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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

HAYSTACK OBSERVATORY

WESTFORD, MASSACHUSETTS 01886

AR107,90

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Telephone: 508-692-4764
Fax: 617-981-0590

Holographers

From: Alan E. E. Rogers AEER

Subject: Diffraction model for the Haystack radome

Fresnel Integrals

The diffraction pattern of the radome hubs and spars on the main reflector surface can be approximated by the Fresnel integral

$$\int e^{\frac{is^2 2\pi}{2d \lambda}} da$$

where d = distance from obscuring element from reflector surface

s = perpendicular distance of obscuring element from direct ray between the radio source and a point on the reflector surface

da = element of surface area

In the case of a straight edge diffractor the Fresnel integral form the well-known "Cornu" spiral. The Fresnel approximation, known to microwave engineers as the Geometrical Theory of Diffraction (GTD), corresponds to the first term in the rigorous diffraction theory of Sommerfeld. When the diffractor is many wavelengths from the "screen" (in this case the reflector) the higher order polarization dependent terms are small. The Fresnel integral is the sum over the clear area and not over the "black" region of geometrical obscuration. However for our purpose it is more efficient to sum elements of the diffractor, normalize and subtract from unity.

Basic Method of Computation

1] For a given source direction compute the geometrical projection of the radome hubs and spars onto the antenna surface. The x,y,z coordinates of 82 hubs are used to obtain the x,y,z coordinates for all the hubs which repeat every 72 degrees (5 times around the radome) in azimuth. The spars are placed using table hub interconnections.
2] Perform the Fresnel sum, normalize and subtract from unity.
3] Convolve the result with the antenna scan pattern used for holography.
4] Convolve the result with the resolution (point spread function) of the holographic maps.

Gridding

In practice both the antenna surface and the diffractor are "gridded" into arrays, and in order to avoid very large arrays the diffractor is divided into a mosaic. The Fresnel integral is only carried out to the edge of each mosaic (40x40) (about 5 feet in radius).

Compute Time

The initial program was written in Basic and on a 386, 20 MHz machine. It takes about 6 hours to compute 45,000 points every 0.5 feet on the antenna surface. A faster version of the program has been written in Fortran to run under UNIX.

Parameters Assumed

Antenna vertex offset	14.13 feet
Radome Azimuth	15.6 degrees (relative to hub #61)
Offset between radome center and antenna axis intersection	0 (zero) feet
Hub coordinates	Table from Parke report
Spar coordinates	From table of hub interconnects
Hub radius	0.64 feet
Spar blockage	0.25 feet wide x 0.42 feet deep

Results

Initial tests of using the model to correct the holographic data looks promising. Figure 1 shows the diffraction model for a source at az=212.8 and el=35.38 degrees. The total loss from the diffraction model for the entire uniformly illuminated 120' diameter is 1 dB and the apparent r.m.s. (at 12 GHz) is 13 mils r.m.s. Figure 2 shows the diffractor geometry relative to the antenna aperture.

Some special corrections and assumptions

1] The effective radius of the radome for the spars is assumed to be that of the hubs minus half the spar depth.

2] The projection of the spars onto the dish accounts for their width and depth.

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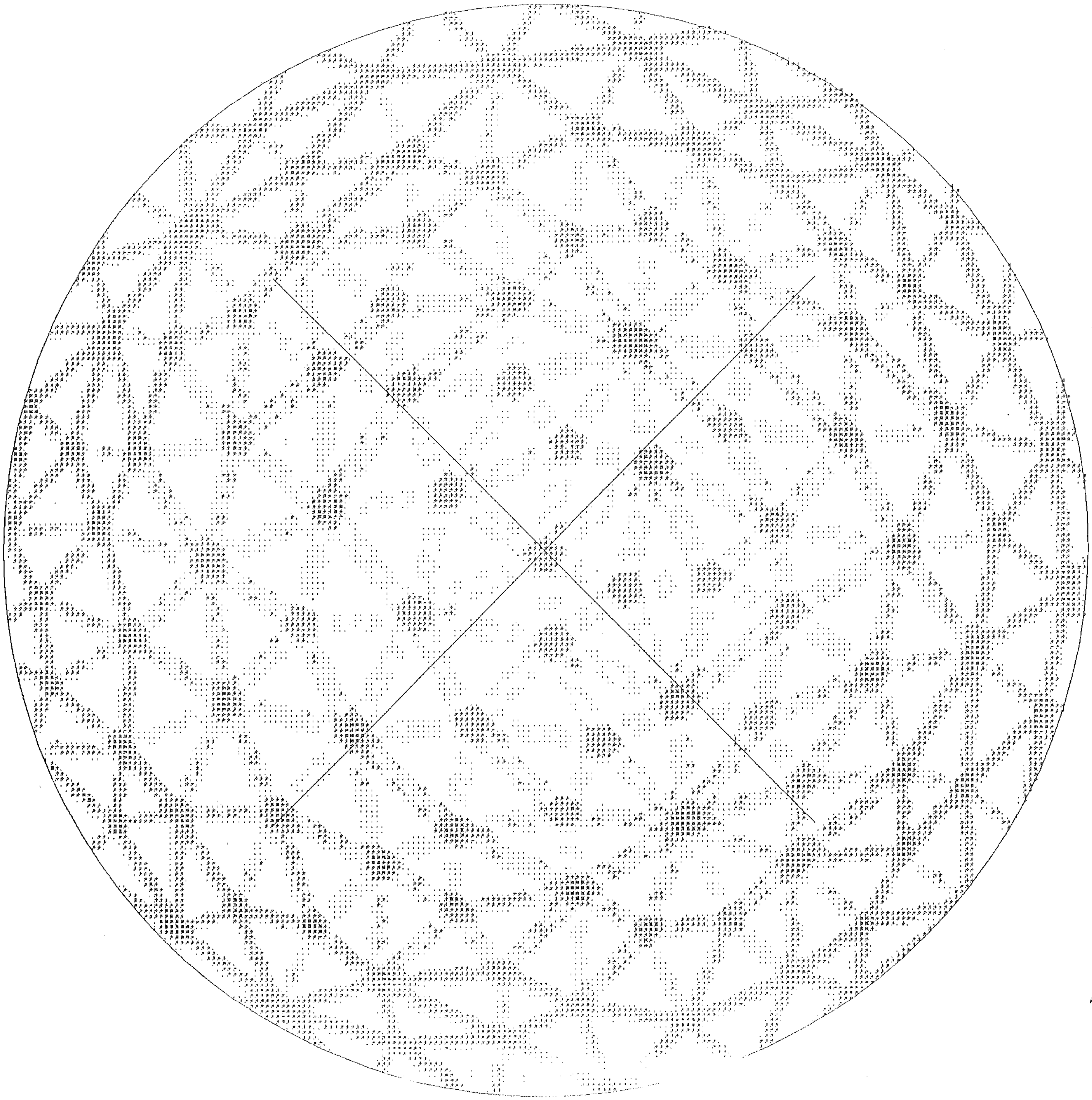

DIFFRACTION MODEL FOR HAYSTACK RADOME HUBS AND SPARS

GREY SCALE OF AMPLITUDES
-10%,-20%,-40%
RESOLUTION
= 1.16 FT.

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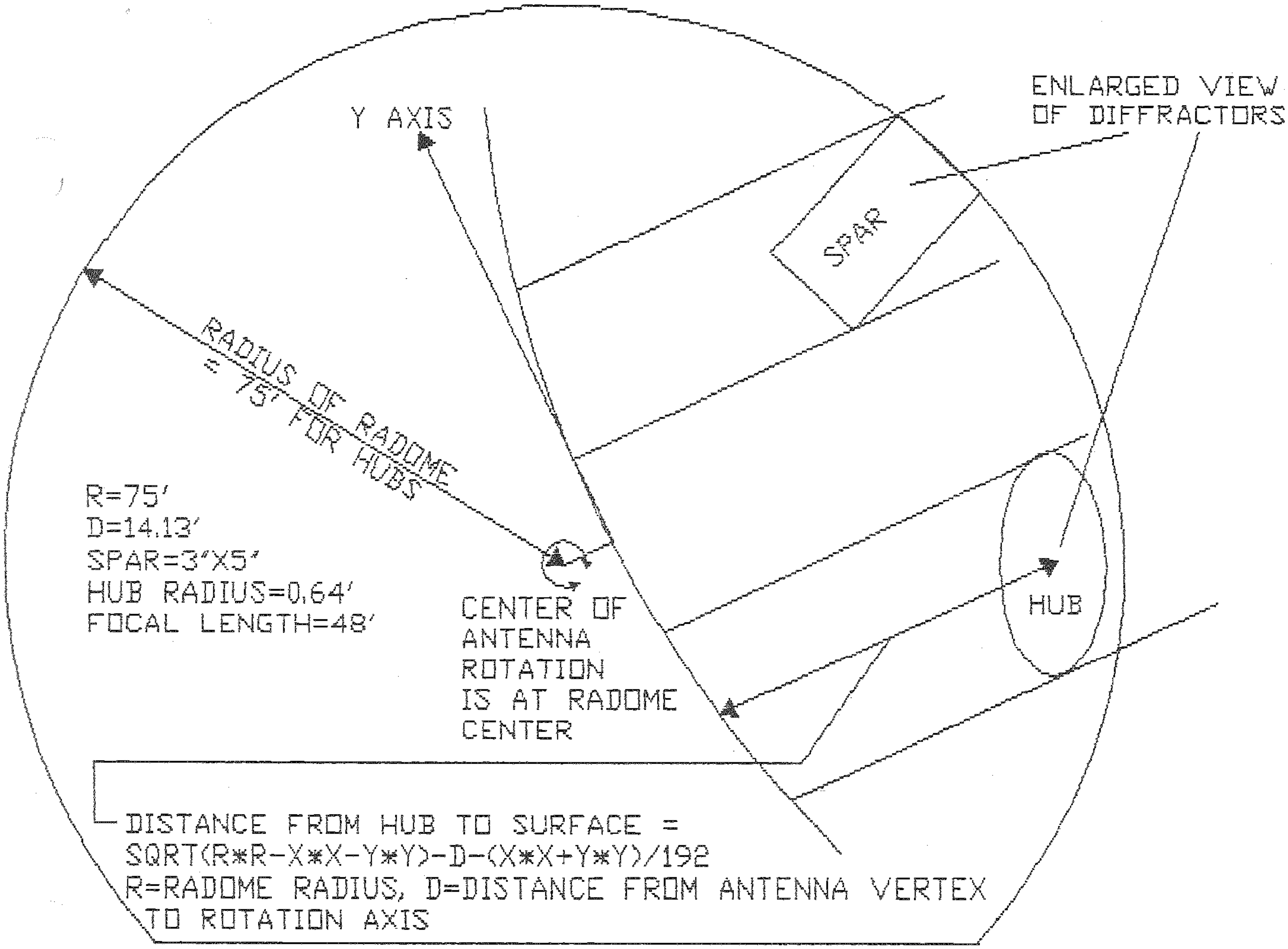

FIG 2. GEOMETRY FOR RADOME DIFFRACTION

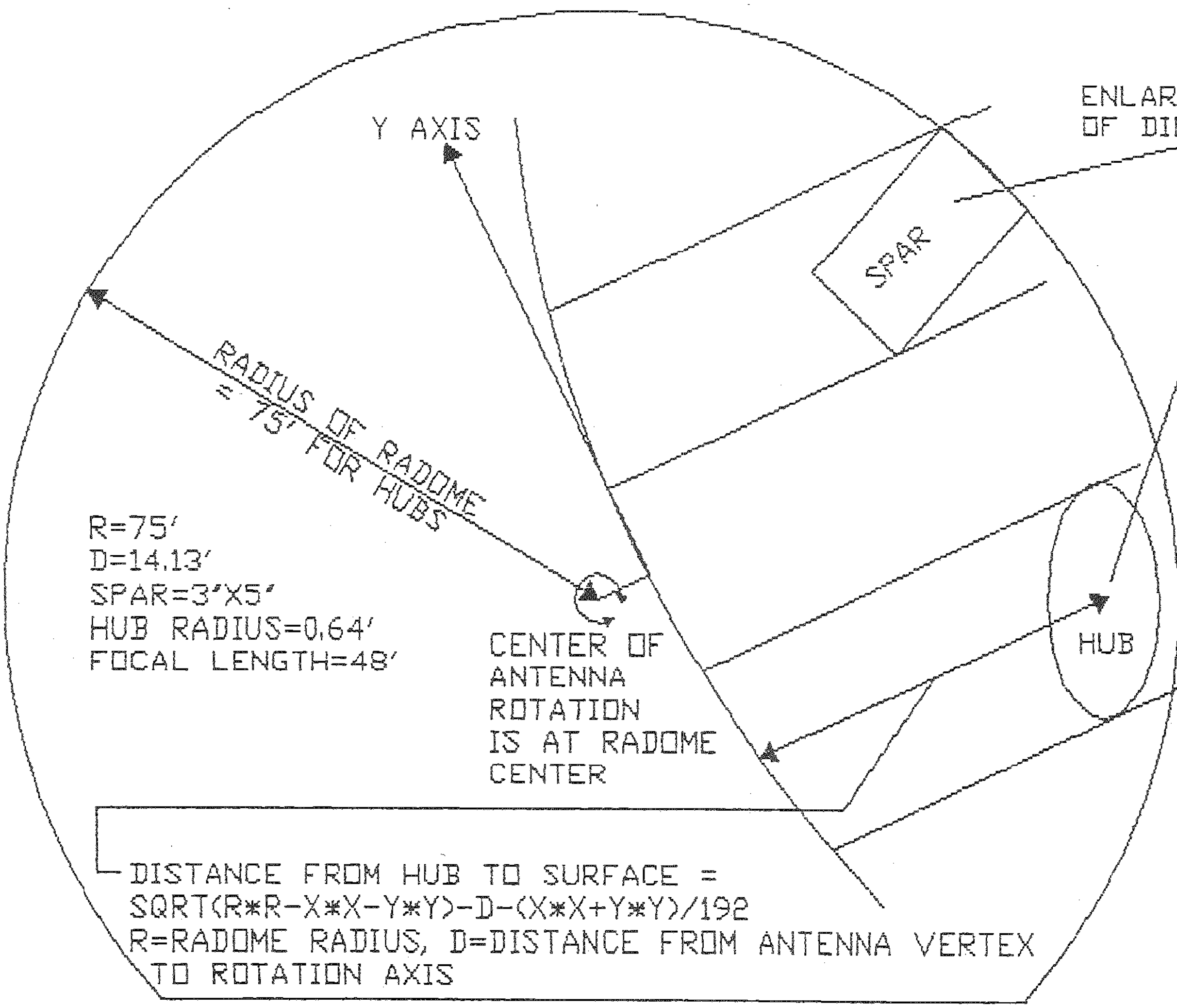

FIG 2. GEOMETRY FOR RADOME DIFFRACTION