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PLYMOUTH ROCK
ELINT RECONNAISSANCE
SYSTEM

Prepared by:

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Approved by:

W. M. Harris

Handle via BYEMAN
Control System

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CONTENTS

System Nomenclature: [illegible] Rock

Function: The [illegible] Rock system is designed to intercept electromagnetic emissions of a pulse nature in the S-band portion of the radio frequency spectrum. It consists of two channels of reception, one of which has a fixed frequency bandwidth, and the other a scanning narrow bandwidth. The fixed band covers the portion of the band between 2.0 and 4.0 Gc/s, and the scanning band covers the portion between 2.5 and 3.5 Gc/s. The receiver is a general purpose video type, and incorporates no special recognizers. The function of the scanning band portion is to furnish frequency information to identify the data received by the wide band channel.

Number of Units Planned: This system is in the R & D phase, and to date only one unit has been built. The second and third units, presently under construction, are copies of the first unit, but, in addition to the receiver, there is being added another module consisting of a traveling wave tube preamplifier. This amplifier is in series with the scanning channel, since the losses in the filter, the pad, mismatch, etc., reduce the sensitivity of the scanning channel, and it is felt that the frequency determination will be much improved by increasing the sensitivity of the scanning channel. Present plans do not extend beyond the third unit. The second unit is scheduled for May 1963.

Contractor: The original [illegible] package was designed and built by [illegible] Laboratory. The additional units are being built under contract [illegible] Applied Technology, Inc.; who is also [illegible] the VHF preamplifier. Antennas are designed and developed by [illegible].

System Characteristics:

A. Overall System Functional/Operational Description

The system is intended to operate from a satellite platform. Operation is programmed on and off by means of an orbit timer-programmer, and the intercepted data is stored on a two-channel analog magnetic tape recorder. The stored data is transmitted by means of a conventional telemetry VHF link during acquisition of the vehicle by the tracking and readout stations at Vandenberg, Hawaii, Kodiak, and New Hampshire. The received data is recorded by the ground stations on magnetic tape recorders, and the data is then forwarded to the Satellite Test Center at Sunnyvale. The data is processed for engineering evaluation, converted to a form suitable for analysis and then delivered to the Air Force at Sunnyvale.

[redacted]

[illegible] description:

1. Antenna: The antenna used with Plymouth Rock receiver [illegible] two [illegible] circularly polarized units, each unit providing the [illegible] for one of the two receiver channels. Each of the antenna units is [illegible] that the [illegible] lobe is considerably suppressed, and a [illegible] pattern is [illegible], directed outward to the horizon. Two [illegible] are used to supply signal to the two channels of the receiver, so that a power splitter is eliminated, and reflections between the [illegible] and [illegible] channels are minimized.

Gain: Directivity gain is approximately five db above isotropic, measured against a linearly polarized wave.

VSWR: The voltage standing wave ratio is 1.3[illegible] max. over the 2.[illegible] to [illegible] Gc bandwidth.

Patterns: A complete set of patterns vs. frequency is included in the Calibration section.

Mounting Location: The two antennas are mounted on the earthward side of a satellite whose attitude is stabilized with the longitudinal axis tangent to the orbit. The relative position is shown on the Antenna Coordinate Diagram, along with the pattern orientation. These patterns apply only to a vehicle whose attitude with respect to earth is that shown in the diagram. The second flight of Plymouth Rock will be on a vertically stabilized (nose earthward) vehicle. Another set of coordinates and patterns will be supplied for that vehicle at a later date.

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B. 2. Receiver Description

a. Purpose

The Plymouth Rock receiver was designed to illustrate the "small-box" philosophy in reconnaissance receivers. This project was specifically slanted toward investigation of techniques suitable for possible future application in satellite-platform reconnaissance systems with two broad objectives in view:

1. To investigate a proposed receiver technique which could simultaneously provide both high intercept probability and a frequency-measurement capability; and

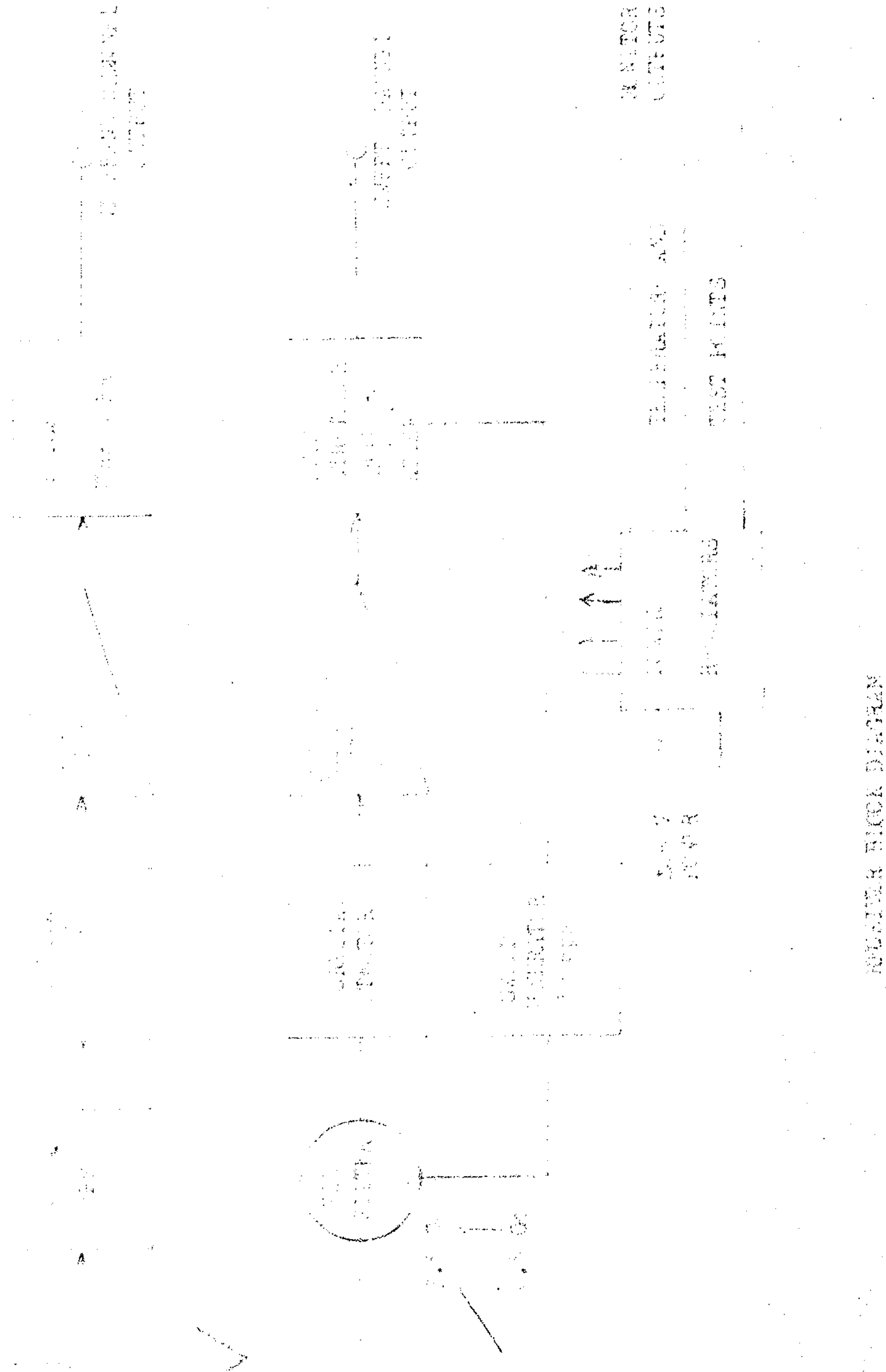
2. To integrate the receiver into an existing readout, data processing, and analysis facility.

Performance objectives were to achieve as high a sensitivity as possible consistent with the state of the art, and to preserve p.r.f. and scan amplitude information for data processing.

The receiver characteristics are listed below.

Plymouth Rock Receiver Characteristics

Frequency Range (Gc)	2.5 - 3.5 2.0 - 4.0	swept channel wide-band channel
Tangential Sensitivity (dbm)	-45 -50	swept channel wide-band channel
Frequency-Measurement Accuracy (Mc)	20	(YIG Filter band-width)
Size (in.)	9 x 11 x 5	
Weight (lb)	12.5	
Power Consumption	5.7 watts @ +28.3 v 4.3 watts @ -28.3 v	(360-ma peak current) (260-ma peak current)
Operating Temperature Range (°C)	±50	



[illegible]

The [illegible] is basically a dual-channel crystal-video [illegible]. One channel is wide open over the [illegible] to [illegible] Gc frequency range with a tangential sensitivity of about -50 dbm. The pulse stretcher is modified to drive a [illegible]-kc-bandwidth output channel with positive-polarity pulses. See "Block Diagram - Receiver".

The frequency-measuring channel is similar to the wide-band channel except for the inclusion of a frequency-sweeping, electrically tuned, YIG pre-selector. It is tuned by a sawtooth sweep generator over the 2.5 Gc to 3.5 Gc portion of the band. The time per sweep is nominally 100 milliseconds, [illegible] milliseconds of which are used for flyback, and to present band end markers and synchronizing pulses. The bandwidth of the YIG filter is 2[illegible] mc., but this is somewhat nominal, since the filter skirts are not steep, and high level signals may result in a wider apparent passband.

A train of three negative-polarity flyback synchronizing pulses is applied to the swept-channel output during the middle of the filter-flyback recovery. These pulses are used in the recovered data for synchronizing the data processing circuits. In addition, positive-polarity band-end marker pulses are generated at 2.5 and 3.5 Gc. Frequency is determined by measuring the time displacement of the intercept from the band end markers.

Monitor circuits are included to permit external tests of various power-supply-regulated voltages, waveforms and temperature-sensing probes. Temperature sensing of the YIG filter is provided to permit internal first-order compensation and external second-order correction of the temperature-sensitive YIG-filter tuning calibration.

[illegible] Microwave Circuits

The heart of the receiver is a type WJ-501 electrically tuned microwave filter, which is a bandpass filter employing a highly polished sphere of single-crystal yttrium iron garnet (YIG) as the resonant circuit. The resonant frequency of the filter is varied by changing the dc magnetic field applied to the YIG. In the WJ-501, a combination of permanent magnet and solenoid tuning is used. With no solenoid current applied, the WJ-501 filter is tuned to a center frequency of [illegible] Gc. A shift of the resonant frequency by 1 Gc in either direction can be accomplished by a current of approximately [illegible] ma of the proper polarity. In the receiver, a frequency shift of [illegible] Gc in each direction from the center frequency ([illegible] – [illegible] Gc) was used. The bandpass is 20 Mc wide at the 3-db points.

Several characteristics of the WJ-501 filter are worth noting, including temperature dependence of resonant frequency. (See Calibration Curve.)

In addition, low VSWR terminations must be used at the input and output to obtain good bandpass shaping. A 6-db attenuator is desirable at both the input and output ports, but, as a compromise between high sensitivity and bandpass shaping, one 3-db attenuator was used at the filter output in the receiver.

The composite frequency response curves show the frequency response of both channels of microwave components in the receiver. The distortion in the bandpass curve because of mismatching is evident in the curves below 2.5 Gc.

From an over-all system point of view based on intercept probability, considerations related to 3-db bandwidths, antenna-pattern beamwidths, etc., the difference in sensitivity between the two channels is somewhat greater [illegible] as a practical value.

[illegible] made separately and used the same [illegible] The 1-db fluctuations [illegible] attributed to the 1[illegible] coaxial antenna cable [illegible] and antenna jack on the receiver.

1. 2. d. Video Circuits

Log video amplifiers (which characteristically have large dynamic ranges) were chosen for both channels of this receiver so that the small signal gain could be made quite large and the adverse effects of saturation by strong signals could be minimized. Each amplifier used had a low noise figure resulting in a tangential sensitivity of -54 dbm at the log video output. The small signal gain was such that the crystal noise seen at the output was 0.5 v, peak to peak. At small signal levels the video bandwidth was approximately 2 Mc; at larger signal levels the bandwidth increased slightly.

The excellent tangential sensitivity obtained may be accounted for in large part by the choice of detector mount and crystal -- an AEL 10R crystal, which is a carefully selected 1N23R.

Good temperature stability with respect to small signal gain and signal-to-noise ratio over a -50°C to +50°C range was obtained by use of a Fenwal thermistor which provided appropriate compensation of the logging-diode bias current as temperature increased. Extensive use of negative feedback minimized the beta fall-off of the individual transistors as the ambient temperature decreased toward -50°C.

The small signal gain and bandwidth are essentially optimized for the overall amplifier when the room-temperature bias current through the logging diode is 10 microamperes.

Exponential stretching of the pulse output of the video amplifiers was desired in order to drive an output channel of 5-kc bandwidth. In addition, the dynamic range of the output channel was presumed to be small and of limited use in preserving signal amplitude; therefore, some small-signal gain along with amplitude limiting was incorporated into the stretcher design.

The pulse-stretching technique employed appeared to cost little or nothing in S/N-ratio deterioration and for signals a few db above tangential at the logarithmic amplifier output -- actually appeared to represent an increase in S/N ratio.

 [redacted]

1. 2. a. Sweep Circuits

The YIG filter used in this receiver was current tuned over the range of 2.5 to 3.5 Gc and had a tuning sensitivity of 2.5 Mc/ma. The zero-current frequency of the filter was 2860 Mc, making the required current swing of the sweep circuit from -160 to +250 ma. The sweep generator consists of (1) a temperature-stabilized, 10-cps clock that sets the repetition rate at which the receiver sweeps; (2) a bipolar saw-tooth generator that generates a low-level, linear-sawtooth waveform; and (3) a direct-coupled output amplifier that amplifies the low-level sawtooth waveform to a level adequate to drive the YIG-filter tuning coil.

In addition, there is a band-end marker and sync pulse generator. This circuitry generates two positive pulses at the start and stop of the sweep to identify the extreme ends of the frequency band and three equally spaced negative pulses, occurring during flyback, for the purpose of synchronizing a frequency-display oscilloscope.

The 10-cps clock is a freerunning multivibrator which gives an 8-msec, 14-v, positive output pulse every 0.1 sec. The 8-msec period is that time required to reset the YIG filter from 3.5 to 2.5 Gc, using a monotonically decreasing discharge path. During this 8-msec period the bipolar sawtooth generator is clamped to its most negative excursion, which is adjustable, and sets the starting frequency of the swept receiver. The bipolar sawtooth generator also has a slope control, which sets the uppermost frequency of the receiver. In this case the bipolar-sawtooth generator was set to sweep from -3.5 to +5.1 v in the 92-msec period.

The direct-coupled power amplifier is more accurately described as a direct-coupled, bipolar, voltage-to-current power amplifier -- it converts the output of the bipolar sawtooth generator to a current sawtooth swinging between -160 and +250 ma to sweep the YIG filter from 2.5 to 3.5 Gc.

 [redacted]

[illegible] clock, [illegible] to triggering the bipolar sawtooth [illegible], is used [illegible] the [illegible] markers and to trigger the [illegible] generator. The leading edge of the positive clock output pulse is differentiated to [illegible] the [illegible]-Gc marker. The trailing edge is in[illegible] and differentiated to produce the [illegible] marker. The positive excursion of the [illegible]-cps clock pulse also triggers the sync-pulse generator, from which a train of three negative pulses of equal spacing and width is obtained. [illegible] pulses are combined with the positive band-end marker pulses and delivered to the stretched video output terminal of the receiver.

The [illegible]-cps clock sets the sweep period of the YIG filter sweeper.

The bipolar sawtooth generator generates a linear sweep that starts at a preset negative voltage and climbs to a desired positive voltage. It is reset by the positive output pulse of the [illegible]-cps clock, which controls the duration of the sweep. The YIG filter has an inherent temperature-dependent drift, which is a translation in the entire tuning curve rather than a change in slope; hence it may be compensated for by deliberately causing the sweeping waveform to shift in the opposite direction. This compensation was accomplished in the sweeper by reflecting the desired compensating drift back through to the bipolar sawtooth generator and designing the circuit that controls the starting point of the sweep, such that at this point, the appropriate emitter drifts in the desired direction and at the desired rate.

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B. 2. f. Monitor Circuits

There are 15 monitor points brought out for possible sampling by a 1-rps commutator. Thirteen of these monitor points are used to monitor circuit operation throughout the receiver. The remaining two are used to monitor the temperature at two locations within the receiver. A data profile of the commutated output is included in the Calibration section (B.3).

Voltage Monitors - Both unregulated supply voltages from both log video amplifiers and the +10 v supplied to each stretching circuit have been made available as monitor points. An offset voltage is applied to the negative voltages to be monitored so that all monitored voltages appear at the output pins at a positive level between 0 and +5 v.

YIG-Filter Sweeper Monitor - The 10-cps clock monitor voltage should be either 0 or +2.8 v, with a 90 percent probability that it will be 2.8 v.

The output of the bipolar sawtooth is monitored so that a portion of the sweep waveform will be sampled with the limits ranging between +0.4 and +4.2 v at 28°C. Circuitry is provided to insure that the monitor voltage will remain within the limits of 0 and +5 v.

The output of the YIG filter sweeper is monitored on four successive monitor points. These points allow one to reconstruct the sweep by recording only a few successive commutator revolutions. The limits of the sweep should be +0.5 and +4.5 v at 28°C. The circuitry is identical to that used to monitor the output of the bipolar sawtooth generator.

Temperature Monitor Circuits - The design goal of the temperature monitor circuits was a 0 to +5 v response for a temperature range of 0°C to 50°C. The temperature-monitor circuits actually gave a 1.1 v to

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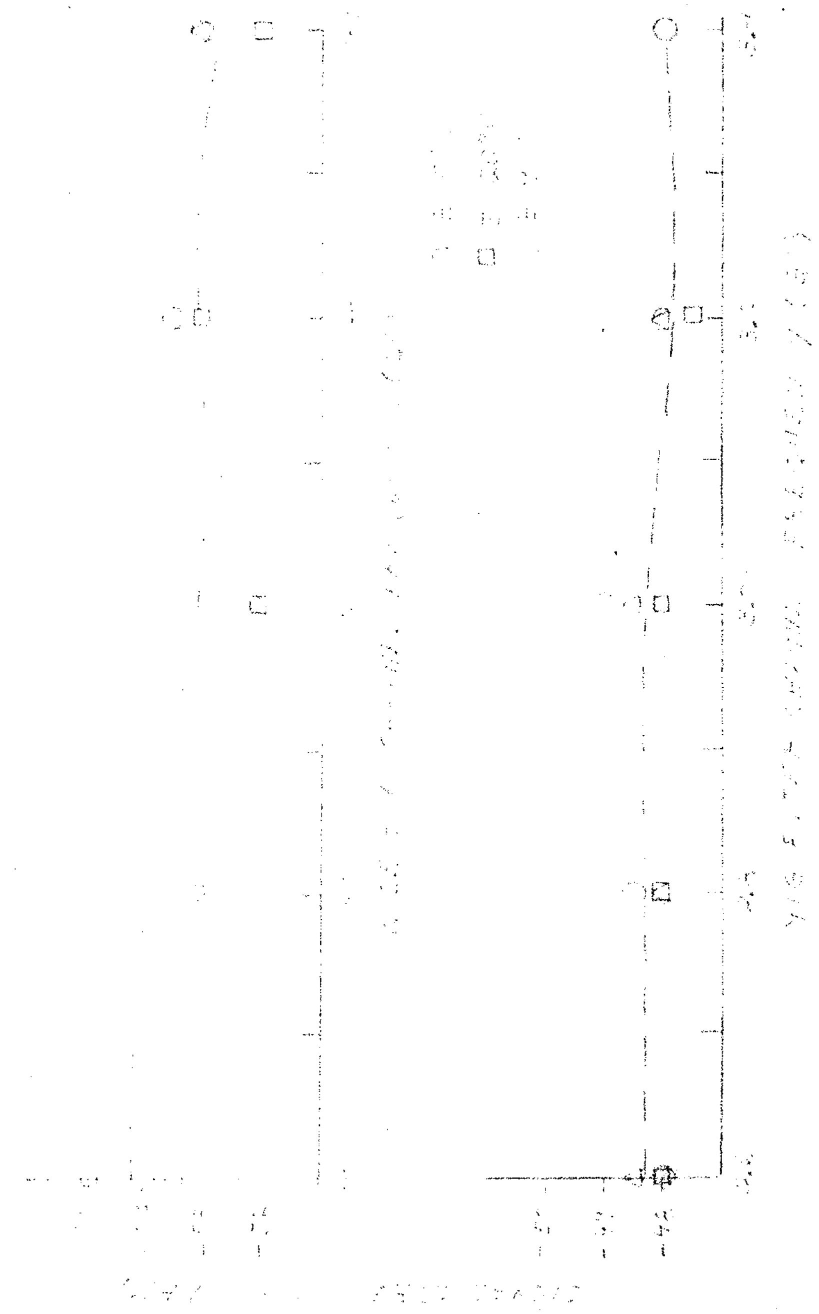
[illegible] response, linear within [illegible] percent of the monitor output voltage, over the [illegible] to [illegible] range. One of the monitor circuits was mounted on the circuit board to monitor the temperature of the circuit elements.

[illegible] Calibration Data: The data and curves appearing in this section are specifically applicable to Unit No. 1. As additional units are built and tested, curves for those units will be added to this report. [illegible] data is self explanatory. The behavior of the first unit may be considered typical so far as showing the trend of the equipment performance is concerned. It is evident that the temperature of the components comprising the YIG filter must be known in order to achieve the best degree of precision of frequency measurement.

The Data Profile is included for assistance in identifying the monitor points for status purposes and for supplying temperature correction to the frequency data. It also gives the values of static monitor points when normal voltages are applied. The profile shows a typical sequential arrangement of the monitor points as they would appear on an analog oscillographic presentation, such as that obtained directly from the output of a subcarrier discriminator. When reducing this data, it is necessary to have an instrumentation schedule for the particular data link used. This schedule identifies the data point number and its corresponding function.

Frequency Readout Calibration: The center frequency f_o of a signal within the tuning range of the receiver may be determined by measuring its relative position between the two band-end markers. In setting up the oscilloscope for frequency readout purposes one should: 1) trigger the oscilloscope on the three negative sync pulses provided; 2) adjust the sweep speed of the oscilloscope so that there is 10.4-cm deflection between the two band-end markers; and 3) center the display, thereby setting the two band-end markers 0.2 cm past the two extreme ends of the normal 10-cm grid. With the display set up in this manner, the band-end markers, in effect, are at 2480 Mc and 3520 Mc respectively, and each of the vertical reticule lines indicates a 100-Mc increment starting at 2.5 Gc and ending at 3.5 Gc.



TANGENTIAL SENSITIVITY VS. FREQUENCY

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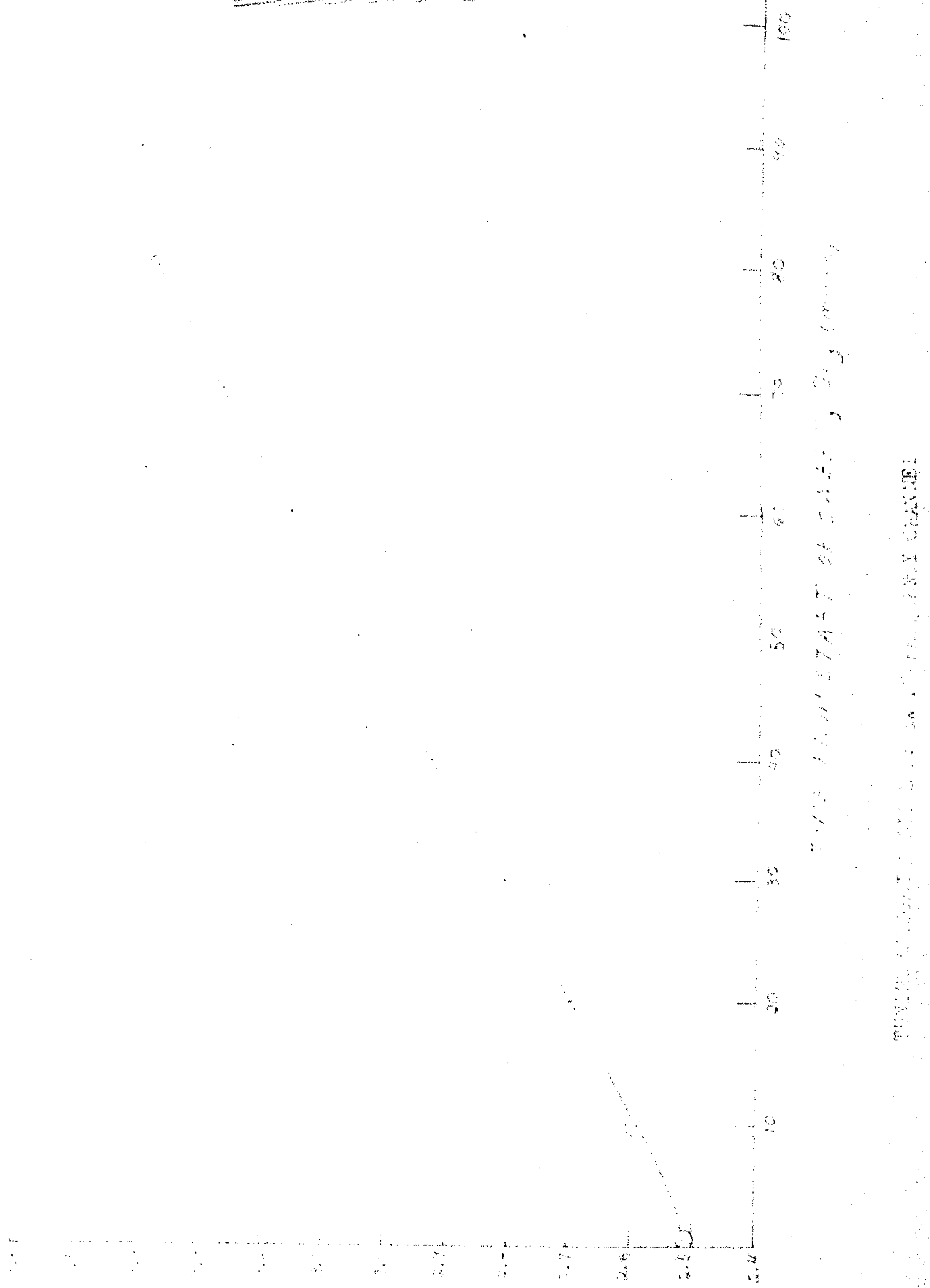

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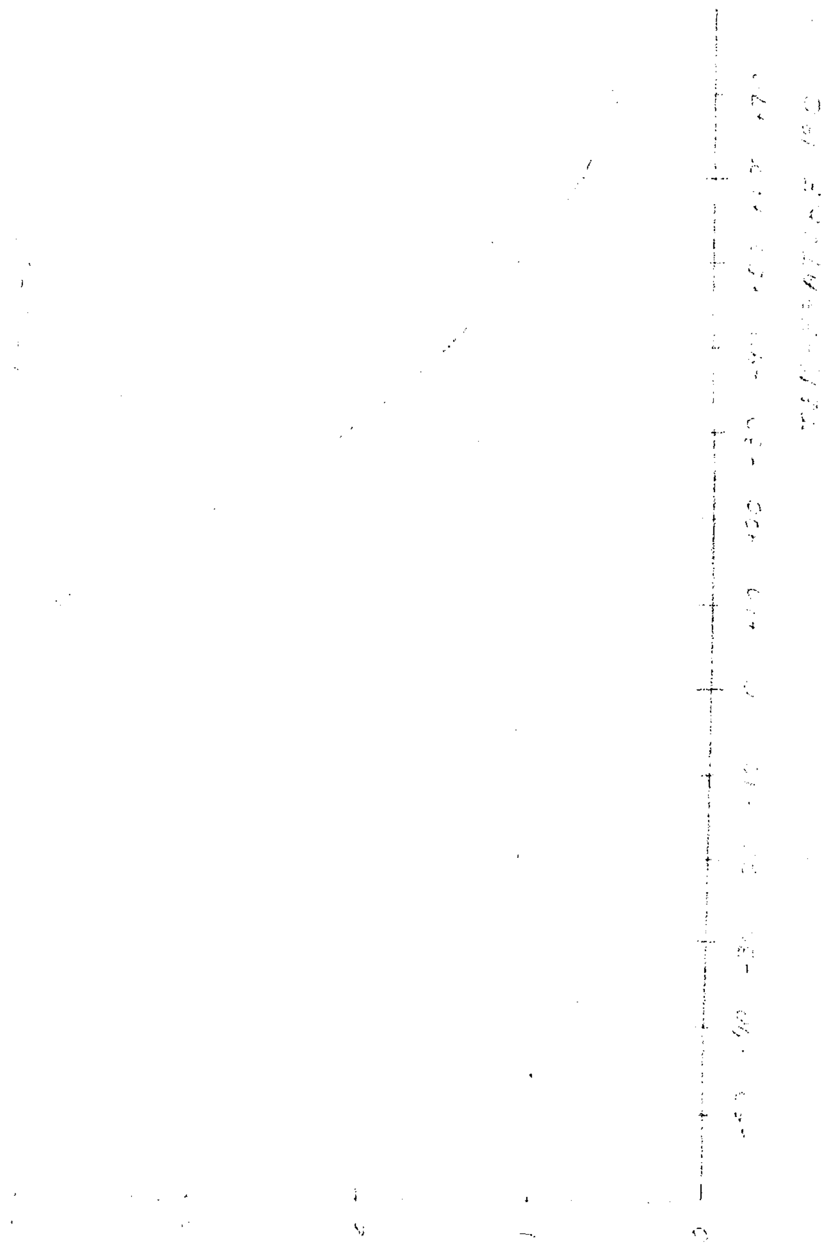
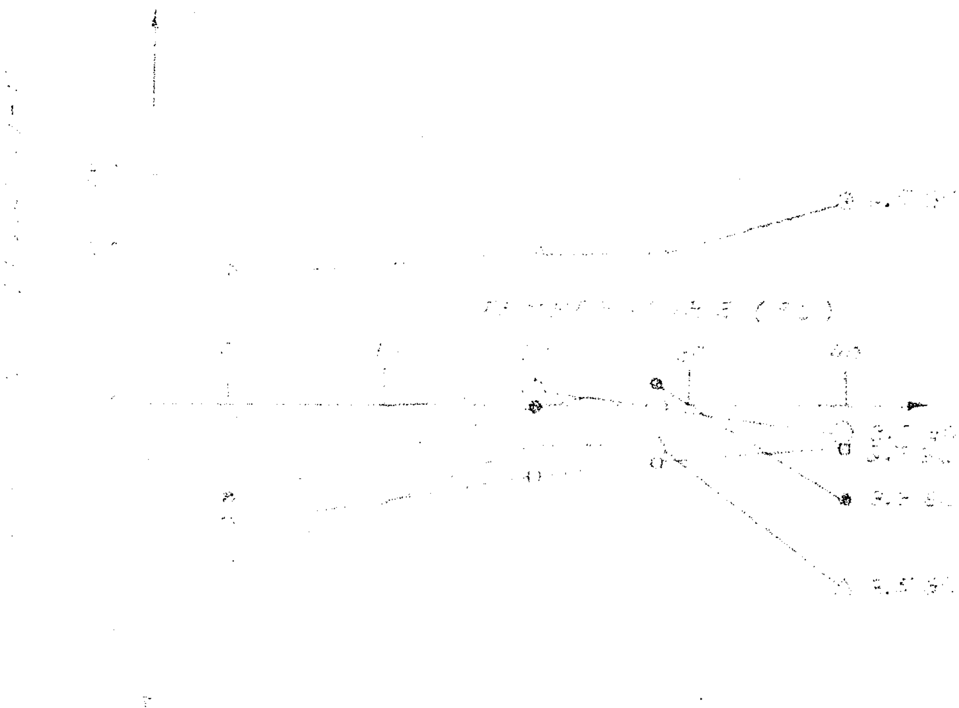


TEMPERATURE MONITOR CALIBRATION



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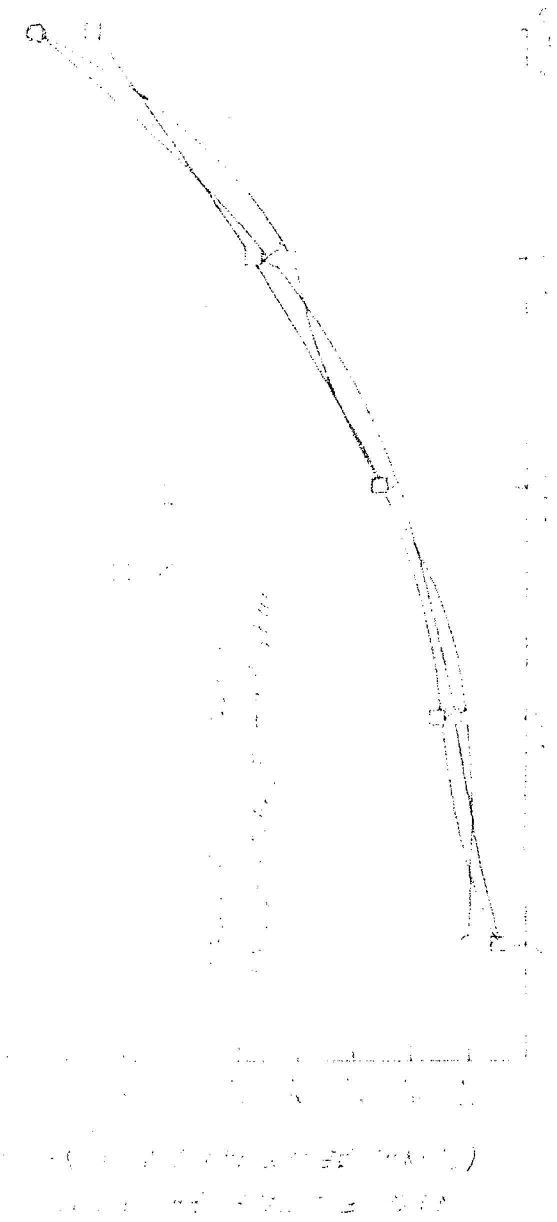

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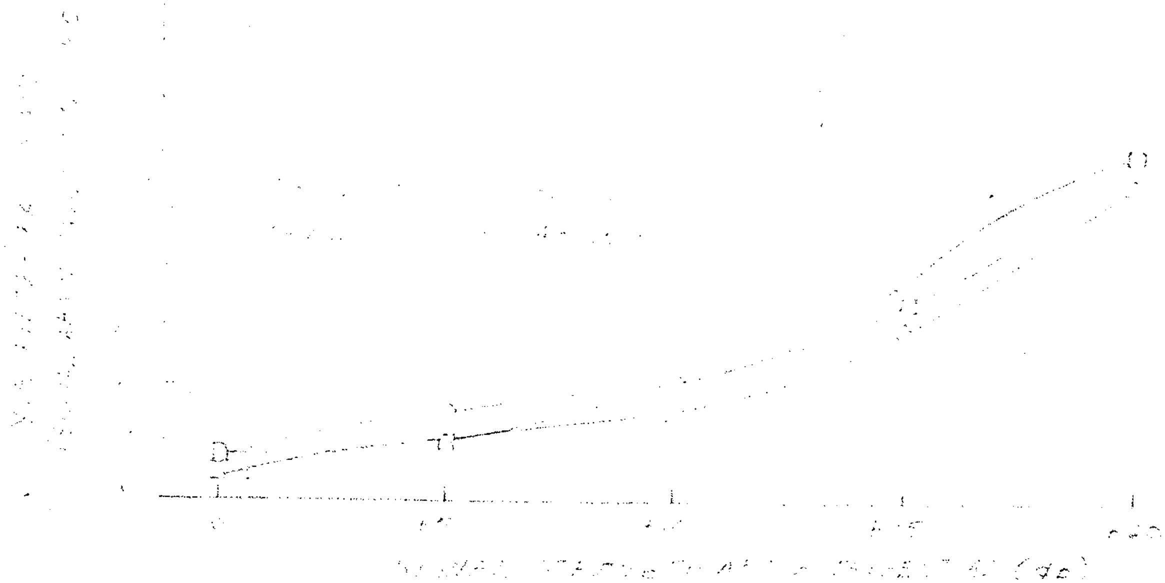

SHIFT CHANNEL BANDWIDTH VS. SIGNAL STRENGTH AT 3.2 KC.

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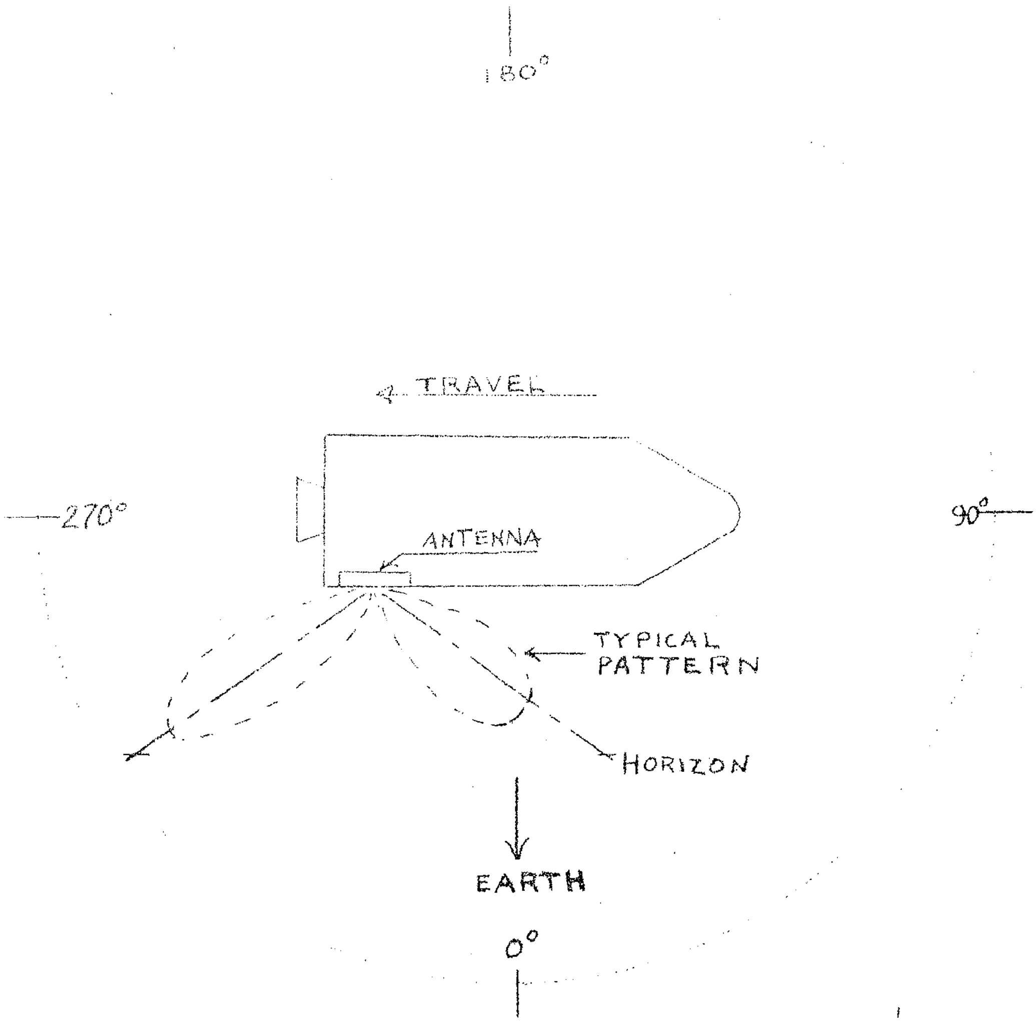
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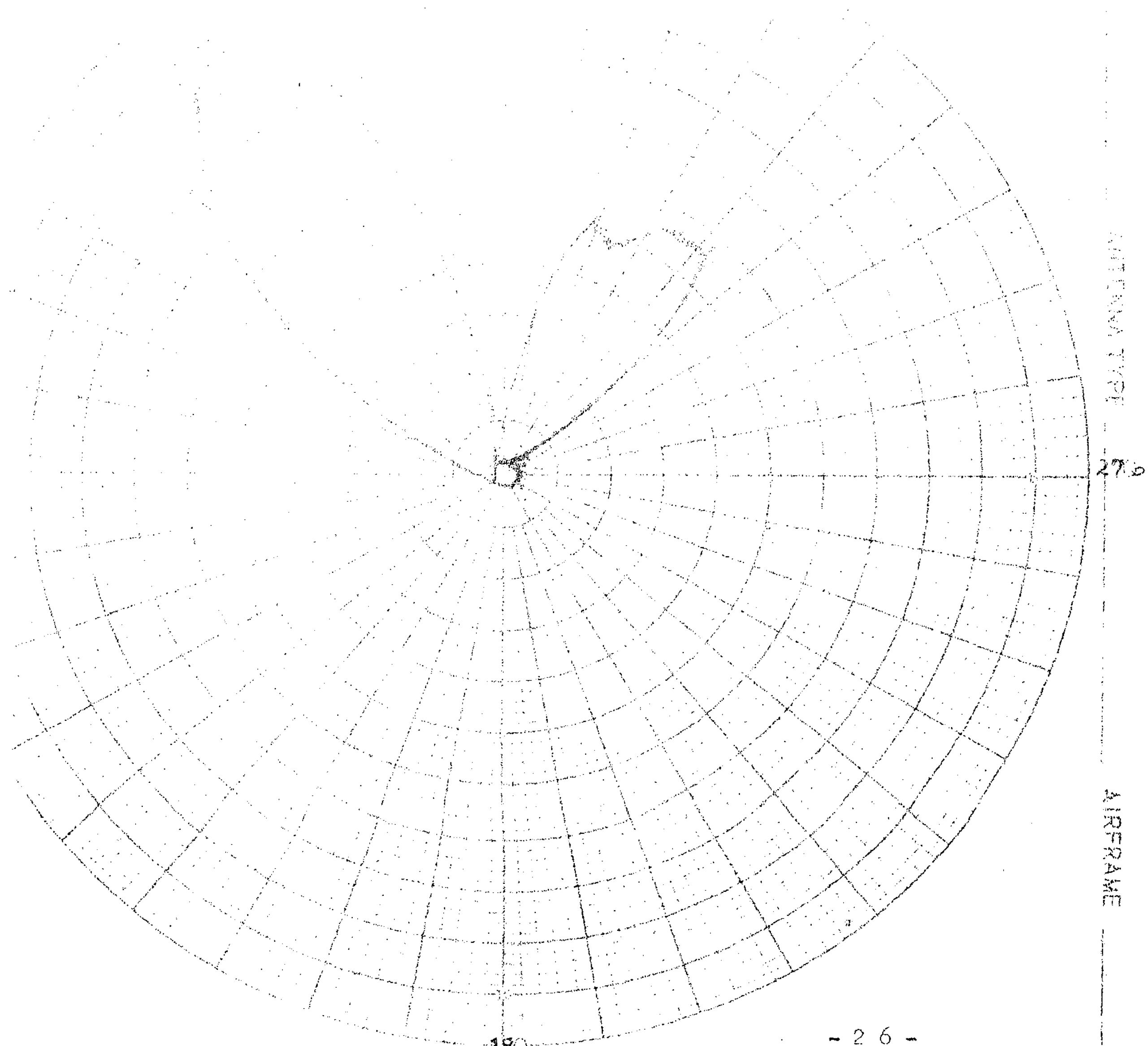

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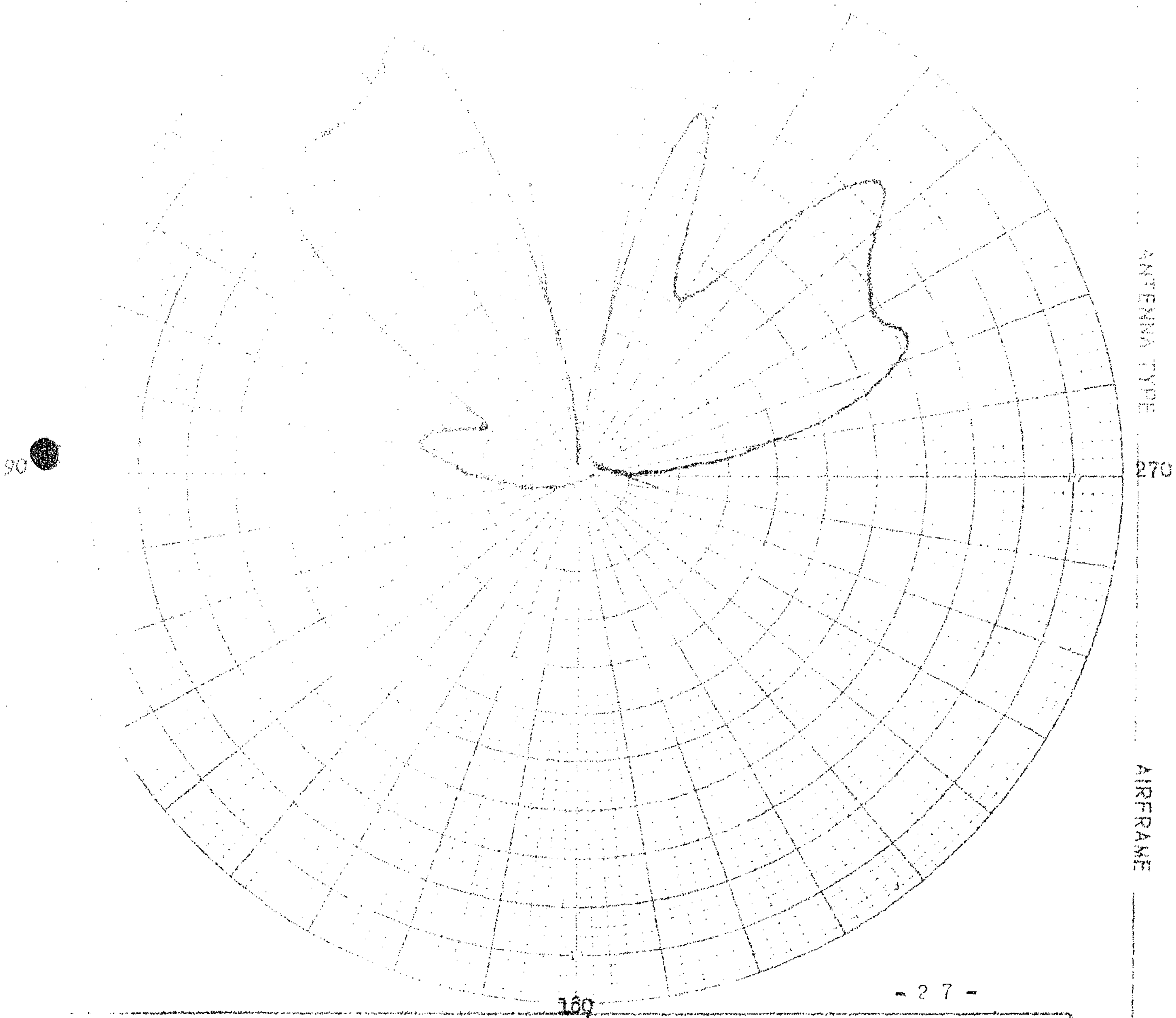

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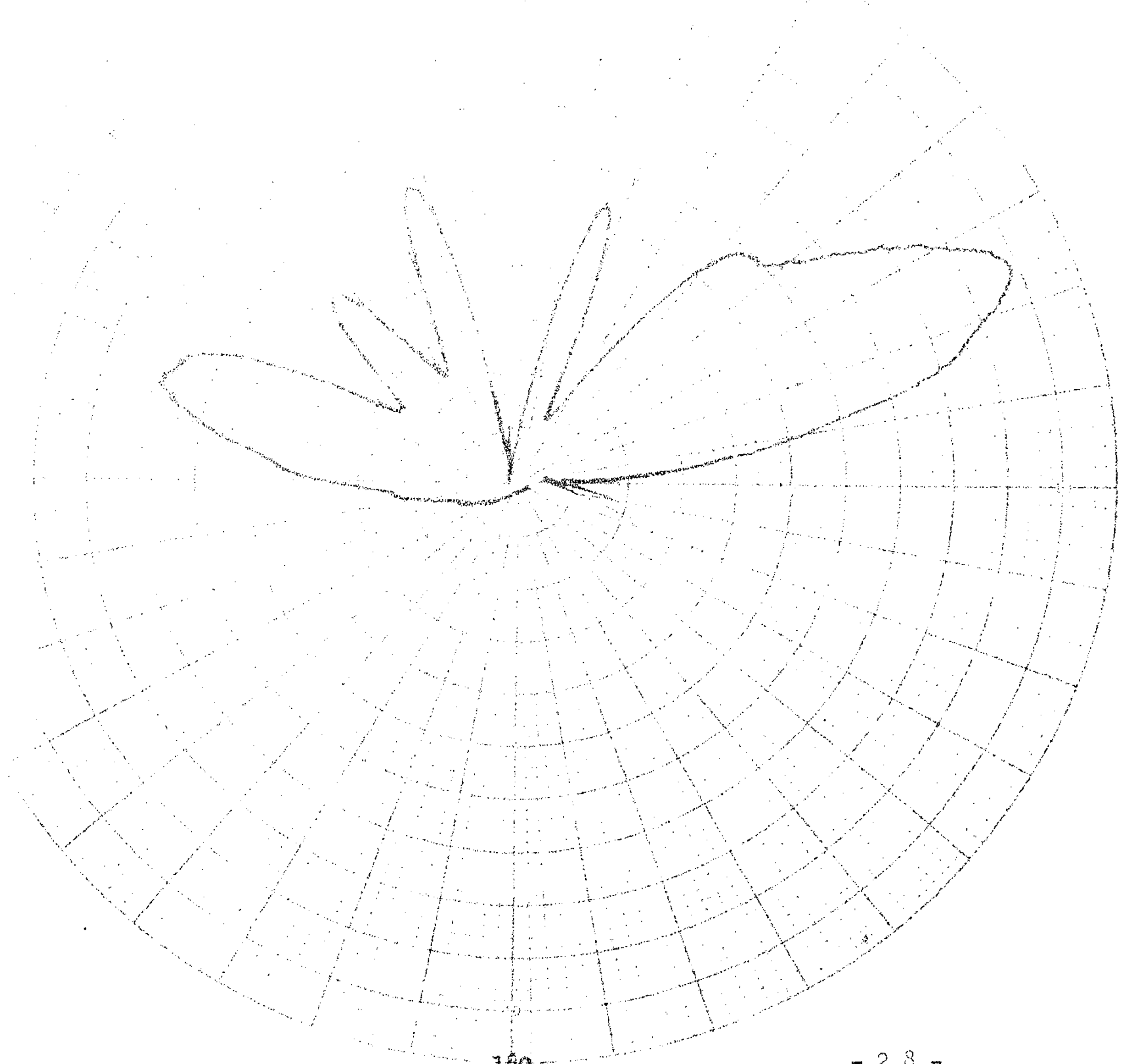

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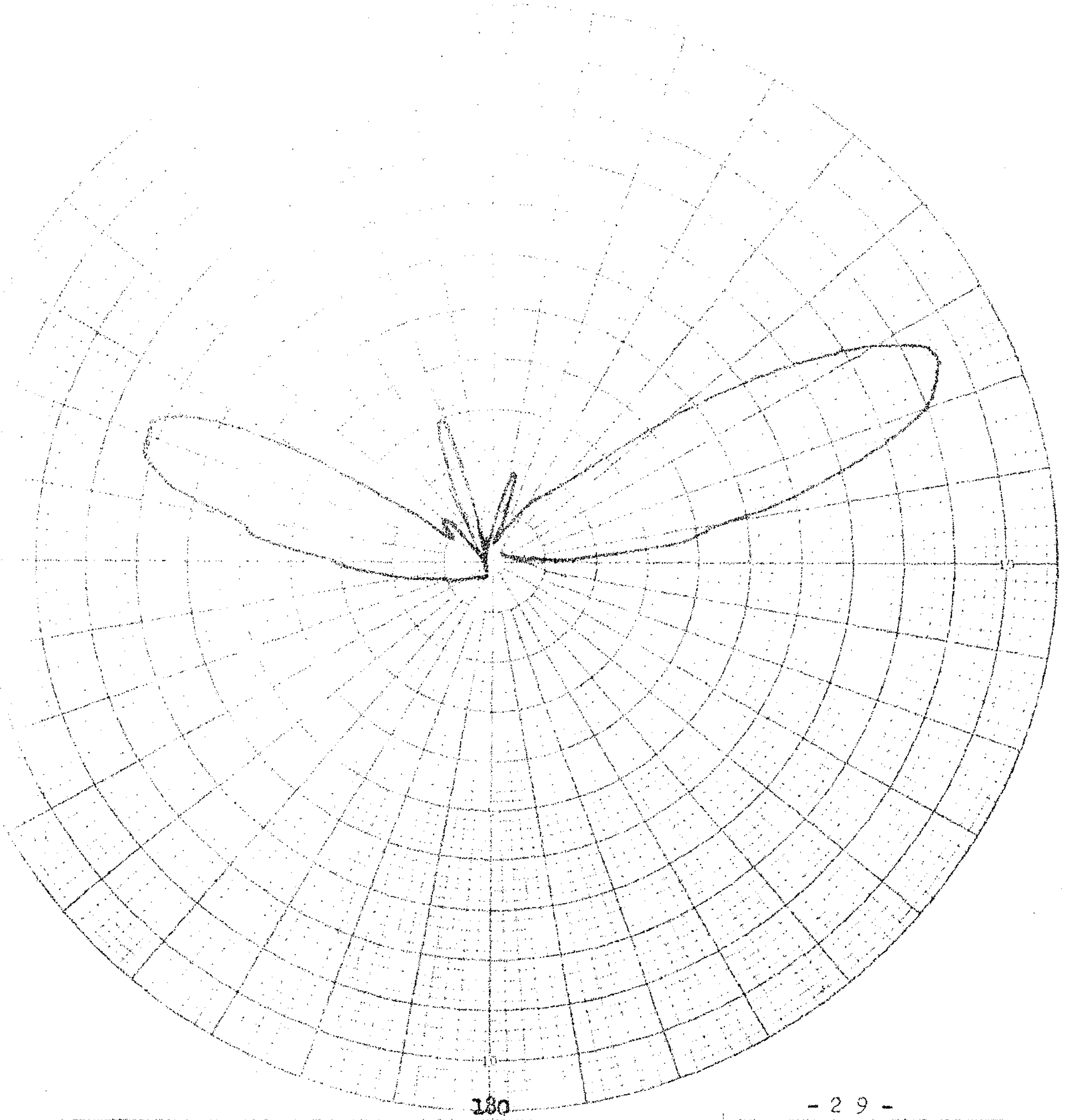

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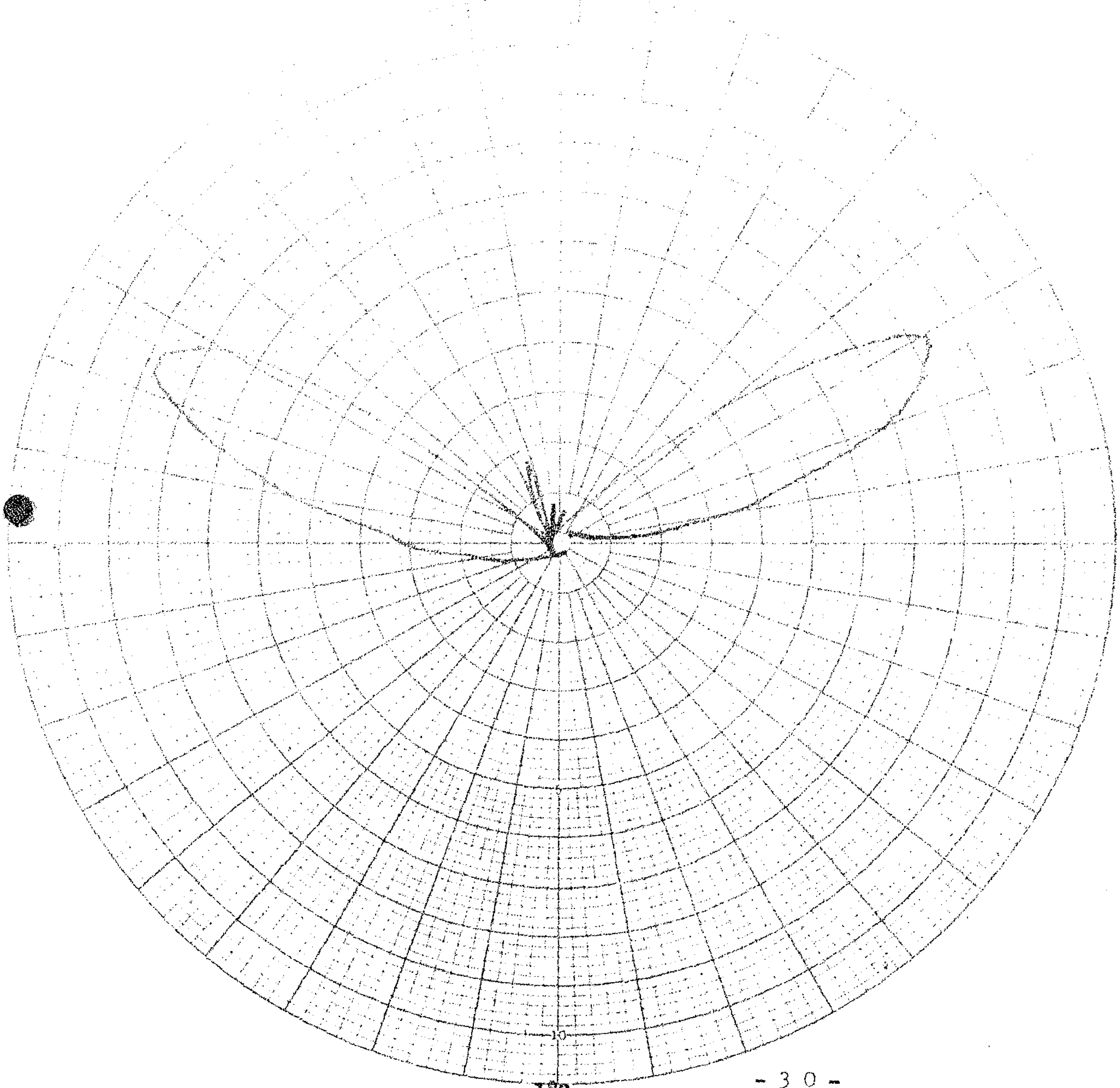

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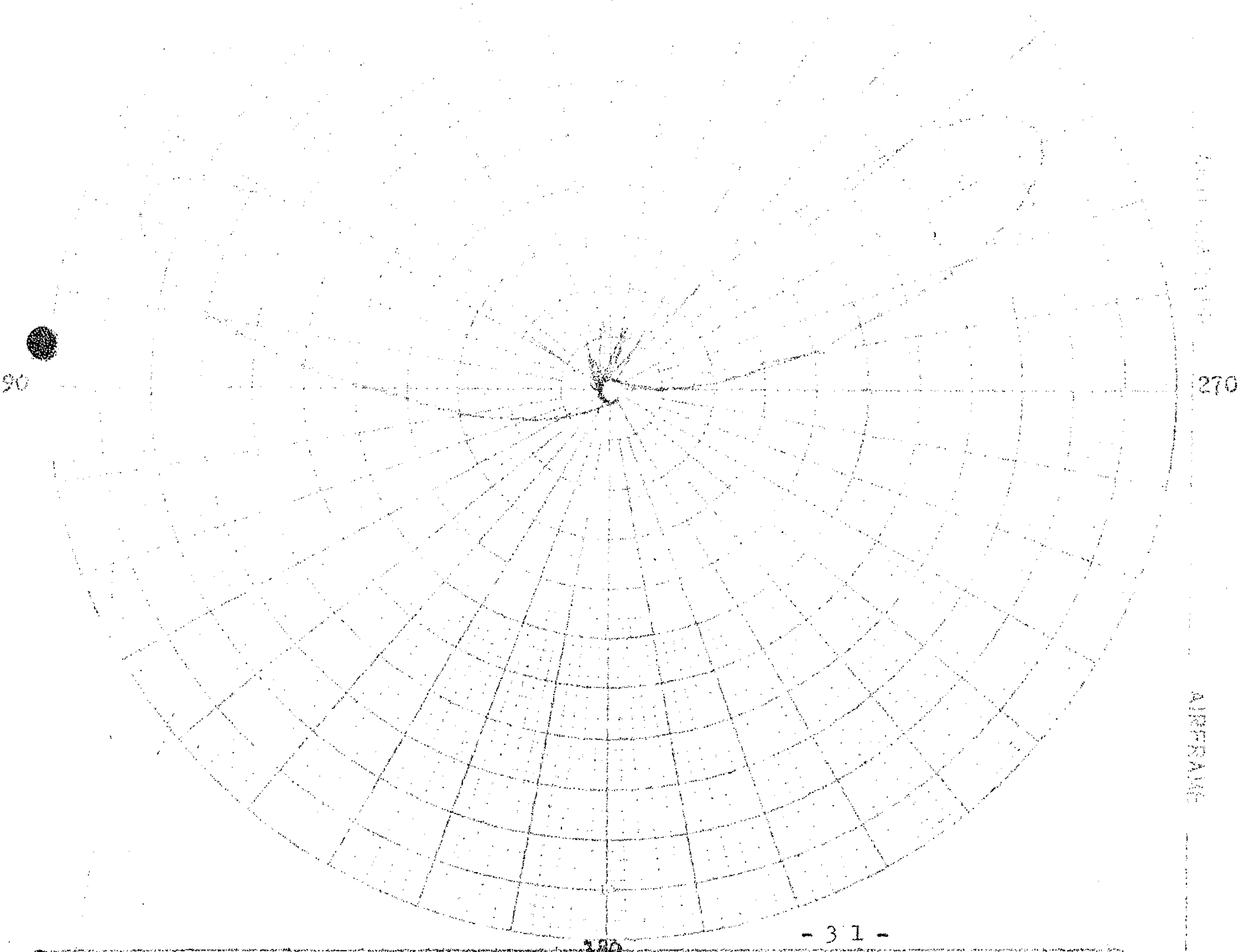

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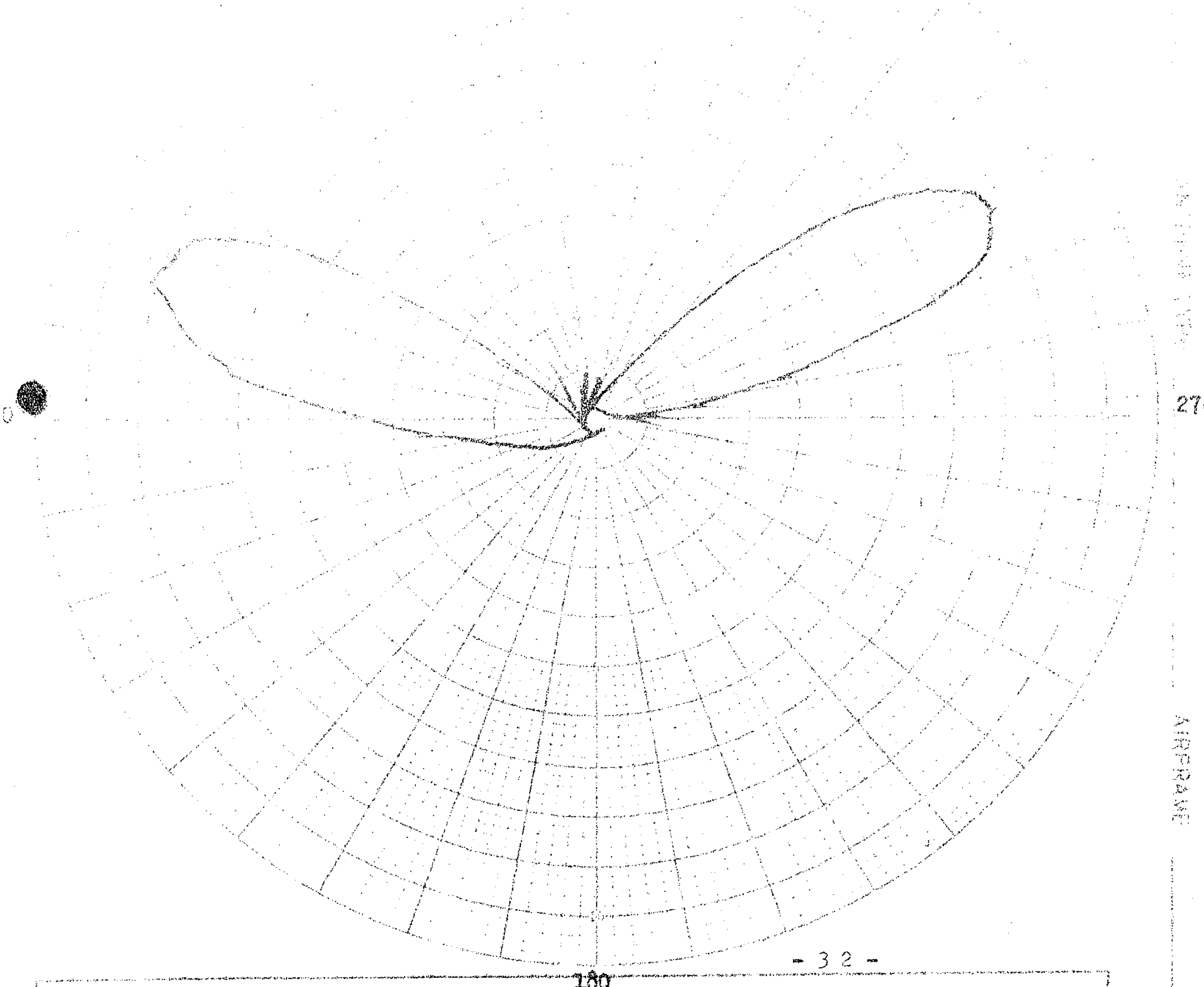

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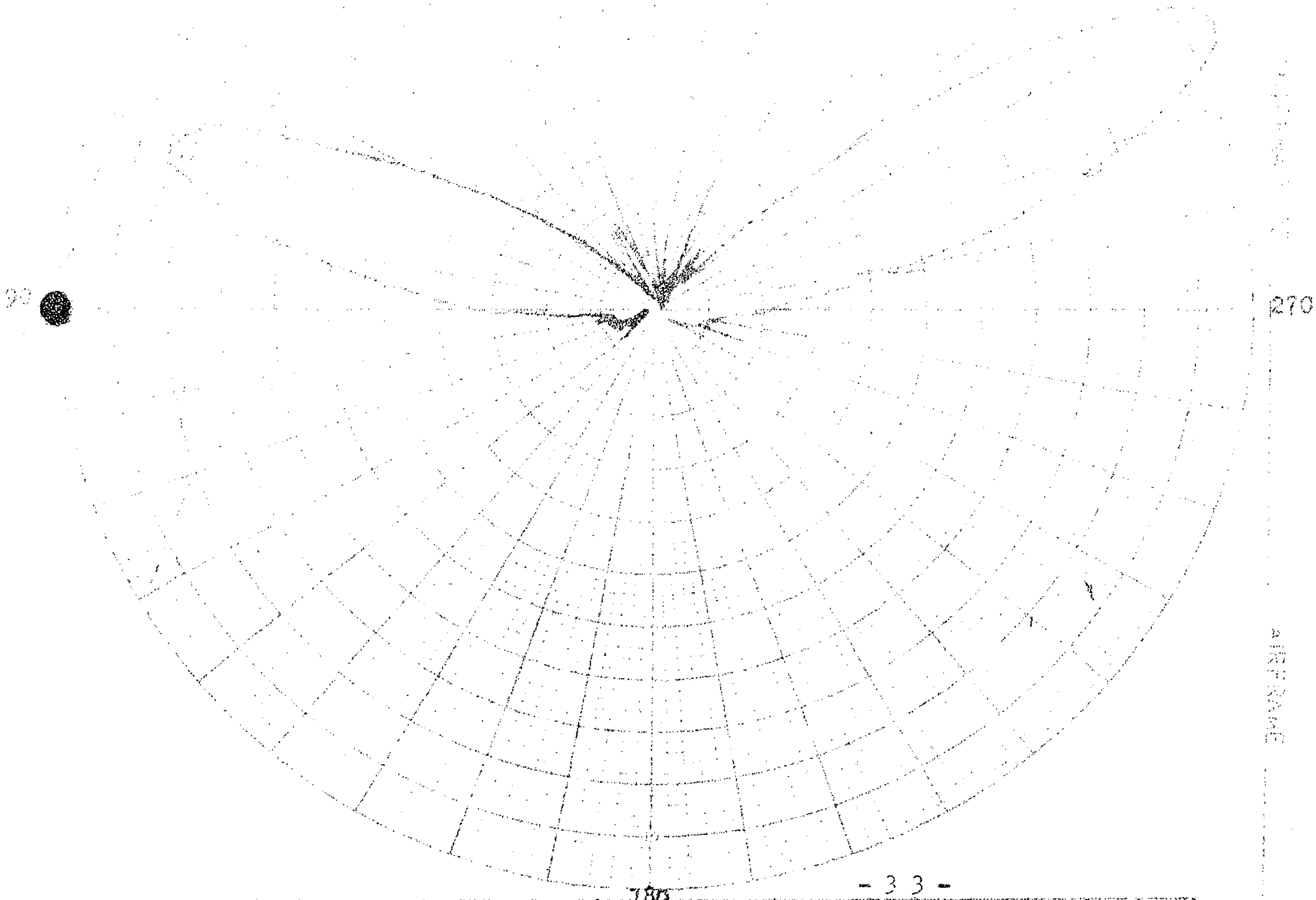

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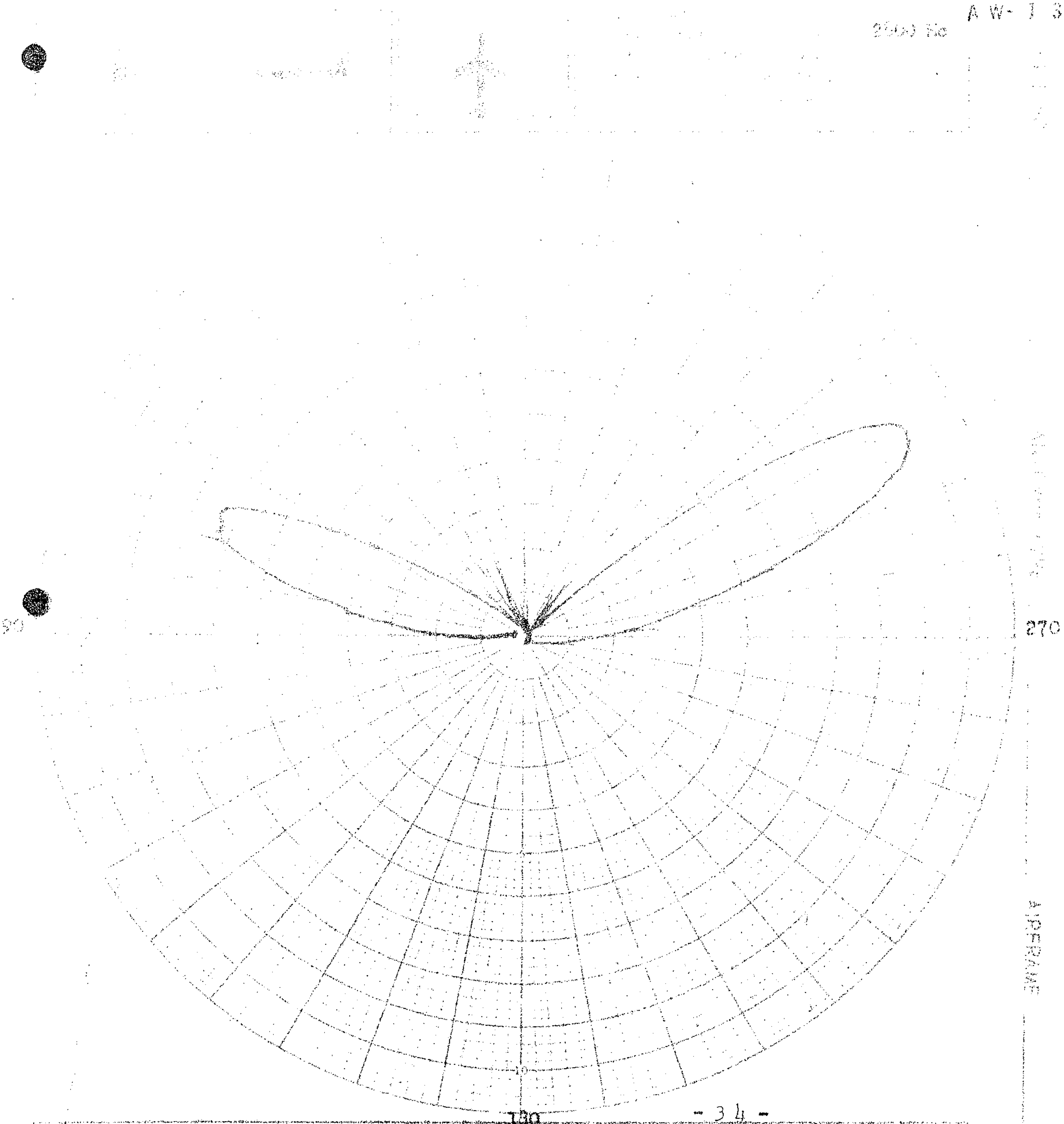

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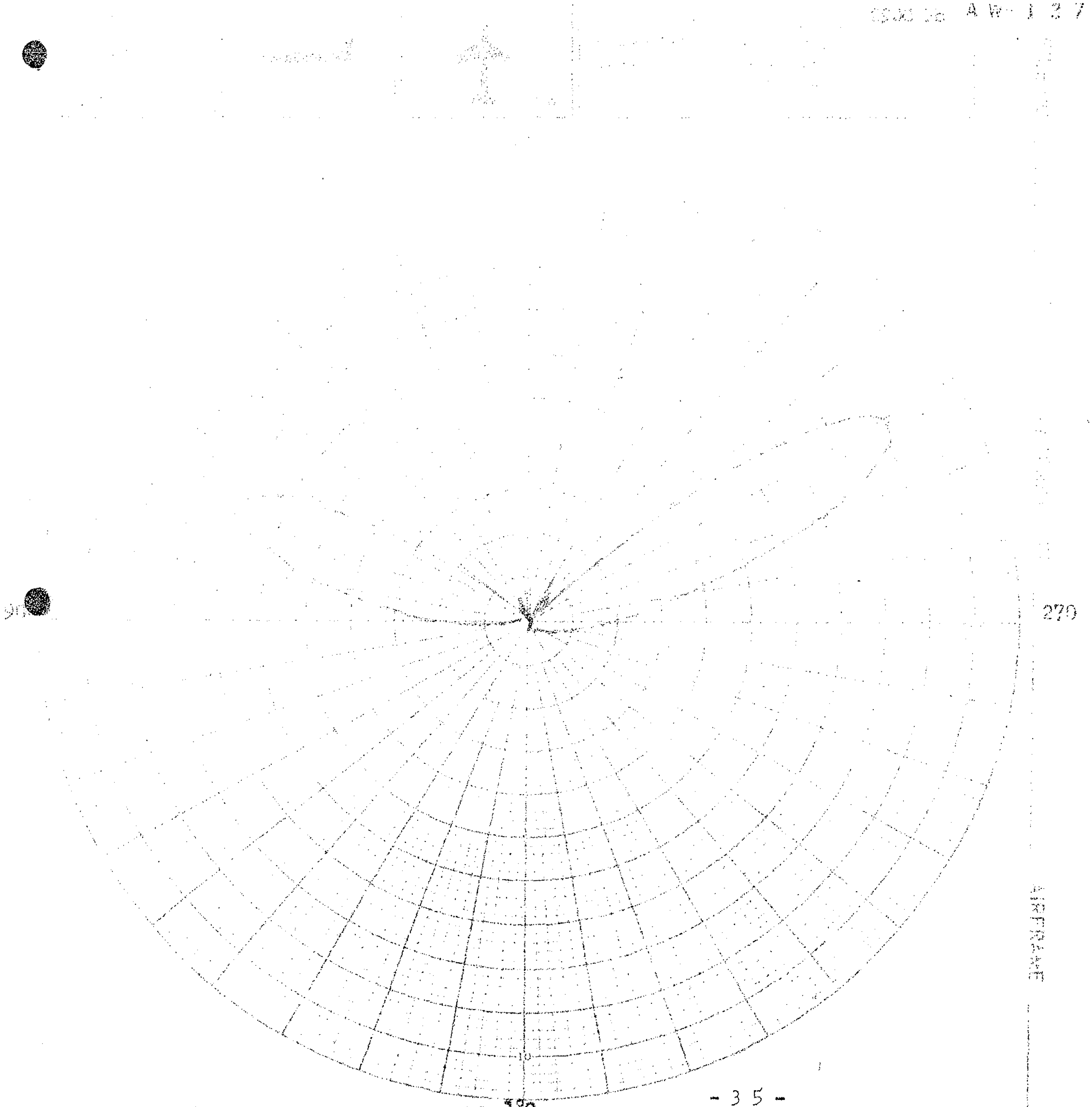

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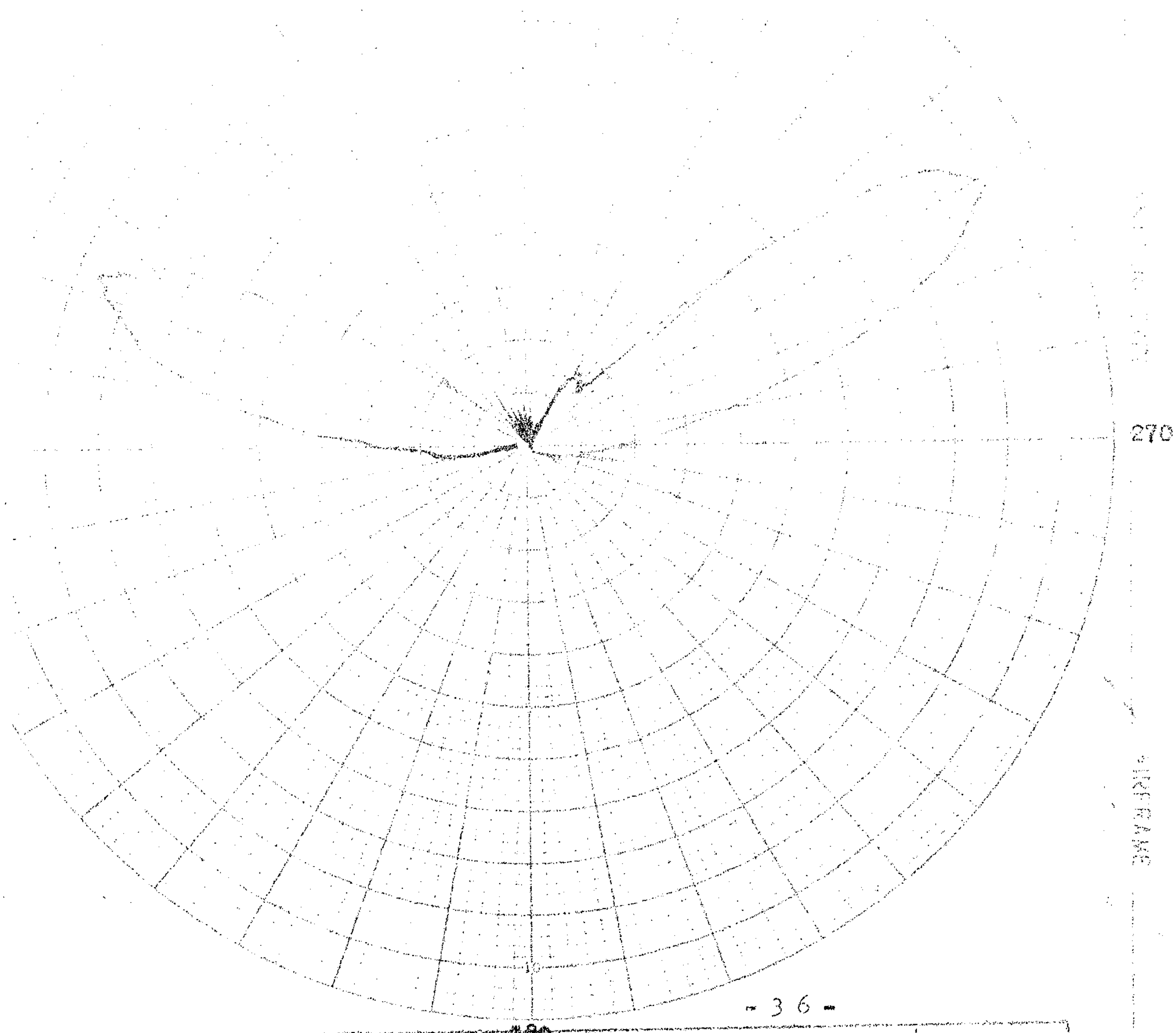

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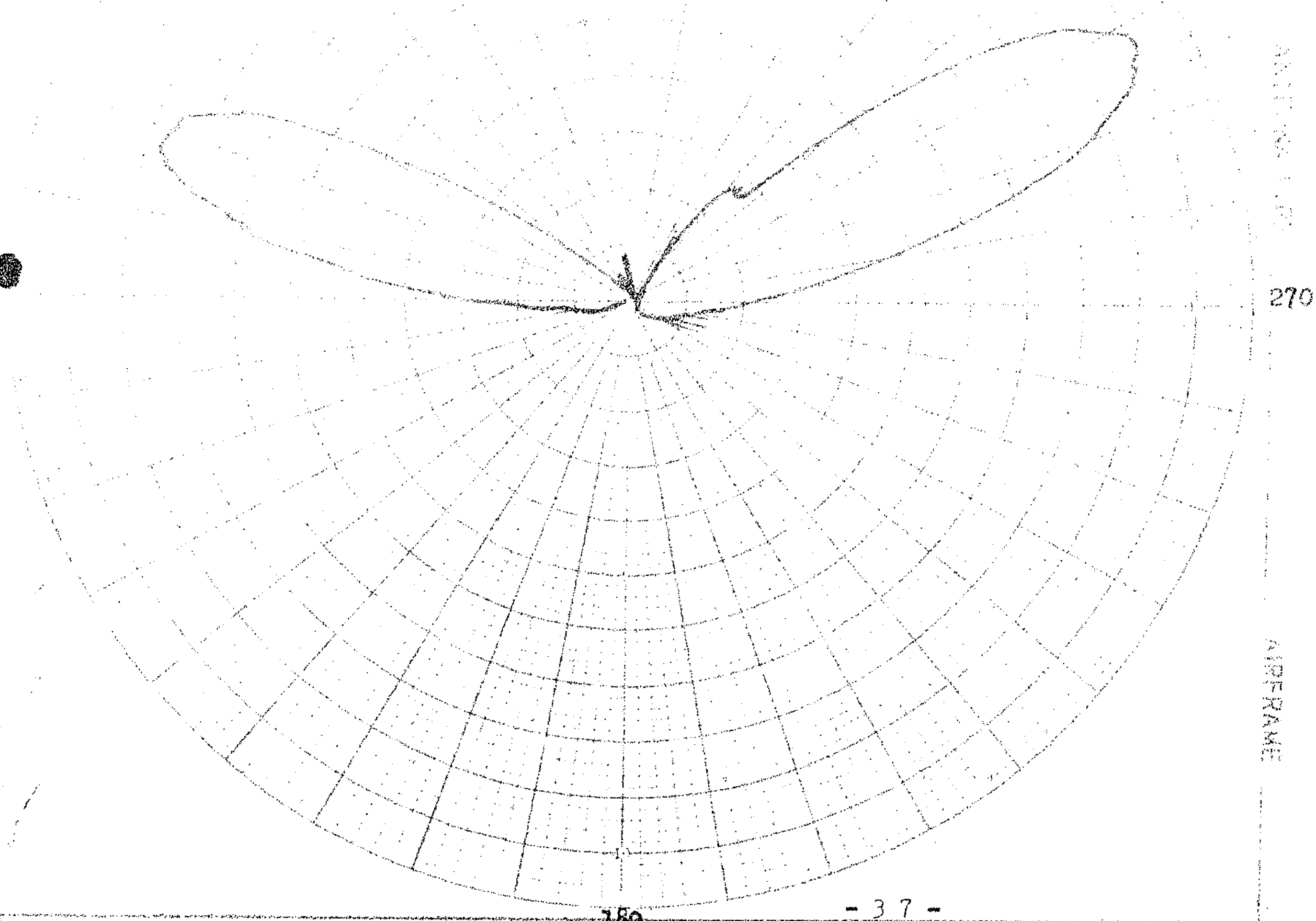

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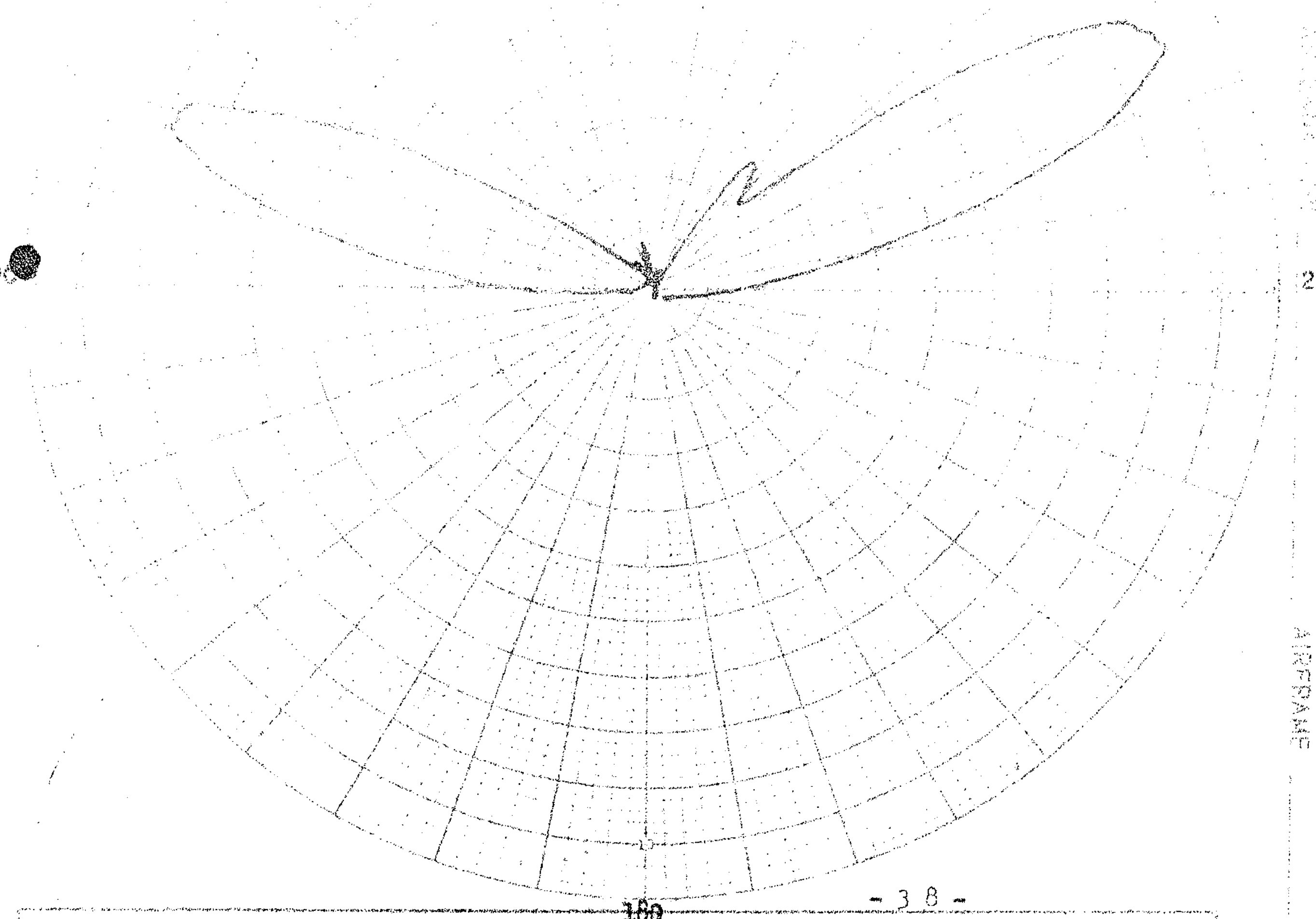

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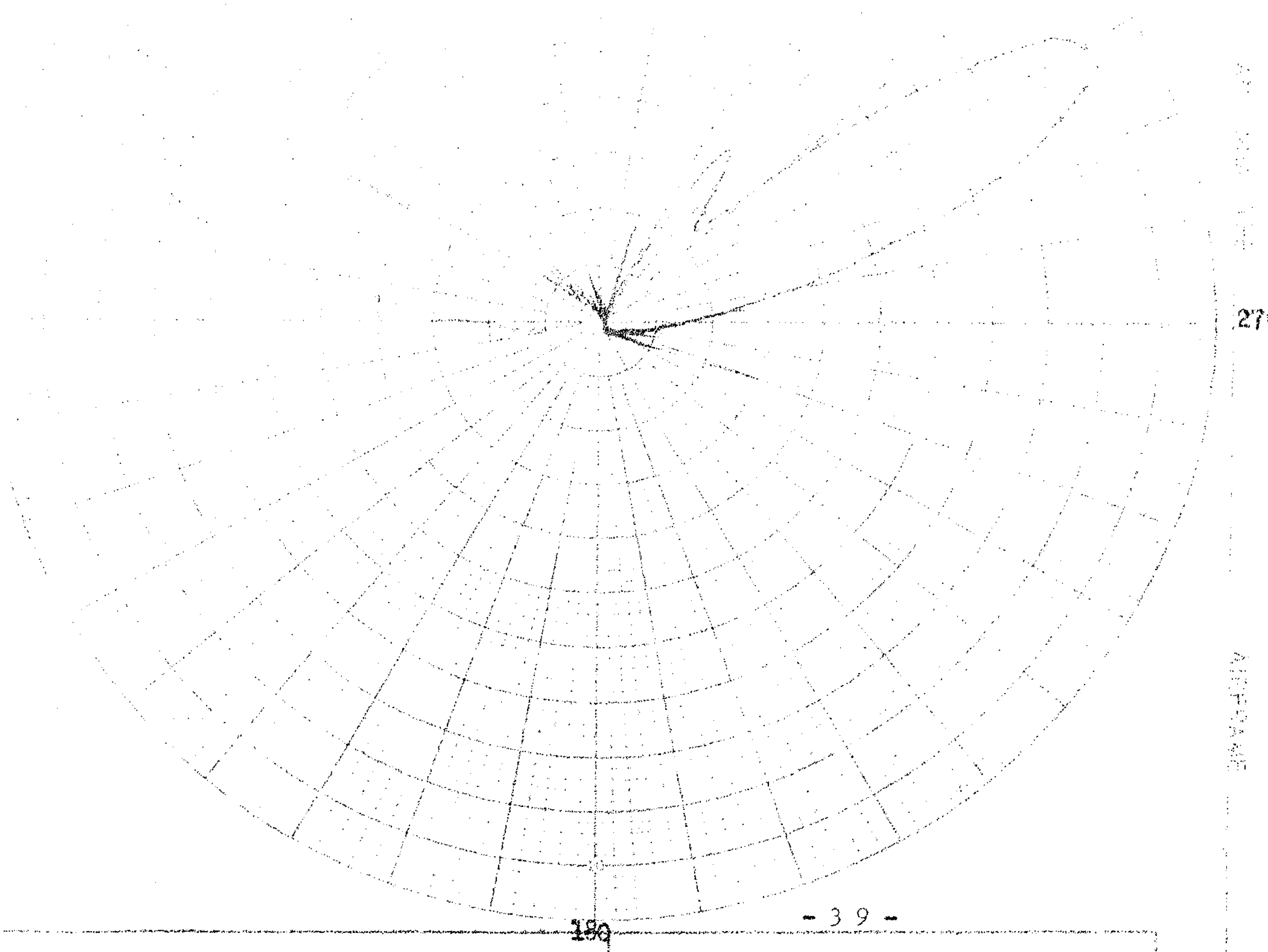
[redacted]

AW-13



OPERATOR ______ APPROVED ______ REMARKS: ______
DATE ______ DATE ______
PATTERN: θ= ______° φ= ______°
CONIC AXIS ______
CONIC ANGLE ______

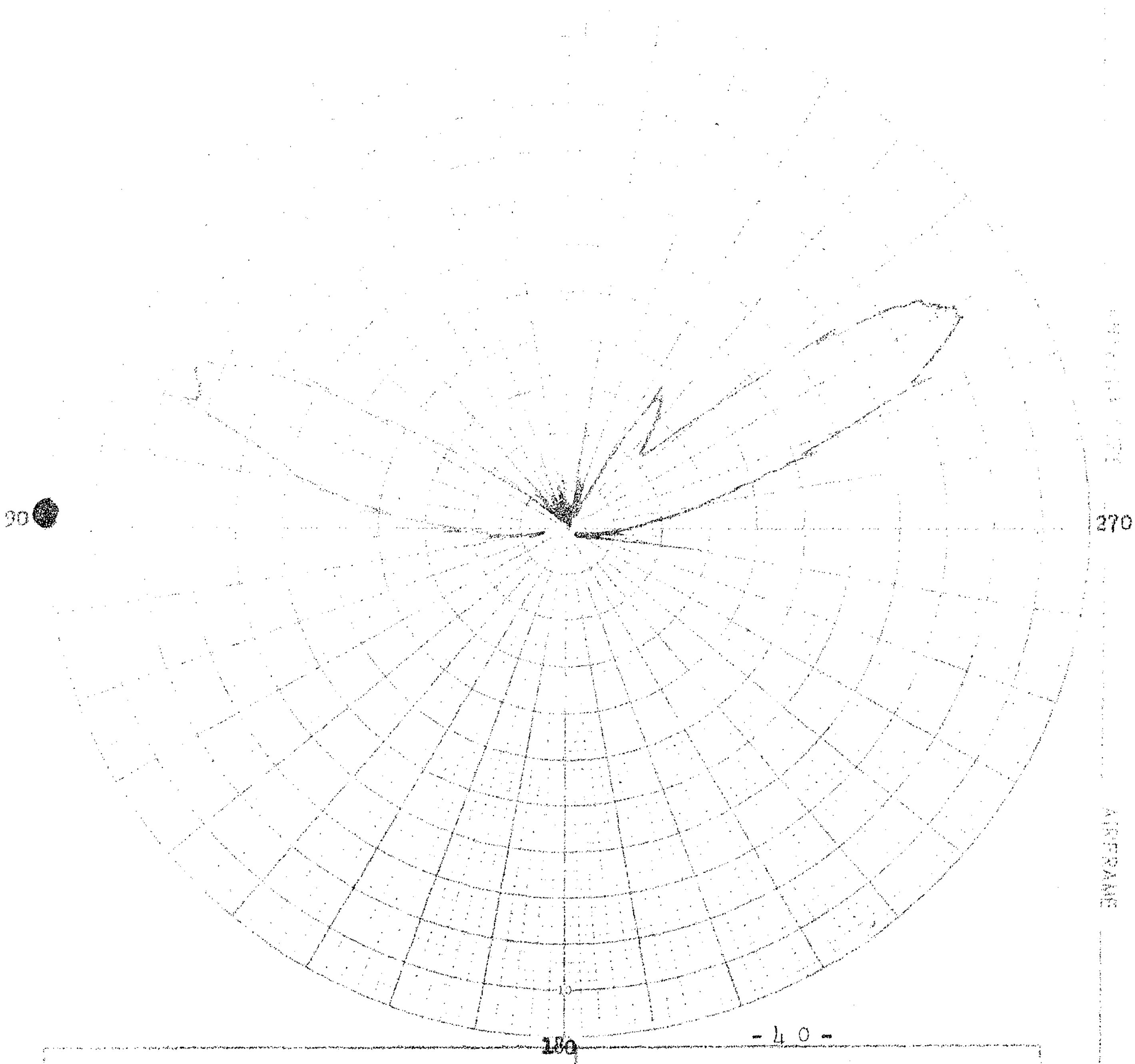
SPECIAL HANDLING

[redacted]

LOCKHEED AIRCRAFT CORPORATION • MISSILE SYSTEMS DIVISION

2,00 Ic AW-1 3 ?

[redacted]



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DATE ______ DATE ______
PATTERN: θ= ______° ϕ= ______°
CONIC AXIS ______
CONIC ANGLE ______

REMARKS: ______

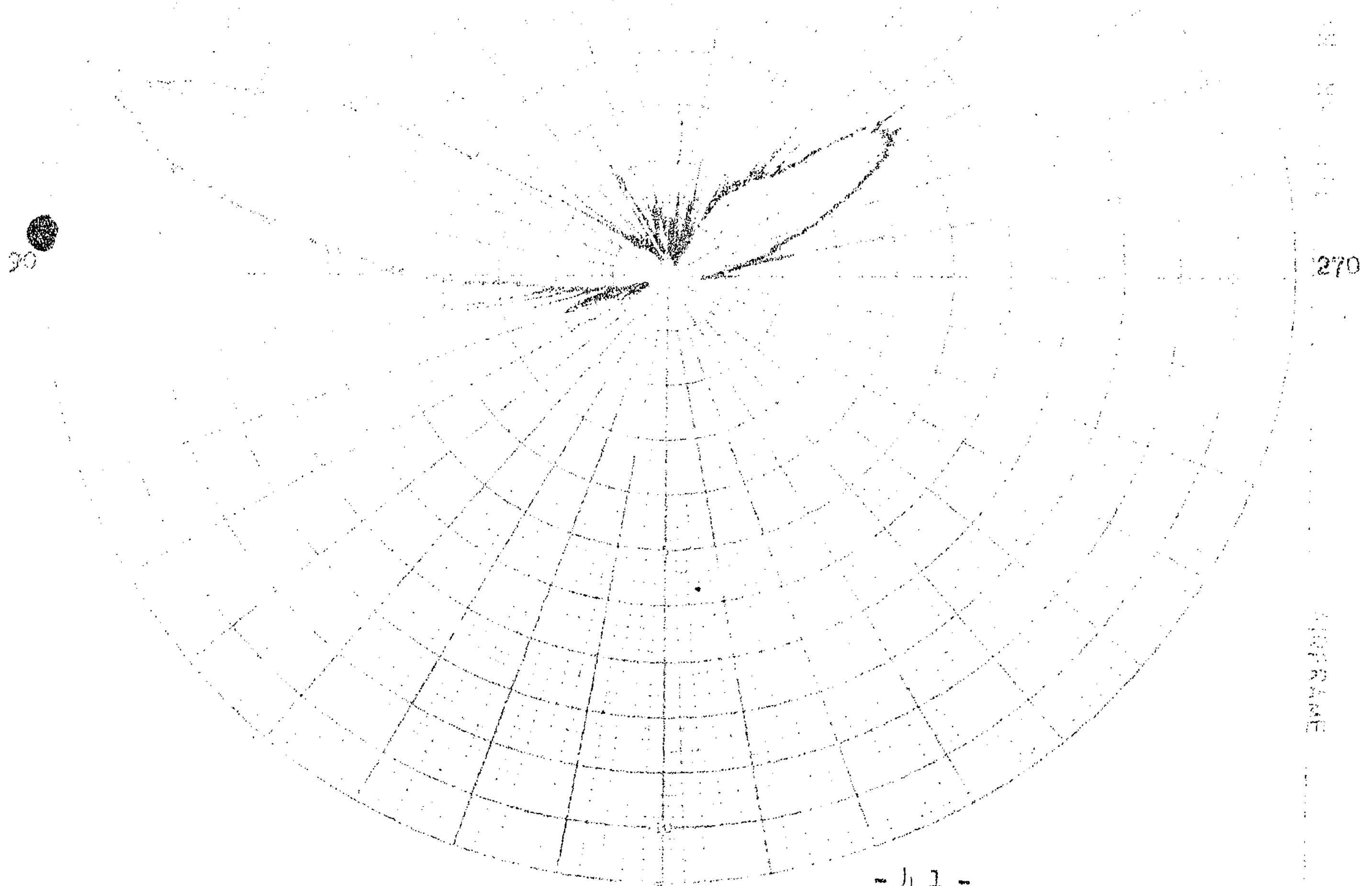
SECRET

SPECIAL HANDLING

[redacted]

FORM ... LOCKHEED AIRCRAFT CORPORATION · MISSILE SYSTEMS DIVISION

3500 Mc AW-137



APPROVED
DATE
DATE
REMARKS:

SPECIAL HANDLING

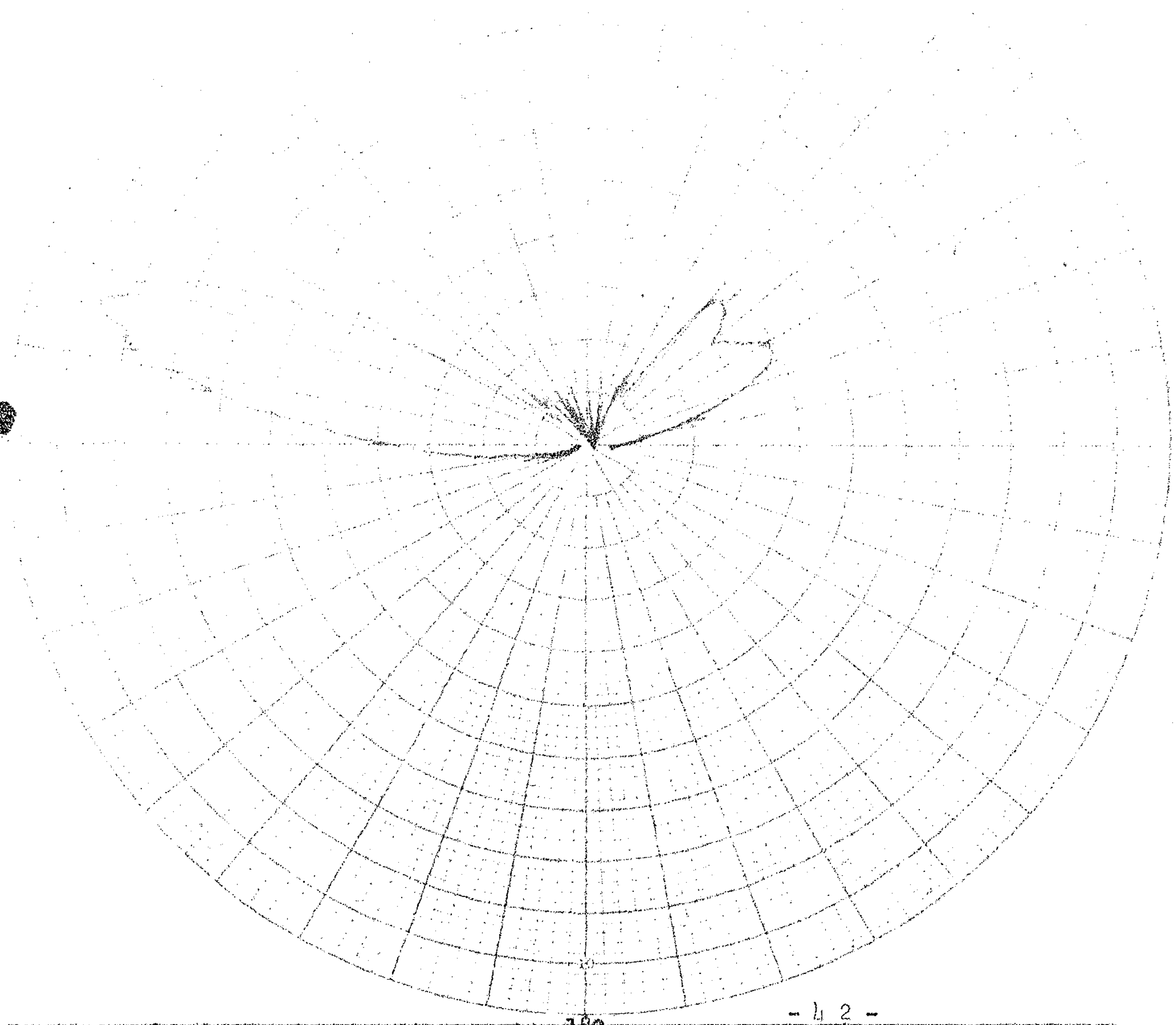
[redacted]

LOCKHEED AIRCRAFT CORPORATION · MISSILE SYSTEMS DIVISION

[redacted]

AW-137

3600



OPERATOR ________ APPROVED ________ REMARKS: ________

DATE ________ DATE ________

PATTERN: θ= ______° ϕ= ______°

CONIC AXIS ________

CONIC ANGLE ________

~~SECRET~~ SPECIAL HANDLING

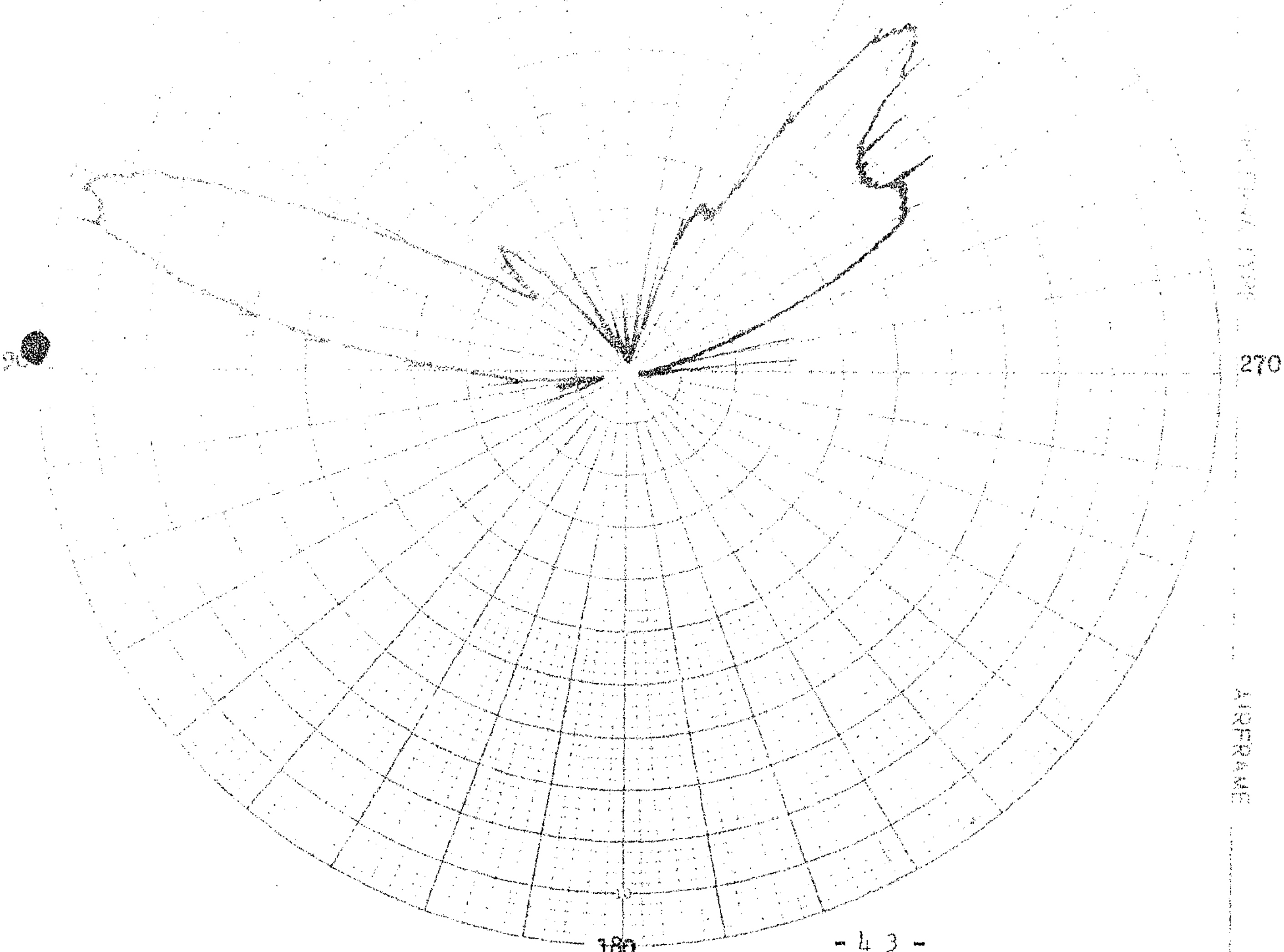
[redacted]

AIRFRAME ________

FORM ___ 588

LOCKHEED AIRCRAFT CORPORATION • MISSILE SYSTEMS DIVISION

3700 Mc AW-137



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DATE ______ DATE ______
PATTERN: θ= ____° φ= ____°
CONIC AXIS ______
CONIC ANGLE ______

REMARKS: ______

SPECIAL HANDLING [redacted]

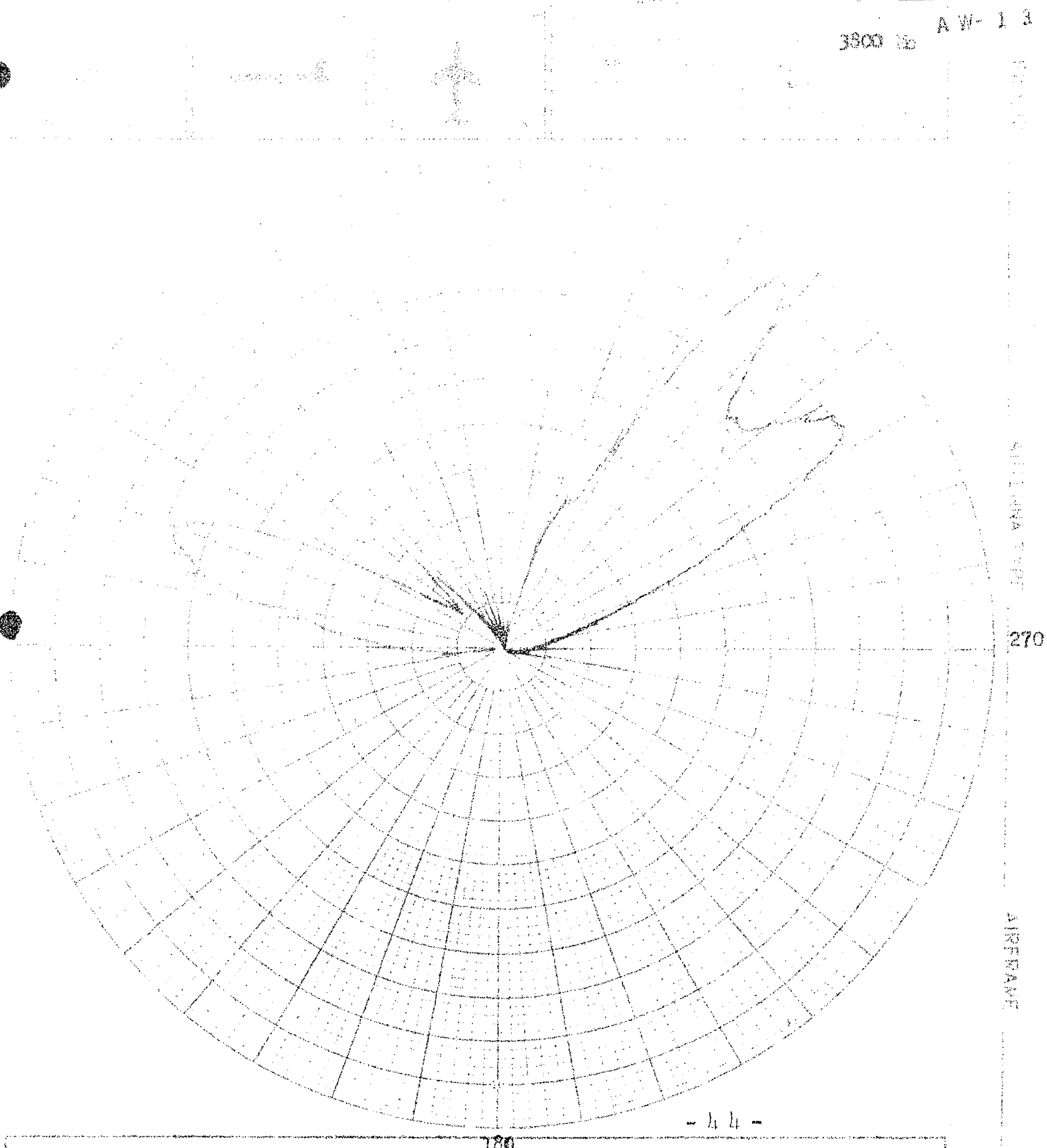
LOCKHEED AIRCRAFT CORPORATION - MISSILE SYSTEMS DIVISION

NRO APPROVED FOR RELEASE
1 AUGUST 2015

[redacted]

AW- 1 3 7

3800 lb



OPERATOR ________ APPROVED ________ REMARKS: ________
DATE ________ DATE ________
PATTERN: θ= ____° δ= ____°
CONIC AXIS ________
CONIC ANGLE ________

[redacted]

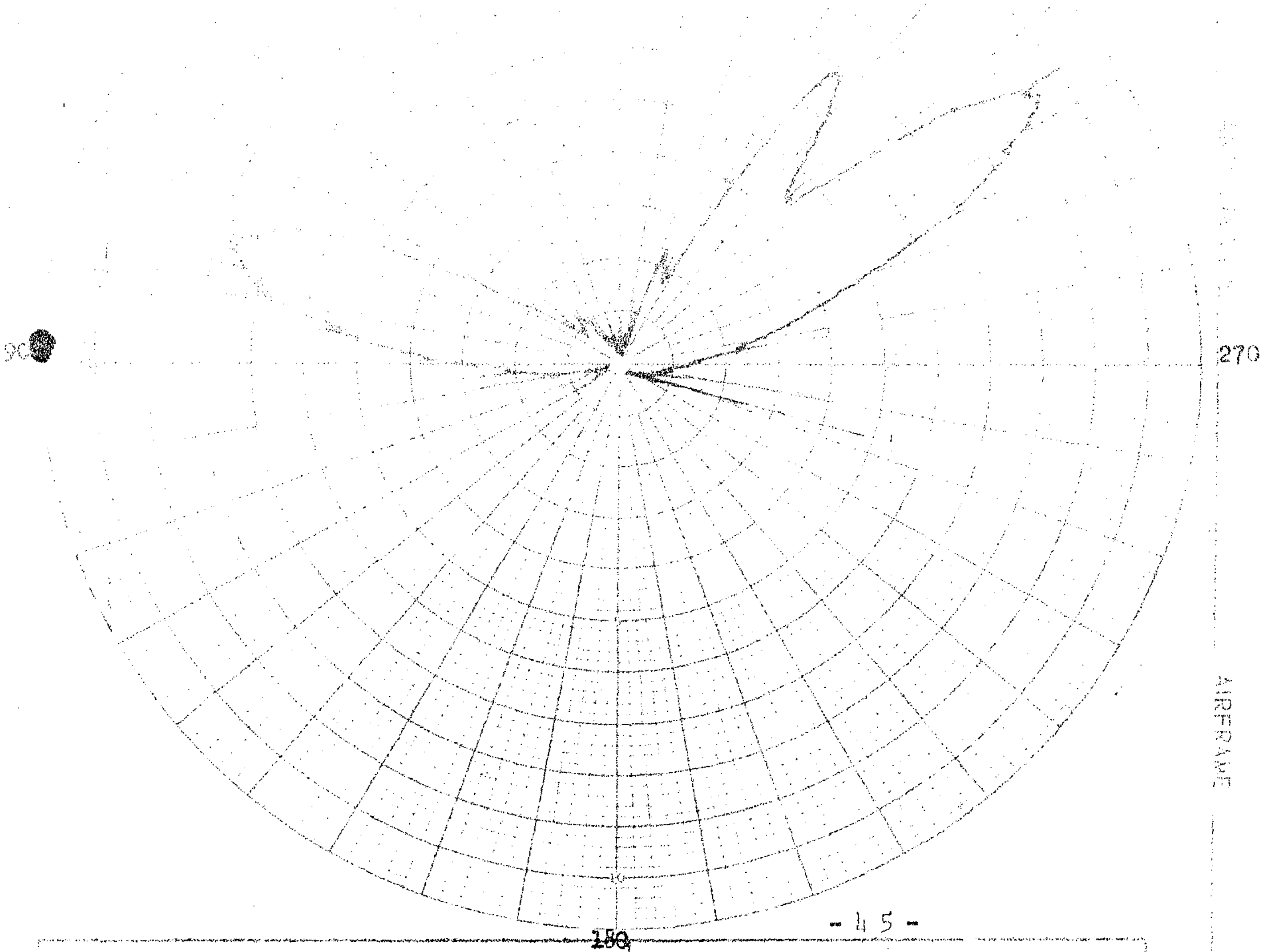
SECRET SPECIAL HANDLING

FORM MSD ...

LOCKHEED AIRCRAFT CORPORATION · MISSILE SYSTEMS DIVISION

NRO APPROVED FOR RELEASE
1 AUGUST 2015

3900 Mc AW-137



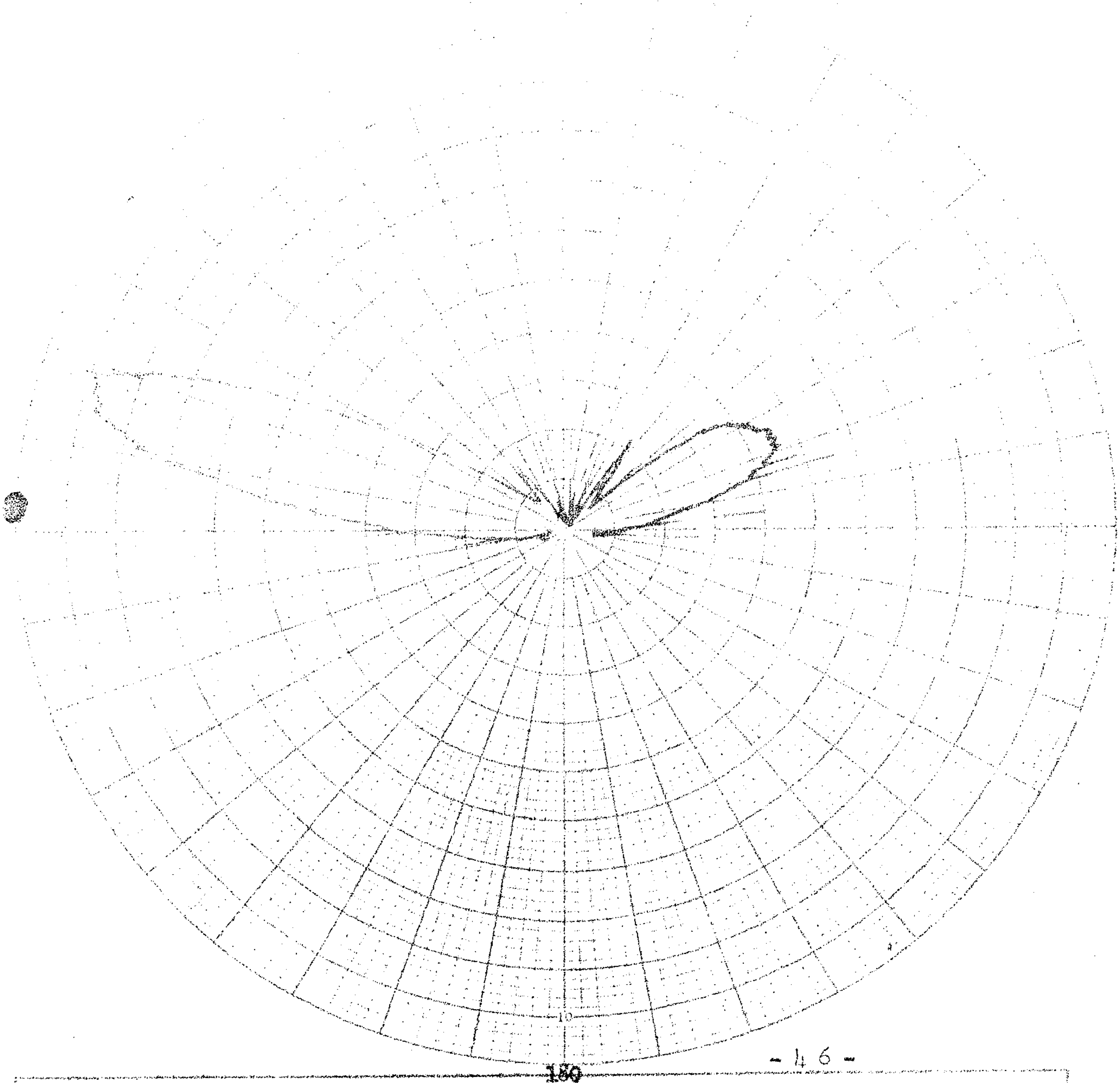
OPERATOR ______ APPROVED ______
DATE ______ DATE ______
PATTERN: θ= ____° φ= ____°
CONIC AXIS ______
CONIC ANGLE ______ ~~SECRET~~

REMARKS: ______

SPECIAL HANDLING [redacted]

LOCKHEED AIRCRAFT CORPORATION • MISSILE SYSTEMS DIVISION

A W- 1 3 7



OPERATOR ______ APPROVED ______
DATE ______ DATE ______
PATTERN: θ= ______ ° φ= ______ °
CONIC AXIS ______
CONIC ANGLE ______

REMARKS: ______

SECRET

SPECIAL HANDLING [redacted]

FORM MSD 546

LOCKHEED AIRCRAFT CORPORATION · MISSILE SYSTEMS DIVISION

[illegible]

[illegible] Recorder: The recorder used in the Plymouth Rock system is [illegible]. The audio frequency response of each track [illegible] for optimum pulse response. Two storage [illegible] read out in a reversed [illegible] of voltage to either one of two [illegible] compensation servo [illegible] recorder.

[illegible] Specifications

[illegible]:

[illegible] Record:	[illegible] minutes plus/minus 1 minute
[illegible] Reproduce:	3 minutes (speed ratio = [illegible]:1 ± [illegible])

Power Requirements:

Source:	+28 volts unregulated. (Range: 22 to 29.25 V.DC
Consumption:	
Record:	[illegible].25 watts (max.)
Reproduce:	12.0 watts (max.)

Control: End of tape sensing shuts off recorder when tape [illegible] at either end. Signal can be used to control other functions or merely be monitored. A command to reproduce will override a record command.

Frequency Response: Each track has a nominal sinewave frequency response of 100 cps to 5 Kc/s. Variation over band is plus/minus 3 db with respect to 1 kc.

Signal/Noise Ratio: 30 db peak signal/r.m.s. noise measured for output band of 700 cps to 10 kc/s.

Impedance:

Input:	25,000 ohms ± 10%
Output:	500 ohms ± 30% resistive at 1 kc.

Note: The recorder will meet all electrical performance requirements for output if output is loaded with 100K ohms minimum.

Dynamic Range:

Input:	1 volt r.m.s.

SPECIAL HANDLING [redacted]

[redacted]

Output:	1 volt r.m.s. ± 15%. Measured at 1 kc with a 1 volt r.m.s. input.
Wow and Flutter:	5% r.m.s. maximum from 0 to 300 cps.

B. 5. Transponder: Present plans for Plymouth Rock do not include use of a transponder.

B. 6. Commutator: The system utilizes fifteen (15) points on a 1 r.p.s. commutator to present status and functional information during data link acquisition. The Data Profile forms a part of the calibration information contained in Section B.3.

B. 7. Payload Telemetry: The Payload requires two wideband channels of [illegible] to 40Kc bandwidth to transmit the two analog signals played back from the tape recorder. This can be accomplished by using the lowest 40Kc of the data link base band and using two data links, by using the base band and a channel F subcarrier, or by using a channel X and a channel F subcarrier. The two latter methods require only one data link transmitter. Tests have shown that the signal to noise ratio of the data is improved by using a subcarrier. Future plans for this system include the use of two subcarriers for the signal data. This also conserves bandwidth, so that the data link can carry other low frequency subcarriers for real time status data. In addition, it leaves room for the insertion of a reference tone when the tone can be added. The data is transmitted on a conventional VHF telemetry link, and recorded at the tracking and readout stations.

B. 8. COMSEC Plans: The analog data is transmitted in the clear on the data link, but speeded up 8 times, due to the RO/RI speed ratio of the recorder. No encipherment is presently planned.

[redacted]

[illegible]. Ground Support Equipment

1. Tracking, Receiving, Recording: The satellite platform is tracked by the stations established for this purpose by the Air Force. Normal operation of this system involves only the four stations of Kodiak, Hawaii, New Hampshire and Vandenburg, although Ascension or Thule are not precluded. The data from the storage system can be read out at any of the above named tracking stations, since the standard seven track instrumentation magnetic tape recorders are capable of recording the data.

2. Data Processing: The method of processing the data was established before the flight receivers were designed. Therefore, the receivers were designed in such a fashion that the data outputs are compatible with the data processing system. The two analog channels are separated from the composite telemetered data, discriminated if necessary, and re-recorded on two tracks of an instrumentation tape recorder, care being taken to maintain time relationship between the two tracks. For purposes of Analysis, the magnetic tape is then played back and the output applied to a dual gun oscilloscope. The output from the swept, or YIG channel, is applied to a "synch" detector which recognizes the group of pulses occurring during the flyback portion of the sweep. The output of the sync detector is applied to the external sync input of one channel of the oscilloscope. The band-end markers and the analog data are then amplified and applied to the beam intensity modulator of the same channel. Intensified markers will appear at the band-ends and wherever an intercept is noted, the intercept marker having a position between the band ends corresponding to the frequency of intercept.

The data from the wide band channel is similarly presented on the second channel of the same oscilloscope. The pulses are first passed through a pulse former to improve the resolution, and the sweep rate adjusted to obtain the desired prf resolution. A film strip is then passed before the face of the oscilloscope, and the swept and wideband channels are simultaneously photographed. Thus time correlation is obtained between the two channels and the frequency and prf of the intercepts can be measured by projecting the image onto a calibrated grid. See "Block Diagram-Data Presentation". The status information is obtained by discriminating the sub-carrier frequency and applying the output to an oscillograph which produces a paper record for visual data reduction.

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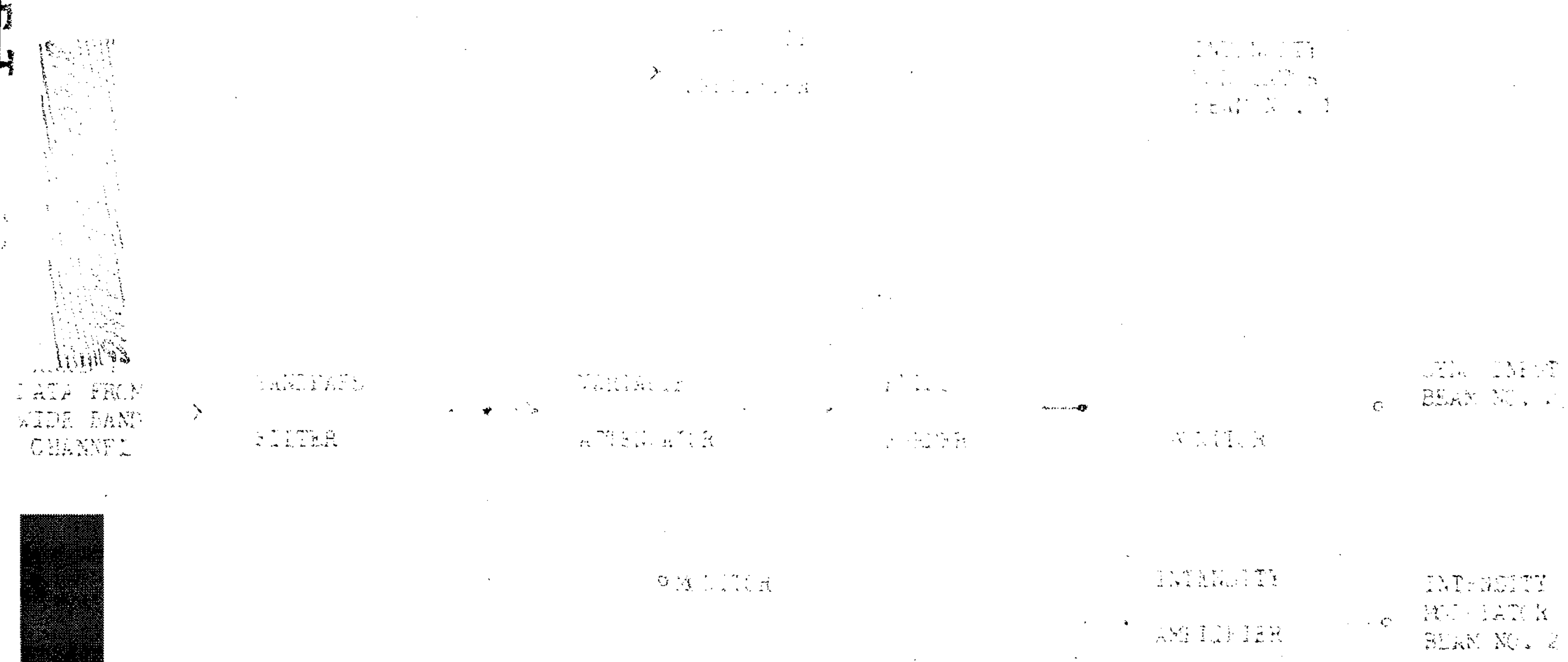

BLOCK DIAGRAM - DATA PRESENTATION UNIT

[redacted]

SECRET

D. Estimate of System Performance:

The reliability to be expected from this system for the specified mission duration of six to fifteen days is very high. Since no statistical analysis has been performed on the components, a numerical figure is meaningless, as it would represent only an engineering opinion. However, equipment of identical construction, of identical com ponent parts, has survived ascent and orbital environment, and operated for a period in excess of the fifteen days mentioned, after having been tested to applicable paragraphs of LMSC 6117B environmental specification. Since recorders, telemetry equipment, command equipment, power supplies, etc., have also survived similar conditions, we can expect that there is essentially a 100% chance that the Plymouth Rock System will perform its function for a fifteen day mission. All flight designs are tested to 6117B.

The confidence to be placed upon the validity of the data of this system depends upon the following factors:

1. The precision with which the calibration curves were plotted. Since this is a laboratory procedure, conditions can be well controlled, and the instruments used for the purpose are carefully maintained. Therefore, the calibration error can be presumed small.

2. The error in the telemetry instrumentation. Since ultimate precision depends upon knowing certain operating voltages and temperatures, it is important to keep the T/M system error to a minimum. With care, it is possible to determine monitor values to within two percent error. A worst case error would be on the order of five percent, for example.

3. Time error caused by repeatedly recording and reproducing the data. There is no speed compensation on the flight recorder, and no reference tone recorded on orbit. While the long time stability of the recorder

[redacted]

is good, there are local speed variations due to wow and flutter. This error must be taken into consideration when evaluating pulse repetition rates. Added to the flight recorder errors is the error of the instrumentation ground recorders. Since reference tones are placed on the ground recorders, however, the wow and flutter of the ground recorders can be compensated, so the error is small compared to that of the flight recorders. The flight recorders are tested for speed variation versus varying conditions of voltage and temperature, so knowing the flight conditions enables some correction to be applied to the timing of the flight data.

4. The YIG filter in the scanning channel probably presents the greatest single error in the entire flight equipment system. In addition to being dependent upon source voltages and temperature, it is affected by the ambient magnetic environment. Masses of magnetic material or magnetic fields in the vicinity of the YIG filter can have the effect of shifting the frequency calibration up or down, but the slope is unaffected for reasonable changes. Therefore, a real time calibration could check the frequency shift in flight. This real time calibration would have to be done with the vehicle beacon non-operating. The vehicle beacon transmits such a strong signal that the wide-band channel is saturated, and the YIG filter skirts are not sharp enough to exclude it even when tuned considerably away from the beacon frequency.

5. Sensitivity difference between the wideband and scanning channels may cause failure to indicate frequency on some of the low level signals, since the scanning channel has less sensitivity than the wideband channel.

In spite of the seeming gross error which might result from totalling the above individual items, results of tests made with the entire system, including the data link, yield excellent correlation with the test inputs.

These are detailed in the Stanford report, which is referenced in this report.

The travelling wave tube preamplifier which is intended for use with the next Plymouth Rock has not yet been completely evaluated. It is expected to increase the frequency resolution, and eliminate error due to sensitivity differences. There should be no error introduced by the addition of the amplifier.

Other errors in the system can result during the data processing or conversion, but since this takes place under laboratory conditions, it is presumed that the conditions can be controlled, and corrections made for errors.

In summary, if care is taken to consider and compensate for the various errors as they occur between the collection and processing, the resultant data can be meaningful.

A P P E N D I X

References:

1. Stanford Electronic Laboratories

   SEL-[illegible] Quarterly Program Report

   Part III - "Project 5[illegible] - Special Purpose Reconnaissance Techniques".

2. Lockheed Missiles and Space Company

   LMSC [illegible]117B - "General Environment Specification for Agena Satellite Programs".