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DESIGN SCHEME FOR DUAL-BAND CAPABILITY AT 2 GHz AND 8 GHz BANDS

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The requirement for one or more dual-band operation at frequencies 5/11 GHz, 5/15 GHz, 2/8 GHz, and 15/43 GHz has been proposed for the VLBA at one time or the other. Out of these band combinations, the 2/8 GHz pair seems to have the most priority and a design scheme has been investigated for this pair of frequency bands.

The scheme proposed here enables the simultaneous use of the S- (2.15-2.35 GHz) and the X- (8-8.8 GHz) bands with coincident beams in the sky. This is achieved by the use of a dichroic (frequency selective surface) reflector which separates the two frequencies before they reach the feed horns. The layout of the feeds in the feed cone was optimized for dual-band observation at any of the above-mentioned pairs of frequencies. Figure 1 shows the plan view of the feeds. The dichroic reflector is positioned over the S-band feed and while operating at S-band or S/X bands the subreflector is positioned so that the secondary focal point lies on the phase center of the S-band feed. The dichroic reflector is designed to reflect at X-band and allow the S-band signal to pass through with minimum signal perturbations into the 2 GHz feed. The X-band signal reflected off the dichroic reflector is focused to the phase center of the 8 GHz feed by an ellipsoidal subreflector placed over that feed. Figure 2 illustrates this arrangement. An alternate scheme is to have the dichroic reflector placed over the X-band feed and have it reflect the S-band signal. The former scheme is chosen to take advantage of the small size of the ellipsoidal reflector which otherwise would be bigger roughly by the ratio of the two frequencies (8.4/2.25).

The following requirements have been satisfied to the extent possible in this design scheme, while working within the constraint of space limitations:

(a) To keep the X-band feed pattern distortionless after reflection off the ellipsoidal and dichroic reflectors.

(b) The spillover of this signal at the two reflectors be minimum.

(c) The blockage created by the two reflectors over adjacent feeds be low.

(d) The translated phase center of the X-band feed, on the axis of the subreflector, be coincident with the phase center of the S-band feed or be close to it so that defocusing is minimum at the two frequencies.

The phase center positions of the feeds as shown in Figure 2 correspond to measured values and presumed to be precise. The ellipsoidal reflector is placed at 60.5 cm above the aperture of the X-band feed at an angle of incidence 34.5°. The spillover efficiencies at this reflector at 8 and 8.8 GHz are 99.8 and 99.63%, respectively. Figure 3 shows the X-band feed pattern and Figure 4 the reflected beam pattern off the ellipsoidal reflector. For this location of the ellipsoidal reflector the dichroic reflector is placed at about 16 cm above the S-band feed aperture, at an angle of 30° to the subreflector axis. The spillover loss at this reflector is 0.32 and 0.17% at 8 and 8.8 GHz, respectively. The translated phase center of the X-band signal is about 4 cm below the feed circle radius, while the phase center of the S-band feed at worst could be 89 cm below the feed circle radius. With the subreflector moved to refocus at a point between these two phase center locations, the loss due to the phase of the signal not being perfectly constant across the subreflector is about 1% at X-band and less than 0.5% at S-band.

The dichroic reflector has a periodic array of crossed dipoles printed on a dielectric material. The dipoles resonate at X-band and reradiate most of the incident signal. The reflection coefficient is expected to be not less than 0.98. At the S-band frequency the dipoles are invisible to the larger wavelengths and hence transparent to this signal. The transmission coefficient at S-band is at least 0.96. The numbers given here are based on a theoretical analysis using the method of moments. The size of the dichroic reflector is 24" x 20.8". The half-cone angle from the phase center at 2.35 GHz to the edge of the dichroic reflector is 16.5°. It is noted that part of the signal which passes outside this reflector would have a different phase velocity compared to that which passes through the reflector. This may result in phase perturbations and needs to be assessed by measurements. To circumvent this, the dichroic reflector could be increased in size to about 27.2" x 23.5", resulting in the reflector being moved up by 1.5 cm. While doing this, the ellipsoidal reflector as well as the X-band feed would have to be raised by the same amount. The phase efficiency at X-band would decrease by 0.2%, but this loss may be offset by the increase in spillover efficiency due to the increased size of the dichroic reflector.

In conclusion, the total loss due to the introduction of the reflectors in the path of the signals is estimated not to exceed 3.5% at X-band and 5% at S-band.

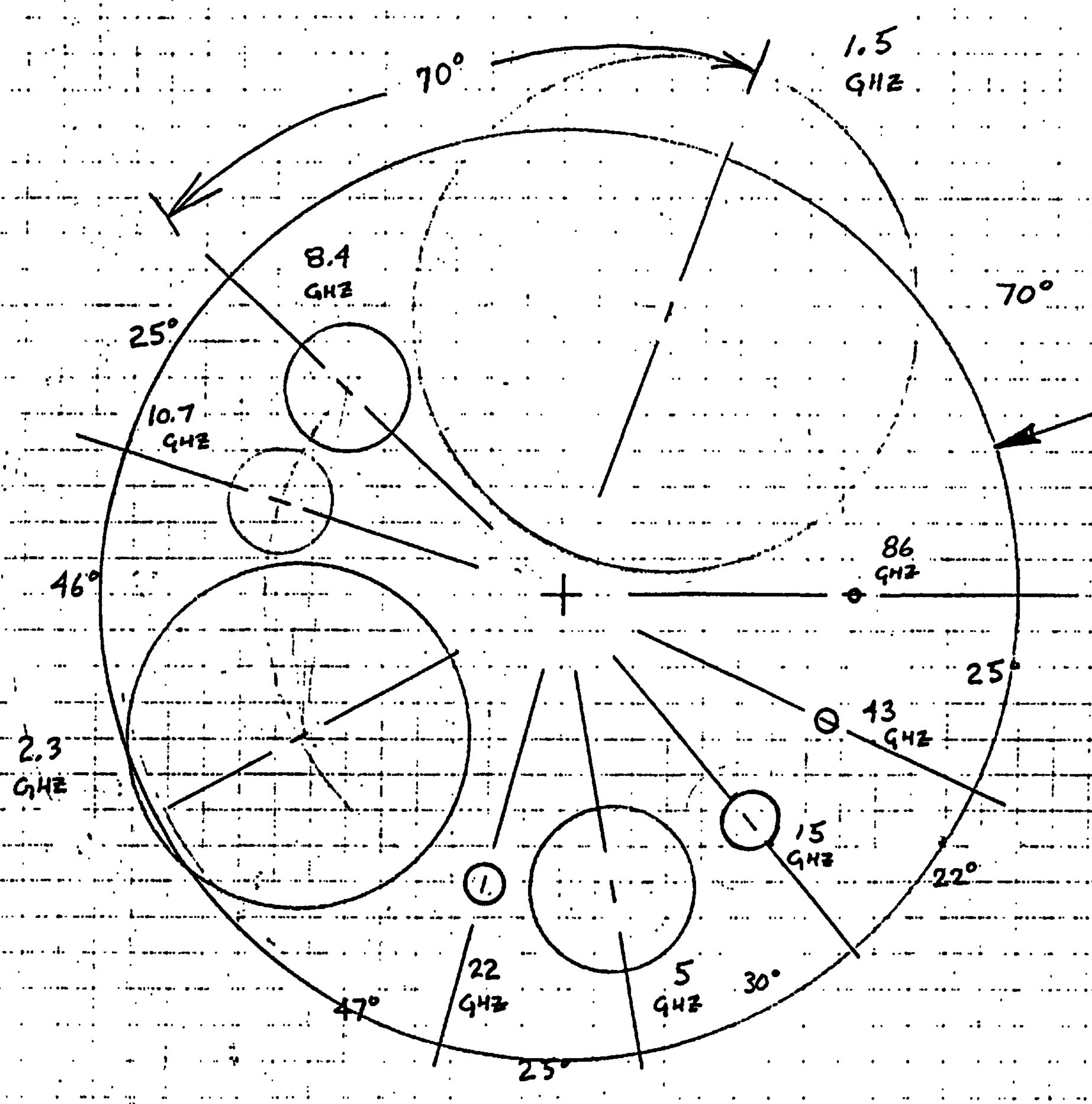
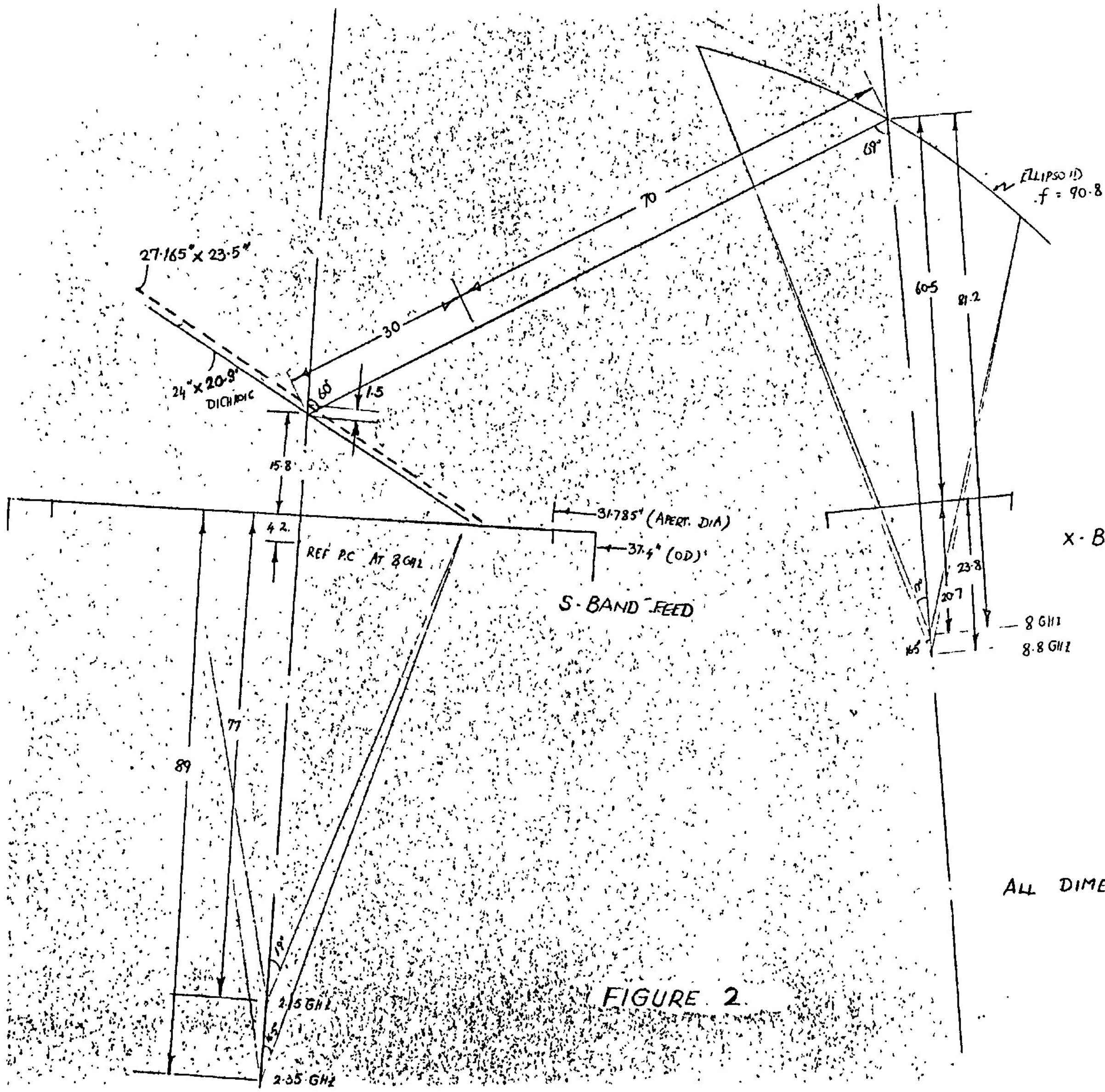

70°
1.5
GHZ
8.4
GHZ
70°
25°
50.75" RAD.
MAX. ALLOWED
AT 5" BELOW
APERATURE ℄
10.7
GHZ
86
GHZ
46°
25°
43
GHZ
2.3
GHZ
15
GHZ
22°
22
GHZ
5
GHZ
30°
47°
25°

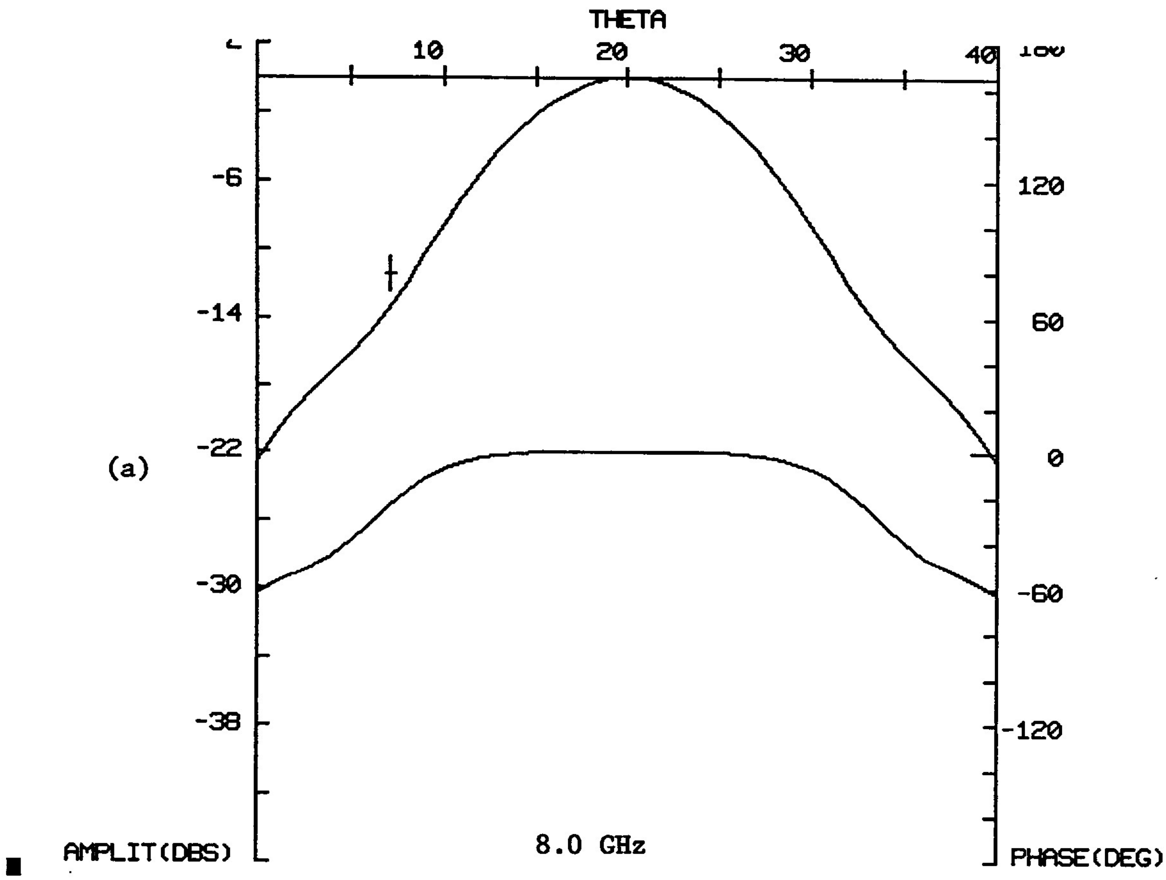
FIGURE 1



X-BAND FEED

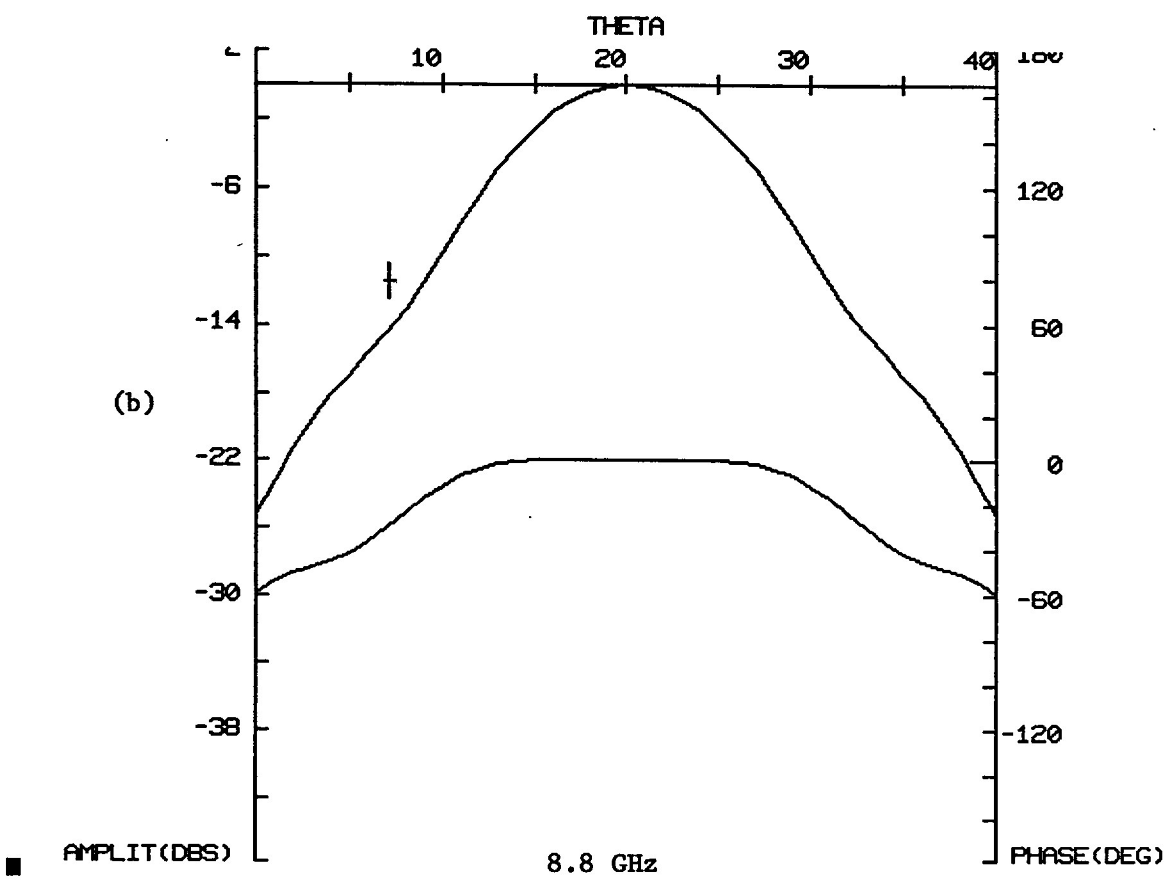
ALL DIMENSIONS IN CMS EXCEPT NOTED

FIGURE 2



(a)

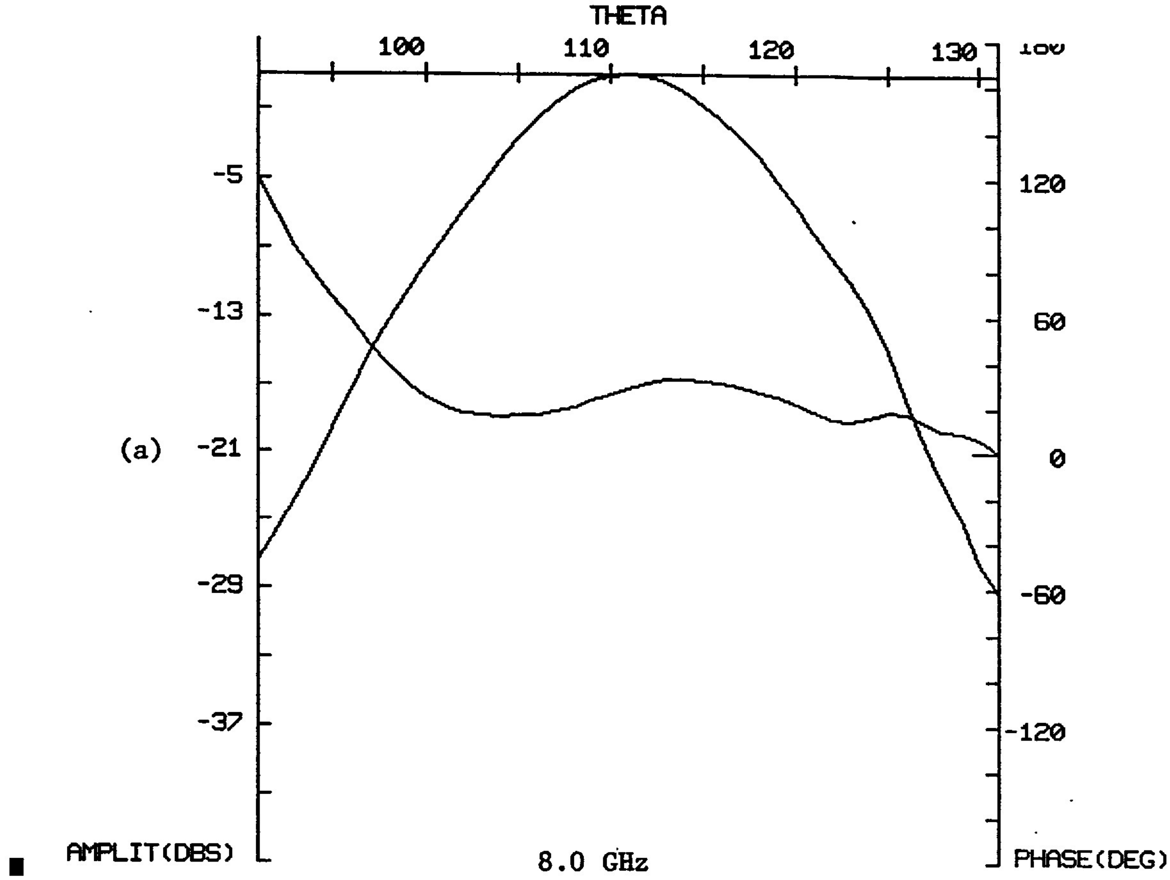
8.0 GHz



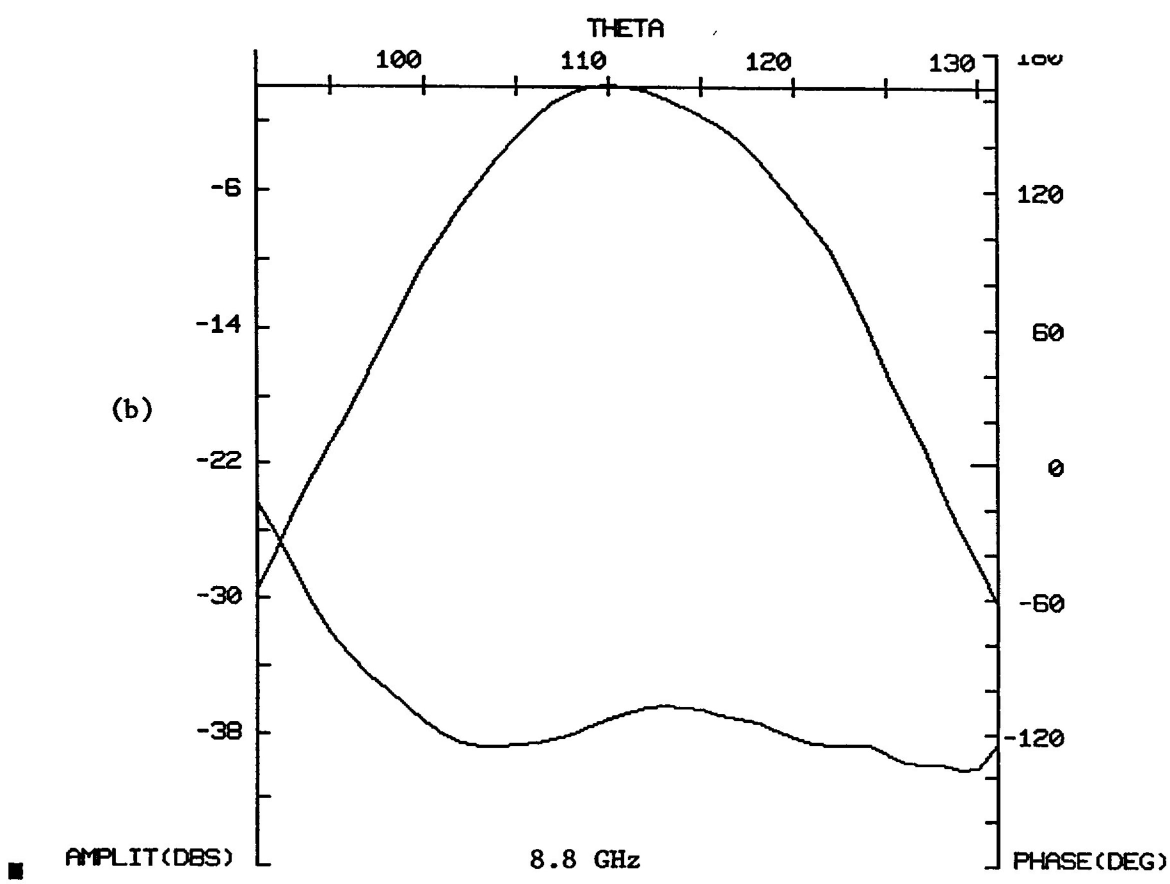
(b)

8.8 GHz

FIGURE 3: FEED PATTERN



(a)



(b)

FIGURE 4: REFLECTED PATTERN