Airrad Fallout Prediction System

Model Validation Report

Frederick L. Wasmer
University of Illinois

January 20, 1989

Sponsoring Agencies

Sandia National Laboratories
Albuquerque, NM

U.S. Army Atmospheric Sciences Laboratory
White Sands Missile Range, NM

Introduction

This report presents the results of a validation study for the Airrad fallout prediction system. Observed and predicted H + 1 hour normalized exposure rate contours are compared for the twenty shots listed in Table 1, using two criterion.

1. Quantitative comparisons of the area inside selected contours.

2. Qualitative comparison of the footprint patterns represented by a pair of contour plots.

Burst data, wind profiles, and observed footprints were taken from DNA 1251 volumes I and II (Hawthorne, 1979). Observed footprints were digitized using a Kurta IS/ONE digitizing pad. The cases were run on an IBM PS/2 model 80, using Airrad 7.0. The contour maps were drawn using an HP 7475A plotter.

Although only twenty test shots are presented in this report, Airrad was validated using over forty, with yields ranging from tens of megatons to less than 10 tons. Acceptable performance was noted over the entire range. The twenty shots presented in this report were selected to give a representative sampling of the full test battery.

Contour Areas

Table 2 presents the measured and predicted contour areas for the 20 validation cases. Contour levels are in Roentgens/Hr. The percent mean error* for each level is given, along with the average error for all levels. Values given in parenthesis are the average areas excluding the highest

---

* The percent mean error of an observed-predicted pair is defined as $\frac{|X_{obs} - X_{pred}|}{X_{obs}}$, where X_{obs} is the observed value, and X_{pred} is the predicted value.

level contour, which is often dominated by induced activity and crater throwout. The Airrad algorithm is not intended to model these effects.

For each of the 20 cases, a figure was selected in DNA 1251 which the author felt best represented the fallout footprint. The Airrad computational grid limits were set to the smallest rectangle which enclosed this figure. Selected contours in this figure were digitized, and the area inside each was computed using an area integration routine. Due to efficiency considerations, only those portions of the contours inside the Airrad computational grid were considered in the contour area calculations. This is conservative, since it tends to emphasize the close-in effects mentioned above.

Contour areas predicted by Airrad compare quite well with those measured. The overall average percent mean error is 51 (38 with the highest level excluded). By comparison, the corresponding values are 61 (42) and 59 (31) from DELFIC and SIMFIC validations (Norment, 1979), respectively. It should be noted, however, that the DELFIC and SIMFIC values represent a different set of shots.

Fallout Footprints

Figures 1 through 20 present the observed and predicted H + 1 hour normalized exposure rate footprints for each of the validation cases, in Roentgens per hour. Contour levels are listed in Table 2. Each pair of observed-predicted plots is drawn to the same scale, so direct comparison of features is possible.

Table 1. Validation Shots

	Operation/Event	Site	Yield
1.	Upshot-Knothole/Annie	Nevada	17.0 kt
2.	Upshot-Knothole/Badger	Nevada	25.0 kt
3.	Hardtack-II/Catron	Nevada	0.021 kt
4.	Tumbler-Snapper/Fox	Nevada	11.0 kt
5.	Tumbler-Snapper/George	Nevada	16.0 kt
6.	Upshot-Knothole/Harry	Nevada	32.0 kt
7.	Teapot/Hornet	Nevada	3.6 kt
8.	Tumbler-Snapper/How	Nevada	14.0 kt
9.	Hardtack-II/Humboldt	Nevada	0.008 kt
10.	Sunbeam/Johnie Boy	Nevada	0.5 kt
11.	Teapot/Moth	Nevada	2.4 kt
12.	Castle/Nectar	Pacific	1.7 Mt
13.	Teapot/Post	Nevada	1.5 kt
14.	Hardtack-II/Rio Arriba	Nevada	0.092 kt
15.	Upshot-Knothole/Ruth	Nevada	0.2 kt
16.	Upshot-Knothole/Simon	Nevada	45.0 kt
17.	Buster-Jangle/Sugar	Nevada	1.2 kt
18.	Teapot/Tesla	Nevada	6.8 kt
19.	Hardtack-II/Vesta	Nevada	0.024 kt
20.	Redwing/Zuni	Pacific	3.38 Mt

Table 2. Comparison of Predicted and Measured Areas Inside Selected Contours for the Airrad Validation Shots

Case 1 - Annie Nevada 17.0 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.010	8.680	4.749	45.28 %
1.000	3.181	3.428	7.78 %
10.000	1.780	2.435	36.79 %
150.000	0.1286	0.9172	613.24 %

Percent Mean Error = 175.77 (29.95) %

Case 2 - Badger Nevada 25.0 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.050	114.4	73.89	35.42 %
0.500	67.15	61.21	8.85 %
50.000	13.09	21.43	63.73 %

Percent Mean Error = 36.00 (22.14) %

Case 3 - Catron Nevada 0.021 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.005	41.25	25.43	38.35 %
0.050	13.41	6.637	50.51 %
0.100	4.159	3.341	19.67 %
0.500	1.111	0.5541	50.12 %

Percent Mean Error = 39.66 (36.17) %

Case 4 - Fox Nevada 11.0 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.150	22.90	15.25	33.41 %
2.000	15.73	10.88	30.83 %
20.000	8.442	6.194	26.62 %
200.000	1.289	1.564	21.28 %

Percent Mean Error = 28.04 (30.29) %

Case 5 - George Nevada 16.0 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
1.000	7.825	10.43	33.29 %
50.000	4.365	4.537	3.93 %
200.000	1.076	1.018	5.44 %

Percent Mean Error = 14.22 (18.61) %

Case 6 - Harry Nevada 32.0 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.100	33.67	28.41	15.62 %
1.000	23.77	25.33	6.58 %
10.000	19.19	20.53	6.99 %

Percent Mean Error = 9.73 (11.10) %

Case 7 - Hornet Nevada 3.6 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.500	7.971	6.916	13.23 %
5.000	4.373	4.707	7.64 %
50.000	1.751	1.488	15.05 %

Percent Mean Error = 11.98 (10.44) %

Case 8 - How Nevada 14.0 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
1.500	5.510	4.104	25.52 %
25.000	2.544	2.875	12.99 %
250.000	0.5565	0.6147	10.44 %

Percent Mean Error = 16.32 (19.25) %

Case 9 - Humboldt Nevada 0.008 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.005	7.522	3.136	58.31 %
0.100	2.686	2.134	20.57 %
0.500	0.6765	0.8245	21.88 %

Percent Mean Error = 33.58 (39.44) %

Case 10 - Johnie Boy Nevada 0.5 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.010	21.18	8.594	59.43 %
1.000	8.945	6.061	32.24 %
100.000	0.5048	1.227	143.12 %

Percent Mean Error = 78.26 (45.83) %

Case 11 - Moth Nevada 2.4 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.500	5.684	2.384	58.06 %
10.000	1.306	1.403	7.45 %
100.000	0.2145	0.0953	55.58 %

Percent Mean Error = 40.36 (32.75) %

Case 12 - Nectar Pacific 1.7 Mt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
10.000	1.442×10^4	4.294×10^4	197.80 %
25.000	1.116×10^4	2.667×10^4	138.88 %
50.000	7.955×10^3	1.785×10^4	124.38 %
250.000	1.650×10^3	4.386×10^3	165.79 %

Percent Mean Error = 156.72 (153.69) %

Case 13 - Post Nevada 1.5 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
10.000	1.086	1.851	70.53 %
100.000	0.2314	0.1753	24.21 %

Percent Mean Error = 47.37 (70.53) %

Case 14 - Rio Arriba Nevada 0.092 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.010	17.36	11.33	34.73 %
1.000	1.850	3.755	103.01 %
10.000	0.1664	0.3109	86.85 %

Percent Mean Error = 74.87 (68.87) %

Case 15 - Ruth Nevada 0.2 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.010	4.474	3.245	27.47 %
0.100	1.917	0.9021	52.95 %
1.000	0.2327	0.0566	75.67 %

Percent Mean Error = 52.03 (40.21) %

Case 16 - Simon Nevada 45.0 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.200	83.98	97.60	16.22 %
20.000	38.71	50.93	31.57 %
200.000	14.13	14.70	4.04 %

Percent Mean Error = 17.28 (23.90) %

Case 17 - Sugar Nevada 1.2 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
1.000	9.139	5.795	36.59 %
100.000	1.566	1.994	27.31 %
500.000	0.1248	0.3649	192.28 %

Percent Mean Error = 85.39 (31.95) %

Case 18 - Tesla Nevada 6.8 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.500	12.61	8.559	32.12 %
20.000	5.766	4.632	19.68 %
150.000	0.9982	0.6739	32.49 %

Percent Mean Error = 28.09 (25.90) %

Case 19 - Vesta Nevada 0.024 kt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
0.010	85.96	61.31	28.68 %
0.100	44.36	43.32	2.34 %
0.500	15.85	20.33	28.26 %
5.000	1.168	2.031	73.82 %

Percent Mean Error = 33.27 (19.76) %

Case 20 - Zuni Pacific 3.38 Mt

Level R/hr	Measured Area (km^2)	Airrad Area (km^2)	% Mean Error
1.000	1.012×10^5	9.887×10^4	2.30 %
5.000	3.937×10^4	6.350×10^4	61.32 %
30.000	1.084×10^4	1.504×10^4	38.75 %
100.000	2.695×10^3	4.798×10^3	78.07 %

Percent Mean Error = 45.11 (34.12) %

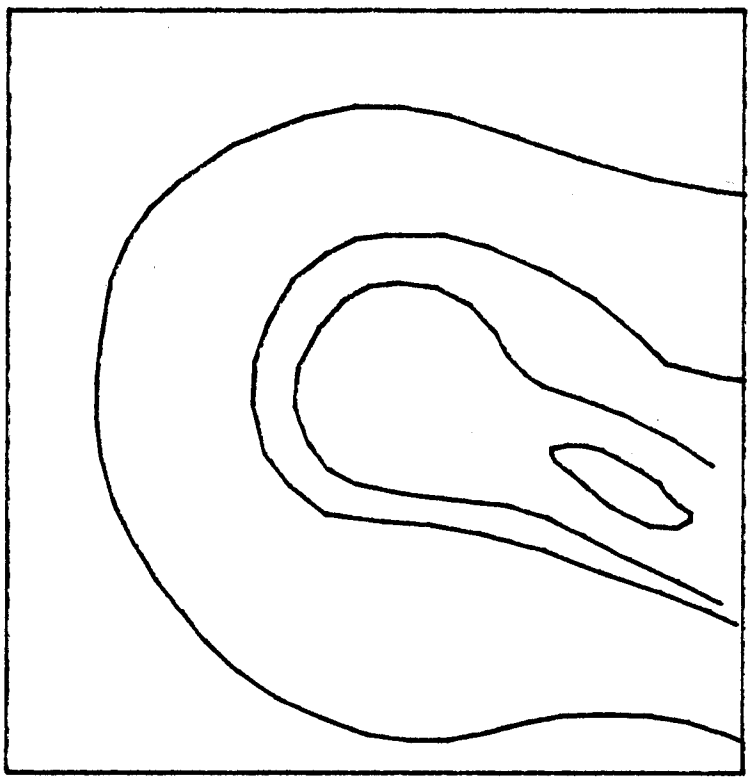

Figure 1a Observed pattern for operation Upshot-Knothole/Annie

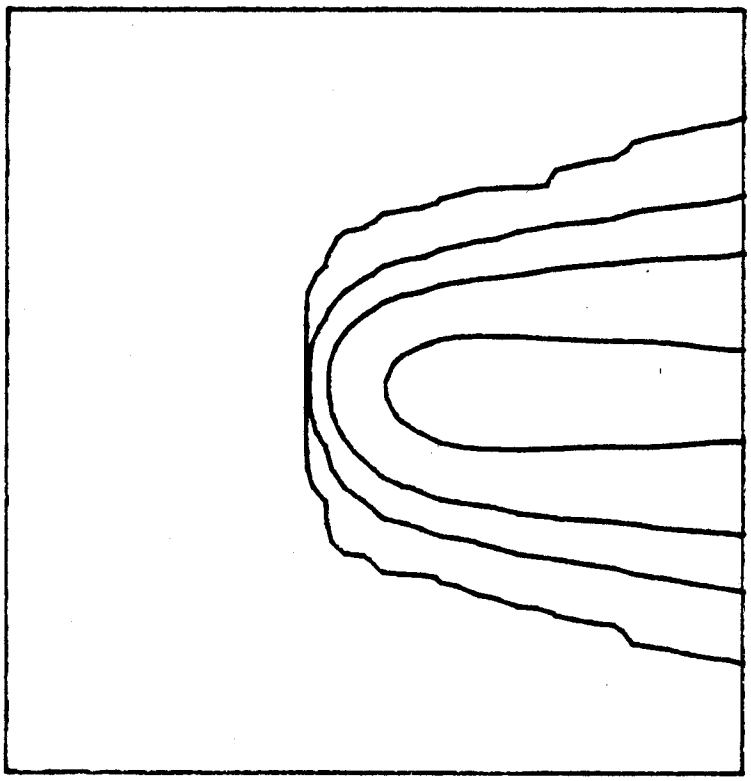

Figure 1b Airrad predictions for operation Upshot-Knothole/Annie

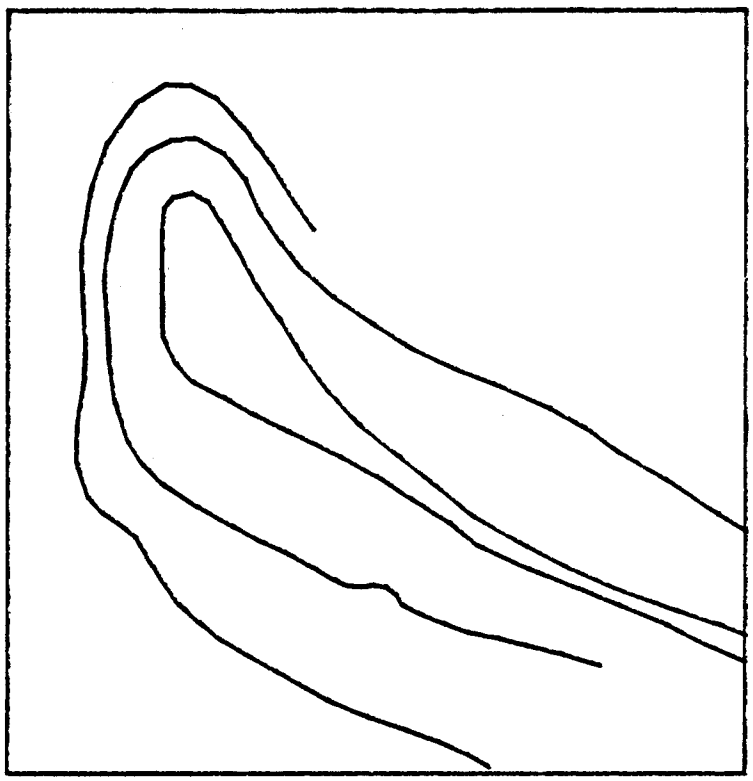

Figure 2a Observed pattern for operation Upshot-Knothole/Badger

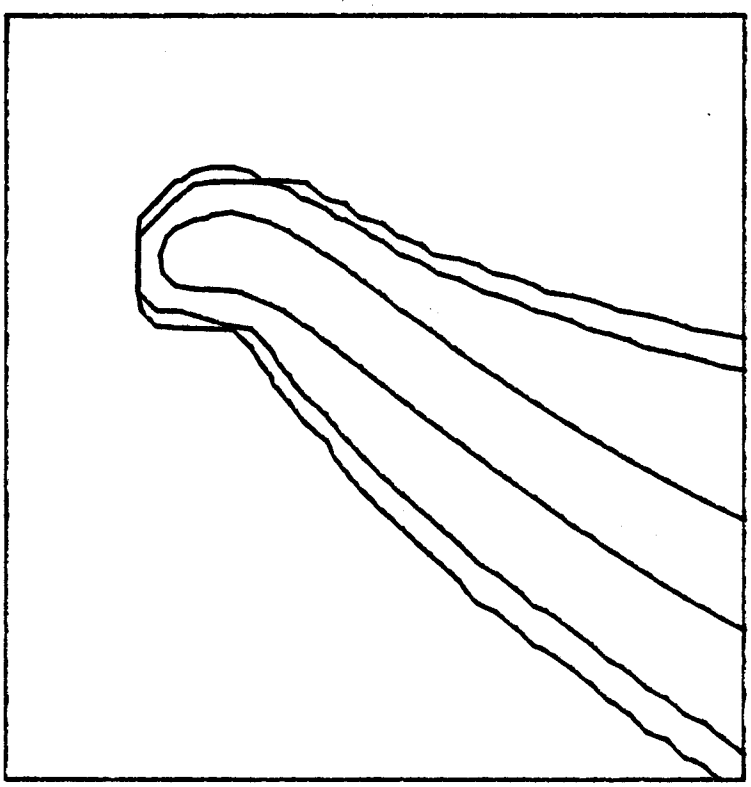

Figure 2b Airrad predictions for operation Upshot-Knothole/Badger

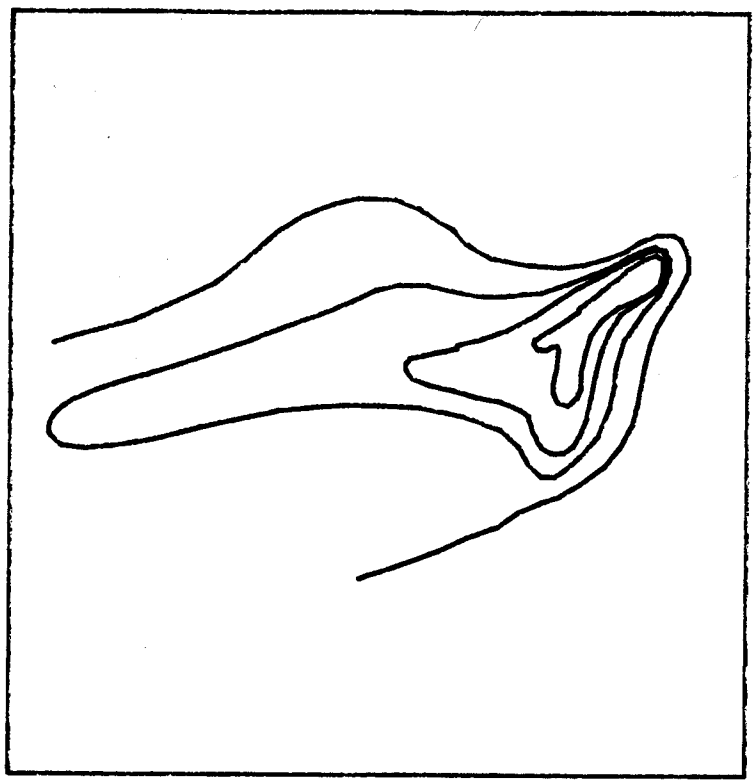

Figure 3a Observed pattern for operation Hardtack-II/Catron

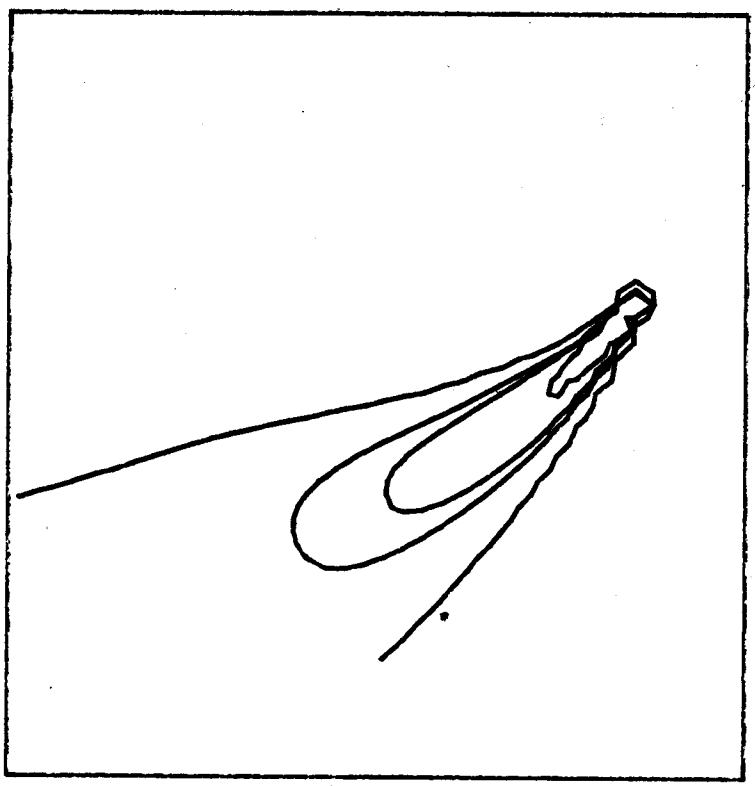

Figure 3b Airrad predictions for operation Hardtack-II/Catron

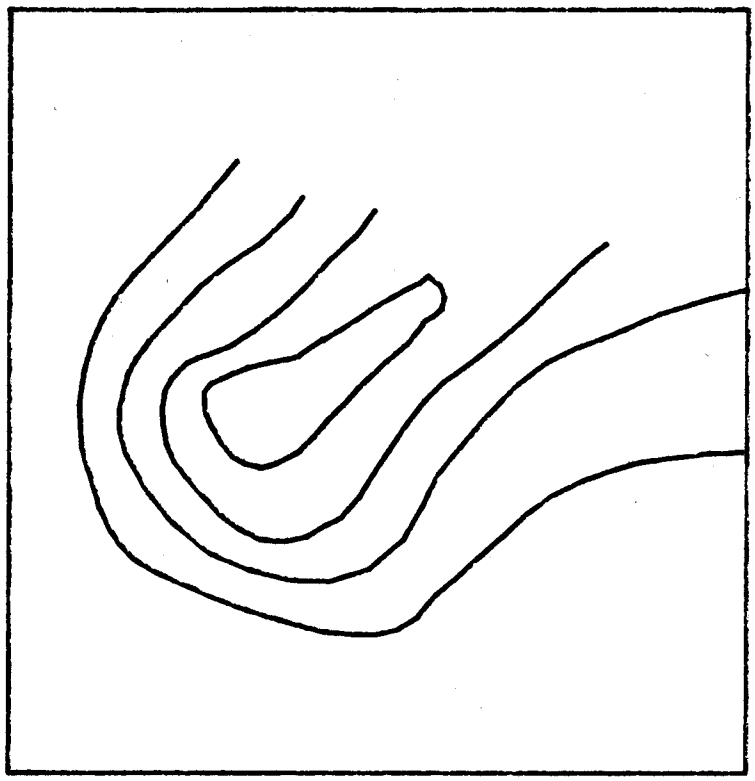

Figure 4a Observed pattern for operation Tumbler-Snapper/Fox

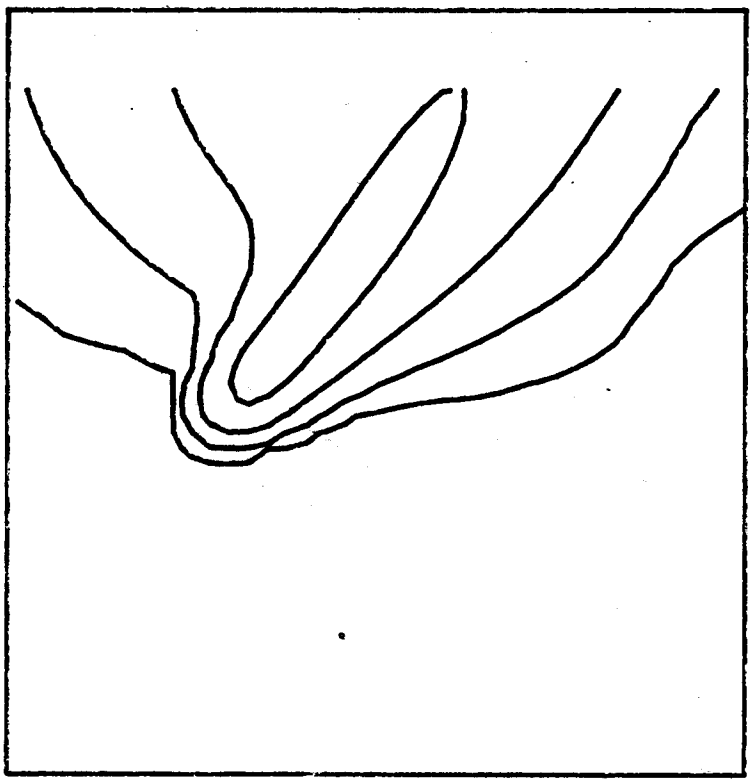

Figure 4b Airrad predictions for operation Tumbler-Snapper/Fox

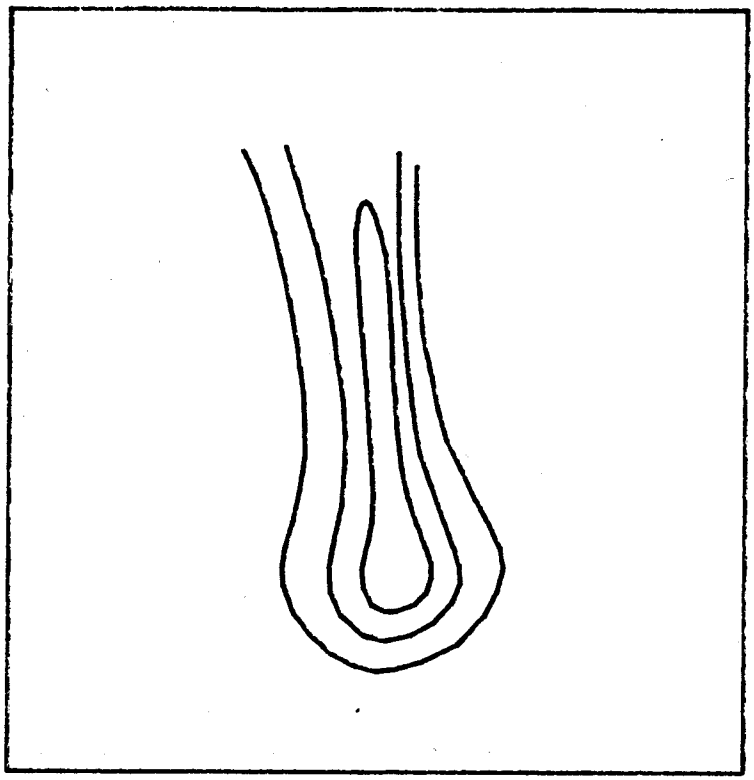

Figure 5a Observed pattern for operation Tumbler-Snapper/George

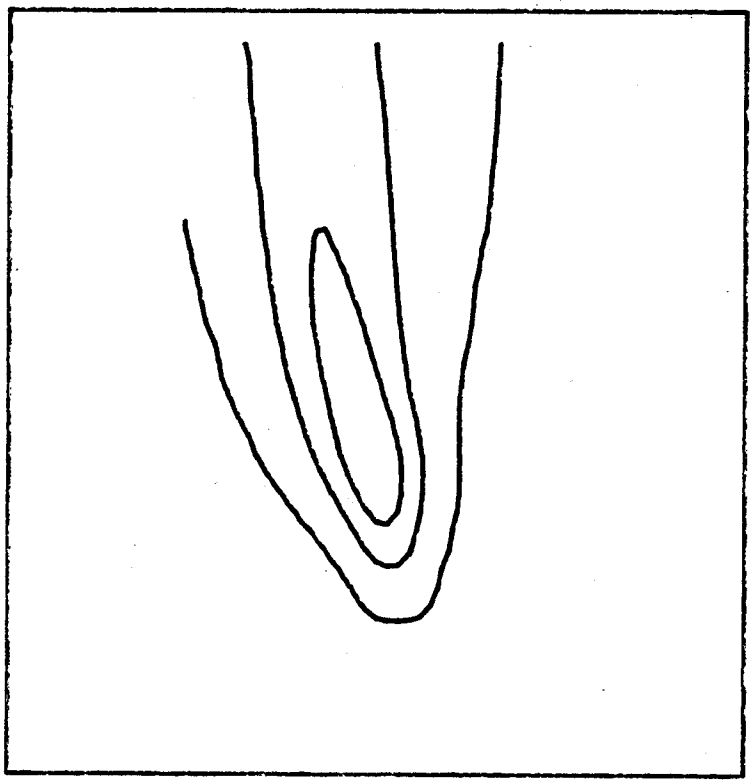

Figure 5b Airrad predictions for operation Tumbler-Snapper/George

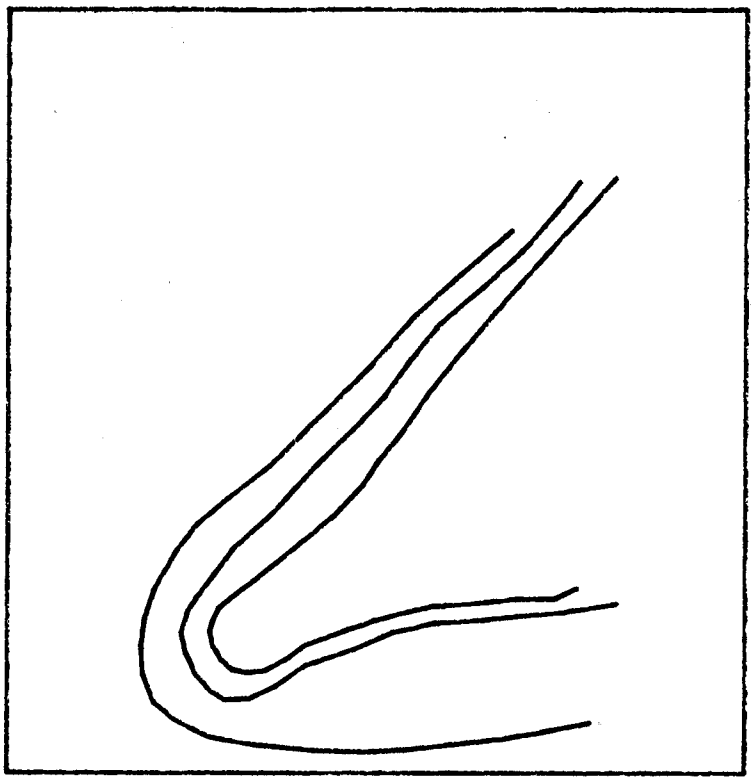

Figure 6a Observed pattern for operation Upshot-Knothole/Harry

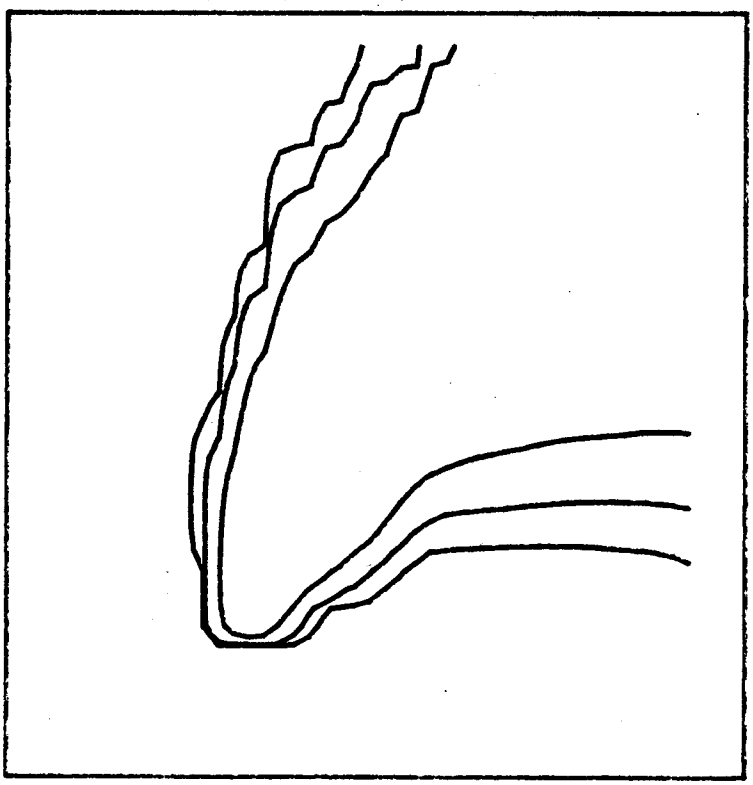

Figure 6b Airrad predictions for operation Upshot-Knothole/Harry

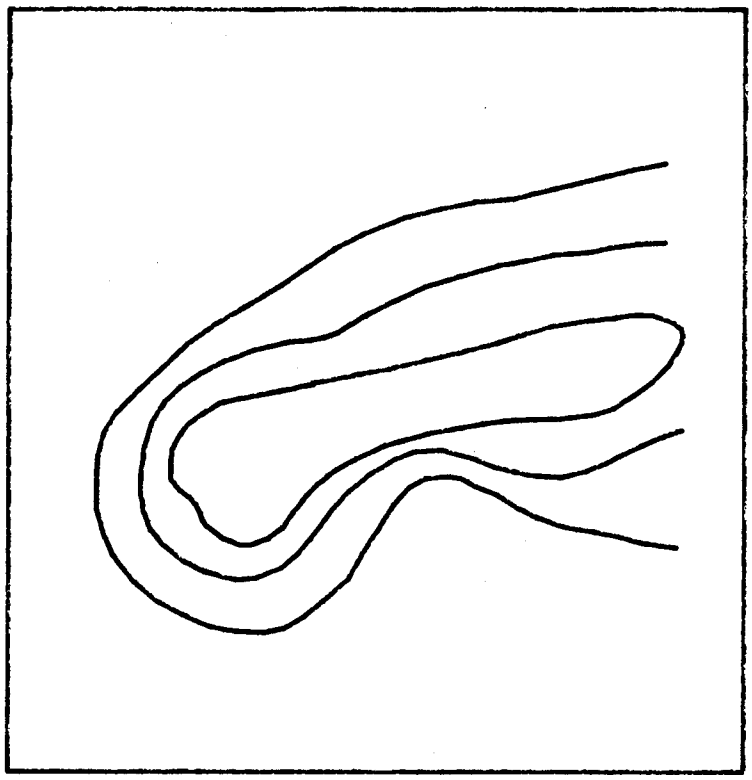

Figure 7a Observed pattern for operation Teapot/Hornet

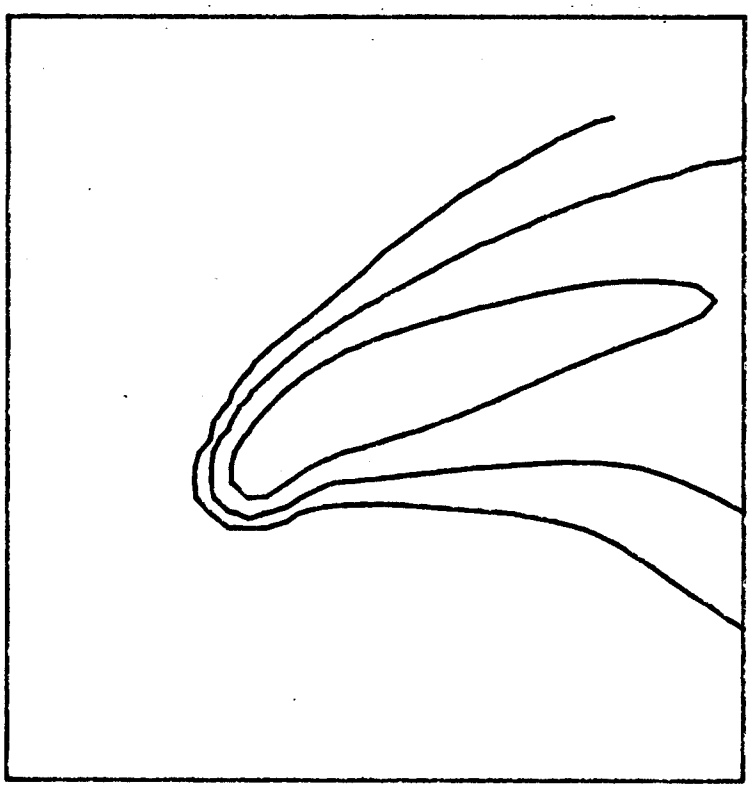

Figure 7b Airrad predictions for operation Teapot/Hornet

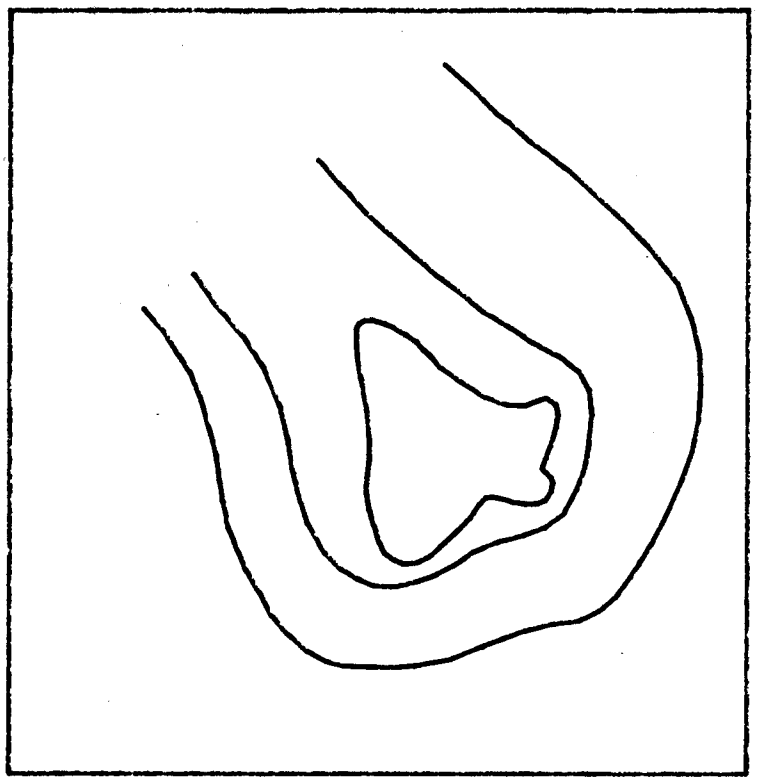

Figure 8a Observed pattern for operation Tumbler-Snapper/How

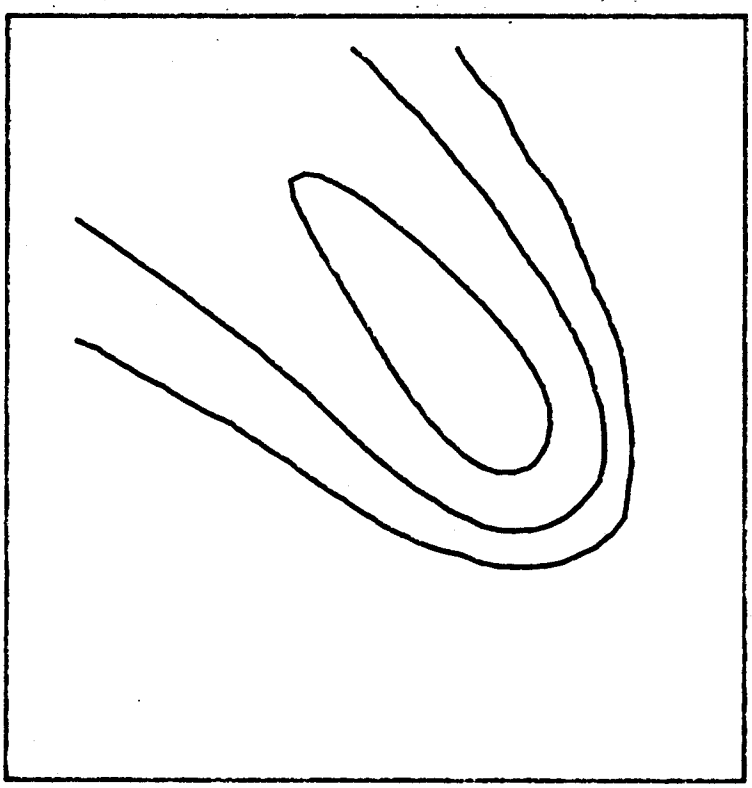

Figure 8b Airrad predictions for operation Tumbler-Snapper/How

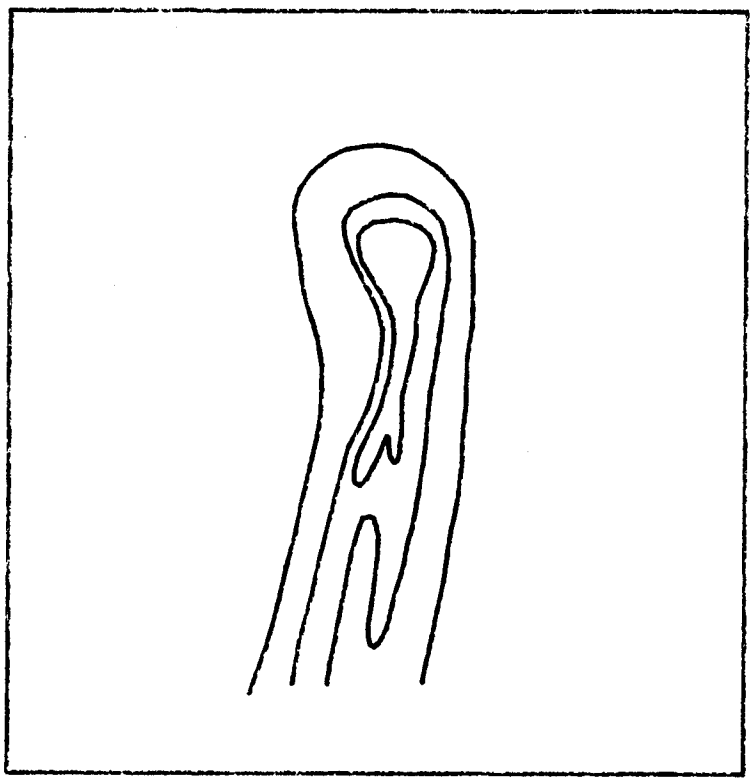

Figure 9a Observed pattern for operation Hardtack-II/Humboldt

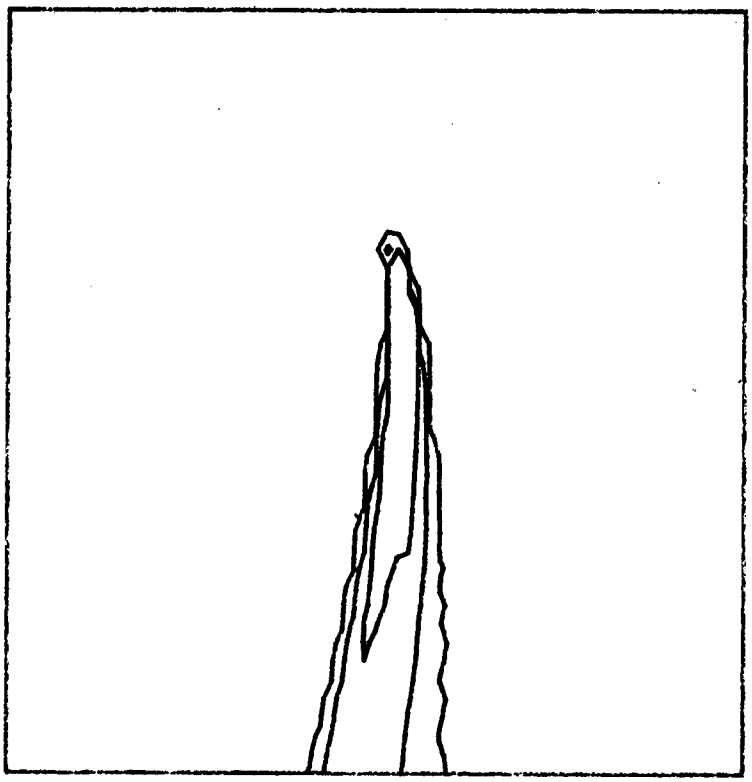

Figure 9b Airrad predictions for operation Hardtack-II/Humboldt

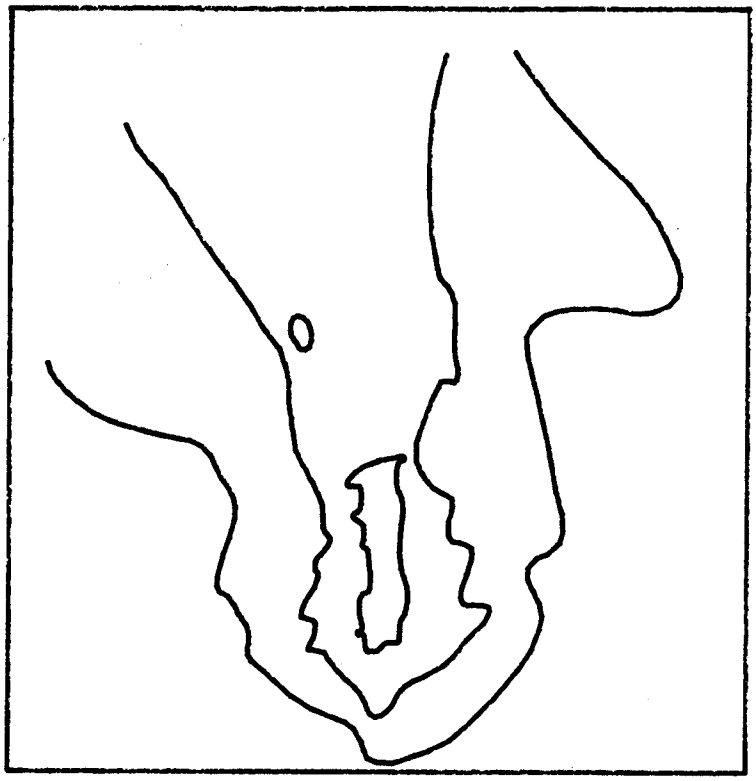

Figure 10a Observed pattern for operation Sunbeam/Johnie Boy

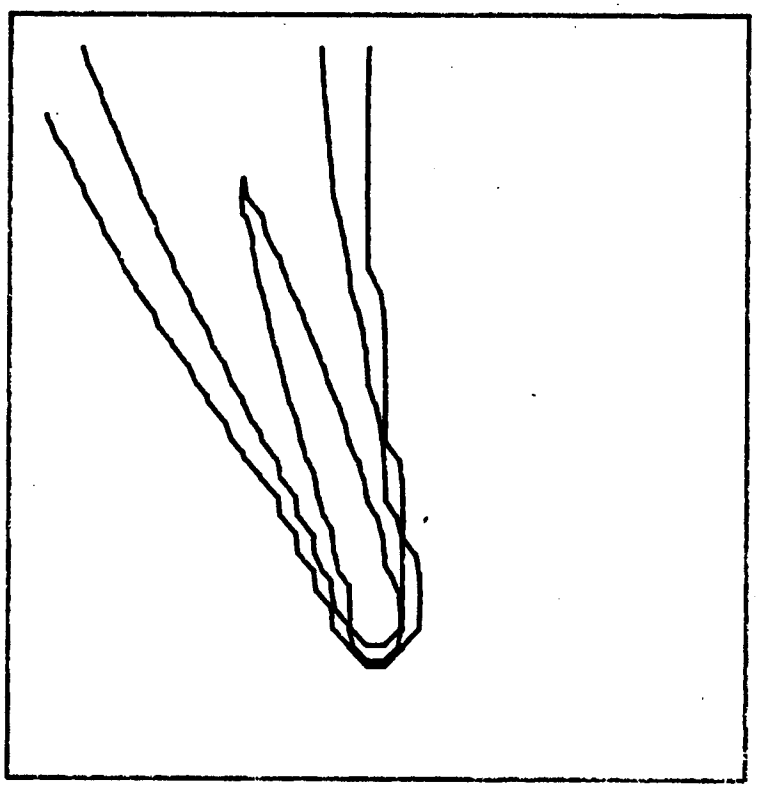

Figure 10b Airrad predictions for operation Sunbeam/Johnie Boy

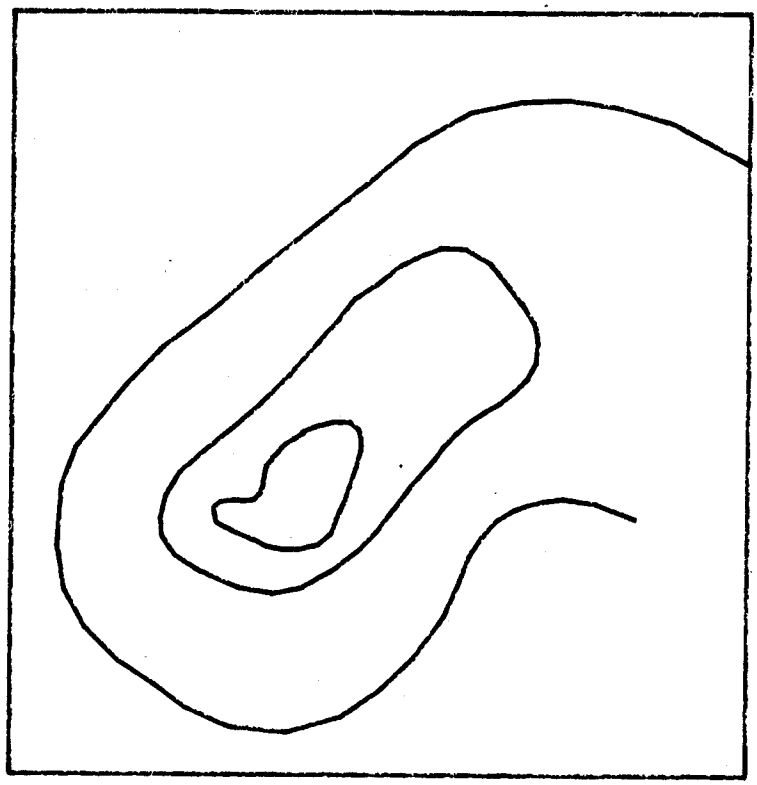

Figure 11a Observed pattern for operation Teapot/Moth

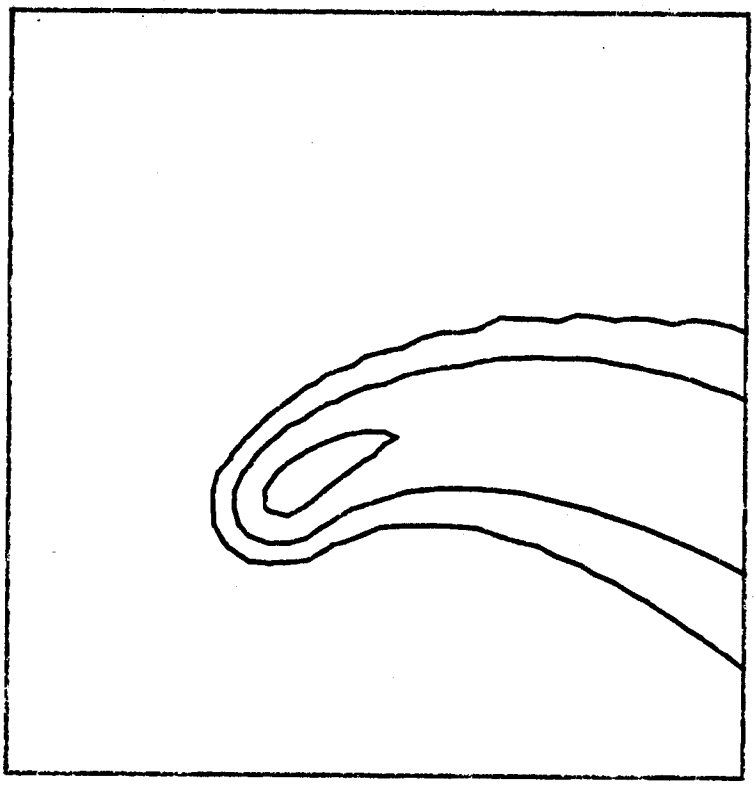

Figure 11b Airrad predictions for operation Teapot/Moth

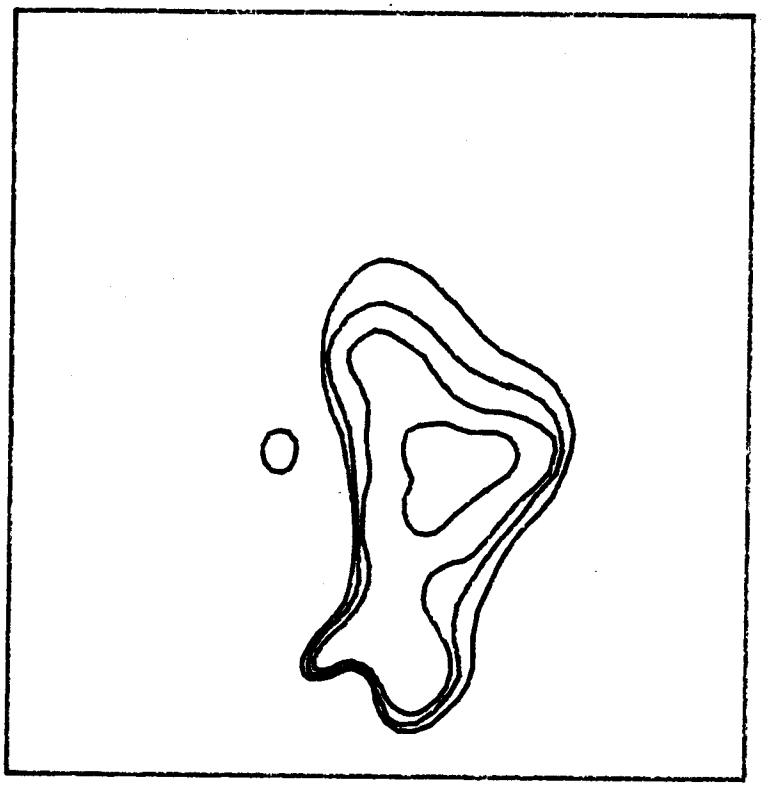

Figure 12a Observed pattern for operation Castle/Nectar

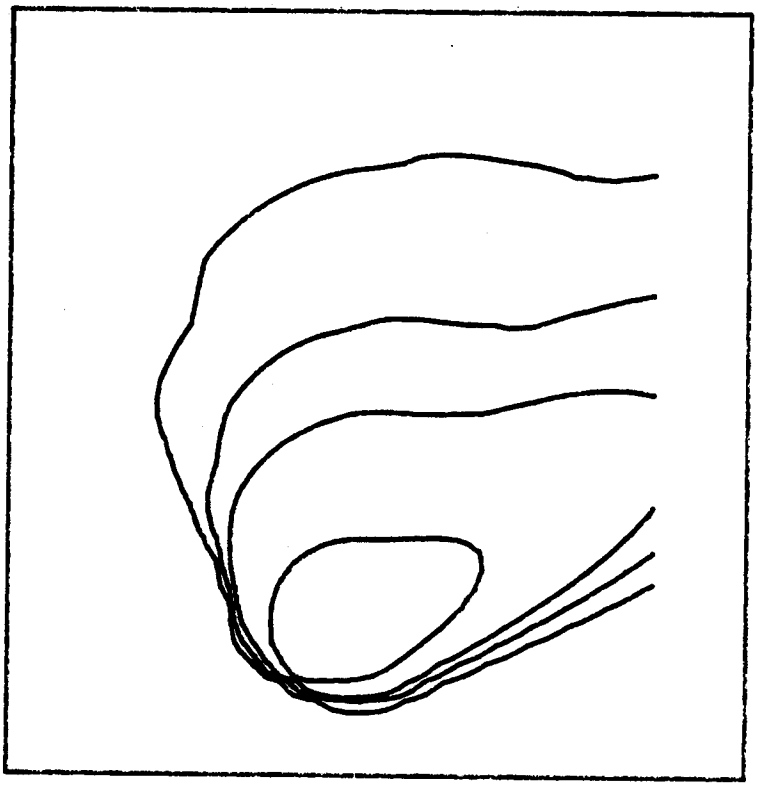

Figure 12b Airrad predictions for operation Castle/Nectar

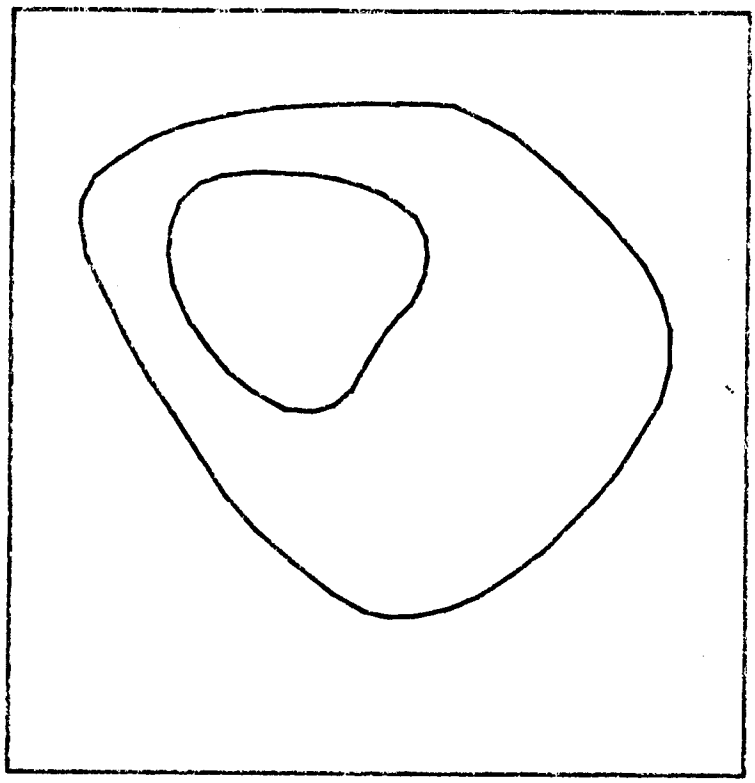

Figure 13a Observed pattern for operation Teapot/Post

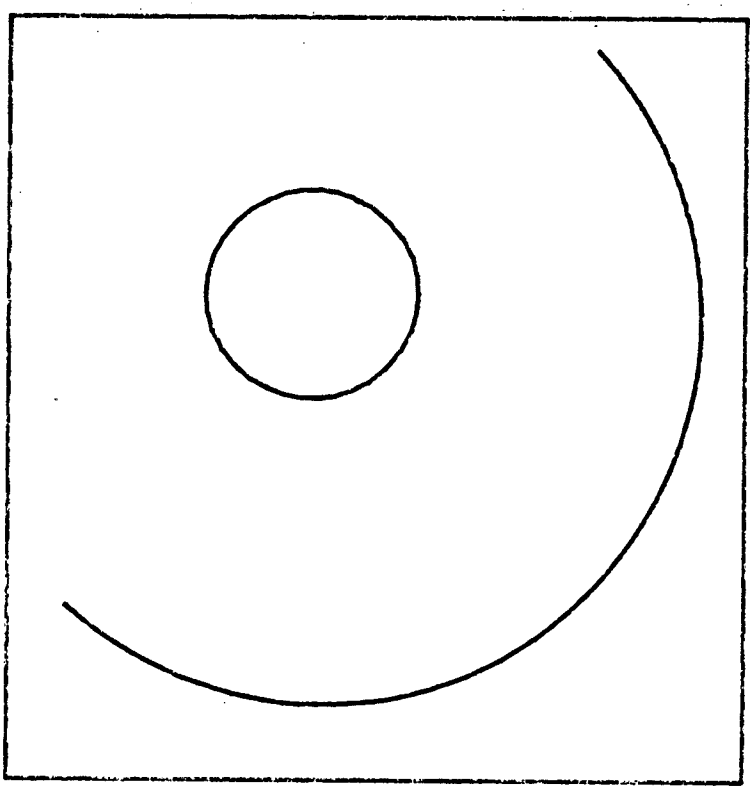

Figure 13b Airrad predictions for operation Teapot/Post

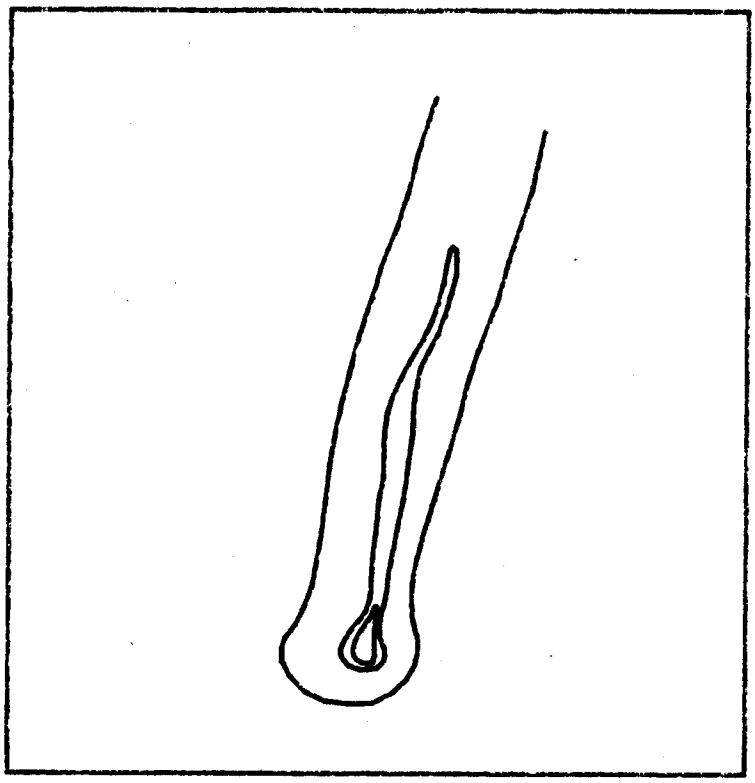

Figure 14a Observed pattern for operation Hardtack-II/Rio Arriba

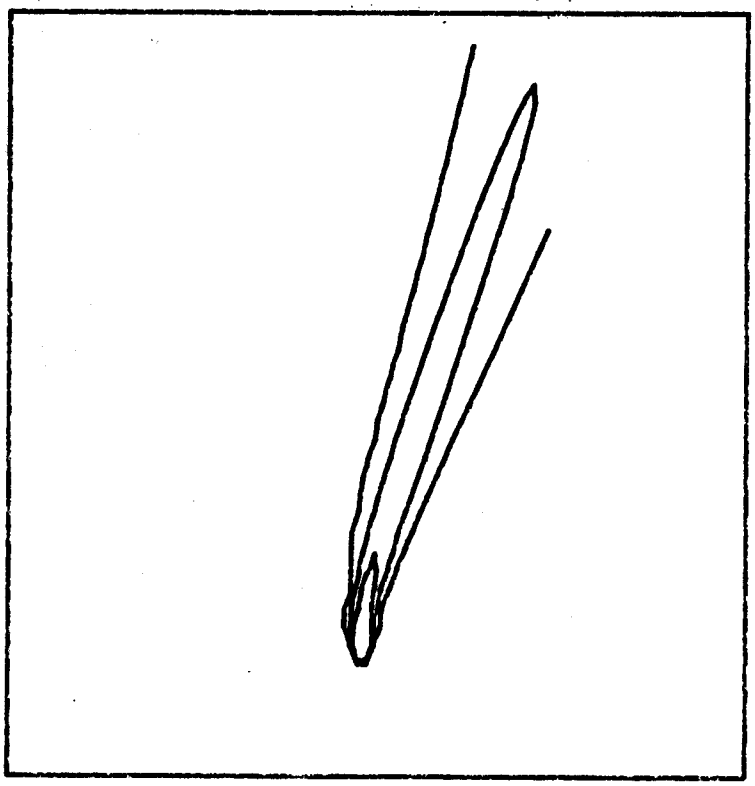

Figure 14b Airrad predictions for operation Hardtack-II/Rio Arriba

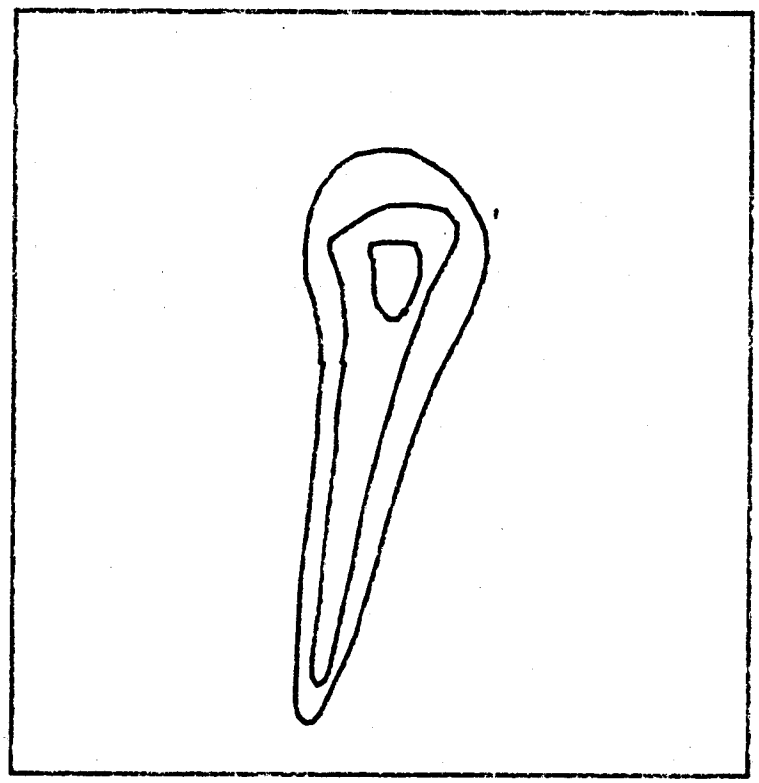

Figure 15a Observed pattern for operation Upshot-Knothole/Ruth

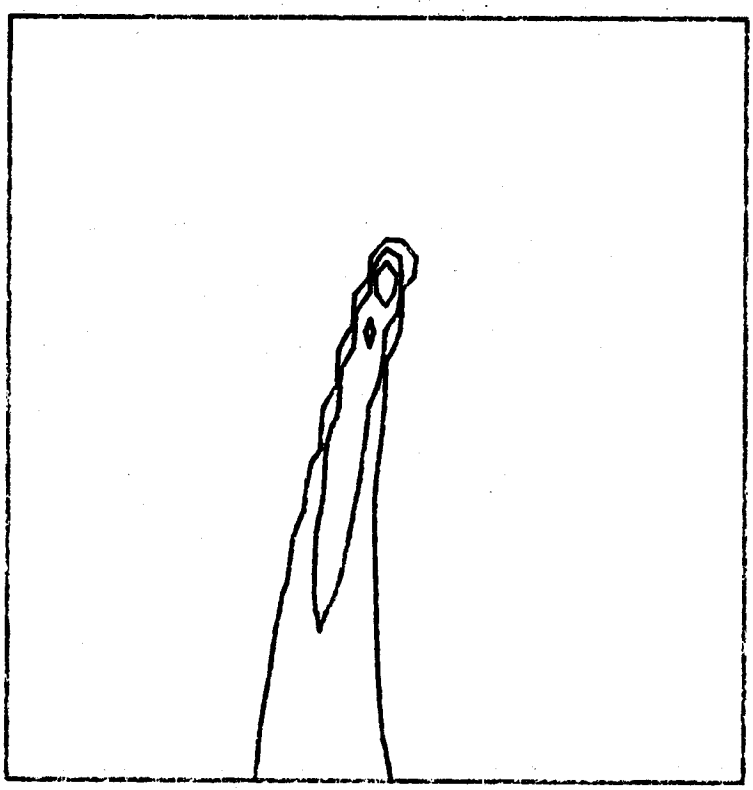

Figure 15b Airrad predictions for operation Upshot-Knothole/Ruth

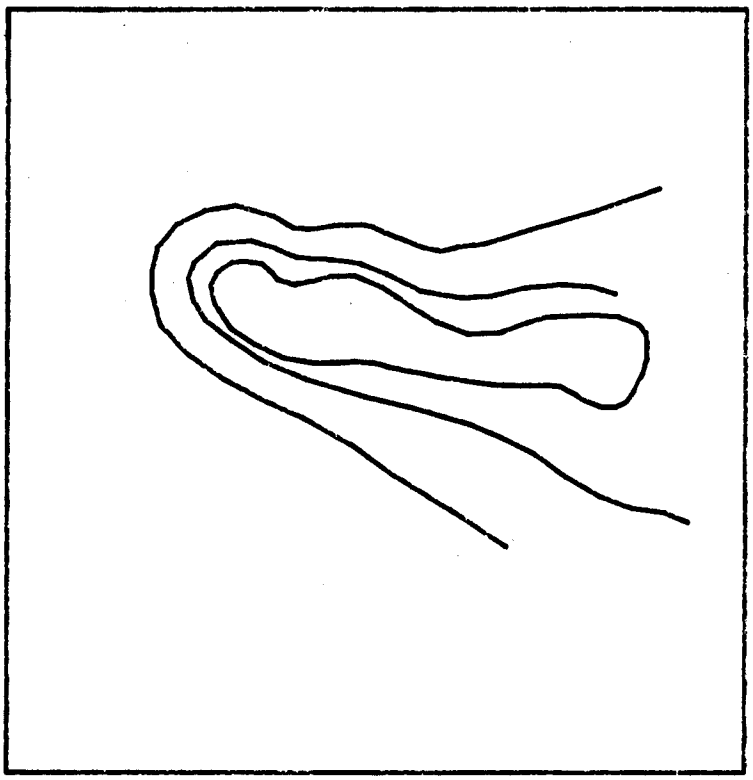

Figure 16a Observed pattern for operation Upshot-Knothole/Simon

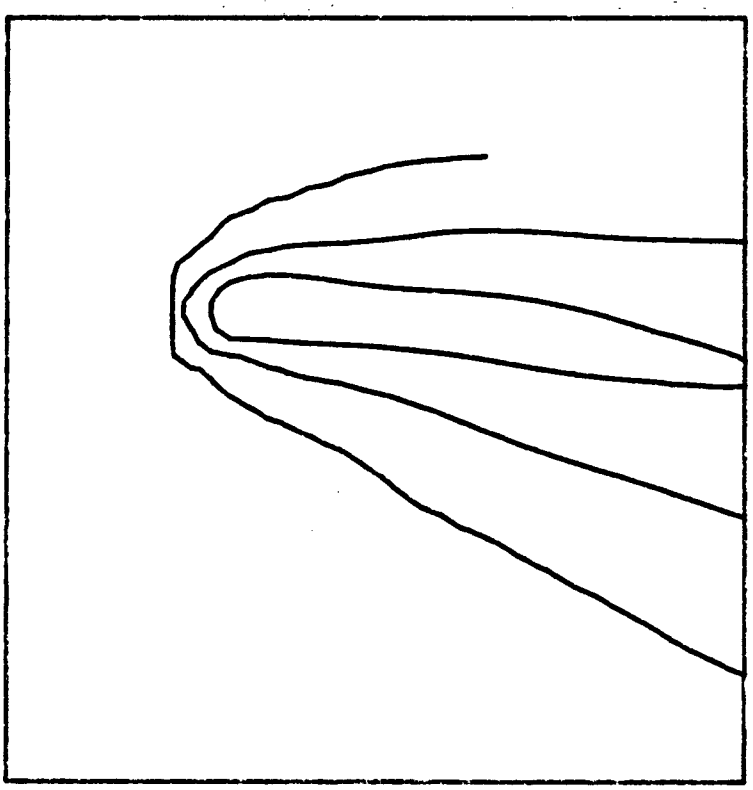

Figure 16b Airrad predictions for operation Upshot-Knothole/Simon

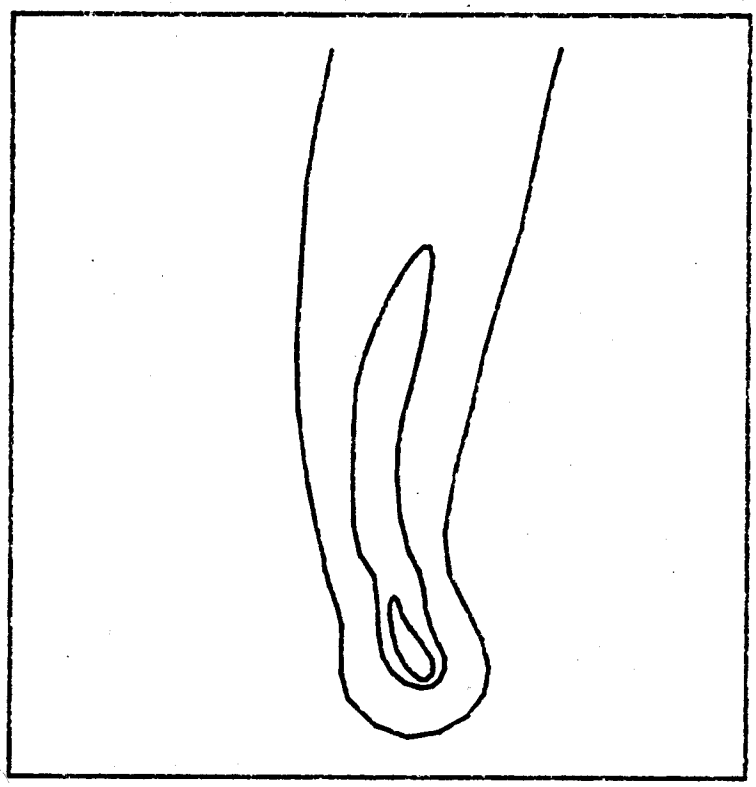

Figure 17a Observed pattern for operation Buster-Jangle/Sugar

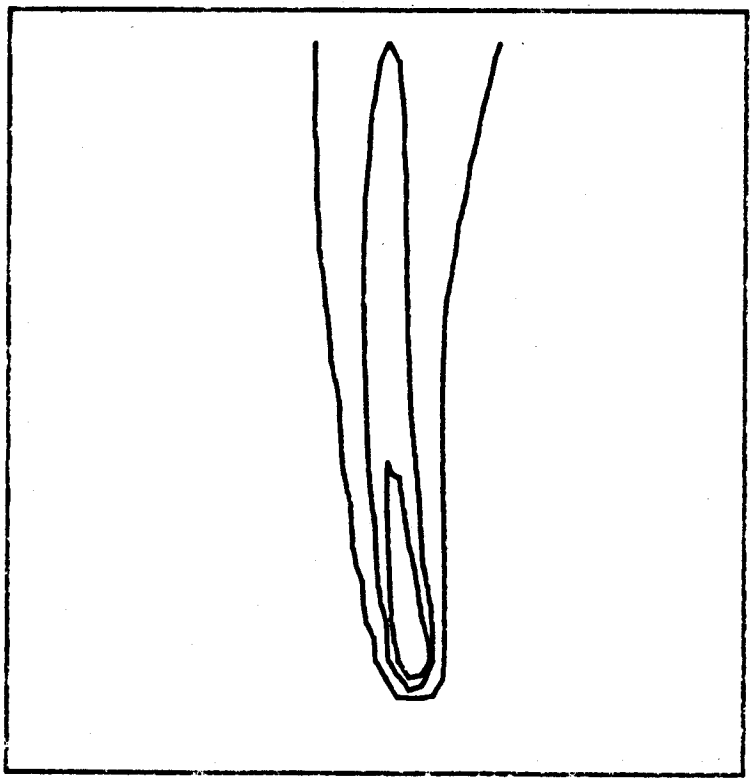

Figure 17b Airrad predictions for operation Buster-Jangle/Sugar

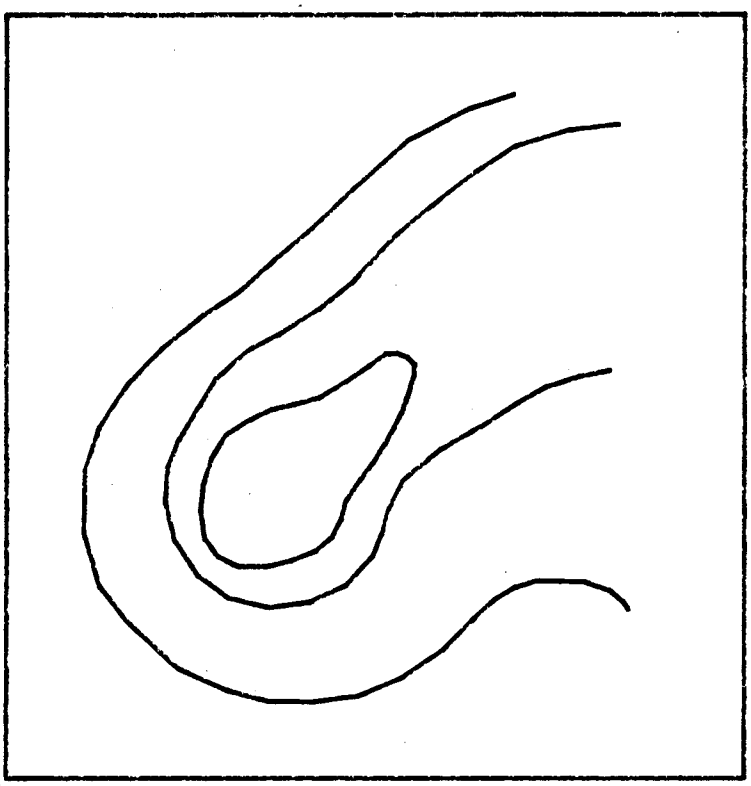

Figure 18a Observed pattern for operation Teapot/Tesla

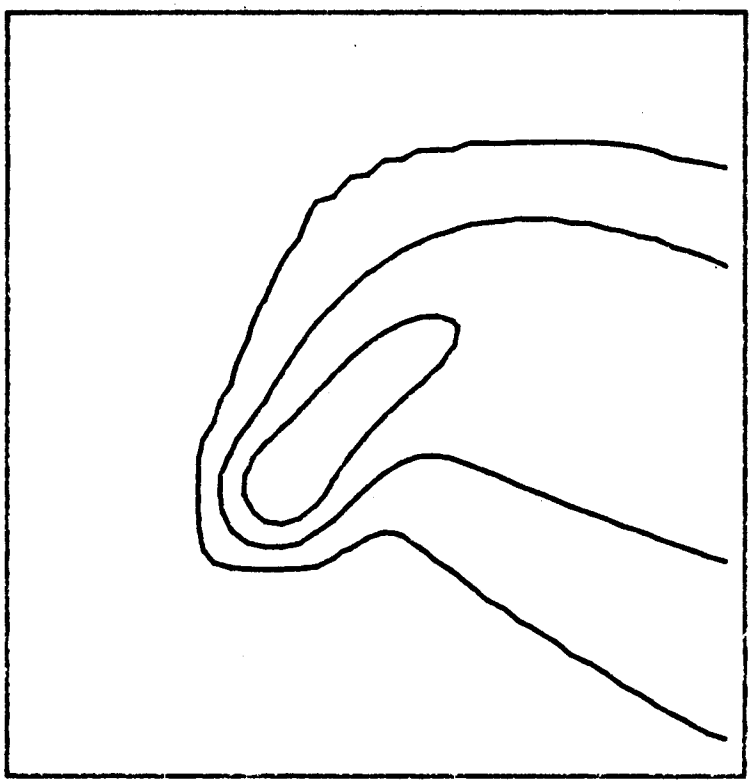

Figure 18b Airrad predictions for operation Teapot/Tesla

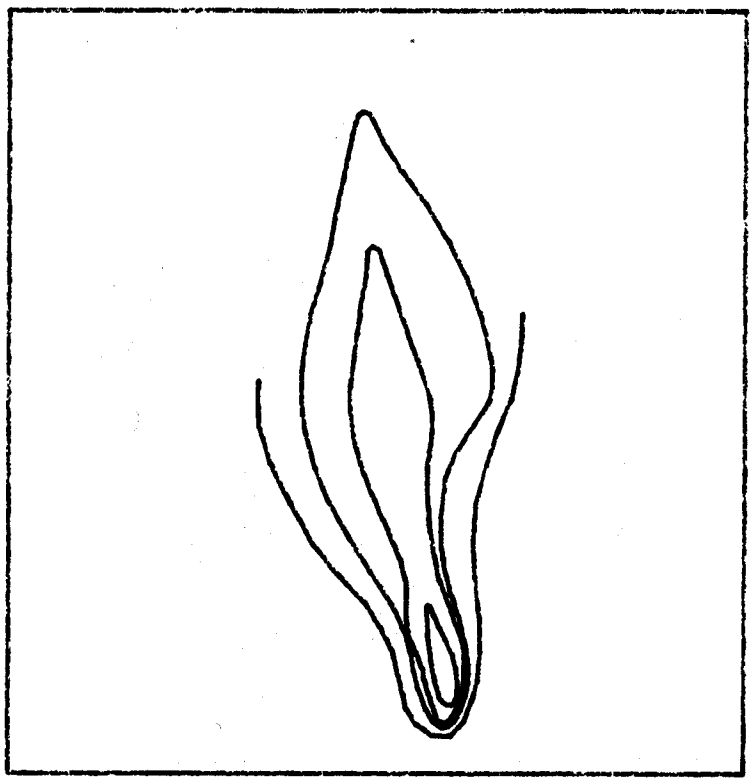

Figure 19a Observed pattern for operation Hardtack-II/Vesta

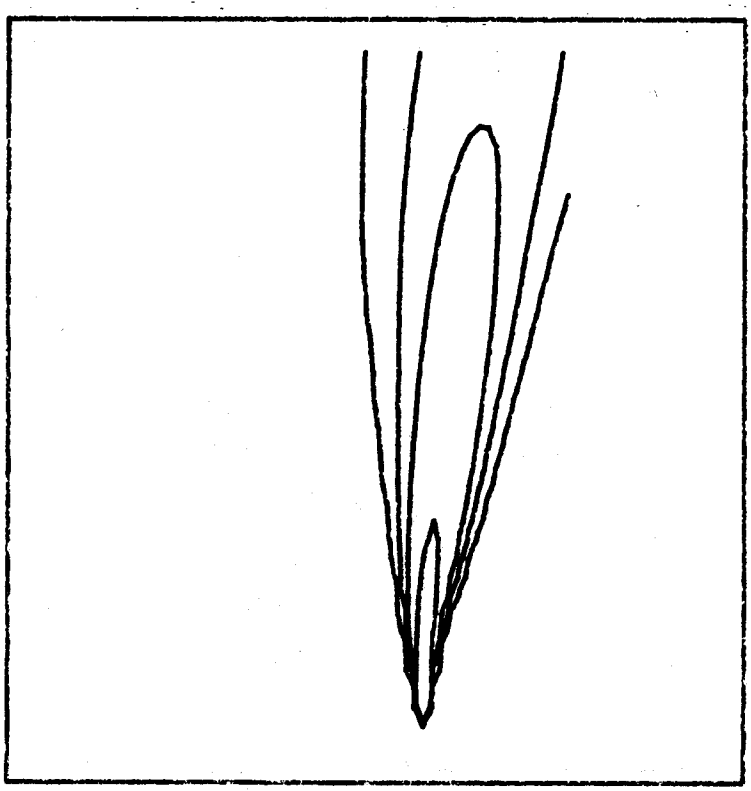

Figure 19b Airrad predictions for operation Hardtack-II/Vesta

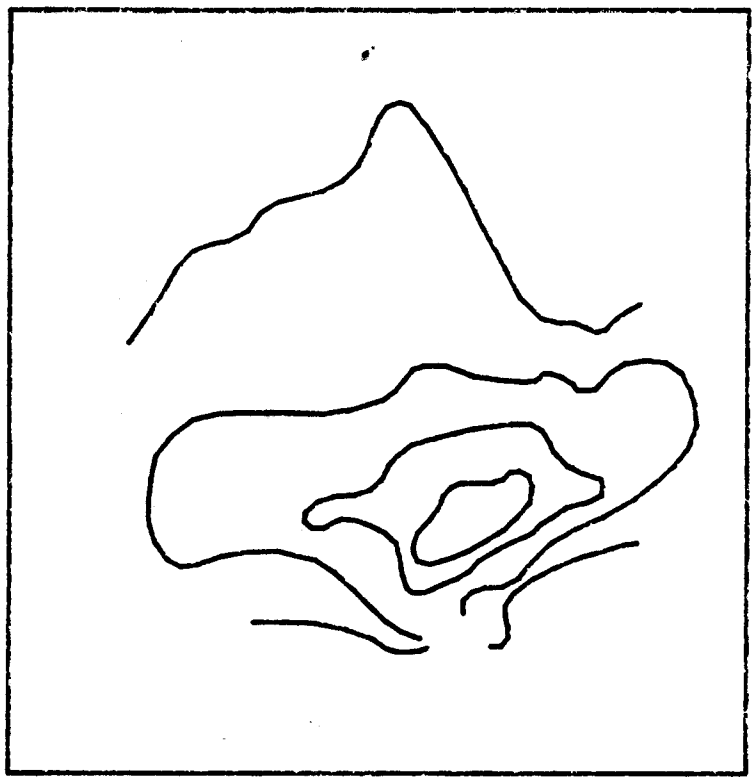

Figure 20a Observed pattern for operation Redwing/Zuni

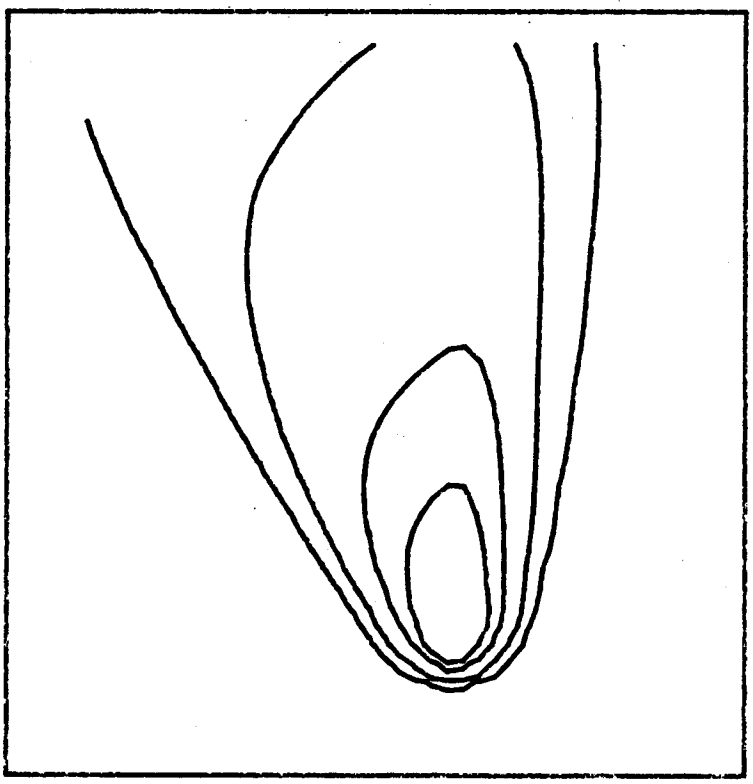

Figure 20b Airrad predictions for operation Redwing/Zuni

REFERENCES

Howard A. Hawthorne, Editor. Compilation of Local Fallout Data from Test Detonations 1945-1962 Extracted from DASA 1251 Volume I - Continental U.S. Tests. DNA 1251-1-EX. 1979.

Howard A. Hawthorne, Editor. Compilation of Local Fallout Data from Test Detonations 1945-1962 Extracted from DASA 1251 Volume II - Oceanic U.S. Tests. DNA 1251-2-EX. 1979.

Hillyer G. Norment. Simfic: A Simple, Efficient Fallout Prediction Model. DNA 5193F. Atmospheric Science Associates, Bedford, MA. December 1979.