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RADAR BEACON SITE INVESTIGATION AT STANTON, CA.

by
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U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
TECHNICAL CENTER
Atlantic City Airport, N.J. 08405

ABSTRACT

The FAA Technical Center was requested by FAA Western Pacific Region (AWP 420), to provide the mobile Radar Beacon Facility Siting system for investigation of a proposed surveillance site at a former Nike site located in Stanton, CA. This location was selected by AWP 438.5 and is being considered for possible use in lieu of the Long Beach radar/beacon site. The Federal Aviation Adminstration (FAA) has been requested by the City of Long Beach to vacate the present site by June 1983. The facility siting system was designed to provide data and live evaluation of coverage and false targets (reflections). On-line analog recording of range, azimuth and run-length were provided. Data were collected utilizing the siting system processor which provides real time data, and a video tape recorder (VTR) which records the analog video from the air traffic control beacon receiver (ATCBI-4) output for playback and analysis with the Automated Radar Terminal System (ARTS III). A data Reduction and Analysis for Maintenance (DRAM) program was used for a computer analysis which provided a summary printout on beacon reflections, false target reports, and overall system operation. The results of the tests conducted at Stanton indicate that the site selected would be equal to or better than the existing Long Beach radar beacon site. This is based on the quantitative data collected by the siting system utilizing a flight inspection aircraft and targets of opportunity. The beacon coverage evaluation was concentrated on the following areas: Long Beach, El Toto, Torrance, and Orange County. Several reflections were detected by the siting system, however they were relatively few in number and probably would be further minimized with the use of the open array beacon antenna and appropriate software parameters in the ARTS III.

The quantitative evaluation of the proposed site was verified by the subjective evaluation of the participating ATC personnel.

PREFACE

Acknowledgement is made to the following personnel for their efforts and support in the project:

1. Michael Hulse, Van Mason and Edward Seiler, all ACT-100A.

2. Edward Couch, AWP 510; Max Hacket, AWP 510; Reg. Bishop, AWP 460; Oscar Flores, AWP 430, and Jim Harvey, AWP 420.

3. Harry Kanarr, William (Nick) Heineck and Ken Champagne, from Long Beach AFS.

INTRODUCTION

BACKGROUND.

The Federal Aviation Administration, (FAA), Technical Center received a telcom from AWP 420 in December 1981, requesting ACT-100 to provide the Radar Beacon Siting System (electronics van and antenna trailer) for the evaluation of a proposed surveillance site in Stanton, CA. The Western Pacific Region (AWP 463) selected only one site for reflection analysis and coverage evaluation. This location was a former NIKE site, approximately 10 miles east of Long Beach. A preliminary trip by ACT-100 was made for planning purposes (see attached letters dated December 10, 22, 1981 and January 11, 1982 (Attachment 1).

GENERAL.

The facility siting system developed at the FAA Technical Center was designed to provide pertinent data required for evaluation of proposed ATCRBS sites including coverage and detection of false targets. Two plan-position indicators (PPIs) are available; one for a subjective evaluation by Air Traffic Control (ATC) personnel and the other for a scan-by-scan photographic record. Digital decoding and signal sampling equipment provide online, real-time records of beacon target parameters (range, azimuth, run-length, and received signal level). In addition, a video tape recorder (VTR) is used to record the analog data from the beacon system for computer data reduction and analysis. When utilizing the VTR, the photographic procedures can be accomplished at a later time so that the second PPI can be available for subjective evaluation (this was accomplished at Stanton). Figure 1 shows the equipment block diagram, and figure 2 shows the processor block diagram. Figures 3 and 4 show the interior of the electronics van. The data reduction and analysis program is described in Users Manual for Data Reduction and Analysis for Maintenance Program (DRAM) ASM04-00, July 1976, by Airways Facilities Sector (AFS) Automation Engineering Division, Automation Engineering Support Branch, FAA Technical Center. Outputs from the Data Reduction and Analysis program provide summary printouts of the collected data for beacon reflections, false target reports, and system operation analysis.

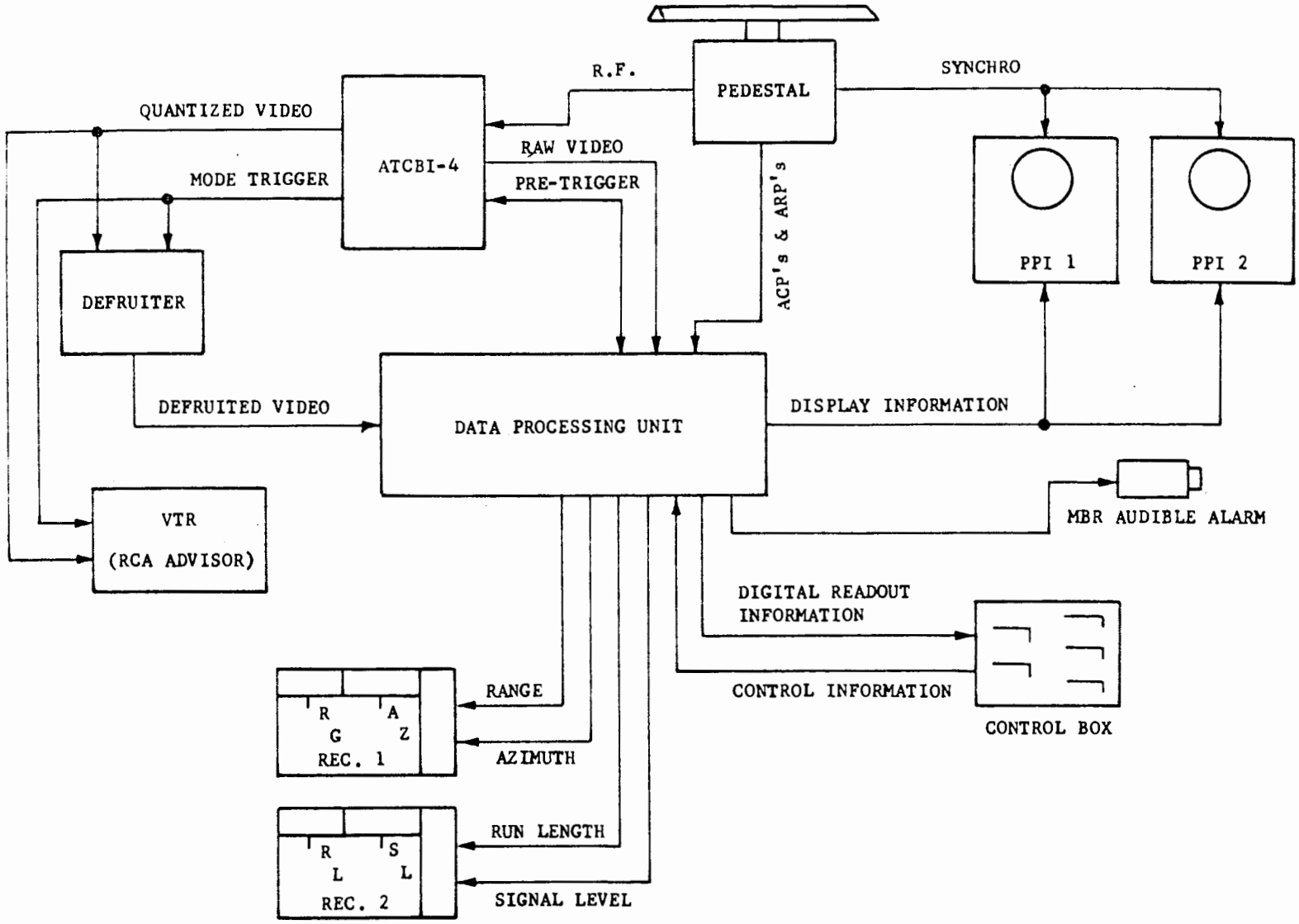


FIGURE 1. SITING SYSTEM BLOCK DIAGRAM

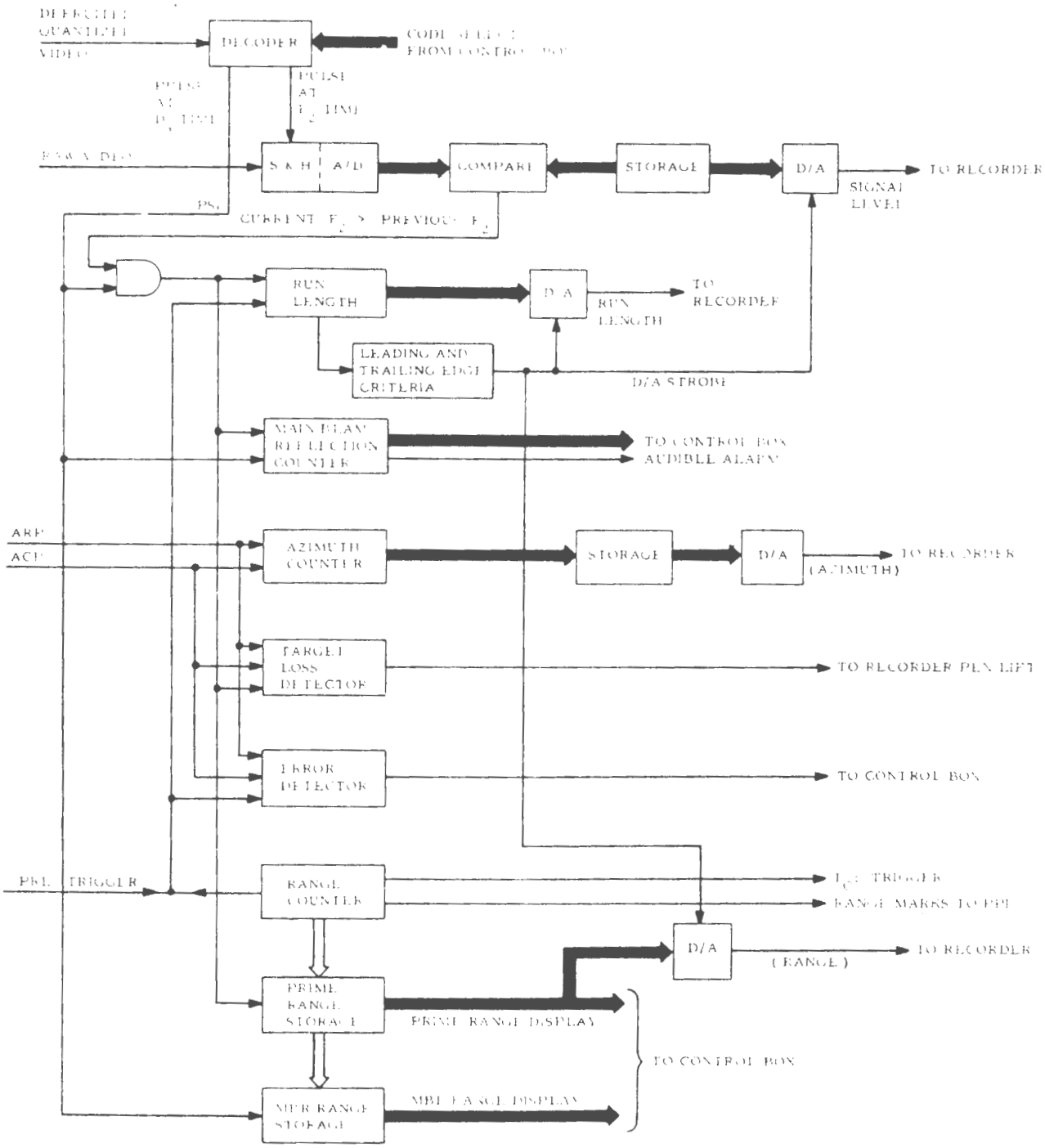


FIGURE 2. PROCESSOR BLOCK DIAGRAM

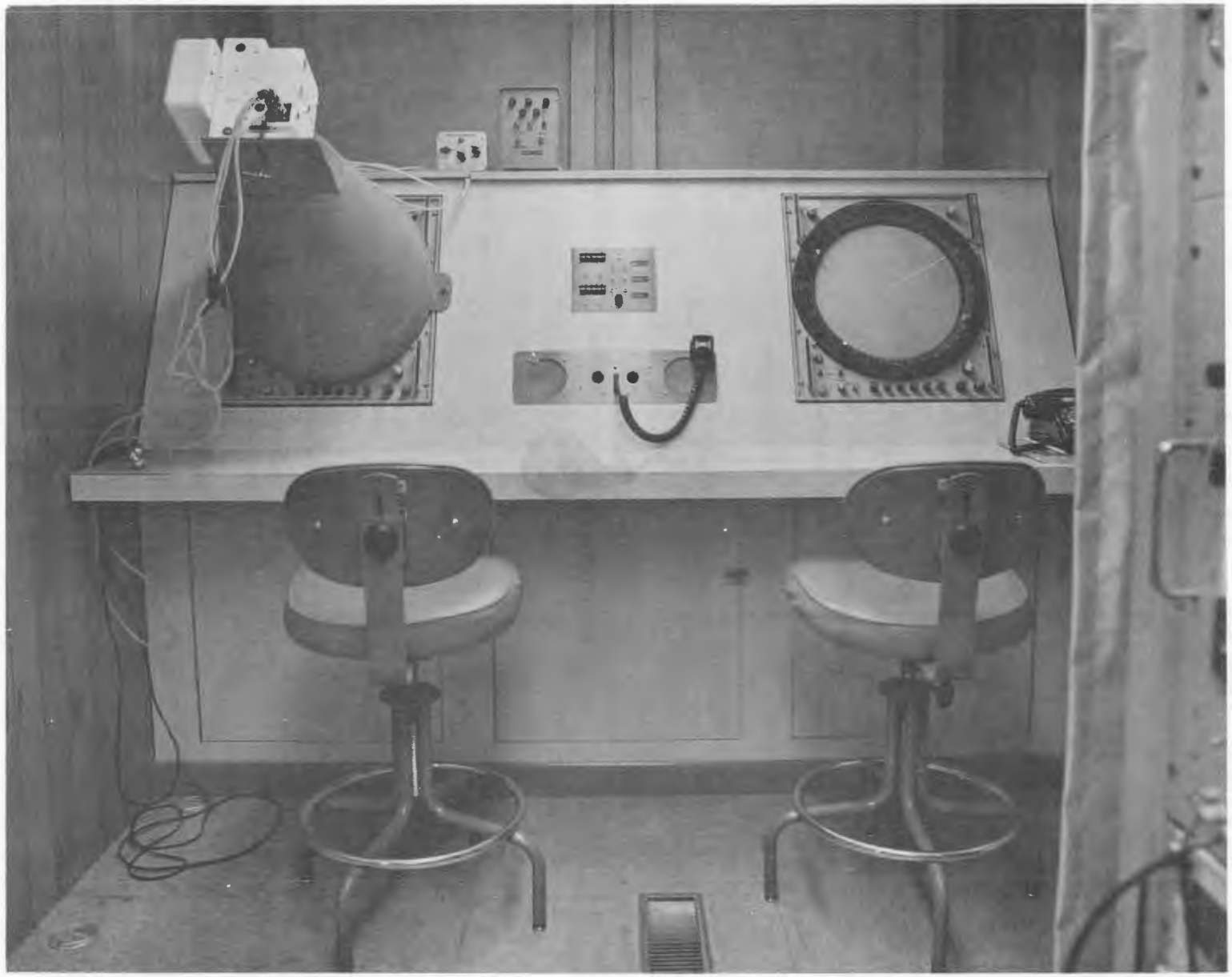


FIGURE 3. INTERIOR OF ELECTRONICS VAN SHOWING PPI'S AND SCOPE CAMERA

FIGURE 4. INTERIOR OF ELECTRONICS VAN SHOWING EQUIPMENT RACKS

INTERPRETATION OF STRIP CHARTS.

Range and azimuth are recorded on one chart. For each recording, time increases from bottom to top, i.e., the track of the target begins at the bottom and ends at the top of the chart. Due to physical alignment of the two styli (one for range on left and azimuth on right) a slight shift between the two traces is always present. The range track is approximately one small division ahead or prior to the start of the azimuth trace.

In figure 19, the tracked target (flight inspection aircraft) was flown along radials of approximately 115° and 154° (each small division represents 7.2°) with inbound range from approximately 24 nmi to 10 nmi, then outbound to approximately 22 nmi, etc. (each small division represents 2 nmi).

When a target on a discrete code is flown on a radial, a straight line will occur (bottom to top) for that radial unless a reflection occurs. The reflection will be indicated to the right or left for azimuth and only to the right on range. (The range of a reflected reply is always greater than the range of the true target). Sometimes the reflected range is so small that the difference is indistinguishable on the chart (the range resolution of the system is 1/2 nmi), indicating that these reflectors were very close to the antenna. An example of a range reflection that is away from the antenna is shown on figure 19 with the target outbound at approximately 20 nmi, a delta range (Δ Rg) of 27 nmi, a target bearing of approximately 120°, and the reflection at 278°. Another example of the Δ Rg phenomenon is shown in figure 15.

Also shown on figure 15 is how the reflector location is determined by simple trigometric functions. Again this is automatically calculated by the DRAM computer program.

INTERPRETATION OF DATA REDUCTION AND ANALYSIS OUTPUTS.

The analog beacon video recorded on site was reproduced at the FAA Technical Center and used as an input to the ARTS III system which processed the beacon video input and generated extractor tapes. These extractor tapes were then used in conjunction with the Beacon Extractor Reduction Program and the Data Reduction and Analysis Program to analyze the data in two primary areas.

Data on overall coverage was analyzed from all of the Targets of Opportunity detected and included:

Percentage of Split Azimuth. The percentage of total discrete reports that the ARTS III processing resulted in azimuth splits.

Percentage of Split Ranges. The percentage of total discrete reports that the ARTS III processing resulted in range splits.

Percentage of Reflections. The percentage of total discrete reports that the ARTS III processing resulted in generating a reflection report.

The results of this analysis are shown in table 1.

The second area of data analysis pertained to radial flights where reflections were projected to occur. This data was analyzed from individual Targets of Opportunity and from radials flown by the flight inspection aircraft. The results of the analysis are shown in table 2 and include:

Percentage of True Targets. The percentage of total scans that a true target report was generated.

Percentage of True Hits. The number of total scans that a true target report was generated plus the number of scans where three or more true hits were reported but no true target report was generated.*

Percentage of Target Reflections. The percentage of total scans that a reflected target report was generated.

Percentage of Reflection Hits. The number of total scans that a reflected target report was generated plus the number of scans where three or more reflected target hits were reported but no reflected target reports were generated.**

The ranges, true azimuths and reflected azimuths are also listed.

* The scans in which three or more true hits were reported are included in this tabulation since the declaration of a target is an ARTS III operational program parameter and is therefore variable. This tabulation represents the best possible result.

** The scans in which three or more true hits were reported are included in this tabulation since the declaration of a target is an ARTS III operational program parameter and is therefore variable. This tabulation represents the worst possible result.

DISCUSSION

TESTS CONDUCTED AT STANTON, CA.

The siting system antenna was erected to approximately 48 feet ±1/2 foot (see figure 5). The interrogation mode of the Air Traffic Control-Beacon Interrogator, (ATCB1-4) was set for 2:1 interlace and the pulse repetition frequency (PRF) assigned by AWP frequency manager was set for 235. Prior to any tests or data collection, the following measurements and conditions were accomplished according to instruction manuals or Federal Aviation (FAA) orders:

1. ATCBI-4

a.	Receiver tangential sensitivity	-89 dBm
b.	Transmitter power output (peak-to peak)	P_1 P_3 = 500 watts P_2 = 1000 watts
c.	Sensitivity Time Curve (STC)	40 dB
d.	ISLS -	ON

2. Calibration of interference blanker (defruiter)

3. Calibration of FAA Technical Center's processor, PPIs and recorders.

4. Voltage Standing Wave Ratio (VSWR)

   a. Directional Antenna (Hog Trough) FA-7201B=1.25:1
   b. Omni Antenna FA-8044 = 1.2:1
      (includes all cables and connectors, etc. for both antennae).

5. Coax Cable Loss

   a. Directional antenna (150 foot LDF4P-50 Andrews Co.) = 4.6 dB
   b. Omni antenna (150-foot LDF4P-50 Andrews Co.) = 4.6 dB.

6. Other losses, each for rotary joint insertion losses, connectors, short lengths of cables for both omni and directional = 2.4 dB for a total loss of 7.0 dB (items 5 and 6).

7. Effective Radiated Power

a.	Directional	100 watts
b.	Omni	200 watts

8. Antenna Speed 12.5 rpm
   ±0.1 rpm

FIGURE 5. SITING SYSTEM ANTENNA TOWER AT 48FT. +1/2'

9. A CESSNA 240 flight inspection aircraft was dedicated for use in these tests. The onboard transponder was originally adjusted for normal operation as used in prior flight tests for AWP.

On March 25, the flight inspection aircraft was assigned a discrete code and flew orbits of 10 and 20 nautical miles (NMI) at altitudes of 4,500 and 8,500 feet. Excellent coverage was obtained from these flights, in addition no reflections were detected at 4,500 ft. altitude, but some reflections were observed at 8,500 ft. on both 10 and 20 nmi orbits. Chart recordings figures 6 and 7 indicate this as well as PPI photos figures 8, 9, and 10, and table 1.

Aircraft Azimuth (degrees)	Reflection Azimuth (degrees)
052 (approx.)	280 (approx.)
154 (approx.)	180 (approx.)
233 (approx.)	100 (approx.)

There were 3 parrots (fixed transponders) at the Stanton site. AWP 463 indicated their geographic positions with respect to the siting system antenna (Attachment 2). The bearings and ranges are as follows: 008.3° @ 37.84 miles, 087.13° @ 23.96 miles and 283° @ 37.10 miles. They are all on the same discrete code of 1275. Chart recording figures 11 and PPI photo figure 12 depicts this and also indicates the accuracy of the recorders range and azimuth. (Note: Interpretation of strip charts are discussed later in the report).

On March 26, targets of opportunity were observed and communications established between the active controller and the siting system. Aircraft on discrete codes were identified for the ACT specialists to observe on the siting system PPIs while reflections were plotted on the strip charts, and raw video was simultaneously recorded on the VTR. Figure 13, 14 and 15 depict some of the target-of-opportunity results obtained from the siting system processor on the strip chart recorders and PPI photos are shown in figures 16 - 18. It should be noted with a PRF of 235 and a 12.5 RPM antenna scan rate, the number of replies per antenna scan (hit count) for run length will be low. The siting system lead edge criteria for target declaration is 3 hits, while most lead edge criteria for ARTS III systems is about 5 hits or more and about 11 hit count for target declaration. ACT-100A requested and received permission to change the PRF from 235 to 320, which increased the hit count. In several cases where reflections occurred on the PPI with very low hit counts, they were not declared as a reflected target in the siting system processor and probably not in the ARTS III. Most reflection run lengths (hit count) were usually less than actual target count.

On March 30, the flight inspection aircraft flew the remaining reflection critical radials. Figures 19 and 20 depict both the aircraft range and bearing and the range and bearing of the reflections. Figure 21 is a time elapsed photograph of the PPI, while figures 22, 23, and 24 are

some single frame shots. In a simultaneous effort of the site evaluation at Stanton, the ATC specialists also performed site coverage tests utilizing both the flight inspection aircraft and targets of opportunity. This will be documented in a separate reporting effort from AWP 463 and 510. Based upon the ATC personnel observations and their expertise they indicate that the coverage was equivalent or better than the existing Long Beach site (beacon only). Some of their observations indicated that aircraft were detected and displayed on the PPIs 3 to 4 scans earlier and longer than the Long Beach active controller. Some of the areas that were covered: El Toro (with beacon reports of aircraft on the ground), Orange County, LAX, Torrance, Chino, and Long Beach. Figure 25 is a PPI photo covering a 50 mile radius of beacon only targets indicating the density of the air traffic in that area.

TABLE 1. OVERALL COVERAGE ANALYSIS

Tape No. Date	Number of Scans	Total Reports	Percentage of Azimuth Splits	Percentage of Range Splits	Percentage of Reflections
82-05 03-26-82	329	18,871	0.05%	0.00%	1.39%
82-06 03-26-82	449	27,496	0.0005%	0.001%	1.09%
82-07 03-26-82	556	32,334	0.0007%	0.0009%	0.95%

TABLE 2. RADIAL FLIGHT ANALYSIS

Tape No. Code and Date	True Azimuth	Reflected Azimuth	Range	Number of Scans	Percent of True Targets	Percent of True Hits	Percent of Target Reflections	Percent of Reflection Hits
82-05 Code # 0706 03-26-82	47° thru 56°	275° thru 282°	27 to 45 miles	47	100%	100%	27.65%	36.17%
82-05 Code # 7354 03-26-82	86° thru 98°	234° thru 245°	15 to 45 miles	152	98.68%	99.34%	12.50%	23.02%
82-07 Code # 0147	117° thru 126°	206° thru 214°	12 to 26 miles	153	98.03%	98.03%	11.11%	22.87%
82-08 Code # 0115 03-30-82	111° thru 116°	180° thru 182°	14 to 20 miles	38	100%	100%	2.63%	7.89%
82-09 Code # 0115 03-30-82	151° thru 159°	174° thru 178° and at 44°, 114°, 120°	8 to 19 miles	86	100%	100%	13.95%	18.60%

RESULTS

Based upon the siting system data obtained during flight inspection tests and Targets of Opportunity (TOO) at Stanton, CA., reflections were detected when flying radials of approximately 052°, 115° - 122°, 154° - 162°, 233° and 274°, (figures 6, 7, 13, 14 and 15) and PPI photos (figures 8, 9, 10, 16 - 18, and 22 - 24). In addition, tabulation of DR&A software results in tables 1 and 2 document a limited quantity of reflection replies. Analysis of the data collected from both the flight inspection aircraft and targets of opportunity demonstrated excellent beacon coverage with a low percentage of false targets.

CONCLUSION

It is concluded that a secondary surveillance beacon system (ATCRBS) located at the proposed site at Stanton, CA., would result in excellent coverage with minimum false targets caused by ATCRBS reflection. The reflections with low run length (hit count), would be eliminated by the ARTS III detection criteria and would not be declared as targets. In addition, the Siting System utilized a hogtrough type antenna, which has an antenna pattern which normally produces more reflections than the operational open array antenna which will be utilized by AWP.

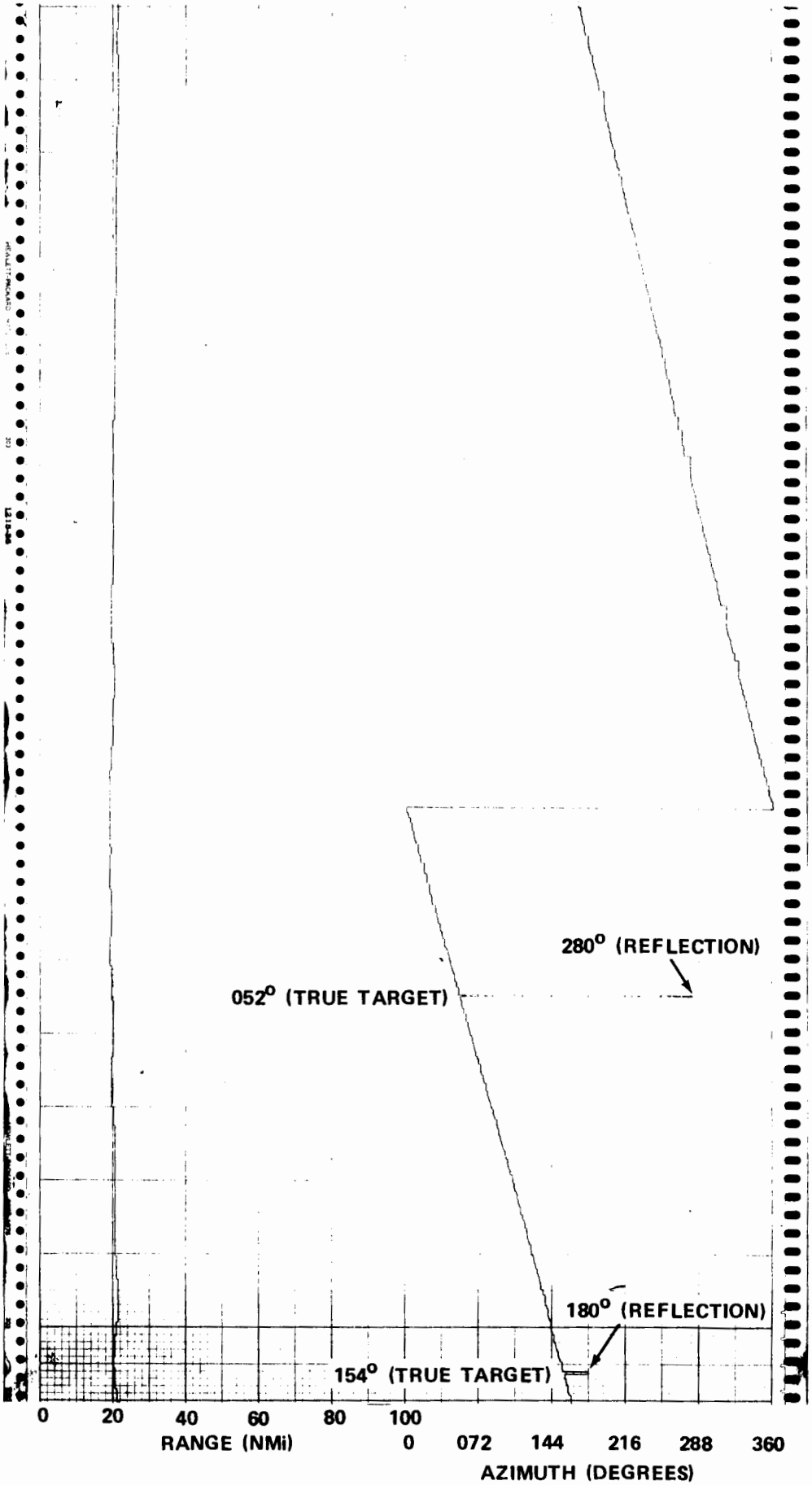


FIGURE 6. 20 MILE ORBIT AT 8,5000 FEET

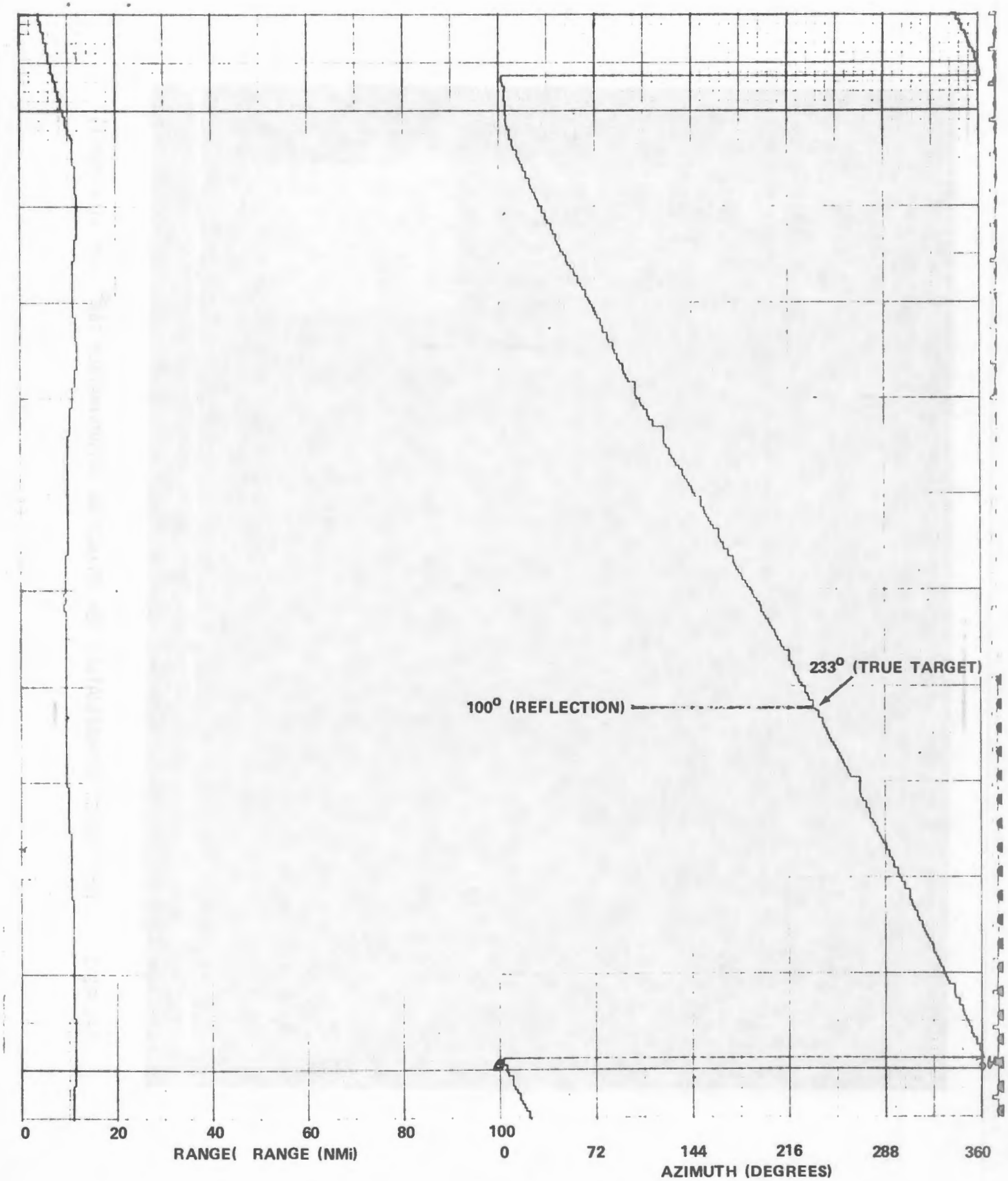


FIGURE 7. 10 MILE ORBIT AT 8,500 FEET

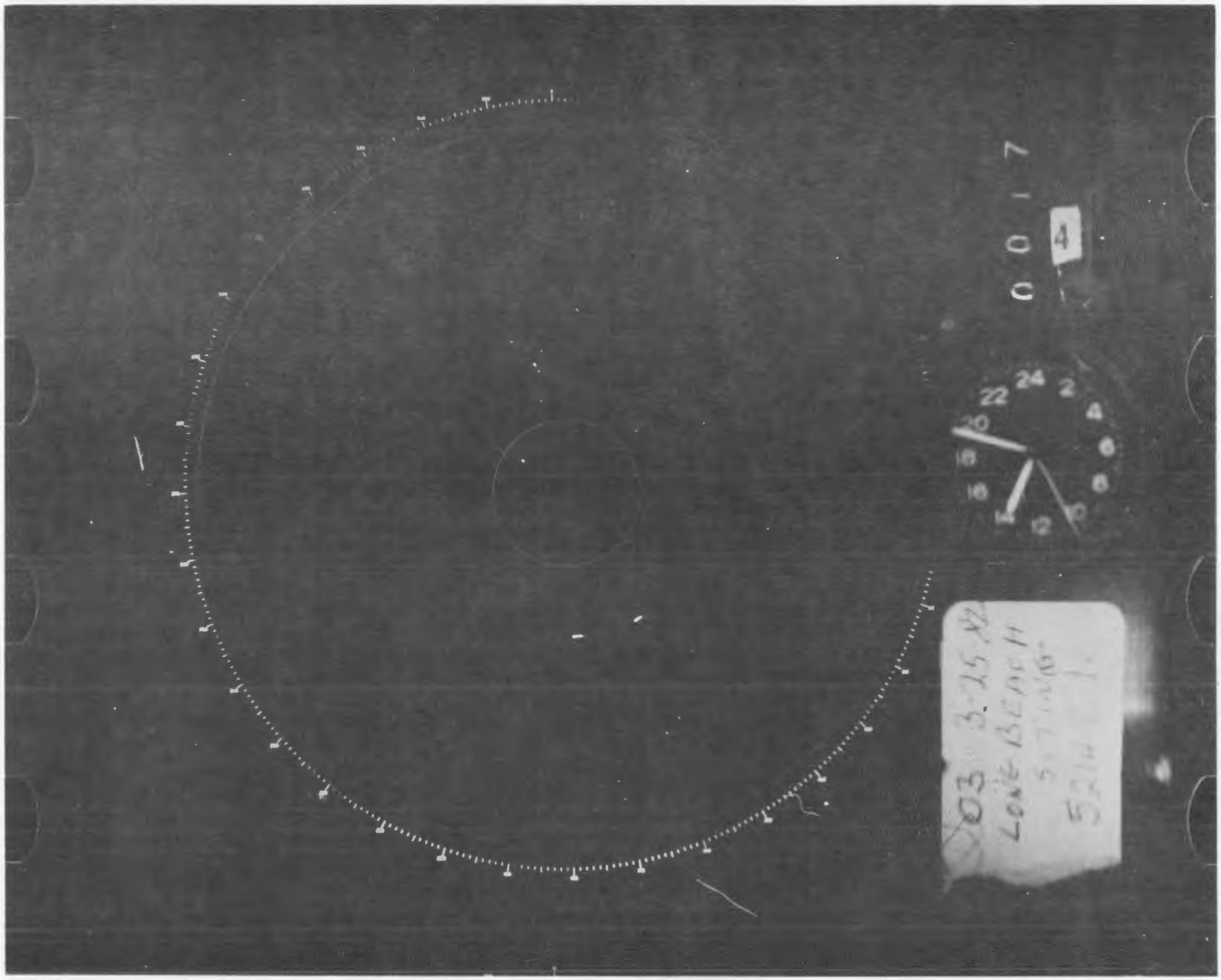


FIGURE 8. TRUE TARGET APPROXIMATELY 154 REFLECTION APPROXIMATELY 180° (20 MILE ORBIT)

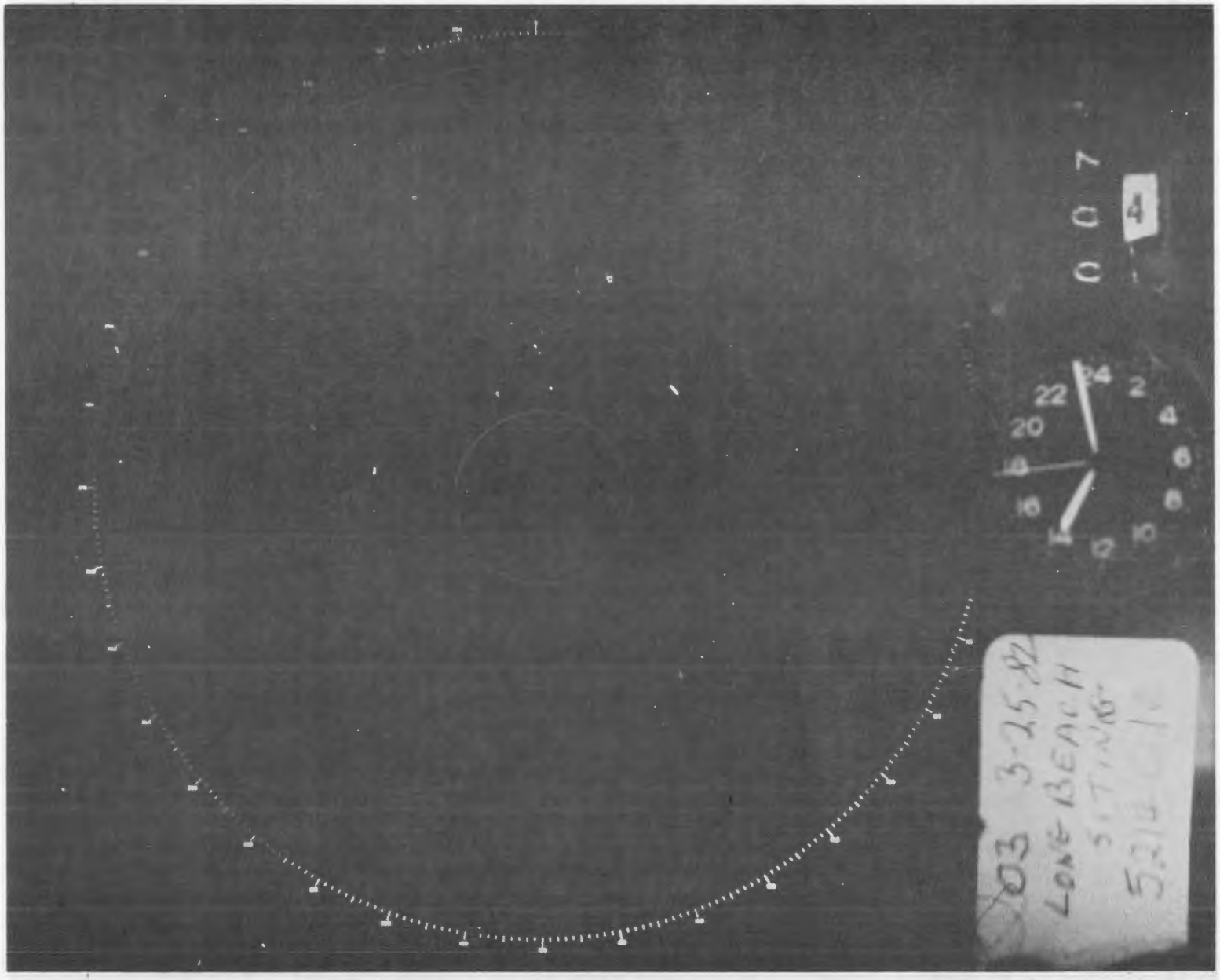


FIGURE 9. TRUE TARGET APPROXIMATELY 052° REFLECTION APPROXIMATELY 280° (20 MILE ORBIT)

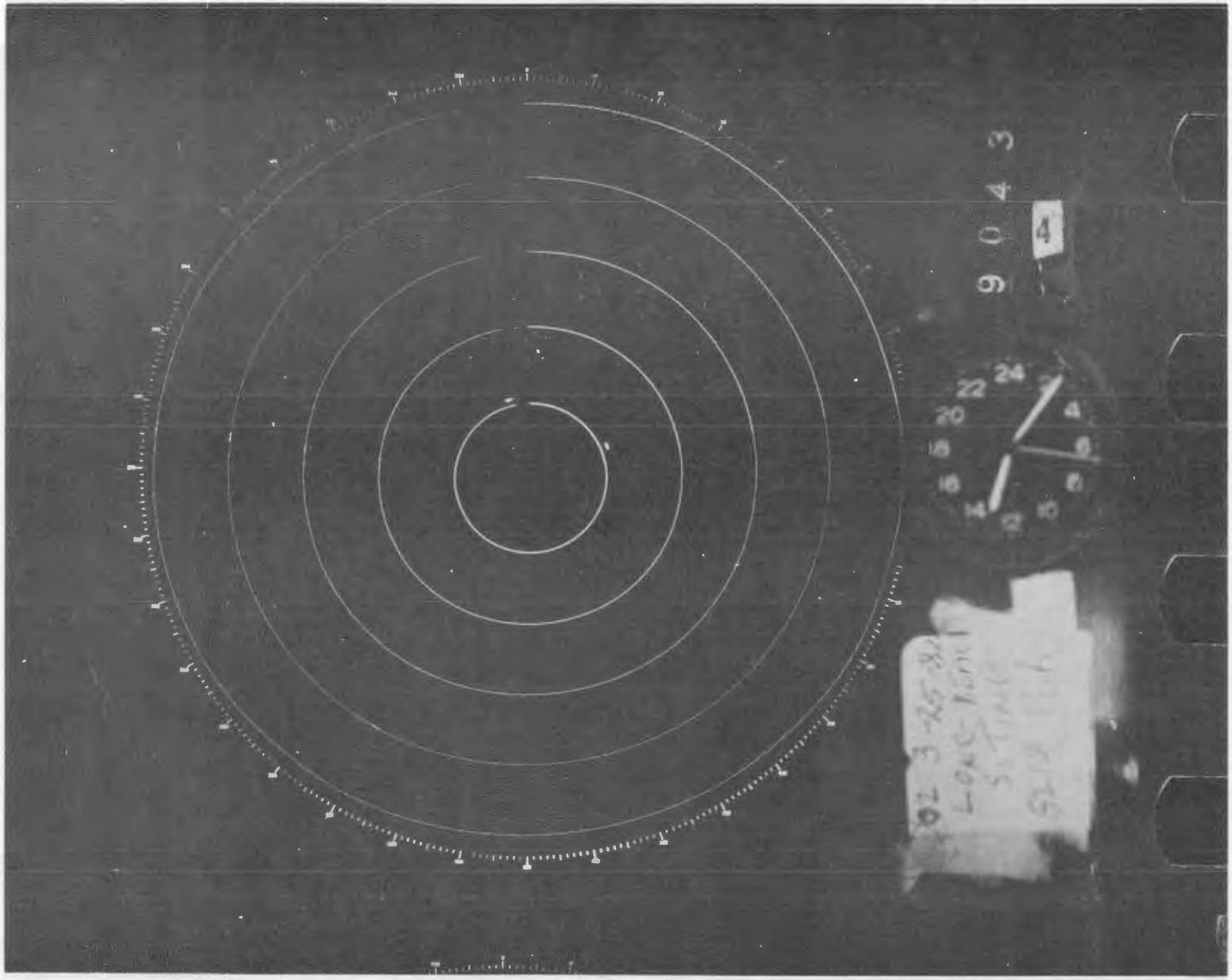


FIGURE 10. 10 MILE ORBIT TRUE TARGET APPROXIMATELY 067° REFLECTION APPROXIMATELY 344°

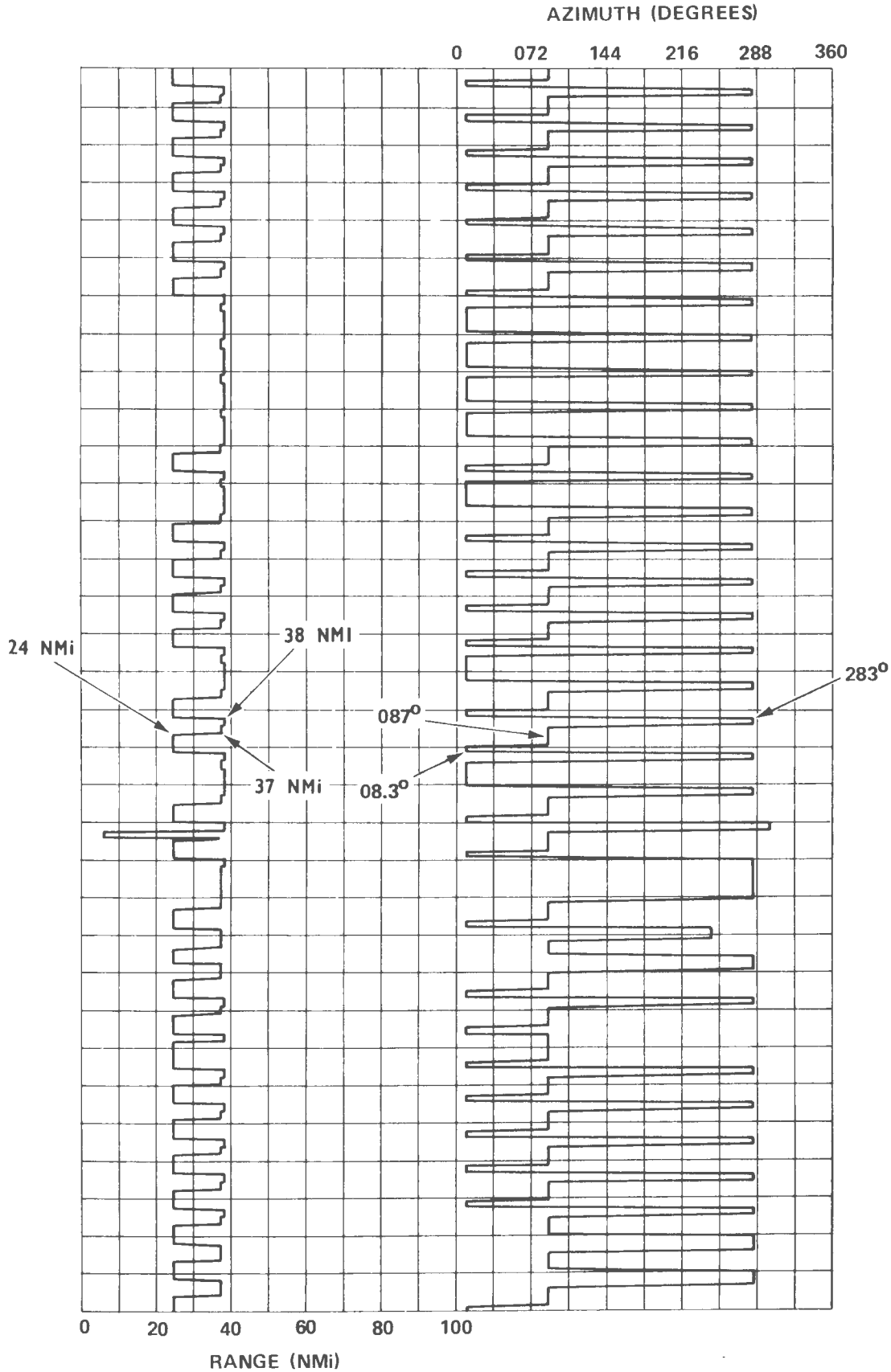
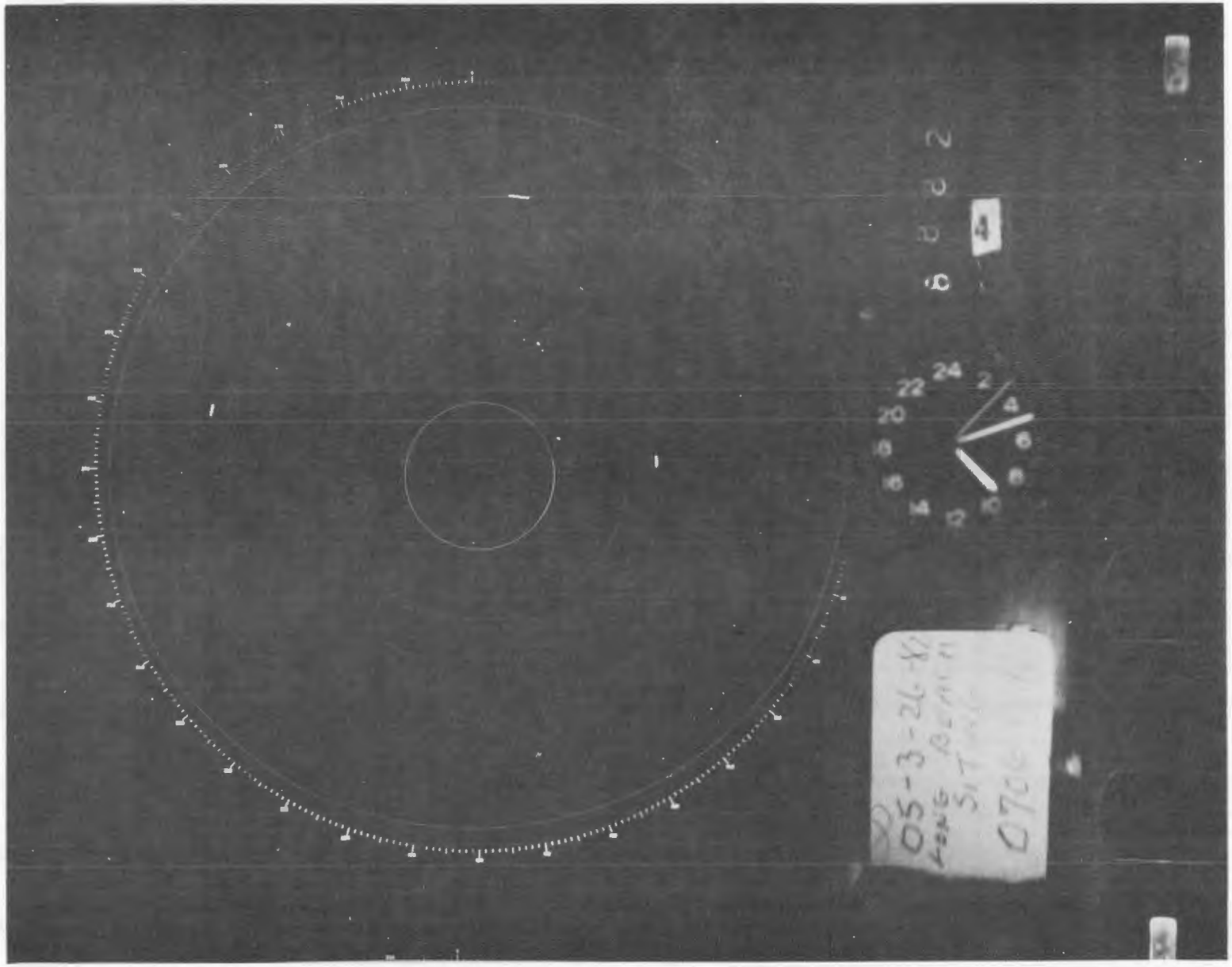


FIGURE 11. THREE FIXED TRANSPONDERS SQUAWKING ON SAME CODE


24
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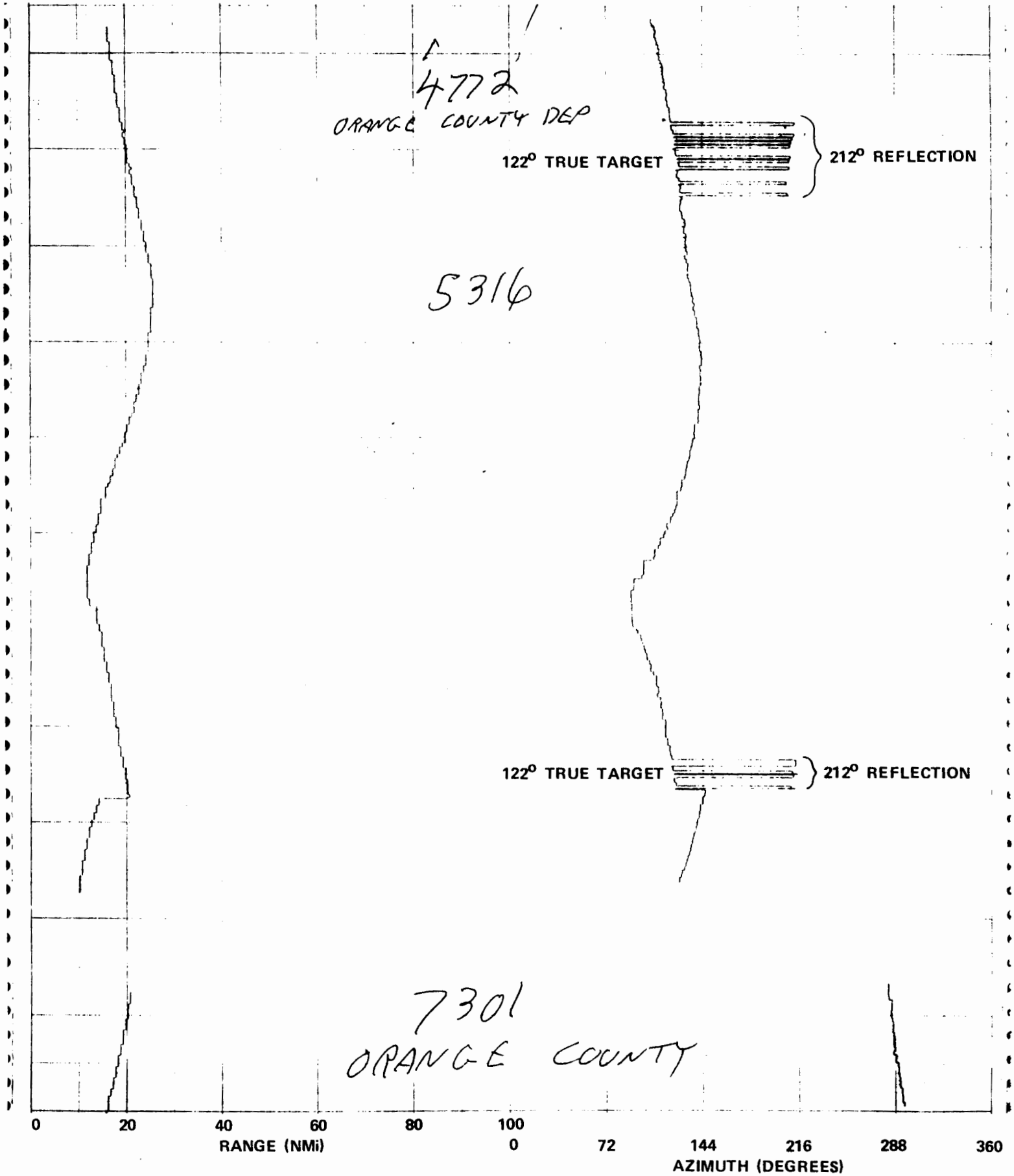


FIGURE 13. T.O.O. APPROXIMATELY TRUE TARGET 122° AND REFLECTION 212°

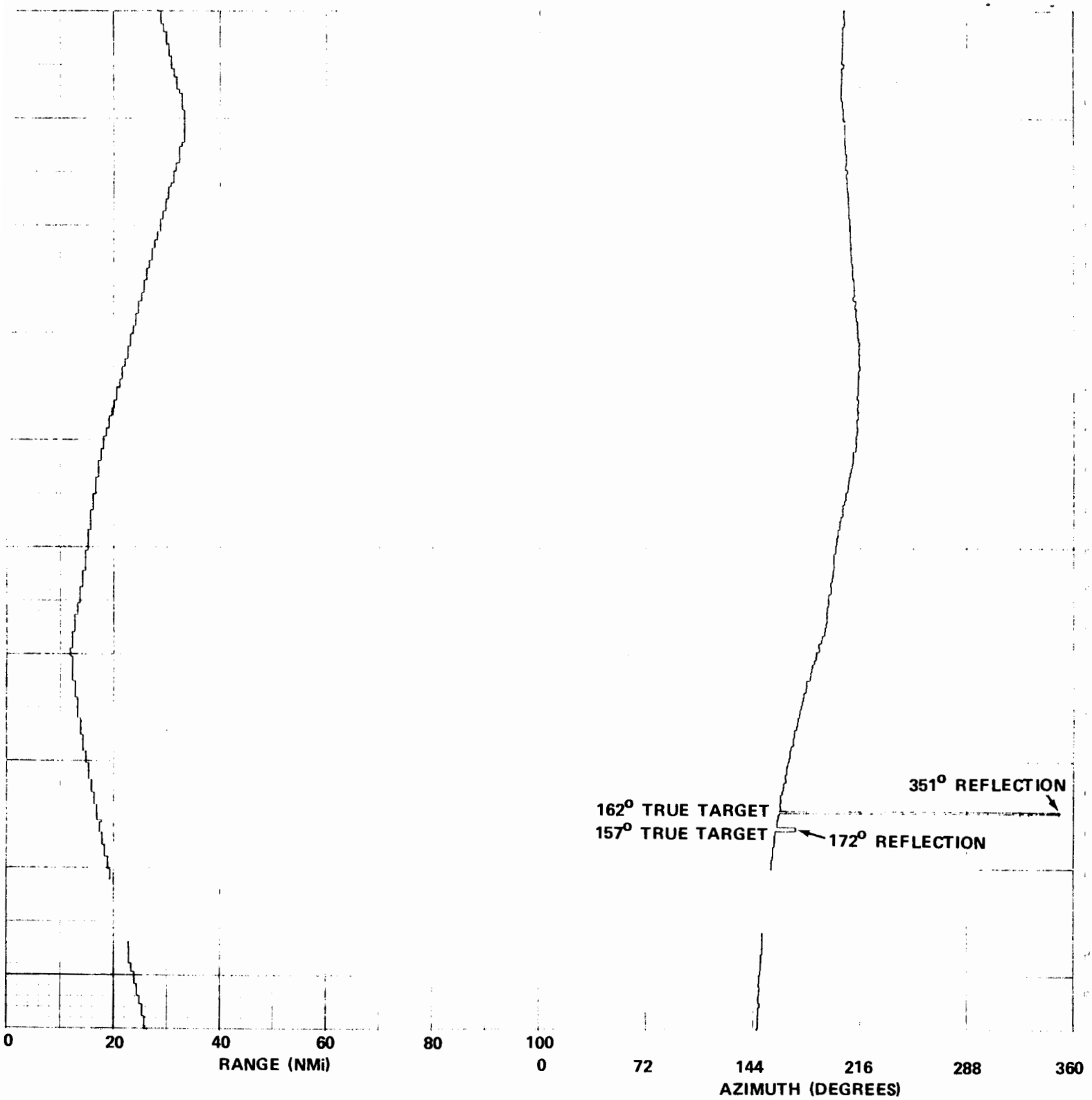
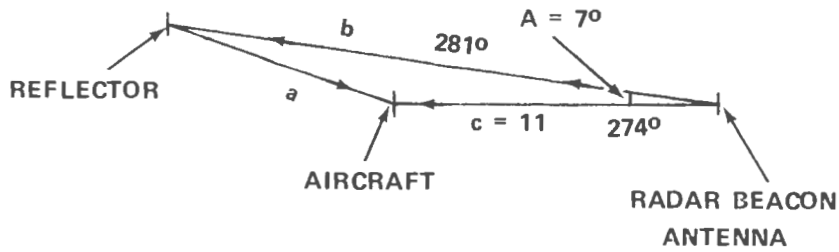


FIGURE 14. T.O.O. APPROXIMATELY TRUE TARGETS 157, 162° AND REFLECTIONS 172°, 351° RESPECTIVELY

TO FIND APPROX. DISTANCE TO REFLECTOR (b)



DIST. FROM ANT. TO REFLECTOR TO AIRCRAFT @ 281° = 23mi

THEN $a + b = 23$ OR $b = 23 - a$

$\cos A = 7^\circ (281 - 274) = 0.9925$

LAW OF COSINES $a^2 = b^2 + c^2 - 2bc \cos A$

$a^2 = (23 - a)^2 + (11)^2 - 2(23 - a)(11)(0.9925)$

$a^2 = 529 - 46a + a^2 + 121 - 21.836(23 - a)$

$24.164\, a = 147.772$

$a = 6.115$

$b = 23 - 6.115 = 16.885$

DISTANCE FROM ANT. TO REFLECTOR IS

APPROX. 17 miles @ 281°

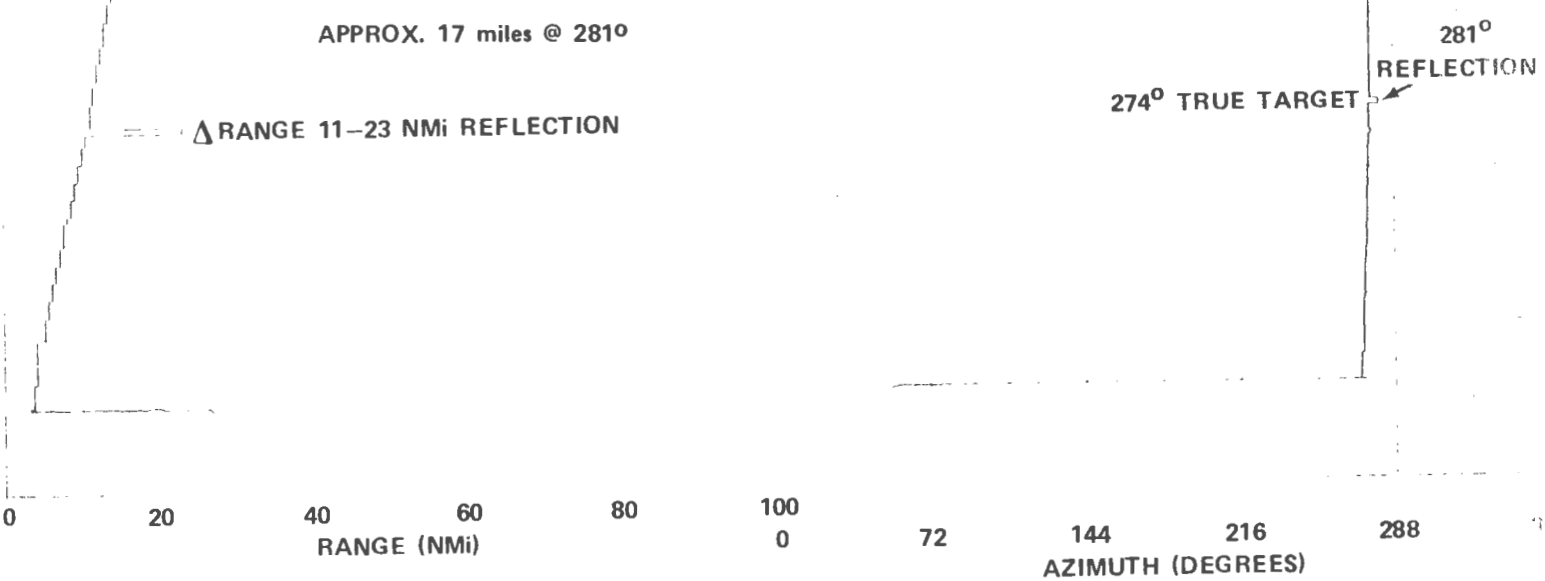


FIGURE 15. T.O.O. Rg REFLECTION AND APPROXIMATELY DISTANCE TO REFLECTOR

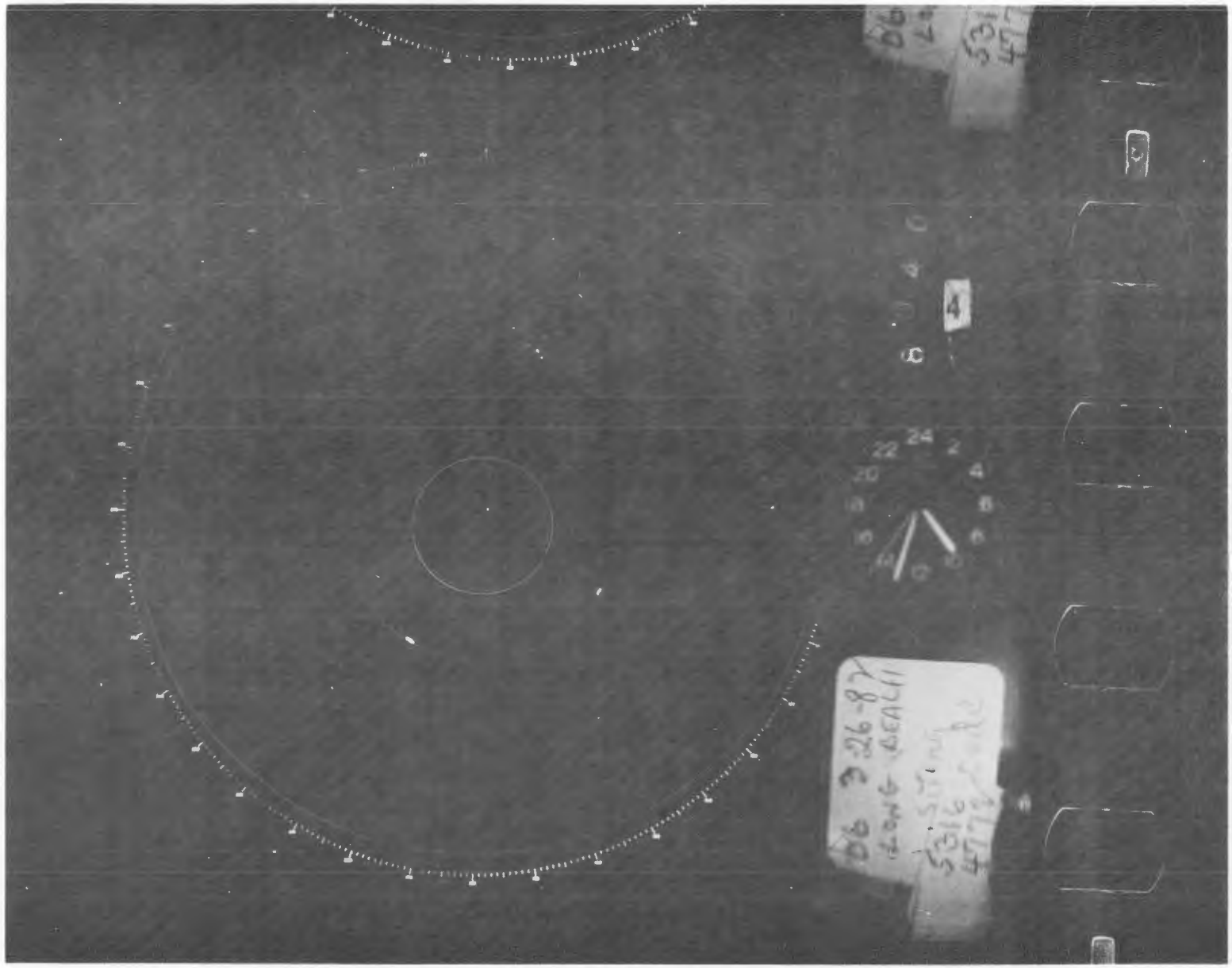


FIGURE 16. T.O.O. TRUE TARGET APPROXIMATELY 122° REFLECTION APPROXIMATELY 212°

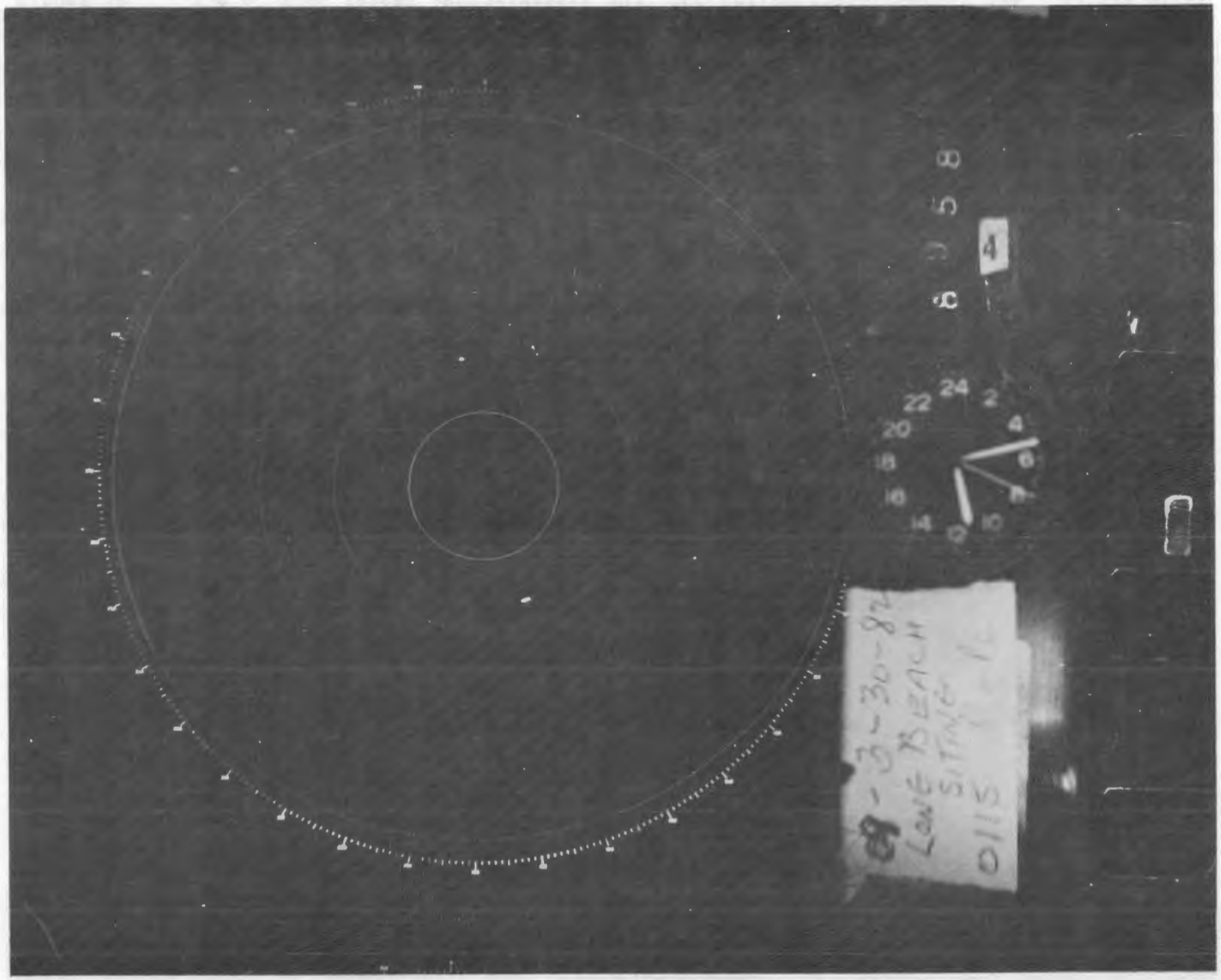


FIGURE 17. T.O.O. TRUE TARGET APPROXIMATELY 162° REFLECTION APPROXIMATELY 351°

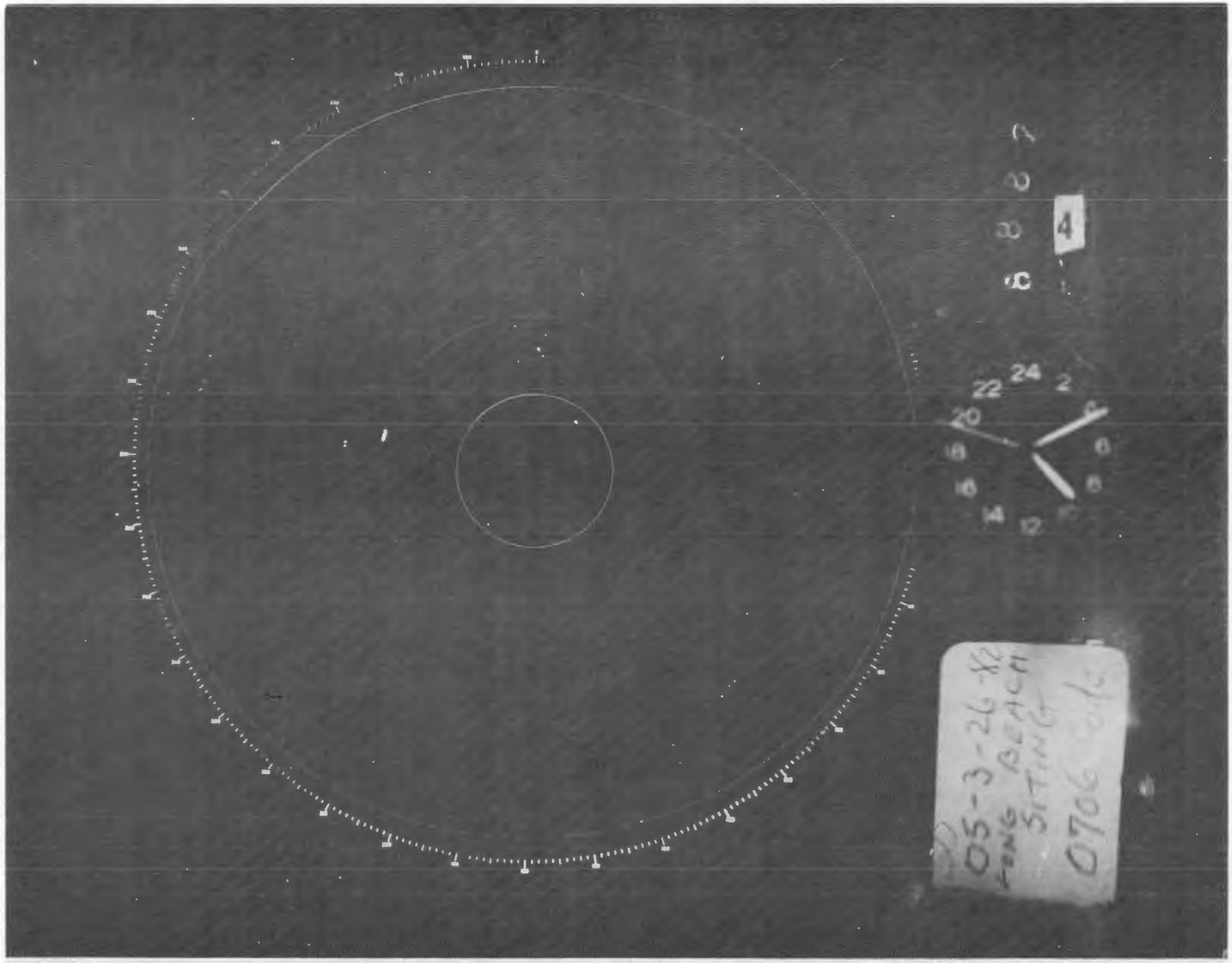


FIGURE 18. T.O.O. TRUE TARGET APPROXIMATELY 281° REFLECTION APPROXIMATELY 274, Rg SIX MILES

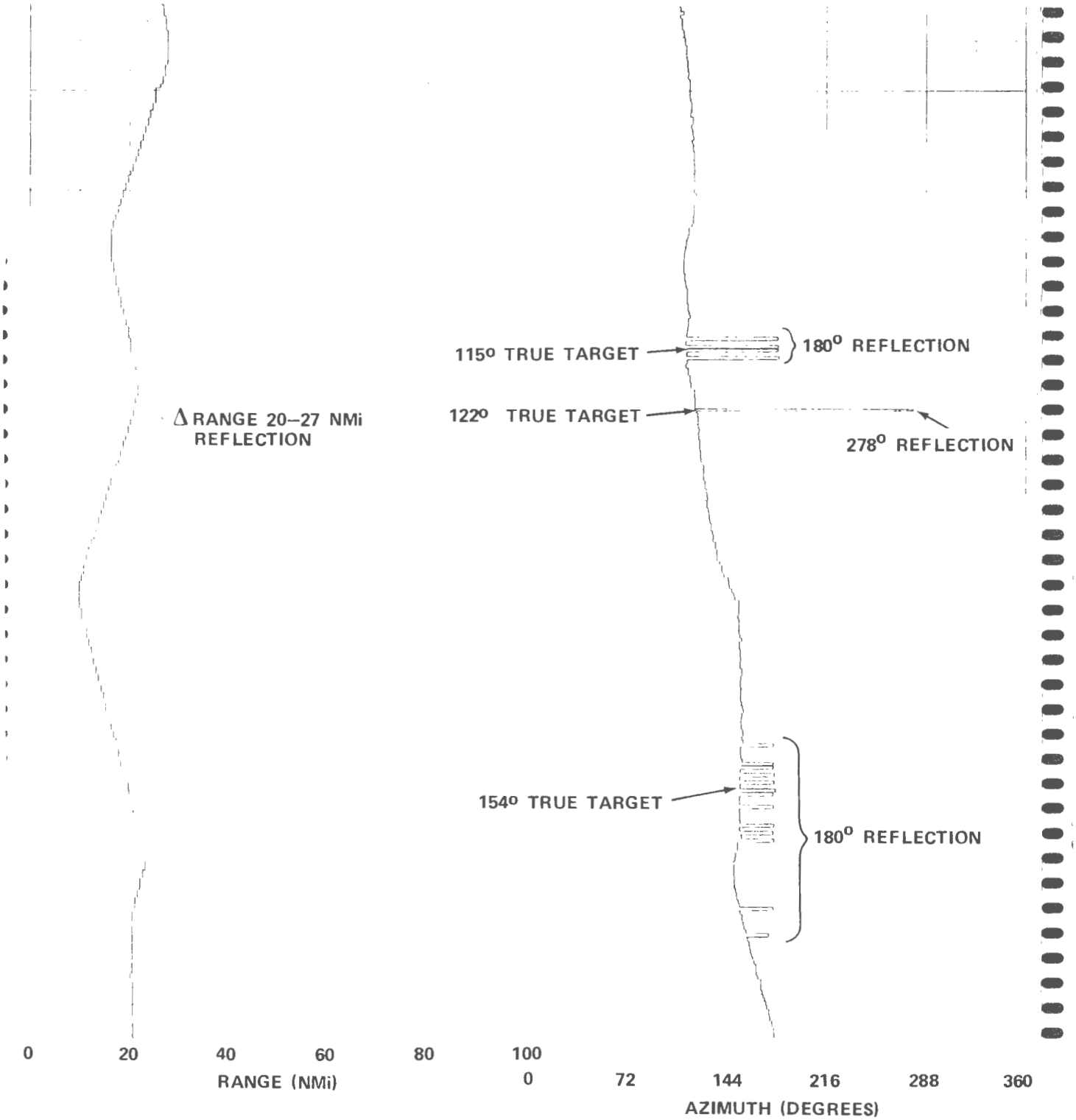


FIGURE 19 REFLECTION RADIALS

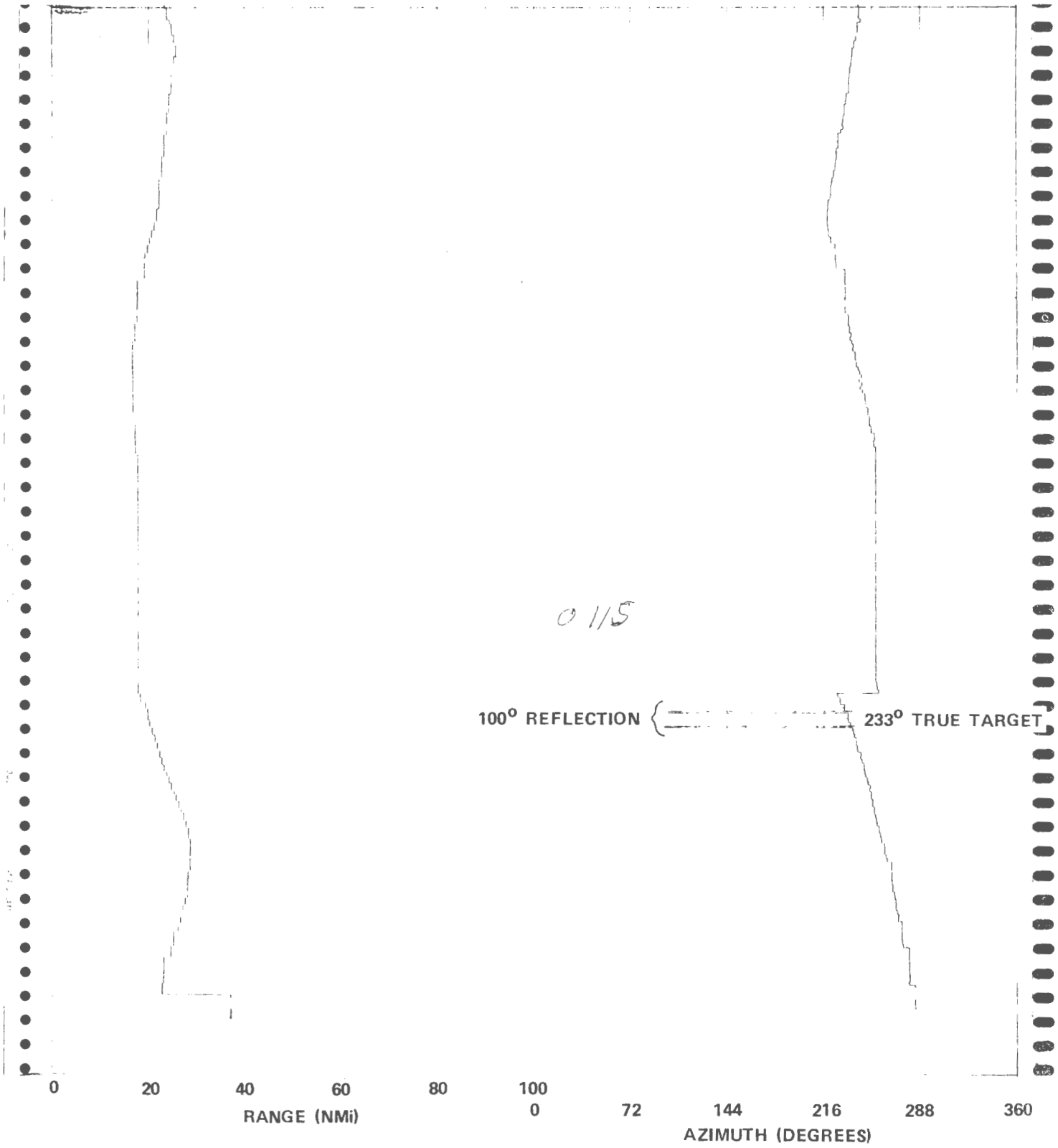


FIGURE 20 REFLECTION RADIAL (Continued)

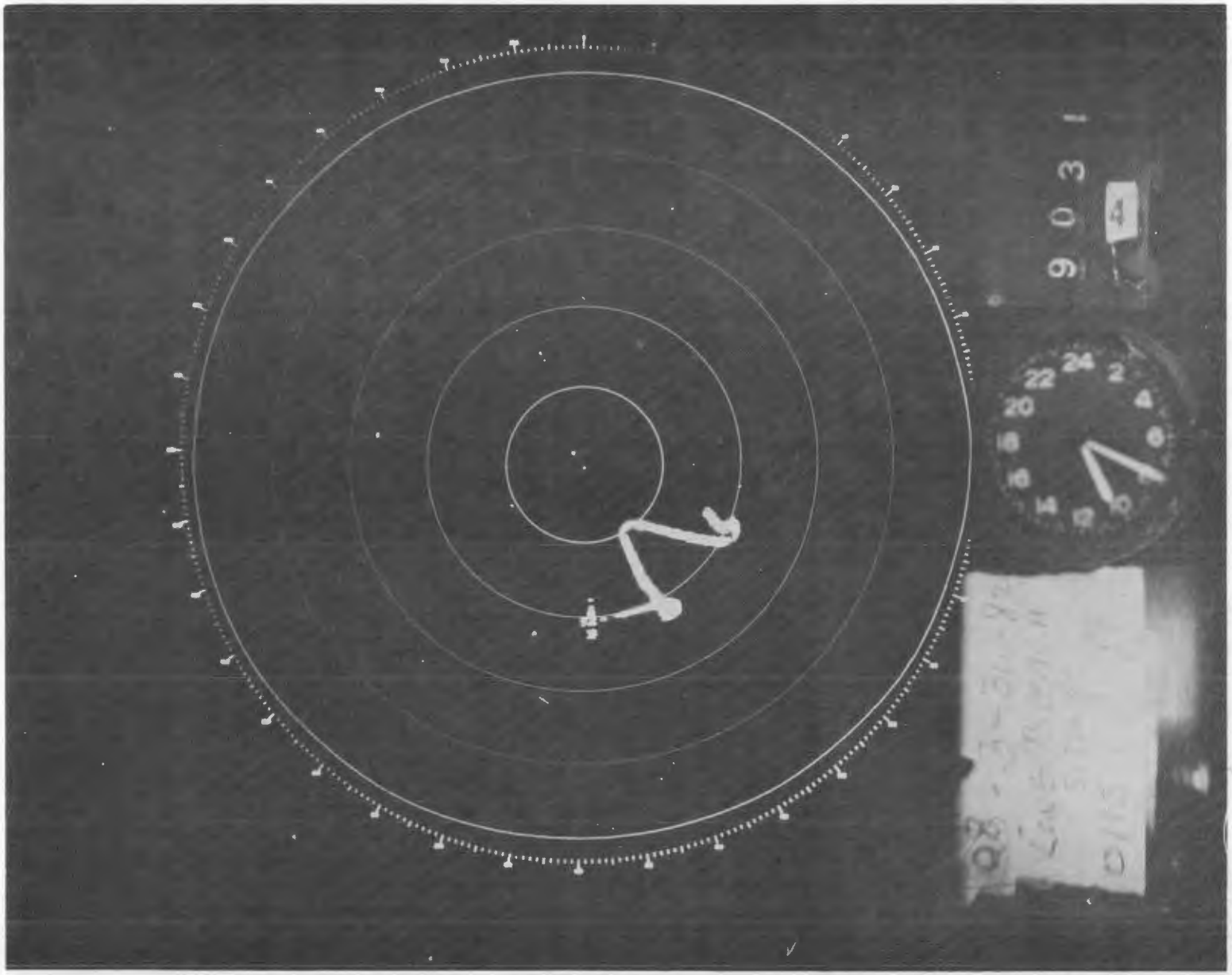


FIGURE 21. TIME ELAPSE TRUE TARGET 115° - 122°, REFLECTIONS APPROXIMATELY 180° AND 278° Rg 20-27 MILES

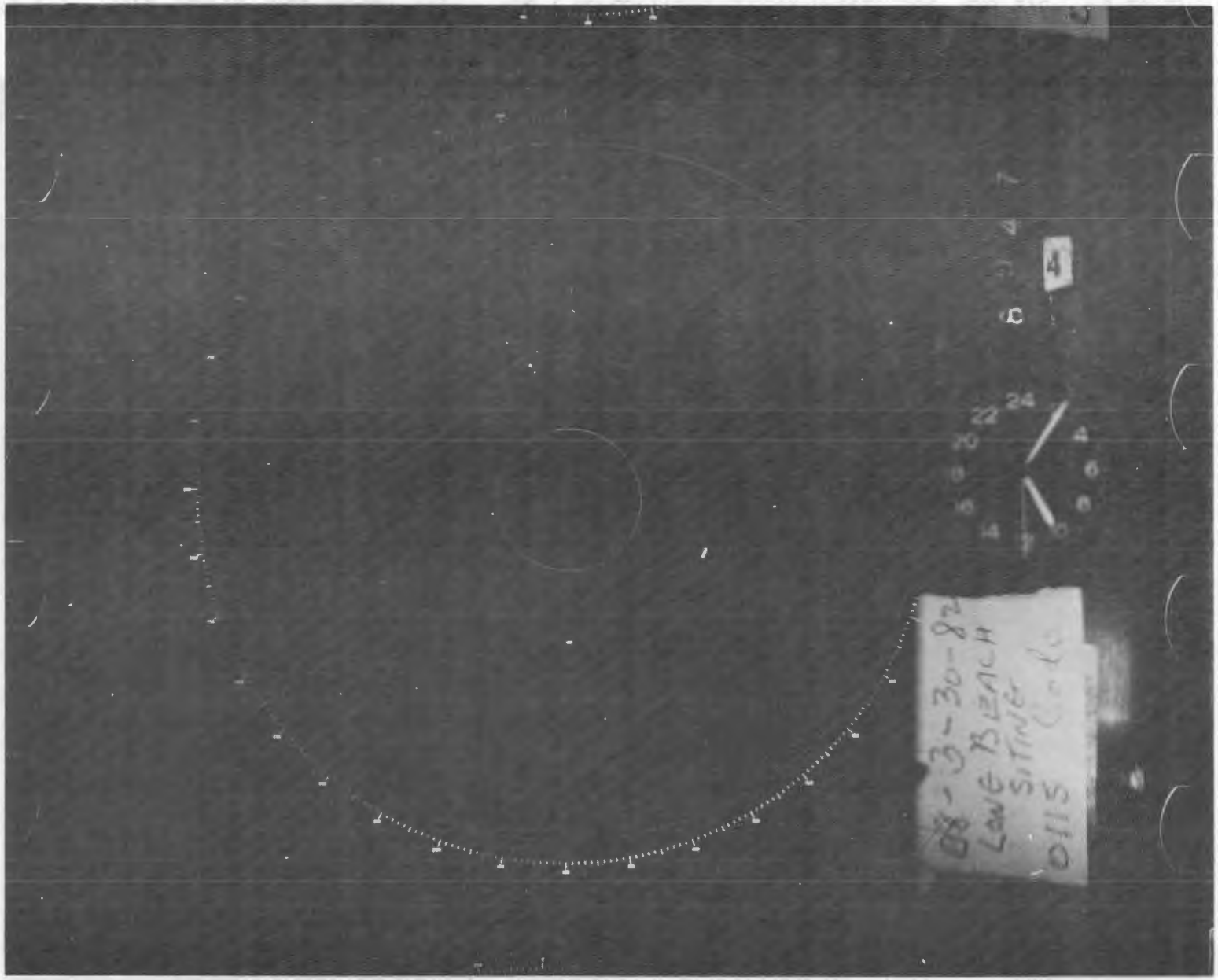


FIGURE 22. TRUE TARGET APPROXIMATELY 115° AND REFLECTION 180°

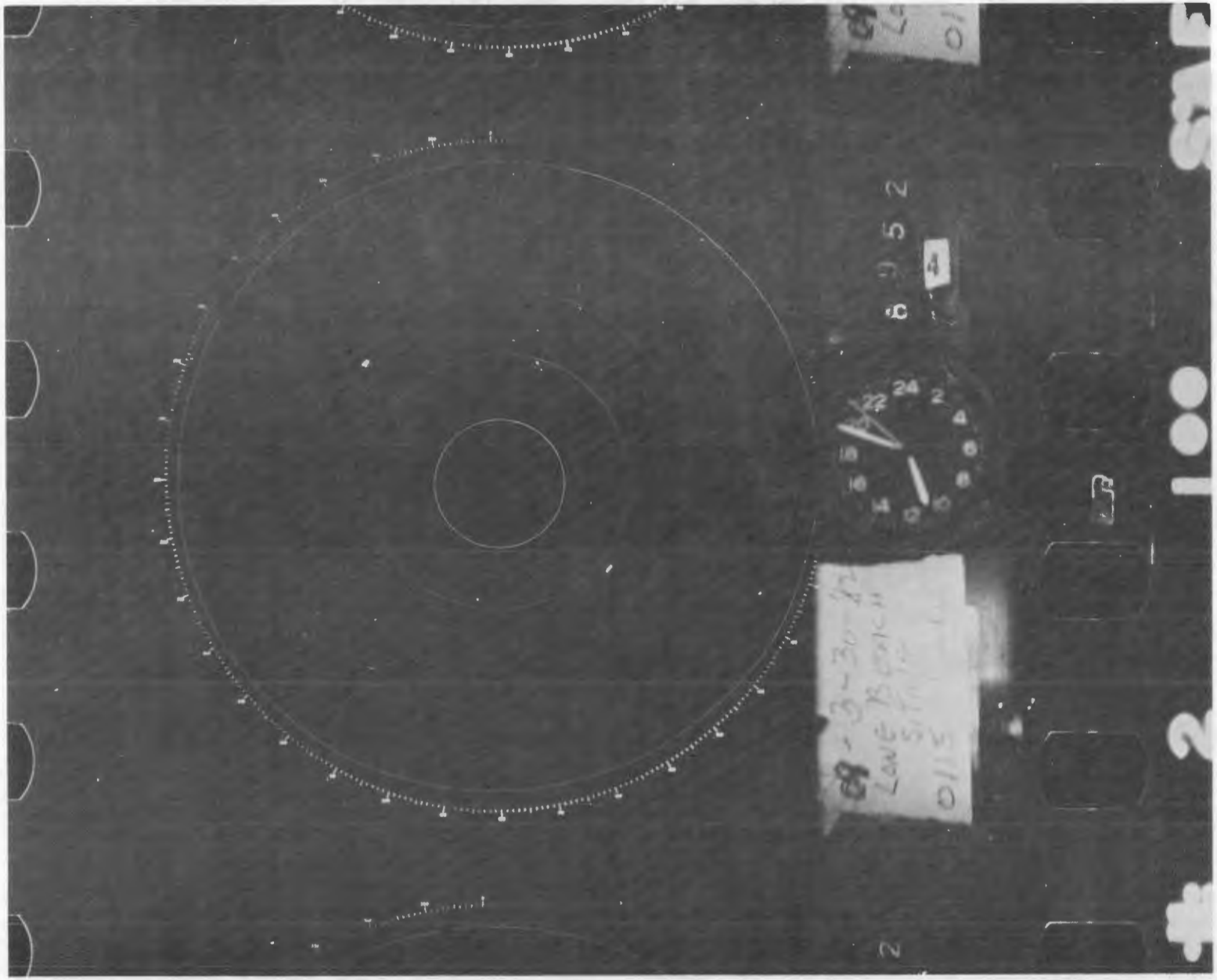


FIGURE 23. T.O.O. TRUE TARGET APPROXIMATELY 130° REFLECTION APPROXIMATELY 312° Rg

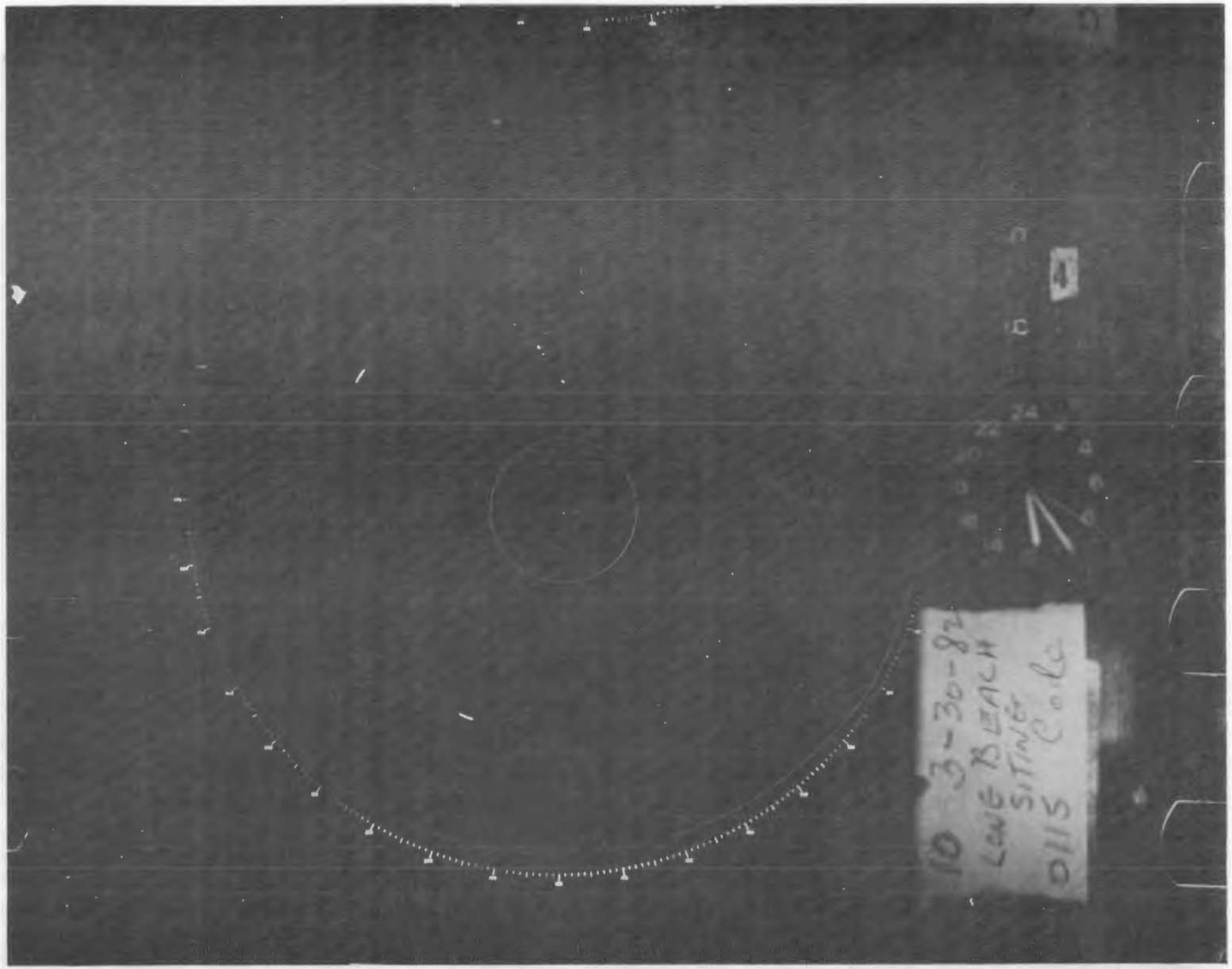


FIGURE 24. APPROXIMATELY TRUE TARGET 206° AND REFLECTION 302° 33 MILES

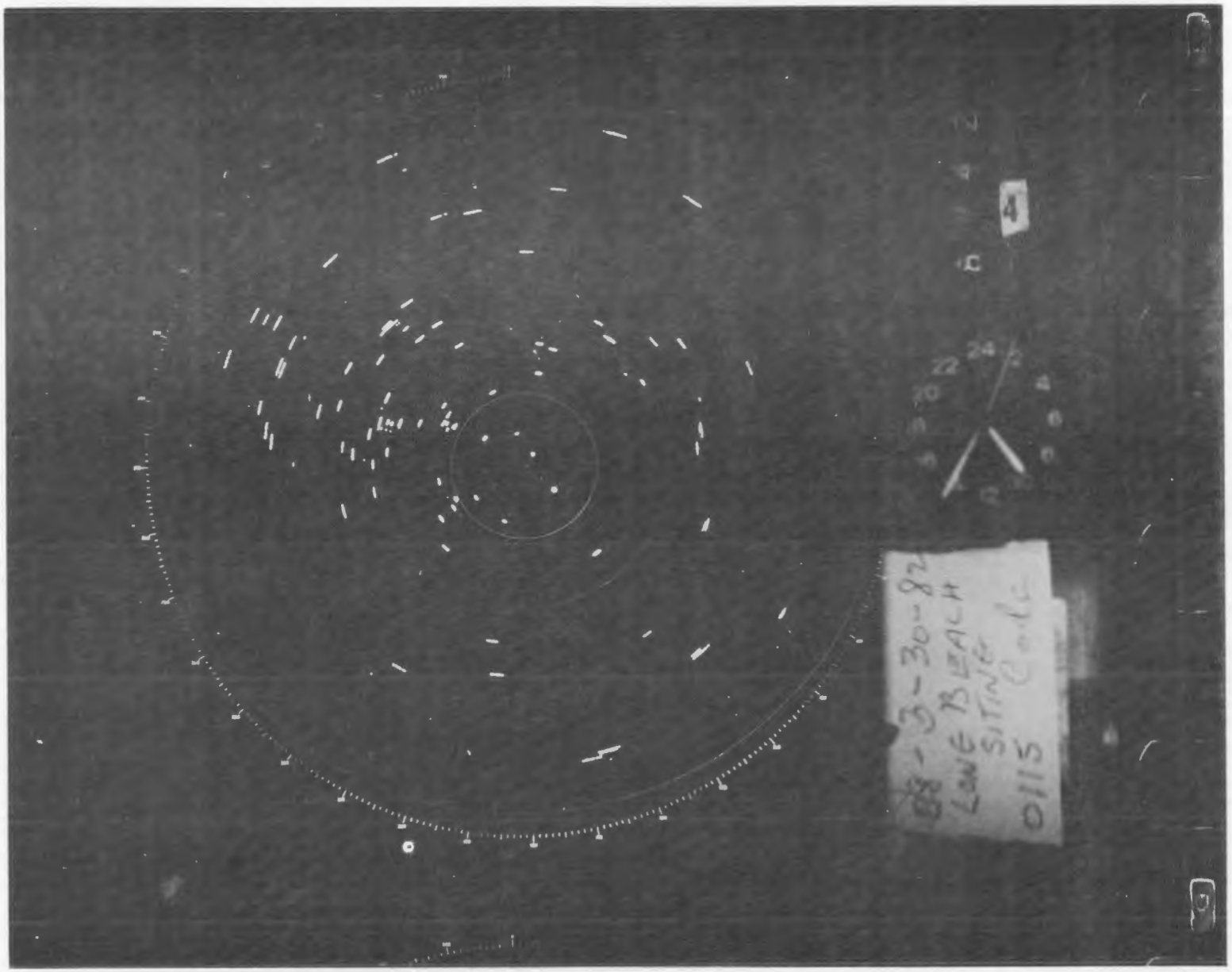


FIGURE 25. FIFTY MILE RADIUS BEACON ONLY TRAFFIC AT STANTON, CA.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WESTERN REGION
P. O. BOX 92007, WORLDWAY POSTAL CENTER
LOS ANGELES, CALIFORNIA 90009

DATE: DEC 10 1981

IN REPLY REFER TO: AWP-420

SUBJECT: ACTION: Request for use of Mobile Radar Beacon Facility for Siting Long Beach ASR

FROM: Acting Chief, Airway Facilities Division, AWP-400

TO: Chief, Systems Test and Evaluation Division, ACT-100

The Western-Pacific Region is requesting the use of the Mobile Radar Beacon Facility (MRBF) to aid us in the siting evaluation for the relocation of the Long Beach ASR-8.

The City of Long Beach does not want to renew our lease at the present ASR-8 site. Our need to relocate the ASR-8 to a suitable site is great, since this radar services one of the nations most dense air traffic control areas.

We understand that MRBF is presently located at Stead Airport, Reno, Nevada, from the telephone conservation between Max Greenberg, ACT-100K and Jim Harvey, AWP-422.3. It is within our time frame and would be a great regional savings to get the MRBF with video tape recorder in February 1982 at the completion of the Reno project.

Please inform us of actual dates that you will be able to furnish the MRBF and provide us with an estimate of regional costs. We currently have F&E project (Project Code 4531-0-210, JON 16094) to conduct an ASR relocate study for the Long Beach ASR.

for Donald Sorn
ALEX HAMMOND

+

DJH.

ATTACHMENT 1

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WESTERN REGION
P. O. BOX 92007, WORLDWAY POSTAL CENTER
LOS ANGELES, CALIFORNIA 90009

DATE: [illegible] 1981

IN REPLY REFER TO: AWP-422

SUBJECT: ACTION: Joint FAA/NAVELEX Site Survey for Long Beach/El Toro Radars (P.C. 4531-0-210, JON 16094)

FROM: Chief, Program and Planning Branch, AWP-420

TO: Acting Chief, Establishment Engineering Branch, AWP-450
Acting Chief, Maintenance Engineering Branch, AWP-430

We have arranged for the Mobile Radar Beacon Facility (MRBF) to be shipped to us at the completion of the current testing at Reno. Considerable cost savings is realized by having MRBF shipped to us from Reno rather than from the FAATC. It is expected to arrive the second week of February 1982 and to be used for siting the Long Beach ASR, since the MASR-8 is not available. NAVELEX expressed an interest in a joint siting with the possible conclusion of eliminating the El Toro ASR-5. The Systems Test and Evaluation Divison, ACT-100 (FAATC) has indicated that the MRBF will cost the region approximately $15,000.

The region is required to provide the following:

- A tractor to move MRBF from site to site
- 208 3 phase 60 amp commercial power
- Magnetic North reference
- Personnel to tune and certify the operation of the ATCBI-4 Beacon Transponder, Digital Defruiter and operational display
- Concrete, if necessary for guy wire anchors
- AWP-430 representative to analyze advisor recordings with ARTS III
- AWP-510 to arrange for a controller to monitor one of the displays
- AWP-510 to provide a beacon equipped small aircraft for flight check
- Test Sites

Please provide an F&E cost estimate for this siting to be conducted at a maximum of four (4) locations. Since the region is providing the funds, please utilize AWP-430 engineering and sector personnel as much as possible. The following manday rates apply for this estimate:

Engineering	$185
Drafting	$125

A copy of the Phoenix siting report is enclosed for your information. We would appreciate your reply by January 13, 1982. This has been coordinated between Reg Bishop, Herman Dohman, Don Lingren, and Jim Harvey. An "In-House" meeting is tentatively scheduled for January 27, 1982 at 9:00am in Room 4W3.

WESLEY A. MARTYN

Enclosure

cc:
AWP-56/406/460/510
ACT-100K
LGB AFS
SAN AFS
NZJ AFSFO

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WESTERN REGION
P. O. BOX 92007, WORLDWAY POSTAL CENTER
LOS ANGELES, CALIFORNIA 90009

DATE JAN 2 2 1982

IN REPLY REFER TO AWP-422.3

SUBJECT: INFORMATION: Long Beach/El Toro ASR Siting

FROM: Chief, Program and Planning Branch, AWP-420

TO: Chief, Systems Test and Evaluation Division, ACT-100
Chief, Real Estate and Utilities Branch, AWP-56
Chief, Frequency Management and Leased Communications Staff, AWP-406
Chief, Maintenance Engineering Branch, AWP-430
Chief, Establishment Engineering Branch, AWP-450
Chief, Maintenance Operations Branch, AWP-460
Chief, Plans and Programs Branch, AWP-510
Navy Representative, AWP-592
Manager, Long Beach AFS
Manager, San Diego AFS
Chief, El Toro AFSFO
Chief, Coast TRACON

This is to advise that a meeting has tentatively been scheduled for February 10, 1982 at 9:00 a.m. in the Regional Office Conference Room, Room 4W3, to discuss the Long Beach/El Toro ASR siting procedures.

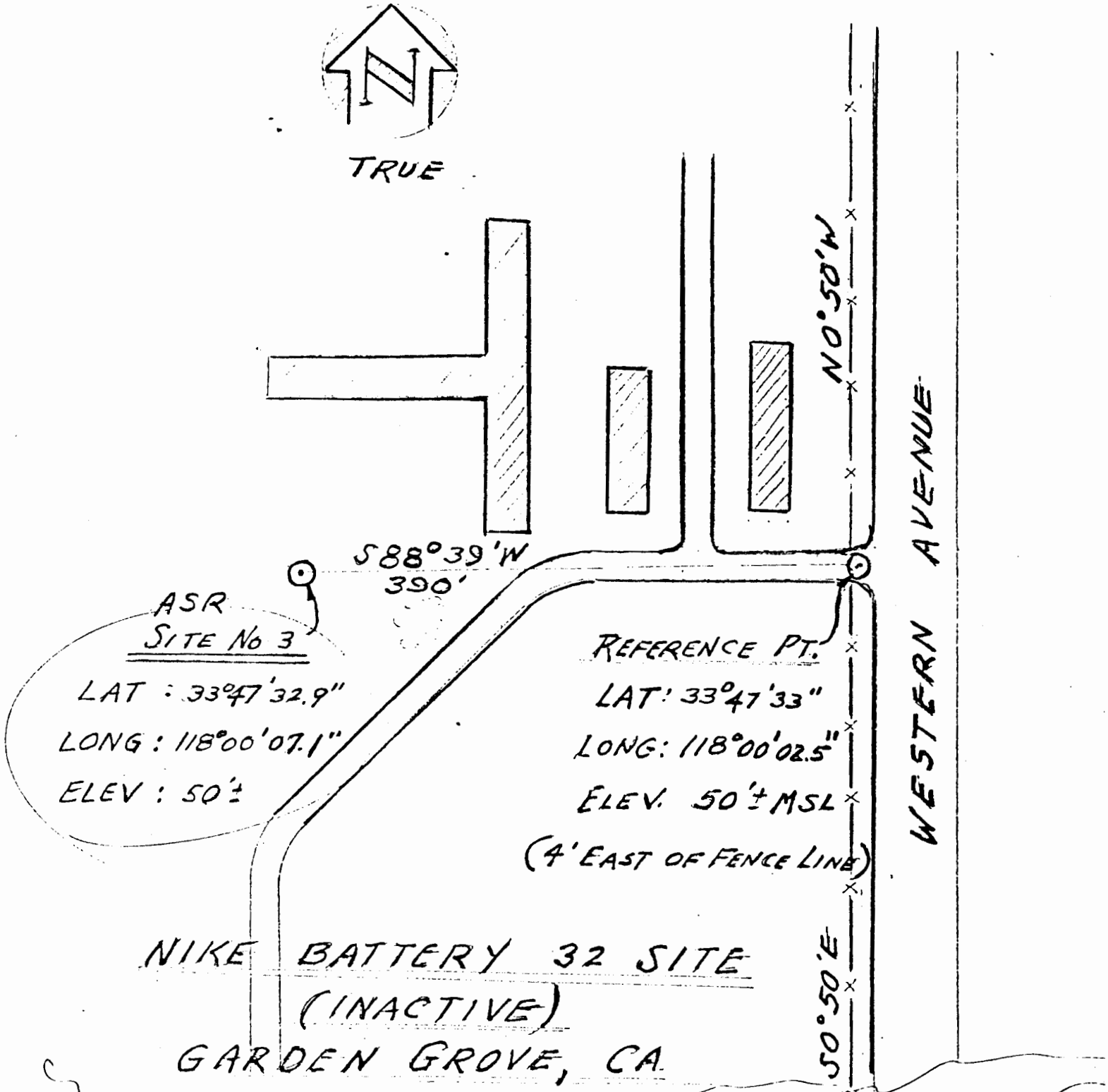
We request that Max Greenberg, ACT-100K, attend this meeting to explain the use of the Mobile Radar Beacon Facility (MRBF).

Costs incurred during this project in using the MRBF will be funded by the Region under Project Code 4531-1-210, JON 26014.

Wesley A. Martyn

WESLEY A. MARTYN

cc: M. Greenberg



RMS

			RANGE	BEARING TRUE	MAG
SANTIAGO PEAK	33°42'40"	117°31'54"	23.96	101.63	87.13
B/6 PANES	34 22 25	117 42 21	37.84	22.8	8.3

MAG VA 14.5

NIKE SITE ASR-8 LOCATION 10-8-81