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Title: Ellipsoidal Reflector for the C-Band Feeds on the 140-ft Telescope (with Polarization Splitter)

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ELLIPSOIDAL REFLECTOR FOR THE C-BAND FEEDS ON THE 140-FOOT TELESCOPE (WITH POLARIZATION SPLITTER)

Sivasankaran Srikanth

For the simultaneous operation of the two 4.7 to 26 GHz maser/upconverter receivers with two independent feeds, Rick Fisher in his memorandum dated April 8, 1983 sketched out a scheme where he used a set of ellipsoidal reflectors, one above each feed and a polarization selective splitter. In his scheme, he suggested the building of two reflector/splitter systems, one above and the other below 7.5 GHz. The design and fabrication of the reflectors for the frequency above 7.5 GHz is complete.

I have worked out the design details of the reflector for the C-band feed which I present here.

I started out in the same direction as that of Rick Fisher's two curved reflectors/splitter design scheme. This scheme, using the C-band feeds already in use, was not a feasible design for the following reason. The C-band feed with the circular to rectangular waveguide adapter is about 36" taller than the tallest (X-band) feed plus adapter in the higher frequency band. This pushed up the ellipsoidal reflectors by at least 3 feet along the feed axes, as compared to the location of the reflectors in Rick's scheme, resulting in interference of the reflectors with the reflected beams off the splitter. I tried to circumvent this problem by using a shorter feed with pattern characteristics close to the existing feed, but for the same reasons of interference, I had to abandon this scheme.

The other option was to use a single reflector above one of the feeds and position the splitter above the other feed as shown in Figure 1. I found this option workable even with the existing C-band feed, obviating the extra time and effort that it would take to fabricate and test a new feed.

Figure 1 is in the plane containing the axes of the two feeds mounted diametrically opposite to one another on the offset feed circle. The central rays of the feeds are inclined at 8.202° to one another and 4.101° to the telescope axis. The ellipsoidal reflector is located at a height of 263 cm above the roof with a tilt angle of 38° to the feed axis. This location and angle are so chosen that the reflected convergent beam is clear of the edge of the feed and also interference of the beam from the other feed with the edge of the ellipsoidal reflector is minimum. The reflected beam from this ellipsoidal reflector is then incident on the polarization splitter above the other feed.

For this location and tilt of the reflector, the reflector curvature was varied, and the reflected far-field beamwidths were computed at the end frequencies of C-band. A focal length of 3.7 meters for the ellipsoid was chosen which gave the required beamwidth. The field strengths relative to the beam center at an angle of 7° from the center of the beam varied between 10.19 and 11.51 dB for the entire range of frequencies (Figure 2) while the beamwidths of the reflected pattern are in the range of 10.98 to 12.61 dB (Figure 3).

The curved reflector, being unsymmetric with respect to the input pattern because of the tilt, will give rise to cross-polarized field in the reflected beam. Computation of this field was made for the above reflector and it was found that the level of cross-polarized power is about 29 dB below the copolar power averaged over the beam. Even with all this power landing on a 300 K absorber, the system temperature will rise by only 0.76 K.

The edge of the reflector is defined by a cone whose apex is at the far-field phase center of the feed. The opening angle of this cone specifies the size of the reflector. While deciding on the size of the reflector, the following factors were considered: the allowable power that spills over its edge, the distortion of the reflected beam by the edge diffracted field, and the amount of interference of the beam from the other feed. The chosen size for the reflector has a half cone angle of 17° To keep the interference of the beam from the other feed down, the ellipsoid is sliced at 14.5° for angles of ϕ between 151° and 209° as shown in Figure 4. The edges are rounded off to avoid corner diffraction. This reflector gave a distortionless reflected beam. The spillover efficiency is 99.46% at 5 GHz and 99.27% at 7.5 GHz. Using the Geometric Theory of Diffraction, computation of the edge diffracted field, due to the field of the other feed incident at the edge, was made. For the above reflector the diffracted field strength is at least 54 dB below the main beam at the Cassegrain.

The effective phase centers of the reflected beams after the second reflection off the polarization splitter are between 133 cm and 157 cm below the center of the splitter. The feed phase centers are between 200 and 252 cm below the same plane.

PAPER IN THE PLANE CONTAINING THE AXES OF BOTH FEEDS

C-BAND FEED.
APERTURE RADIUS = 38·95 cm
AXIAL LENGTH = 246 cm

PHASE CENTER DEPTH = { 171·17 cm (5 GHz)
222·85 cm (7.5 GHz)

SCALE 1 : 20

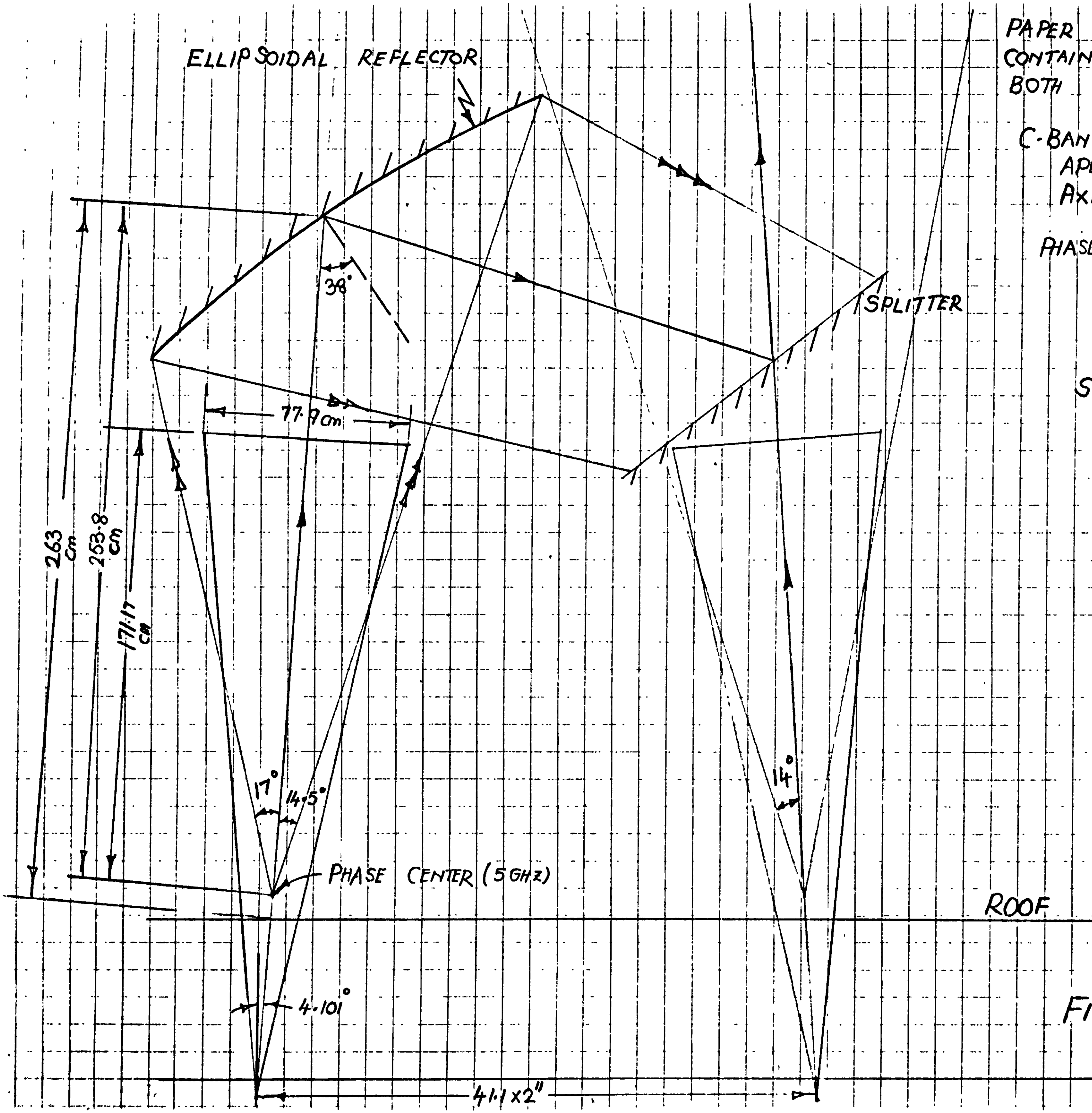
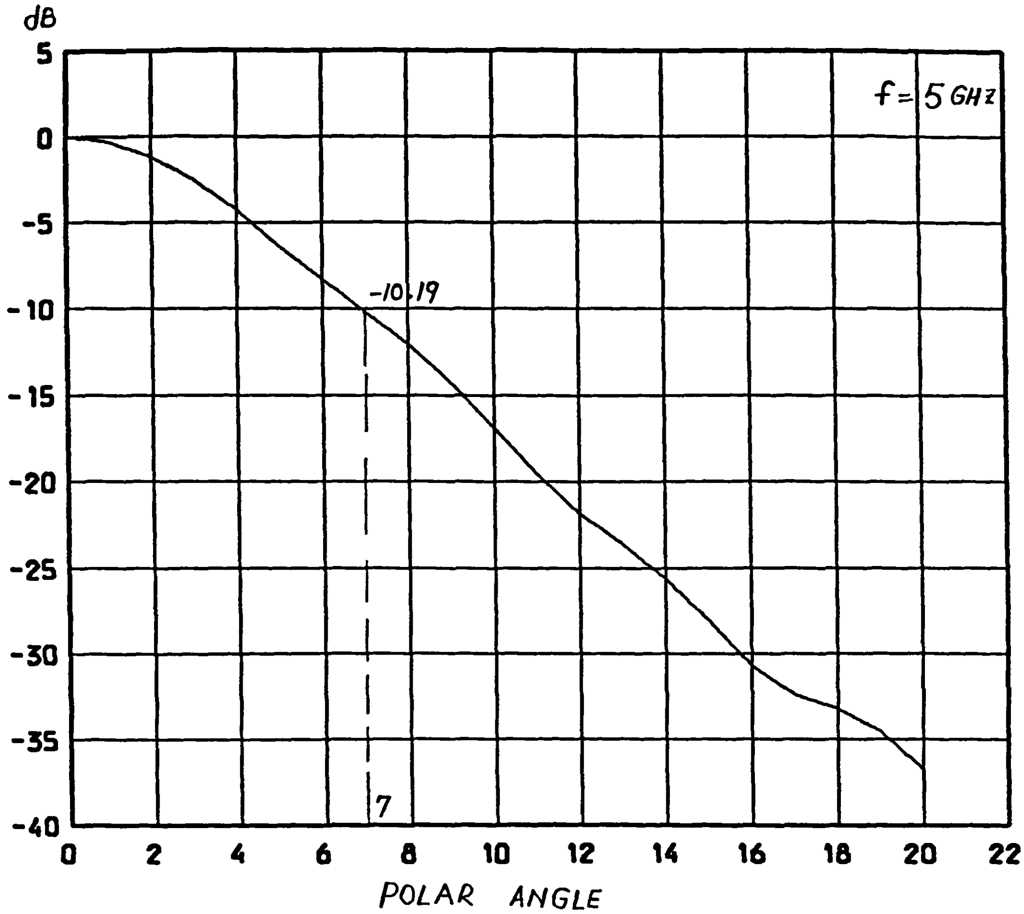


FIGURE 1.



APERTURE RAD.=38.95 cm

AXIL LENGTH = 246 cm

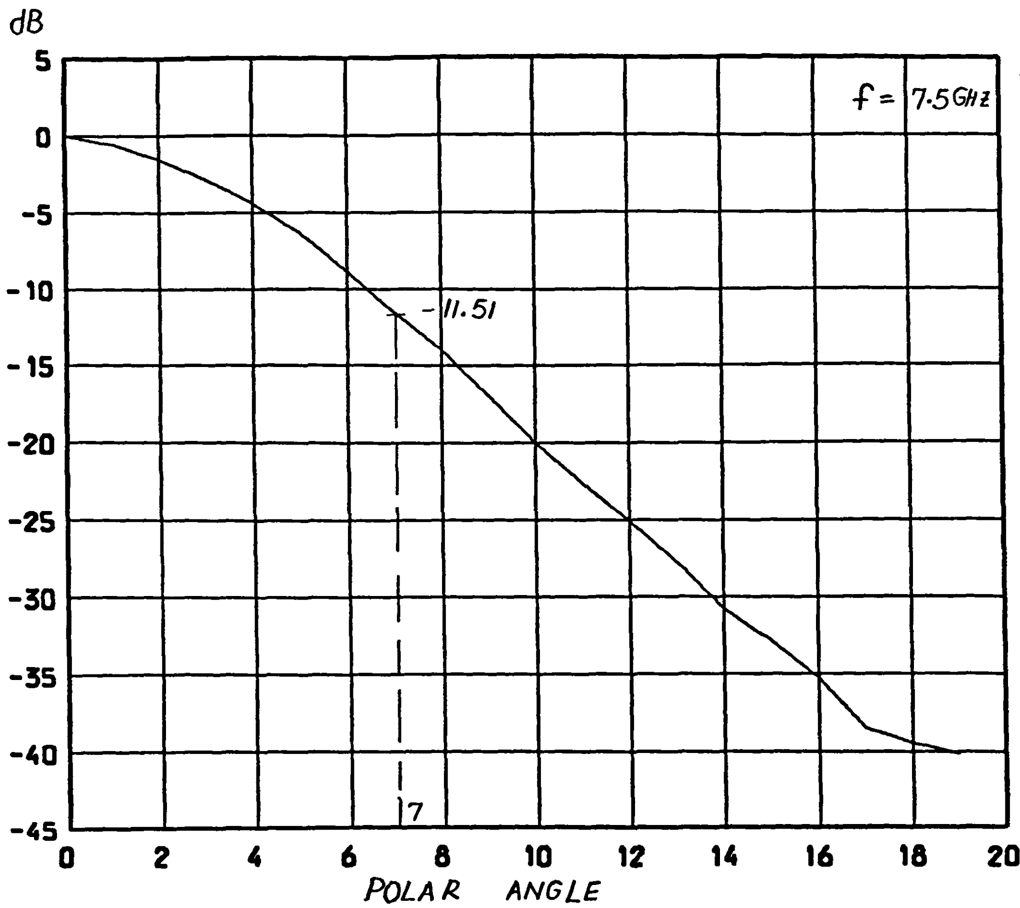
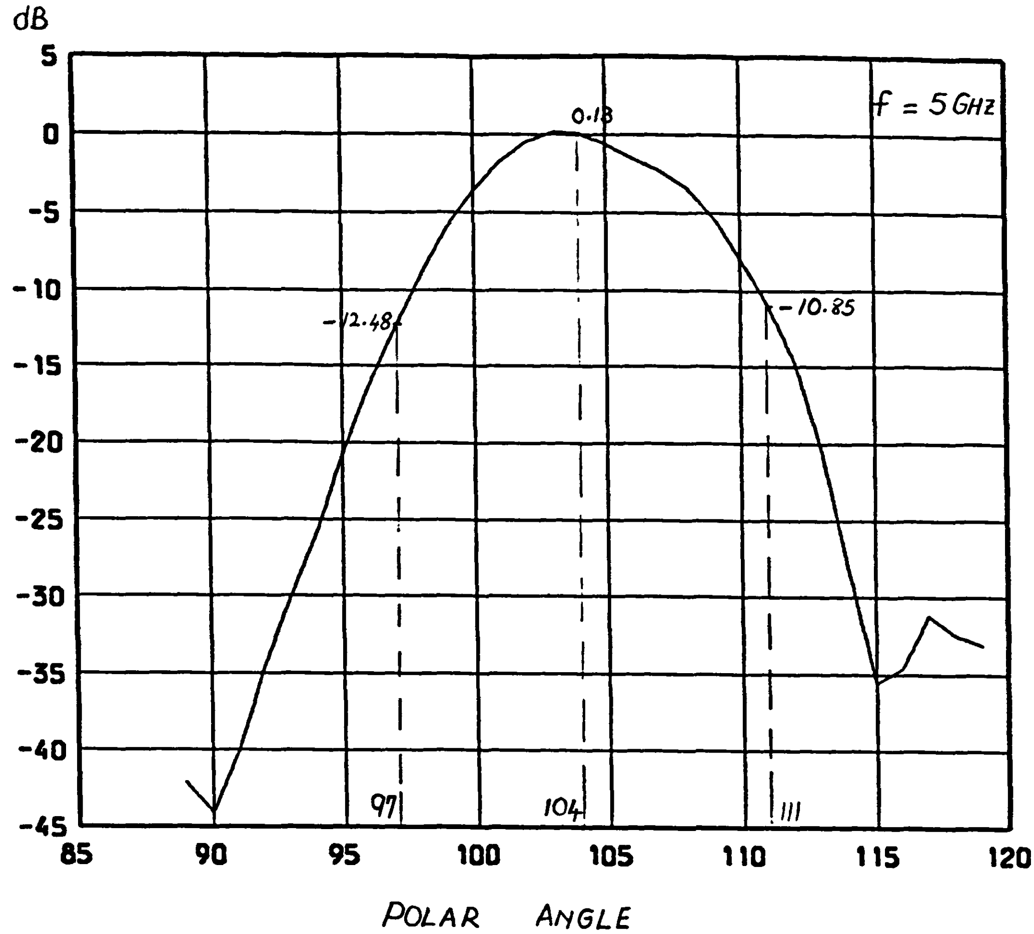


FIGURE 2. FAR-FIELD PATTERN OF C-BAND FEED



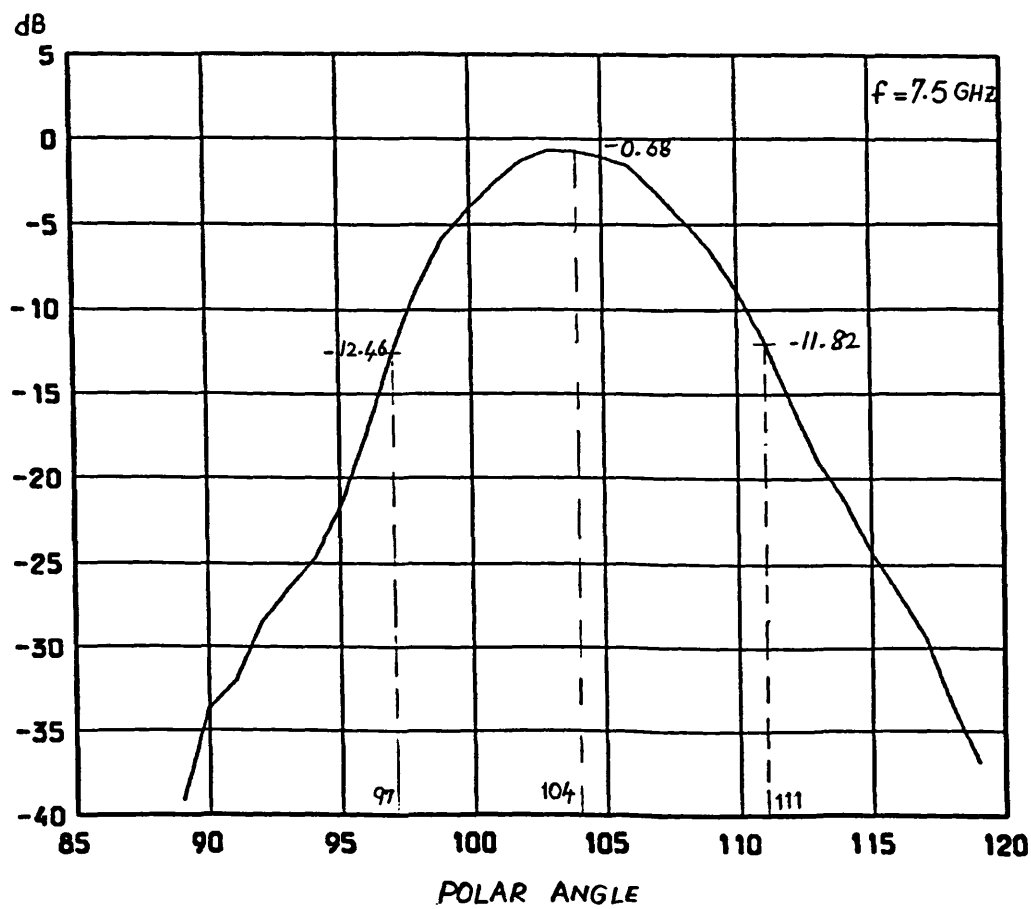


FIGURE 3. REFLECTED BEAM PATTERN

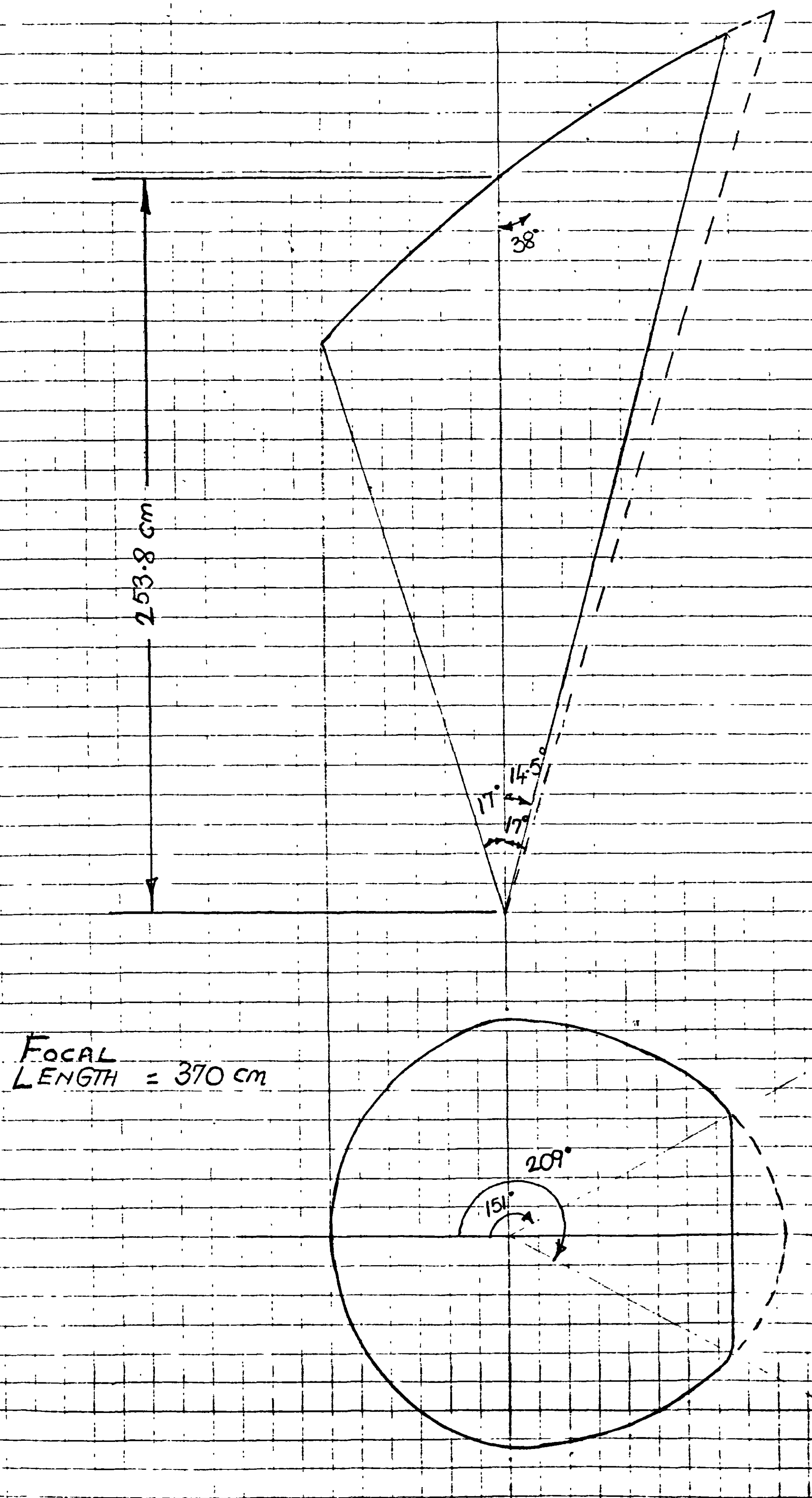


FIGURE 4