GBT Memo No. 63

NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

GBT FEED TURRET

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May 16, 1991

Purpose

This memo describes a proposed modification to the current arrangement for the GBT feed turret and associated rooms at the secondary focus. This "Plan B" arrangement has several apparent advantages, and it is hoped that others at NRAO will consider the relative merits and provide input before it is decided whether to present the alternate design to RSI. Their schedule indicates detail work on this part of the antenna will begin in the Fall, but they should be alerted in the design review the first week of June, if it is agreed that Plan B is preferred by NRAO.

Description

The left side of Figure 1 shows a cross-section through the feed turret and the two associated rooms of the current, "Plan A", arrangement. The turret surface forms the floor of the top room and the feeds illuminate the subreflector through a large (9 ft. X 9 ft.) window in the ceiling. The larger feeds protrude through the turret into the lower room which also holds electronics racks. Feeds for about 5 GHz and above are small enough that the receiver dewars can be located in the upper room so that only a few large holes are required in the turret. Several nagging concerns with Plan A have become apparent:

1. The window is a tough design problem. Reflections from the window material, while they can be made small, may not be very stable due to wind forces moving the fabric. The window area will produce a large thermal load on the HVAC systems in the rooms; trying to insulate it runs counter to the desire for zero loss and reflection. Another concern is the possible penetration of the window by ice shedding from the subreflector and feed arm above. This has happened a couple of times to the much smaller feed radomes on the 140-foot, and would be quite a mini-disaster if it happened to the costly GBT window, giving the electronics below a bath. The window may well have to be made retractable to allow loading of large feeds into the turret and for certain observations without looking through the radome material.

2. Self-interference is a concern due to inadvertent radiation from electronics in the room reflecting off the walls and into feed sidelobes. Similarly, RFI from the room, through the window, could interfere with prime focus receivers.

3. There are limitations on the distance both above and below the focus (5 feet above, and 3 feet below except at spots where we have requested holes through the turret for the large feeds). For instance, neither the L-band feed nor the C-band array feeds are located at the optimum focus position. The L-band would like to be a few inches higher and the C-band array a few inches lower. The loss in efficiency is probably not enough to be noticeable, but it is an irritating compromise at this stage. Also a S/X dichroic reflector system will be very tight in the room.

While all these problems can probably be minimized or lived with, their cumulative effect leads one to pause and ask whether there is some alternative arrangement that will bypass many of the problems. Plan B described below appears to have several advantages.

Refer again to Figure 1. Eliminate the upper room of Plan A, and shift the lower room and turret up three feet so that the turret surface is level with the secondary focus point, leaving the feeds fixed relative to the focus. The turret now forms part of the ceiling of the (sole) receiver room, and the feed apertures protrude through it into open air. This arrangement addresses the concerns of Plan A in the following ways:

1. The large window is eliminated. Each feed will have an individual radome that can be tailored to the applicable wavelength range, and can be pressurized to keep the radome stiff, which should reduce movements due to wind.

2. There is much superior RFI shielding to the gregorian and prime focus feeds.

3. There is almost unlimited room above the focus, for dichroics and such, and increased room below, giving more freedom to position feeds.

In addition, the elimination of one of the rooms decreases the structural weight, wind cross-section, and HVAC needs on the arm.

Negatives of Plan B

A water seal will have to be designed at the joint between the rotating turret and the room ceiling. The only other obvious cost is that the turret diameter will have to increase from 12 feet to 14 feet to allow us to support the L-Band feed or a seven-feed C-Band array. This requirement is described further in the following sections.

Details of Plan B

Figure 2 shows the feed mounting arrangement that will be required. A mounting hole must be provided at each feed location, a 48 inch for a L-Band feed or C-Band array, a 36 inch for feeds in the 2-4 GHz range or large arrays at short wavelengths, and six 24 inch holes for smaller feeds or arrays. Each feed will have a mounting plate and gasket or O-ring that will bolt at the appropriate turret hole. The feeds can be lowered into the holes with a winch cable, much like is now done at the 140-foot and other antennas. The 56 inch feed circle and spacing of feeds on that circle are identical to that in Plan A, so weight distribution on the turret should be the same. There is room between any of the mounting holes for at least a 6 inch wide (wider at most) radial beam if required for strength.

Figure 3 shows a possible feed layout on the turret, indicating the relative feed aperture sizes for various operating frequencies. There are a few restrictions on where specific feeds can be located. The L-Band should go into the 48 inch hole. It will fit into the 36 inch or even the 24 inch by defocussing it (see paragraph below on arrays), but would overshadow adjacent feeds. A seven-feed C-Band array would have to go into the 48 inch hole as well. A S-Band (2.3 Ghz) feed should go into the 36 inch hole. Higher frequency feeds can fit into any of the 24 inch holes without shadowing problems.

Support for Arrays

Users would like multiple L-band feeds available for certain types of observations. Figure 4 illustrates a three-feed L-Band array that could be possible with the Plan B turret. L1 is located in the 48 inch hole; L2 and L3 are located in the adjacent 24 inch holes. L2 and L3 must be raised up by about 36 inches to fit. By moving the subreflector about 9 inches to compensate the defocussing, the aperture phase error RMS of the offset feeds is less than 3.8 mm (less than 2% gain loss). Additional gain loss will occur because of poor illumination of the main reflector by the offset feeds, but the aperture efficiency of the offset feeds should be about 90% of that of the boresight feed. One would not expect the beam shape to be too bad, but this should be confirmed. The offset beams will be about 28 arcmin from boresight (about 3 BW), 24 minutes AZ and 13 minutes EL. It does not seem possible to rotate the L-Band array to track the parallactic angle. The two feed positions adjacent to L2 and L3 could not be used because of shadowing, but the remaining three should be usable unless we run into weight limitations.

A seven-feed C-Band array has also been requested as mentioned previously. Figure 5 shows a cross section of such an array mounted on the turret. Beam spacing and performance would be identical to that in Plan A and has been discussed before. It will be necessary to remove the L-Band feed from the 48 inch hole to mount the C-Array. Rotation of the array will require an auxiliary mechanism attached to the turret.

These are the only two specific array arrangements that have been requested to date by potential users, so it is difficult to access how well Plan B would support other types. However, the following estimates have been made as to how many feed apertures would fit into various mounting holes:

45 GHz into 24 inch - 19
45 GHz into 36 inch - 75
22 GHz wideband into 24 inch - 7
15 GHz narrowband into 24 inch - 7
15 GHz wideband into 24 inch - 3

In general, it seems possible to support many conceivable array arrangements, but if someone has a specific example that will be necessary, we should consider those now.

Recommendation

Plan A was chosen over Plan B as the NRAO design concept during preparation of the RFP. At that time, we had two subreflectors and two feed circles on the turret, so B looked impractical because of the number of large holes required in the turret. In addition, the Australian Telescope uses a scheme similar to A, but with a much smaller turret and window, so it was felt that A would probably be the way to go. However, in view of the advantages of B (RF, structural, and RFI), I now feel that it should be the scheme implemented. It has aspects very similar to the VLBA, VLA, and 140-foot arrangements which are familiar and well proven. However, others in NRAO should input their views in case I have failed to consider some aspect.

FIGURE 1

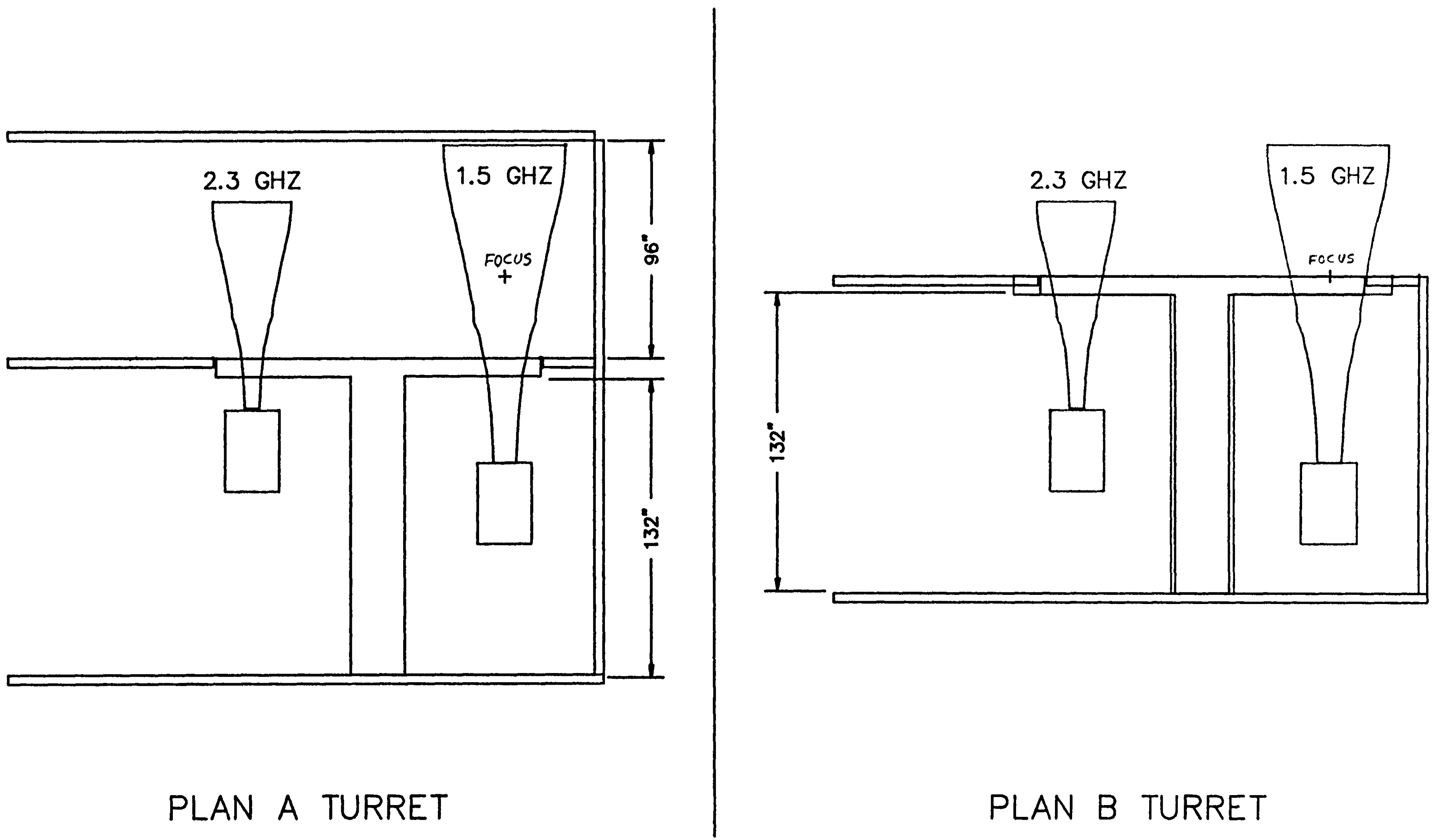

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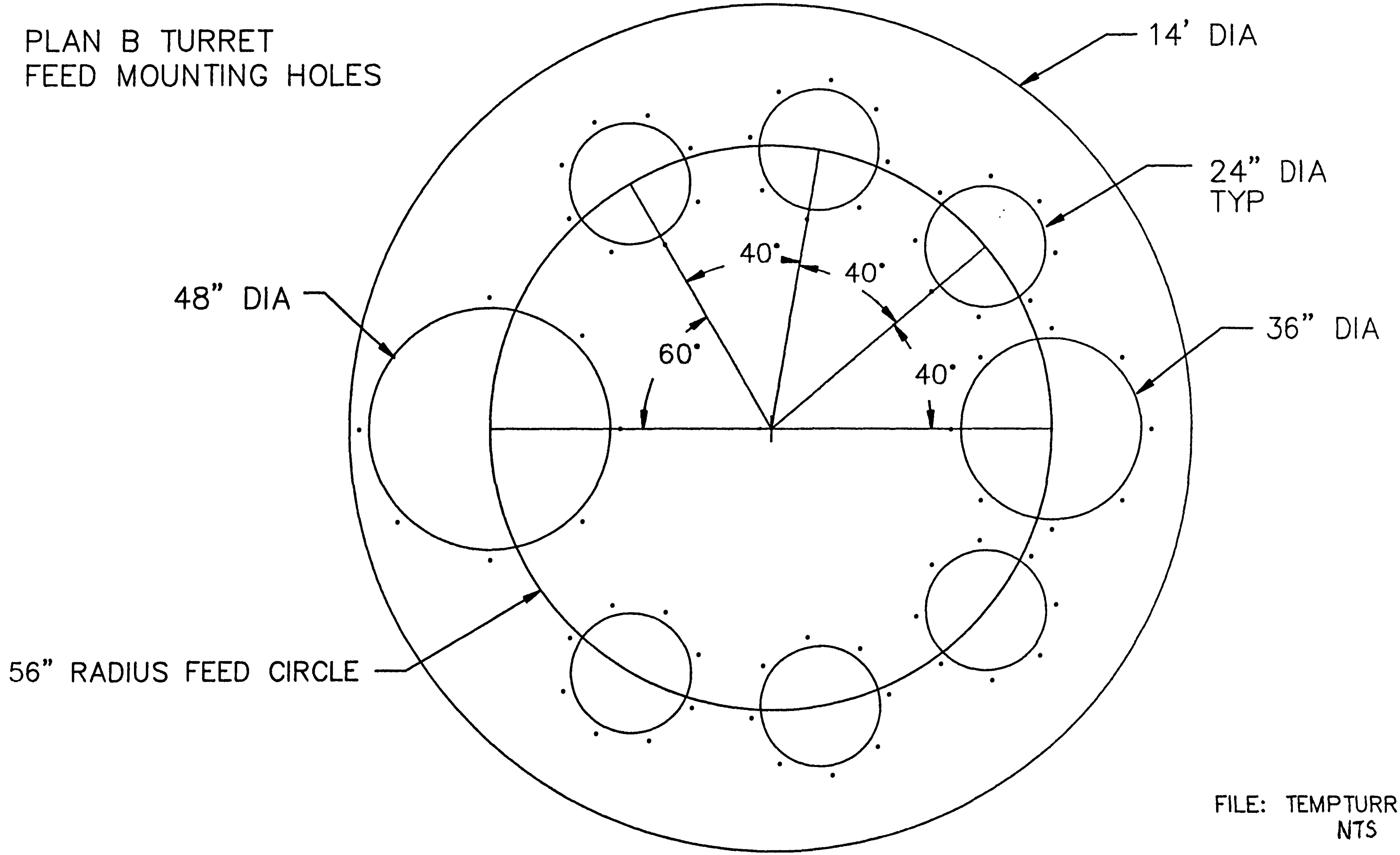
FIGURE 2



PLAN B TURRET
FEED MOUNTING HOLES
14' DIA
24" DIA
TYP
48" DIA
36" DIA
40°
40°
60°
40°
56" RADIUS FEED CIRCLE
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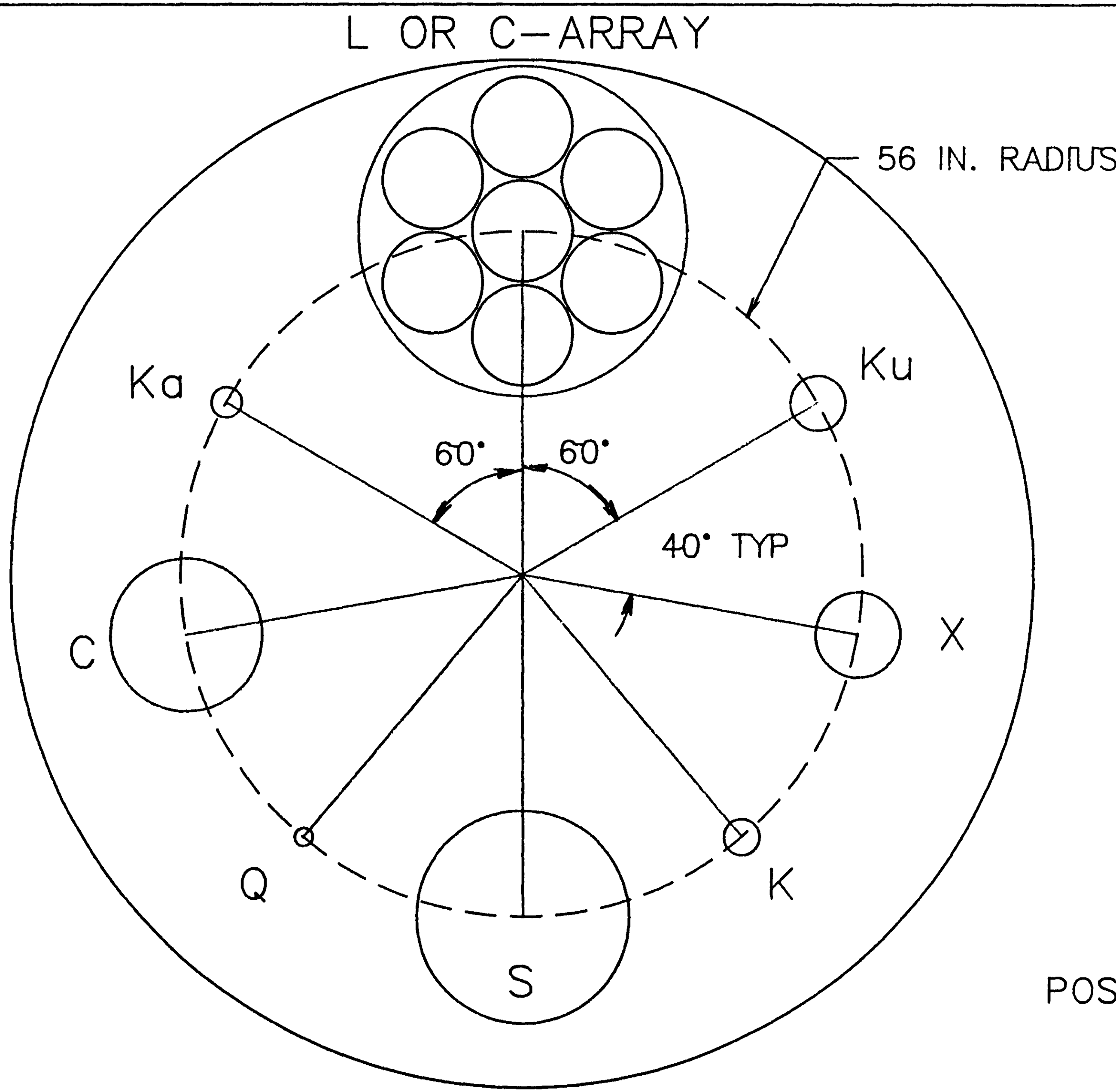
FIGURE 3



PLAN B TURRET
POSSIBLE FEED LAYOUT
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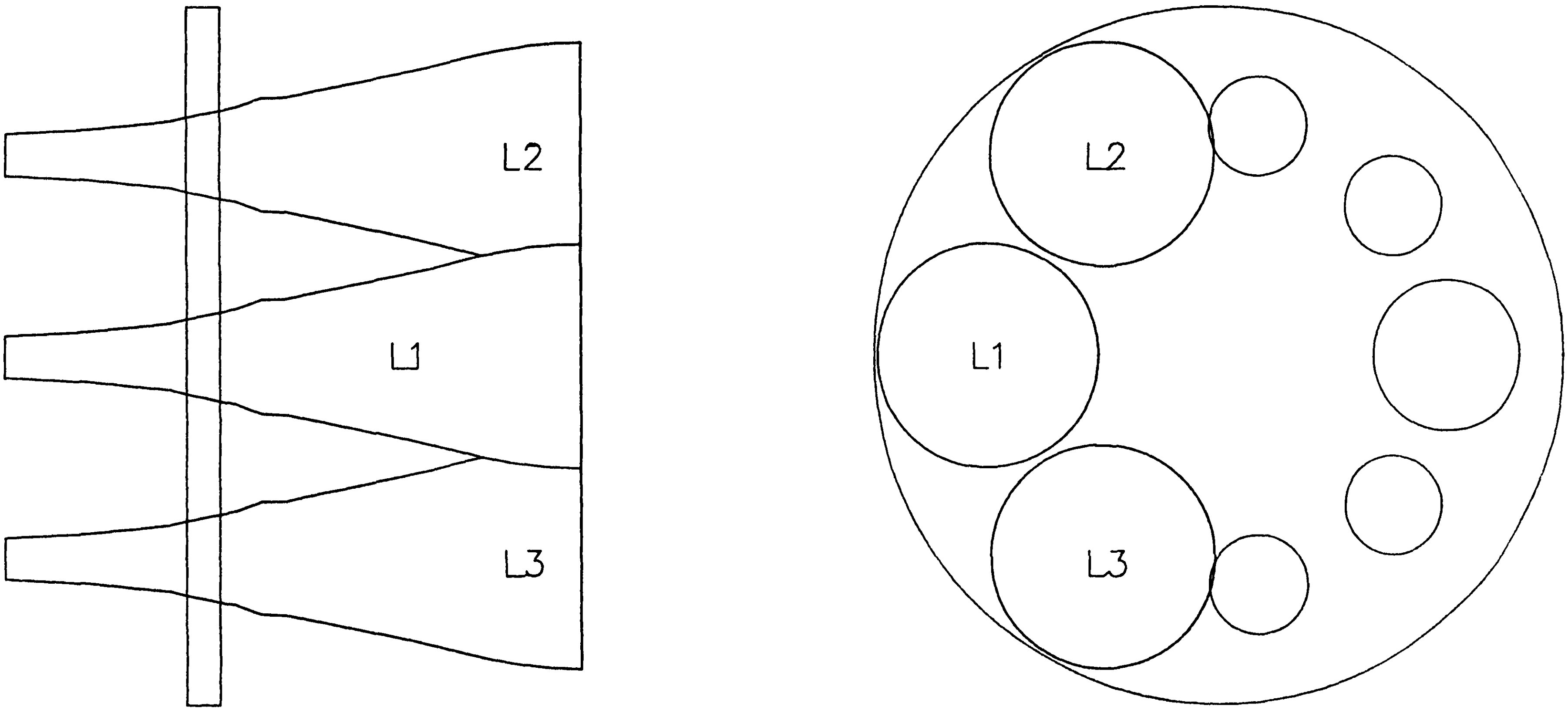
FIGURE 4
L-BAND 3-FEED ARRAY



SIDE VIEW TOP VIEW

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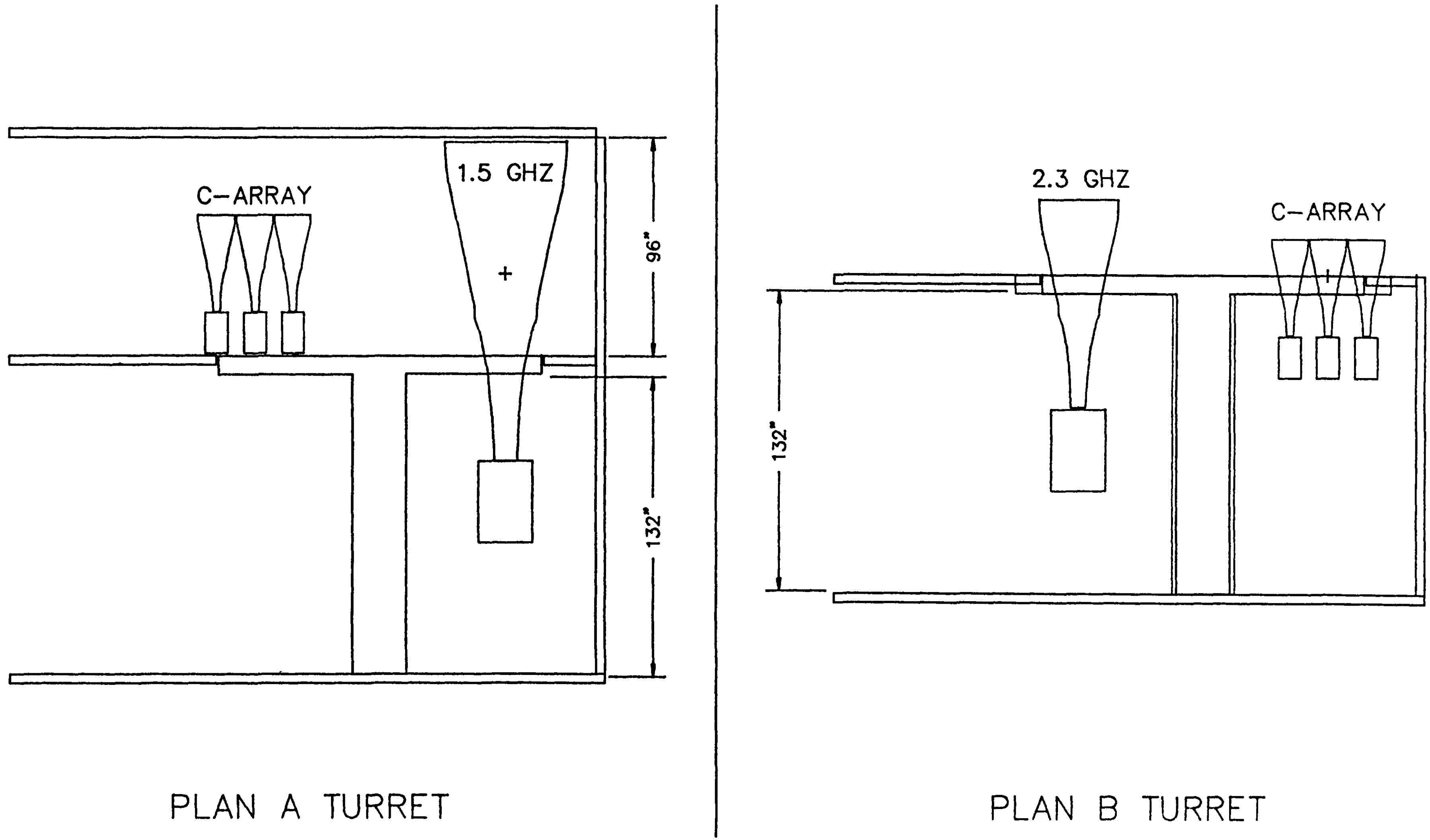
FIGURE 5
C-ARRAY



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