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Multiple-Reflection Conical Microwave Antenna

The problem:

A conical-Gregorian antenna concept for a spacecraft, using a conical reflector, promises excellent rf performance and also offers potential advantages in the areas of mechanical and structural design, surface measurement, and in furlability. However, it requires a relatively large diameter for the subreflector (e.g., 0.4 to 0.5 that of the O.D. of the main reflector), which degrades aperture efficiency and increases stowed volume.

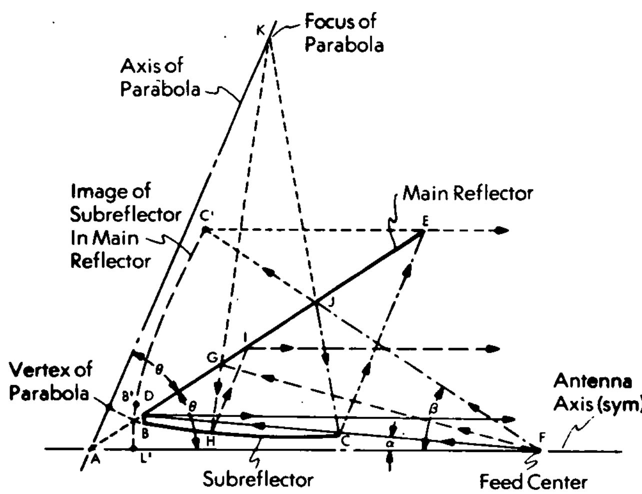
The solution:

Utilize a multiple reflection scheme between one or more subreflectors and the main reflector. Then, the subreflector can be reduced to as little as 0.1 the diameter of the main reflector.

How it's done:

The basic principle of the multiple reflection conical antenna is illustrated in the first diagram. The main reflector surface is a frustum of a cone with its vertex at A and with a half-cone angle Θ. The axis of the cone is coincident with the antenna axis. The subreflector surface is generated by rotation about the antenna axis (through A and F) of an arc B-C of a parabola. The vertex L and focus K of this generator parabola lie on the cone with half-angle 2Θ and vertex A. The image F of this focus K (as reflected in the main reflector cone) then lies on the antenna axis.

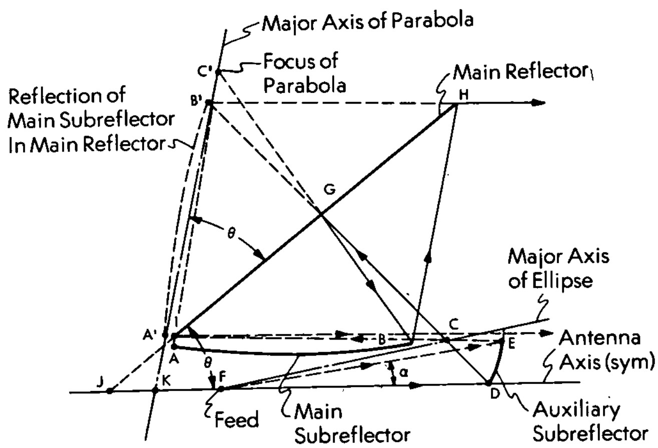
The effective center of the feed is then made to coincide with focal point F. For specularly reflective surfaces, a typical ray emanating from feed center F and forming some angle between ϕ and β with the antenna axis, will be reflected by the main reflector at G, by the subreflector at H, and again by the main reflector at I. This ray then emerges from the antenna parallel to the antenna axis. The outermost usable ray travels the path F-J-C-E and emerges from the antenna parallel to the antenna axis. The innermost



usable ray just grazes the subreflector at C, is reflected to the main reflector at D, by the subreflector at B, and again by the main reflector near D, and emerges from the antenna in a direction parallel to the antenna axis. Each ray thus experiences three reflections before emerging from the antenna. For geometrically exact and perfectly reflective surfaces, all optical rays emanating from the feed between the cones with half angles ϕ and β will emerge from the antenna parallel to the antenna axis. Also, all path lengths of these rays from the feed center F to any plane normal to the antenna axis, and to the right of point E, will be equal.

(continued overleaf)

This multiple-reflection conical antenna configuration represents, in a sense, an optically folded version of a conventional focal-point feed paraboloidal antenna. The similarity between this concept and the conventional antenna suggests that some of the disadvantages of the latter will be exhibited. The feed horn, being relatively far forward from the vertex of the main reflector, requires long feed lines, resulting in feed-line losses. Further, all energy associated with rays emanating from the feed within the cone with half-cone angle ϕ is lost. Both these disadvantages can be virtually eliminated by incorporating a modified Cassegrainian feed as suggested in the second diagram. The main subreflector surface is generated



by rotation about the antenna axis of a segment A-B of a parabola, the axis of which passes through K and C′ and with it's focus at C′. The reflection in the conical main reflector of this focus C′ is at C, which lies above the axis of the antenna. An auxiliary subreflector surface is generated by rotation about the antenna axis of a segment D-E of an ellipse, the major axis of which passes through the effective center F of the feed and through the point C. F and C are the foci of this generator ellipse. Thus, an effective ring source is created on the circle generated by rotating the point C about the antenna axis.

Considering the geometrical properties of ellipses, parabolas, and cones, it is clear that all optical rays emanating from the feed within the cone with half-cone angle ϕ will ultimately radiate from the antenna parallel to the antenna axis. All path lengths associated with these rays from the feed F to any plane normal to the antenna axis and to the right of point H are equal. For geometrically exact and perfectly specularly reflecting surfaces, the performance of this antenna would be identical to that of an antenna with a main reflector surface generated by rotation about the antenna axis of a segment A′-B′ of a parabola with its focus at C, with a point-source feed at F, and using the auxiliary subreflector as the only subreflector. Thus, this version of the multiple-reflection conical antenna represents an optically folded version of a more nearly conventional antenna configuration.

Notes:

1. A conical microwave antenna is also described in NASA Tech Brief B73-10291 .
2. Requests for further information may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: TSP 73-10299

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,705,406). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

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Source: Robert E. Oliver of Caltech/JPL under contract to NASA Pasadena Office (NPO-11661)