Progress Report
Missile Monitoring Program

22 January, 1962

Office of Naval Research
Contract 3163(00)

AERO GEO ASTRO
CORPORATION
ALEXANDRIA, VIRGINIA

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

SECURITY NOTICE

THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U. S. C., SECTIONS 793 AND 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

A.G.A. Log No. 1111
Copy 18 of 100 Copies

PROGRESS REPORT OF

MISSILE MONITORING PROGRAM

(Short Range)

(May to August 1961)

22 January 1962

Aero Geo Astro Corporation
13624 Magnolia Avenue
Corona, California

Prepared under Office of Naval Research Contract 3163(00). A portion of the effort described is jointly supported by the Advanced Research Projects Agency and is directed by Rome Air Development Center under ARPA Order 235-61.

NOTICE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, USC Section 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

EXEMPTED FROM AUTOMATIC DOWNGRADING BY
Capt. H.E. Ruble, Deputy and Assistant Chief of Naval Research

TABLE OF CONTENTS

SHORT RANGE MONITORING PROGRAM

I. INTRODUCTION

Aero Geo Astro Corporation operated a VLF missile monitoring site located south of Miami, Florida, from May to August 1961. The primary purpose of the experiment was to study the reflections from missile trails and/or ionospheric perturbations using artificial atmospheric noise generators as the illuminating source. In addition to this, two high range resolution (less than 20 miles) Licor systems were operated during this period. They used atmospheric noise originating in thunderstorm areas as the illuminating source on frequencies of 10 Kc and 25 Kc. Detections on these radars extended the frequency coverage of VLF backscatter measurements outside the previous 14-22 Kc region. Discussion of medium and long-range detection at other AGA sites has been included in this report in order to give a more complete picture of the VLF research.

II. DISCUSSION OF SHORT-RANGE EXPERIMENT

A. Geometry

The Aero Geo Astro monitoring equipment was located at Richmond Naval Air Station, south of Miami, Florida, which is at a range of about 200 miles from Atlantic Missile Range launches (Figure 1). One of the artificial atmospheric noise generators was shipborne in the general area of Fort Pierce, Florida. Later in the monitoring period, a second generator was activated near Avon Park, Florida. The Aero Geo Astro site was near the range limit for the direct line-of-sight to the missile at D layer altitudes. This site location was chosen for technical reasons to be described later and since the shorter range areas were already instrumented.

B. Artificial Atmospherics Generator[1]

The transmitter used for part of the studies described in this report was an artificial atmospherics generator operating in the frequency range of 19-28 Kc. In operation of the generator, capacitors are charged in parallel to a voltage of about 50 killovolts each and then switched through an initiating gap system to a series arrangement to produce an impulse with peak voltages of 1-to-2 million volts. A multiple gap trigger system is utilized to provide a smooth wave form with a typical transmitted pulse length of about 1/5 millisecond.

---

1 "Artificial Atmospherics Generator," Lightning and Transients Research Institute Report No. 326, September 1957.

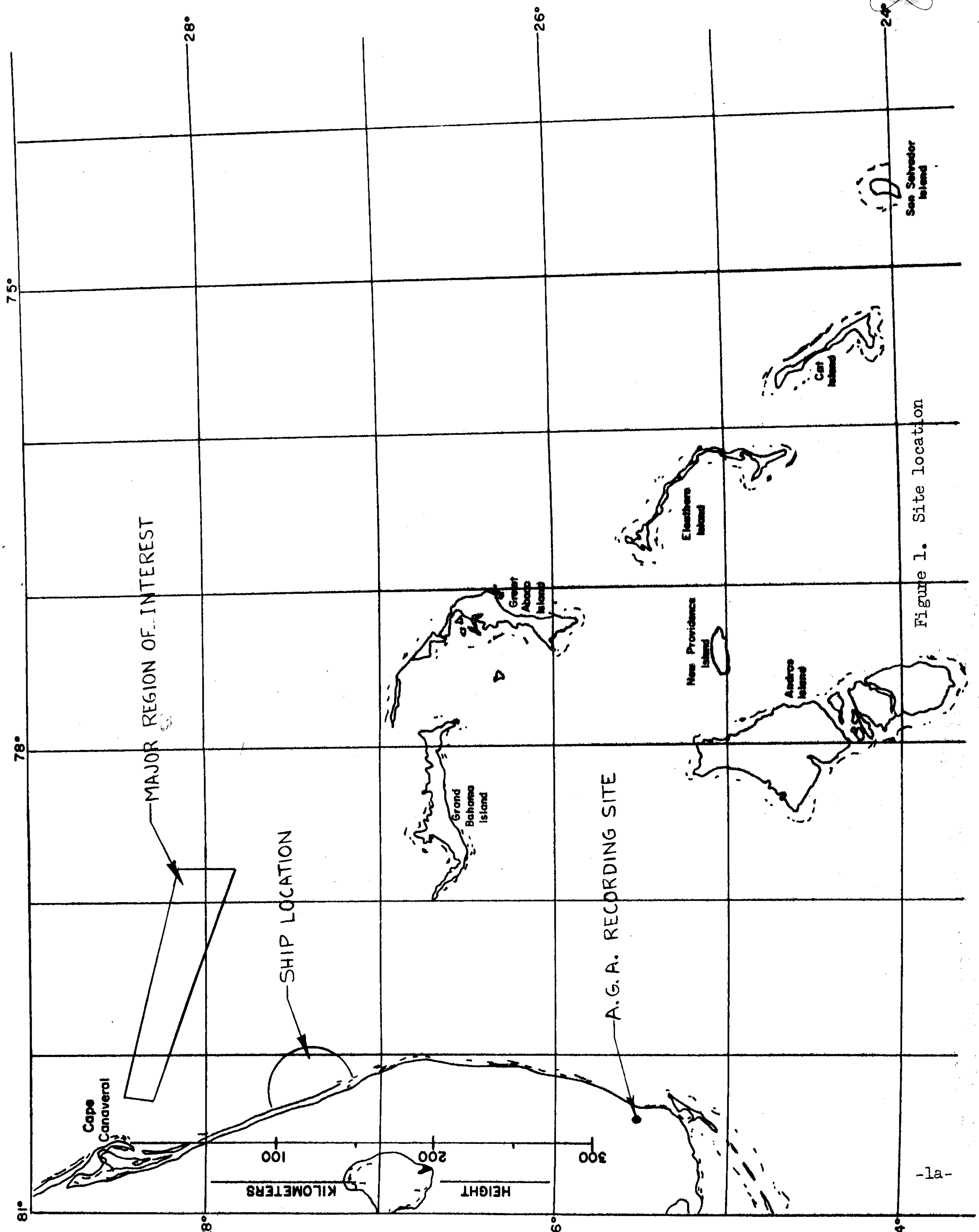


Figure 1. Site location

The peak radiated power is generally on the order of 10 megawatts, (strongly dependent on the antenna length). The antenna utilized was either a helicopter- or balloon- supported vertical wire. The transmitter emitted a pulse every six seconds on the order of 70 milliseconds before the WWV pulse. The direct pulse received at the monitoring site had a fairly sharp rise and a smooth exponential decay.

C. Target Characteristics

Theoretical studies[1,2] have predicted scatter cross sections in the VLF region from about 10^6 to 10^8 square meters. Both short and long range measurements have, in general, yielded within this range. Theoretical studies have indicated that the ionization should last for a considerable time just below the D layer and this has been confirmed with experimental results which have shown echo durations of up to 30 minutes or more. The experimentally measured echo duration appears to be primarily a function of the signal-to-noise or signal-to-clutter ratio with the large signals lasting much longer. (Most of the recent Florida short-range measurements have yielded fairly short duration signatures.)

The reflection pattern of the trail, or perturbation, in the VLF region is far from well defined. Occasions have arisen in the past where good long-range signatures were detected while the same event viewed "in-close" produced a poor signature. This could indicate some aspect sensitivity in the vertical plane and was one reason for chosing the Miami recording site. This allows a different target aspect to be viewed than would be seen from the close range recording. While the shape of the trail may be quite different from cylindrical, some indication of the possible types of patterns may be obtained by looking at cylindrical reflection patterns for various lengths. Figure 2a shows the reflection patterns of thin cylindrical reflectors of 1/2 and 1-1/2 wavelengths long[3]. It is noticed that for the shorter trail, the peak reflection would be normal to the cylinder; while for the longer trail, the peak reflection has changed direction considerably. Figure 2b shows the normal, or broadside, cross section

---

1 "Theory of Exhaust Trail Reflections at VLF," Paul Von Handel, Symposium on Detection of Ionospheric Perturbations, Stanford University, 20 June 1960.

2 "Mides Interim Report," D. J. Adrian, R. H. Espeland, H. H. Burroughs, NOLC Tech. Memo No. 45-23, 18 January 1960.

3 "Radar Response From Thin Wires," C. T. Tai, Stanford Research Institute Report No. 18, March 1951.

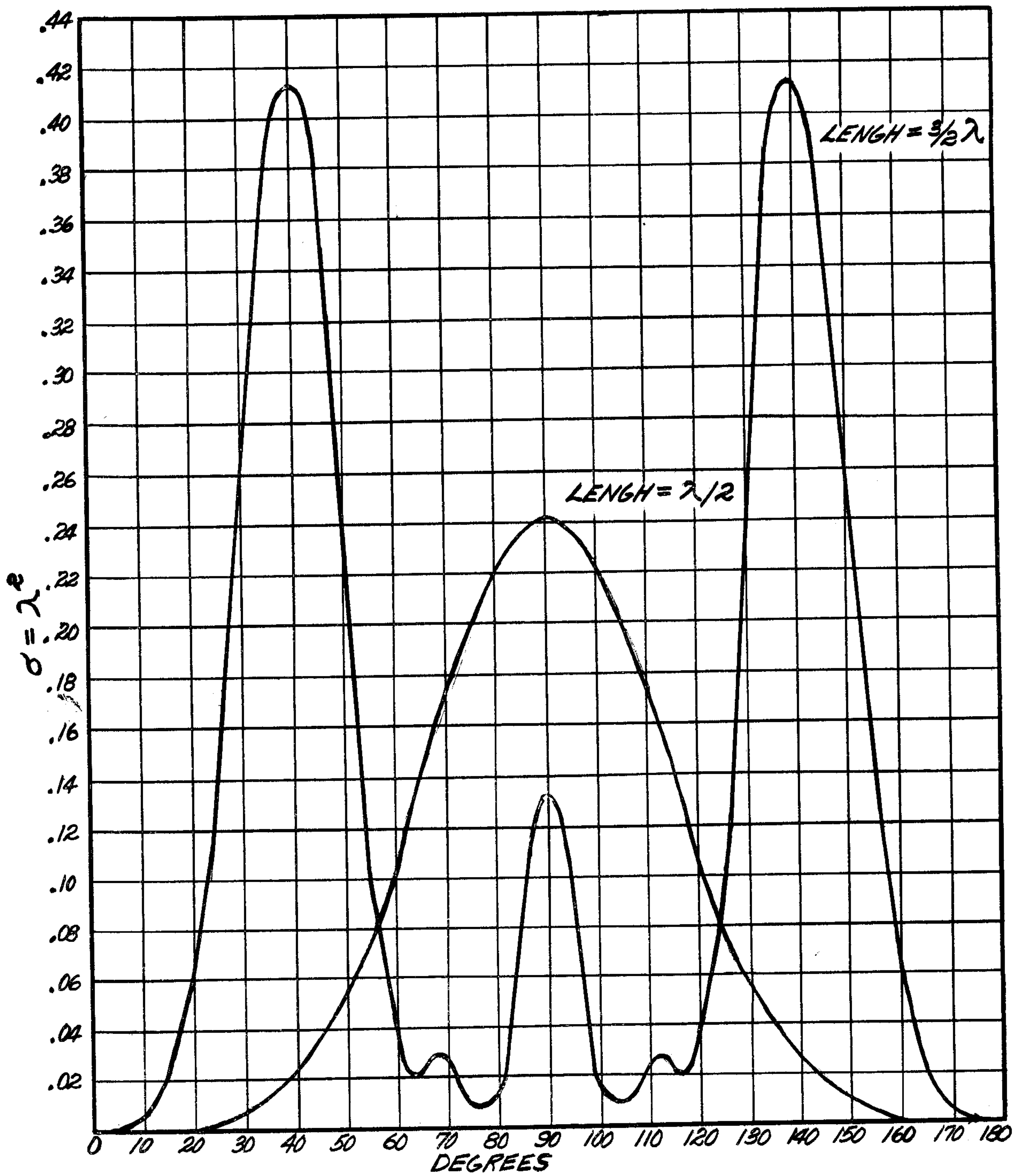


Figure 2a. Reflection Patterns of Thin Cylindrical Reflectors

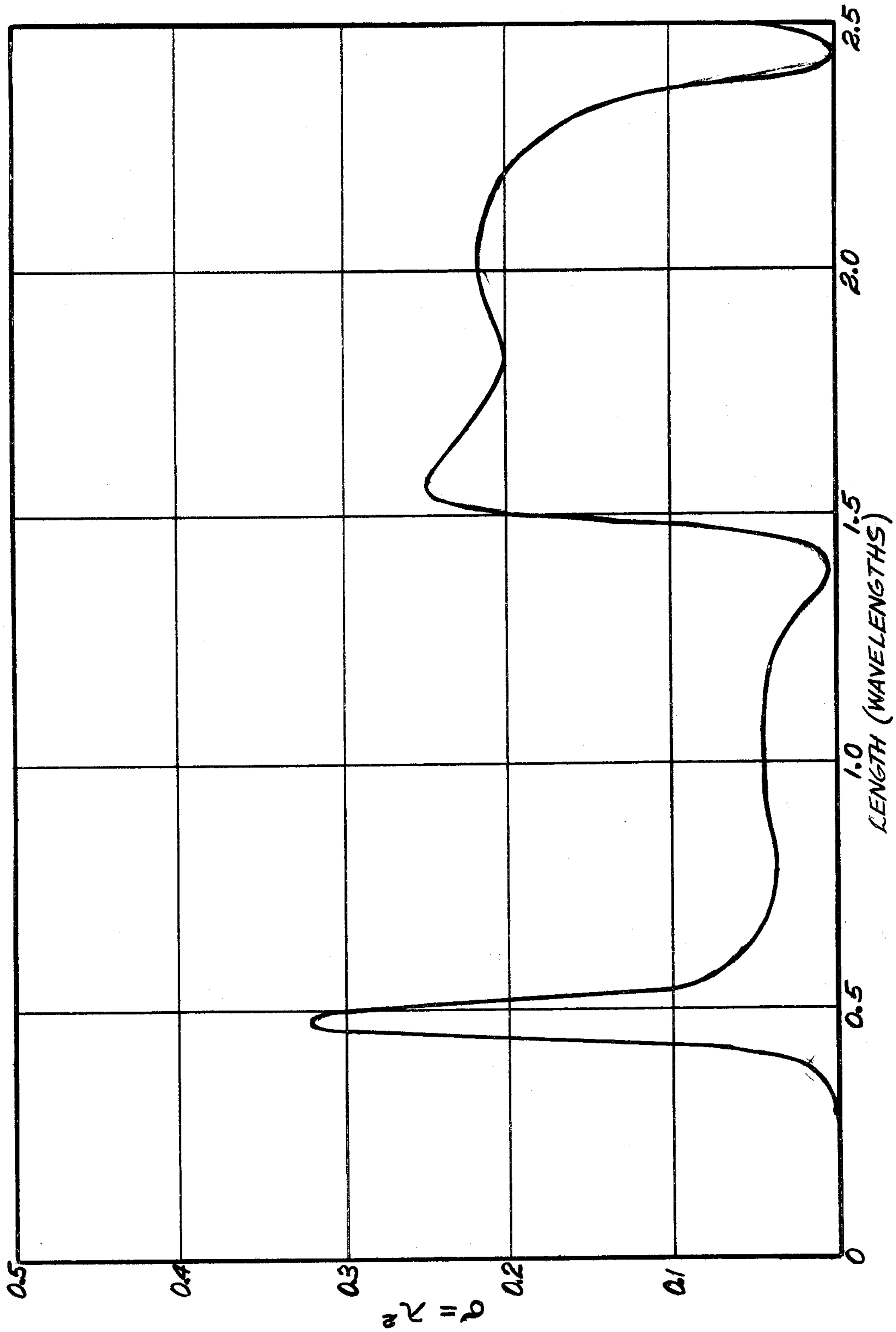


Figure 2b. Normal Cross Section Versus Length

versus length. It is seen that if this aspect is viewed, it is possible for a longer trail to give considerably smaller reflection than a shorter one. These effects, among others, have made it impossible thus far to draw any firm conclusions from the experimental data about the cross section versus frequency behavior of the reflector. Vertical aspect sensitivity can give rise to very marked differences in detection between two different short-range receiving stations, while medium and long-range stations, in general, view the same vertical aspect.

D. Expected Signal Intensity

An estimate of the echo signal intensity may be obtained as follows: "Assume that the transmitted power spreads out uniformly over a hemisphere with radius equal to the transmitter-to-missile range. The power density at the missile trail, or perturbation, is then

$$p_i = \frac{P_o}{A} = \frac{P_o}{2\pi\ (d_1^2 + h^2} \qquad (1)$$

where d_1 is the ground range to the missile and h is the height of the ionosphere. The reflected pwer from the trail is then

$$P = p_i \sigma \qquad (2)$$

where σ is the backscatter cross section. It is then assumed that this energy spreads out over a hemisphere, with a radius equal to the missile-to-receiver range, to give the received target power density, as shown in

$$p_r = \frac{P_o \sigma}{(2\pi)^2\ (d_1^2 + h^2)\ (d_2^2 + h^2)} \quad \text{(hemisphere)} \qquad (3)$$

The power density may be related to the field intensity by the known relation

$$E^2 = 120\pi\ p_r \qquad (4)$$

An alternate method of computing the signal attenuation is to assume that the transmitted and reflected energy spreads out uniformly in the cylindrical region bounded by the ionosphere and the earth. Under these assumptions, the received echo power density is

$$p_r = \frac{P_o}{(2\pi h)^2 \, d_1 d_2} \text{ (cylinder)} \qquad (5)$$

It is believed that the hemisphere approximation would be the most nearly correct at very short ranges, while the cylindrical surface case would be a better approximation at somewhat larger ranges. The expected field intensity versus range, assuming a transmitted power of 10 megawatts and a cross section of $10^6 m^2$, is shown in Figure 3 for both cylindrical and inverse range squared approximations.

E. Receiving System

A simplified block diagram of the recording equipment is shown in Figure 4. The operation is as follows: The VLF pulse from either lightning, or the artificial atmospherics generator, is picked up on the tuned 25 Kc loop with a 6 Kc bandwidth. (It was necessary to have this wider than desired bandwidth since the transmitted frequency of the artificial atmospherics generator was not known prior to a test.) The reference and echo signals are amplified and the various VLF station signals are notched out with 50 db rejection filters. The reference signal is delayed in a sonic delay line system an amount equal to the round trip propagation time to the target. This delayed pulse is then used as reference signal for the dual channel RF correlator. A similar system centered at 10 Kc with a bandwidth of about 2 Kc was also in operation.

The general operating procedure was to record on magnetic tape the four RF signals (two reference and two scatter) and the WWV timing signal. The station was also operated on 25 Kc with "real-time" processing with the time delay set for the artificial atmospherics generator (if there was a possibility that it would be operating during the test). If word was received that the generator would definitely not be operating, then the direct paper readout system was changed to operate in the Licor mode, generally on the 10 Kc channel. After the test, the usual procedure was to send the taped signals through the processing system, using several different delays and thus determine the echo range if a signature was present.

The advantage of the correlation technique over that of viewing single pulse echoes depends upon the number of independent samples occurring during the integration time and on any excess bandwidth

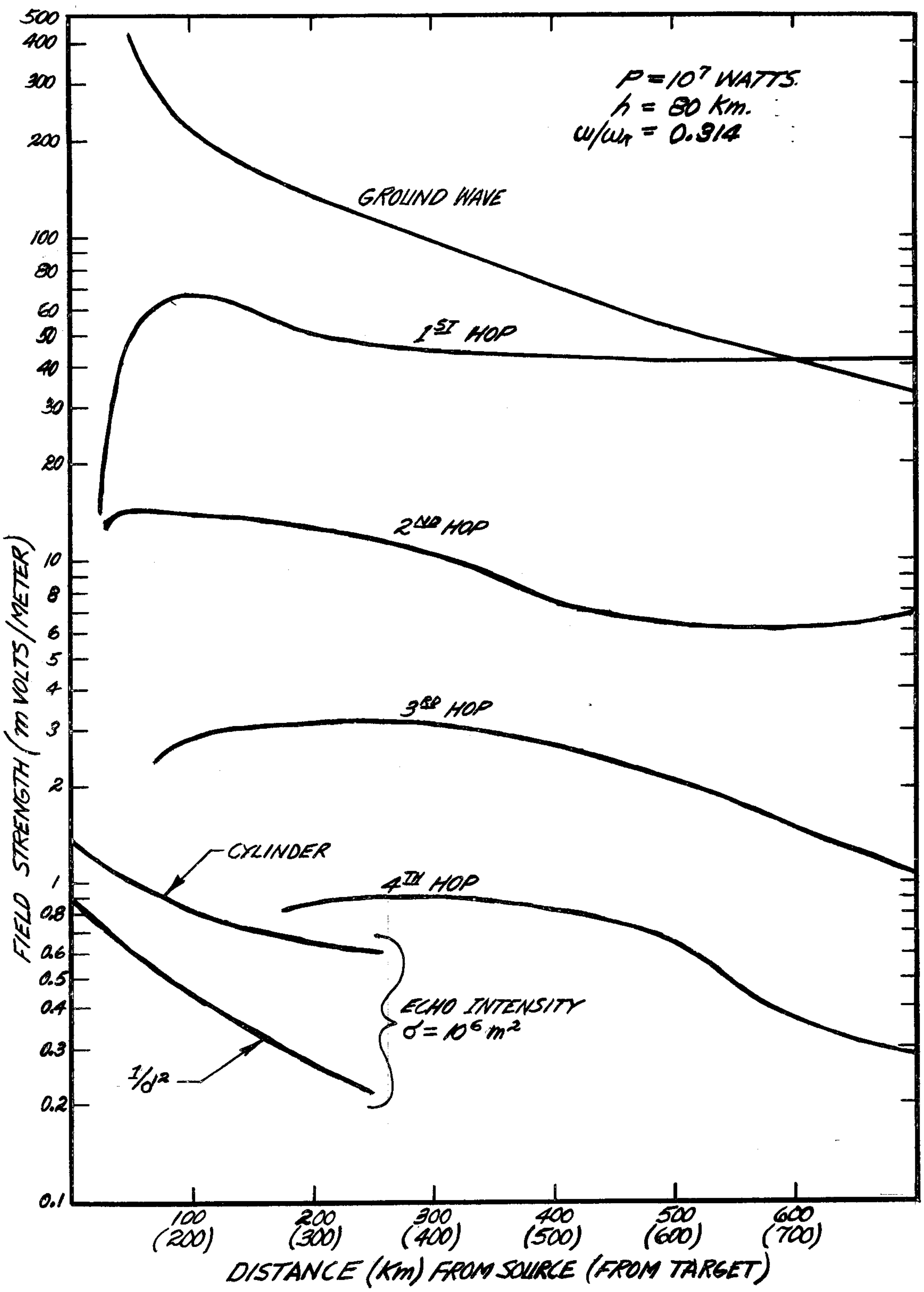


Figure 3. Field Intensity versus Range

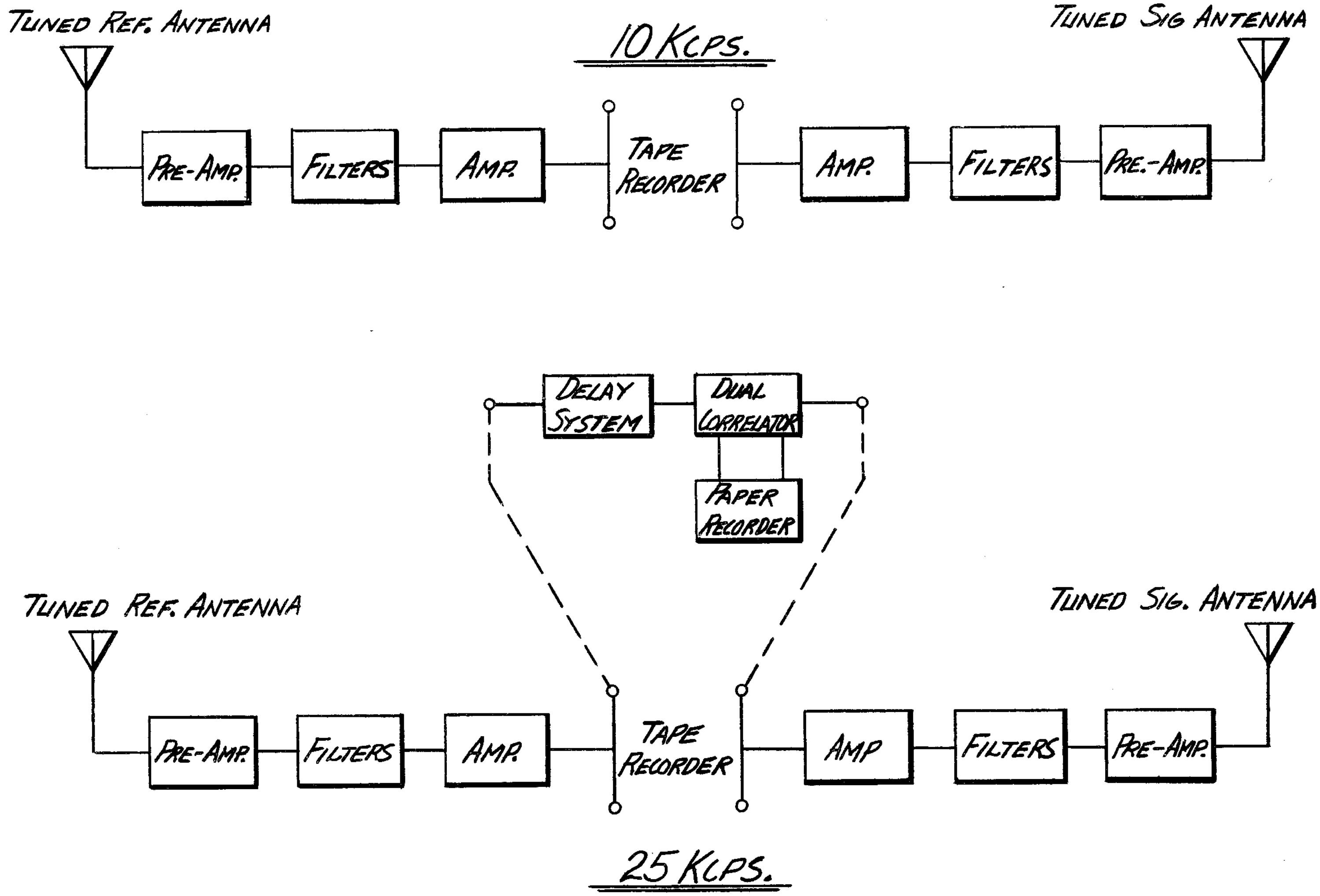


Figure 4. Block Diagram of Recording Equipment

required to accomodate the uncertainty in transmission frequency. Due to the extremely low duty cycle of the artificial atmospherics generator, the advantage of the correlation system over a direct echo system was only about 12 db in this case, compared to between 20 and 40 db in the usual VLF monitoring. However, this advantage was quite important in the Miami operations since the output signal-noise ratios were below 12 db. It was also possible that the system might be of some advantage in seeing a target against a multi-hop, or clutter, background since both phase and amplitude information are recorded.

In some of the later monitoring, a direction-of-arrival gating system was incorporated into the Miami Licor station. This system makes use of the conventional "look" df system with the directional ambiguity eliminated by intensity modulating with a monopole signal. A photo tube picks up the direction-gated reference signal which appears on the cathode ray tube and gates the reference channel open only when sferics are received from the proper direction so as to contribute to the in-phase target return signal[1,2].

F. Calibration

A relative field intensity method of calibration was used at the Miami Site. This compares to an absolute field intensity measurement method used at the medium and long-range sites. For use with the artificial atmospherics generator, the intensity of the echo relative to the ground wave intensity was determined (the ground wave-produced offset on the paper chart was obtained by using zero time delay in the signal processing system.) For example, in Test No. 105 (to be described later), it was found that the echo offset was about 43 db below the offset caused by the undelayed ground wave. Using the cylindrical surface approximation discussed above, the cross section would be somewhat less than $2 \times 10^6 m^2$; while using the inverse squared approximation for the signal attenuation, the cross section would be about $8 \times 10^6 m^2$.

In the Licor operation, an estimate of the target cross section was obtained by calibrating the system relative to the atmospheric noise intensity. The assumption is then made that the noise intensity at the target is approximately the same as the noise intensity at the

---

1 "Distributed Source Effects in Licor Systems," Aero Geo Astro Corporation, 5 August 1960.

2 "Applications of Distributed Sferics Sources," NOLC Rpt. 543, 1 April 1961.

monitoring site. This will be nearly true when the noise fields have low divergence such as occurs for sources located at a very large range. However, if the sources are quite close as was true much of the time in Florida, the field intensity at the missile will be overestimated with a resulting underestimation of the cross section. Thus numbers obtained by this method should be taken as lower limits rather than actual values.

G. Major Difficulties

One of the major problem areas in the short-range experiment was the high atmospheric noise levels. The period of this experiment coincided with the peak thunderstorm activity in Florida and local thunderstorms were very abundant. The second problem was that of obtaining coincidence between operation of the artificial atmospheric generator and missile launches. The operation of the generator was restricted to daytime use because of air clearance problems while the great majority of the large missile launches occurred at night. Weather conditions further restricted the generator operation. In addition, the long delays in missile launches quite often outlasted the helicopter gasoline supply.

A third problem is that of masking the echo by multiple hop reflection and even the possibility of masking of the echo by the exponential decay of the ground wave pulse for sites located quite close to the transmitter. Figure 3 shows the ground wave and sky wave field intensity for the first four hops, assuming a radiated power of 10 megawatts from a vertical antenna. It is further assumed that the ionospheric height is 80 kilometers, and that the generally accepted ionospheric parameters are in effect[1]. The relative delay between the various hops in the ground wave will vary with ionospheric height and the echo, at times, may appear between hops. However, the echo can often coincide, or be very close to one of the hops and, as seen from the figure, the magnitude of these skywave signals are many times larger than the expected echo signal. In general, for monitoring sites very close to the transmitter or between the transmitter and the target, one would expect interference from the first hop; while, between about 50 and somewhat over 100 kilometers distance from the transmitter, one would expect the second hop to be the primary interfering signal. At a distance of 200 kilometers from the transmitter, the third hop skywave would be the primary masking signal. This distance corresponds

---

[1] The figure was derived from Figure 7 of NBS Report 5019, "Multiple Reflections Between the Earth and the Ionosphere in VLF Propagation," James R. Wait and Anabeth Murphy.

approximately to the distance to the Aero Geo Astro site. By comparing the echo return amplitude to the respective skywave amplitude it is found that the Miami site shows about a 10 db improvement over closer sites with the possible exception of those located quite close to the transmitter. These locations could take advantage of the transmitting pattern effect of the monopole antenna. This effect is seen in Figure 3 as reduced intensities at very short distances from the source.

III. MEDIUM AND LONG RANGE DETECTION EXPERIMENTS

The Aero Geo Astro Corporation operates two long-range VLF bi-static stations. The first station, at Boulder, Colorado, uses the station NPG (18.6 Kc located near Seattle, Washington) as a transmitter for monitoring missile launches at White Sands Proving Grounds (500-mile range) and the Atlantic Missile Range (1600-mile range), and uses station NSS (22.3 Kc located near Annapolis, Maryland) as the illuminator for viewing Pacific Missile Range launches (1000-mile range). The second station is located at Patuxent, Maryland, and is used for medium-range detection of launches at Atlantic Missile Range (700 miles), for long-range detection of launches at Pacific Missile Range (2500-miles) and for White Sands launches (approximately 1500 miles). The station NSS was used as a transmitting source for the measurements described in this report. The operation of the Patuxent station is somewhat unique in that it allows test by test correlation with an HF backscatter radar also situated at the same location. From time to time, very striking correlations have been obtained from these two radars.

A. Monitoring System

The bi-static radar systems used for the medium and long-range experiments are quite similar to the type described above for the short-range experiments. A simplified description is as follows:

> "The VLF pulse from a station is picked up on a reference loop antenna and is delayed in a sonic delay line system an amount equal to the round-trip propagation time to the target. This delayed pulse is used as the reference signal for the RF correlator which consists of a synchronous detector and an integrator. The backscattered energy is picked up on a signal antenna which is currently either a loop or loop-monopole combination (cardioid pattern). This signal is passed through an elementary atmospheric noise reduction circuit and then fed to the correlator. The output of the correlator is recorded on a paper chart recorder. Both the delayed reference channel and the signal channel are gated off for the duration of the station's transmitted pulse. This gating, or blanking, prevents the system from correlating on that portion of the direct transmit pulse that is received on the signal antenna.

B. Calibration

The first step in the calibration procedure is to measure the station field intensity at the site. The measurement also serves to indicate any abnormal attenuation conditions that may be present. Next, the signal antenna is rotated so that the maximum of the pattern is in the direction of the station. A calibrated attenuator is inserted into the signal channel and the deflection on the paper chart record is correlated with the field intensity. The radars are calibrated by using both CW transmission and typical pulse code signals. The calibration is generally indicated in db relative to a CW field intensity of 1 microvolt per meter; i.e., a -20 db calibration indicates that a CW signal of 0.1 microvolt per meter produced the indicated deflection. Code transmission requires higher signal field intensities than CW for the same deflection due to the lower duty cycle. At the Boulder site, for example, this factor is typically about 17 db; thus, by knowing the echo field intensity and making use of the VLF bi-static equation (developed in the next section), one can calculate the backscatter cross section. In the various calculations, the attenuation coefficient is assumed to be 2 db per 1000 kilometers unless otherwise indicated. The backscatter cross sections thus calculated generally have ranged between 10^6 and $4 \times 10^8 m^2$.

C. VLF Bi-Static Radar Equation

Wait[1] has shown that the vertical electric field at great distances can be represented by

$$Ed = \frac{0.4 \, E_o \times 10^{-Ad/2 \times 10^4}}{\sqrt{f} \; \sqrt{a \sin d/a}} \qquad (6)$$

where d is in kilometers, a is the earth's radius in kilometers, f is in kilocycles, A is the attenuation factor in db per 1,000 kilometers, and E_o is the effective radiated field at 1 mile from the source. Making use of the expression for the field at 1 mile from a short vertical antenna

$$E_o = 5.9 \times 10^{-3} \sqrt{Pr} \quad \text{volts/meter} \qquad (7)$$

where P is the radiated power in watts, the power density p at the range d_1 can be found from

$$p = E_d^{\,2}/120\pi \qquad (8)$$

---

1 "Mode Theory of VLF Propagation," J. R. Wait, June 1957, IRE, pg.760

Assuming that the power density on the trail is uniform and the same as on the ground, we find that the power reflected by the trail is

$$P_t = P_{d1}\sigma \quad \text{watts} \tag{9}$$

where σ is the backscatter cross section of the trail in square meters. Next, treating the trail reflection as a re-radiation, we can find the receiver power density at a range d_2. Since the atmospheric noise data is generally given in field intensity, we make use of equation (6) to find the field intensity at the radar receiver.

$$E_{d_2} = 5.9 \times 10^{-3} \times 4\sqrt{P_t} \; \times 10^{\frac{-Ad_2}{2\times 10^4}} \; v/m$$

$$= \frac{0.284}{f} \sqrt[?]{\frac{P_1\sigma}{a^2 \sin\frac{d_1}{a} \sin\frac{d_2}{a}}} \times 10^{\frac{-A(d_1+d_2)}{2\times 10^4}} \; \mu v/m \tag{10}$$

where f is in kilocycles, a and d in kilometers and σ in square meters.

The attenuation factor A is about 1 db/1000 km for sea paths and about 2 or 3 db/1000 km for land paths. For ice caps, it may be as high as 10 db/1000 km. Equation (10) may be represented in db relative to a microvolt per meter by the following:

$$E(db) = 20 \log \frac{0.284}{f} + 10 \log P\sigma - 10 \log a^2 \sin\frac{d_1}{a} \sin\frac{d_2}{a} - \frac{A(d_1+d_2)}{10^3} \tag{11}$$

IV. DATA

The data is presented on a test-to-test basis with the results from all of the sites being discussed together. In addition to tests occurring during the period of the Miami operation, other selected data have been included in order to give a more complete picture of the status of the VLF research. The geophysical background at the time of the event is given for most of the tests. Meteor shower data are obtained from the Handbook of Geophysics and the data on aurora, solar radio noise bursts, magnetic storms, sudden enhancements and sudden cosmic noise absorption are obtained from the Preliminary Reports of Solar Activity by the High Altitude Observatory, University of Colorado.

In addition to the ICBM and IRBM launches, some smaller missiles in which burnout occurs before the vehicle reaches the D layer were detected. This type of signature is apparently caused by the shock wave associated with the missile body perturbing the D layer as it passes through. A discussion of a much larger number of tests may be found in earlier reports[1].

V. PACIFIC MISSILE RANGE TESTS

Two Pacific Missile Range test results have been included in this report to show examples of long range (2500-miles) detections.

Test. No. 1053. This was a Discoverer launch on 18 February 1961. The trajectory is shown in Figure 5. This launch was detected at the Patuxent site using NSS as the source. The signature is shown in Figure 6. The station was off the air from a few minutes before T_0 to about T_0 + 2 minutes. The signature appears to begin at about T_0 + 2-1/2 minutes and reaches a first peak at around 3 minutes. The calculated cross section for this first portion is about $2 \times 10^6 m^2$. There is a larger rise beginning at about +4 minutes. This time coincides closely to the Agena ignition; however, this is most probably a coincidence. The cross section corresponding to this peak is about $6 \times 10^7 m^2$. Only one channel was available at this time so that the decreasing signal beginning at about +7 minutes does not necessarily inidcate the decay rate of the perturbation but could represent a drift in the reflecting area.

Test No. 1054
Vehicle: Discoverer
Launch: 2034:43Z; 30 March 1961
Geophysical Background: The geophysical conditions within several hours of this test were quite calm with no meteor showers, flares, solar noise bursts or magnetic storms. The mean Belvoir magnetic A index for March 30 was 10
Results: The conventional type of signature is shown in Figure 7, and Figure 8 for the Boulder and Patuxent sites respectively. The onset of the signature began at about +2 minutes at Patuxent and at about +2-1/2 minutes at Boulder. The difference in onset time between these two stations is attributed to a relative phase difference between the two stations. At this time, both stations lacked a quadrature channel. The sharp onset of the signature is followed by a slowly oscillating type of record. This indicates a drifting in range of the reflection point. The drift velocity component in line with the radars is roughly 30 miles per hour. The scatter is still visible on the record out to the end at about +35 minutes. The scatter cross sections for these figures were calculated using the VLF radar equation with an assumed transmitter power of 200 kilowatts at an attenuation factor of 2 db per 1000 kilometers. The sigma for Boulder is $2.5 \times 10^8 m^2$ and that for Patuxent is $4 \times 10^8 m^2$.

---

1 "Missile Monitoring Program," Progress Rpts. 1 April 1961 and 22 August 1961.

SECRET

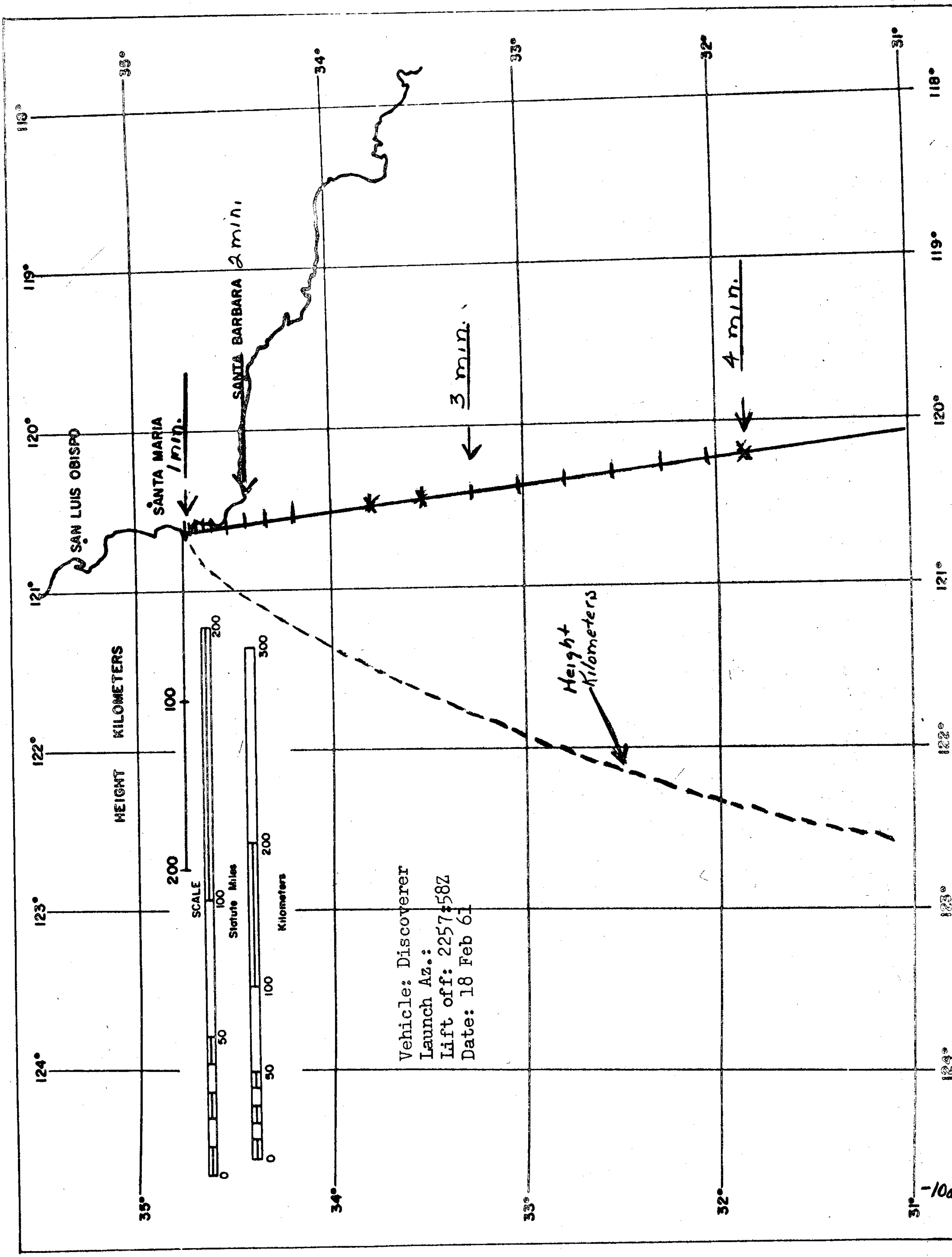
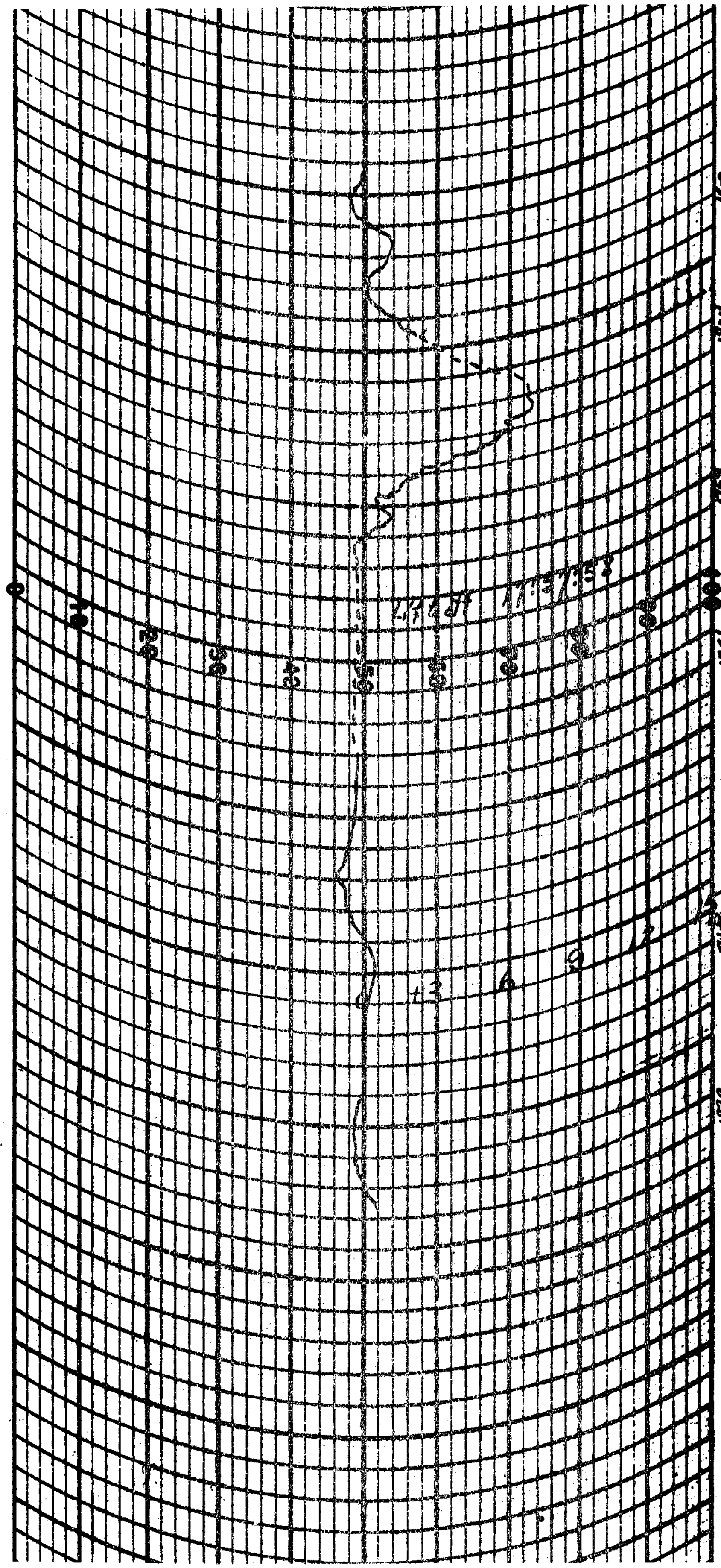


Figure 5. Test No. 1053; Trajectory of Discoverer Launched from PMR

-10a-

SECRET



G.6 - 1053 - PATUXENT - 2-18-61

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

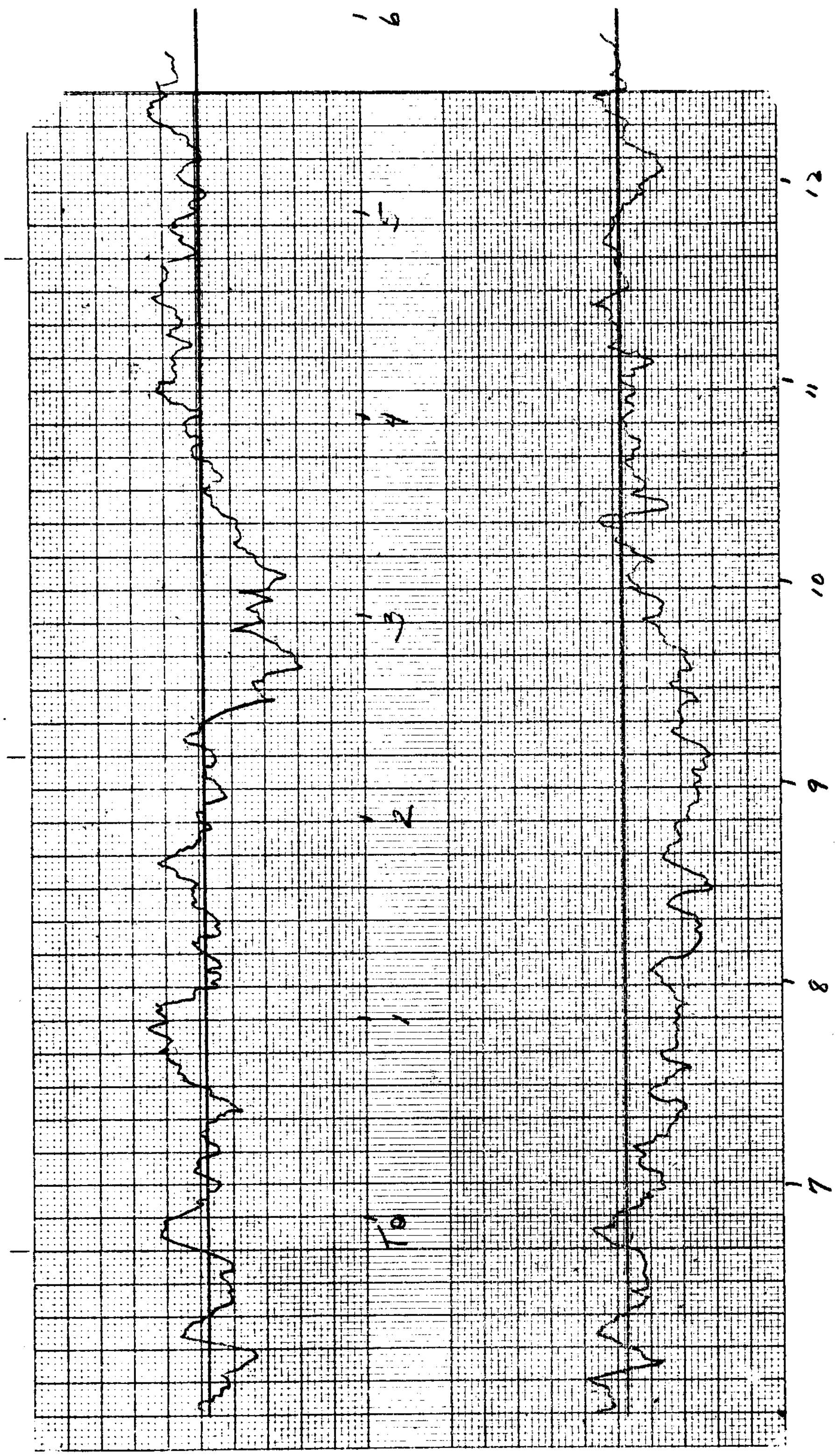


Figure 7. Test No. 1054 - Boulder - 30 March 1961

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

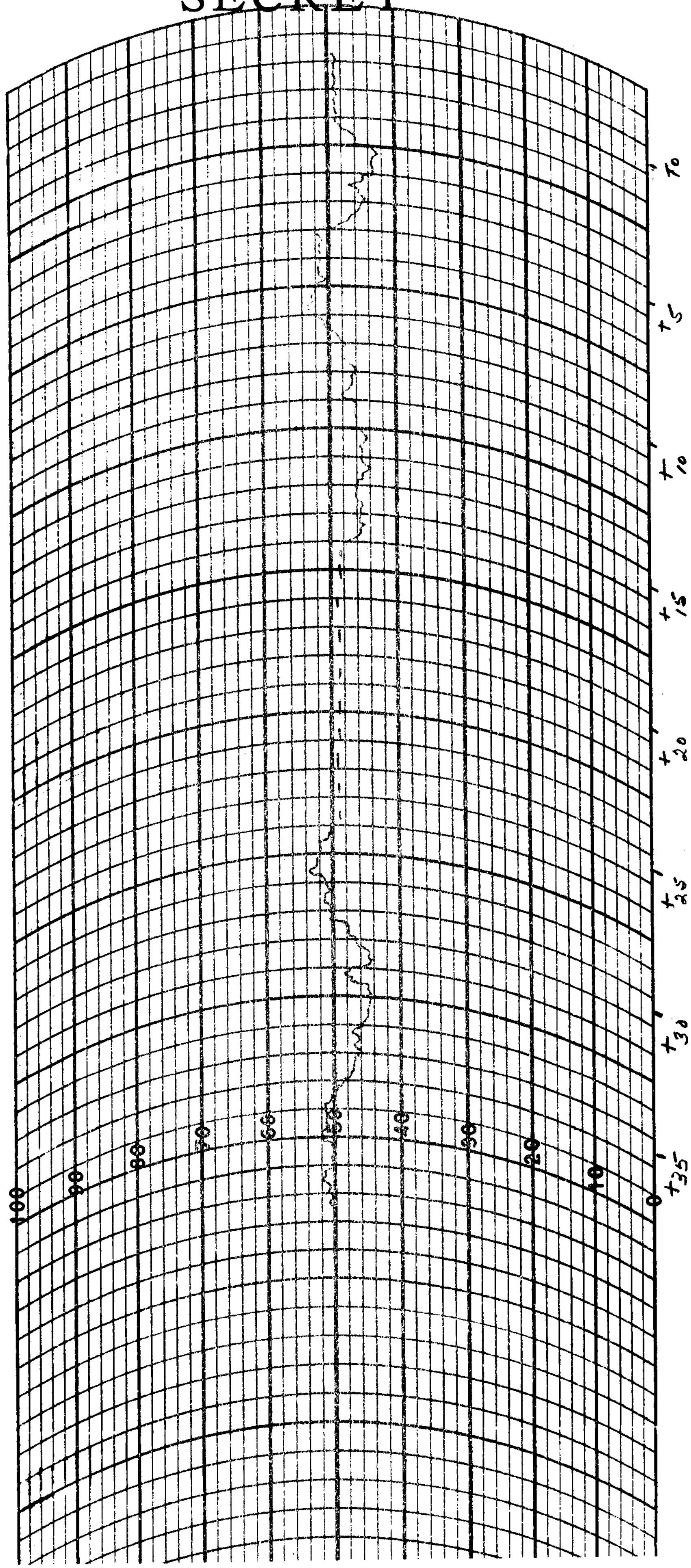


Figure 8. Test No. 1054 - Patuxent - 30 March 1961

VI. ATLANTIC MISSILE RANGE TESTS

Most of the tests reported in this section took place during the Miami monitoring operation; however, some earlier tests of special interest have been included. For example, Test No. 407 shows an hour's test background during which two small flares occurred and Test No. 1263 shows a possible detection in a background of meteor shower clutter.

Test No. 407
Vehicle: Delta IV
Launch: 1517:05Z; 25 March 1961
Geophysical Background: The geophysical conditions were fairly stable with a magnetic index of 5. There were, however, some small solar flares beginning at about 1490Z. The two small flares nearest to test time occurred from 1436 to 1446 with a maximum at 1441, and from 1458 to 1521 with the maximum at 1517. The system was being operated during both of these flares, and no correlation was noted between scatter received and the onset of these flares, although scatter was apparent from the beginning of the recording at about 1425Z.
Results: The trajectory is shown in Figure 9 and the signature in Figure 10. The scatter may be associated with the series of flares mentioned above; however, little change in the scatter level was noted during two flares which appeared during the pre-test recording time. Figure 11 shows the background recording beginning at about -50 minutes. A large signal change occurs sometime between +4 and +6 minutes when the VLF station was off the air. The scatter signal was still clearly evident at +20 minutes when the VLF station went off the air.

Test No. 1352
Vehicle: Polaris
Launch: 1040:52 EST; 11 April 1961
Geophysical Background: The mean magnetic index for April 11 was 16. Conditions were, however, relatively calm at test time although there were some small flares a few hours after the launch.
Results: The Patuxent signature in Figure 12 shows a drifting reflector apparent at about +4 minutes. The reflector may have had its onset earlier but may have been at the incorrect phase to show up in this channel. The scatter signal dropped below the detection level at about +60 minutes.

Test No. 1263
Vehicle: Jupiter
Launch: 1407:19Z; 22 April 1961
Geophysical Background: The mean magnetic index was 6 and there were no solar or magnetic disturbances; however, the edge of the Lyrids meteor shower was within the range gate at the time of the test.
Results: Pre-test scatter is noted on the record, probably arising from the Lyrids shower. Even though the recorder was set on a low gain, Figure 13 shows an abrupt change in level reaching a peak at about +2 minutes. The

SECRET

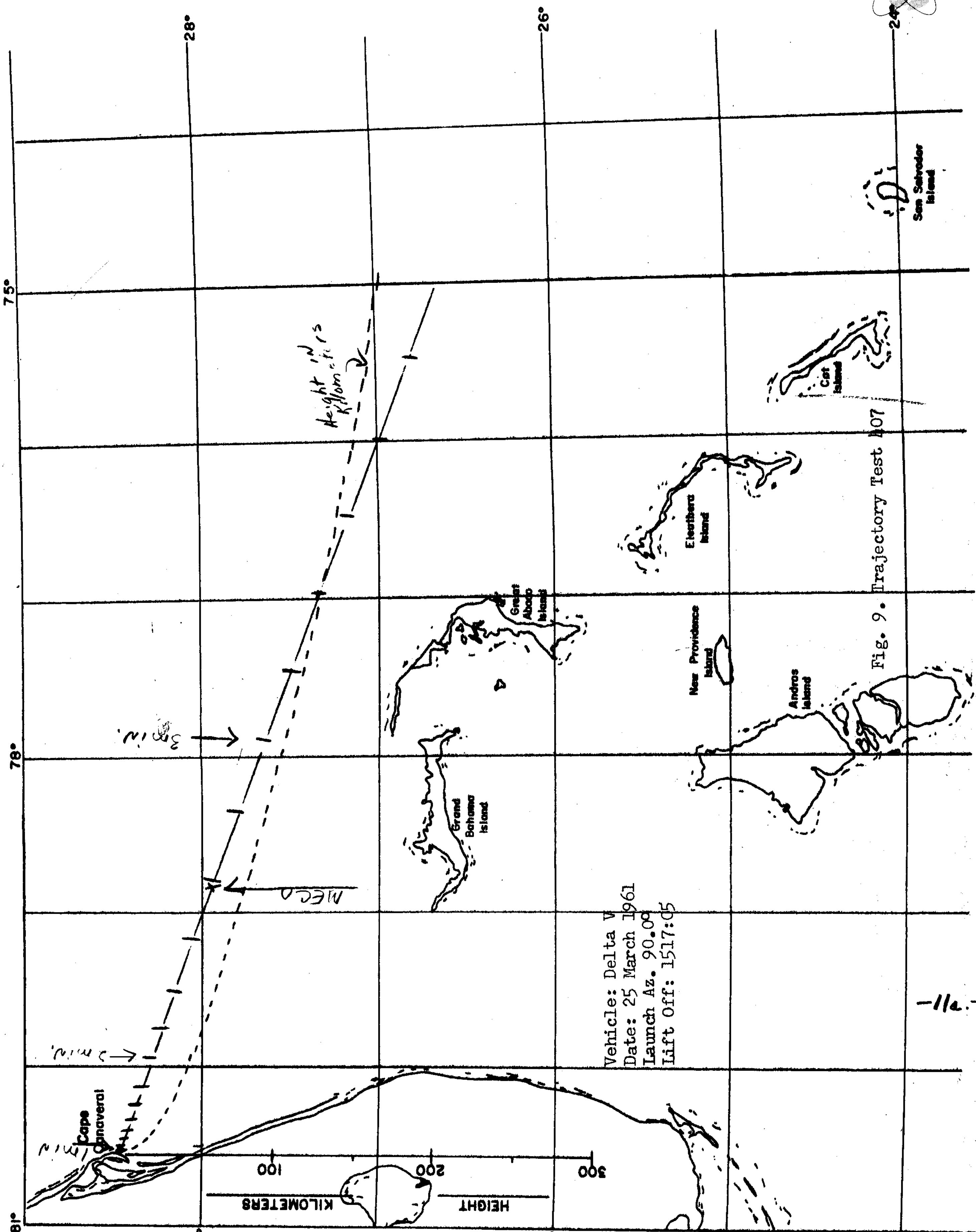


Fig. 9. Trajectory Test 407

SECRET

AGA

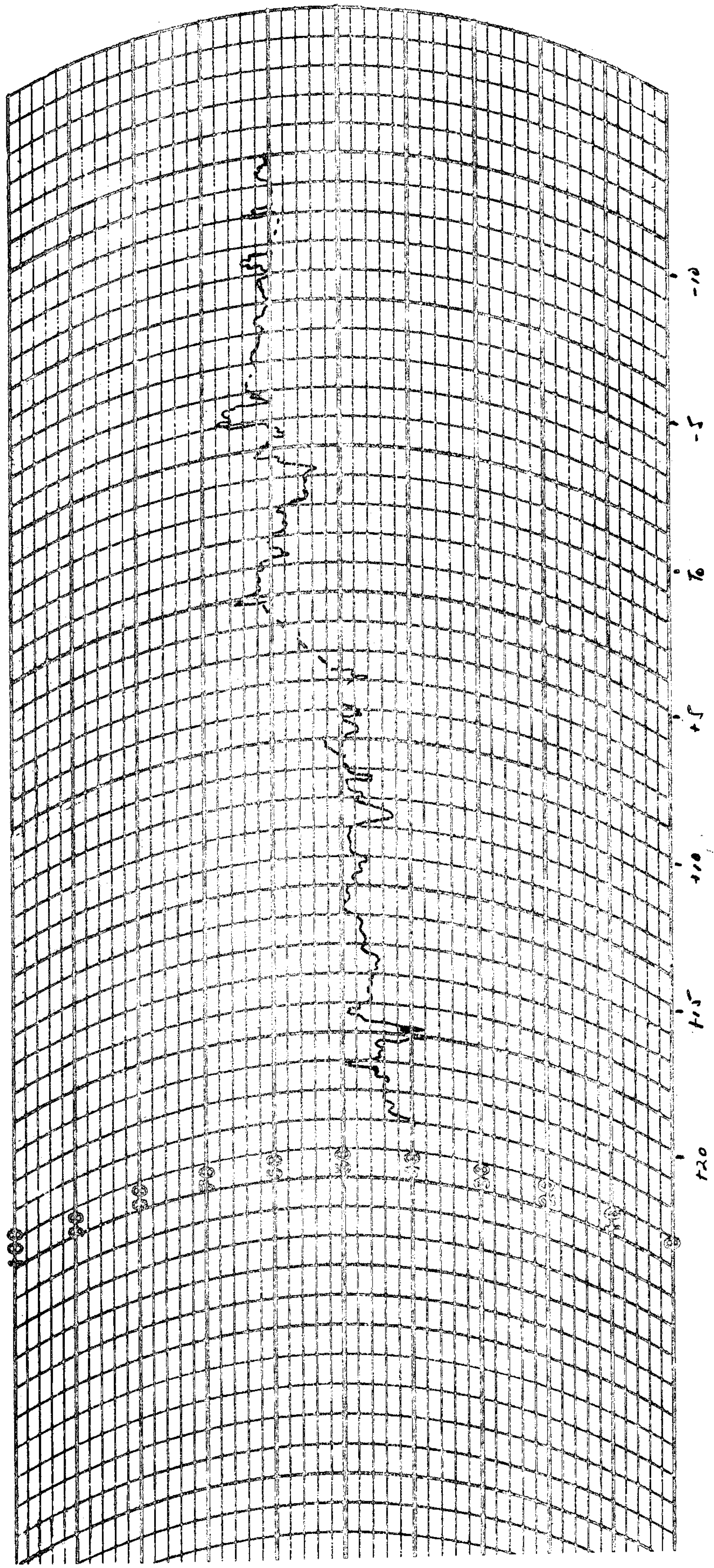


Figure 10. Test No. 407 - Patuxent - 25 March 1961

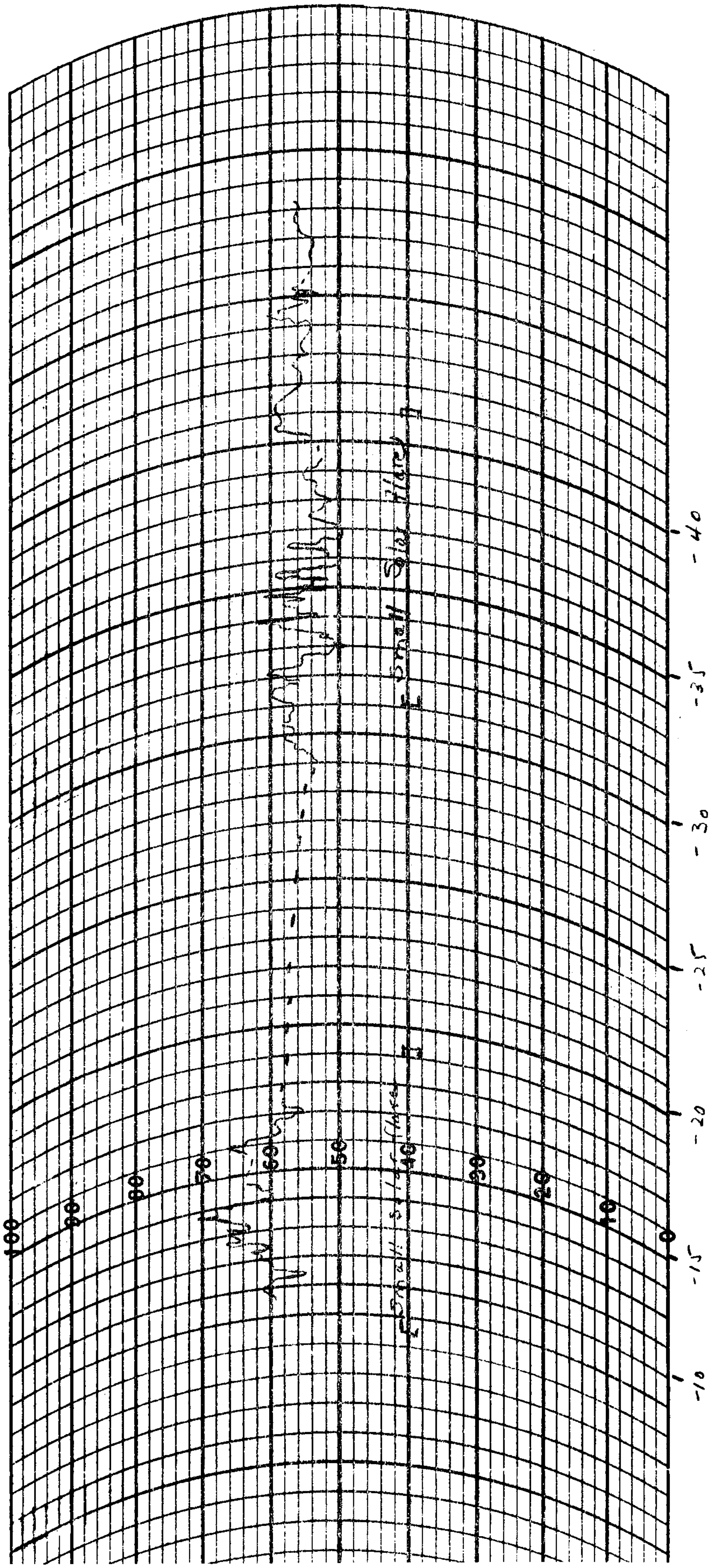


Figure 11. Test No. 407 - Patuxent (Background) 25 March 1961

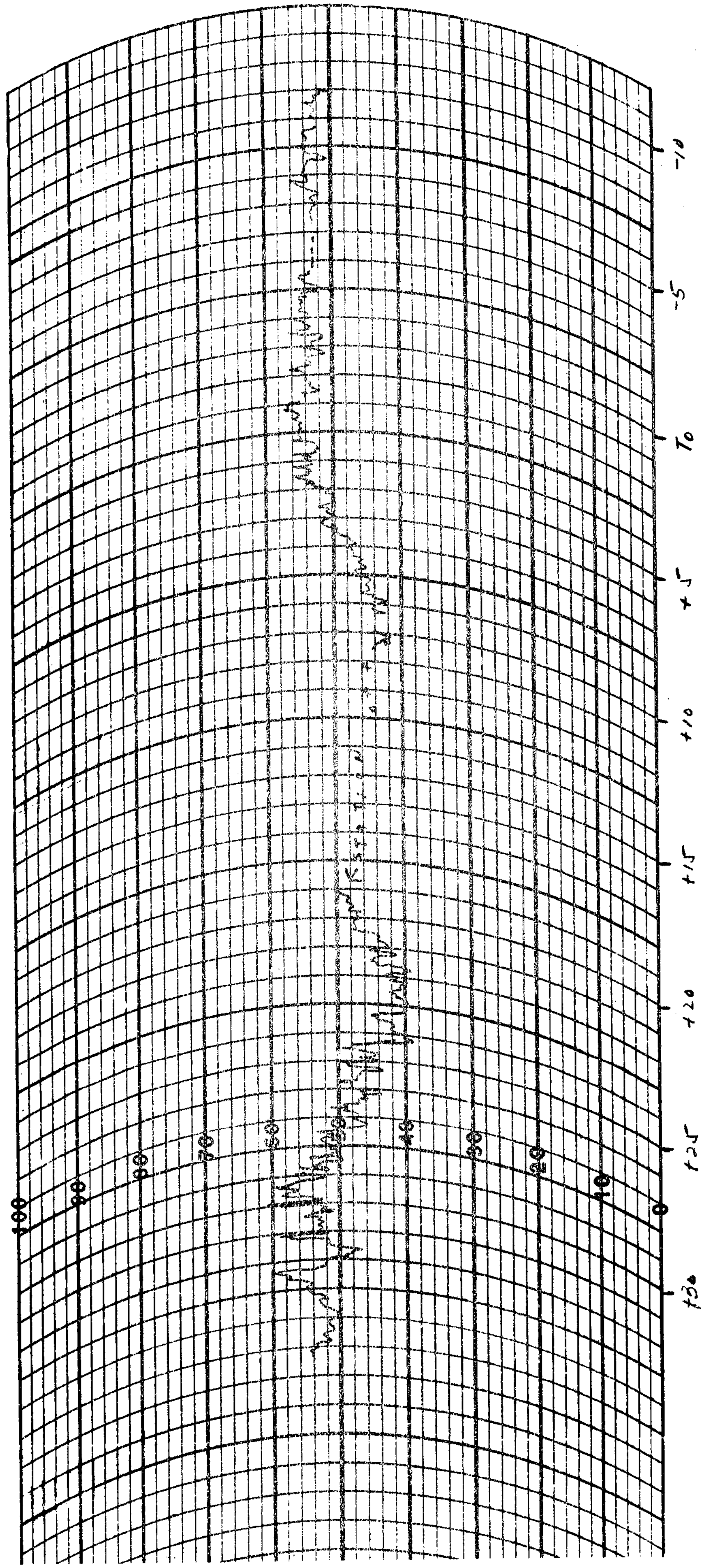


Figure 12. Test No. 1352 - Patuxent - 11 April 1961

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

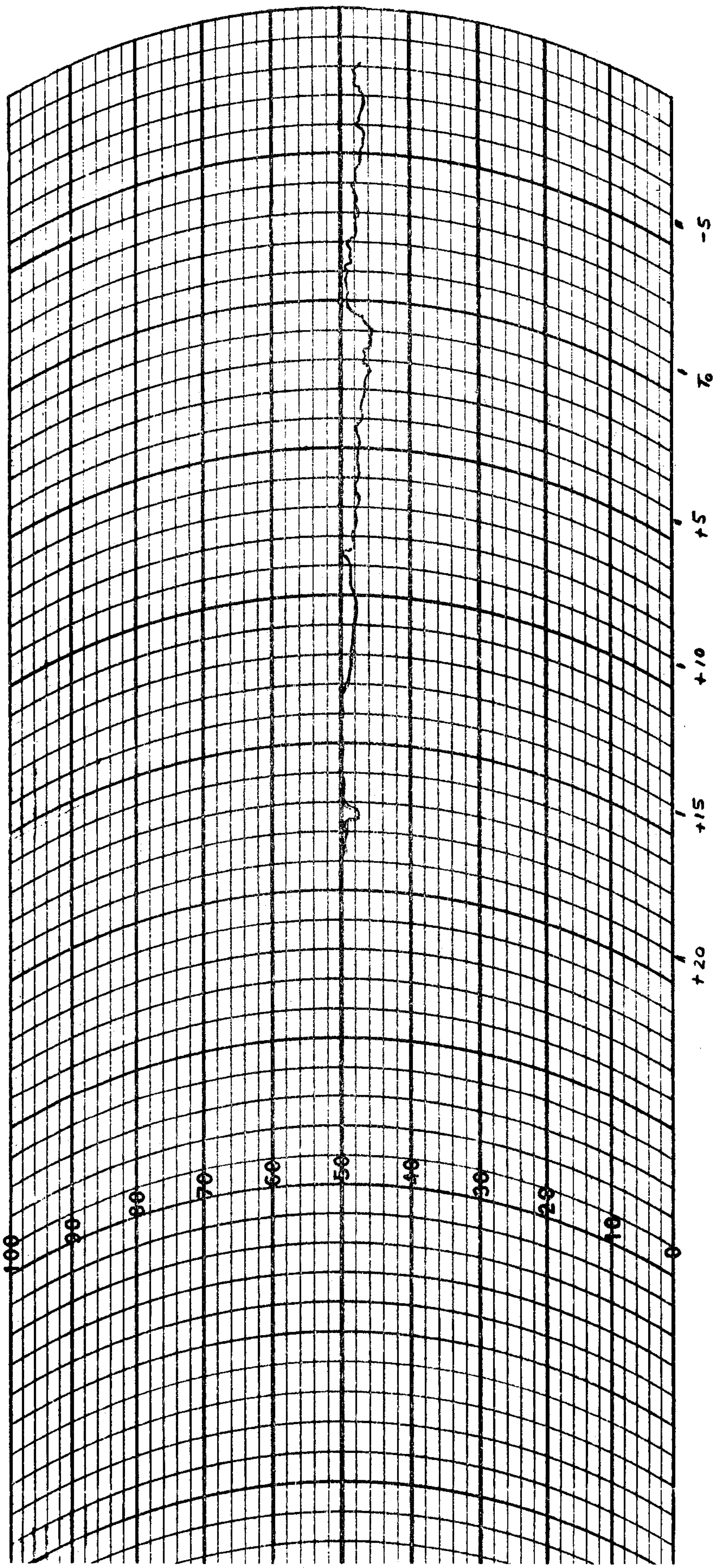


Figure 13. Test No. 1263 - Patuxent - 22 April 1961

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

signature fades into the background scatter at about +15 minutes. This signature is quite interesting as it shows a possible detection in the presence of meteor shower clutter. Meteor showers monitored in the past have not shown the sharp offset type of signature but, in general, have shown a slow oscillatory type of response. Since some missile signatures have been of this type, a multi-gate and multi-station approach should be used for the most reliable detection.

Test No. 0404
Vehicle: Atlas
Launch: 0200:47Z; 12 May 1961
Geophysical Background: The magnetic index for May 12 was a fairly high value of 22, but there were no flares or other disturbances within four hours of the test period.
Results: The Patuxent and Boulder staions were both inoperative for this test. The Miami Licor system obtained a signature, shown in Figure 14. The signature onset was at about +2 minutes corresponding to an altitude of about 60 kilometers. This signature was of very short duration, fading to below the detection level by +4 minutes. Even though the signal was low in amplitude, it was produced by a localized reflector. The experimental range response for this reflector is shown in Figure 15. The ± 10 mile limits on the range response are also shown plotted on the trajectory (Figure 16). It is noticed that the measured range coincides quite well with the trajectory at +2 minutes. In a short range Licor system, an estimate of the target cross section may be obtained by calibrating the system relative to the atmospheric noise power density. Thus, on Test 404, the reflected signal was about 46 db below the received atmospheric noise. If we assume that this noise field is incident upon the perturbation, one then gets a sigma of approximately $10^6 m^2$. This figure assumes that all the incident noise energy contributes to the in-phase reflection. In general, this is not true so that the actual cross section should be somewhat larger than this value.

Test No. 406
Vehicle: Minuteman
Launch: 1418:28Z; 19 May 1961
Geophysical Background: Conditions were stable with a magnetic index of 8.
Results: This test was viewed by the Boulder, Patuxent and Miami radars. The Boulder station had a negative result. The Patuxent station had a weak signature from +3 to +8 minutes which was super-imposed on some fairly bad system drift at this time so that results must be labeled "doubtful". The Miami site achieved a small signal on the 10 Kc Licor system (Figures 17 and 18). The signature began at slightly after +1-1/2 minutes and was visible out to about +6 minutes. Even though the signature was not too large, a good deal of confidence can be placed in the results since the range response peaked at the correct range (Figure 19). The measured range is also shown in the cross-sectioned area on the trajectory (Figure 20). The signal change between about +1/2 minute and +1 minute was shown not to peak in range, and it is therefore assumed not to be a scattered signal but some type of noise burst.

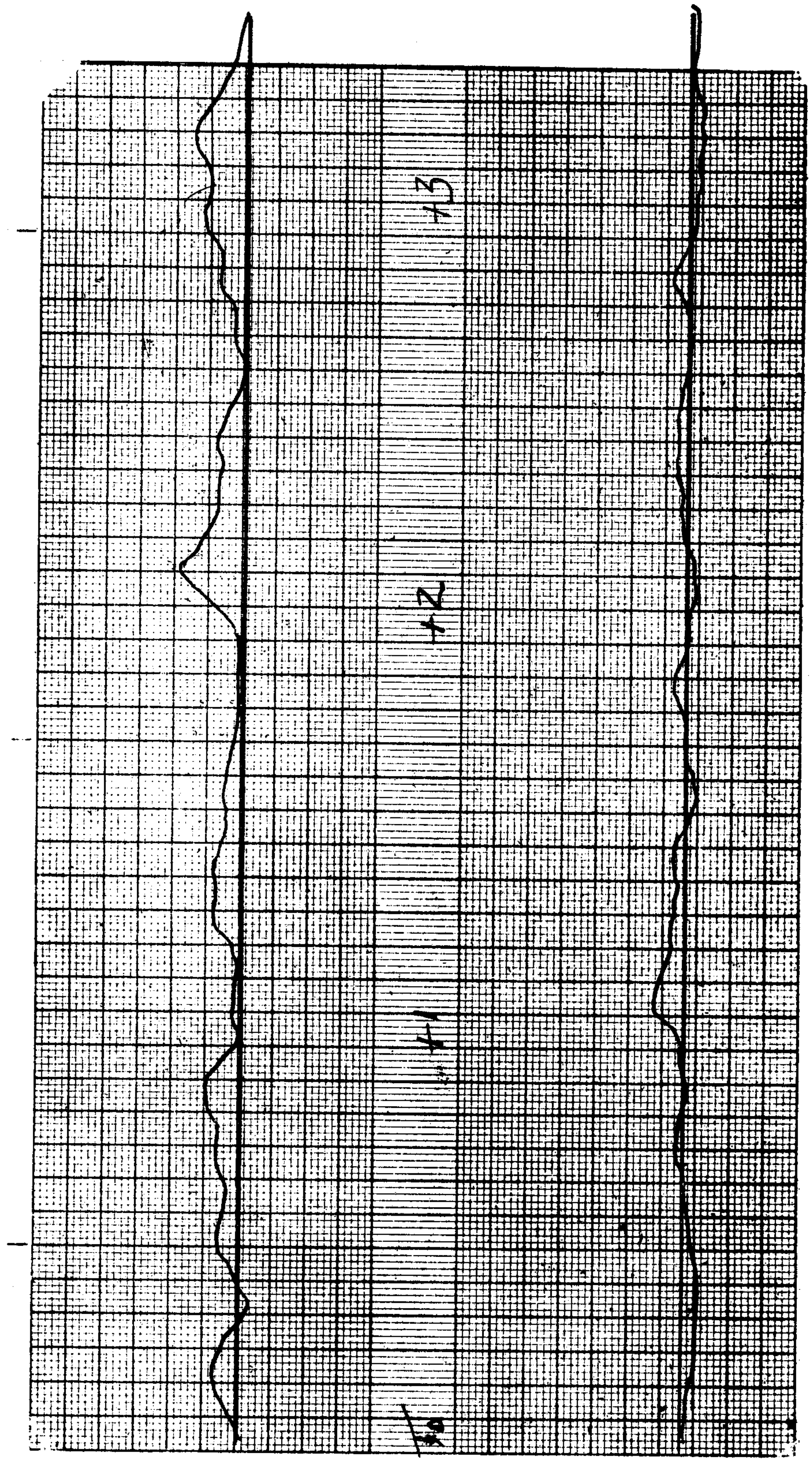


Figure 14. Test 0404 - Miami - 12 May 1961

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

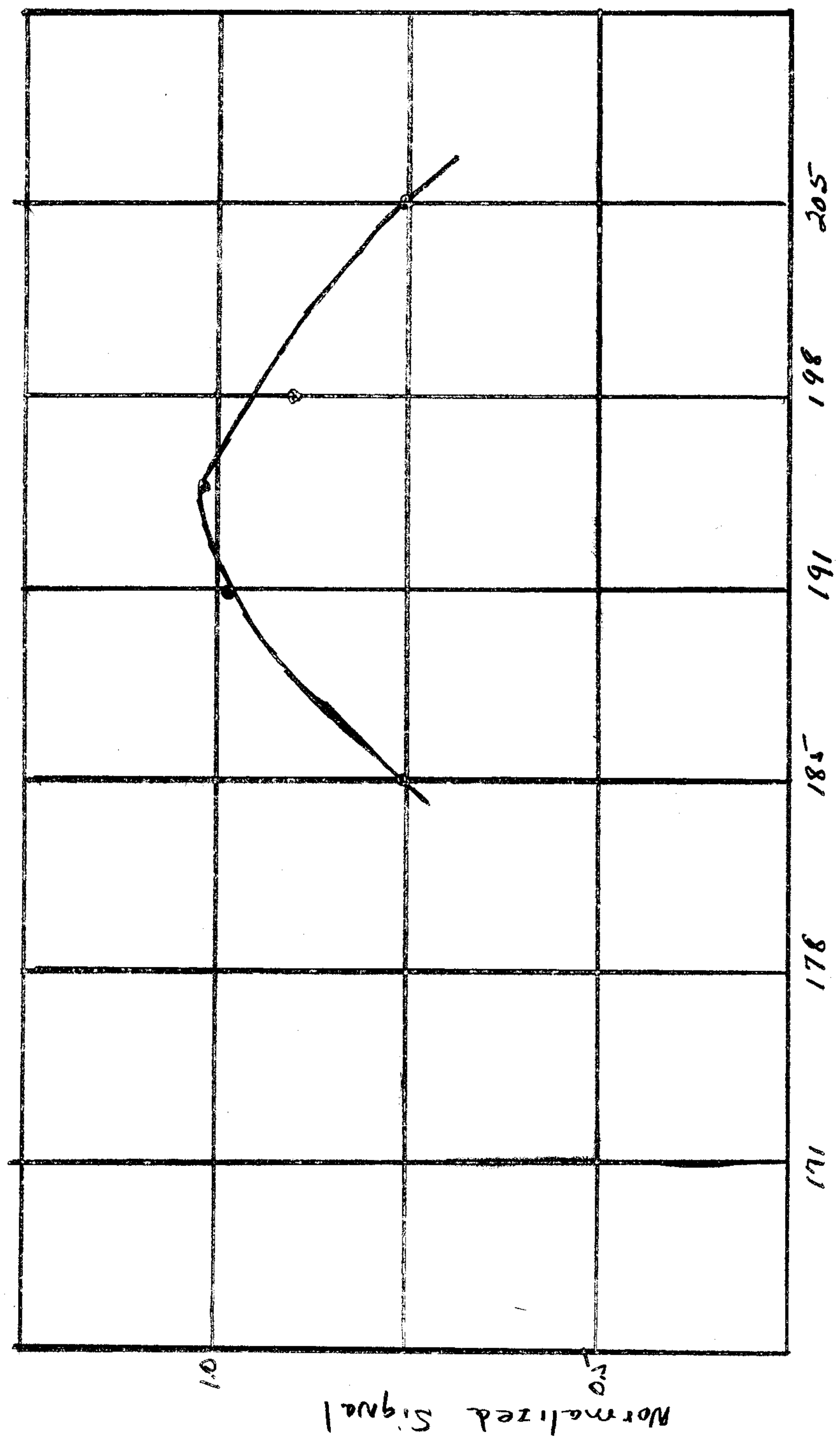


Figure 15. Range Response - Test 404

SECRET

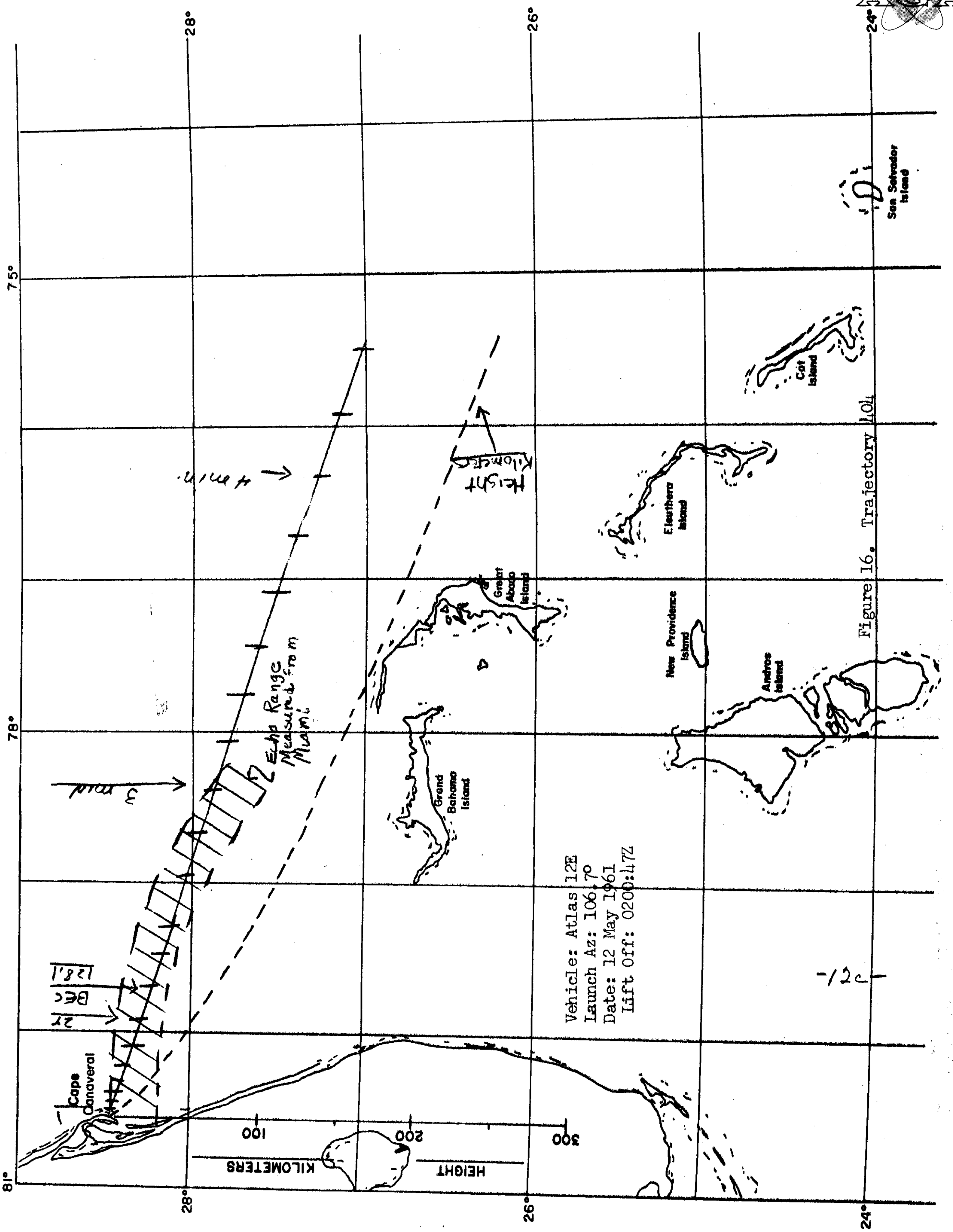


Figure 16. Trajectory 104

SECRET

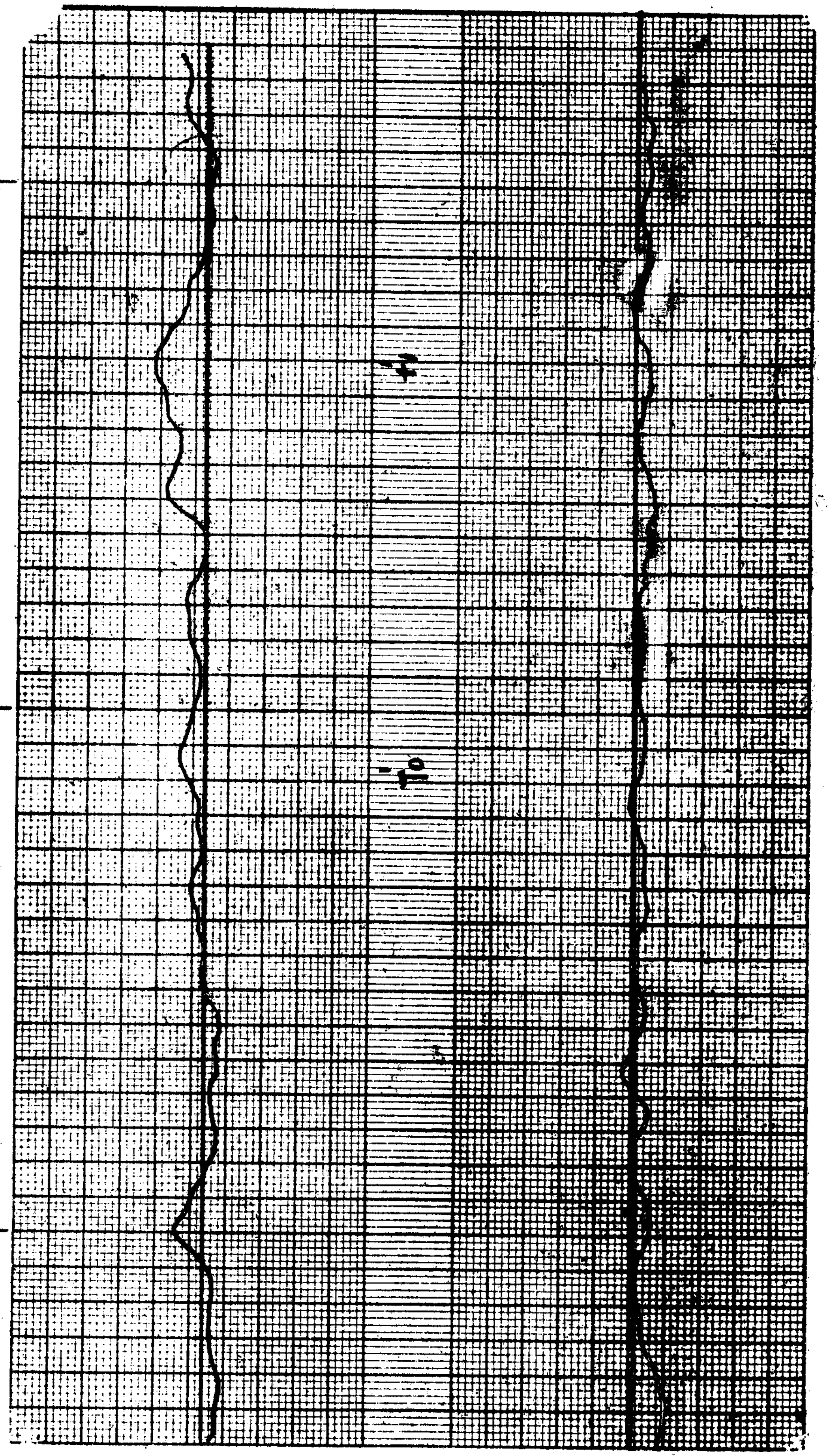


Figure 17. Test No. 0406 - Miami - 19 May 1961 (page 1)

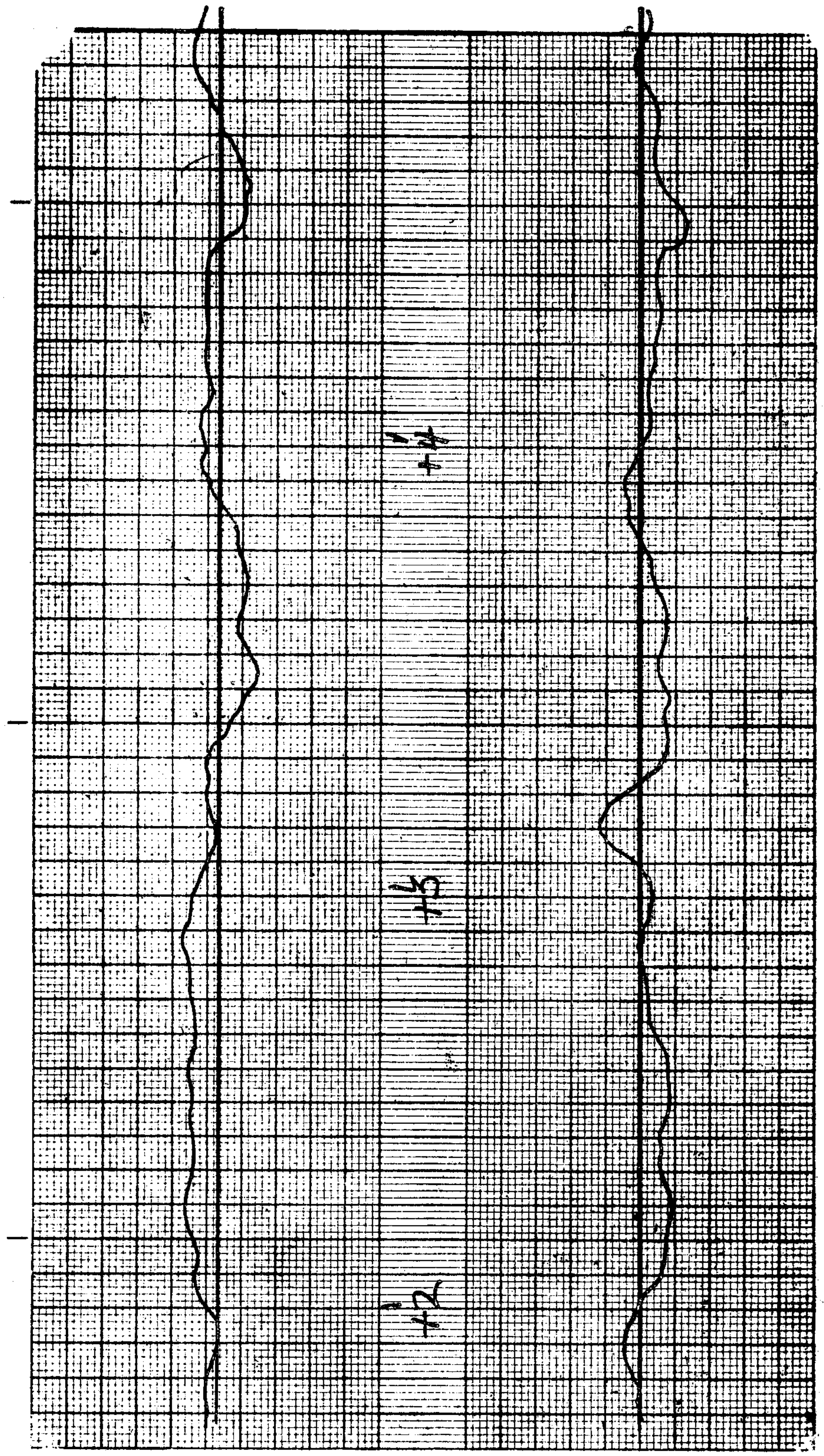


Figure 18. Test No 0406 - Miami - 19 May 1961 (page 2)

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

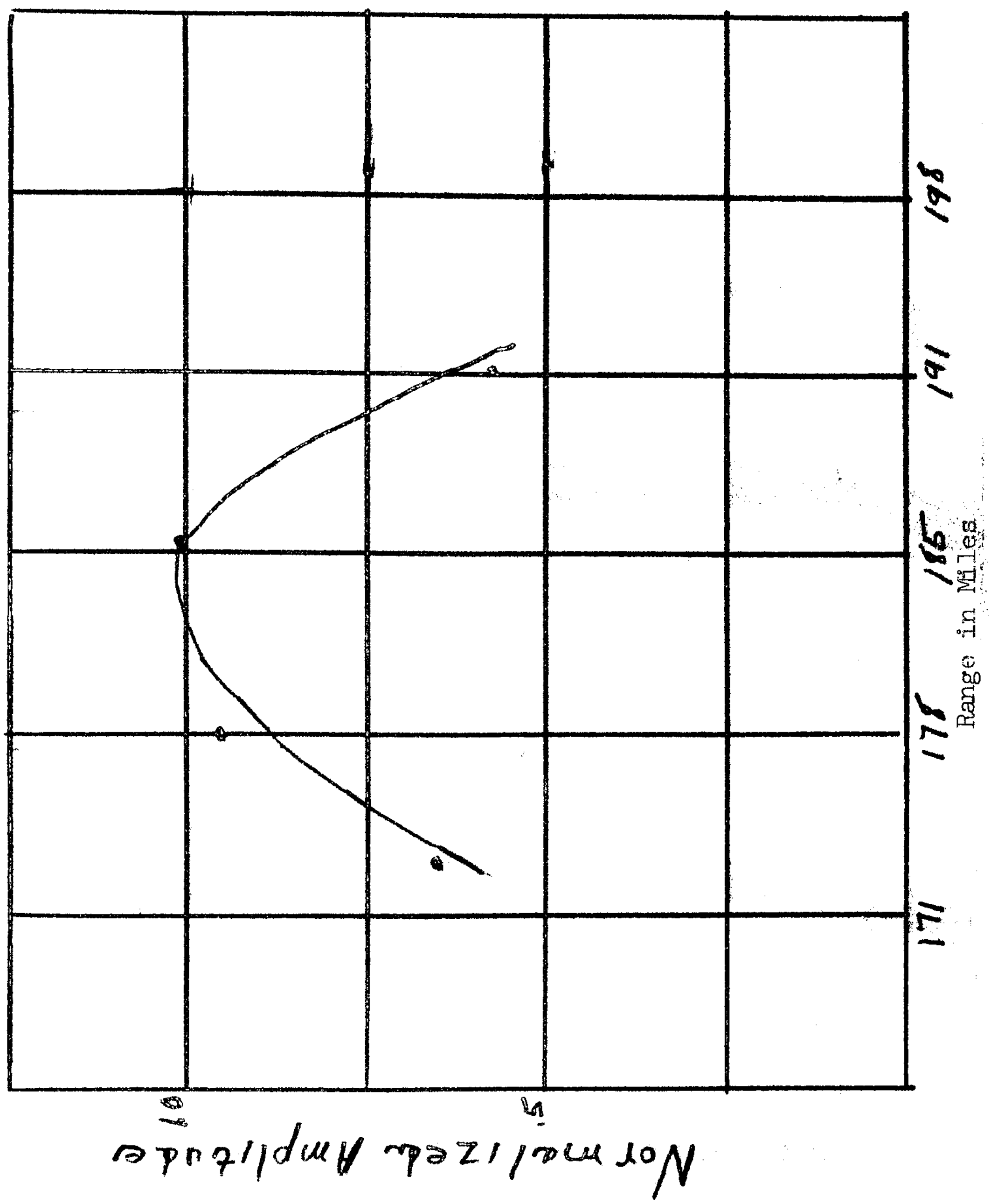


Figure 19. Range Response Test No. 406

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

SECRET

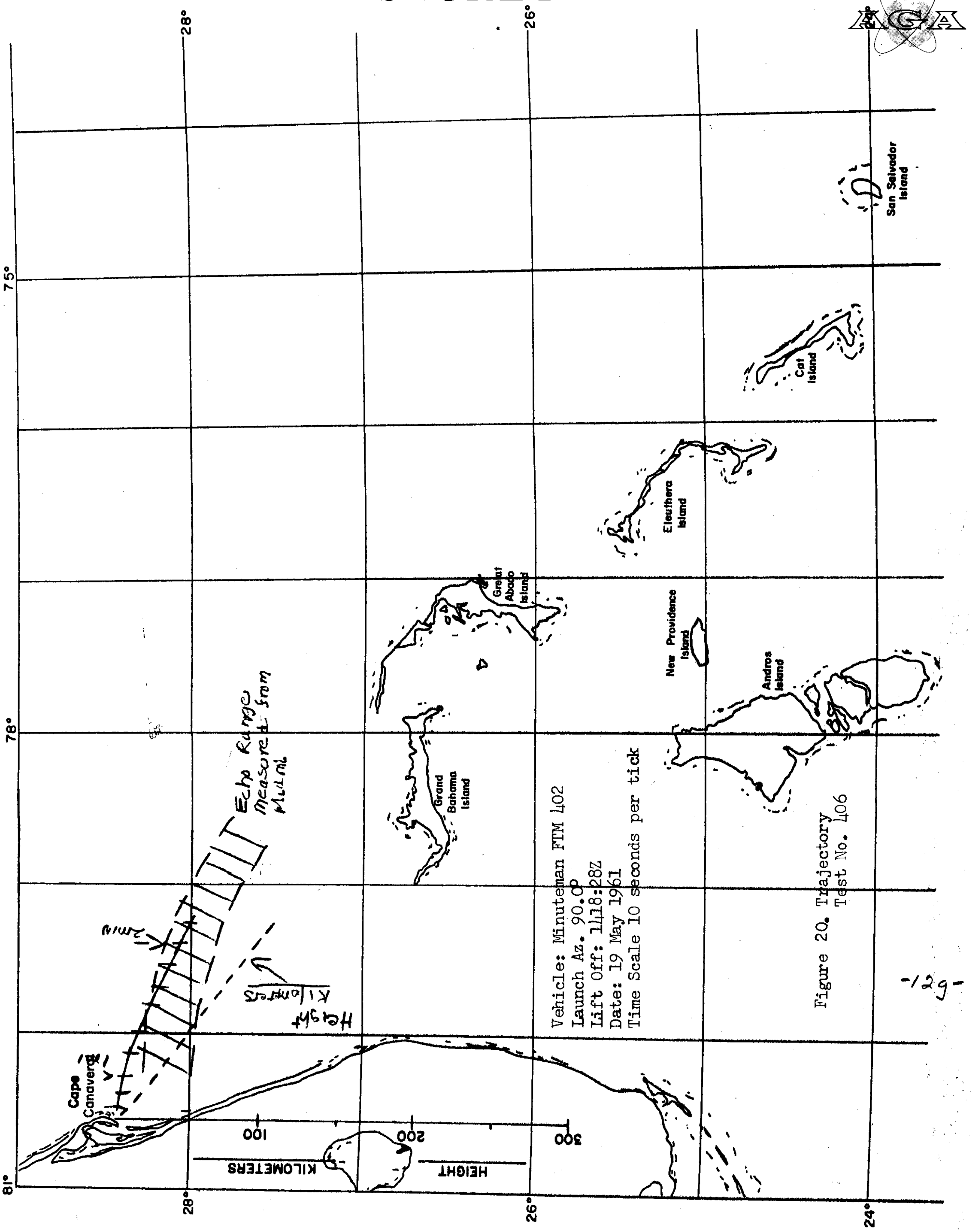


Figure 20. Trajectory Test No. 406

SECRET

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

Test No. 44
Vehicle: Polaris
Launch: 1951:05Z; 25 May 1961 (Terminated at 20 Km altitude)
Geophysical Background: There was a magnetic storm which began at 2300Z on the 24th of May and ended at 0400Z on May 26th. The mean magnetic index for May 25th was 20. There were no solar flares or other disturbances noted.
Results: This launch is of particular interest, since it was detected at all three sites on three separate frequencies: 18.6 Kc for Boulder, 22.3 Kc for Patuxent and 10 Kc for Miami. Figure 21 shows the Boulder signature. There is a clear signal indication at about +3 minutes, with possibly a slightly earlier indication. This signature is approximately 2 minutes after missile termination and may have been caused by the shock wave perturbing from the ionosphere. (At Patuxent, the transmitter was on low duty cycle from -1 to about +1 minute and then off the air until +9 minutes. When the station returns to code transmission, there is clear evidence of a scatter signal. The perturbation is evident to beyond +40 minutes. One-half hour of background data for the Patuxent record is shown in Figure 22, and the signature is shown in Figure 23. The two-channel direct readout signature obtained on the 10 Kc Licor system is shown in Figures 24 and 25. It is noted that the signature begins in the upper channel at about + 3 minutes and shows up clearly in the lower channel at about +4 minutes. The lower channel was inoperative until about +2 minutes due to an open circuit between the integrator and the paper recorder, so this channel does not have a long background indication. The tape recording for this test was not achieved due to technical difficulties; therefore, it cannot be shown that the disturbance peaked up at the correct range. However, the signature is quite clear and did occur with the gate centered at approximately the correct range.

Test No. 105
Vehicle: Polaris
Launch: 1653Z; 12 June 1961
Geophysical Background: The magnetic index was 10 and very minor flares occurred from 1628 to 1640Z and from 1724 to 1732Z. In addition, the edge of the Arietids and Perseids meteor showers were within the range gate at the time of the test.
Results: The two daytime meteor showers mentioned above did not produce the dramatic perturbations of the nighttime meteor showers previously reported; however, there were perturbations appearing between the start of the record at -2 hours and -1 hour which might be attributed to these showers. The station NSS went from its regular code transmission to the low duty cycle (beeping) transmission at about -2 minutes. With this low duty cycle, the gated noise output is too low to see on the record (Figure 26); however, even with this low duty cycle transmission, an offset is noticed beginning at about +1-1/2 minutes. The station goes off the air at +4-1/2 minutes and returns to its code transmission at about +7 minutes. At the Miami site, there was an indication on the 10 Kc Licor system between about +2 and +3 minutes, with a further indication occurring between +5 and +6 minutes. The 25 Kc Licor system showed an indication only between +5 and +6 minutes. The direction-of-arrival gating was not in the system at this time

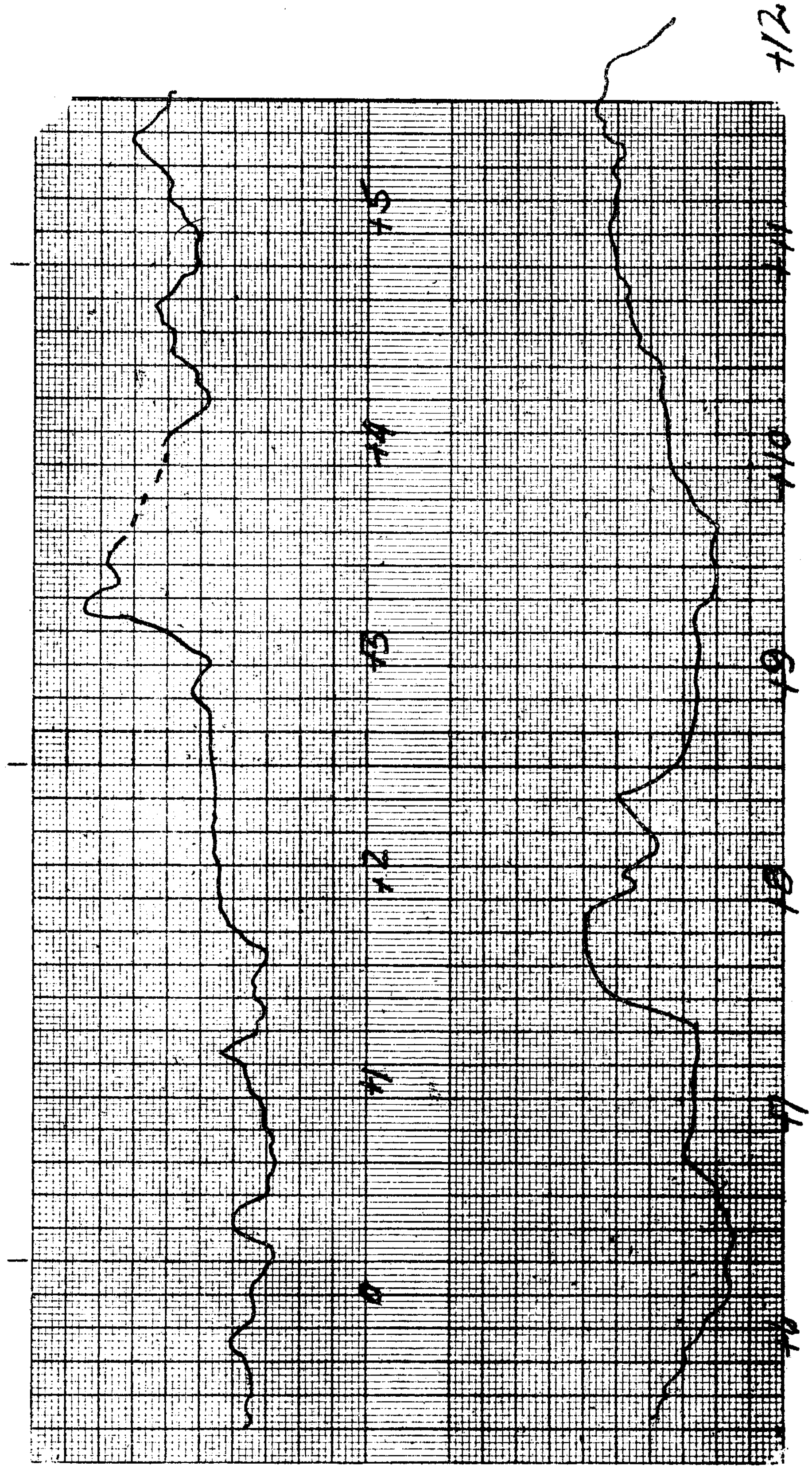


Figure 21. Test 0411 - Boulder - 25 May 1961

SECRET

AGA

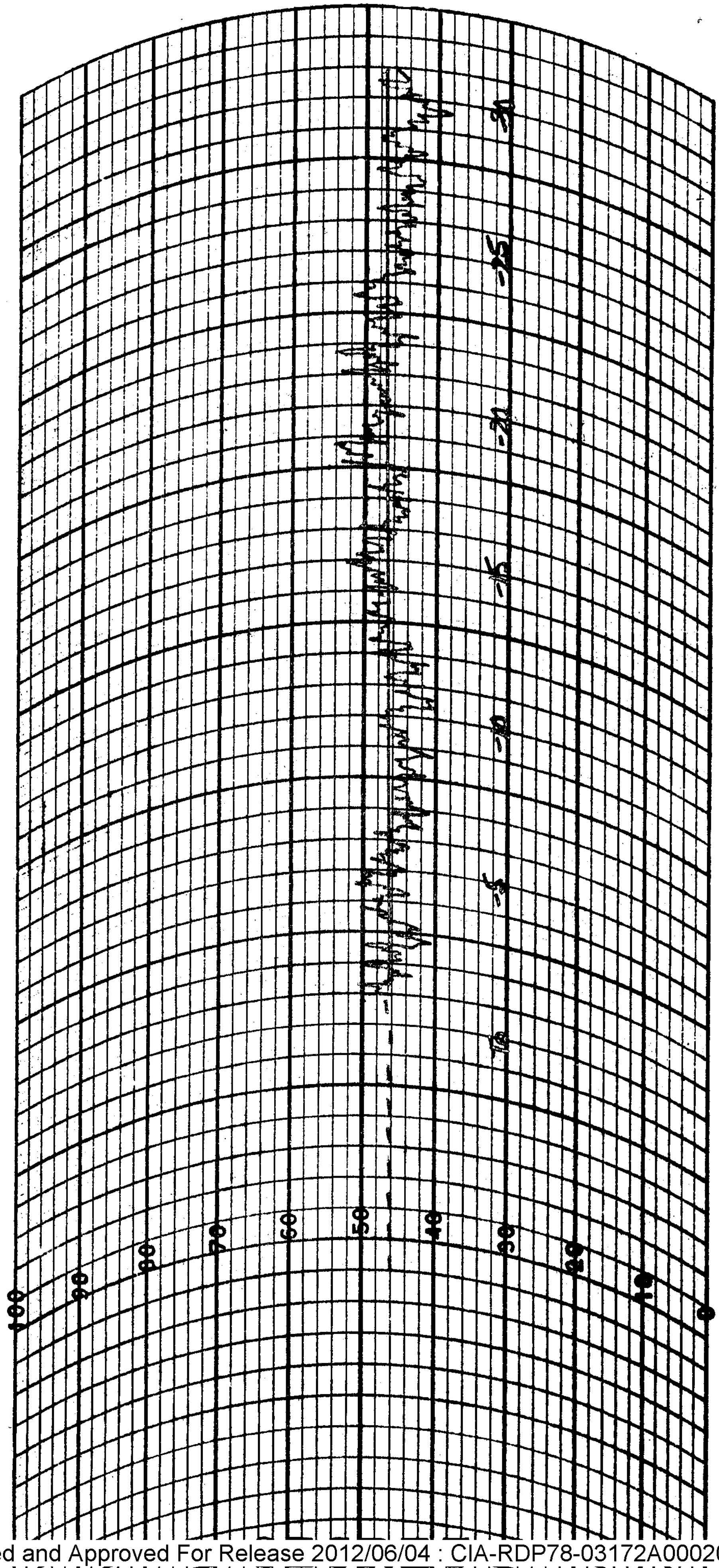


Figure 22. Test 414 - Patuxent - 25 May 1961 - Background

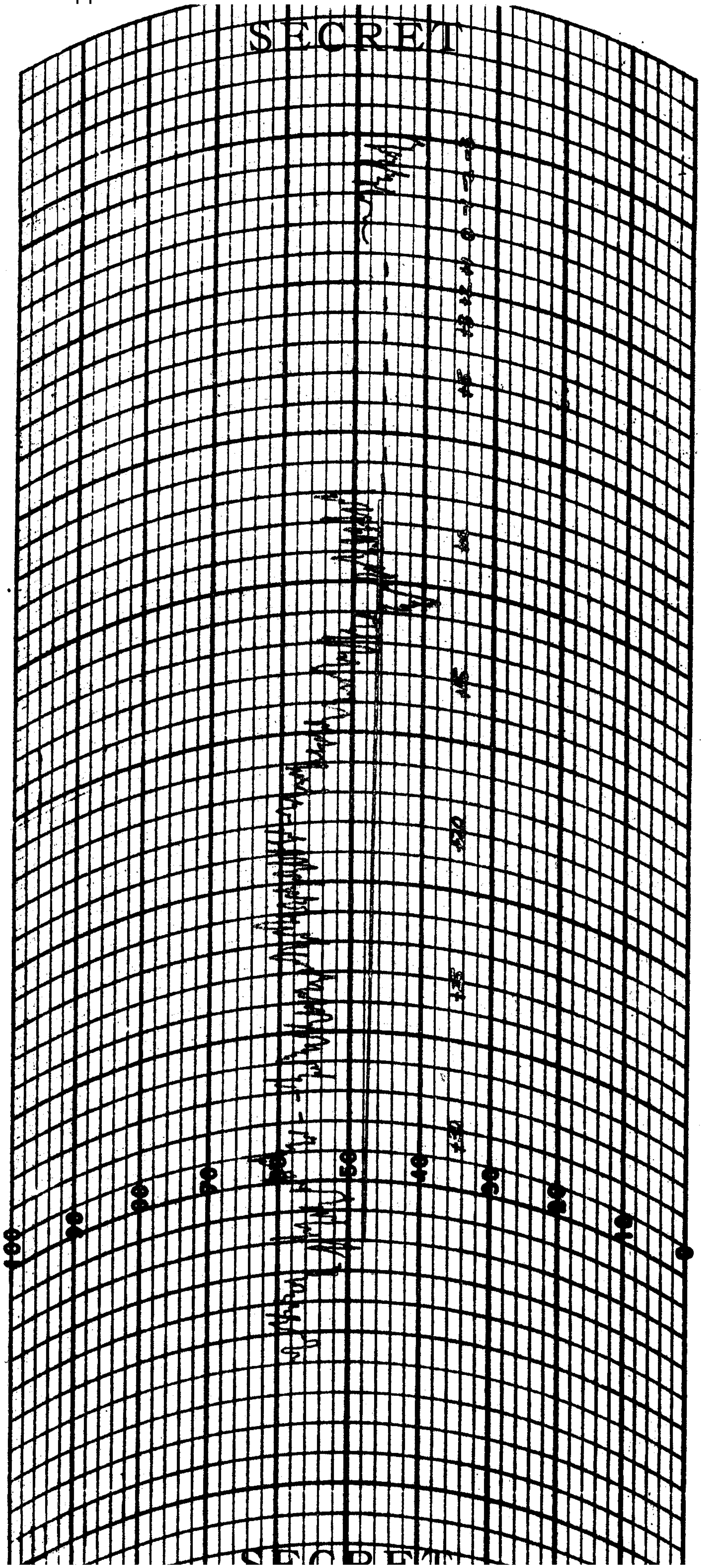


Figure 23. Test 0414 - Patuxent - 25 May 1961

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

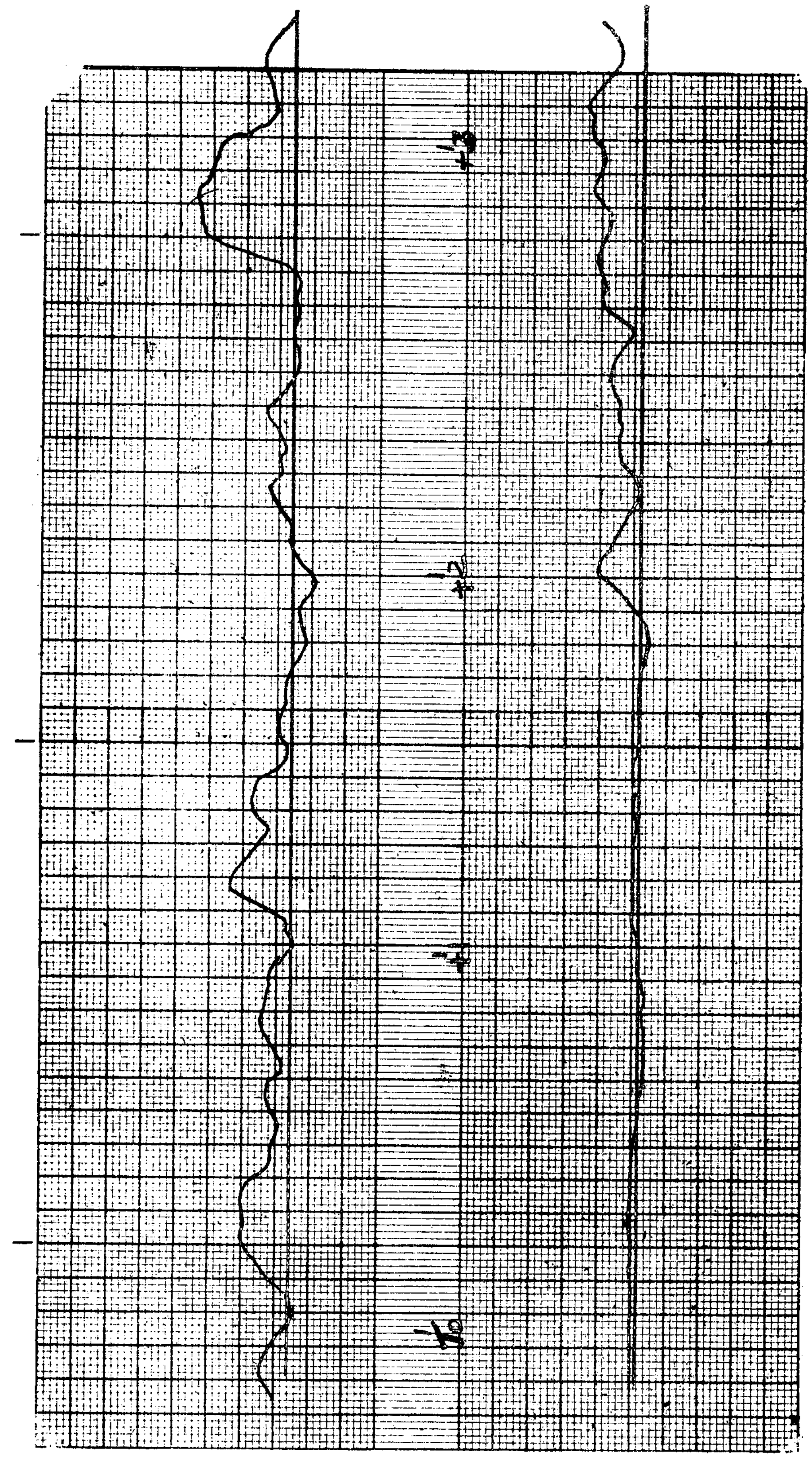


Figure 24. Test 0414 - Miami - 25 May 1961 (page 1)

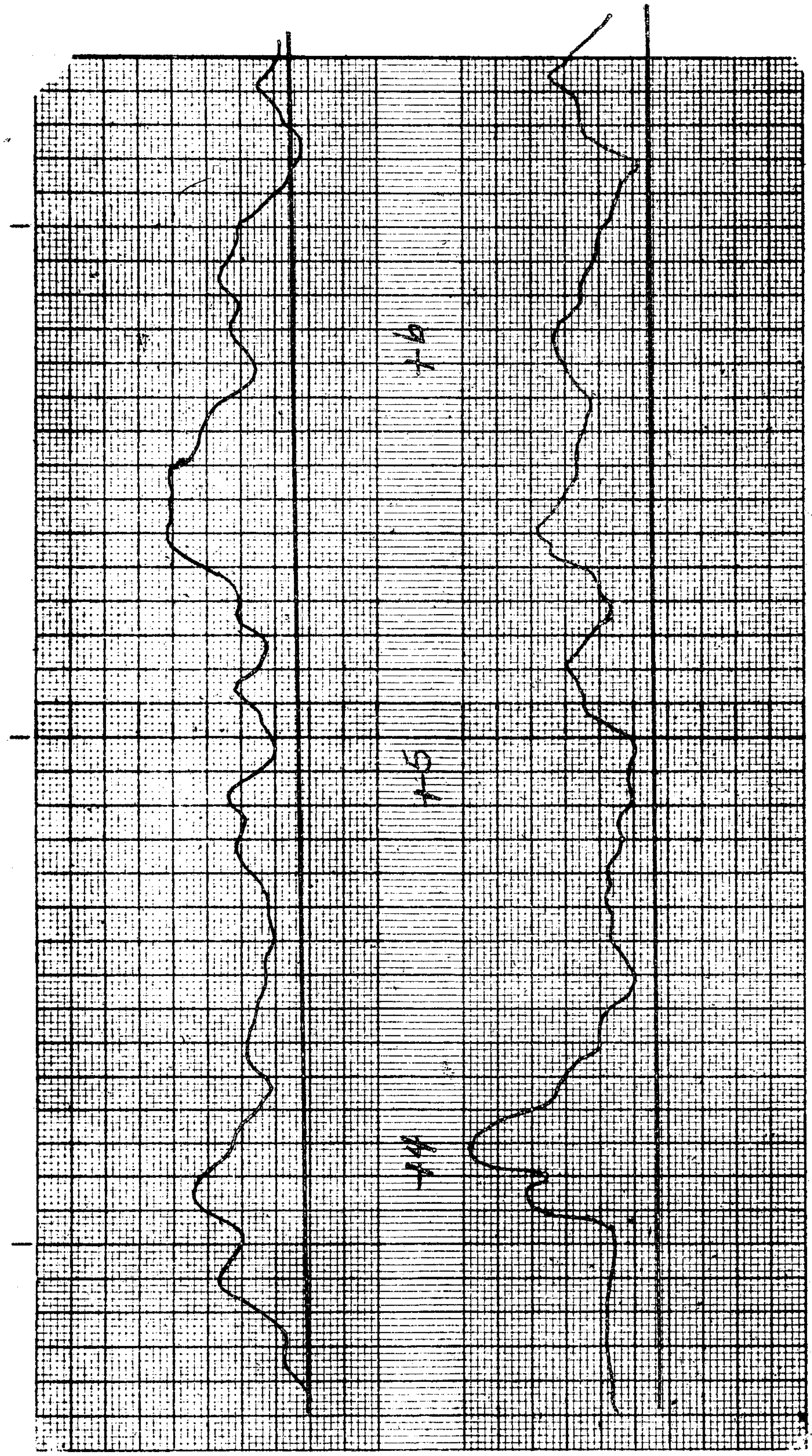


Figure 25. Test 0414 - Miami - 25 May 1961 (page 2)

AGA

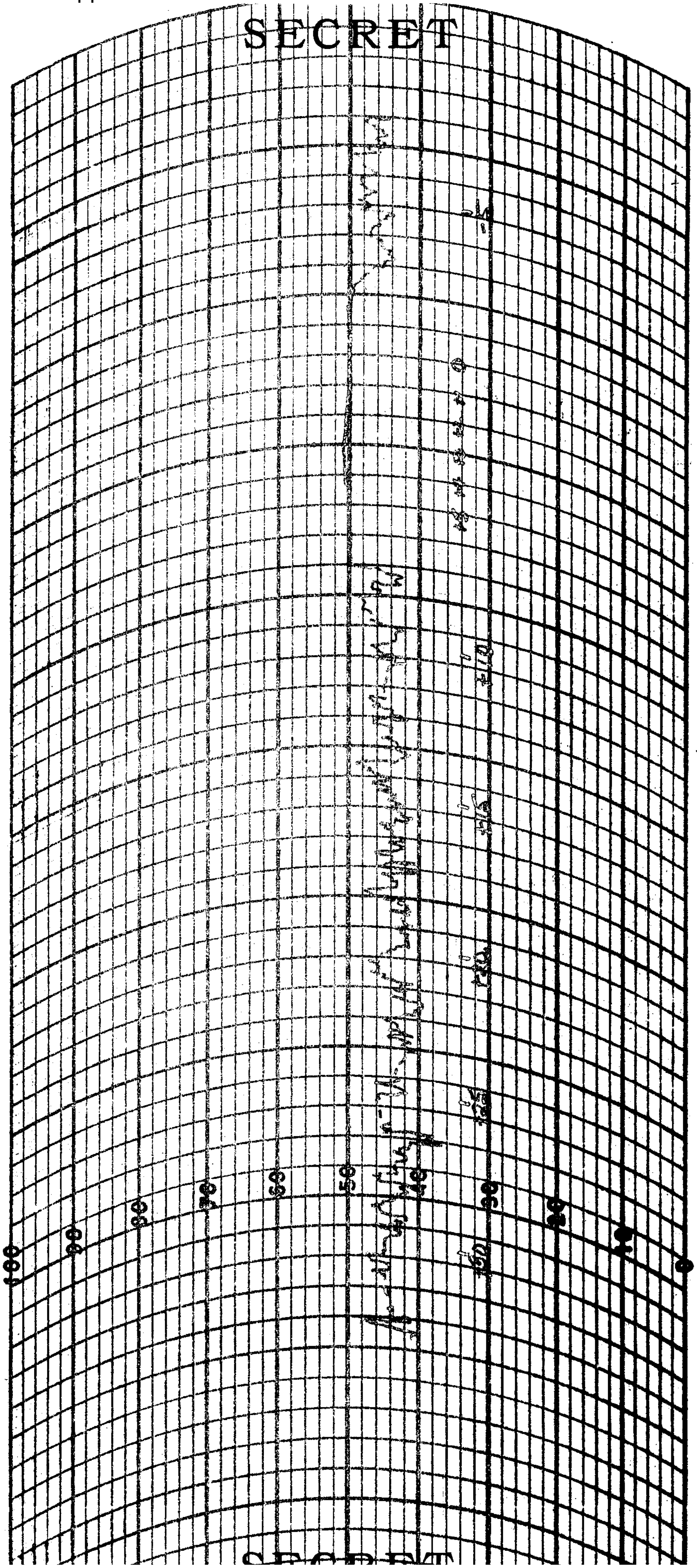


Figure 26. Test No. 105 - Patuxent - 12 June 1961

-13F-

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

so that an unfavorable spheric distribution could lead to the small signals noted. A good signature was obtained using the artificial atmospherics generator at Fort Pierce as the source (Figure 27). It is believed that this signature is generated by the effective reflection center passing through the first side lobe on the range gate interference pattern at about 1-1/4 minutes, giving a peak positive signal. Slightly after 1 minute and 20 seconds, the reflector moves through the null in the interference pattern, reaching the peak lobe near +1-1/2 minutes. The cross hatched area on the trajectory (Figure 28) shows the range to the disturbance as measured from Miami, assuming that the generator is in the ocean just off Fort Pierce. The transmitting ship sometimes changes its position from test to test, but the variation is generally less than the range gate width.

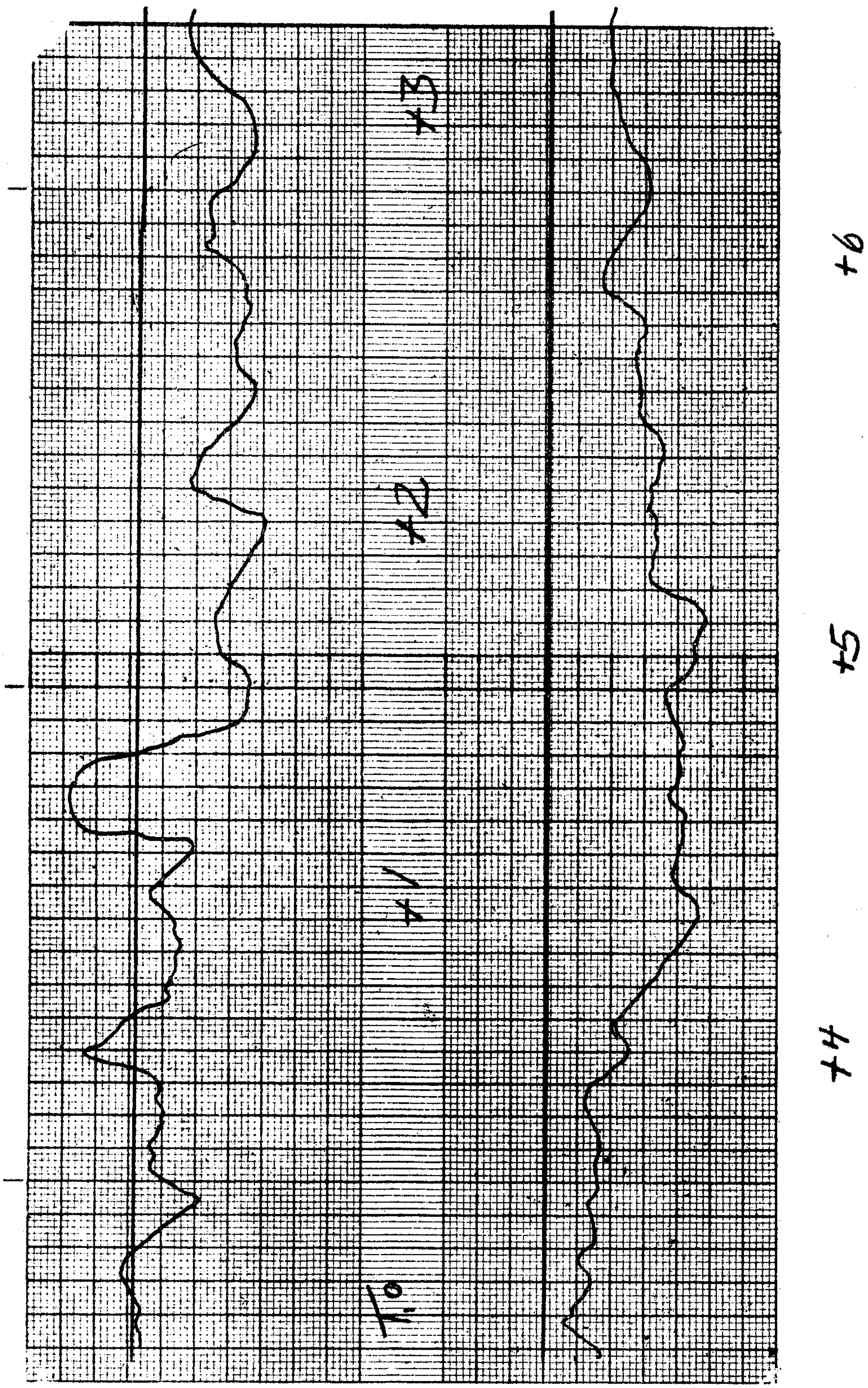


Figure 27. Test 0105 - Miami - 12 June 1961 - Machine

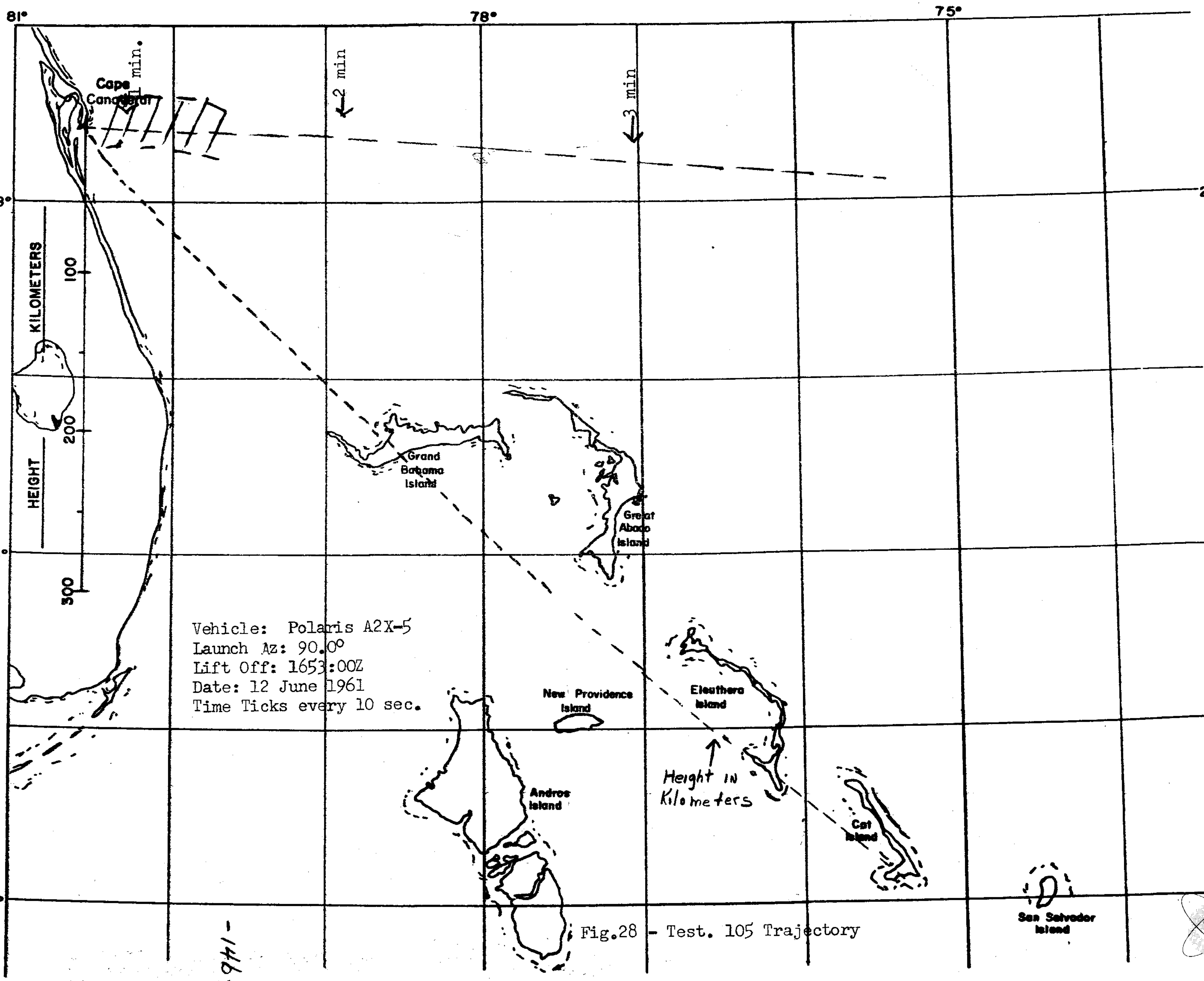


Fig.28 - Test. 105 Trajectory

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6

Declassified and Approved For Release 2012/06/04 : CIA-RDP78-03172A000200010004-6