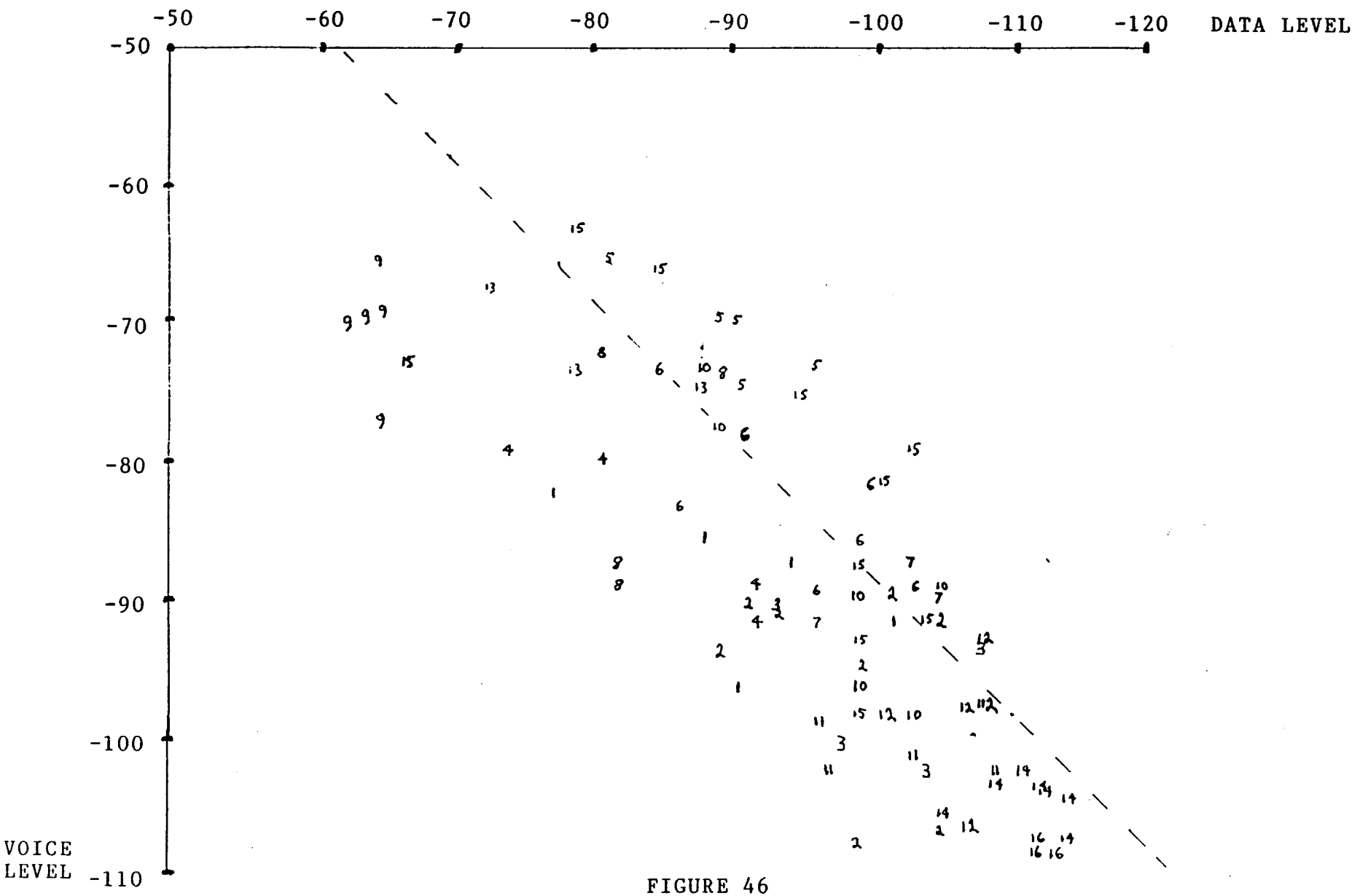

FIGURE 46

Signal Level Measurements

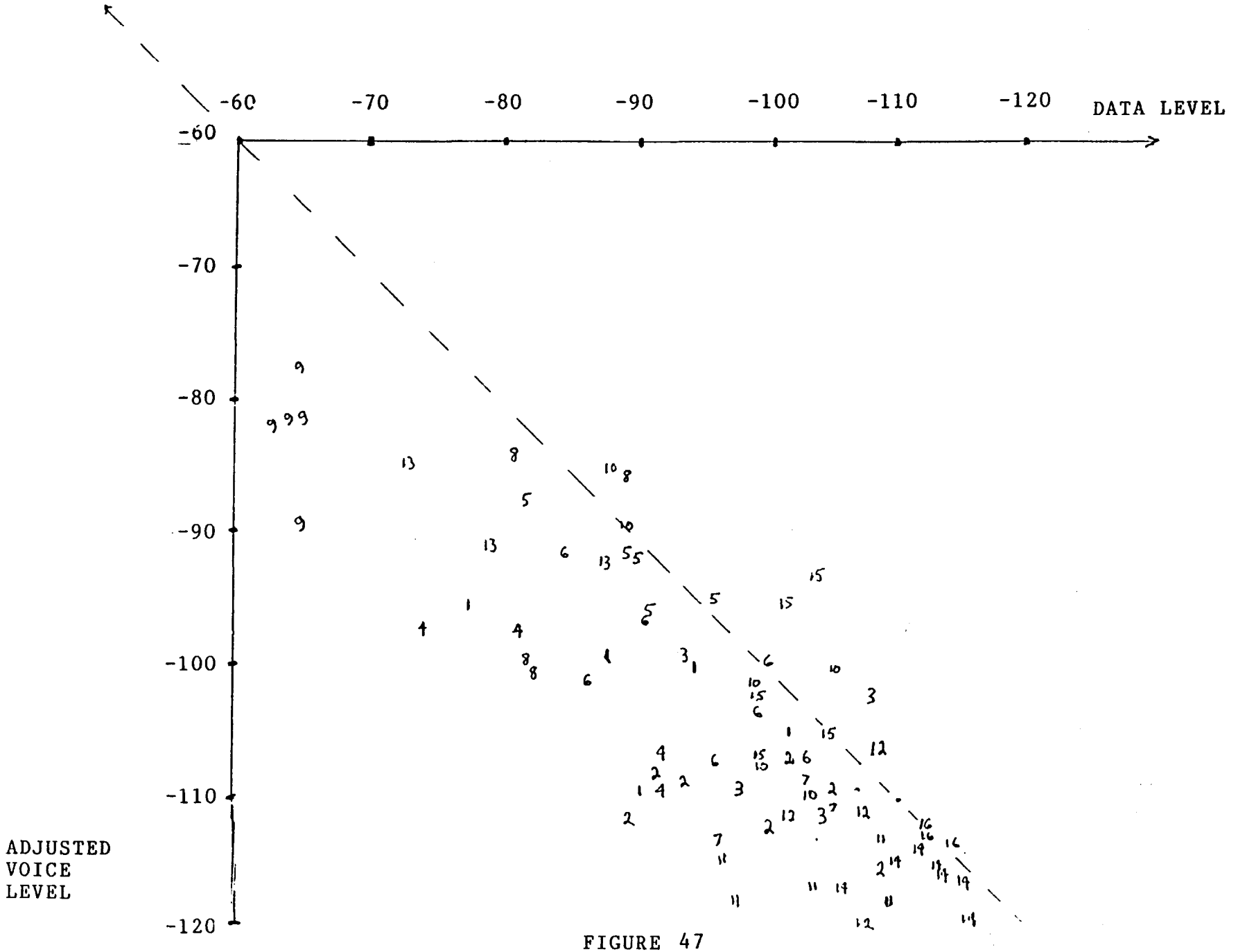

FIGURE 47

Adjusted Signal Level Measurements

Vertical Field Patterns

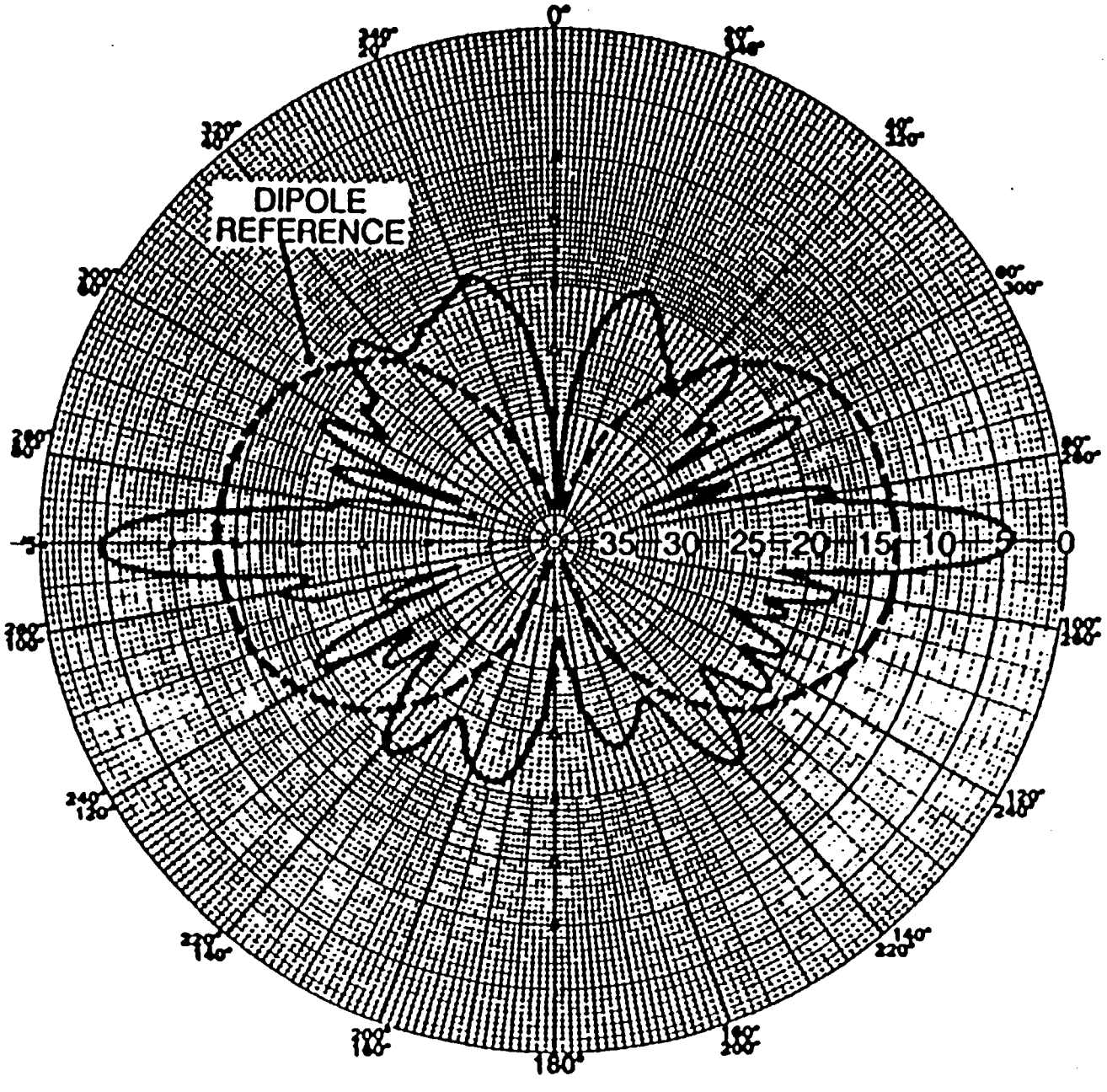

FIGURE 48

TransTech International Corporation
950 North Rengstorff, Unit F
Mountain View, CA 94043

USER UNIT FIELD TEST

C D I

Date: July 6, 1989
Author: Bruce Lusignan

I. TEST SET-UP

The Field Test of the CDI User Unit was carried out on the San Diego Cell Site in Mission Valley on June 26 and June 27, 1989. The procedures and programs for the test were described in TTI reports; "The User Unit Demonstration", June 21 and "User Unit Test Program", June 26. The actual Field tests used these procedures with one major exception; Instead of a normal Pac-Tel antenna, a substitute antenna had to be rigged at the last moment. (Pac-Tel had installed a new set of active Cellular channels on the antenna CDI had previously been using as a spare test antenna.)

The CDI Base Station that was installed is sketched in Figure 1. It consists of the code generator, and HP 8656A synthesizer set to an output power of -12dBm, a power amplifier with a gain of 42dB, and an antenna which is a 8.5cm wire connected to the output of the power amplifier. (The antenna came with the Motorola R2008D/R2010D test set.)

The test antenna gain is about 0dB. It will have its lobes tilted somewhat because the platform on which it sat was not symmetrical. The non-symmetry is thought to account for some experimental variation. The average EIRP of the CDI signals was about +29dBm, 0.8watts.

The power used in the normal Mission Valley voice channels is 12dBw (10.8dBw) watts. This feeds an antenna typically with 8dB gain, including cable loss. The EIRP is thus 20dBw or 100 watts.

The CDI signal was thus set 21dB lower than the normal Cellular voice channel. The recommended protection level resulting from the CDI Frequency Coordination Tests were 20 to 25dBm below the voice levels.

Figure 2 shows the signal levels measured earlier at 16 sites around the Mission Valley Base Station. The (+'s) are from the Voice channel transmissions on the normal vertical antennas at an EIRP of 20dBw. (The 0's are from a CDI horizontal antenna developed for the polarizations tests.)

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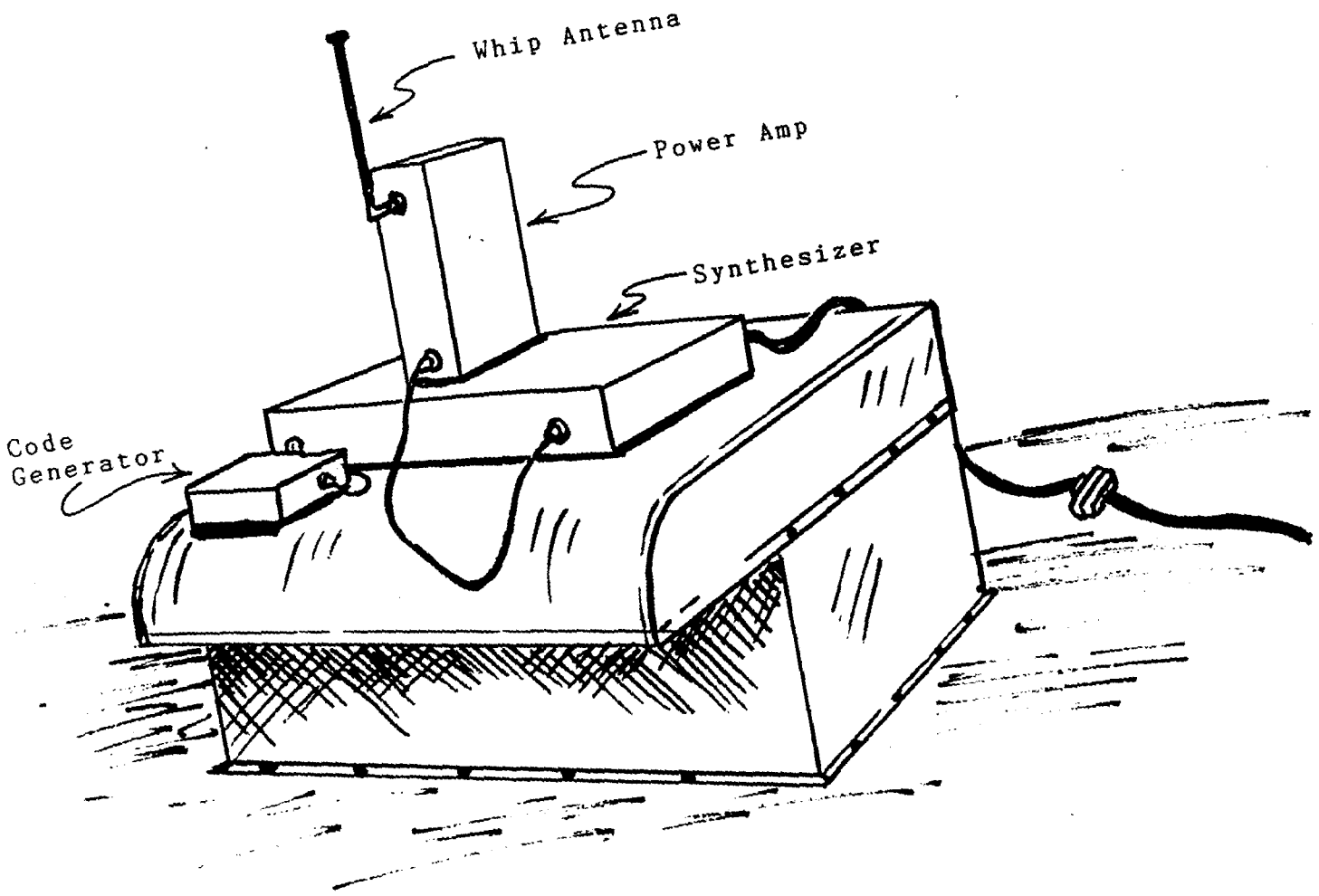


FIGURE 1: CDI Base Station Transmitter

Since the User Unit tests were run on a linear antenna, the CDI signals in these locations would be approximately 21dB lower in power than the linear voice channels. The fields measured in Figure 2 were measured by a test dipole in an open area pointing towards the Mission Valley Base Site. Thus, they measure the fields received by a typical dipole in the open space; no local structure shielding is accounted for.

In typical applications, the CDI User Unit antenna is expected to have 0dB gain, the test dipole has 2.15dB gain, but has a cable loss that is about 2dB. For this analysis the effective gain of the User Unit receiver was the same as the test Dipole.

Figure 3 shows the test area with each of the test sites numbered. (The numbers are the same as on Figure 2 and as on the test data described below.) In the tests all sites were visited except #13. Site #13 was skipped only because it had very high field strength and would present no difficulties.

To put the tests in perspective, the coverage areas of Mission Valley and other cells are shown in Figures 4 and 7.

Several test sites could be reached by coverages of several Base Stations. In particular, Sites #12, #14 and #16 could be covered either by 30th Place or Aviation Drive.

The User unit is shown in Figure 8. Figure 8(a) shows the unit with the external battery package. Figure 8(b) shows the unit alone, the wire sticking out at the right is its antenna.

The unit was taken to each site and placed in the test location. It was then turned on. The program scanned the receiver through the range of expected frequencies stopping at each step to see if CDI data was detected. If the signal was detected the program reduced the frequency error to zero and then transmitted the data back for a period. At the end of the period of data transmission the power was reduced step-by-step to lower levels. If no data was detected, a shorter interval of test pattern was transmitted.

Figure 9 shows the test patterns received at the Mission Valley test site for four examples.

Figure 9(a) shows a typical good data transmission, a period of steady level followed by eight step of data reduction. The level of the signal is used to measure the received signal strength at the Base Station. Figure 9(b) shows an unsuccessful transmission, the User Unit has not received the Base Station transmissions and is transmitting the shorter pulse.

Figure 9(c) and 9(d) show two data transmissions recorded at higher scan speed to show the data pattern. Note that this pattern is very rough and differs between 9(c) and 9(d). The

"detector" used is just the spectrum analyzer detector offset to a side frequency to show variation with the FSK signal from the User Unit. The signals provide only a rough indication of received data, a regular receiver was not available.

II. RESULTS

The tests were run as indicated, the results are summarized in Table I.

The Site numbers in the left hand column correspond to the 16 Sites on Figure 3. In Column 1, the power level of the Cellular Voice signal measured at each site has been recorded. These are from the earlier tests reported in Figure 2. Since the CDI signal was transmitted with 21dB less EIRP, its expected value is 21dB less. This expected CDI level is recorded in Column 2 of the table. Note that these levels were measured in open areas pointing the receiver towards the Base Stations. The effect of local structure shielding is not included in the projection. Such structural shielding typically causes 15 to 25dB added loss, thus the field strengths at the User receiver will typically be 15 to 25dB lower than the level indicated in Column 2, depending on structural shielding.

Column 3 shows the mileage measured from the Mission Valley test site to each test location. Range varies from 0.5 miles to 2.7 miles.

Column 4 shows the results of the tests. An "x" represents a successful reception and an "o" represents an unsuccessful reception. Note that at five sites two locations were tried to test different local shielding.

Column 5 represents the CDI User signal level received at the Mission Valley Base Station. This is received from the common distribution amplifier used for the Cellular voice signals. It is the power received in a detector bandwidth of 10kHz. The lowest level, -110dBm, represents the noise floor of the Base Station receiver in 10kHz bandwidth. (The CDI receiver has a 3kHz bandwidth.)

Under most normal conditions, the shielding measured by the inbound link (Column 5) will approximate the shielding on the outgoing link. Even though the two signals differ by 48MHz in frequency, they do experience similar structural shielding.

In these tests a number of installation conditions were tried to simulate conditions expected in an operational system. The tests are recorded in Appendix 1. Each test, one or two per site, is shown in three ways. A picture shows the User Unit in its test position. A Polaroid photo of the receiver at the Mission Valley Base Station shows the signal received, indicating data reception or not and level of signal on the return path. A comment indicates the location and test condition.

Most sites used shielded installations, within structures, behind buildings or posts, within metal enclosures, etc. In residential areas it was not feasible to put the unit inside of houses because of the late hour. In these areas, the unit was held inside the test vehicle experiencing shielding that would be equivalent to structural shielding in a frame house. (These locations have pictures showing Dr. Rezvani in the car holding the User Unit.)

III. INTERPRETATION OF RESULTS

The general conclusion is that the User unit successfully received data throughout the normal coverage area ot the Mission Valley Cell. The signals returned by the User unit were strong enough to be received by a normal receiver in the Base Station. (15dB above the noise of the common Base receiver would equal about -100dBm.)

The largest range tested was at Site #3 where signals were received successfully at 2.7 miles. The outgoing EIRP was -109dBm in a clear line of sight. At this test the unit was in the car giving an expected 7 to 10dB additional attenuation. The return signal was -93dBm, sufficient to be received by a normal Base Station receiver.

The weakest signal received was at Site #14 where the distance was 1.3 miles, but was attenuated by a cliff edge that blocked the line of site to the Base Station. At this location outbound signal level was about -118dBm in the open field and may have been lower in the garage installation. The returned signal was at -105dBm, just sufficient to receive at the Base Station.

The other sites illustrate a wide variety of signal levels and shielding requirements with successful reception, and return transmission. Shielding variations of 28dB was experienced going from line of sight to an underground garage at site #1. At sight #2, variation of 17dB was experienced from outside to inside a garage. At site #12, a variation of 14dB resulted from outside a van to inside its aluminum compartments.

Signals were not received at four locations, all sites that would be served by other Base Stations in the full systems. Two of the difficult locations, Sites #11 and #12, appear to be due an anomaly in the CDI transmit antenna. The third site, #16, is simply outside the coverage area of the Base station; it is covered by two other Base Stations.

The anomaly at Site #11 and #12 may represent a null in the CDI transmit antenna in the southern direction. The signals getting to this location may be 5 to 10dB weaker than signals in other directions due to the irregular shape of the CDI test antenna. This may explain why the signals were not received even though they were "expected" to be no weaker than those received at Site #14.

In any event, these sites are beyond the normal coverage area of Mission Valley and would normally be served by other sites.

In conclusion, it is seen that within the normal coverage area of the cell, no problems are encountered. In most areas no pains must be taken in installation. Normal shielding loss is not sufficient to cause loss of signal.

On the edges of the cells, care must be taken to know which Base Site is best to use. In the case of the Mission Valley Base Station, the ridge to the South of the Base Station reduces its cell radius while open terrain to the North East extends coverage. Installations should be guided by predictions of expected signal strength from each nearby site.

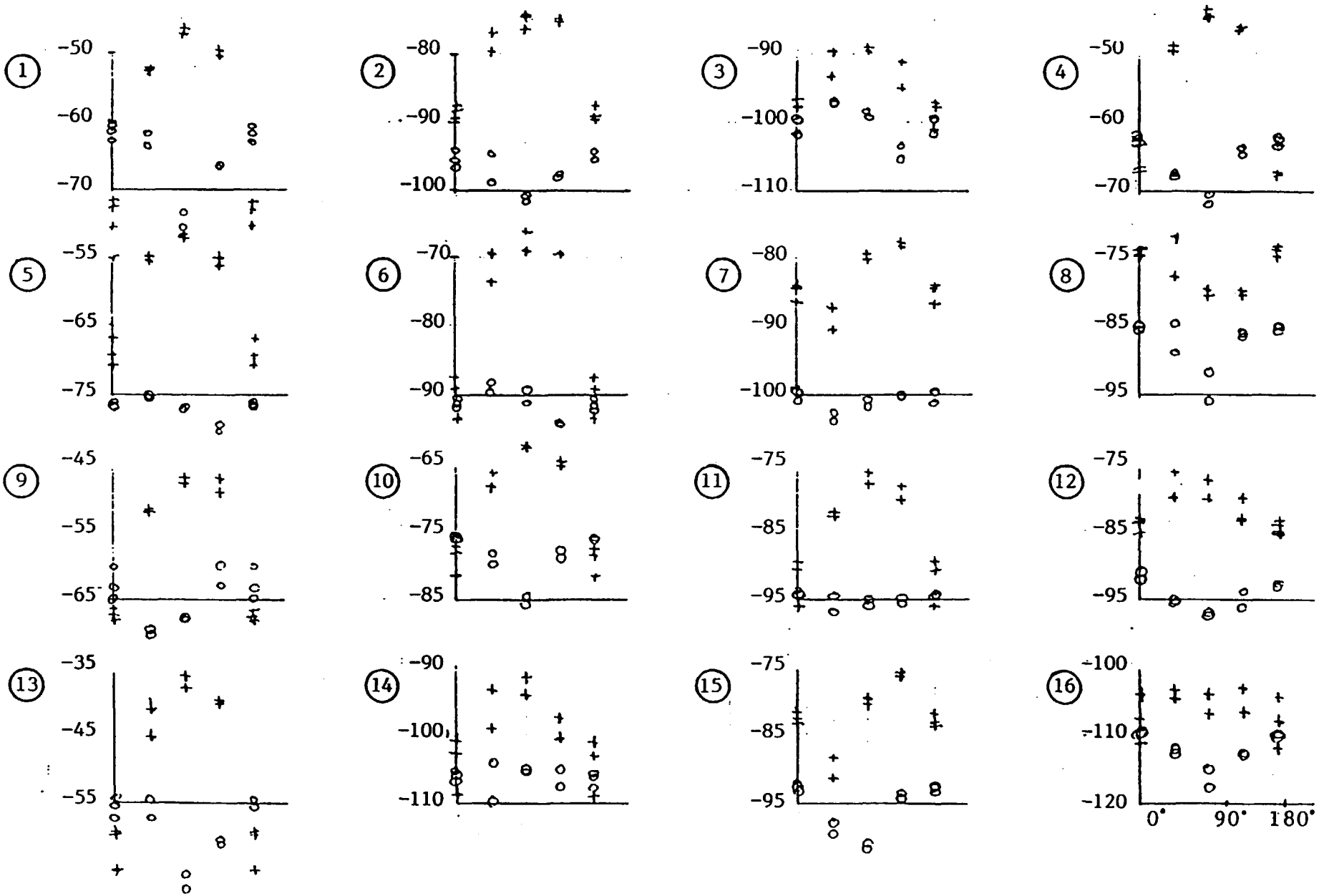


FIGURE 2: Field Strength Measurements at 16 Sites around Mission Valley

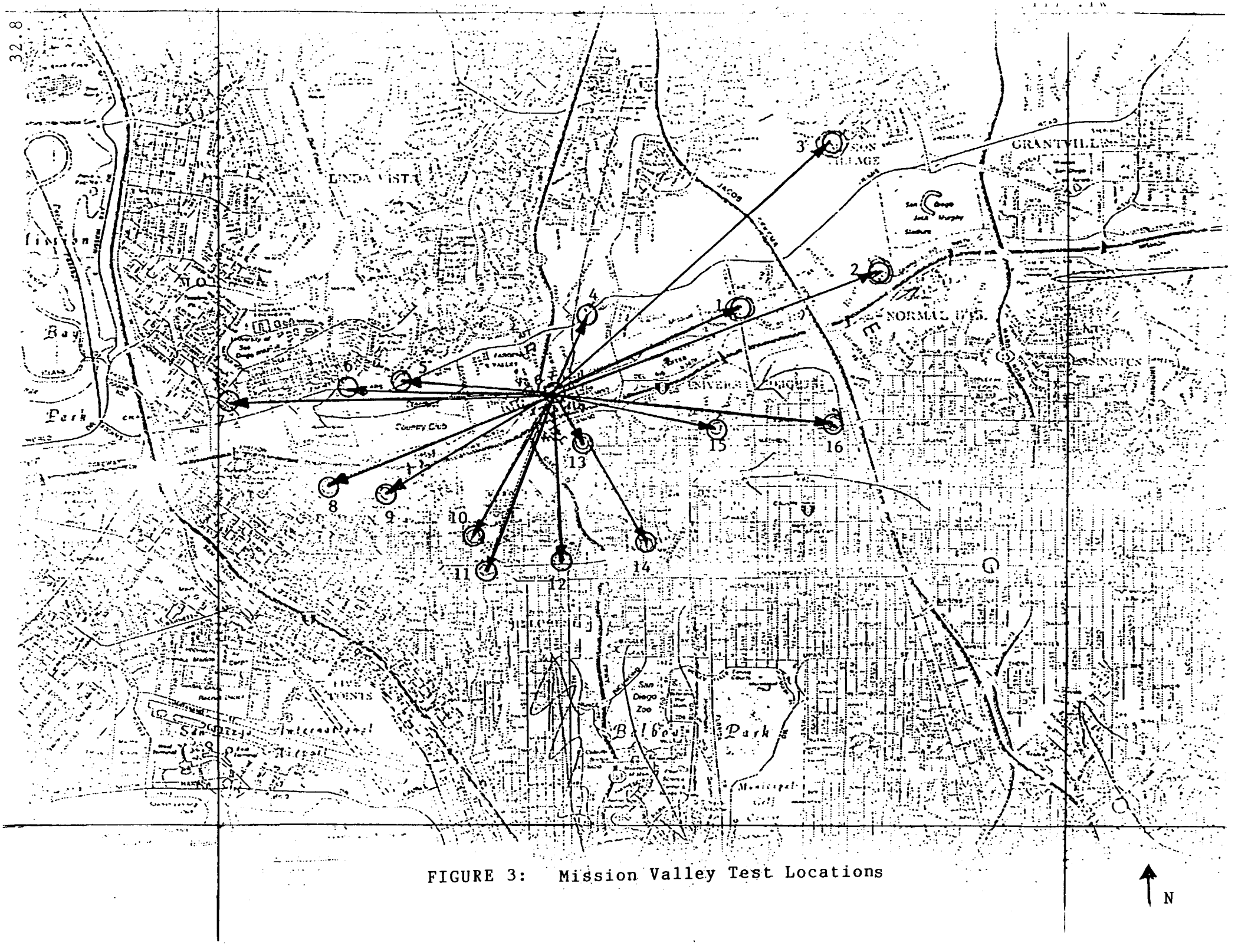


FIGURE 3: Mission Valley Test Locations

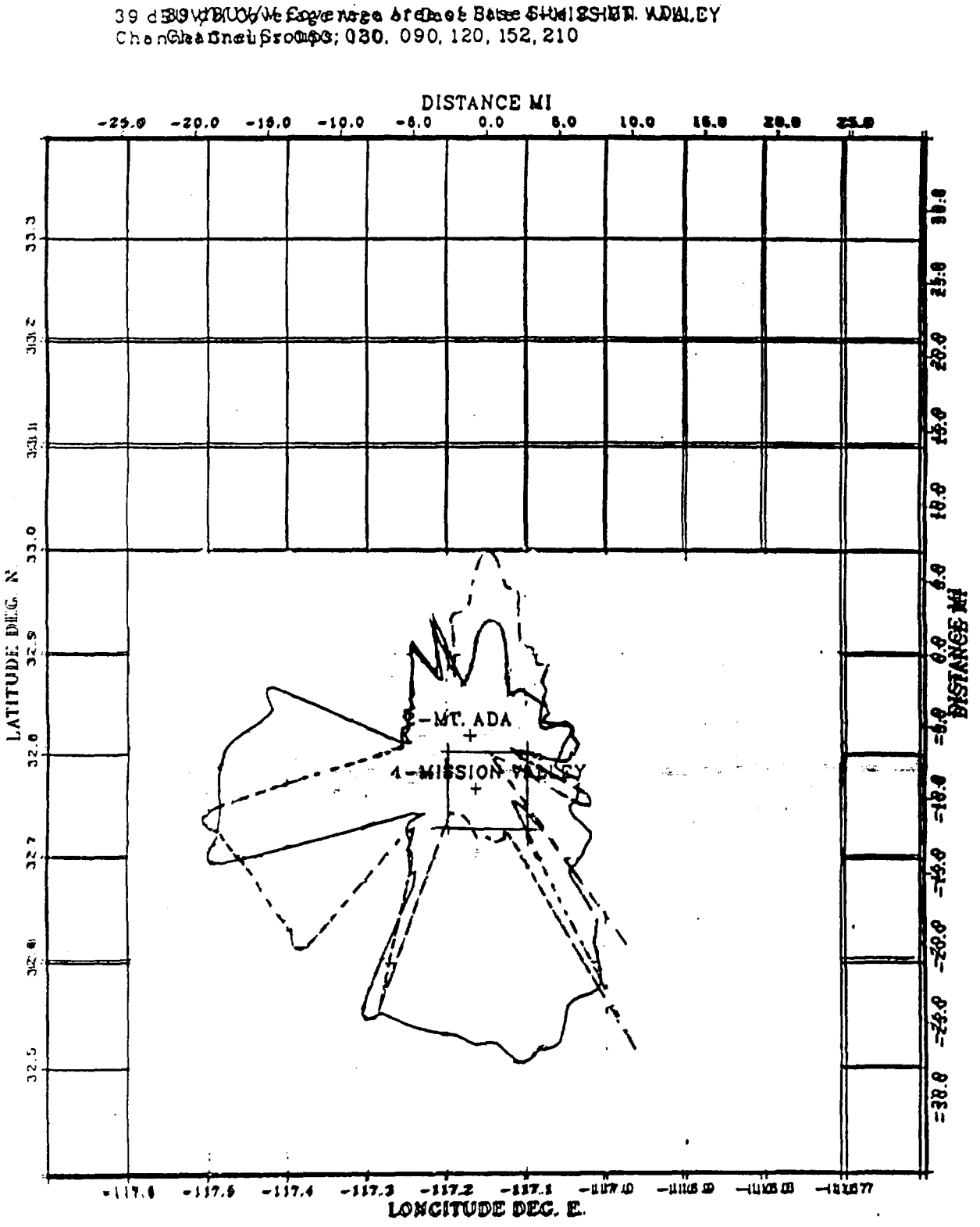


FIGURE 4: Mission Valley and Mt. Ada

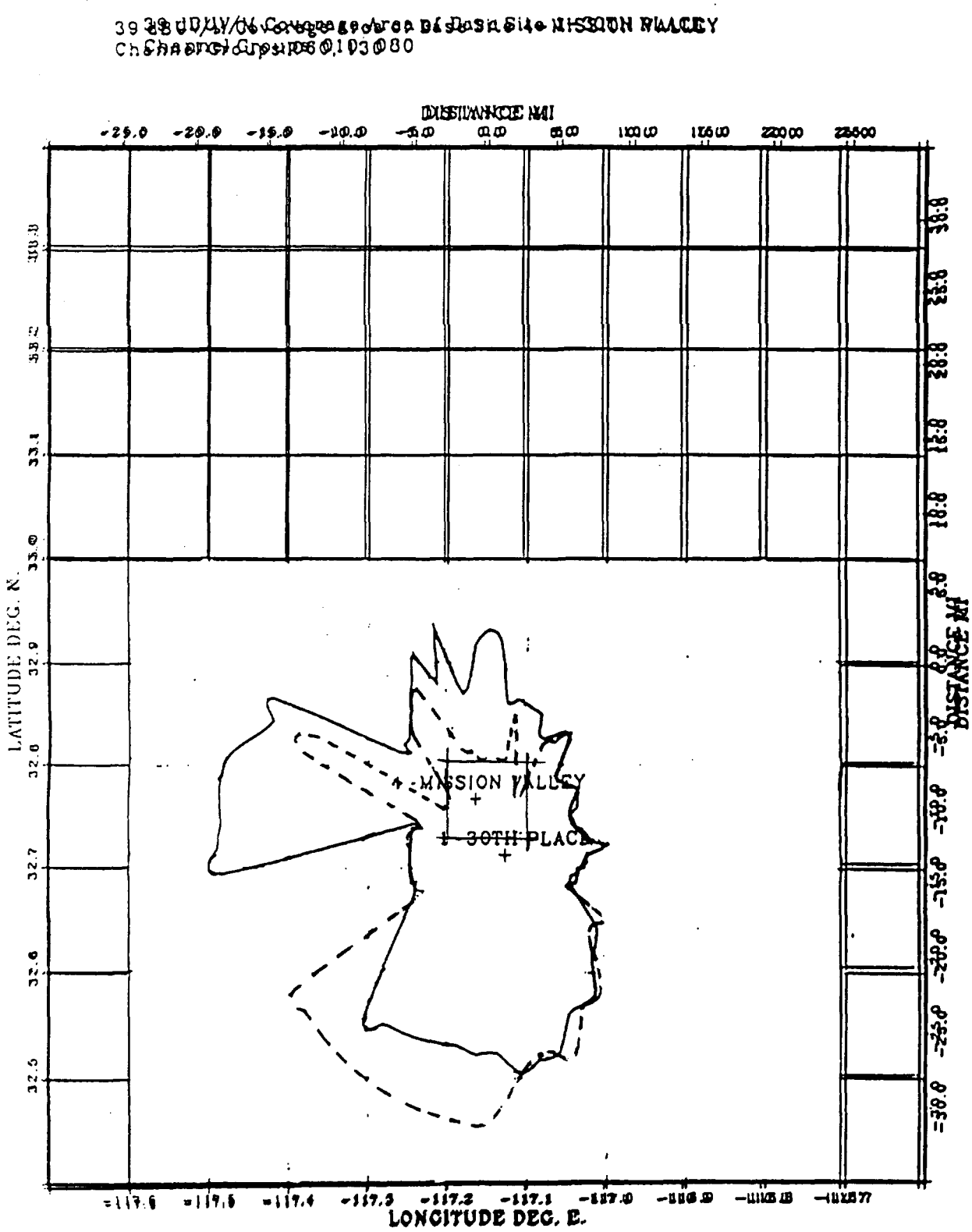


FIGURE 5: Mission Valley and 30th Place

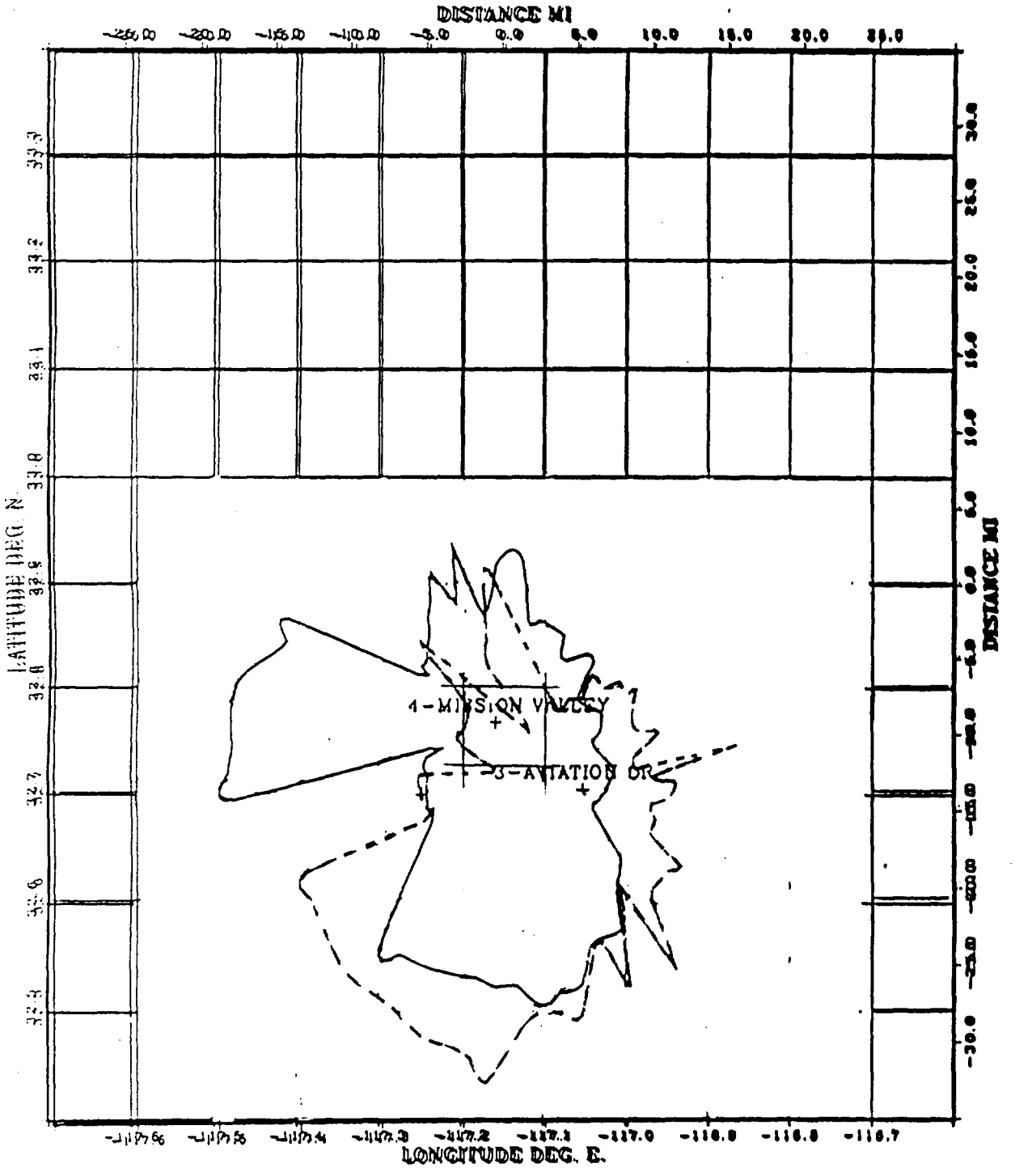


FIGURE 6: Mission Valley and Aviation Drive

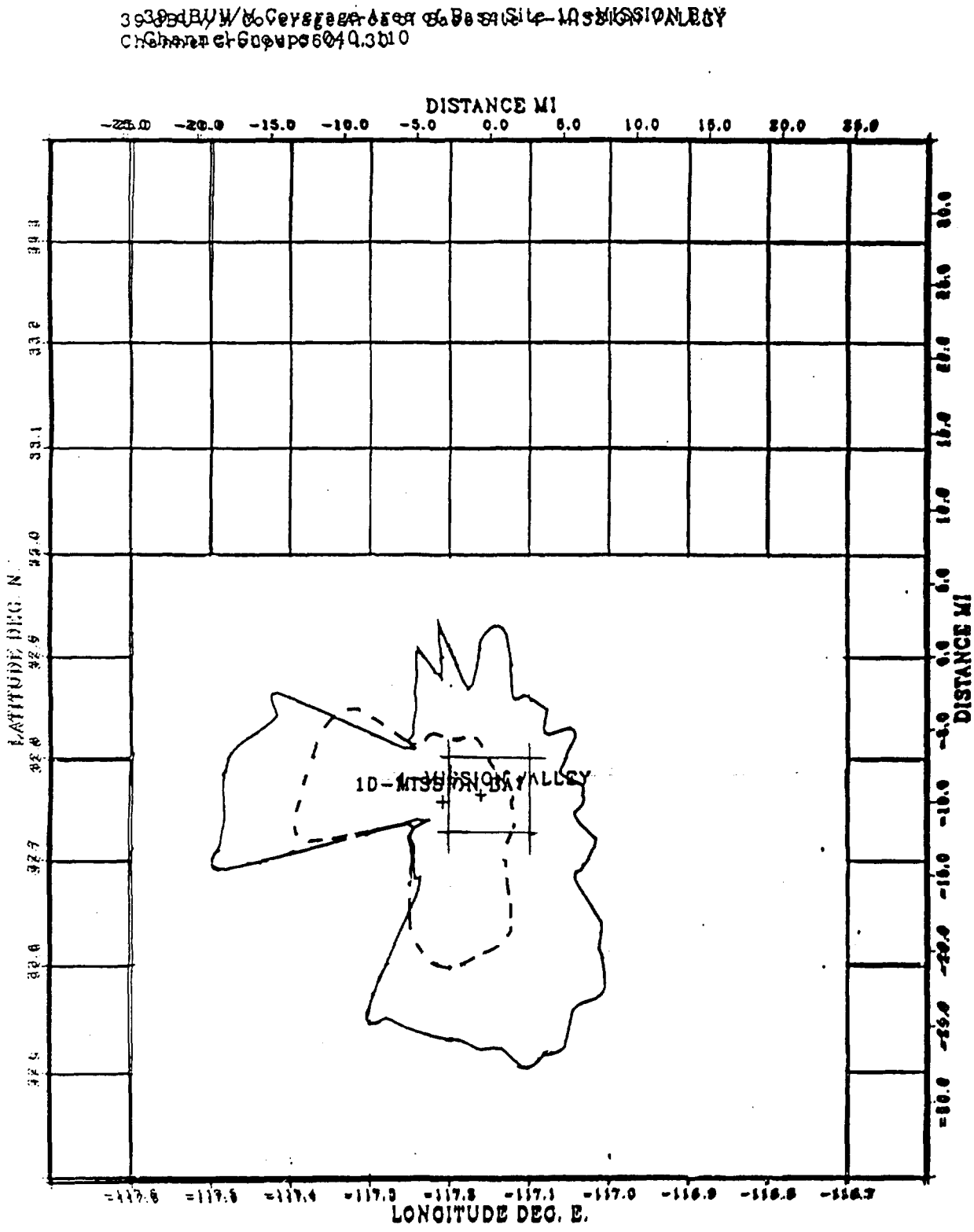


FIGURE 7: Mission Valley and Mission Bay

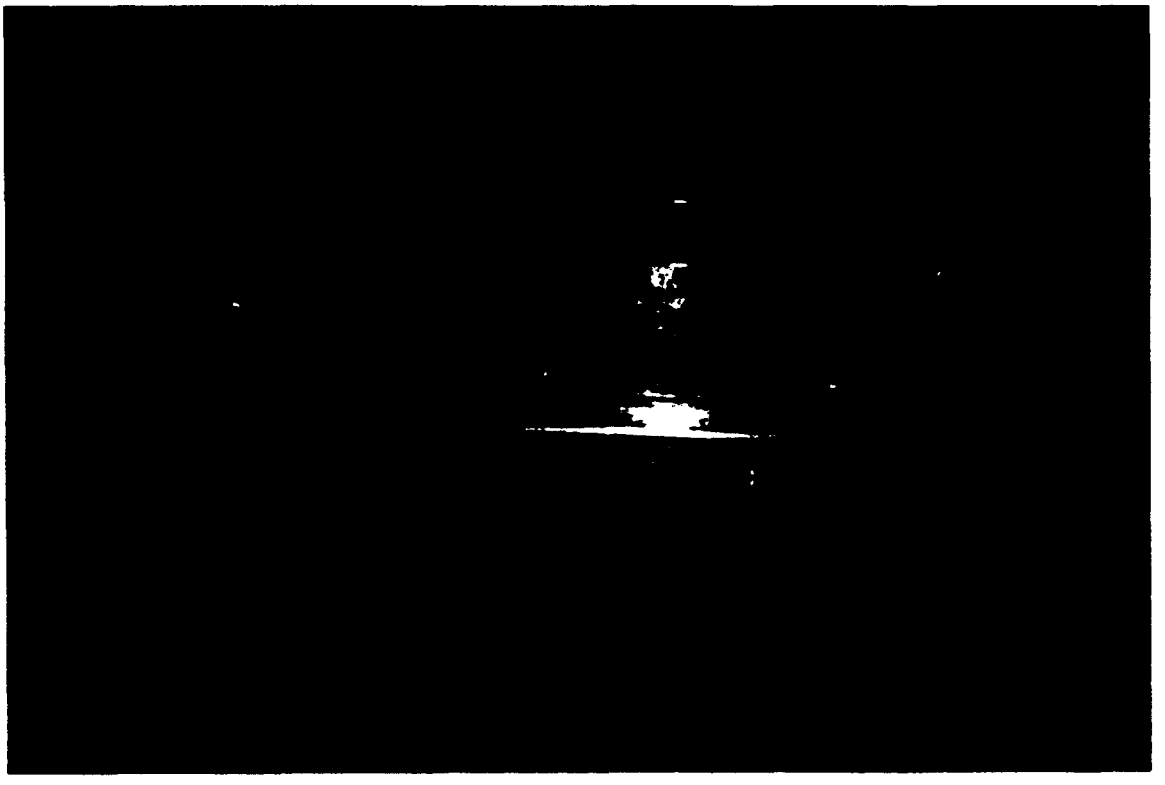


FIGURE 8a: User Unit and Battery Pack

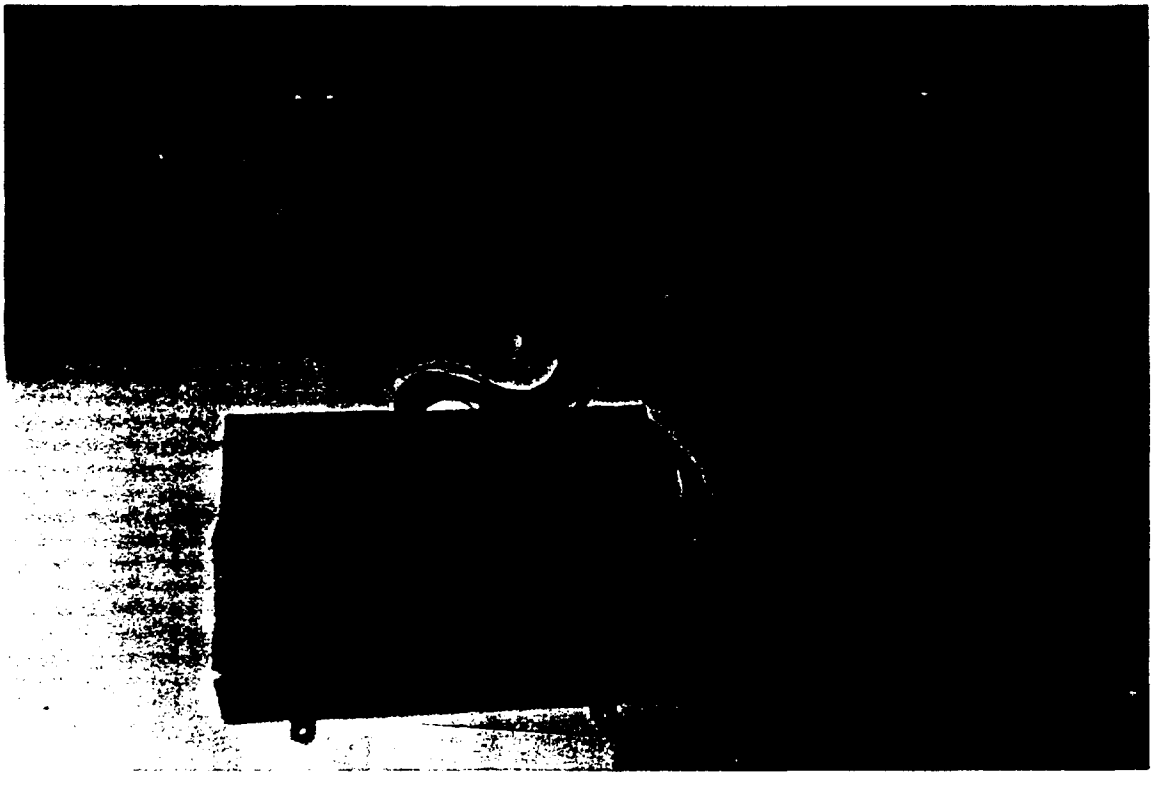
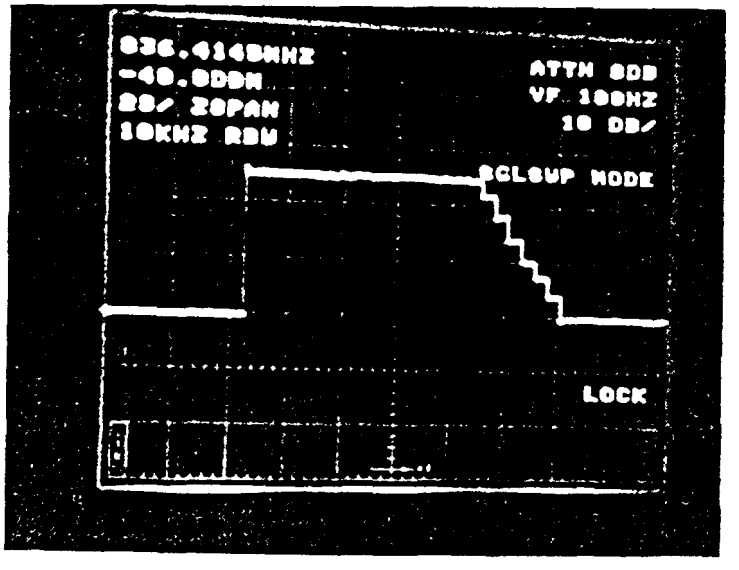
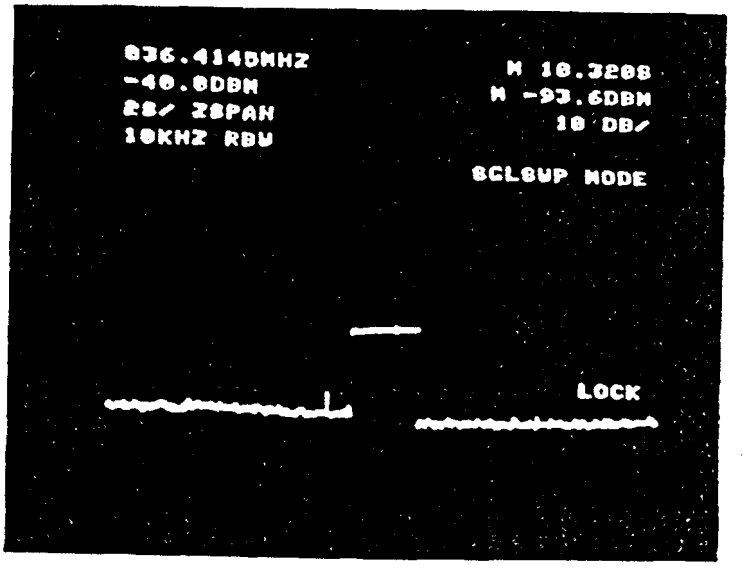


FIGURE 8b: User Unit

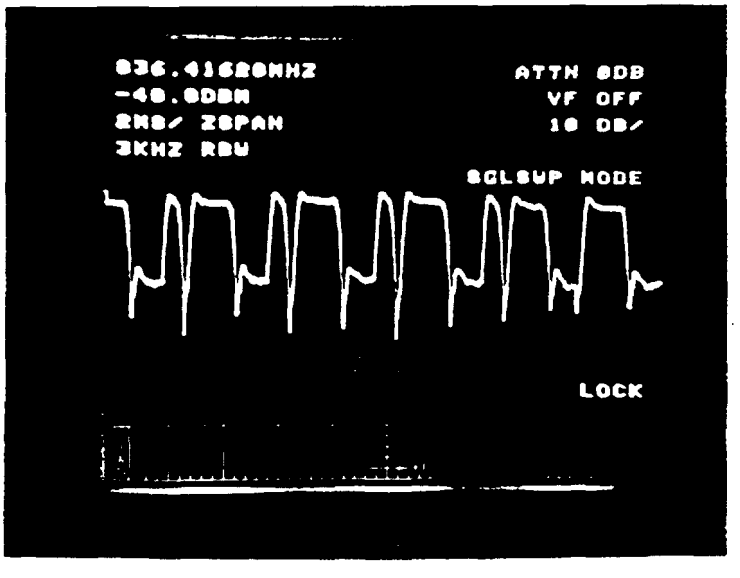
FIGURE 9: Typical Reception at Base Station



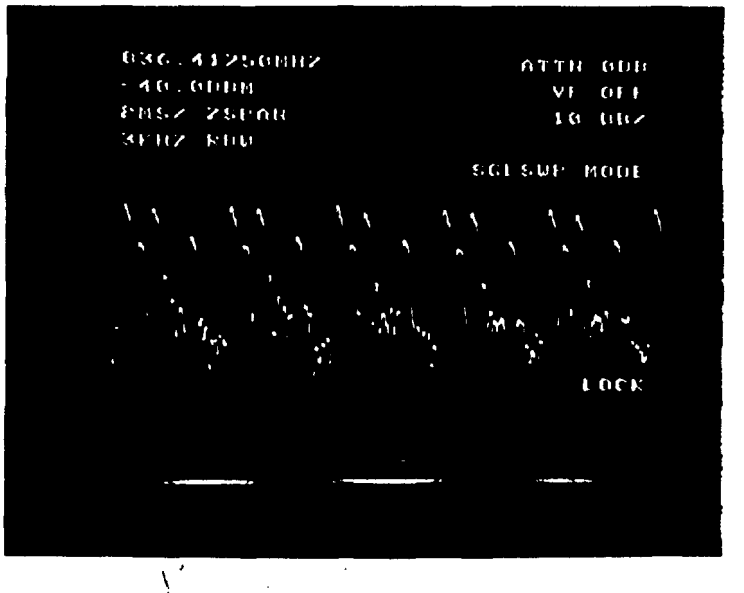
(a): Slow Scan Data Received



(b): Slow-Scan No-Data Received



(c): Fast Scan Data Received



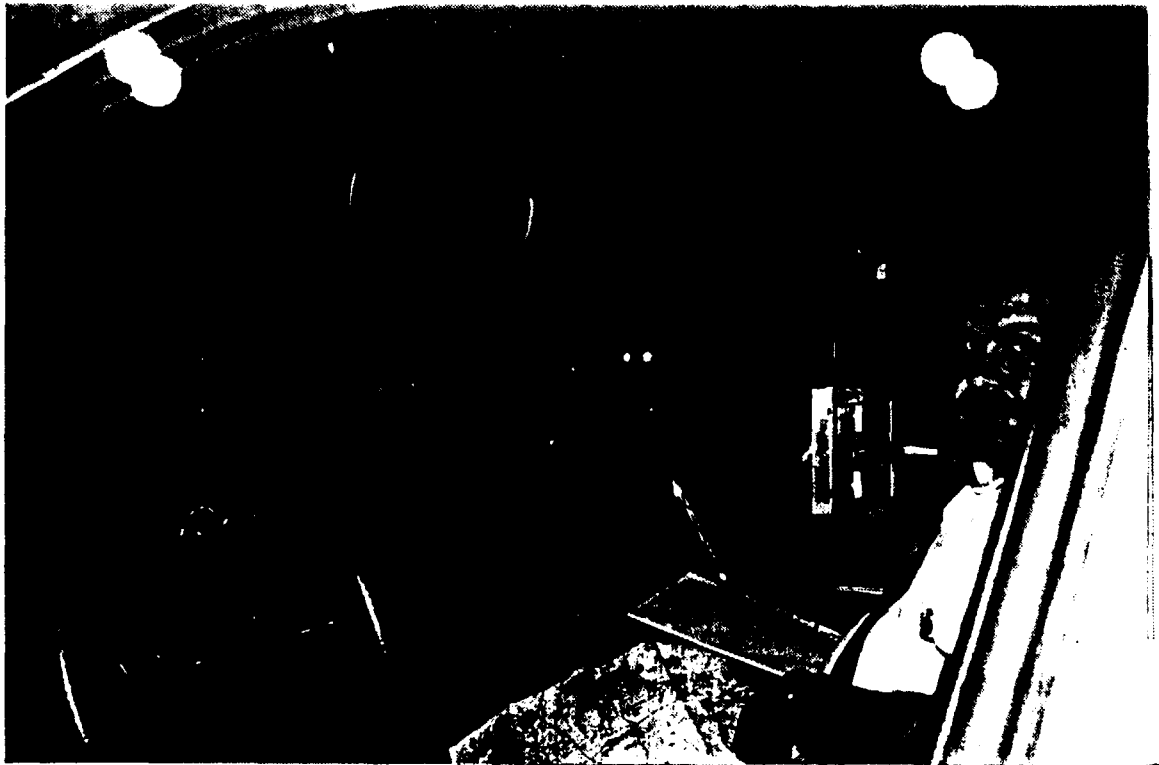
(d): Fast Scan Data Received

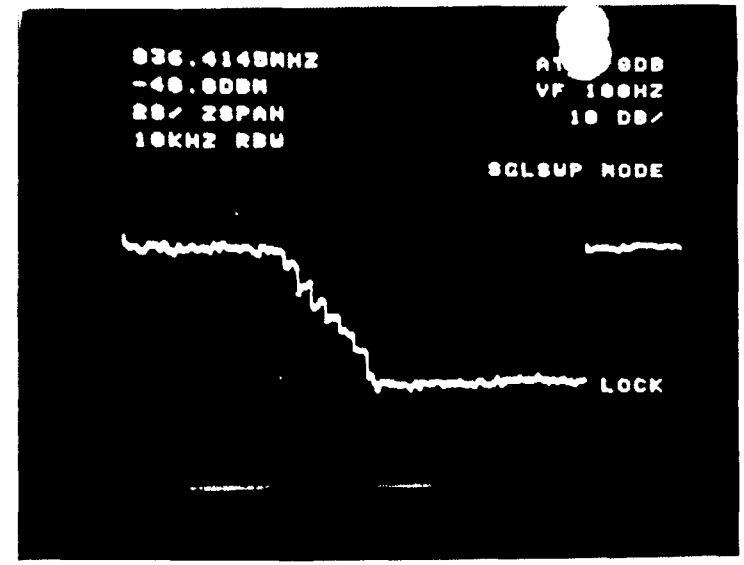
TABLE I

Column	1	2	3	4		5	
Site	Voice Pwr. Level in Area	CDI Est. Pwr. Level in Area (dBm)	Miles from Base	Data Rcvd. Outbound		Signal Rcvd. Inbound (dBm)	
1	-47	-68	1.5	x	x	-50	-78
2	-74	-95	2.3	x	x	-77	-94
3	-88	-109	2.7	x		-93	
4	-43	-64	.5	x		-66	
5	-51	-72	1.1	x		-65	
6	-68	-89	1.4	x		-73	
7	-78	-99	2.3	x		-92	
8	-73	-94	1.7	x		-75	
9	-47	-68	1.3	x		-59	
10	-61	-82	1.2	x		-90	
11	-78	-99	1.3	o	o	-98	-93
12	-77	-98	1.1	o	x	-91	-77
14	-97	-118	1.3	x		-105	
15	-75	-96	1.2	x	x	-88	-85
16	-105	-126	2.0	o		-110	

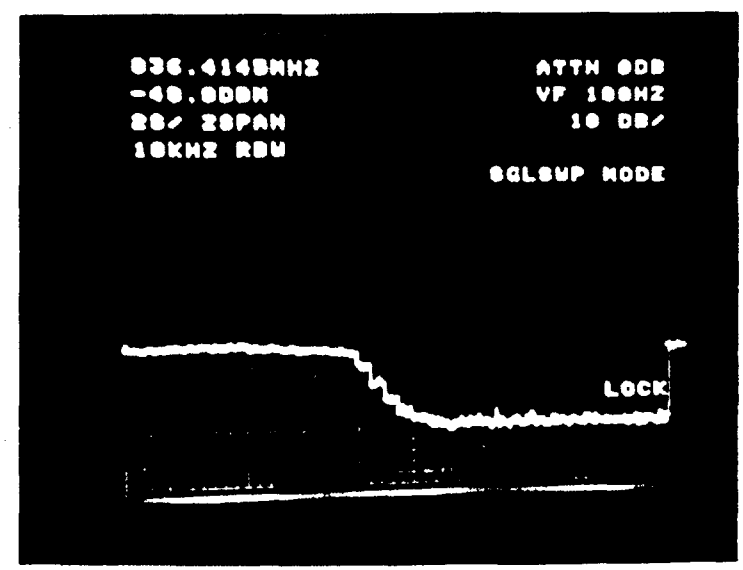
A P P E N D I X

TEST RESULTS SITE BY SITE

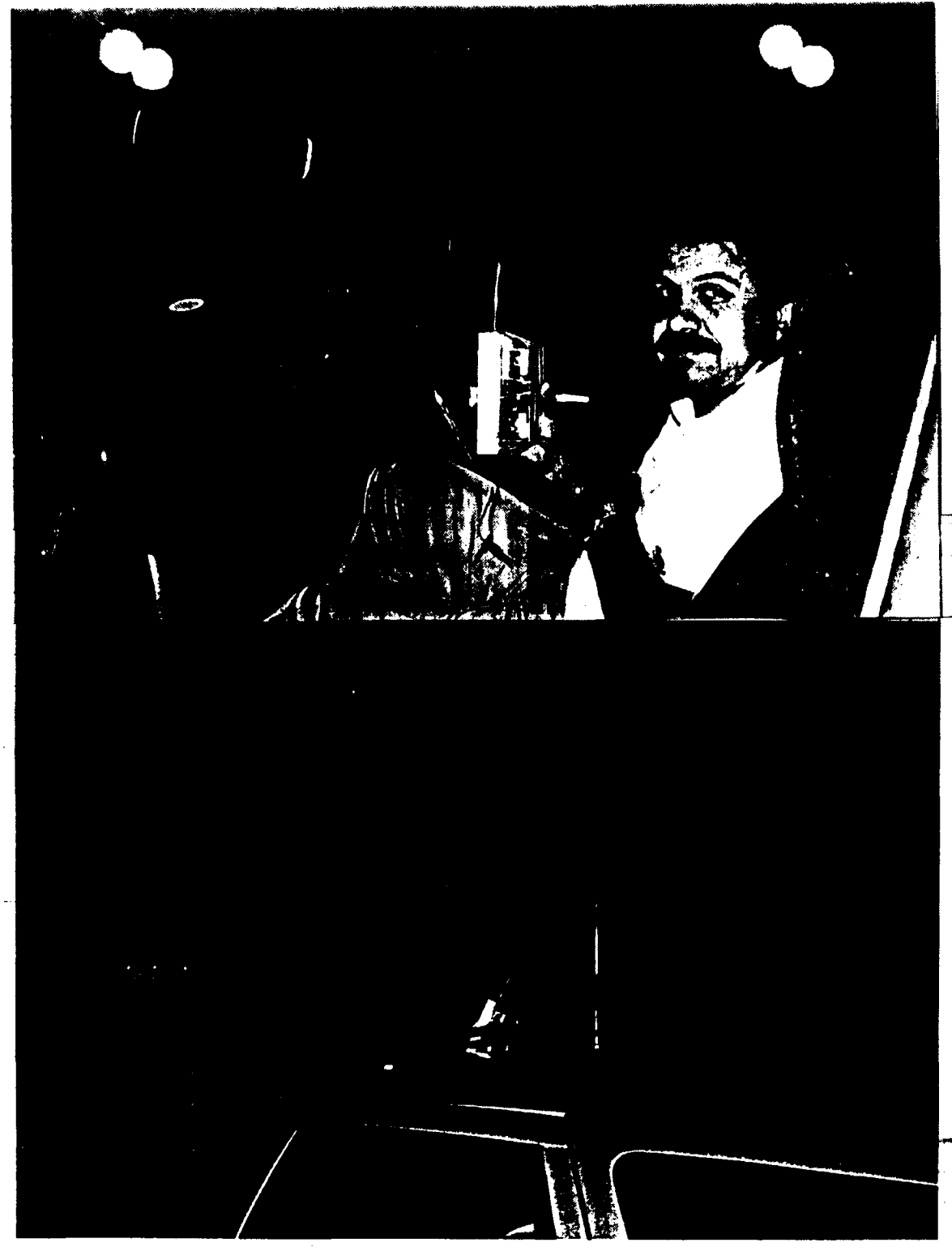


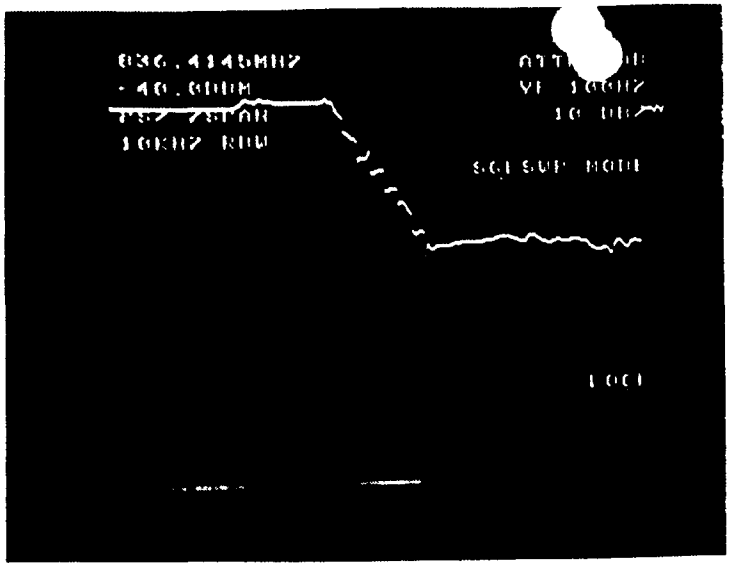


SITE 1: Bridge Stadium Way line of sight

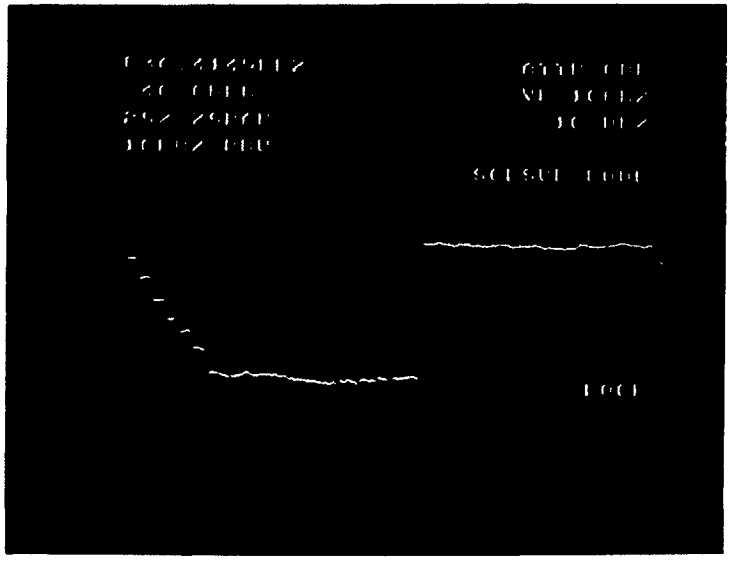


SITE 1: Parking Garage in Marriot Hotel

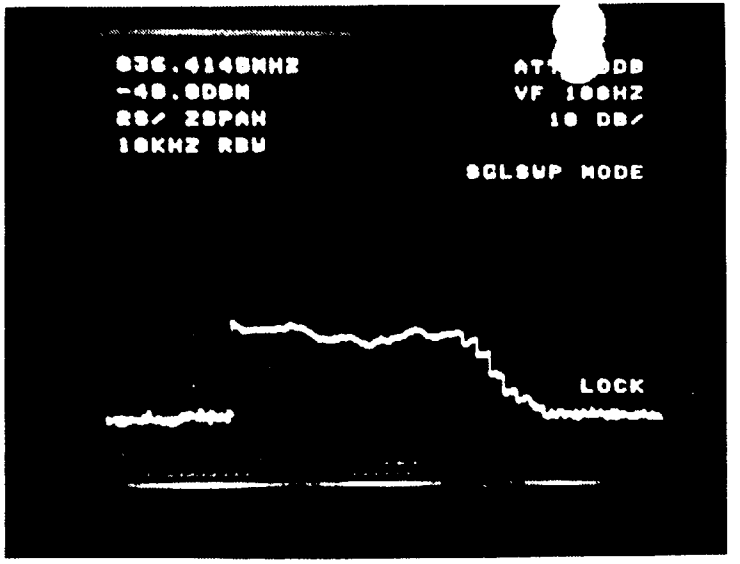




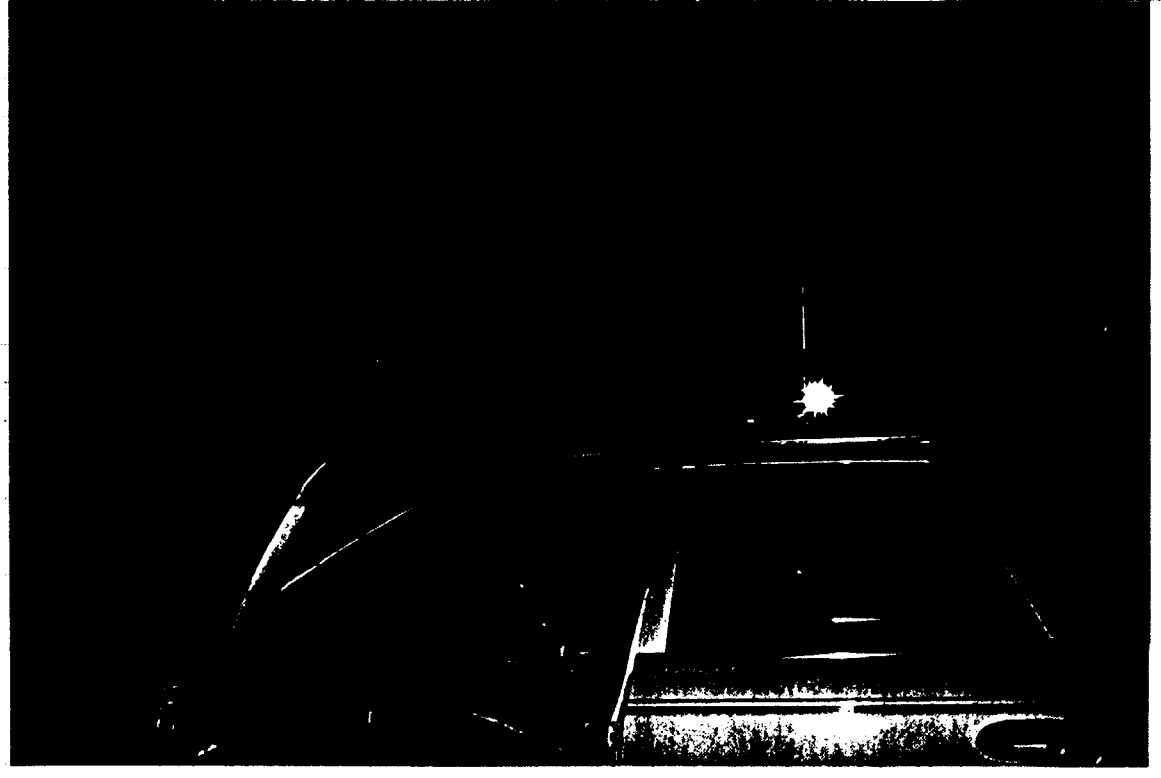
SITE 2: Camino Del Rio N.
and Milly Way (open area)

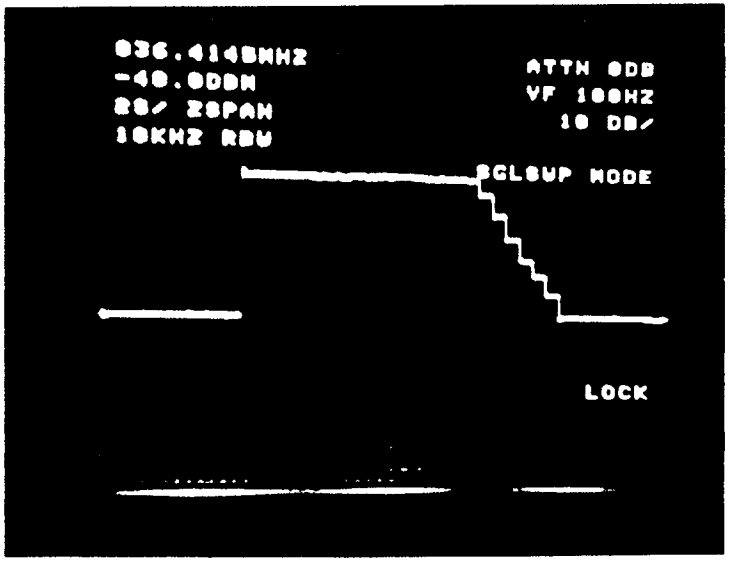


SITE 2: Inside Parking Structure,
Second Floor



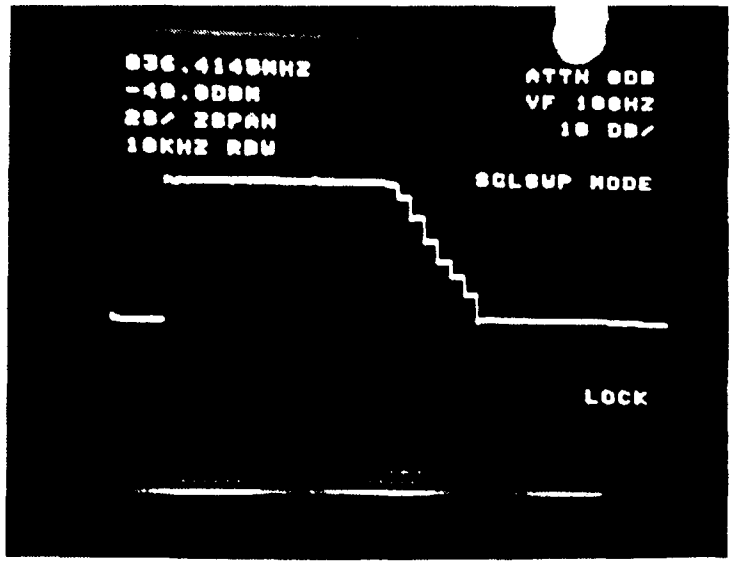
SITE 3: Ronda & Bartel





SITE 4: Behind Unical Building
Mission Ctr. Rd. & Briars Rd.

MISSING PHOTO



SITE 5: Friars Road West of Fashion Valley Road

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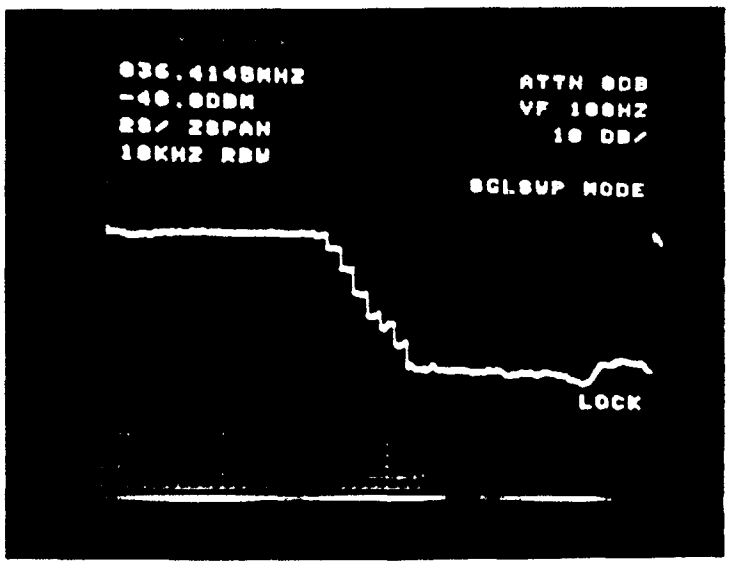
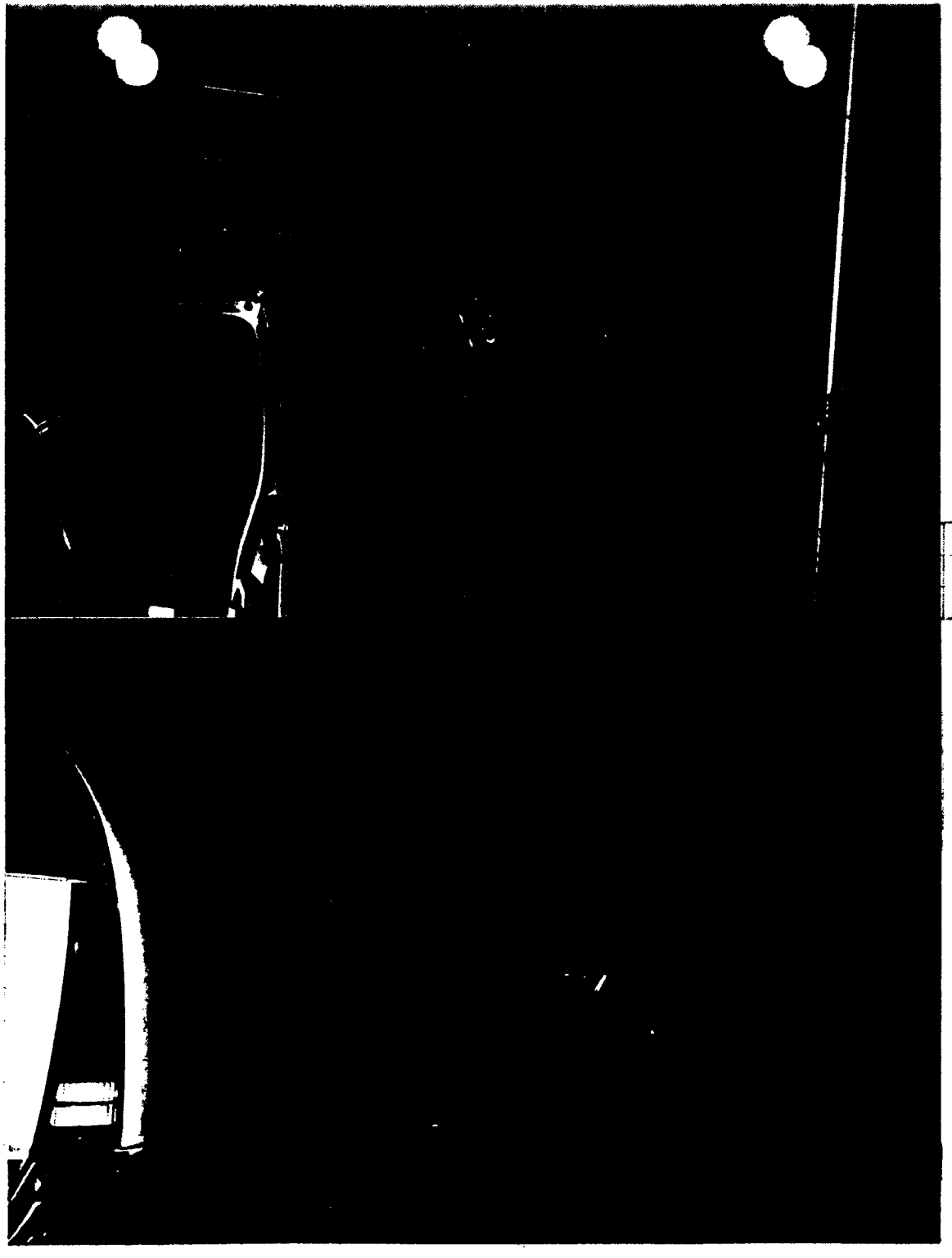
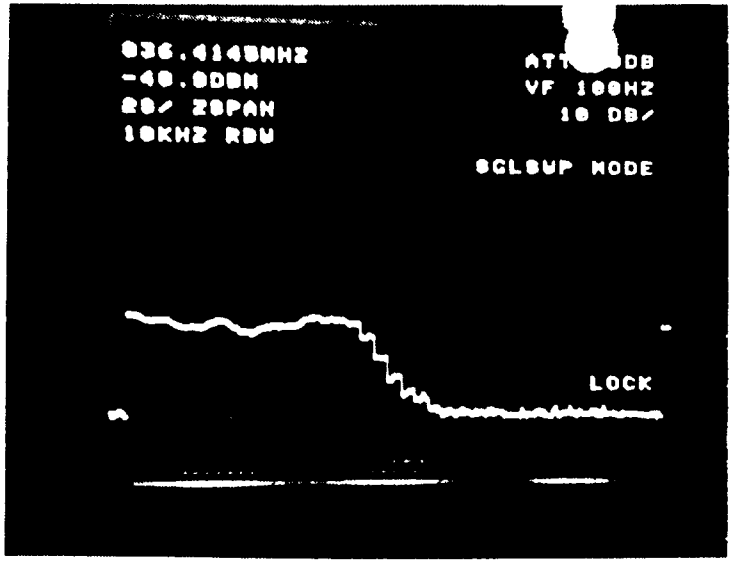
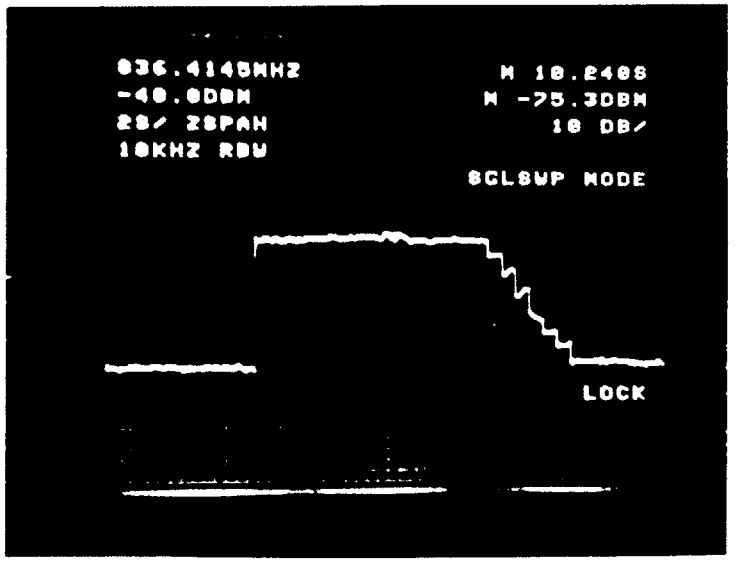


SITE 6: Friars Road & Via Las Cumbres, Near Pizza Parlor

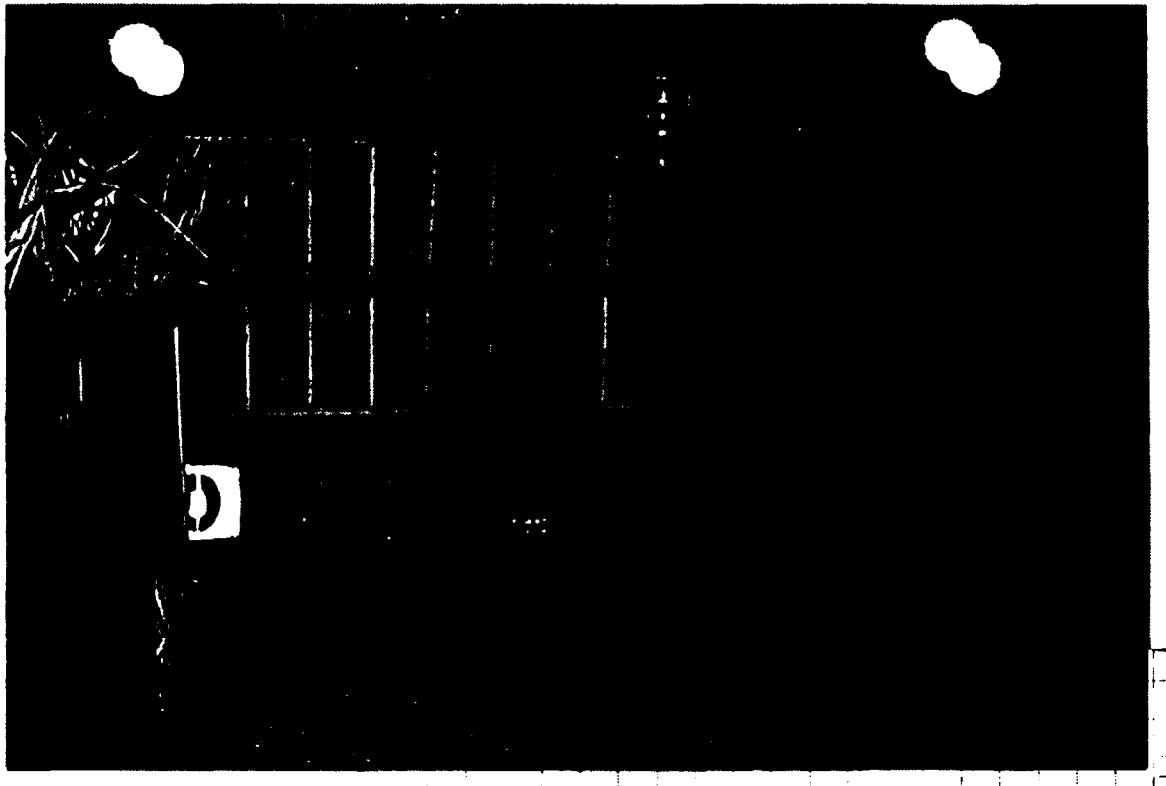




SITE 7: Napa Street & Linda Vista, Behind Building



SITE 8: Base of Triest Street, Base of Utility Pole



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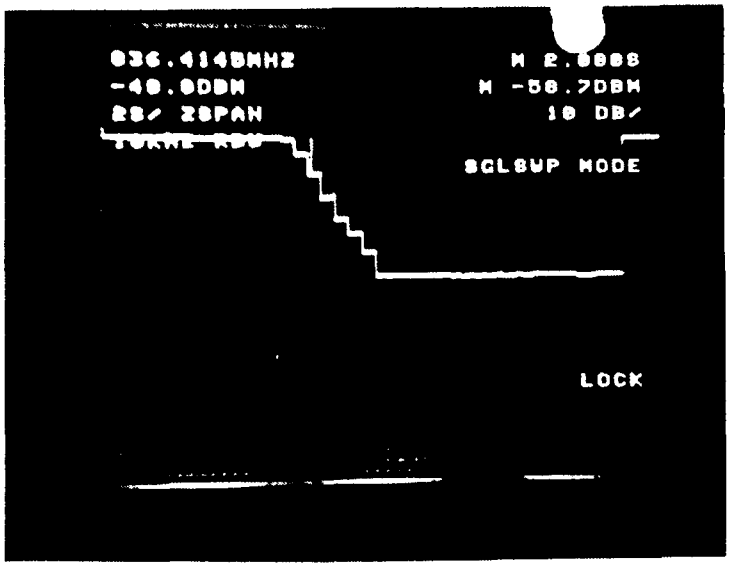
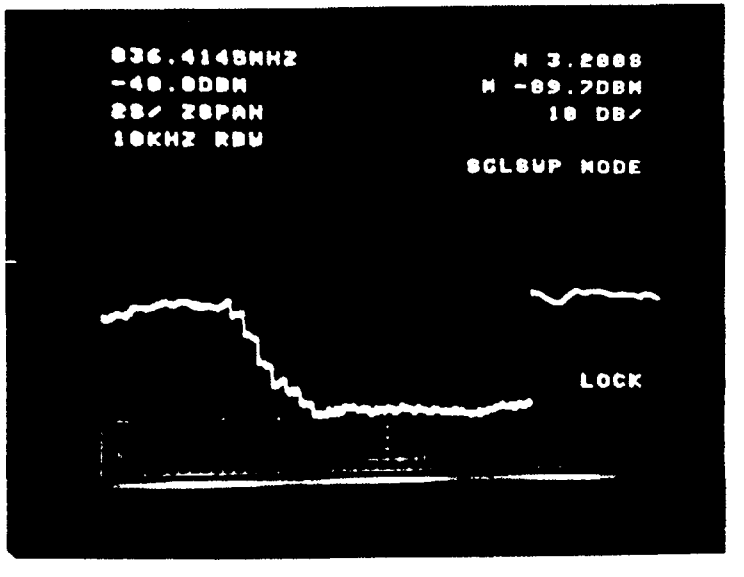


SITE 9: Base of Teralta Street, Ground Level



SITE 10: Eagle & Montecito