D. BROWN ASSOCIATES, INC.
PHOTOGRAMMETRIC STRUCTURAL CALIBRATION
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PHOTOGRAMMETRIC CALIBRATION of The 85-FOOT HOWARD E. TATEL RADIO TELESCOPE (Axis at Zenith Distance of 0°)

Prepared for:
ASSOCIATED UNIVERSITIES INC.
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NATIONAL RADIO ASTRONOMY OBSERVATORY
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SECTION 1.

Introduction

PHOTOGRAMMETRIC CALIBRATION OF THE 85-FOOT HOWARD E. TATEL RADIO TELESCOPE (Axis at Zenith Distance of 0°)

INTRODUCTION

The ensuing report presents the results of a photogrammetric calibration performed by D. Brown Associates, Inc. on the 85-Foot Howard E. Tatel Radio Telescope located at the National Radio Astronomy Observatory at Green Bank, West Virginia. This report is submitted as fulfillment and completion of the work set forth in Paragraph 1(d), Schedule A, of Subcontract No. RAP-33 between Associated Universities Incorporated and the Instrument Corporation of Florida.

The photogrammetric theory and techniques employed in this calibration are based on recently perfected adaptations and extensions, by Duane C. Brown, of his earlier derivation of the general solution to the problem of multistation analytical stereotriangulation. Inasmuch as the mathematics of the least squares adjustment and error propagation of this solution are rather involved, they will not be reproduced here. Complete detailed treatments are available in references [1], [2] and [3].

The raw data for this calibration consisted of three photographs of the antenna taken with a special 1000 mm focal length metric camera, shock-mounted in a Bell-J-2 helicopter. These photographs, taken on ultra-flat, one quarter inch thick glass plates coated with a 103-F emulsion, were obtained on 2 January 1963. The antenna, illumined by sunlight was exposed for 1/400 of a second at f/35 from three aerial stations situated on an arc approximately 510 feet from the vertex of the antenna in such a manner as to obtain a 75°

angle of intersection between the camera axes at the vertex of the antenna. Ideally this angle should be 90°, however it was necessary to decrease it to compensate for a critical foreshortening problem caused by shadow over a large area of the antenna. This shadow was caused by a combination of the low elevation angle of the sun at Green Bank at this time of the year and the vertical orientation of the dish. It was further intensified by the solid state of the surface of the antenna. The photographs were taken with the helicopter hovering at an altitude of 520 feet at each station. The antenna axis remained in a fixed position between exposures with approximately five minutes elapsing between each exposure. During this time the temperature ranged from 31°F on the ground to 22°F at an altitude of 520 feet, and wind velocity was 0 to 10 miles per hour from NNE.

Prior to exposure, 256 targets, fabricated from 1 mil thick Mylar having an adhesive backing were affixed to the dish in a predetermined pattern. These targets consisted of a solid white circle of 7.6mm diameter against a 50x50 mm square black background. One such target was also affixed to the RF head of the antenna. To permit precise scaling of the calibrated surface and analysis of anomolistic refraction a calibrated black-faced steel tape, with 7.6mm diameter white circles accurately spaced every 9 inches along its face, was stretched across the dish under controlled tension.

Figures 1, 2 and 3 are contact prints of the plates, acquired from the aerial stations, used for the calibration. The closeness of the target images on the plates made circling and numbering of the target points impractical. A graphical display of the target point distribution and identification numbers if presented in Figure 4.

The plates were processed under controlled conditions and proved to be of acceptable quality. The plates were measured on a Mann 422 C/D optical comparator and the resultant coordinates of the target images, properly

corrected for comparator errors and lens distortion, were processed through the rigorous, least squares analytical stereotriangulation adjustment on an IBM 1620 electronic computer. Ultimately the adjustment converged to a stable solution which yielded a root mean square error of 11.6 microns for plate residual vectors. This is equivalent to an angular closure of 2.32 arc seconds.

The triangulated X, Y, Z coordinates of the target points, and their associated standard deviations, are presented in Table 1. These coordinates have been properly scaled and are referred to a Cartesian system with origin at the computed vertex of the dish and with the Z axis normal to the dish at the vertex and increasing positively toward the focal point. Thus the Z axis is coincident with the axis of the best-fitting paraboloid of revolution. The positive quadrant of the YZ plane passes precisely through target No. 27 and the positive quadrant of the XZ plane passes approximately through target No. 15. The root mean square of the standard deviations of the triangulated target points (from three-station triangulations) are:

$$\sigma_x = 0.0043 \text{ feet},$$

$$\sigma_y = 0.0043 \text{ feet},$$

$$\sigma_z = 0.0061 \text{ feet}.$$

Since the diameter of the dish is 85 feet, these are equivalent to proportional accuracies of:

$$\frac{\sigma_x}{85} \cong \frac{1}{19{,}800},$$

$$\frac{\sigma_y}{85} \cong \frac{1}{19{,}800},$$

$$\frac{\sigma_z}{85} \cong \frac{1}{13{,}900}.$$

The root mean square of the standard deviations in the Z coordinate is somewhat larger than had been predicted although the mean error of the solution (11.6 microns) is consistent with expected accuracies. This is due to the previously discussed acute intersection angle of the camera axes which resulted in less than optimum geometry for the mathematical solution. Obscuration of certain targets by the feed supporting structure, and the poor quality of the plate images of a few due to sun shadow and other causes, limited triangulation of 50 of the target points to two stations. These points are noted in the data tables. In addition, several rivet heads which were measured on the horizontal orientation (points 350 - 395) were obscured by snow and therefore were not measured on this (the vertical) orientation.

Next, the plate coordinate residual vectors from each camera for each triangulated point are tabulated in Table 2. These vectors represent the differences between the projection of each triangulated point onto the plate and the measured coordinates of the image of this point on the plate. Analysis of these residual vectors revealed no patterns of systematic errors, thus from a point of internal consistency, the solution is completely satisfactory.

Finally, the X, Y, Z coordinates of each target point, and their associated covariance matrix, were utilized to determine the paraboloid of revolution which, from a statistical sense of minimum variance, best fitted the array of triangulated target points. Table 3. lists DX, DY, DZ, the X, Y, Z components of the departures of each triangulated target point from the best fitting paraboloid. Subtraction of DX, DY, DZ from X, Y, Z respectively would adjust the triangulated point to the surface of the paraboloid. Table 3. also lists the perpendicular distance, D, from each target point to the best

fitting paraboloid. A positive D signifies that a target point lies above the best fitting paraboloid, i.e. toward the focal point. The root mean square perpendicular departure was .0091 feet. This is 1.5 times the rms attributable solely to errors in triangulation. The maximum positive departure from the best fitting paraboloid was .0575 feet (target No. 18) and the maximum negative departure was .0403 feet (target No. 80). These perpendicular departure vectors have been plotted in Figure 5. The departures of these vectors from a true paraboloidal surface are sufficiently systematic to define an error surface. A map of this error surface, with isoerror contours inscribed at intervals of .005 feet, is presented in Figure 6. Finally, focal length and coordinates of the vertex of the best fitting paraboloid are discussed in Section 9.

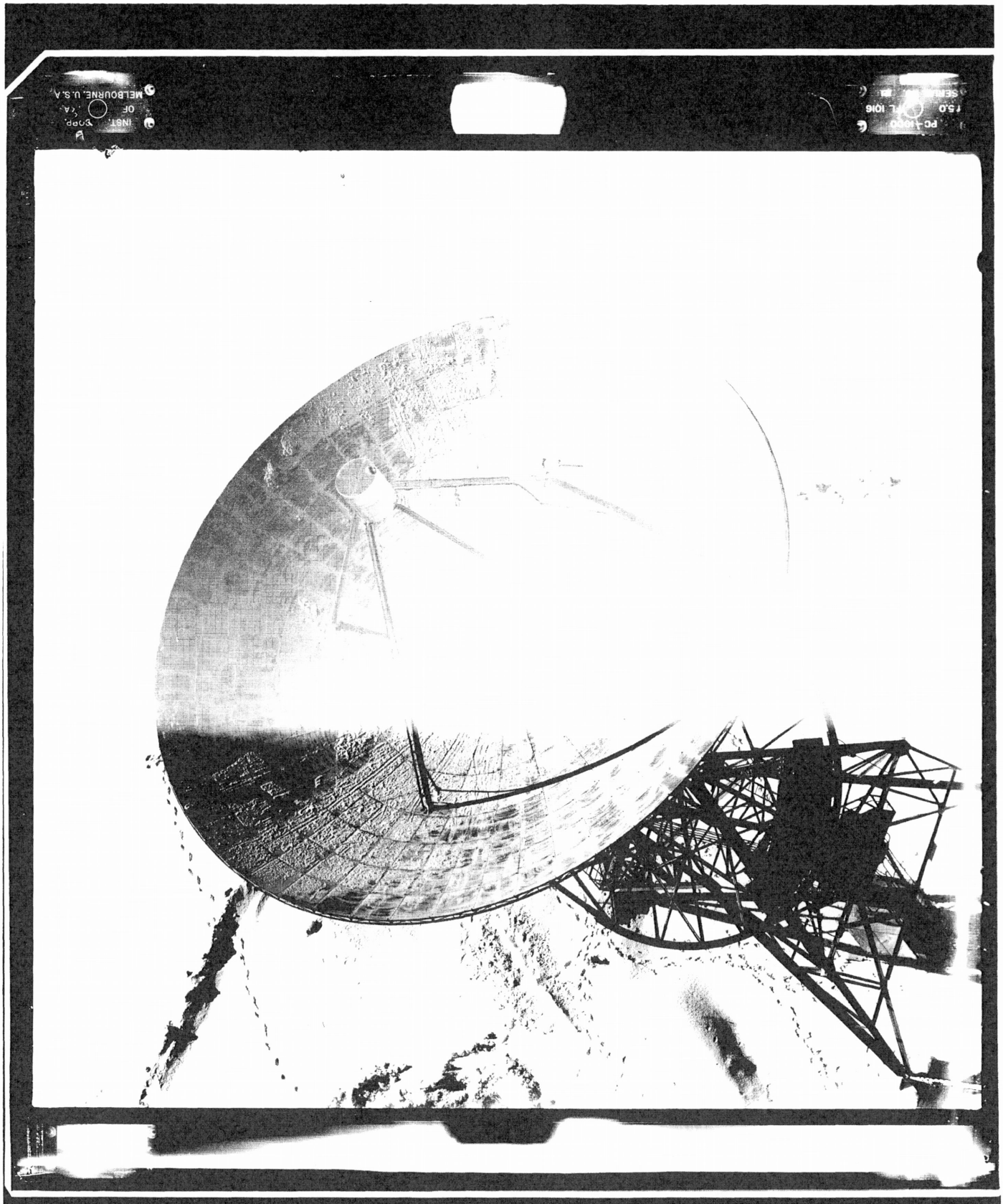

FIGURE 1. Contact print of PC-1000 plate of 85 - foot Howard E. Tatel Radio Telescope - Station 1.

SECTION 2.

Contact Prints of Calibration
Photographic Plates

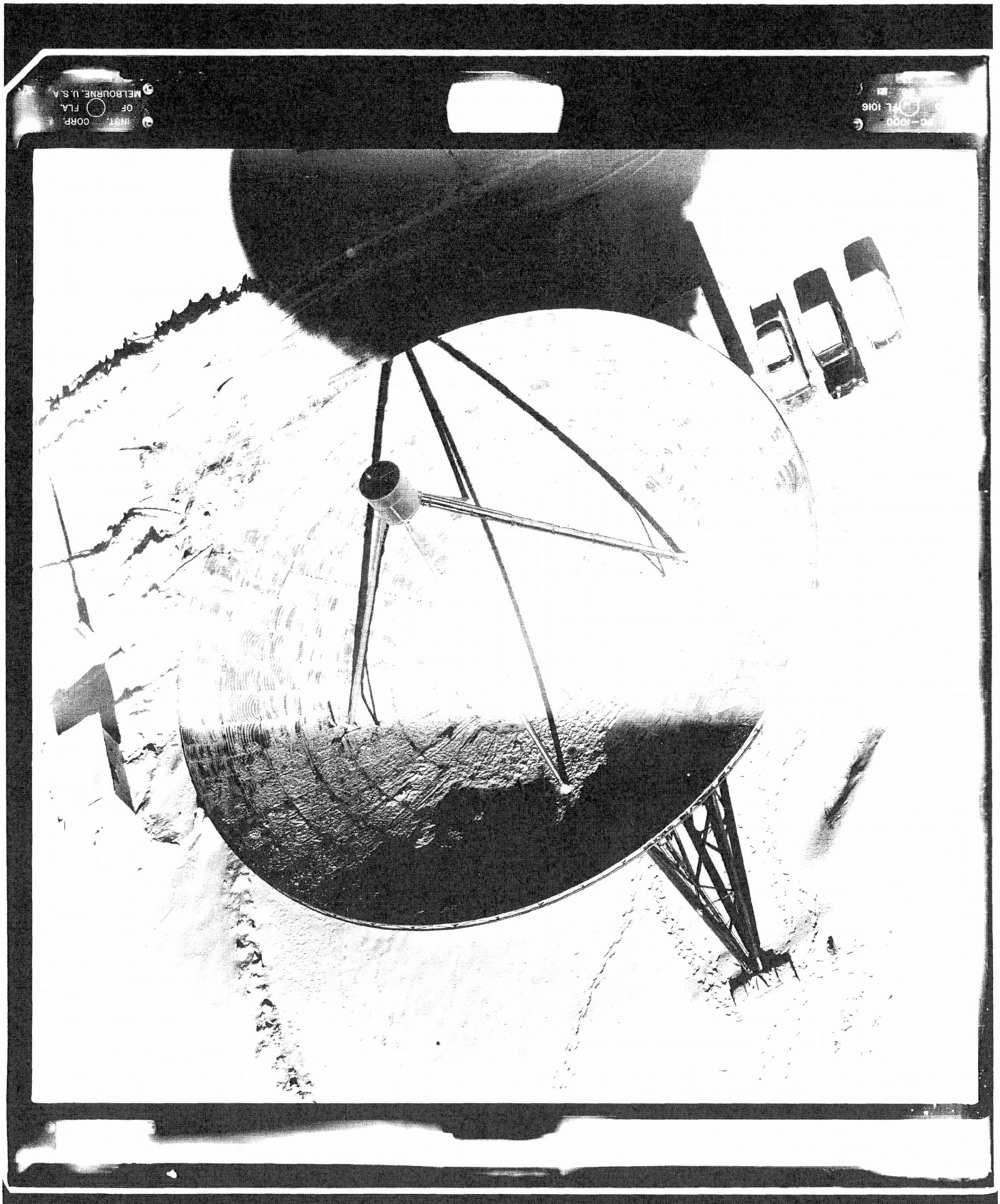

FIGURE 2. Contact print of PC-1000 plate of 85 - foot Howard E. Tatel Radio Telescope - Station 2.

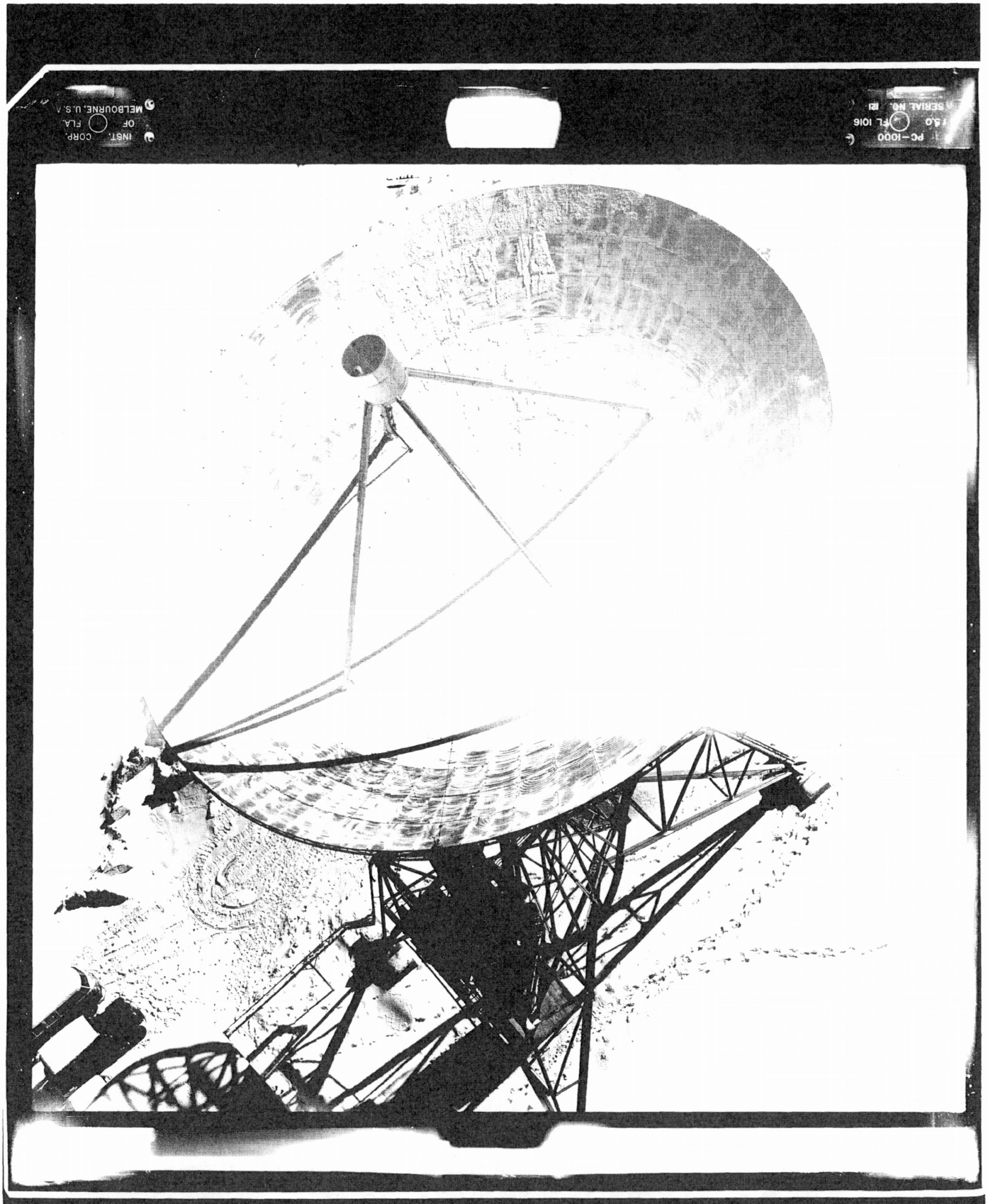

FIGURE 3. Contact print of PC-1000 plate of 85 - foot
Howard E. Tatel Radio Telescope - Station 3.

SECTION 3.

Diagram of Target Point Distribution
on Dish Surface

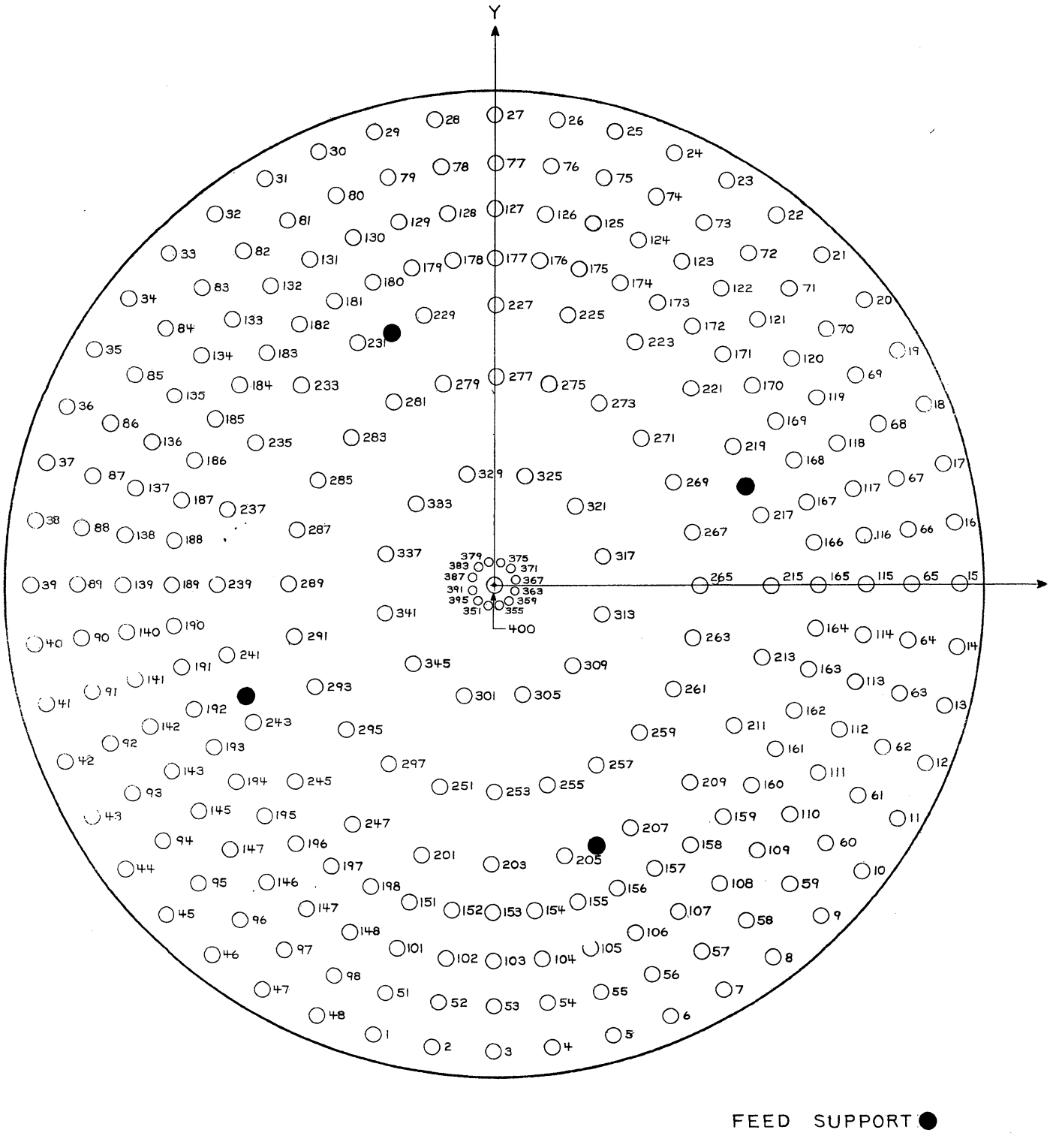

FIGURE 4. POSITION AND IDENTIFICATION OF TARGET POINTS

SECTION 4.

Vector Plot of Perpendicular Departures of Photogrammetrically Triangulated Target Points from Best Fitting Paraboloid of Revolution

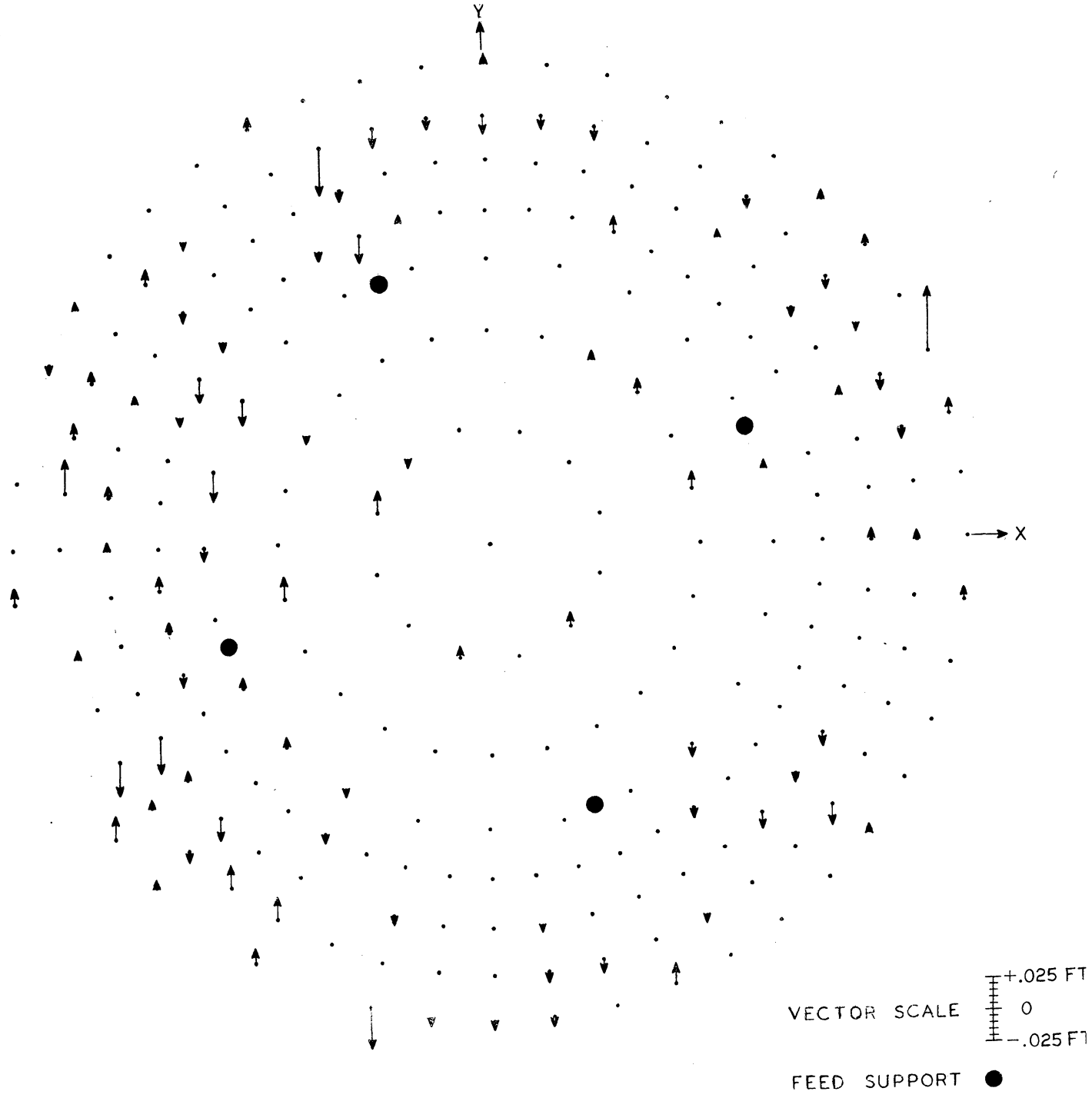

FIGURE 5. Plot of Perpendicular Departures of Photogrammetrically Triangulated Target Points from Best Fitting Paraboloid of Revolution. Positive Departures indicated by Upward Arrows, Negative Departures by Downward Arrows.

SECTION 5.

Contour Map of Error Surface of Dish

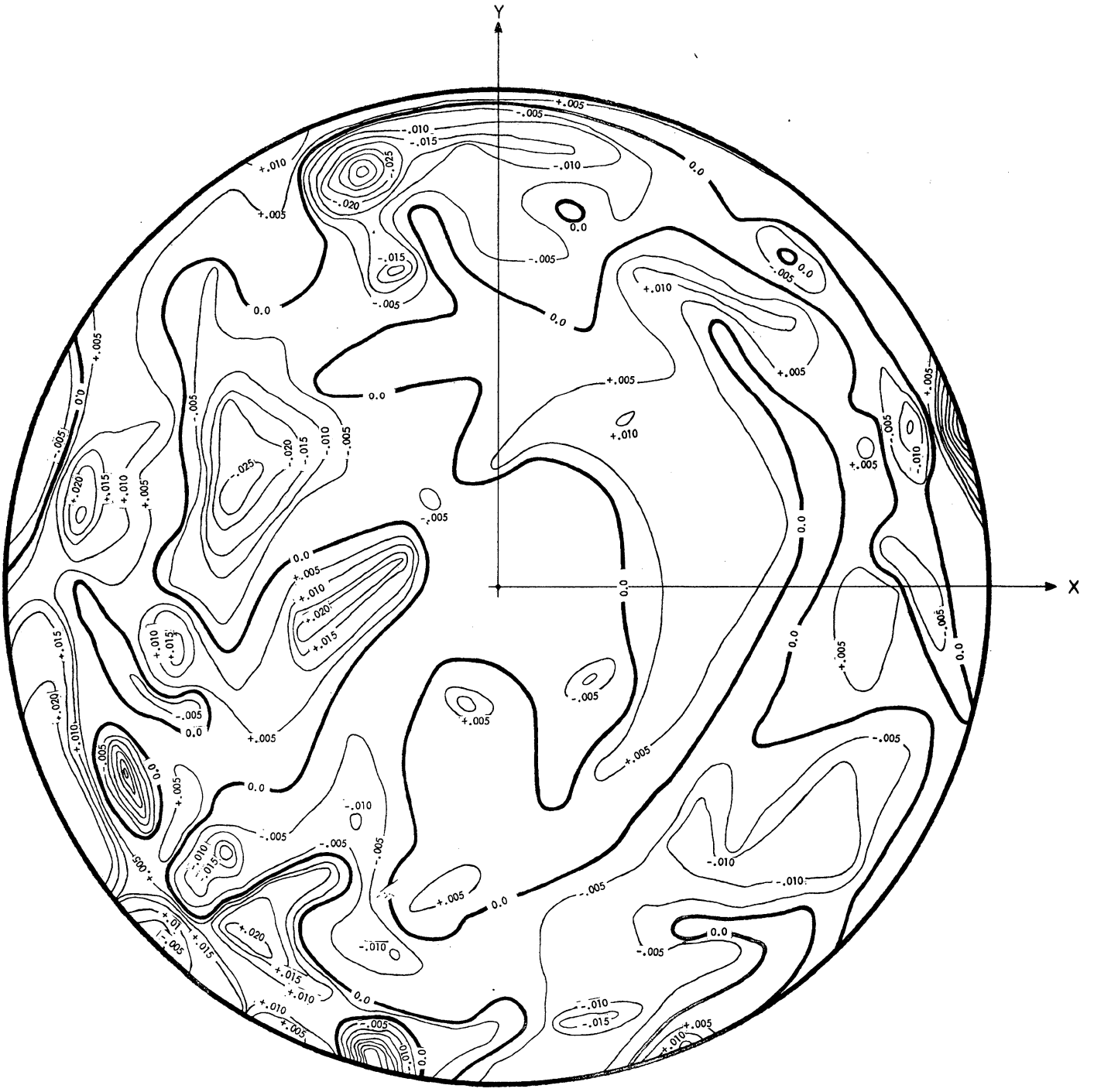

FIGURE 6. Contours of Error Surface of 85-Foot Antenna (.005 Contour Intervals)

SECTION 6.

XYZ Coordinates (and their associated standard deviations) of Photogrammetrically Triangulated Target Points (in antenna Coordinate System Associated with Best Fitting Paraboloid of Revolution).

TABLE 1. COORDINATES AND STANDARD DEVIATIONS OF TRIANGULATED TARGET POINTS.

POINT NO.	X (FEET)	Y (FEET)	Z (FEET)	X SIGMA (FEET)	Y SIGMA (FEET)	Z SIGMA (FEET)
1*	-11.2668	-40.5617	12.3015	.0058	.0063	.0086
2*	-5.8559	-41.6455	12.3305	.0059	.0060	.0087
3	-.1167	-42.0567	12.3146	.0043	.0043	.0060
4	5.1350	-41.7331	12.3085	.0043	.0042	.0060
5	10.5516	-40.7051	12.3147	.0043	.0042	.0060
6	15.7930	-38.9611	12.3314	.0043	.0042	.0060
7	20.7653	-36.5678	12.3184	.0043	.0042	.0060
8	25.3689	-33.5271	12.3097	.0043	.0042	.0060
9	29.5328	-29.9381	12.3227	.0043	.0042	.0060
10	33.2207	-25.8055	12.3359	.0043	.0042	.0060
11	36.3194	-21.2414	12.3360	.0043	.0042	.0060
12	38.7787	-16.3414	12.3414	.0043	.0042	.0060
13	40.5990	-11.1302	12.3479	.0043	.0042	.0060
14	41.7186	-5.7286	12.3651	.0043	.0042	.0060
15	42.0964	.0276	12.3505	.0043	.0042	.0060
16	41.7860	5.3165	12.3588	.0043	.0042	.0060
17	40.6390	10.7760	12.3308	.0043	.0042	.0060
18	38.9980	15.9242	12.4293	.0043	.0042	.0060
19	36.5924	20.9167	12.3810	.0043	.0042	.0060
20	33.5974	25.5097	12.4080	.0042	.0042	.0060
21	29.9666	29.6937	12.4067	.0042	.0042	.0060
22	25.8611	33.3759	12.4236	.0042	.0042	.0060
23	21.2821	36.4589	12.4213	.0042	.0042	.0060
24	16.3570	38.9443	12.4347	.0042	.0042	.0060
25	11.1456	40.7506	12.4414	.0042	.0042	.0060
26	5.7290	41.8507	12.4345	.0042	.0042	.0060
27	.0000	42.2439	12.4418	.0042	.0042	.0060
28	-5.2610	41.9342	12.4490	.0042	.0042	.0060
29	-10.6764	40.8873	12.4493	.0042	.0042	.0060
30	-15.9249	39.1666	12.4464	.0042	.0042	.0060
31	-20.8719	36.7324	12.4482	.0042	.0042	.0060
32	-25.4825	33.6953	12.4362	.0042	.0042	.0060
33	-29.6497	30.0849	12.4373	.0042	.0042	.0060
34	-33.3419	25.9678	12.4493	.0042	.0043	.0060
35	-36.4105	21.4109	12.4364	.0042	.0043	.0060
36	-38.8656	16.4835	12.4090	.0042	.0043	.0060
38*	-41.8008	5.8785	12.4058	.0050	.0054	.0079
39*	-42.1758	.1301	12.4007	.0050	.0054	.0079
44*	-33.6808	-25.3245	12.4059	.0051	.0055	.0079
45*	-30.0514	-29.5116	12.3617	.0052	.0055	.0079
47	-21.3488	-36.2526	12.3543	.0043	.0043	.0060
51	-10.0308	-36.1942	9.8268	.0043	.0043	.0060
52	-5.1997	-37.1872	9.8202	.0043	.0043	.0060
53	-.3074	-37.5424	9.8266	.0043	.0043	.0060
54	4.6039	-37.2731	9.8107	.0043	.0043	.0060
55	9.4284	-36.3489	9.8060	.0043	.0043	.0060

* TWO STATION SOLUTION

TABLE 1. (CONT.)

POINT NO.	X (FEET)	Y (FEET)	Z (FEET)	X SIGMA (FEET)	Y SIGMA (FEET)	Z SIGMA (FEET)
56	14.1113	-34.7928	9.8143	.0043	.0043	.0060
57	18.5321	-32.6530	9.8123	.0043	.0043	.0060
58	22.6318	-29.9432	9.8143	.0043	.0043	.0060
59	26.3751	-26.7300	9.8250	.0043	.0043	.0060
60	29.6635	-23.0515	9.8140	.0043	.0042	.0060
61	32.4334	-18.9735	9.8329	.0043	.0042	.0060
62	34.6329	-14.6378	9.8448	.0043	.0042	.0060
63	36.2604	-9.9053	9.8448	.0043	.0042	.0060
64	37.2575	-5.0817	9.8554	.0043	.0042	.0060
65	37.6097	-.1939	9.8454	.0043	.0042	.0060
66	37.2985	4.7511	9.8495	.0043	.0042	.0060
67	36.3750	9.5784	9.8465	.0043	.0042	.0060
68	34.8461	14.2511	9.8570	.0043	.0042	.0060
69	32.6942	18.6784	9.8727	.0043	.0042	.0060
70	29.9859	22.8145	9.8810	.0043	.0042	.0060
71	26.7731	26.5279	9.8918	.0043	.0042	.0060
72	23.0821	29.8235	9.8974	.0042	.0042	.0060
73	18.9923	32.5843	9.9098	.0042	.0042	.0060
74	14.5746	34.7951	9.9126	.0042	.0042	.0060
75	9.9318	36.4009	9.9080	.0042	.0042	.0060
76	5.1104	37.4140	9.9185	.0042	.0042	.0060
77	.1893	37.7520	9.9054	.0042	.0042	.0060
78	-4.7258	37.4644	9.9253	.0042	.0042	.0060
79	-9.5752	36.5328	9.9192	.0042	.0042	.0060
80	-14.2423	34.9908	9.8978	.0042	.0042	.0060
81	-18.6430	32.8316	9.9348	.0042	.0043	.0060
82	-22.7683	30.1115	9.9328	.0042	.0043	.0060
83	-26.4849	26.8762	9.9141	.0042	.0043	.0060
84*	-29.7692	23.1879	9.9372	.0054	.0058	.0086
85	-32.5187	19.1226	9.9214	.0042	.0043	.0060
86	-34.6951	14.6920	9.9012	.0042	.0043	.0060
87	-36.3549	10.0541	9.9258	.0042	.0043	.0060
88*	-37.3205	5.2801	9.9291	.0063	.0060	.0090
89*	-37.6875	.3349	9.8896	.0054	.0059	.0086
91*	-36.5016	-9.4379	9.9111	.0051	.0054	.0079
92*	-34.8964	-14.0748	9.8566	.0051	.0055	.0080
93*	-32.7900	-18.4827	9.8369	.0051	.0055	.0080
94*	-30.0808	-22.6002	9.8741	.0052	.0055	.0080
95*	-26.8301	-26.3501	9.8368	.0052	.0055	.0080
96*	-23.1739	-29.6143	9.8780	.0053	.0055	.0080
97	-19.0850	-32.3623	9.8556	.0043	.0043	.0060
98	-14.6796	-34.5833	9.8482	.0043	.0043	.0060
101	-8.8734	-31.9635	7.6564	.0043	.0043	.0061
102	-4.6117	-32.8171	7.6479	.0043	.0043	.0061
103	-.2949	-33.1430	7.6503	.0043	.0043	.0061
104	4.0307	-32.8862	7.6420	.0043	.0043	.0061
105*	8.3404	-32.0530	7.6354	.0058	.0052	.0082

* TWO STATION SOLUTION

TABLE 1. (CONT.)

POINT NO.	X (FEET)	Y (FEET)	Z (FEET)	X SIGMA (FEET)	Y SIGMA (FEET)	Z SIGMA (FEET)
106	12.4464	-30.7286	7.6512	.0043	.0043	.0061
107	16.3501	-28.8455	7.6627	.0043	.0043	.0061
108	19.9728	-26.4392	7.6430	.0043	.0043	.0061
109	23.2642	-23.6181	7.6424	.0043	.0043	.0061
110	26.1837	-20.3566	7.6548	.0043	.0043	.0061
111	28.6332	-16.7526	7.6524	.0043	.0043	.0061
112	30.5787	-12.8691	7.6601	.0043	.0043	.0061
113	32.0165	-8.7471	7.6805	.0043	.0043	.0061
114	32.9053	-4.4943	7.6857	.0043	.0043	.0061
115	33.2135	-.1351	7.6955	.0043	.0043	.0061
116*	33.0054	4.2169	7.7039	.0057	.0056	.0083
117	32.1427	8.4842	7.7047	.0043	.0043	.0061
118	30.7557	12.5979	7.7047	.0043	.0043	.0061
119	28.8547	16.5228	7.7033	.0043	.0043	.0061
120*	26.4972	20.1484	7.7061	.0051	.0054	.0079
121	23.6312	23.4523	7.7261	.0043	.0042	.0061
122	20.3773	26.3479	7.7406	.0043	.0042	.0061
123	16.7860	28.7810	7.7365	.0042	.0042	.0061
124	12.8871	30.7471	7.7451	.0042	.0042	.0061
125	8.7790	32.1544	7.7319	.0042	.0043	.0061
126	4.5171	33.0476	7.7550	.0042	.0043	.0061
127	.1819	33.3541	7.7451	.0042	.0043	.0061
128	-4.1697	33.0982	7.7442	.0042	.0043	.0061
129	-8.4336	32.2752	7.7549	.0042	.0043	.0061
130	-12.5603	30.9010	7.7398	.0042	.0043	.0061
131	-16.4726	29.0097	7.7553	.0042	.0043	.0061
132	-20.1153	26.6045	7.7524	.0042	.0043	.0061
133	-23.4003	23.7494	7.7443	.0042	.0043	.0061
134	-26.2756	20.4784	7.7218	.0042	.0043	.0061
135	-28.7328	16.9207	7.7447	.0042	.0043	.0061
136	-30.6717	13.0233	7.7459	.0042	.0043	.0061
137*	-32.1092	8.9153	7.7428	.0051	.0054	.0080
138*	-32.9993	4.6514	7.7513	.0051	.0054	.0080
139	-33.2859	.3197	7.7266	.0042	.0043	.0061
140	-33.0232	-4.0218	7.7133	.0042	.0043	.0061
141*	-32.1810	-8.2778	7.6859	.0051	.0055	.0080
142*	-30.8619	-12.4152	7.7118	.0051	.0055	.0080
143*	-28.9673	-16.3258	7.6661	.0058	.0063	.0088
144	-26.5689	-19.9495	7.7001	.0042	.0043	.0061
145*	-23.6937	-23.2520	7.6549	.0052	.0055	.0081
146*	-20.4528	-26.1440	7.6839	.0053	.0055	.0081
147	-16.8535	-28.5855	7.6690	.0043	.0043	.0061
151	-7.7175	-27.6147	5.7350	.0043	.0043	.0061
152	-4.0353	-28.3722	5.7237	.0043	.0043	.0061
153	-.2892	-28.6534	5.7187	.0043	.0043	.0061
154	3.4950	-28.4457	5.7170	.0043	.0043	.0061
155*	7.1699	-27.7146	5.7040	.0058	.0052	.0082

* TWO STATION SOLUTION

TABLE 1. (CONT.)

POINT NO.	X (FEET)	Y (FEET)	Z (FEET)	X SIGMA (FEET)	Y SIGMA (FEET)	Z SIGMA (FEET)
156	10.7419	-26.5775	5.7207	.0043	.0043	.0061
157	14.1360	-24.9221	5.7139	.0043	.0043	.0061
158	17.2374	-22.9009	5.7103	.0043	.0043	.0061
159	20.0917	-20.4132	5.7205	.0043	.0043	.0061
160	22.6285	-17.6160	5.7232	.0043	.0043	.0061
161	24.7511	-14.5046	5.7296	.0043	.0043	.0061
162	26.4518	-11.1850	5.7461	.0043	.0043	.0061
163	27.6679	-7.5779	5.7382	.0043	.0043	.0061
164	28.4522	-3.9164	5.7546	.0043	.0043	.0061
165	28.7316	-.1490	5.7532	.0043	.0043	.0061
166	28.4960	3.6118	5.7460	.0043	.0043	.0061
167	27.7898	7.3021	5.7493	.0043	.0043	.0061
169	24.9871	14.2769	5.7689	.0043	.0043	.0061
170*	22.9392	17.4146	5.7836	.0051	.0055	.0079
171*	20.4672	20.2725	5.7847	.0051	.0055	.0079
172*	17.6726	22.7987	5.7946	.0055	.0056	.0083
173	14.5536	24.9150	5.8060	.0043	.0043	.0061
174	11.1769	26.5991	5.8161	.0042	.0043	.0061
175	7.6131	27.8238	5.7964	.0042	.0043	.0061
176	3.9386	28.6036	5.8028	.0042	.0043	.0061
177	.1862	28.8801	5.8093	.0042	.0043	.0061
178	-3.5838	28.6579	5.8084	.0042	.0043	.0061
179	-7.2743	27.9416	5.8135	.0042	.0043	.0061
180	-10.8599	26.7411	5.7799	.0042	.0043	.0061
181	-14.2513	25.1005	5.7987	.0042	.0043	.0061
182	-17.3799	23.0387	5.7941	.0042	.0043	.0061
183	-20.2287	20.5432	5.7849	.0042	.0043	.0061
184	-22.7350	17.7663	5.7904	.0042	.0043	.0061
185*	-24.8428	14.6565	5.7723	.0063	.0061	.0091
186	-26.5332	11.3025	5.7857	.0042	.0043	.0061
187*	-27.7763	7.7361	5.7938	.0051	.0055	.0081
188*	-28.5447	4.0550	5.7902	.0051	.0055	.0081
189	-28.8310	.3139	5.7838	.0042	.0043	.0061
190	-28.5712	-3.4369	5.7831	.0042	.0043	.0061
191*	-27.8792	-7.1490	5.7888	.0063	.0059	.0090
192	-26.6945	-10.6903	5.7492	.0042	.0043	.0061
193*	-25.0714	-14.0494	5.7597	.0056	.0059	.0087
194	-22.9916	-17.2288	5.7517	.0043	.0043	.0061
195	-20.5220	-20.0888	5.7437	.0043	.0043	.0061
196	-17.7117	-22.5661	5.7269	.0043	.0043	.0061
197	-14.6020	-24.6949	5.7440	.0043	.0043	.0061
198	-11.2423	-26.3888	5.7241	.0043	.0043	.0061
201	-6.5264	-23.1923	4.0475	.0043	.0043	.0061
203*	-.2488	-24.0689	4.0414	.0058	.0053	.0083
205*	5.9949	-23.3058	4.0385	.0058	.0053	.0083
207*	11.8759	-20.9656	4.0467	.0058	.0053	.0083
209	16.8814	-17.1513	4.0237	.0043	.0043	.0061

* TWO STATION SOLUTION

TABLE 1. (CONT.)

POINT NO.	X (FEET)	Y (FEET)	Z (FEET)	X SIGMA (FEET)	Y SIGMA (FEET)	Z SIGMA (FEET)
211	20.8062	-12.1760	4.0524	.0043	.0043	.0061
213	23.2585	-6.3826	4.0554	.0043	.0043	.0061
215	24.1456	-.1210	4.0596	.0043	.0043	.0061
217	23.3792	6.1493	4.0787	.0043	.0043	.0061
219	20.9883	12.0187	4.0793	.0043	.0043	.0061
221	17.2071	17.0469	4.0924	.0043	.0043	.0061
223*	12.2477	20.9420	4.1032	.0051	.0055	.0080
225	6.4182	23.4059	4.1042	.0043	.0043	.0061
227	.1698	24.2925	4.1116	.0042	.0043	.0061
229	-6.0937	23.5234	4.1144	.0042	.0043	.0061
231	-11.9378	21.1509	4.1094	.0042	.0043	.0061
233	-16.9892	17.3585	4.1142	.0042	.0043	.0061
235	-20.8770	12.3600	4.0817	.0042	.0043	.0061
237*	-23.3717	6.5610	4.1340	.0056	.0059	.0088
239	-24.2025	.3058	4.0697	.0042	.0043	.0061
241*	-23.4255	-5.9286	4.0659	.0052	.0055	.0081
243	-21.0783	-11.7894	4.0735	.0043	.0043	.0061
245*	-17.3062	-16.8391	4.0729	.0057	.0060	.0088
247	-12.3273	-20.7231	4.0405	.0043	.0043	.0061
251	-4.7801	-16.7518	2.1172	.0043	.0043	.0061
253	-.2618	-17.4060	2.1141	.0043	.0043	.0061
255	4.2879	-16.8564	2.1062	.0043	.0043	.0061
257	8.5401	-15.1543	2.1157	.0043	.0043	.0061
259	12.1636	-12.4317	2.1167	.0043	.0043	.0061
261	15.0220	-8.8141	2.1188	.0043	.0043	.0061
263	16.8259	-4.6177	2.1263	.0043	.0043	.0061
265*	17.4610	-.1050	2.1214	.0052	.0056	.0081
267	16.9205	4.4338	2.1491	.0043	.0043	.0061
269	15.2131	8.6986	2.1368	.0043	.0043	.0061
271	12.4960	12.3360	2.1612	.0043	.0043	.0061
273	8.8928	15.1589	2.1618	.0043	.0043	.0061
275	4.7057	16.9727	2.1637	.0043	.0043	.0062
277	.1575	17.6106	2.1643	.0043	.0043	.0062
279*	-4.3958	17.0646	2.1722	.0052	.0056	.0081
281*	-8.6242	15.3796	2.1612	.0052	.0056	.0081
283*	-12.3370	12.5903	2.1713	.0052	.0057	.0082
285*	-15.0919	9.0253	2.1489	.0053	.0055	.0082
287	-16.9085	4.8351	2.1508	.0043	.0043	.0061
289	-17.5532	.3151	2.1541	.0043	.0043	.0061
291*	-16.9915	-4.2243	2.1603	.0053	.0055	.0082
293	-15.2856	-8.4312	2.1303	.0043	.0043	.0061
295	-12.5686	-12.1281	2.1198	.0043	.0043	.0061
297	-8.9679	-14.9524	2.1198	.0043	.0043	.0061
301	-2.6711	-8.8179	.6022	.0043	.0043	.0062
305	2.1142	-8.9280	.5851	.0043	.0043	.0062
309	6.3520	-6.6477	.5782	.0043	.0043	.0062
313	8.8789	-2.5099	.5872	.0043	.0043	.0062

* TWO STATION SOLUTION

TABLE 1. (CONT.)

POINT NO.	X (FEET)	Y (FEET)	Z (FEET)	X SIGMA (FEET)	Y SIGMA (FEET)	Z SIGMA (FEET)
317*	8.9802	2.2752	.5949	.0059	.0055	.0084
321	6.6936	6.5310	.6131	.0043	.0043	.0062
325	2.5664	9.0336	.6110	.0043	.0043	.0062
329*	-2.2436	9.1443	.6226	.0054	.0056	.0083
333	-6.4524	6.8364	.6087	.0043	.0043	.0062
337	-8.9427	2.7208	.6289	.0043	.0043	.0062
341	-9.0775	-2.0872	.6062	.0043	.0043	.0062
345	-6.7741	-6.3034	.5942	.0043	.0043	.0062
400	-.0604	.1091	.0023	.0043	.0043	.0062
401*	.1889	.0869	43.2062	.0055	.0058	.0080

* TWO STATION SOLUTION

SECTION 7.

Tabulation of Plate Coordinate
Residual Vectors from Each Camera

TABLE 2. PLATE COORDINATE RESIDUALS FROM TRIANGULATED TARGET POINTS

POINT NO.	CAMERA NO. 1 VX (MICRONS)	CAMERA NO. 1 VY (MICRONS)	CAMERA NO. 2 VX (MICRONS)	CAMERA NO. 2 VY (MICRONS)	CAMERA NO. 3 VX (MICRONS)	CAMERA NO. 3 VY (MICRONS)
1*	-8.4	.0	-	-	-2.0	7.4
2*	-	-	-1.3	8.3	-8.1	-.6
3	7.6	-9.6	12.7	-20.4	19.3	-2.2
4	-16.0	-6.4	7.0	-1.4	-4.4	16.8
5	-2.7	.3	-.9	4.1	-4.6	2.0
6	3.5	13.1	-14.4	4.6	-.0	-7.8
7	7.7	5.0	-5.4	-.8	4.3	-8.7
8	-3.1	2.6	-2.1	-4.1	3.6	2.4
9	-3.5	3.2	-2.8	-3.3	2.8	2.5
10	13.2	-3.4	2.0	7.5	-3.8	-11.9
11	4.6	-4.3	4.1	1.8	-1.3	-3.2
12	-.1	-2.3	2.4	.8	-1.3	.7
13	7.2	1.2	-2.4	3.9	-.9	-7.4
14	-4.5	-11.2	12.8	.6	-4.6	7.4
15	-7.5	-5.8	7.4	-1.3	-2.4	8.6
16	-2.1	-2.5	4.3	-9.2	6.8	3.5
17	5.6	-12.1	13.7	-4.8	3.5	-1.3
18	-3.5	-10.7	11.9	3.6	-6.4	5.6
19	14.2	-10.8	12.5	-14.0	14.5	-8.7
20	-.1	-1.7	1.5	2.4	-2.4	.3
21	-11.2	10.6	-9.2	-8.7	5.8	7.7
22	-6.1	-2.7	4.5	-5.4	2.3	6.3
23	-3.8	8.2	-7.4	-6.9	6.0	1.7
24	-3.2	3.4	.0	-20.5	16.9	3.3
25	-5.3	4.7	-3.1	-7.8	5.8	3.8
26	-.3	4.0	-4.6	2.3	-1.5	-.7
27	7.2	-5.2	3.9	5.2	-3.2	-5.0
28	7.0	-5.0	4.0	3.1	-1.4	-4.7
29	1.9	14.9	-15.7	1.3	1.4	-4.8
30	-1.4	3.4	-4.5	5.6	-4.8	.1
31	-12.9	-4.3	5.6	-2.6	-1.6	11.4
32	2.8	15.0	-12.7	-11.0	12.4	-5.1
33	12.8	17.4	-17.9	1.3	4.5	-14.1
34	21.0	-12.4	9.6	7.2	-3.0	-14.4
35	-11.5	.7	-1.2	4.2	-6.5	8.9
36	-9.5	7.9	-3.7	-16.4	13.9	6.4
38*	-	-	-2.5	11.9	-11.1	-.4
39*	-	-	-.3	1.4	-1.3	-.0
44*	-	-	2.2	-11.6	11.2	.6
45*	-	-	-.3	2.0	-1.9	-.0
47	4.6	13.2	-9.4	-18.2	21.9	-6.7
51*	-	-	-.1	1.1	-1.0	-.0
51	7.1	1.6	-2.0	1.8	.4	-6.9
52*	-	-	-2.5	15.3	-14.9	-1.1
52	-4.7	7.9	-10.3	15.1	-13.9	.6

* TWO STATION SOLUTION

TABLE 2. (CONT.)

POINT NO.	CAMERA NO. 1 VX (MICRONS)	CAMERA NO. 1 VY (MICRONS)	CAMERA NO. 2 VX (MICRONS)	CAMERA NO. 2 VY (MICRONS)	CAMERA NO. 3 VX (MICRONS)	CAMERA NO. 3 VY (MICRONS)
53	-11.4	-3.0	3.2	.6	-4.3	11.1
54	3.4	2.9	-2.9	-.8	2.4	-3.9
55	-10.0	17.5	-18.4	4.6	-2.7	3.2
56	-9.7	10.1	-10.9	5.3	-5.2	5.3
57	-6.2	5.4	-6.0	3.6	-3.8	3.7
58	12.3	-1.0	.4	.4	2.8	-11.0
59	1.5	9.2	-9.7	-1.2	3.9	-4.1
60	11.1	14.5	-17.5	8.6	-1.0	-15.5
61	7.8	-7.9	7.7	2.4	-1.7	-5.0
62	-1.9	-2.0	2.1	1.3	-2.3	2.3
63	1.0	-7.3	8.2	-1.0	-.4	1.2
64	-6.6	-6.4	6.0	12.2	-14.5	6.8
65	-2.7	-3.8	4.4	.9	-2.5	3.4
66	-15.8	7.0	-6.2	-1.3	-2.3	12.5
67	12.1	.6	-1.4	-2.6	6.2	-10.9
68	.2	-9.5	10.9	-2.1	-.0	2.5
69	-1.2	-4.2	4.0	5.0	-5.6	1.8
70	2.8	7.2	-8.8	3.6	-.9	-4.5
71	-5.5	3.2	-.7	-14.3	11.2	5.0
72	-4.3	-1.0	1.4	.9	-2.3	3.9
73	2.2	-2.7	4.1	-8.4	7.5	-.6
74	-5.6	.0	1.0	-3.6	1.4	4.9
75	-2.1	12.4	-12.2	-5.0	5.6	-.7
76	3.3	-4.0	5.1	-6.2	5.6	-1.4
77	-2.9	8.3	-10.0	8.5	-6.9	.1
78	4.8	-5.8	5.9	-1.7	1.9	-2.5
79	5.4	16.9	-16.0	-8.7	11.6	-7.7
80	-2.8	7.6	-8.7	5.9	-4.8	.3
81	-8.5	-3.3	4.0	-.9	-1.8	7.6
82	11.1	15.9	-12.8	-17.5	20.7	-11.8
83	-14.5	-4.3	1.6	15.9	-18.5	12.0
84*	-	-	.3	-1.7	1.5	.0
85	16.6	4.0	-2.1	-11.3	14.9	-13.9
86	14.9	-8.3	6.5	4.8	-2.0	-10.3
87	17.4	1.5	-3.1	5.4	-.6	-14.8
88*	.1	-.5	.5	-.0	-	-
89*	-	-	2.4	-11.4	10.6	.4
91*	-	-	-2.9	14.2	-13.4	-.6
92*	-	-	-4.3	21.3	-20.4	-1.0
93*	-	-	2.7	-13.7	13.1	.7
94*	-	-	-6.1	31.2	-30.1	-1.6
95*	-	-	-3.2	17.1	-16.6	-.9
96*	-	-	-3.2	17.5	-17.0	-1.0
97	-2.4	-22.8	21.7	2.5	-8.1	8.6
98	-1.6	22.9	-20.0	-13.2	17.7	-4.4
101	-2.0	17.0	-16.1	-3.8	7.0	-3.0

* TWO STATION SOLUTION

TABLE 2. (CONT.)

POINT NO.	CAMERA NO. 1 VX (MICRONS)	CAMERA NO. 1 VY (MICRONS)	CAMERA NO. 2 VX (MICRONS)	CAMERA NO. 2 VY (MICRONS)	CAMERA NO. 3 VX (MICRONS)	CAMERA NO. 3 VY (MICRONS)
102	-2.6	11.1	-9.2	-11.2	12.7	-.1
103	-.9	7.0	-8.4	8.6	-6.8	-1.9
104	-2.8	7.7	-9.5	11.0	-9.4	-.6
105*	-1.0	2.9	-3.0	.4	-	-
106	11.1	9.3	-10.5	3.0	2.4	-13.3
107	-5.1	4.3	-5.1	5.2	-5.4	2.9
108	8.2	-1.6	1.3	-.1	2.1	-7.0
109	8.2	1.2	-3.1	9.6	-6.2	-8.7
110	3.1	-1.6	1.4	1.3	-.7	-2.4
111	2.3	2.6	-3.9	7.0	-5.1	-3.6
112	7.3	5.7	-7.0	2.5	1.2	-8.6
113	1.1	-6.3	7.4	-4.5	2.9	1.1
114	2.9	-8.5	8.0	8.4	-8.6	-.9
115	14.2	-7.6	7.5	-2.1	4.6	-10.5
116*	-	-	.1	-1.4	1.2	.1
117	6.3	-11.1	13.1	-10.3	8.7	-1.8
118	3.3	2.1	-3.2	3.8	-1.8	-3.8
119	-2.4	-2.5	3.5	-2.9	1.2	3.0
120*	-5.1	.4	-	-	-1.5	4.4
121	5.9	-6.7	5.8	6.2	-4.9	-3.8
122	-4.9	-19.3	21.5	-1.1	-3.9	9.0
123	-1.1	5.5	-2.1	-22.5	20.0	1.1
124	-4.8	-2.7	2.9	2.6	-4.1	4.5
125	-2.5	10.9	-11.5	1.1	.0	-.5
126	-.1	3.8	-3.1	-5.1	5.0	-.4
127	5.3	-2.3	.2	9.5	-7.1	-4.4
128	-.5	.2	-.1	-.3	.2	.4
129	2.4	-6.7	8.6	-9.8	8.2	.0
130	-7.7	7.4	-7.5	2.5	-3.1	4.5
131	-13.3	5.5	-5.7	5.3	-7.4	9.4
132	14.1	2.8	-4.0	2.0	2.3	-12.3
133	2.1	9.0	-8.2	-4.0	5.5	-3.6
134	20.5	20.4	-18.5	-11.8	19.0	-20.9
135	-9.6	5.3	-3.4	-6.6	4.4	6.9
136	21.2	7.0	-9.6	9.6	-2.3	-19.4
137*	-	-	.0	-.2	.2	.0
138*	-	-	-1.0	5.0	-4.6	-.2
139	22.0	-14.5	12.7	3.2	-.2	-14.8
140	-6.0	-18.4	16.3	7.1	-11.4	9.3
141*	-	-	-2.3	11.5	-10.9	-.5
142*	-	-	1.5	-7.9	7.5	.3
143*	1.5	-.0	-	-	.3	-1.3
144	-15.9	-11.4	9.3	9.6	-15.4	16.2
145*	-	-	3.5	-18.7	18.0	1.0
146*	-	-	.1	-.9	.8	.0
147	-4.0	-3.3	2.6	4.1	-5.7	4.2

* TWO STATION SOLUTION

TABLE 2. (CONT.)

POINT NO.	CAMERA NO. 1 VX (MICRONS)	CAMERA NO. 1 VY (MICRONS)	CAMERA NO. 2 VX (MICRONS)	CAMERA NO. 2 VY (MICRONS)	CAMERA NO. 3 VX (MICRONS)	CAMERA NO. 3 VY (MICRONS)
151	1.9	7.6	-7.9	1.5	.7	-4.0
152	-9.0	12.8	-10.9	-10.0	10.1	4.8
153	1.5	6.6	-4.8	-11.9	13.3	-2.4
154	-9.7	-2.6	5.1	-13.3	9.3	10.5
155*	-3.7	10.8	-11.2	1.6	-	-
156	7.0	3.4	-3.5	-2.2	4.9	-7.2
157	5.5	10.9	-11.3	-2.0	6.1	-8.1
158	-8.7	8.2	-8.2	-.0	-.4	5.5
159	5.2	2.1	-3.7	8.2	-5.6	-6.1
160	4.9	-2.9	2.7	.8	-.0	-3.7
161	6.7	1.7	-2.5	1.8	.6	-6.8
162	5.7	-.3	.7	-5.3	6.5	-4.7
163	1.7	-1.5	2.1	-3.7	3.6	-.8
164	22.7	-20.8	22.7	-12.8	13.8	-13.5
165	.2	-3.0	3.3	-.7	.0	.7
166	2.8	1.0	-2.4	6.9	-5.0	-3.4
167	3.5	6.1	-7.2	1.6	.9	-4.9
169	-1.5	-4.2	4.9	-1.6	.1	2.5
170*	-7.0	.5	-	-	-2.0	5.9
171*	-7.4	.6	-	-	-2.1	6.2
172*	-	-	-1.2	7.3	-6.4	-.5
173	-4.8	-9.6	10.0	4.0	-6.7	6.2
174	.1	-12.6	17.1	-21.8	16.8	4.3
175	9.2	.3	-2.0	4.8	-1.5	-8.1
176	-1.1	7.6	-5.1	-15.5	14.4	.0
177	4.0	4.7	-5.2	-.1	2.0	-4.5
178	6.7	.0	-2.2	9.0	-6.0	-6.0
179	-7.4	.0	-3.9	22.9	-22.2	4.9
180	2.4	.6	-.6	-.7	1.4	-2.1
181	1.2	3.8	-4.5	3.0	-1.7	-2.0
182	8.1	10.8	-14.0	13.8	-8.4	-9.8
183	5.4	15.9	-18.6	12.4	-7.1	-8.7
184	7.2	1.8	-2.9	3.5	-.9	-6.6
185*	-.9	3.1	-3.1	.3	-	-
186	9.8	4.6	-5.2	1.6	1.7	-9.2
187*	-	-	.8	-4.4	4.0	.2
188*	-	-	-.6	3.4	-3.1	-.1
189	11.8	17.8	-20.1	12.1	-5.2	-14.9
190	4.1	-2.5	-.5	14.4	-12.9	-3.5
191*	-1.3	4.0	-3.9	.4	-	-
192	14.4	16.3	-17.7	8.1	-.9	-16.9
193*	-	-	-.9	4.7	-4.4	-.2
194	-15.8	14.0	-13.4	1.0	-2.0	9.6
195	-14.3	17.7	-16.9	.0	.0	7.3
196	17.2	12.1	-14.1	10.5	-3.1	-19.0
197	-1.7	6.0	-5.8	-.0	.9	-.1

* TWO STATION SOLUTION

TABLE 2. (CONT.)

POINT NO.	CAMERA NO. 1 VX (MICRONS)	CAMERA NO. 1 VY (MICRONS)	CAMERA NO. 2 VX (MICRONS)	CAMERA NO. 2 VY (MICRONS)	CAMERA NO. 3 VX (MICRONS)	CAMERA NO. 3 VY (MICRONS)
198	-.3	11.5	-10.8	-3.2	5.6	-2.8
201	2.5	13.3	-11.9	-8.8	12.0	-5.5
203*	-2.0	5.8	-5.9	.8	-	-
205*	-2.1	6.4	-6.6	.9	-	-
207*	-3.0	9.0	-9.4	1.3	-	-
209	-2.7	6.1	-6.5	1.7	-.9	.4
213	3.3	.1	1.6	-13.6	13.4	-1.9
215	-3.2	-.8	2.5	-8.8	6.7	3.8
217	.1	-19.2	2.7	-6.2	1.6	5.5
219	-1.7	-3.2	3.4	1.1	-2.7	2.2
221	-14.7	8.4	-7.7	-.8	-2.0	10.6
223*	-4.5	.3	-	-	-1.2	3.8
225	-.4	.0	1.0	-6.5	5.6	.7
227	-16.6	5.0	-5.7	9.6	-12.2	12.1
229	-9.3	-.6	-1.6	15.6	-16.5	7.1
231	-.9	-1.5	1.9	-1.7	1.0	1.2
233	5.2	-9.9	7.7	9.6	-8.9	-2.4
235	-8.2	10.7	-10.4	.9	-1.1	4.1
237*	-	-	-1.0	5.3	-4.8	-.2
239	12.9	-11.0	8.1	10.6	-8.6	-8.5
241*	-	-	3.1	-16.0	15.0	.8
243	1.4	-2.6	1.8	3.3	-3.3	-.7
245*	-	-	1.3	-7.0	6.7	.4
247	2.0	4.4	-1.9	-13.9	14.8	-2.1
251	.5	.9	-.0	-5.4	5.4	-.3
253	-6.6	16.8	-15.8	-6.0	7.6	1.4
255	2.0	8.1	-9.9	9.2	-6.2	-4.8
257	12.2	1.4	-2.4	2.2	1.6	-11.5
259	3.7	7.5	-9.0	6.0	-2.8	-5.9
261	6.2	-10.9	10.4	4.7	-4.9	-2.8
263	14.1	-4.0	4.3	-6.2	8.9	-11.0
265*	-.3	.0	-	-	-.0	.3
267	2.9	-9.6	11.4	-8.5	6.5	.6
269	9.2	14.7	-14.0	-14.3	18.5	-11.0
271	3.0	11.6	-11.7	-4.7	7.3	-5.3
273	-3.9	-4.1	7.0	-13.8	10.3	5.3
275	-1.7	-.5	.0	3.9	-4.1	1.3
277	2.2	-5.2	4.7	2.7	-2.7	-.7
279*	14.4	-.9	-	-	3.8	-11.9
281*	3.0	-.1	-	-	.7	-2.4
283*	-3.4	.1	-	-	-.9	2.8
285*	-	-	-.1	1.1	-.9	-.0
287	12.3	10.3	-9.3	-7.4	11.9	-12.6
289	.6	-12.5	13.0	-3.2	.8	2.8
291*	-	-	-1.6	8.4	-7.8	-.4
293	.5	6.7	-5.9	-3.7	5.0	-2.1

* TWO STATION SOLUTION

TABLE 2. (CONT.)

POINT NO.	CAMERA NO. 1 VX (MICRONS)	CAMERA NO. 1 VY (MICRONS)	CAMERA NO. 2 VX (MICRONS)	CAMERA NO. 2 VY (MICRONS)	CAMERA NO. 3 VX (MICRONS)	CAMERA NO. 3 VY (MICRONS)
295	4.6	9.4	-12.3	15.1	-11.0	-7.5
297	7.2	6.8	-8.6	8.6	-4.7	-8.7
301	16.6	-4.6	5.8	-10.4	13.2	-12.5
305	-.2	12.9	-13.8	3.3	-.4	-3.6
309	7.9	2.4	-1.8	-6.8	9.0	-7.2
313	4.7	8.9	-9.8	1.2	2.1	-6.7
317*	-.9	3.0	-3.2	.3	-	-
321	-.3	9.3	-8.9	-4.8	6.1	-1.9
325	-12.9	21.1	-19.9	-5.9	5.7	6.0
329*	-	-	-1.8	10.2	-9.2	-.6
333	16.9	20.7	-21.3	-3.8	12.0	-19.5
337	13.4	-1.8	-1.5	14.9	-10.4	-11.7
341	3.2	7.8	-10.2	11.7	-8.4	-5.5
345	9.0	.0	-.2	-.9	3.3	-7.7
400	4.1	19.8	-22.6	11.6	-5.5	-9.6
401*	-	-	-1.9	12.7	-11.5	-.9

* TWO STATION SOLUTION

SECTION 8.

Tabulation of XYZ Departures and Perpendicular Distances of Target Points from Best Fitting Paraboloid of Revolution

TABLE 3. X,Y,Z, COMPONENT DEPARTURES AND PERPENDICULAR DEPARTURE OF TARGET POINTS FROM BEST-FITTING PARABOLOID OF REVOLUTION.

POINT NO.	DX (FEET)	DY (FEET)	DZ (FEET)	D (FEET)
1*	-.0052	-.0190	-.0337	-.0391
2*	.0005	.0035	.0061	.0071
3	-.0000	-.0037	-.0063	-.0073
4	.0004	-.0040	-.0069	-.0080
5	.0005	-.0019	-.0035	-.0040
6	-.0029	.0072	.0133	.0154
7	.0004	-.0007	-.0015	-.0018
8	.0014	-.0019	-.0041	-.0048
9	-.0004	.0004	.0011	.0013
10	-.0025	.0019	.0054	.0063
11	-.0008	.0004	.0016	.0019
12	-.0015	.0006	.0029	.0033
13	-.0004	.0001	.0008	.0009
14	-.0046	.0006	.0079	.0092
15	-.0017	-.0000	.0030	.0035
16	.0013	.0001	-.0022	-.0026
17	-.0065	-.0017	.0115	.0133
18	-.0269	-.0110	.0496	.0575
19	-.0014	-.0008	.0028	.0033
20	-.0034	-.0026	.0073	.0085
21	-.0022	-.0022	.0053	.0062
22	-.0008	-.0010	.0022	.0026
23	-.0010	-.0017	.0035	.0041
24	-.0006	-.0016	.0029	.0034
25	-.0007	-.0026	.0046	.0053
26	-.0001	-.0013	.0023	.0026
27	.0000	-.0038	.0065	.0075
28	.0002	-.0020	.0035	.0041
29	.0008	-.0033	.0058	.0067
30	-.0013	.0032	-.0060	-.0069
31	.0027	-.0048	.0093	.0108
32	.0004	-.0006	.0013	.0016
33	.0020	-.0020	.0049	.0057
34	.0021	-.0016	.0045	.0052
35	.0023	-.0013	.0045	.0052
36	-.0031	.0013	-.0058	-.0068
38*	-.0036	.0005	-.0062	-.0072
39*	.0033	-.0000	.0057	.0066
44*	.0119	.0090	.0255	.0296
45*	.0006	.0006	.0015	.0017
47	.0049	.0084	.0167	.0194
51	-.0001	-.0004	-.0009	-.0010
52	-.0001	-.0011	-.0022	-.0024
53	.0000	.0026	.0049	.0056
54	.0008	-.0066	-.0127	-.0143
55	.0019	-.0073	-.0145	-.0164
56	.0010	-.0026	-.0054	-.0061

* TWO STATION SOLUTION

TABLE 3. (CONT.)

POINT NO.	DX (FEET)	DY (FEET)	DZ (FEET)	D (FEET)
57	.0017	-.0031	-.0069	-.0078
58	.0002	-.0002	-.0006	-.0007
59	-.0001	.0001	.0003	.0003
60	.0060	-.0046	-.0145	-.0164
61	.0014	-.0008	-.0031	-.0035
62	.0017	-.0007	-.0035	-.0040
63	-.0003	.0000	.0006	.0006
64	-.0017	.0002	.0034	.0038
65	.0040	-.0000	-.0076	-.0086
66	.0000	.0000	-.0001	-.0001
67	.0044	.0011	-.0087	-.0098
68	.0067	.0027	-.0139	-.0157
69	.0018	.0010	-.0041	-.0046
70	.0032	.0024	-.0076	-.0086
71	.0014	.0014	-.0040	-.0045
72	.0028	.0036	-.0088	-.0099
73	.0001	.0001	-.0004	-.0004
74	.0003	.0008	-.0018	-.0020
75	.0011	.0042	-.0084	-.0095
76	.0008	.0065	-.0124	-.0141
77	.0000	.0100	-.0190	-.0215
78	-.0004	.0037	-.0071	-.0080
79	-.0018	.0072	-.0141	-.0160
80	-.0070	.0173	-.0356	-.0403
81	.0006	-.0012	.0026	.0030
82	.0010	-.0013	.0031	.0036
83	-.0015	.0016	-.0042	-.0048
84*	.0055	-.0042	.0133	.0150
85	.0022	-.0013	.0049	.0056
86	.0040	-.0017	.0084	.0095
87	.0052	-.0014	.0104	.0118
88*	.0126	-.0017	.0243	.0275
89*	-.0027	.0000	-.0052	-.0059
91*	.0031	.0008	.0062	.0070
92*	-.0029	-.0011	-.0061	-.0068
93*	-.0121	-.0068	-.0266	-.0300
94*	.0037	.0028	.0089	.0101
95*	-.0046	-.0045	-.0124	-.0140
96*	.0066	.0085	.0206	.0233
97	.0044	.0075	.0166	.0188
98	.0022	.0053	.0112	.0126
101	-.0010	-.0037	-.0083	-.0091
102	-.0001	-.0013	-.0028	-.0031
103	-.0000	-.0012	-.0027	-.0029
104	.0002	-.0022	-.0050	-.0055
105*	.0006	-.0026	-.0058	-.0064
106	.0009	-.0023	-.0055	-.0060

* TWO STATION SOLUTION

TABLE 3. (CONT.)

POINT NO.	DX (FEET)	DY (FEET)	DZ (FEET)	D (FEET)
107	-.0006	.0010	.0026	.0029
108	.0014	-.0019	-.0053	-.0059
109	.0039	-.0039	-.0120	-.0132
110	.0026	-.0020	-.0072	-.0079
111	.0049	-.0028	-.0123	-.0135
112	.0029	-.0012	-.0068	-.0075
113	-.0021	.0005	.0047	.0052
114	-.0005	.0000	.0011	.0012
115	-.0037	.0000	.0080	.0088
116*	.0036	.0004	-.0079	-.0087
117	-.0018	-.0004	.0042	.0046
118	-.0030	-.0012	.0071	.0079
119	-.0001	-.0000	.0004	.0004
120*	.0042	.0032	-.0114	-.0126
121	-.0009	-.0009	.0028	.0031
122	-.0025	-.0033	.0090	.0099
123	-.0004	-.0007	.0018	.0020
124	-.0002	-.0005	.0012	.0013
125	.0008	.0030	-.0068	-.0076
126	-.0001	-.0014	.0031	.0034
127	.0000	.0022	-.0048	-.0053
128	-.0004	.0035	-.0076	-.0084
129	.0001	-.0006	.0015	.0016
130	-.0017	.0042	-.0098	-.0109
131	.0003	-.0005	.0013	.0014
132	.0004	-.0006	.0017	.0019
133	-.0000	.0000	-.0002	-.0002
134	-.0030	.0023	-.0082	-.0090
135	-.0006	.0003	-.0015	-.0016
136	.0035	-.0014	.0082	.0090
137*	.0022	-.0006	.0049	.0055
138*	.0052	-.0007	.0113	.0124
139	.0025	-.0000	.0055	.0061
140	.0010	.0001	.0023	.0025
141*	-.0024	-.0006	-.0055	-.0060
142*	.0007	.0003	.0017	.0019
143*	-.0122	-.0069	-.0303	-.0334
144	.0028	.0021	.0076	.0084
145*	-.0062	-.0061	-.0190	-.0209
146*	.0017	.0022	.0061	.0067
147	-.0005	-.0009	-.0024	-.0026
151	.0006	.0023	.0061	.0066
152	.0000	.0006	.0016	.0017
153	-.0000	-.0006	-.0016	-.0018
154	.0002	-.0019	-.0048	-.0051
155*	.0004	-.0018	-.0047	-.0051
156	.0005	-.0014	-.0039	-.0041

* TWO STATION SOLUTION

TABLE 3. (CONT.)

POINT NO.	DX (FEET)	DY (FEET)	DZ (FEET)	D (FEET)
157	.0009	-.0016	-.0048	-.0052
158	.0028	-.0037	-.0118	-.0127
159	-.0011	.0011	.0041	.0045
160	.0017	-.0013	-.0054	-.0058
161	.0012	-.0007	-.0036	-.0039
162	.0001	-.0000	-.0002	-.0002
163	-.0015	.0004	.0040	.0043
164	-.0026	.0003	.0066	.0071
165	-.0005	.0000	.0014	.0015
166	.0007	.0000	-.0019	-.0020
167	.0008	.0002	-.0023	-.0024
169	.0003	.0001	-.0009	-.0010
170*	-.0012	-.0009	.0039	.0042
171*	-.0006	-.0006	.0024	.0026
172*	.0005	.0007	-.0023	-.0024
173	-.0009	-.0016	.0046	.0050
174	-.0022	-.0052	.0142	.0153
175	.0000	.0003	-.0008	-.0009
176	.0002	.0018	-.0046	-.0050
177	.0000	.0006	-.0015	-.0017
178	-.0001	.0010	-.0025	-.0027
179	.0004	-.0018	.0046	.0050
180	-.0031	.0076	-.0205	-.0221
181	-.0009	.0017	-.0050	-.0054
182	-.0017	.0023	-.0072	-.0077
183	-.0015	.0015	-.0053	-.0057
184	-.0026	.0021	-.0085	-.0091
185*	-.0071	.0042	-.0207	-.0223
186	-.0029	.0012	-.0078	-.0084
187*	.0005	-.0001	.0013	.0014
188*	-.0003	.0000	-.0009	-.0010
189	-.0027	.0000	-.0069	-.0074
190	.0046	.0005	.0116	.0125
191*	.0058	.0015	.0151	.0163
192	-.0037	-.0015	-.0100	-.0108
193*	.0015	.0008	.0044	.0048
194	.0002	.0001	.0006	.0007
195	-.0005	-.0005	-.0018	-.0019
196	-.0013	-.0017	-.0056	-.0060
197	.0016	.0028	.0083	.0090
198	-.0010	-.0025	-.0069	-.0075
201	.0002	.0009	.0029	.0030
203*	.0000	.0014	.0043	.0045
205*	-.0002	.0011	.0035	.0037
207*	-.0002	.0004	.0015	.0015
209	.0023	-.0024	-.0101	-.0107
211	-.0009	.0005	.0031	.0033

* TWO STATION SOLUTION

TABLE 3. (CONT.)

POINT NO.	DX (FEET)	DY (FEET)	DZ (FEET)	D (FEET)
213	-.0007	.0002	.0023	.0025
215	.0007	-.0000	-.0021	-.0022
217	-.0020	-.0005	.0063	.0067
219	-.0010	-.0005	.0034	.0036
221	-.0010	-.0010	.0044	.0047
223*	-.0003	-.0006	.0023	.0024
225	-.0000	-.0001	.0003	.0004
227	.0000	-.0000	.0000	.0000
229	.0000	-.0001	.0004	.0004
231	-.0000	.0000	-.0002	-.0002
233	.0008	-.0008	.0035	.0037
235	-.0050	.0029	-.0172	-.0182
237*	.0083	-.0023	.0255	.0269
239	-.0036	.0000	-.0107	-.0113
241*	-.0006	-.0001	-.0019	-.0020
243	.0025	.0014	.0087	.0091
245*	.0023	.0022	.0095	.0101
247	-.0015	-.0026	-.0091	-.0096
251	.0001	.0006	.0027	.0027
253	.0000	.0006	.0027	.0027
255	.0000	-.0003	-.0014	-.0014
257	-.0008	.0014	.0070	.0073
259	-.0014	.0014	.0086	.0089
261	-.0010	.0006	.0050	.0052
263	-.0011	.0003	.0050	.0051
265*	.0006	-.0000	-.0026	-.0027
267	-.0038	-.0010	.0164	.0169
269	.0005	.0003	-.0026	-.0027
271	-.0021	-.0021	.0123	.0127
273	-.0011	-.0019	.0093	.0096
275	-.0001	-.0005	.0023	.0023
277	-.0000	-.0008	.0032	.0033
279*	.0005	-.0019	.0082	.0084
281*	-.0005	.0009	-.0046	-.0048
283*	.0010	-.0010	.0061	.0062
285*	-.0010	.0006	-.0051	-.0052
287	-.0008	.0002	-.0036	-.0037
289	.0015	-.0000	.0063	.0065
291*	.0054	.0013	.0230	.0237
293	.0014	.0008	.0068	.0070
295	-.0009	-.0008	-.0052	-.0054
297	.0002	.0003	.0016	.0017
301	.0003	.0012	.0105	.0106
305	.0000	-.0001	-.0013	-.0013
309	.0009	-.0009	-.0106	-.0107
313	.0007	-.0002	-.0058	-.0058
317*	.0003	.0000	-.0029	-.0029

* TWO STATION SOLUTION

TABLE 3. (CONT.)

POINT NO.	DX (FEET)	DY (FEET)	DZ (FEET)	D (FEET)
321	-.0003	-.0003	.0037	.0037
325	.0001	.0004	-.0033	-.0033
329*	.0001	-.0006	.0049	.0049
333	-.0006	.0006	-.0068	-.0069
337	.0024	-.0007	.0198	.0199
341	.0002	.0000	.0017	.0017
345	-.0002	-.0002	-.0023	-.0023
400	.0000	-.0000	.0021	.0021

* TWO STATION SOLUTION

SECTION 9.

Focal Length and Vertex of Best Fitting Paraboloid of Revolution

FOCAL LENGTH AND VERTEX OF BEST FITTING PARABOLOID OF REVOLUTION

The focal length of the paraboloid which best fit the triangulated target points was 35.8833 ft. ± .0059 ft. The coordinates of target No. 401, which was situated near the feed point of the dish, were:

X = .1889 ft. ± .0055
Y = .0869 ft. ± .0058 ft.
Z = 43.2062 ft. ± .0080 ft.

The X, Y, Z coordinates of target No. 400, located near the center of the dish, may be used to locate the mechanical vertex of the best fitting paraboloid. This point, in the previously defined coordinate system, lies .0604 ft. to the left (X-coordinate), .1091 above (Y-coordinate), and .0023 ft. above (Z-coordinate) the vertex.

SECTION 10
References

REFERENCES

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