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(54) Scanning dual reflector antenna.

(57) An antenna system, on a spacecraft for example, comprises a movable reflector dish so that the antenna pointing direction can be varied or scanned and a fixed feed. To reduce separation of the feed from the focal point of the dish during such scanning, the feed is positioned at the point about which the dish is movable and is directed towards a convex auxiliary dish fixed to and movable with the main dish and producing a virtual image of the feed at the focal point of the main dish.

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ANTENNA SYSTEMS

This invention relates to antenna systems, more particularly but not exclusively, antenna systems for use on board spacecraft such as communications satellites.

It is desirable to be able to vary or 'scan' the pointing direction of an antenna on a spacecraft with respect to the spacecraft, ie to vary the antenna pointing direction without varying the position of the spacecraft as a whole. A known, advantageous way of doing this is to use an antenna system comprising a movable reflector dish but a fixed antenna feed (the feed being the horn, waveguide aperture or the like from which the communications signal is emitted to the dish or which receives the signal from the dish). The antenna feed should be positioned at the focus of the reflector dish. However, for practical reasons, the movement of the dish to scan the antenna pointing direction will not be about this focal point. Hence, during such scanning, the fixed position of the feed will not remain at the focal point and there will be a loss of gain and performance.

An object of this invention is to substantially reduce or even eliminate the separation of the focus from the feed during movement of the reflector.

According to the invention there is provided an antenna system comprising support means, a main radio-frequency reflector dish of which the reflector surface is its concave surface, an auxiliary radio-frequency reflector dish of which the reflector surface is its convex surface, the two dishes being fixed with respect to one another with the reflector surfaces thereof facing one another, the two dishes being supported by said support means for together turning with respect to the support means about a point lying between the reflector surfaces, antenna pointing means connected to the reflector dishes and operable for controlling said turning of the reflector dishes to point the main reflector dish in a desired direction, and antenna feed means which is fixed with respect to the support means and which has a portion at least near to said point for emitting radio-frequency energy to or receiving such energy from said main reflector dish by way of said auxiliary reflector dish.

The antenna system is particularly suitable for use in space but may be useful for other applications. Cassegrain, Gregorian and Newtonian reflector dishes may be used as well as other forms shaped for a particular application.

By way of example, one embodiment of the invention will now be described with reference to the accompanying figures in which:-

Figure 1 is a diagrammatic view of an antenna system on board a spacecraft,

Figure 2 corresponds to figure 1 but shows the reflectors of the antenna system turned to point the antenna beam in a different direction with respect to the spacecraft, and

Figure 3 shows typical sum and difference signal strengths.

Figure 1 shows part of a spacecraft 1 to which there is mounted a Cassegrain antenna system comprising a main parabolic reflector dish 2 and an auxiliary reflector dish 3 which is fixed, for example by way of support arms (not shown), to the main dish 2 such that the convex reflector surface of the dish 3 faces the concave reflector surface of dish 2. The dish 2 is fixed to the movable part 4 of a swash-plate antenna pointing mechanism of which a fixed part 5 is supported via a hollow cone-shaped support pillar 6 on the surface of the spacecraft. The antenna pointing mechanism is shown only diagrammatically but its construction which includes a suitable drive motor (not shown) and its operation are well known to those skilled in the art. Its function is to permit the antenna system to be turned so that the direction of the transmission/reception beam of the antenna dish 2 can be varied or scanned with respect to the spacecraft as shown in figure 2. A fixed antenna feed horn 7, communicating via a waveguide 8 with radio communications apparatus (not shown) on board the spacecraft, is positioned within the pointing mechanism so as to feed the antenna dish 2 by reflection from the auxiliary dish 3. The effect of dish 3 is to produce a virtual image of the horn aperture at point 9, which point is at least near the focal point of the dish 2. Meanwhile, the horn aperture is in fact positioned at least near the point about which the antenna dish 3 is turned by the antenna pointing mechanism. Thus, despite such turning, the apparent position of the horn aperture (as far as dish 3 is concerned) remains at the proper focal point.

Because the main and auxiliary reflector dishes move together and rotate as a unit there are no distortions introduced when the beam scans. Some loss of gain occurs through spillover at the edges of the auxiliary reflector as illustrated at 10 in Figure 2 but these losses may be controlled by increasing the subtended angle of the auxiliary reflector from the focus. With proper design, the illustrated system may be able to achieve comparatively large scans with low loss (eg 35 beamwidths with an approximate 1 dB loss).

The centre of rotation of the reflector dish assembly may be displaced somewhat from the feed horn aperture, say to accommodate other system design features, but increased distortion will occur.

It is desirable for many uses to be able to control the antenna pointing direction by receiving the signal from a beacon sited upon the earth *via* a special r.f. sensing part of the antenna. For this r.f. sensing components (not shown) may be attached to the feed horn. The scanning process introduces asymmetry into the main reflector aperture illumination which has more serious effects upon the shape of a difference pattern (see Figure 3) than a sum pattern. To correct this asymmetry a combination of sum and difference patterns may be used to squint the reception beam pattern of the beacon signal receiving components so as to follow the rotation of the antenna system and hence correct the asymmetry. The sum and difference patterns may be generated by either multiple horn systems or mode extraction systems in which the signals are obtained from the various modes of waveguide. For circular waveguides, the modes TE11 or HE11 are normally used for sum signal and the combinations TM01/TE21, dual TE21 and TM01"TE01 as the difference signal. To maintain the null depth whilst scanning, the antenna sum and difference modes are added which squint the feed illumination to follow the auxiliary reflector. This is also possible with the communications signal but it is not usually necessary. The addition of sum and difference modes may be made in several ways. The modes can be added in an r.f. comparator, in a multiplexer modulator or at low frequency or baseband within the tracking receiver. The sum pattern is usually added at a low level (*eg* 20dB) relative to the difference pattern.

CLAIMS

1. An antenna system comprising support means, a main radio-frequency reflector dish of which the reflector surface is its concave surface, an auxiliary radio-frequency reflector dish of which the reflector surface is its convex surface, the two dishes being fixed with respect to one another with the reflector surfaces thereof facing one another, the two dishes being supported by said support means for together turning with respect to the support means about a point lying between the reflector surfaces, antenna pointing means connected to the reflector dishes and operable for controlling said turning of the reflector dishes to point the main reflector dish in a desired direction, and antenna feed means which is fixed with respect to the support means and which has a portion at least near to said point for emitting radio-frequency energy to or receiving such energy from said main reflector dish by way of said auxiliary reflector dish.

2. An antenna system according to claim 1, including radio-frequency signal receiving means fixed to said antenna feed means for receiving via said main and auxiliary reflector dishes a beacon signal for assisting in the correct pointing of said main reflector dish.

3. An antenna system according to claim 1, wherein the axial direction of the reception pattern of the radio-frequency signal receiving means is variable to follow the turning of said auxiliary dish reflector.

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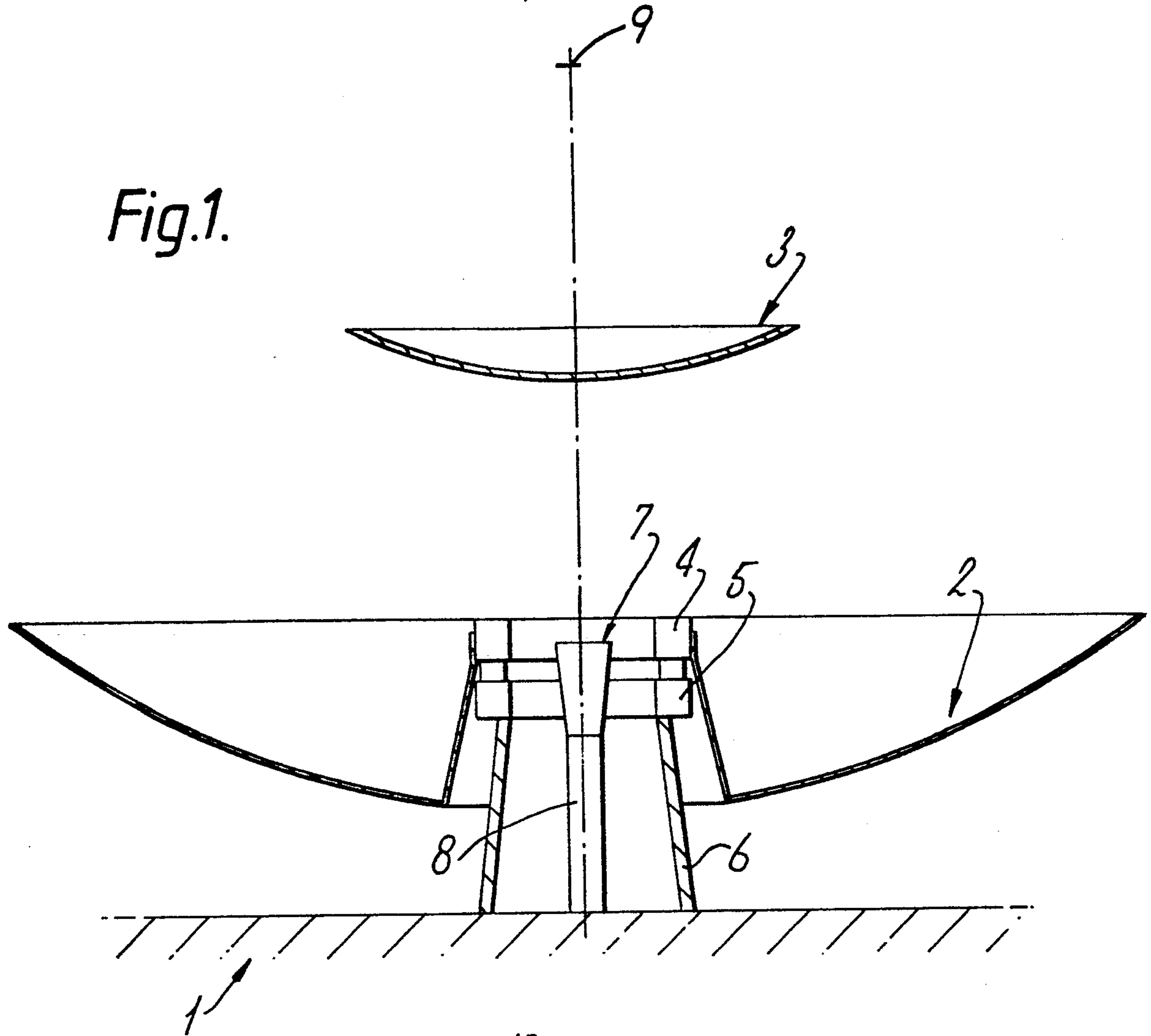

Fig.1.

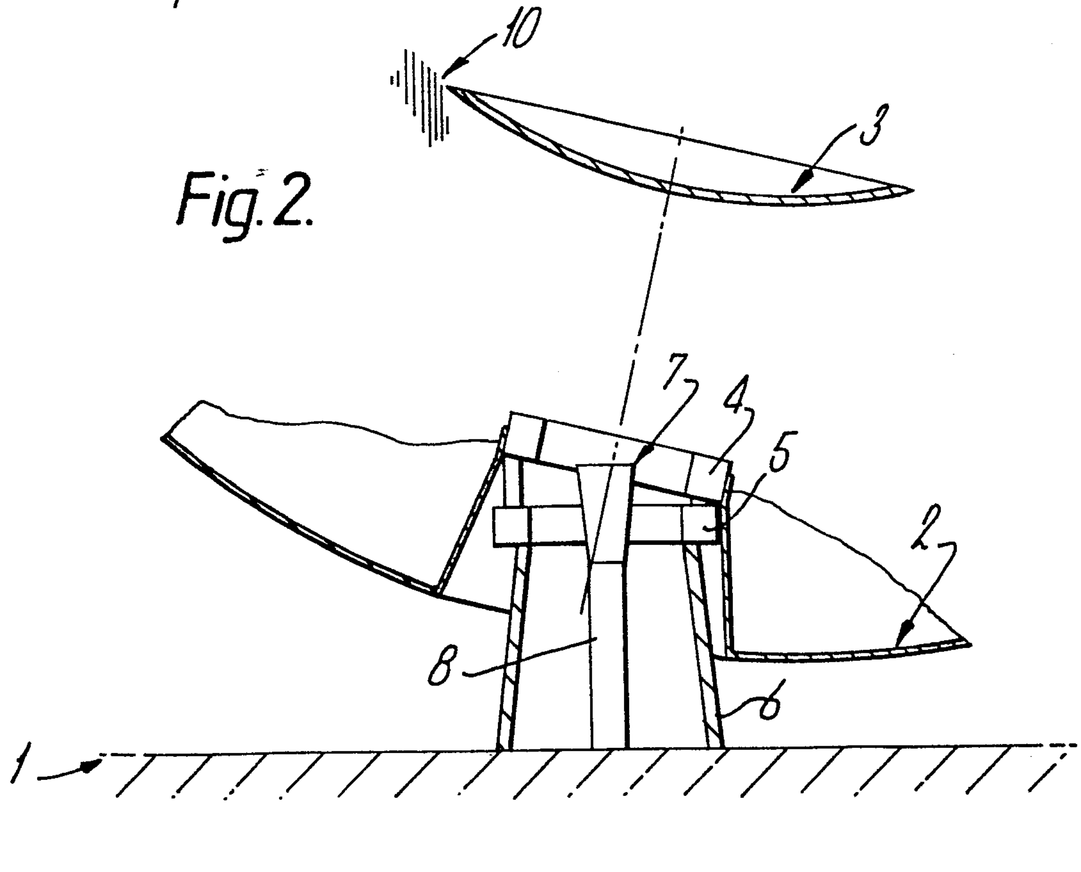

Fig.2.

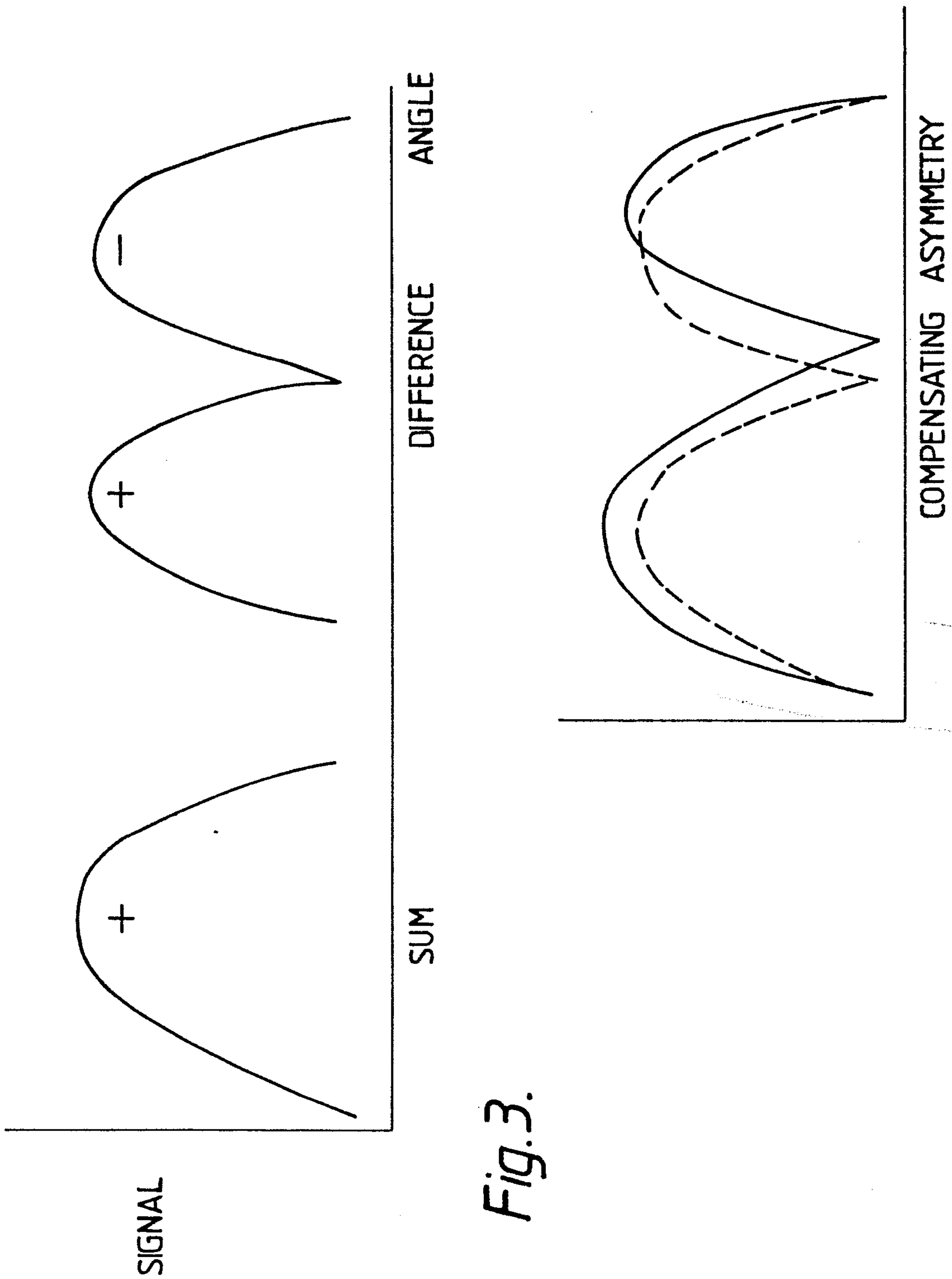

Fig.3.