a supporting structure, a main antenna pivotted relative to the supporting structure about orthogonal axes, a sub-reflector, a feed and a supporting frame carrying the

sub-reflector and pivotted relative to the reflector so as to enable the sub-reflector to be pivotted from an operational position where it is spaced from the main reflector to a position for transportation where it is located relatively close to the main reflector.

7. An antenna according to Claim 6 in which the feed is also carried on the frame.

8. An antenna according to Claim 6 or 7 in which a shielding device is mounted on the frame between the feed and the sub-reflector so as to obstruct stray radiation from a feed which would otherwise miss the sub-reflector.

9. An antenna according to Claim 8 in which the shielding device includes a frusto-conical surface tapering towards the sub-reflector.

10. An antenna according to Claim 5, 6 or 7 comprising a flexible waveguide connected to the feed.

11. A dual-reflector antenna comprising a feed, a sub-reflector arranged to be illuminated by the feed and a main reflector arranged to receive the radiation after reflection from the sub-reflector, characterised by a shielding device defining an annular region of shielding between the feed and the sub-reflector so as to obstruct radiation from the feed which would otherwise miss the sub-reflector.

12. An antenna according to Claim 11 in which the shielding device is supported by struts on a frame carrying the feed and/or the sub-reflector.

13. An antenna according to Claim 11 or 12 in which
5 the shielding device comprises a frusto-conical shielding surface tapered towards the sub-reflector and whose axis is aligned with the optical axis between the feed and the sub-reflector.

