 OVLBI-ES MEMO NO. 52

Subject: Plan for Modifications to 45' Access Hatch
Date: 94 December 12
From: Glen Langston

Overview

This document describes planned modifications to panel # 6 of the Green Bank Earth Station (GBES) 45' antenna. Panel # 6 is one of the 24 inner antenna panels. Panel 6 contains the original access hatch which lies outside the antenna "Hub". Use of this hatch is a difficult and slightly dangerous manner for accessing the radome and tertiary optics, which lie above the antenna surface.

The modifications outlined below will replace the existing access hatch with a hatch closer to the antenna vertex. Ladders attached to the antenna are already in place which allow much easier access to the antenna surface via the new hatch.

Placing the access hatch closer to the vertex and radome, allows workers to avoid walking on most of the antenna surface, when making adjustments at the radome.

Current Status

Panel # 6 is one of 24 of the inner panels of the antenna surface. It is the 6th panel, counting clockwise from up, when viewing the antenna in its lowest elevation position. The inner panels are attached to the backup structure at 4 pairs of points, labeled A, B, C, and D in figure 1. (Also see ESSCO drawing #929-4, dated 1972 January 7.)

The original existing access hatch lies between points C and D, just outside the rib holding mounting point C. The original access hatch cover was lost, and the existing access hatch was fabricated out of a thin (0.04 in) sheet of aluminum. The existing hatch is attached to the panel at six points, but does not have any ribbed backing to keep the surface curved in the parabolic shape of the panel surface.

The panel surface is mounted on a ribbed backup structure constructed out of 0.04 inch aluminum sheets. The ribs are 3.5in tall Z-shaped structures, and have lips 5/8in on the top and bottom. In all inner panels but #6, there are 13 ribs along the tangential direction which attach to two ribs that run radially along the edge of the panel. At the joints of the ribs, gusset plates are riveted. The mounting points for the panels are at the gusset plates. At the mounting points, the gussets are drilled with 0.312 diameter holes and have captive nuts riveted above the holes.

After a decade of service, it was found that the panel surface was becoming separated from the ribs. The surfaces of all panels were re-epoxied and riveted to the backup structure. (M. Barkley private communication.)

Panel #6 has one rib removed which lies between mounting points C and D, to allow room for the trapezoid shaped access hatch. The hatch dimensions are 19.5in height, 30.0in base and 26.0in top. This hatch lies outside the antenna "hub", and is difficult to access without a long ladder reaching from the ground to the hatch, a distance of about 30 feet.

Panel Modification Plan

To allow easier access to the radome and tertiary optics, a new access

hatch will be placed inside the antenna backup structure hub. A ladder is already in place that allow access to the antenna surface from inside the hub. The existing hatch will be replaced with a stronger section of aluminum, and be more securely mounted to the rest of the panel.

The new access hatch will consist of the entire panel section setting inside the "hub", and will be attached to the backup structure as described latter.

The modifications to the panel follow the guidelines listed below:

A: Existing attachment points connecting panel ribs to antenna backup structure will not be modified.
B: No other panels will be affected by these changes.

The already existing hatch *MUST* be attached to the panel surface with sufficient strength to hold the weight of a large (~ 400 lb) person. In order to meet this requirement, a rib must be added behind the existing hatch. This rib will be bolted to the structure, to allow removal at a later date, should that become necessary.

New Access Hatch

A new rib will be added to panel 6, just inside the rib holding the "B" mounting point (see Figure 2). The new rib will have the same "Z" cross section as all existing panel ribs.
The new rib will be epoxied and riveted to the existing ribs and panel surface. After a series of checks (described later), panel 6 will be cut between the new rib and the "B" mounting point rib.
The cut width between the two pieces will 1/16th inch.
After the cut, the upper edge of the new rib will be flush with the edge of the panel surface. Figure 2 shows the "B" mounting point, the proposed location of the panel cut, the existing "B" mounting hardware, the locations of the new rib and the new mounting hardware.
This new rib is short, only approximately 14 inches. It will be shaped to the exiting curvature of panel before riveting.

The new mounting hardware (shown in Figure 3) will function identically to the existing hardware, and will consist of two pieces. One piece is an upside down "T" section bolted to the backup structure with 4 - 1/4" bolts. The top part of the new mounting hardware is an "L" structure, which is bolted to the new "T" structure.
The "L" structure will have a wide, 1" by 3/4", hole drilled 1/2 inch from extream end of the "L". An 2 1/2 inch externally tapped, hollow rod will be mounted by washers and bolts from top and bottom, in order to adjust the panel height. The design of this mounting bolt and the new mounting place attached to the rib of the panel is identical to the existing mounting points on the panels.

The panel will be attached to the backup structure with four 4 inch long, 0.25 in diameter, hex head bolts which are inserted through the hollow adjustment rod and gusset plate. These bolts will also have wing nuts added to the ends, to allow removal by hand.

Modification Sequence

The panel will be modified in three major steps:

1: Rivet the panel surface to the rib holding attachment point "B". Measure radial curvature.
2: Attach the new rib to the existing panel ribs and rivet the panel surface to the new rib. Attach gusset plates at the corners of the shorter panel section and add mounting nuts.

Measure radial curvature.
3: Cut the panel between the new rib and "B" rib.
Measure radial curvature.

Before and after each step, the radial panel curvature will be checked in the manner devised by Larry D'Addario in December 1992 (and described in Appendix A). If the panel curvature changes significantly, we will adjust the panel back to nominal curvature.

Panel Attachment

Because the mounting points of the longer section of panel 6 will not be modified, the alignment of the surface with the rest of the antenna surface will not be changed.

The "A" mounting points at the end of the sorter section of panel will not be modified. The new hatch will be adjusted so the edges of the panel are flush with the neighboring panel sections. The accuracy required is 0.02in (.5 mm).

The short section of the panel will be aligned by a straight edge between the longer section of panel 6 and the shorter section.

Access

The mounting bolts for the short section of panel 6 will have wing-nuts, so that they may be removed without tools. The steps for removing the new hatch are simple: 1) remove 4 attachment bolts, (the panel will remain in place, as it sets on the mounting points), 2) lift the panel section up and place it on an adjacent panel. The short section of panel is light, weighing not more than 30 lbs.

Existing Access Hatch

The existing access hatch will be made to conform to the parabolic shape of the panel by adding braces along the edge of the access panel, behind the panel surface. The existing hatch has tabs which rise above the antenna surface, to hold the hatch in place; these will be removed. Twelve new screws, with heads mounted flush with the antenna surface, will be used to bolt the existing hatch in place and force the hatch to follow the shape of the rest of the panel. (See figure 4.)

The replacement hatch will not be useful for access to the antenna surface, because the mounting screws are only accessible from the top, and because a new rib runs behind the replacement hatch.

Calculations show that the existing flat access hatch is 0.1in higher than the curve of a parabola (See Figure 1). When the new curved, replacement hatch is firmly attached to the existing panel, better surface accuracy should be achieved.

Appendix A: Panel Curvature check

In connection with replacing some existing antenna panels, Larry D'Addario devised a scheme for checking the panel curvature. This scheme, developed in December 1992, is described below.

The basic idea of the test is to measure the offset in panel curvature relative to a fixed length straight edge. One end of the straight edge is placed at a panel mounting point, and the straight edge

is oriented radially on the panel. The nominal deviation between the straight edge center and the panel surface is calculated below. The deviation is then measured to determine whether the panel surface lies above or below the nominal curvature.

The measurements made in January 1993 indicated that most of the inner panels were bowed down by about 0.1 inches between mounting points. This is thought to be the result of walking on the panels.

Calculation of Defections

The equation of the 45′ antenna surface is a parabola, with formula:

$$X^2 + Y^2 = 800" Z$$

Where X and Y are distances from the antenna vertex (in the plane below the antenna surface, containing the vertex) and Z is the height above the vertex plane (all measures in inches).

Since the measurements are made *along* the panel surface (not in X, Y coordinates), the displacement measurements must include a calculation of lengths along the panel and account for the fact that the offsets are measured perpendicular to the antenna surface, *not* in the Z direction. This is illustrated in Figure 5.

The device used to measure the deviations is shown in Figure 6. The radial distances from the mounting points are also given.

Measurements of a few panels on 1992 December 31 relative to mounting points "D" indicated that panel #6 accuracy was good, when compared with neighboring panels:

	Point	Measured (zero=1.028)	Depth (zero-measure)	Depth Error (Nominal-Depth)
Panel 4	D Left	.489	.539	-0.066
	D Right	.467	.561	-0.088
Panel 5	D Left	.408	.620	-0.147
	D Right	.420	.608	-0.135
Panel 6	D Left	.553	.475	-0.002
	D Right	.544	.484	-0.011

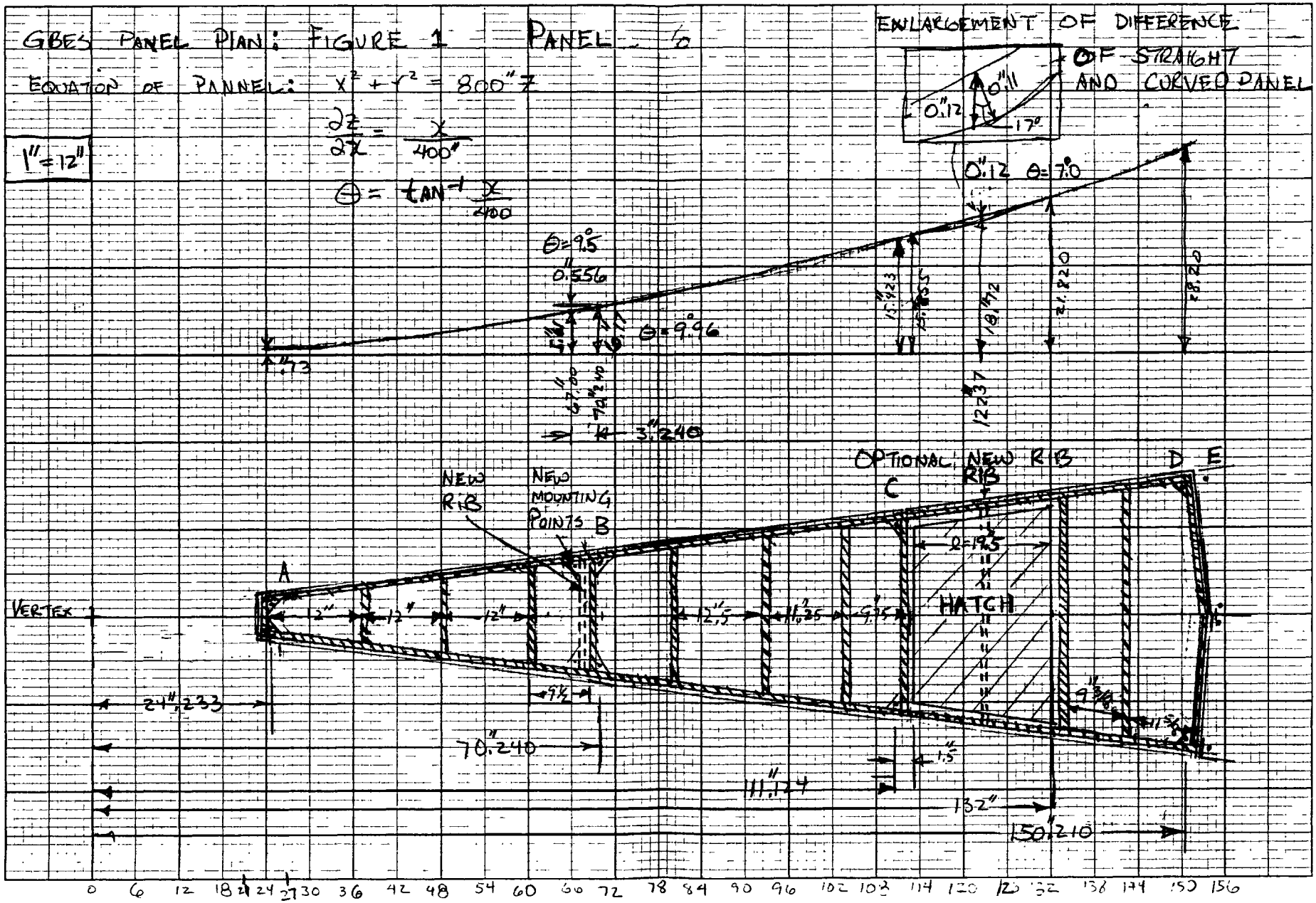
Where the nominal depth is 0.473 inches for a 42 inch straight edge. A negative depth error indicates the panel is low at the measurement point. Left or Right designations are as the panel is viewed from the antenna vertex. The measurements were made with the panels mounted on the antenna.

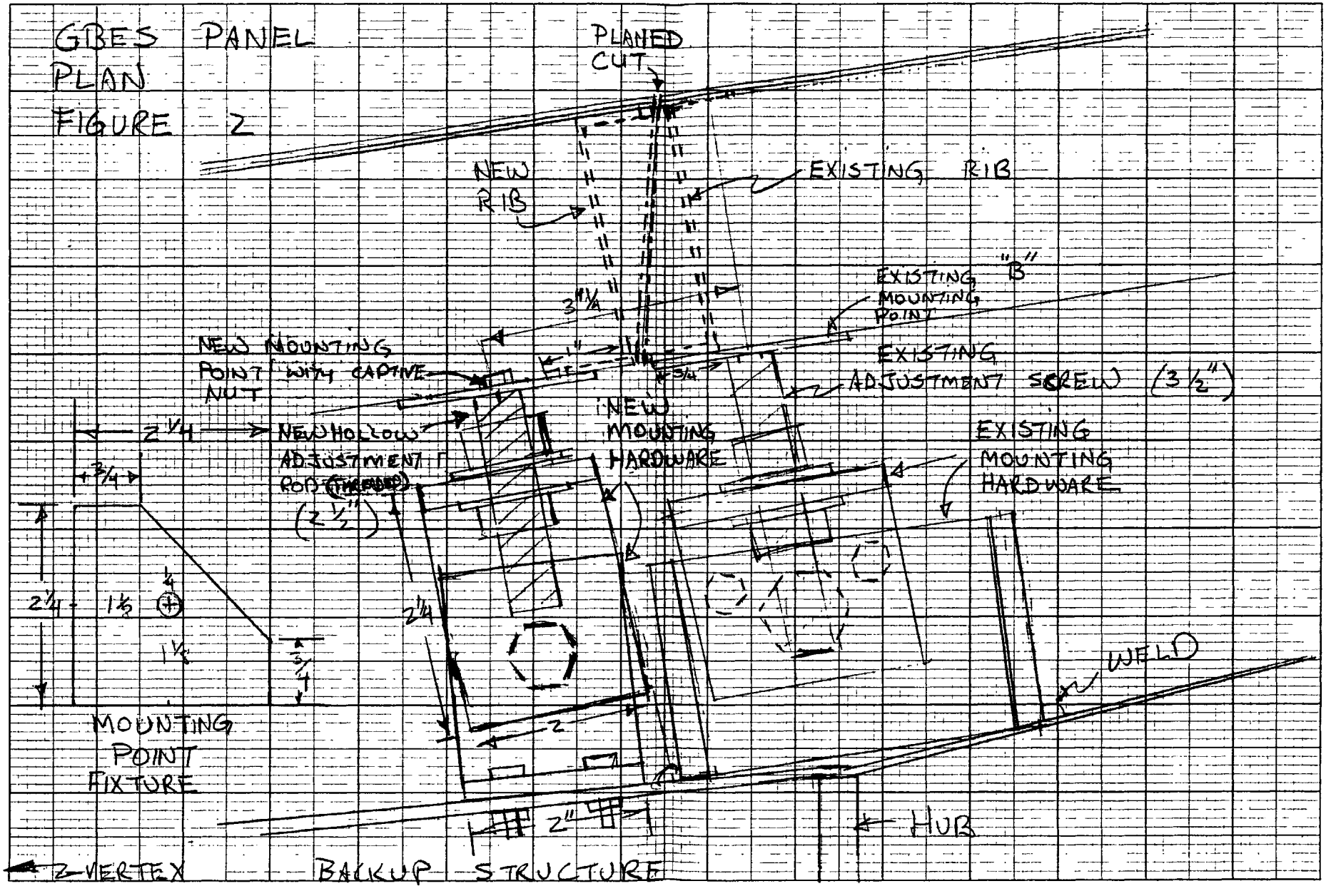
Panel 6 was re-measured on 1994 November 18, with the panel off the antenna, with the follow results:

	Point	Measured (zero=1.028)	Depth (zero-measure)	Depth Error (Nominal-Depth)
Panel 6	D Left	.562+/-.005	.466	0.007-/+.005
	D Right	.562	.466	0.007
Panel 6	C Left	.514	.514	-0.003
	C Right	.508	.520	-0.007
Panel 6	B Left	.470	.558	0.019
	B Right	.461	.567	-0.028

The point C nominal depth is 0.511in and point B nominal depth is 0.539in. The error estimate for the D left measurement was made by repeating the measurement twice.

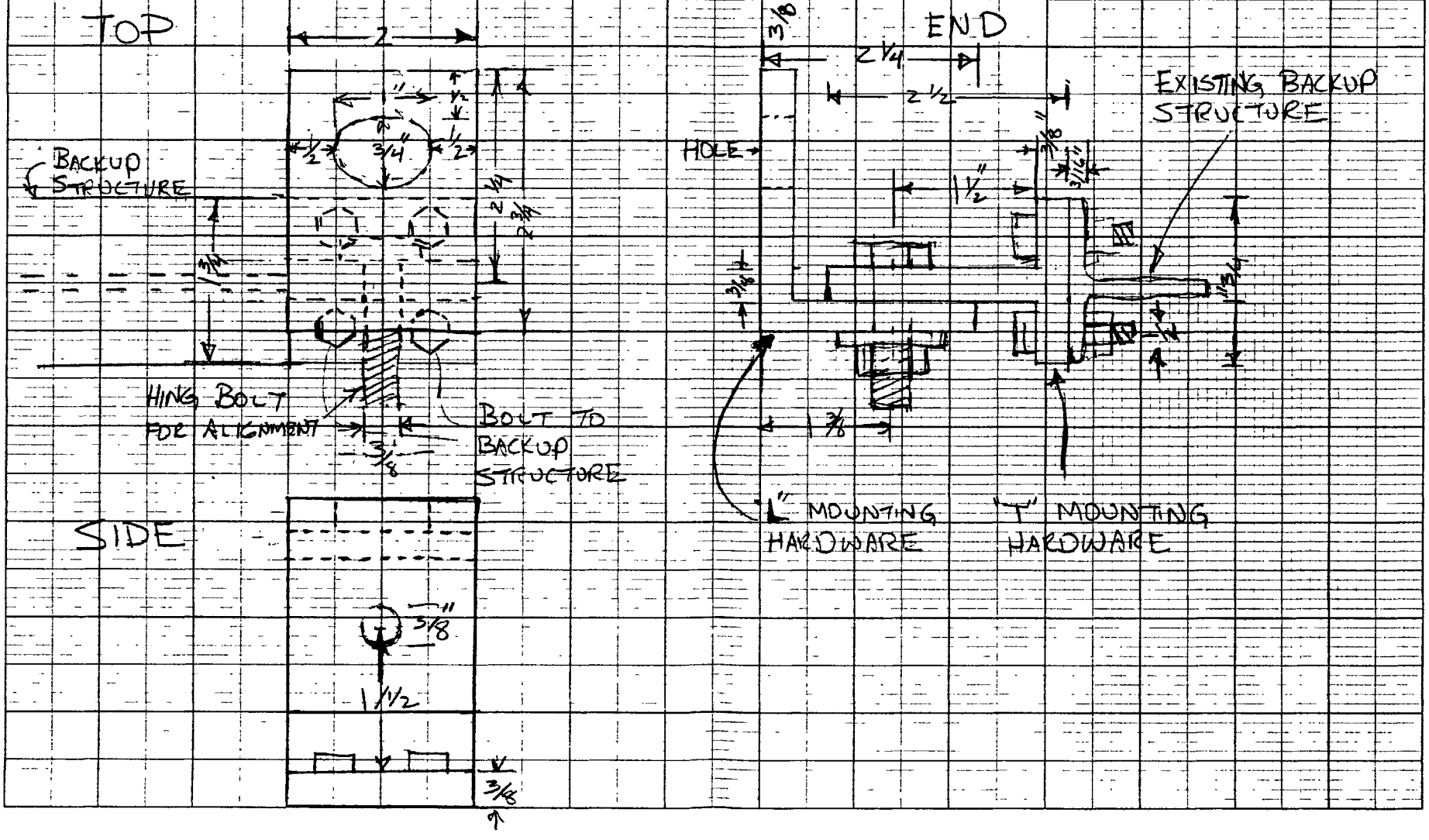
The tangential curvature of panel 6 at the center of the hatch and at the location of the new "B" rib is shown in figure 4.



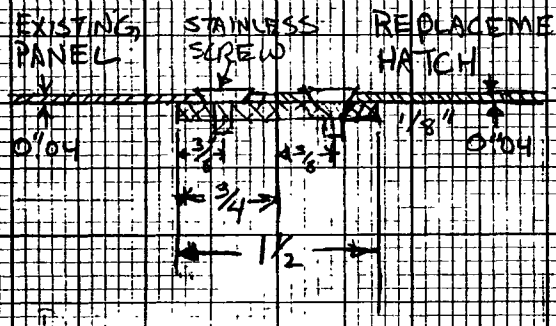


GBES PANEL PLAN

FIGURE 3: NEW MOUNTING HARDWARE



PANEL PLAN FIGURE 4



1/8" THICK ALUMINUM (6061) STRIPS WILL ATTACH PANEL TO HATCH. THE STRIPS WILL BE EPOXIED TO THE PANEL (BUT NOT TO HATCH). THE STRIP WILL ATTACH TO PANEL AND HATCH BY COUNTERSUNK FLAT HEAD SCREWS PLACED EVERY 6".

PANEL HEIGHT ABOVE VERTEX (IN)

CURVE OF PANEL (TANGENTIAL DIRECTION) IN LINE THROUGH CENTER OF HATCH

Z ∠73° X

18.718 18.729 18.763 18.819 18.898 18.999

Y

1" 2" 3" 4" 5" 6" 7" 8" 9" 10" 11" 12" 13" 14"

DPOINT OF ATCH

CURVATURE OF RIB AT "B" MOUNTING POINT: TANGENTIAL DIRECTION

NOTE THESE CURVES ARE NOT PERPENDICULAR TO THE PANEL SURFACE.

Z

HEIGHT ABOVE VERTEX (IN)

5.951 5.953 5.996 6.053

Z ∠80.5° PANEL X

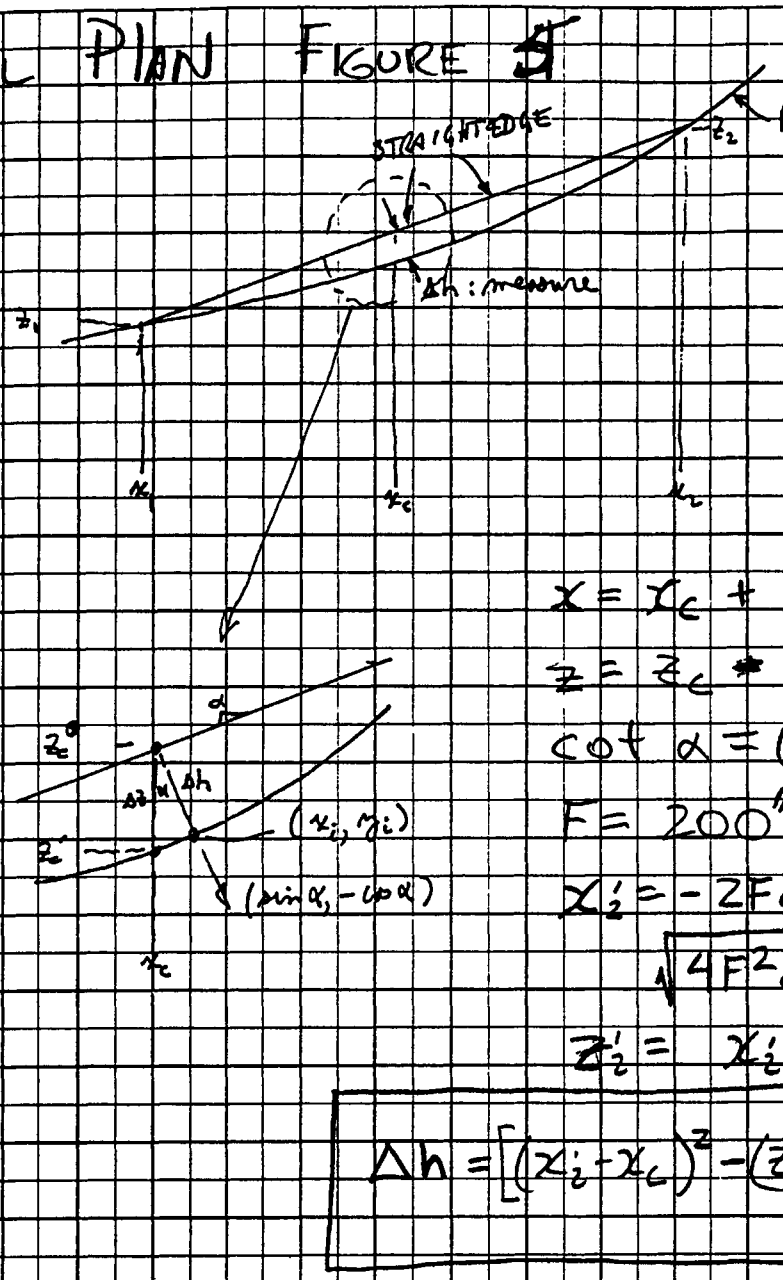
Y

5 4 3 2 1 MIDPOINT 2 3 4 5 6 7 8 9

DISTANCE FROM PANEL CENTER (IN)

NRAO

PANEL PLAN FIGURE 5



$$x = x_c + \ell \sin\alpha$$

$$z = z_c + \ell \cos\alpha$$

$$\cot\alpha = (x_2 - x_1)/(z_2 - z_1)$$

$F = 200''$ = FOCAL LENGTH

$$x_i' = -2F\cot\alpha + \sqrt{4F^2\cot^2\alpha + 4F(x_c\cot\alpha + z_c)}$$

$$z_i' = x_i'^2/4F$$

$$\Delta h = \left[(x_i' - x_c)^2 - (z_i' - z_c)^2\right]^{1/2}$$

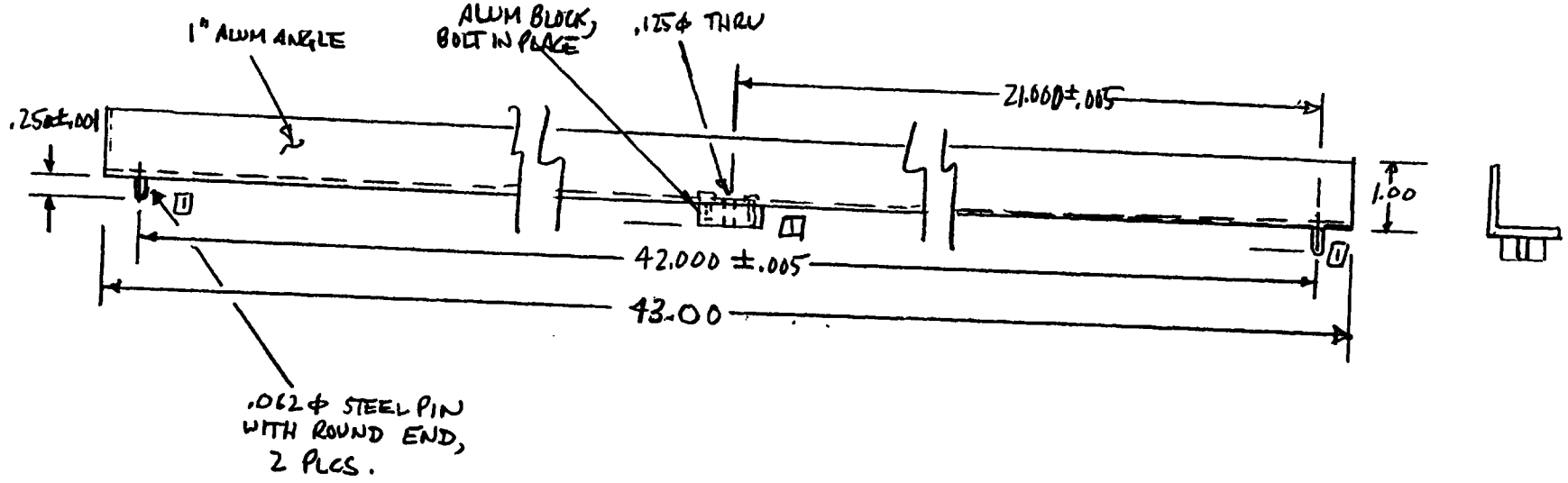
Length of bar = L: $L^2 = (x_2 - x_1)^2 + (z_2 - z_1)^2 = (x_2 - x_1)^2 + \left(\frac{x_2^2}{4F} - \frac{x_1^2}{4F}\right)^2$

given x_2, solve for x_1.

	TARGET		RADIUS	INNER R*	NOM. ΔH
INNER	A	(1)	24.272	—	—
	B	2	70.632	28.9535	0.539
	C	3	111.860	70.315	0.5117
	D	4	151.280	111.375	0.473
OUTER	E	1	154.781	—	—
	F	2	203.389	165.2475	0.413
	G	3	257.721	217.533	0.3526

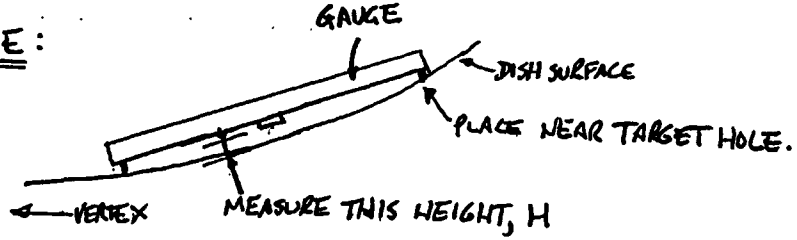
* FOR GAUGE LENGTH = 42.000", OUTER R = TARGET

18 X 25 CM



NOTE [1]: BOTTOM OF ALUM BLOCK AND ENDS OF TWO STEEL PINS MUST BE ON STRAIGHT LINE WITHIN .003".

USE:



	TARGET	NOMINAL H	TARGET R	INNER R
INNER	A	—	24.272	
	B	.50414	70.632	30.950
	C	.54696	111.860	72.885
	D	.58698	151.280	111.375
OUTER	E	—	154.781	
	F	.57742	203.389	167.072
	G	.66146	253.721	219.290

see \T2002\STRTEDGE.BAS.

45' ANTENNA
PANEL TEST GAUGE.

PANEL PLAN
FIGURE 6

921210 LRD