NASA CR-122375

STAR

GENERAL INSTRUMENT CORPORATION

ELECTRONIC SYSTEMS DIVISION

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CAT. 14

NASA CR-122375

STAR

FINAL REPORT

NIMBUS 4/IRLS BALLOON INTERROGATION

PACKAGE (BIP)

Prepared for:

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Contract No. NAS5 - 21110

Prepared by:

General Instrument Corporation
Electronic Systems Division
Hicksville, New York

October 1971

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1.0 INTRODUCTION

The Balloon Interrogation Package (BIP), an integral part of the overall Interrogation, Recording, and Location Subsystems (IRLS) for the Nimbus 4 program, was produced by the General Instrument Corporation/Electronic Systems Division, Hicksville, New York, for the National Aeronautics and Space Administration, Greenbelt, Maryland, under contract number NAS5-21110. The BIP is a self-contained, integrated transponder designed to be carried aloft by a constant altitude, superpressure balloon to an altitude of 67,000 or 78,000 feet. After launch the BIP senses high-altitude balloon overpressure and temperature, and upon receipt of an interrogated command from the IRLS aboard the Nimbus 4 satellite, the BIP encodes the data on a real-time basis into a pulse-code modulation (PCM) format and transmits this data to the satellite.

The Nimbus 4/IRLS Balloon Interrogation Package experiment was highly successful in delivery of equipment, Ascension Island support, and equipment flight life. Extensive meteorlogical data was obtained from the many BIP balloon flights; some of which had made many revolutions of the earth at the equator. While the reduction and analysis of the balloon flight data will take an extended period of time, there is no doubt that the results of this program will significantly contribute to the understanding of the upper atmosphere.

This final report presents a summary of the program activity to produce thirty BIP systems and to support balloon launches from Ascension Island.

2.0 TRANSMITTER

Figure 2-1 is a photograph of the transmitter assembly, the receiver, and interconnection cable. The complete transmitter schematic is shown in Figure 2-2.

2.1 Diplexer

The 3 pole filter and the 5 pole filter which comprise the diplexer were not changed electrically, however, extensive mechanical changes were implemented. Instead of machining the housings for these two units out of a solid block of aluminum, investment castings were used. This technique reduced the cost and ensured uniformity of units. Previously the coils were dip brazed to the housing. This technique presented problems, such as an elaborate fixture to prevent heat distortion, as the housing and the coil must be subjected to 1100°F for dip brazing. The diplexer coils are now dip brazed to an aluminum flange which in turn is fastened by screws to the side wall of the housing. These mechanical changes resulted in a smooth production test of the 3 pole and 5 pole filters.

2.2 Low Level

Two resistor-thermistor networks are used to temperature compensate the VCXO for center frequency and deviation sensitivity. Previously, decade resistor boxes in conjunction with many temperature runs were used to synthesize each network. Obviously this method would be too laborious and expensive for

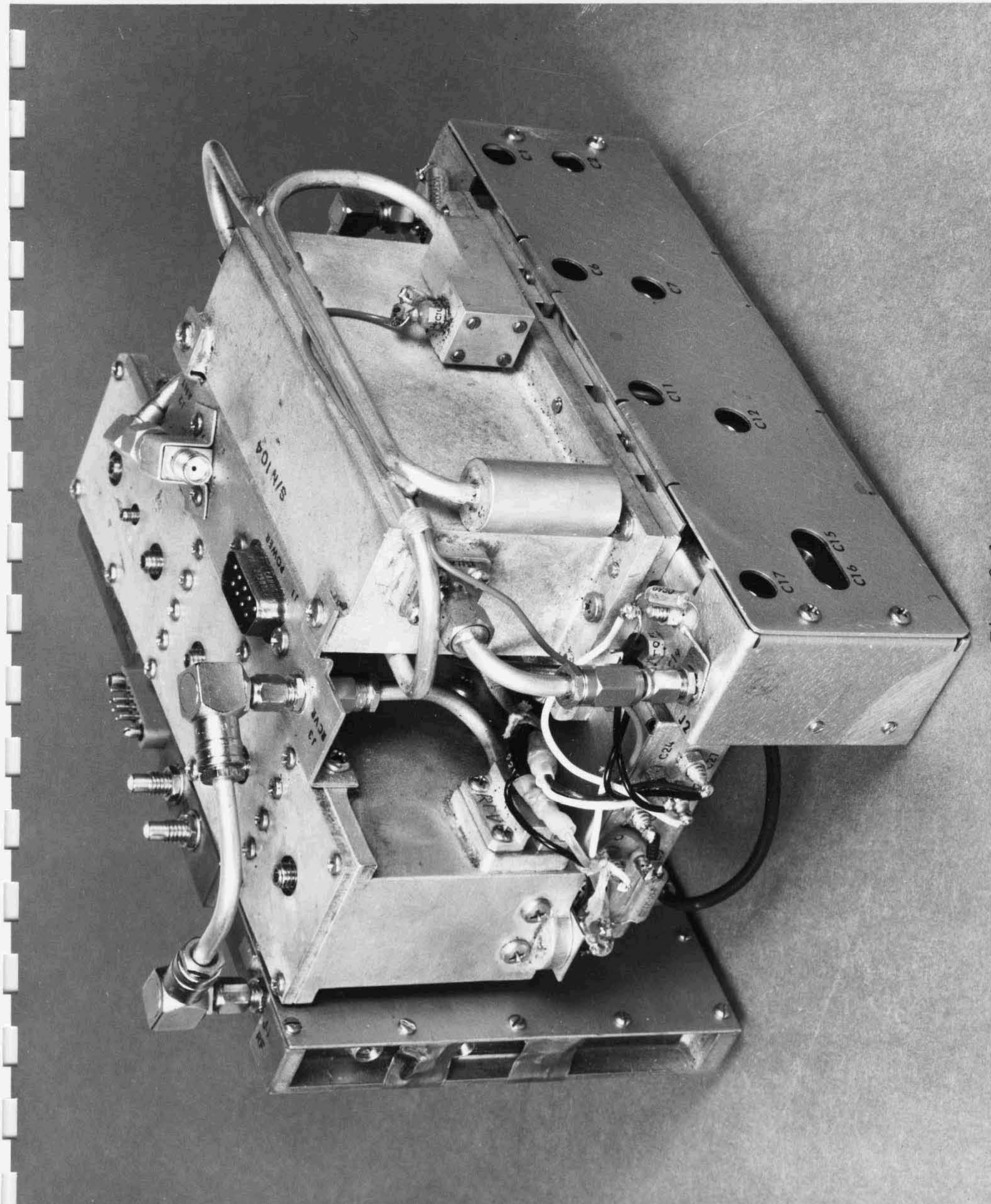

Fig. 2-1

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production; therefore a computer program was developed to synthesize the required networks. After the initial debugging of the computer program, the VCXO temperature compensation became a routine production test.

2.3 Multiplier

The X4 multiplier was completely redesigned to eliminate the previous design limitations and tuning difficulty. The technique of a floating printed circuit board ground was used. This eliminated an empirically derived emitter tuning network which could not be controlled in production. Also the new design provided a test point between the first and second multiplier that made the alignment relatively simple. Each multiplier stage is aligned separately with a signal generator and then the two are cascaded together. The new multiplier also has an RF power output safety margin of 40 milliwatts minimum.

2.4 Power Amplifier

The power amplifier was not changed other than some minor decoupling modifications.

The output stage of the power amplifier uses a 2N4431 overlay transistor. These devices were originally purchased from Solid State Scientific (SSS) for the thirty production units. It was found, however, that the SSS transistors were very sensitive to load VSWR variations. An increase in VSWR from 1:1 to 1:12 or 1:13 would in most cases cause the transistor to fail. For the development contract, these transistors were purchased from TRW and were not load sensitive. Investigations revealed that while the SSS 2N4431 met the JEDEC specifications it had a typical VCEO of 45 volts, just over the specified minimum. However, the TRW 2N4431 has a nominal VCEO of 60 volts. This higher VCEO allows the TRW 2N4431 to withstand the variation in load VSWR without damage. The SSS 2N4431 transistor was replaced with TRW transistors and no further difficulties were encountered.

3.0 RECEIVER

Figure 3-1 and 3-2 are photographs of the BIP receiver. A complete schematic of the BIP receiver is shown in Figure 3-3.

3.1 Housing

As in the case of the 3 pole and the 5 pole filters, the receiver housing was not machined from solid aluminum, but an investment casting was used.

3.2 Local Oscillator

The 37 MHz crystal oscillator was purchased from Frequency Electronics. This compact unit is very similar to one of its product line items, and as in the past this item has worked well with no problem areas.

3.3 RF and Multiplier Assemblies

The preselector had minor modifications. For example, the neutralization loop was removed as it proved to be a source of instability under variation of driving source impedance. The gain difference, with and without neutralization, was negligible. Additional supply line decoupling was added to the X10 step recovery diode multiplier to ensure stable operation over all conditions (C217, RFC201, and RFC202 as shown in Figure 3-3). The multiplier output tapped coil was changed

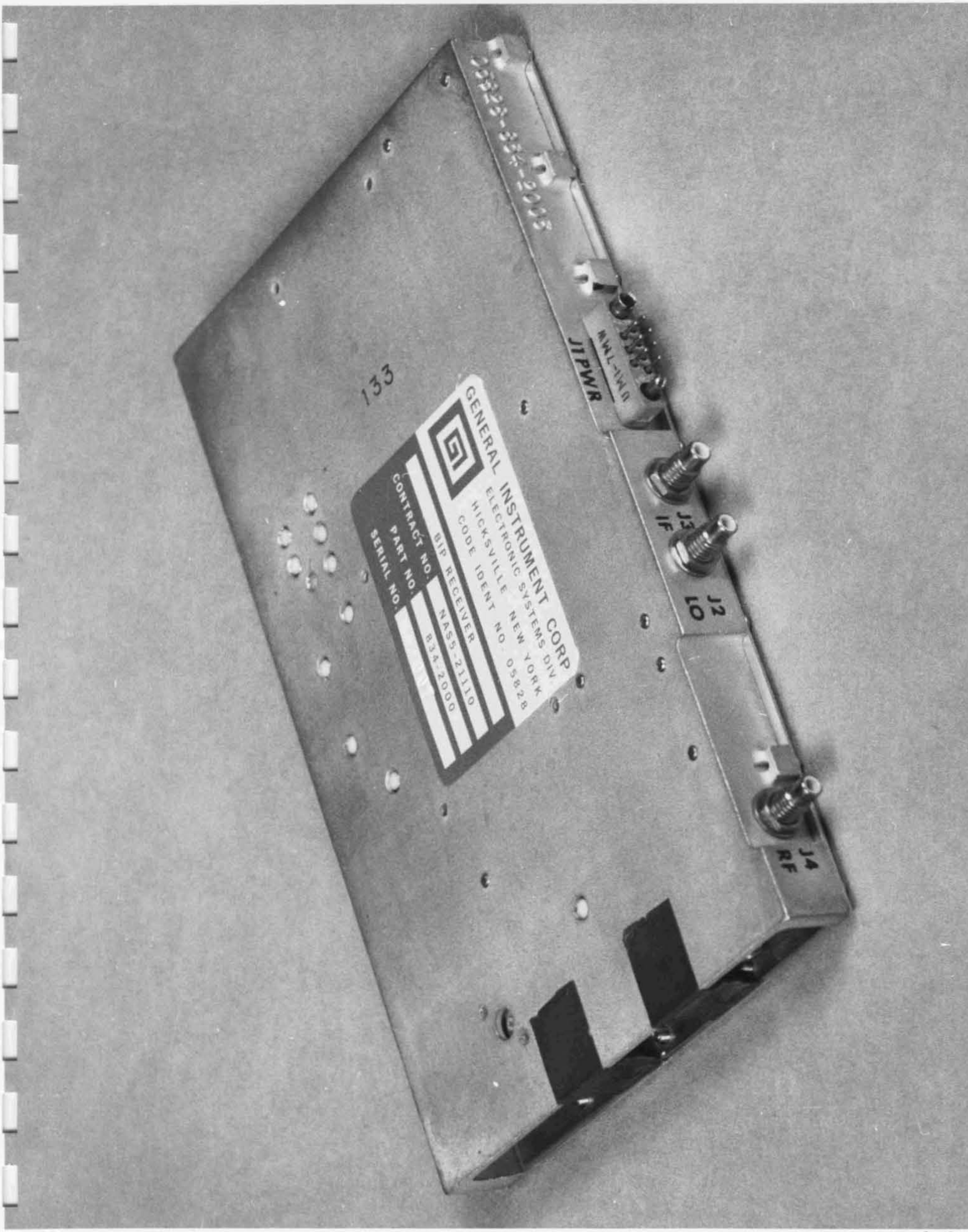

GENERAL INSTRUMENT CORP
ELECTRONIC SYSTEMS DIV
HICKSVILLE NEW YORK
CODE IDENT NO. 05828
BIP RECEIVER
CONTRACT NO. NAS5-21110
PART NO. 834-2000
SERIAL NO.
133
J1 PWR
J3 IF
J2 LO
J4 RF

Fig. 3-1

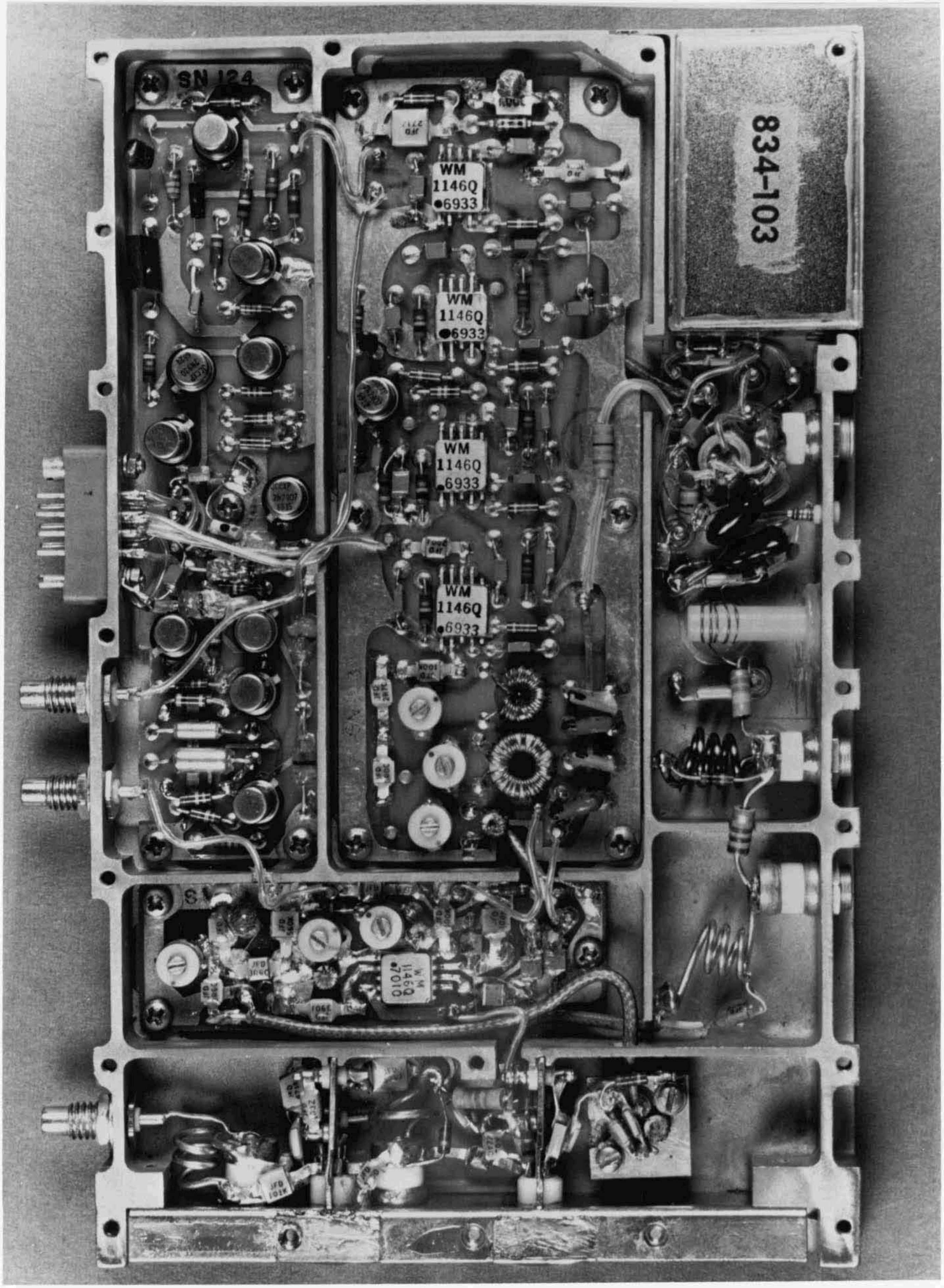


Fig. 3-2

FOLDOUT FRAME 1

FOLDOUT FRAME 2

ZONE	LTR	DESCRIPTION
	D	REPLACES REV C WITH CHANGES ECN 70-1519
	E	EXTENSIVELY REVISED PER ECN 70-1648
	F	[illegible] R10 AND R11 ECN 70-1878

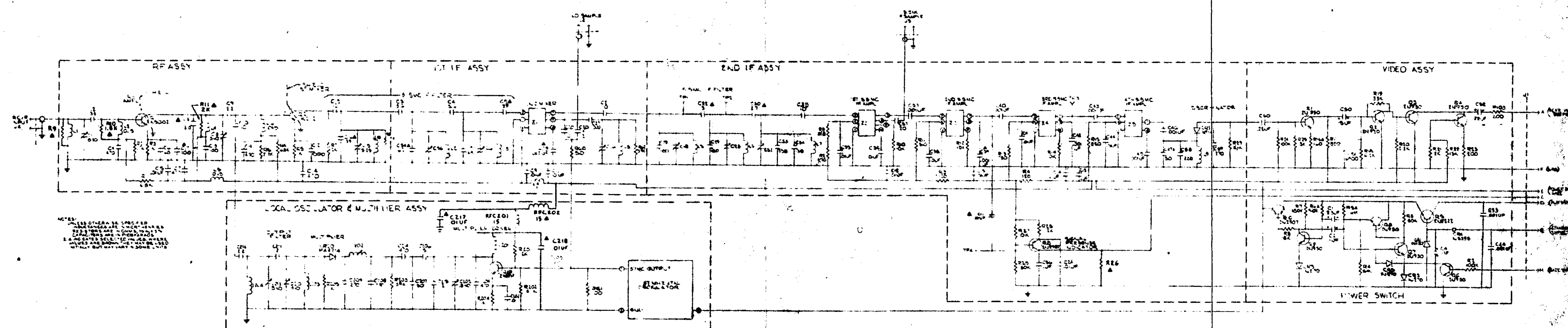


FIG. 3-3 - RECEIVER SCHEMATIC

1834-2001

to top capacitive loading. Small turn, tapped coils are too difficult to control in production.

3.4 First IF, Second IF, and Video Assemblies

The First IF amplifier, the Second IF amplifier, and the video amplifier had minor circuit component modifications. The input impedance of the power switch which is located in the video assembly printed circuit board was reduced to 100K ohms (see Figure 3-3). This change was implemented, per NASA's direction, to reduce the possibility of "pick-up" in this high impedance circuit.

3.5 Special Radio Set Tests

A time delay variation vs. incoming frequency signal level, and temperature study was conducted during the initial phases of this contract. First a new method of measuring time delay variation was perfected. Previous to this contract, time delay variation was measured on an oscilloscope by observing the raw video signal out of the receiver. At low signal levels the video signal is, of course, very noisy, thereby making accurate time delay variation measurements very difficult, if not impossible. Figure 3-4 shows the test set-up of the new method devised under this contract. By using the bit synchronizer, located in the electronics sub-assembly, the reconstituted video signal is observed on the oscilloscope. This new method also measures the time delay variations of the bit synchronizer, as well as the BIP receiver. Using this method the total time delay variations of GFE receivers #32401 and #32403 was 1.3 and 0.8 μsec, respectively. BIP S/N 004 bit synchronizer was used for these measurements. All production BIP receivers had time delay variations of less than ±1.0 μsec.

During the months of December 1969 and January 1970 GFE BIP systems #002 and #003 were interrogated approximately 10,000 times. This investigation was initialed, at NASA's direction, in order to try to simulate the "transmitter turn-on, receiver turn-off" phenomenon that was claimed occurred in the BIP animal pack.

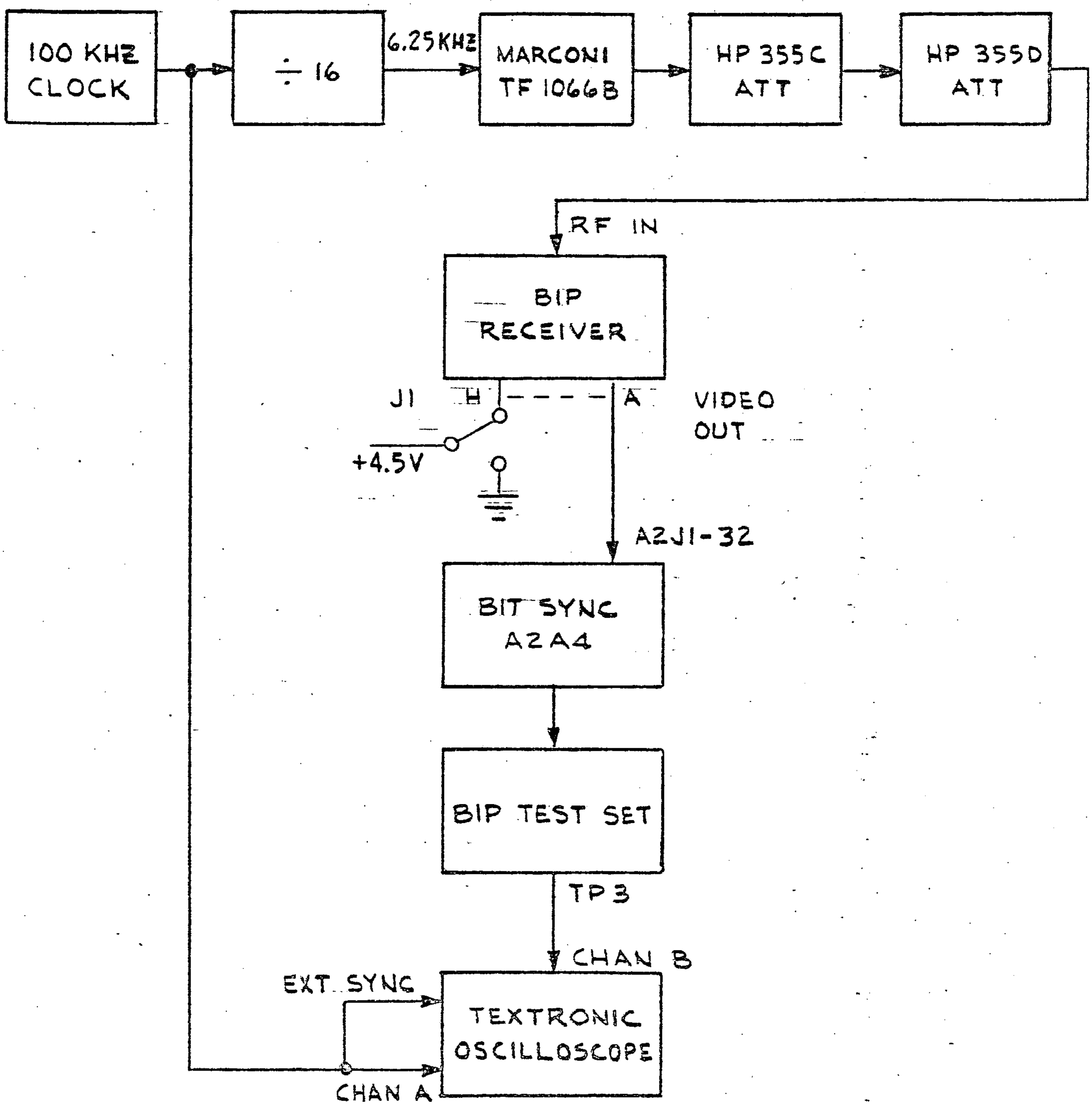
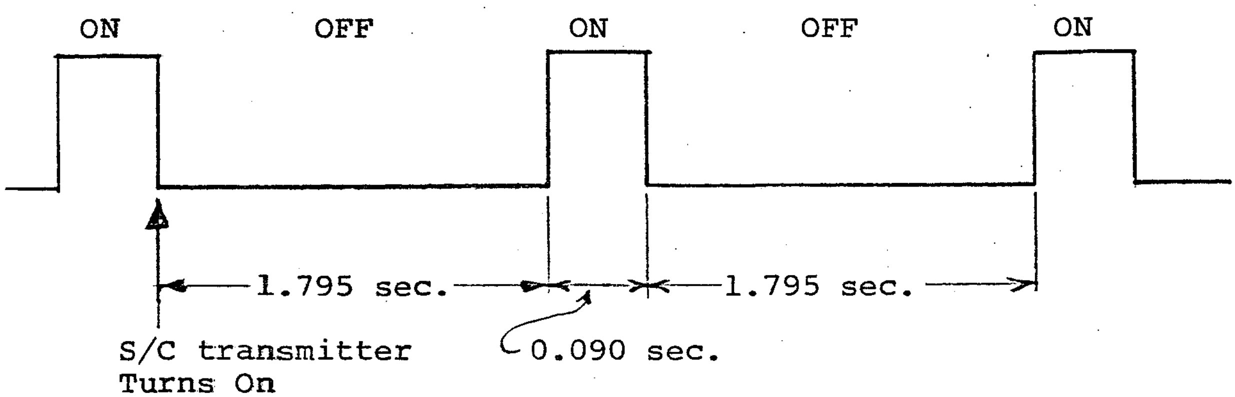


FIGURE 3-4, TIME DELAY VARIATION TEST SET-UP

It was further claimed that RF energy from the BIP transmitter was causing the BIP receiver power switch to turn-off. This problem manifested itself by a normal receiver "ON" cycle (97.5 msec) after BIP interrogation, instead of the normal data frame transmission. However, the normal data frame transmission always occurred when the receiver turned on the second time. In investigating this problem it was observed that address correlation did not occur when the receiver recycled, therefore the transmitter power could not come on. The problem appeared to be in the address correlator.

Discussions with R. Morrison, Radiation, Inc. engineer, brought to light the fact that this was a statistical phenomena that had been observed in the past. This phenomena is due to the positions of the phase locked loop in the bit synchronizer and the receiver "on-time". Thus, when the receiver "on-time" is at the minimum specified width (90 msec) and the frequency difference between the incoming signal and the phase locked loop oscillator is large, the probability of missing an address correlation is highest. This would only be a system problem if a data frame transmission is not completed in 3.6 seconds which may occur if the S/C transmitter turns on at or near the end of the receiver "on cycle". The diagram shown on the following page illustrates this point if it is assumed that the S/C transmitter turns on at the end of the first receiver on period, and address correlation is not made during the second receiver on period. Thus, the total time before the receiver will turn on again is 1.795 + 0.090 + 1.795, or 3.680 sec.

RECEIVER DUTY CYCLE



Since the S/C transmitter is programmed to turn off if the BIP address is not received in 3.6 seconds, an unsuccessful data link would result.

During the above described investigations the receiver was subjected to conducted and radiated RF power from 10 to 480 MHz to try to simulate the BIP animal pack problem. No degradation of receiver or transmitter performance was observed.

4.0 ANTENNA

In the early part of December 1969 a subcontract was placed with the Technical Appliance Corporation (TACO), a division of the General Instrument Corporation, to manufacture thirty (30) BIP antenna systems. A GFE BIP antenna (manufactured by Radiation, Inc.) was shipped to TACO for testing in order to determine conformance to paragraph 3.4.2 of GSFC specification S-733-P-8-A dated May 1969. The salient requirements of this specification are listed below.

1. The antenna must be right circularly polarized and have a bifolium shaped power pattern.

2. The transmitting frequency shall be 466.0 MHz. The receiving frequency shall be 401.5 MHz.

3. The input VSWR shall be 1.5/1 or less.

4. The axial ratio shall be less than 3 db over the pattern of interest (between 15 and 75 degrees above the horizontal.

5. The gain of the antenna over isotropic shall be at least 5 db. The 15 to 75 degree elevation angle gains are 3 db and 0 db respectively. At angles below 15 degrees, the antenna gain should drop abruptly.

However, it was agreed that as a minimum the BIP antennas, as manufactured by TACO, would conform electrically to the performance characteristics of the GFE BIP antenna.

TACO reported to General Instrument Corporation that their evaluations of this GFE BIP antenna showed that it was tuned to 460 MHz rather than 466 MHz. This fact was uncovered after most of the evaluation data had been taken. This GFE BIP antenna had an axial ratio greater than 3 db at 466 MHz and low gain both at 401.5 MHz (15° from horizontal) and at 466 MHz (all elevation angles). At NASA's direction, Radiation was consulted in order to determine if this was a representative sample of the Radiation manufactured antennas. Radiation agreed that the axial ratio data that TACO measured was representative of the data that they had measured. Also, the directional pattern data measured by both firms were almost identical. As for the antenna gain, Radiation used the technique of pattern integration (directional pattern), instead of absolute gain measurements, to calculate the gain. For this calculation, Radiation assumed a cable loss, axial ratio, and other losses to arrive at their predicted gain. However, TACO measured the gain of the BIP antenna by comparison with a linearly polarized standard gain antenna. TACO then added 3 dB to these measurements as the BIP antenna is circularly polarized. Both TACO and Radiation agreed that the gain comparison measurements would be more accurate if the linear elements were considered separately. Since this antenna was tuned at 460 MHz, and possibly damaged, no further measurements were made.

Data (Figures 4-1 through 4-20) obtained from the first TACO built production antenna are included at the end of this section.

First, a brief description of the figures is given:

Figure 4-1   The BIP element gain is compared to a standard gain antenna (+2.7 dBi) at 401.5 MHz in the E-plane.

Figure 4-2   The BIP element gain is compared to a standard gain antenna (+2.7 dBi) at 466 MHz in the E-plane.

Figure 4-3 through 4-8   - These polarization patterns of the BIP antenna were obtained by periodic electronic switching of the E & H plane of the illumination antenna while rotating the BIP antenna about the symmetrical axis. The axial ratio at any angle is obtained by measuring the maximum to minimum excursion during a switching period. The table below summarizes the pertinent data relating to these figures.

Figure No.	Frequency MHz	Maximum Axial Ratio, dB	Ground Plane Angle Degrees
4-3	401.5	1.9	15
4-4	401.5	1.9	45
4-5	401.5	3.1	75
4-6	466	3.0	15
4-7	466	3.9	45
4-8	466	15.5	75

Figures 4-9 through 4-20 show the directional patterns of the BIP antenna.

The test variables for these patterns were:

1. Frequencies of 401.5 and 466 MHz.
2. E and H plane illumination.
3. Axis of symmetry angle.

The directional patterns were generated by rotating the BIP antenna about a ground plane diameter. The table below summarizes the test conditions of these figures.

Figure No.	Frequency, MHz	Plane	Axis of Symmetry Angle, Degree
4-9	466	E	0
4-10	466	E	45
4-11	466	E	90
4-12	466	H	0
4-13	466	H	45
4-14	466	H	90
4-15	401.5	E	0
4-16	401.5	E	45
4-17	401.5	E	90
4-18	401.5	H	0
4-19	401.5	H	45
4-20	401.5	H	90

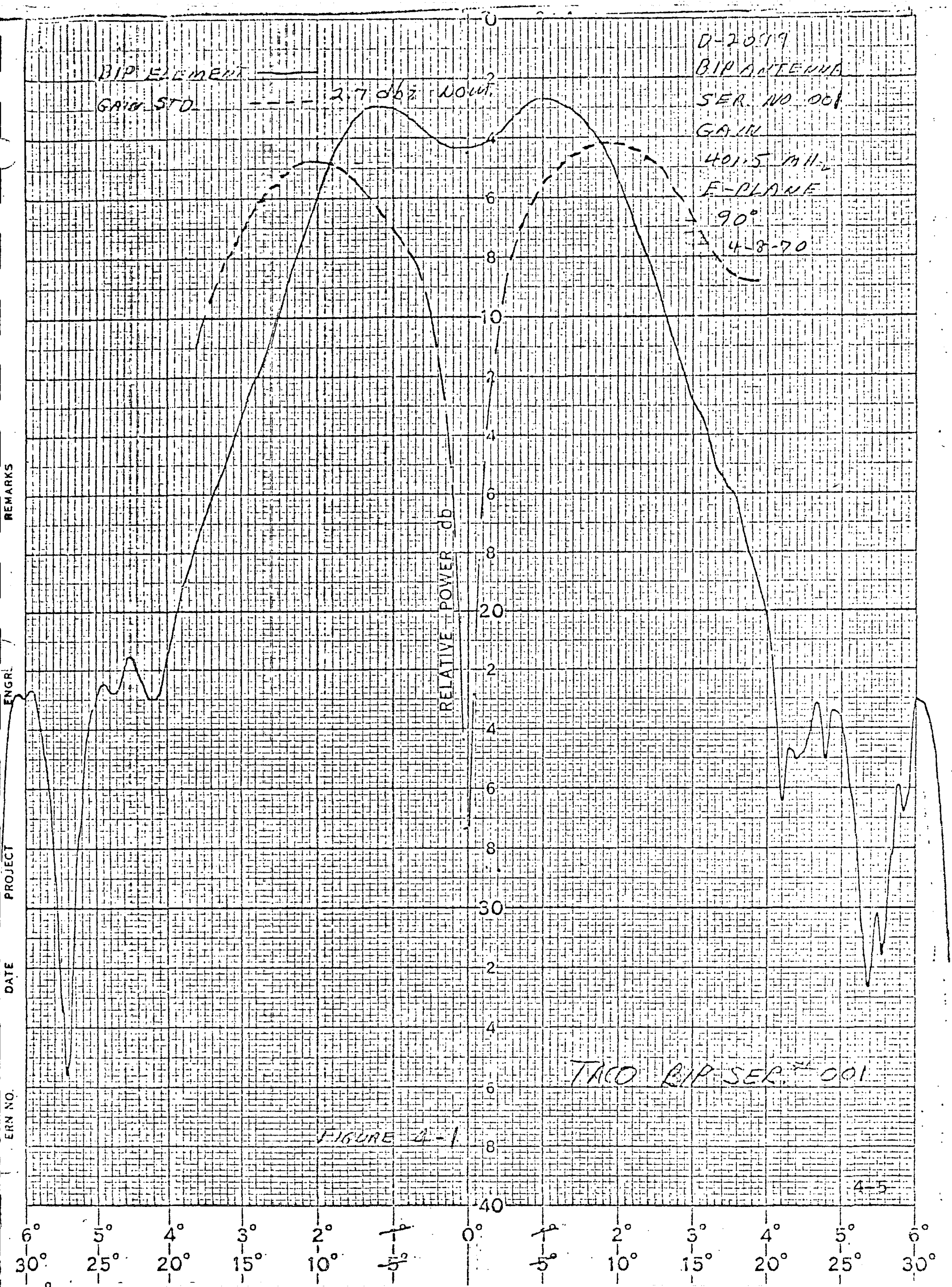

BIP ELEMENT
GAIN STD 2.7 dbi NOM.
D-2079
BIP ANTENNA
SER NO 001
GAIN
401.5 MHz
E-PLANE
90°
4-8-70
RELATIVE POWER db
0
2
4
6
8
10
20
30
40
TACO BIP SER # 001
6° 5° 4° 3° 2° 1° 0° 1° 2° 3° 4° 5° 6°
30° 25° 20° 15° 10° 5° 5° 10° 15° 20° 25° 30°
REMARKS
ENGR.
PROJECT
DATE
ERN NO.

FIGURE 4-1

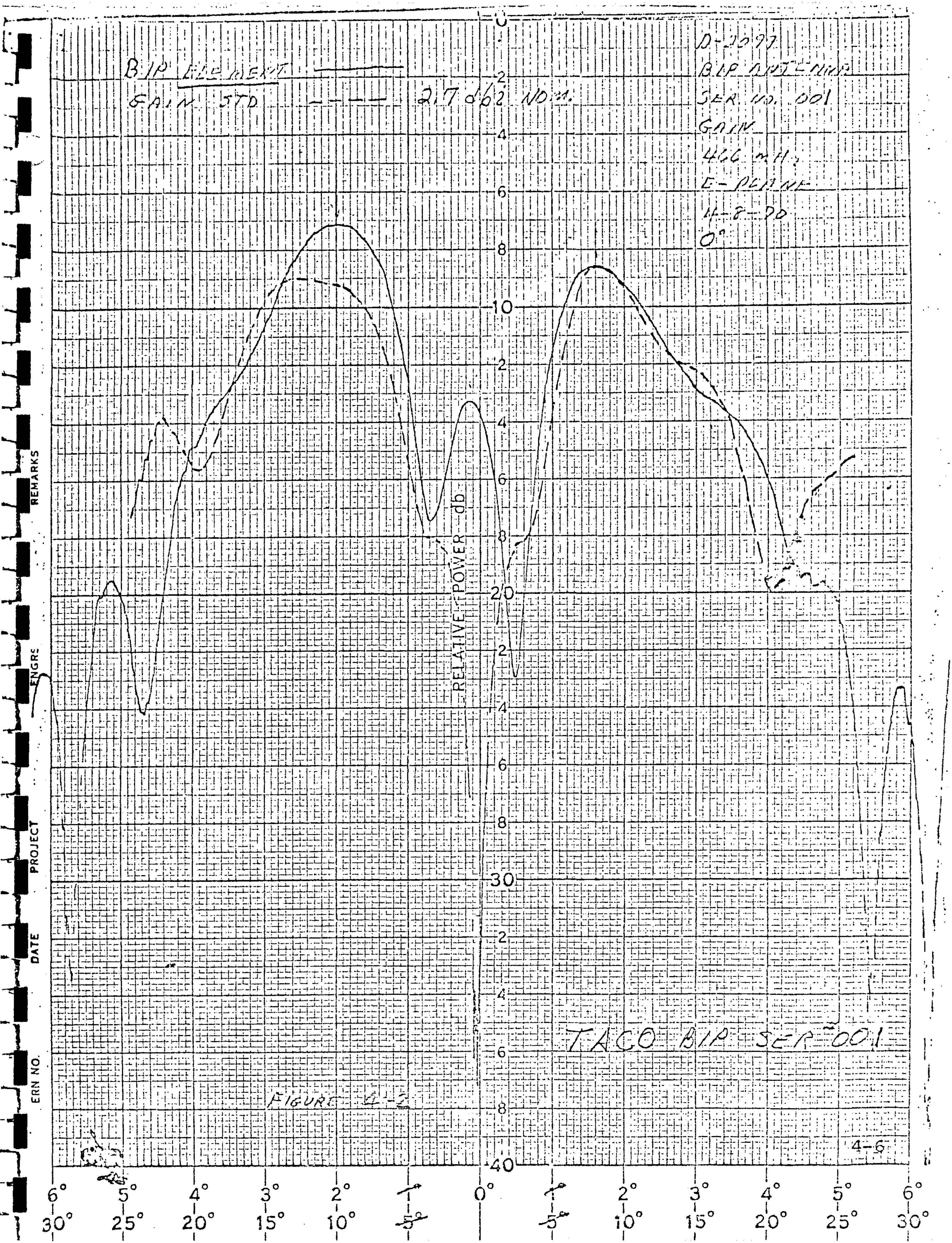

BIP ELEMENT
GAIN STD 21.7 dbi NOM.
D-2097
BIP ANTENNA
SER. NO. 001
GAIN
466 MHz
E-PLANE
11-8-90
0°
RELATIVE POWER db
TACO BIP SER 001
REMARKS
ENGRS
PROJECT
DATE
ERN NO.
6° 5° 4° 3° 2° 0° 2° 3° 4° 5° 6°
30° 25° 20° 15° 10° 5° 5° 10° 15° 20° 25° 30°

FIGURE 4-2

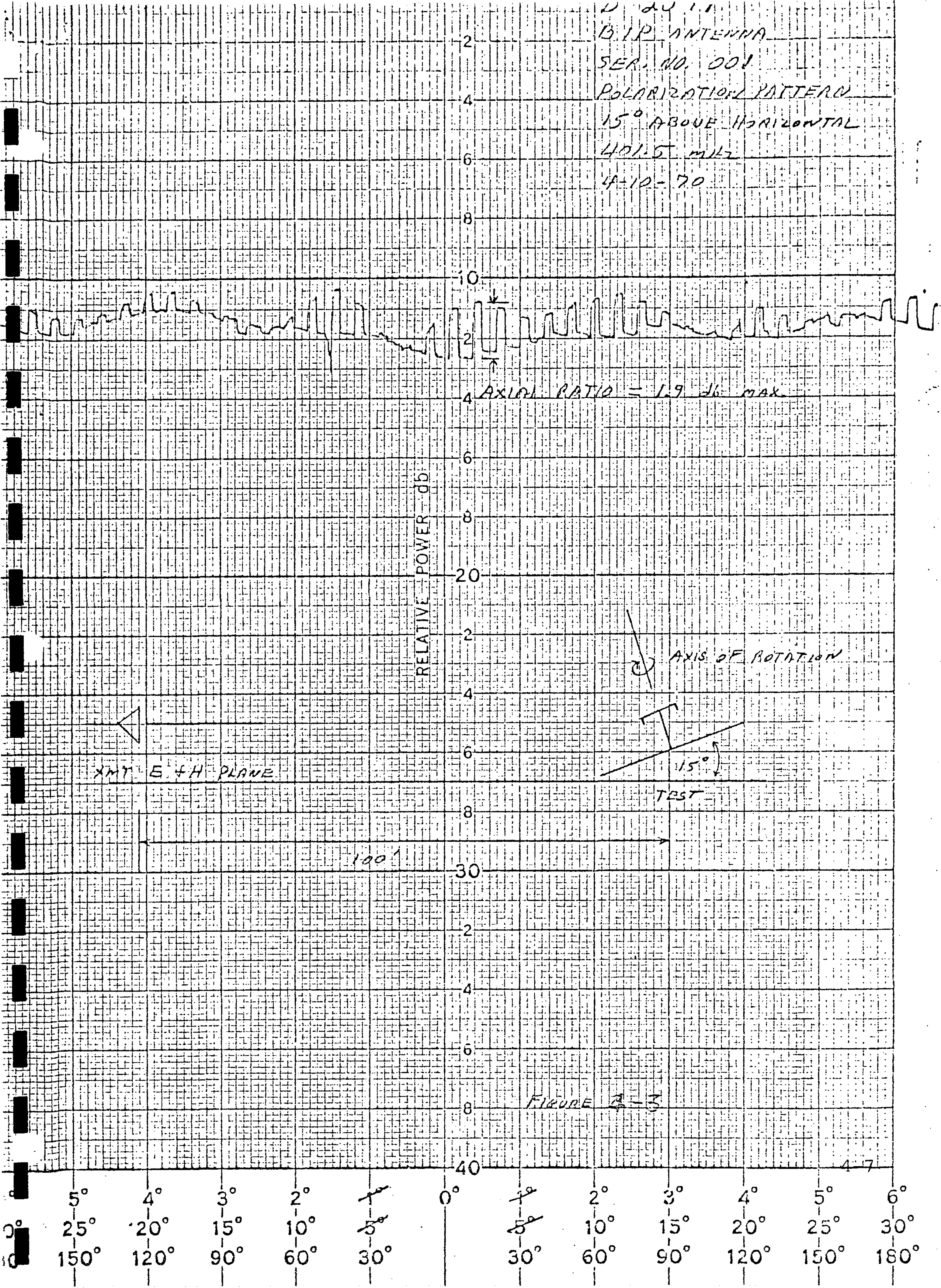
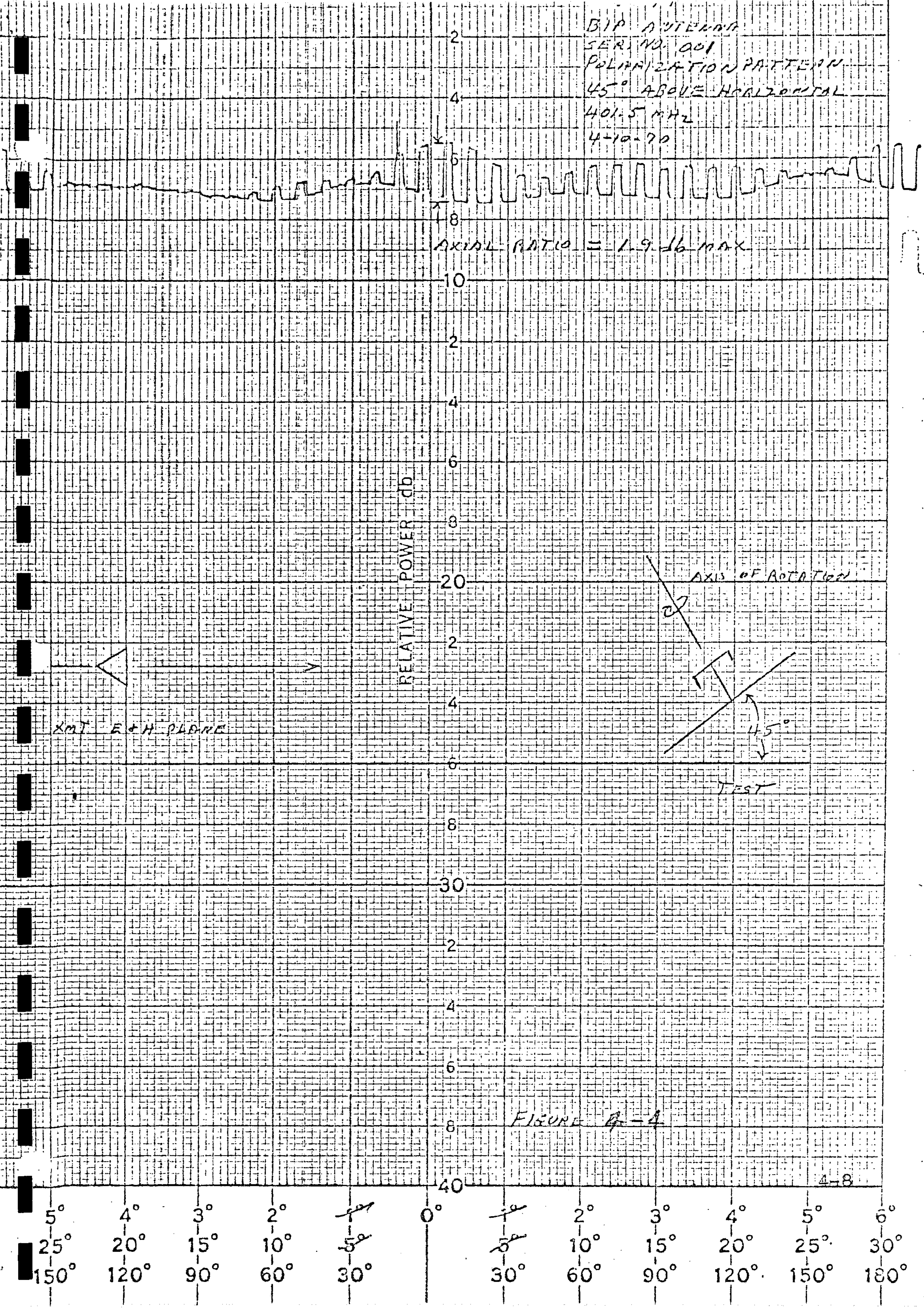
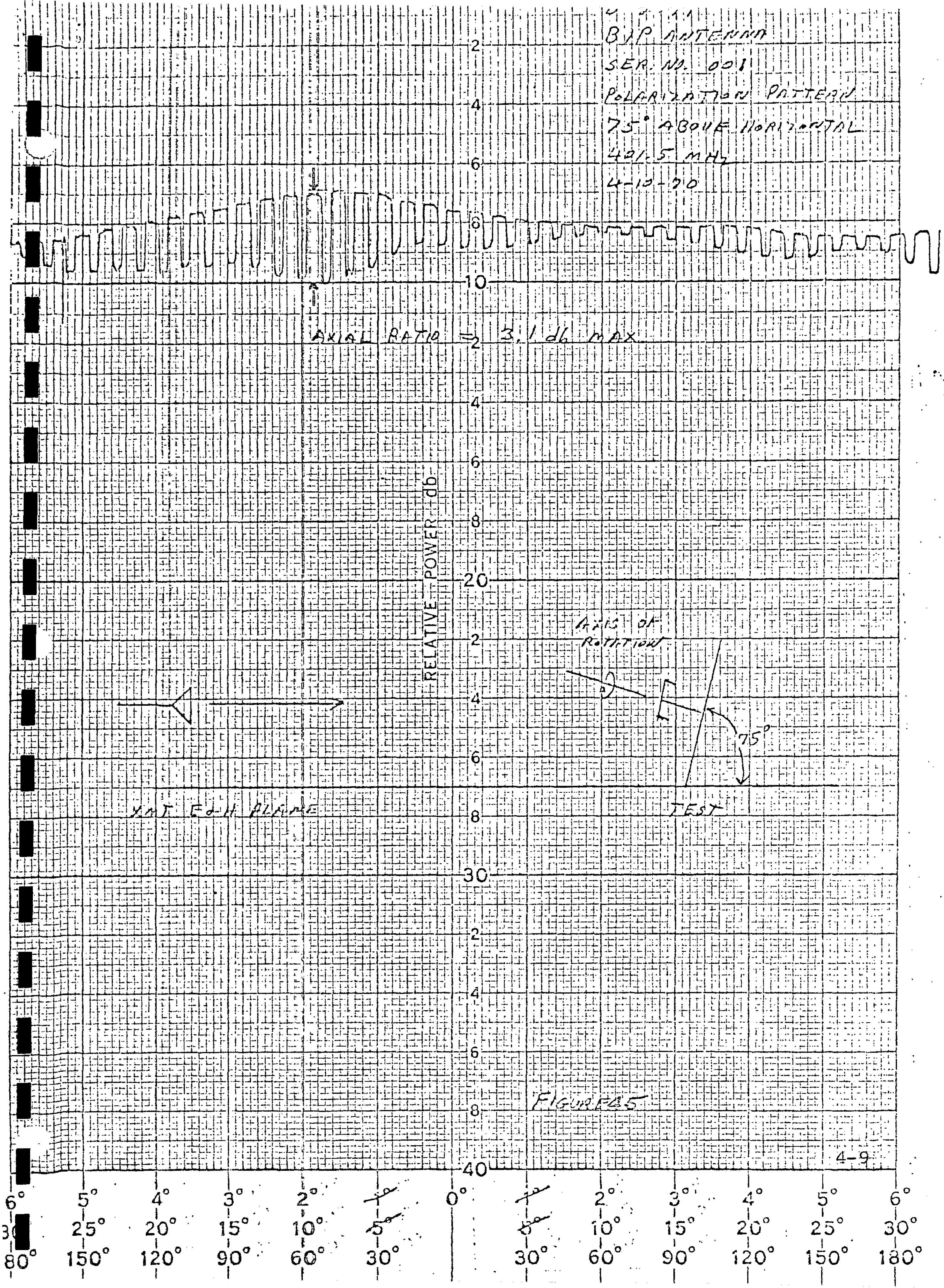

B.I.P. ANTENNA
SER. NO. 001
POLARIZATION PATTERN
15° ABOVE HORIZONTAL
401.5 MHz
4-10-70
AXIAL RATIO = 1.9 db MAX.
RELATIVE POWER db
AXIS OF ROTATION
XMT E & H PLANE
15°
TEST
100'
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
5° 4° 3° 2° 0° 2° 3° 4° 5° 6°
25° 20° 15° 10° 10° 15° 20° 25° 30°
150° 120° 90° 60° 30° 30° 60° 90° 120° 150° 180°

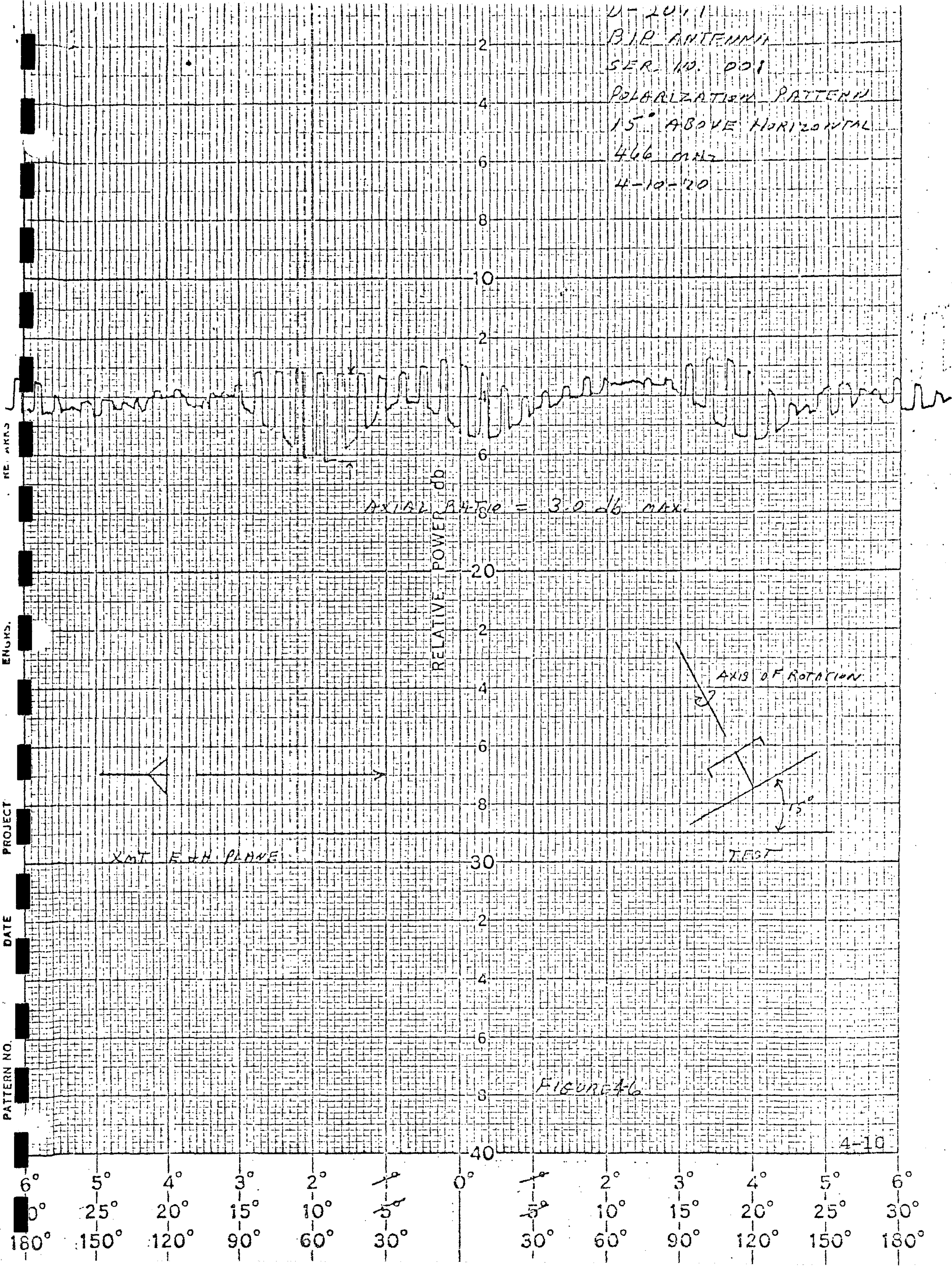
FIGURE 4-3



BIP ANTENNA
SER. NO. 001
POLARIZATION PATTERN
45° ABOVE HORIZONTAL
401.5 MHz
4-10-70
AXIAL RATIO = 1.9 db MAX
RELATIVE POWER db
AXIS OF ROTATION
45°
TEST
XMT E & H PLANE
2
4
6
8
10
20
30
40
5° 4° 3° 2° 0° 2° 3° 4° 5° 6°
25° 20° 15° 10° 10° 15° 20° 25° 30°
150° 120° 90° 60° 30° 30° 60° 90° 120° 150° 180°

FIGURE A-4


B.I.P. ANTENNA
SER. NO. 001
POLARIZATION PATTERN
75° ABOVE HORIZONTAL
401.5 MHz
4-10-70
AXIAL RATIO = 3.1 db MAX
RELATIVE POWER db
AXIS OF ROTATION
75°
TEST
XMT E & H PLANE
FIGURE 5



BIP ANTENNA
SER. NO. 001
POLARIZATION PATTERN
15° ABOVE HORIZONTAL
466 MHz
4-10-70
AXIAL RATIO = 3.0 db MAX.
RELATIVE POWER db
AXIS OF ROTATION
15°
XMT E & H PLANE
TEST
4-10
REMARKS
ENGRS.
PROJECT
DATE
PATTERN NO.

FIGURE 4-6

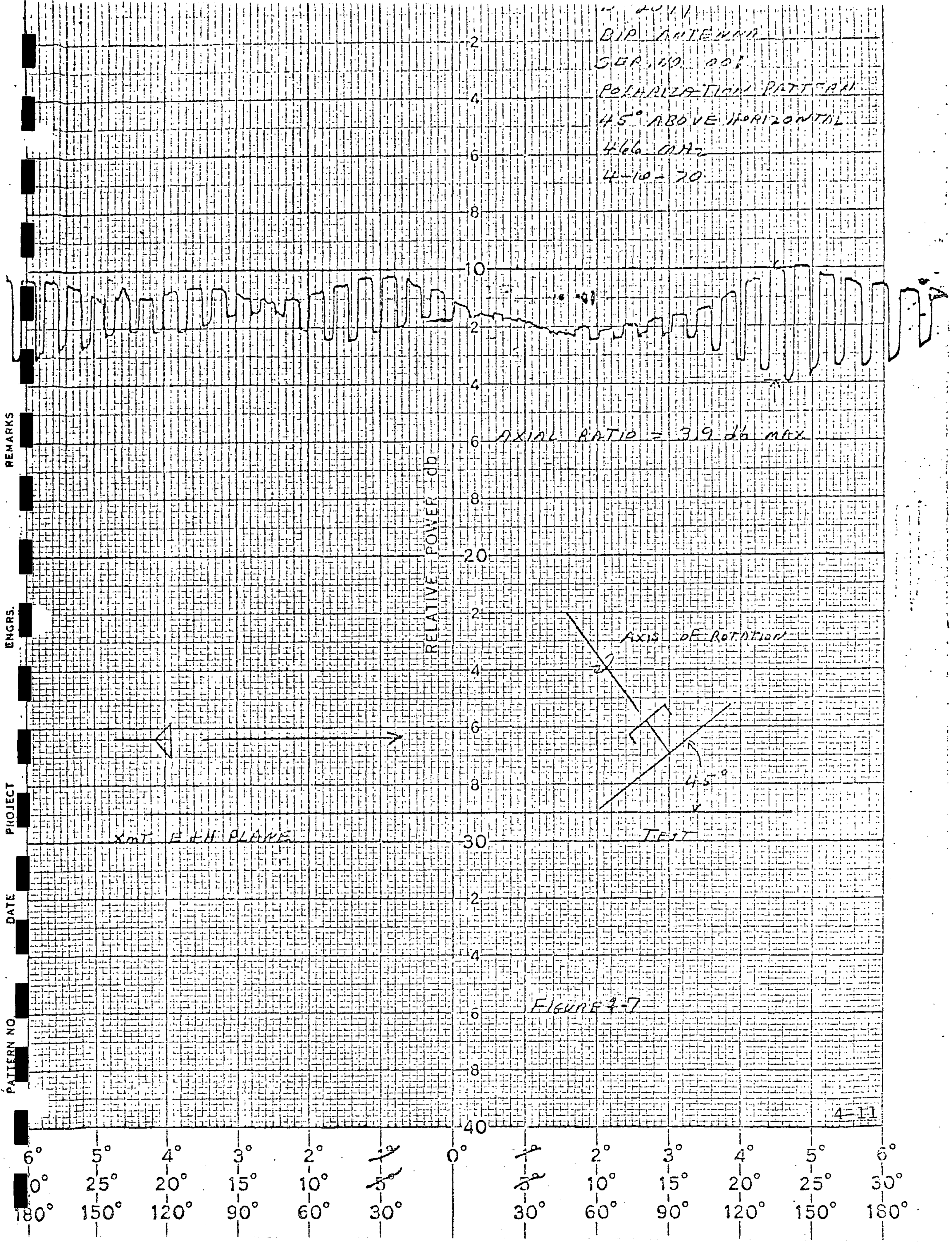

BIP ANTENNA
SER. NO. 001
POLARIZATION PATTERN
45° ABOVE HORIZONTAL
466 MHz
4-10-70
AXIAL RATIO = 3.9 db MAX
RELATIVE POWER db
AXIS OF ROTATION
45°
XMT E+H PLANE
TEST
REMARKS
ENGRS.
PROJECT
DATE
PATTERN NO.
10
20
30
40
0°
30°
60°
90°
120°
150°
180°

FIGURE 4-7

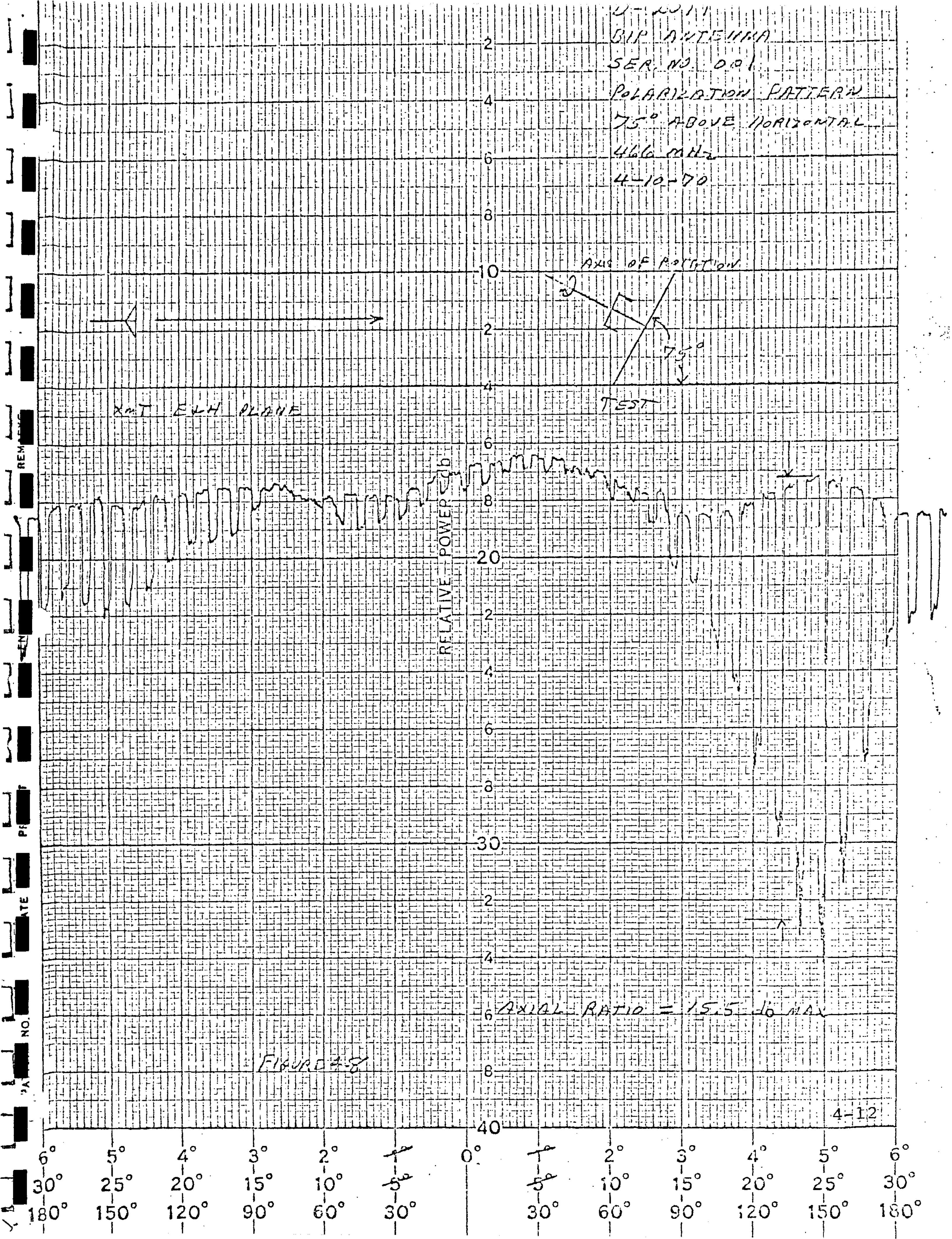

BIP ANTENNA
SER. NO. 001
POLARIZATION PATTERN
75° ABOVE HORIZONTAL
466 MHz
4-10-70
AXIS OF ROTATION
75°
TEST
XMT E+H PLANE
RELATIVE POWER db
AXIAL RATIO = 15.5 db MAX

FIGURE 4-8

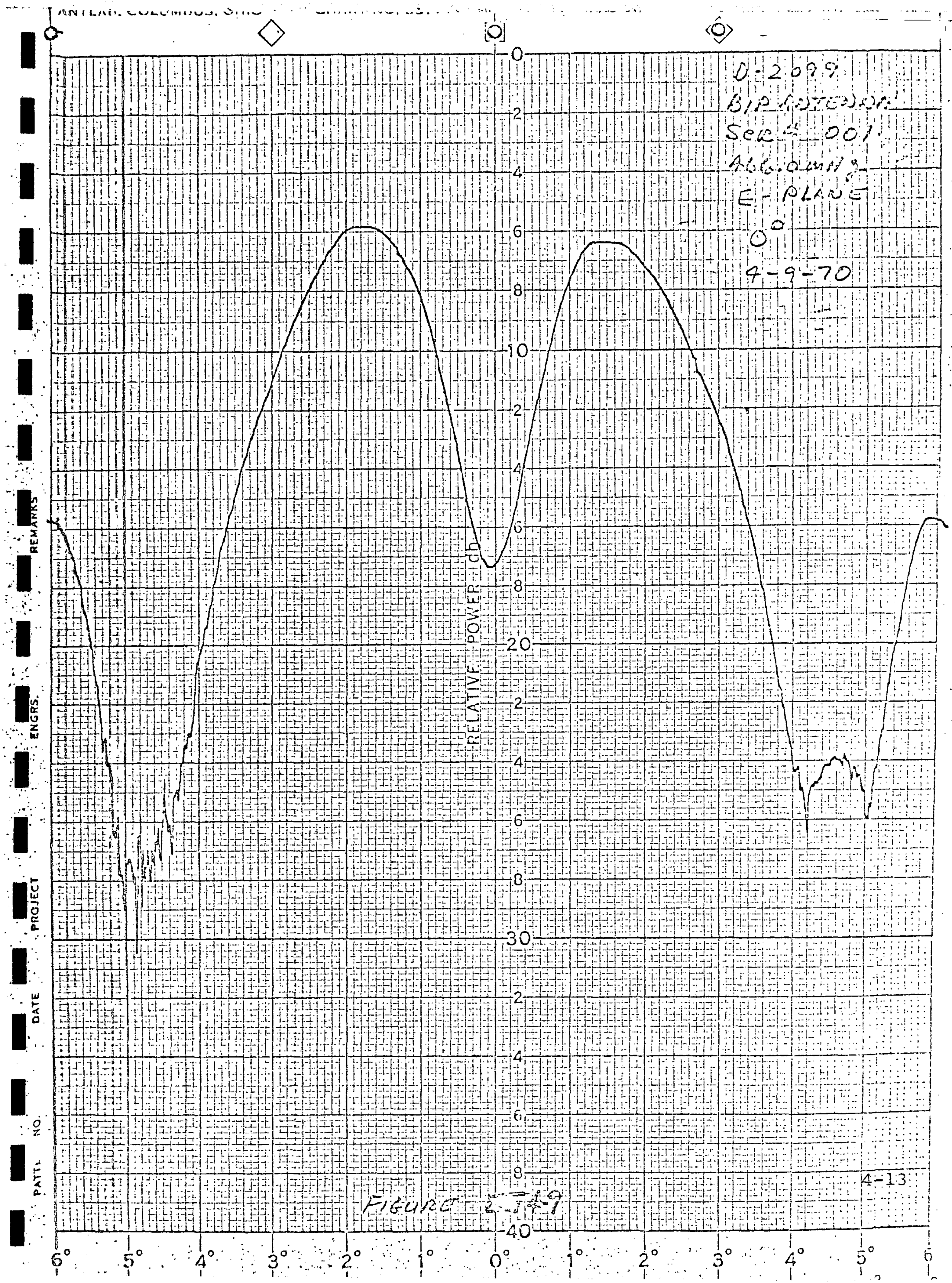

D-2699
B/P ANTENNA
Ser # 001
466.0 MHz
E-PLANE
0°
4-9-70
REMARKS
ENGRS.
PROJECT
DATE
NO.
PATT.
RELATIVE POWER db
0
2
4
6
8
10
20
30
40
6°
5°
4°
3°
2°
1°
0°
1°
2°
3°
4°
5°
6°

FIGURE 4-49

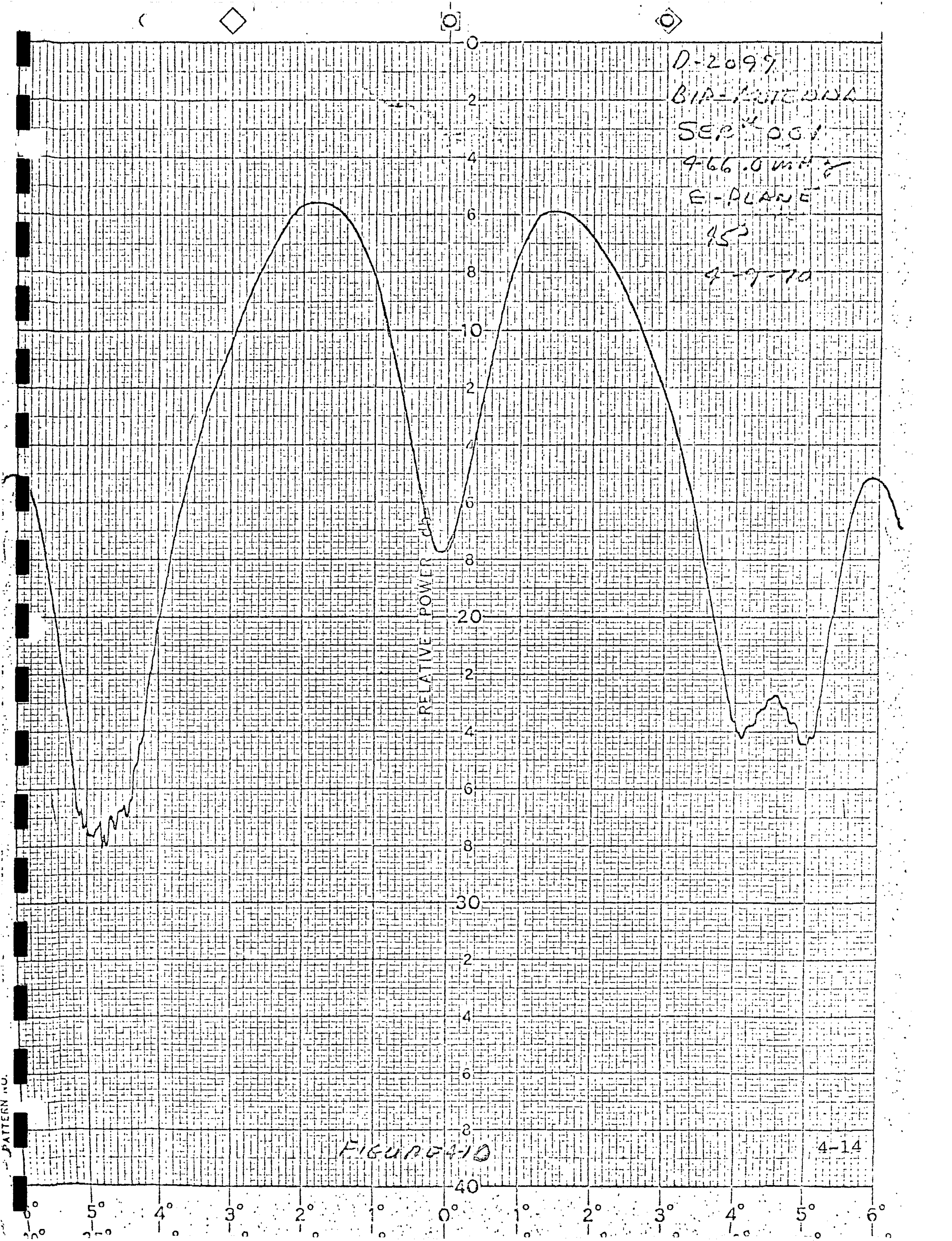

D-2097
E-PLANE
4-9-70
RELATIVE POWER dB
0
2
4
6
8
10
20
30
40
5°
4°
3°
2°
1°
0°
1°
2°
3°
4°
5°
6°
PATTERN NO.

FIGURE 4-10

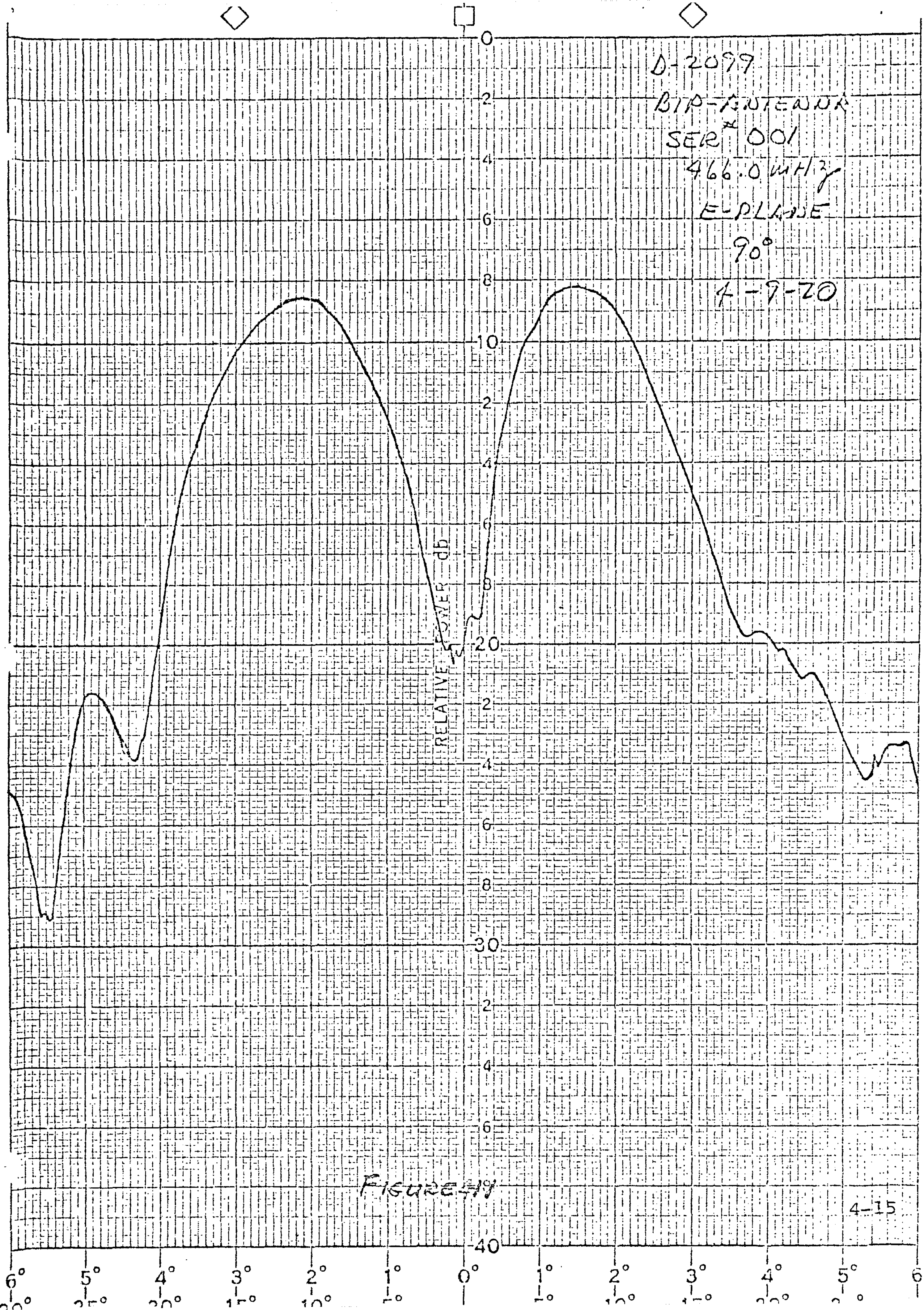
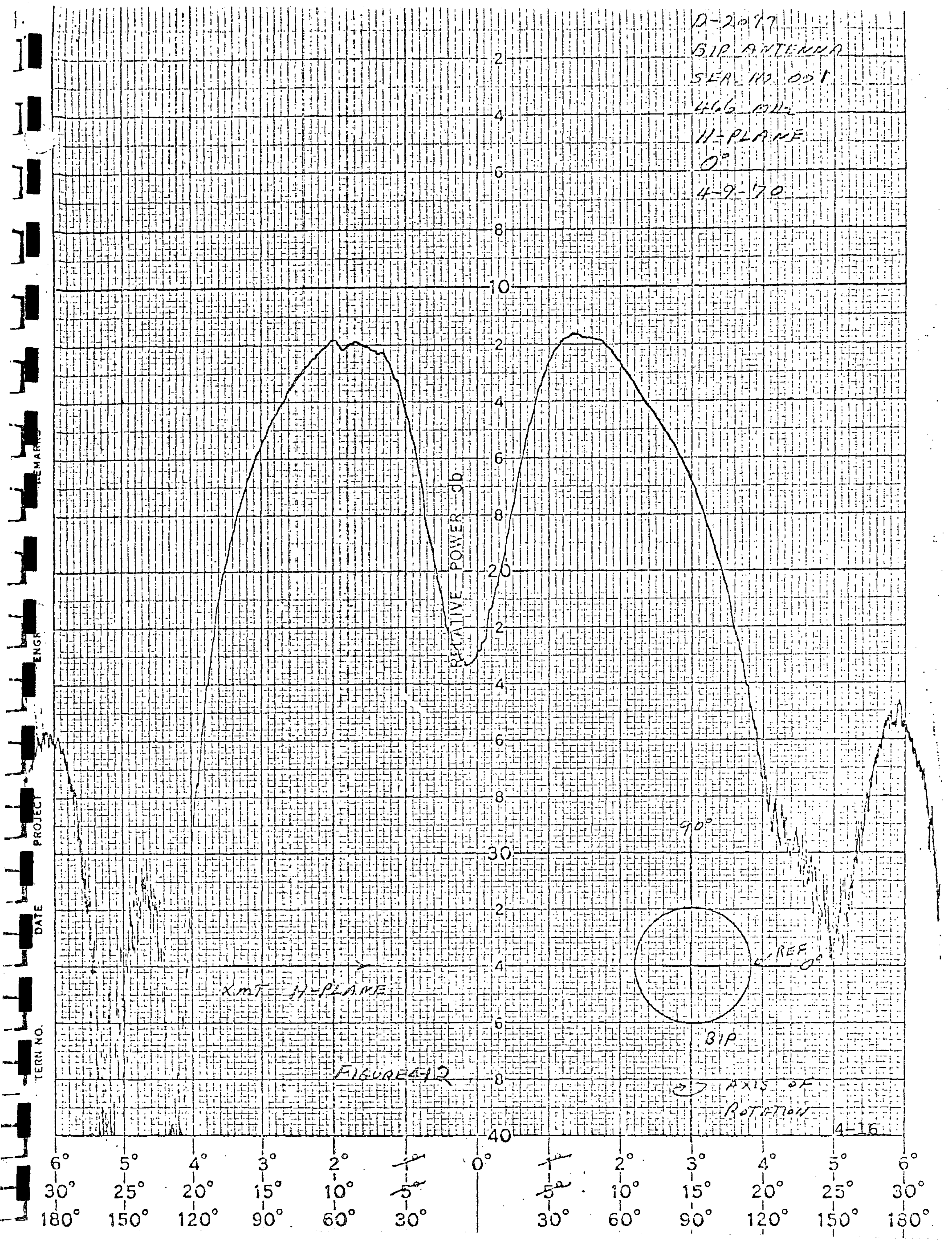
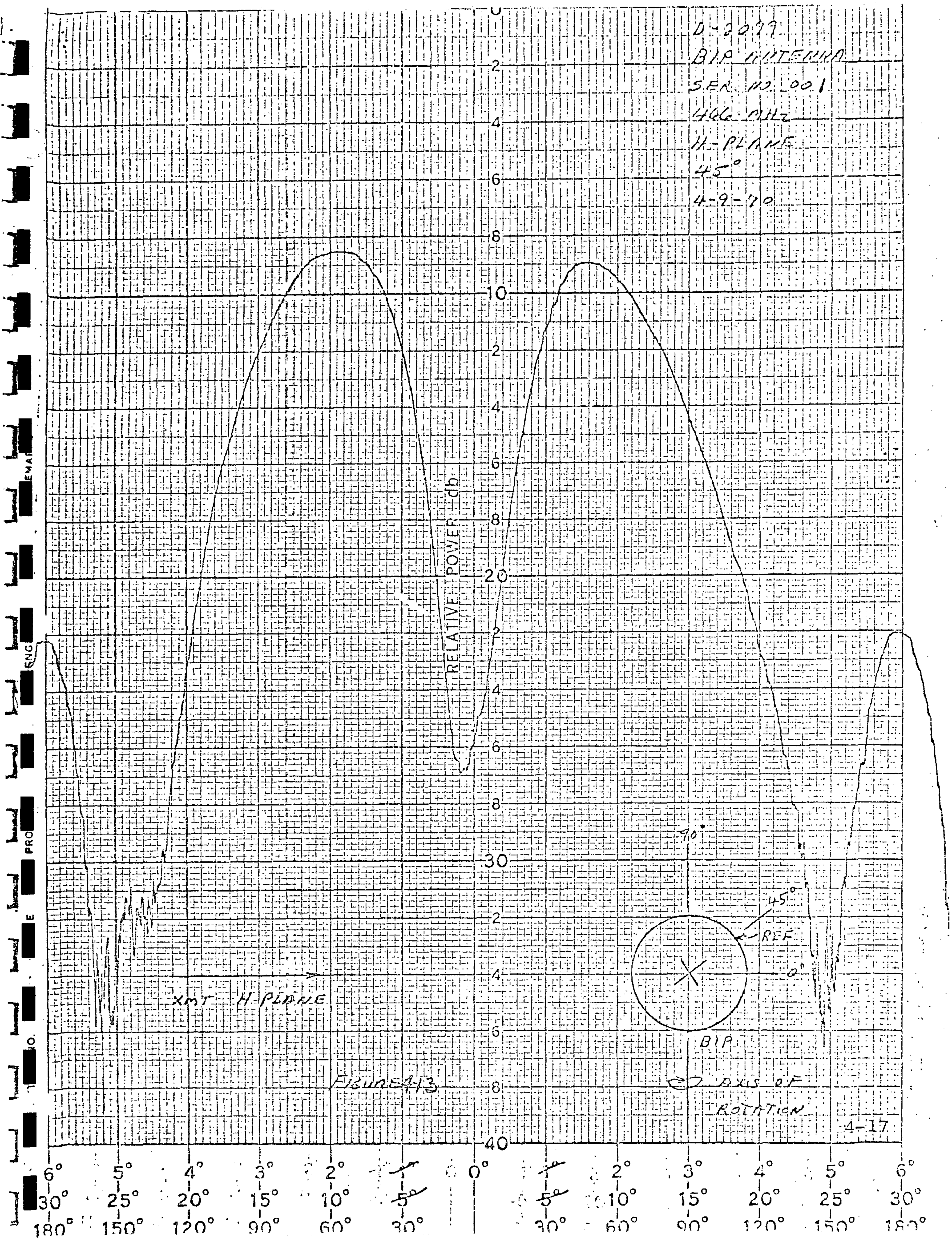

D-2099
BIP-ANTENNA
SER # 001
466.0 MHz
E-PLANE
90°
4-9-70
RELATIVE POWER db
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
40
6°
5°
4°
3°
2°
1°
0°
1°
2°
3°
4°
5°
6°

FIGURE 4.19

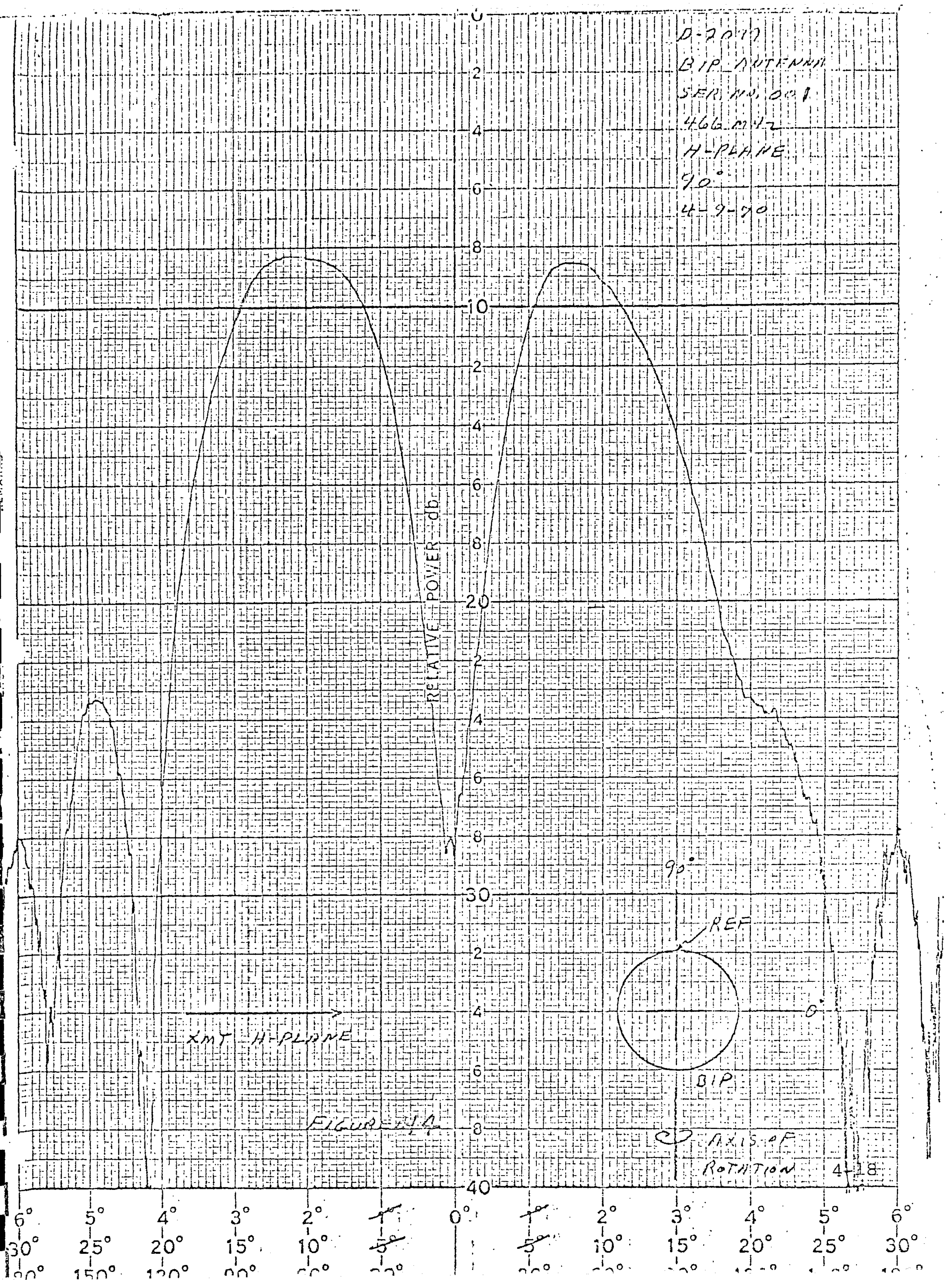


D-2077
BIP ANTENNA
SER NO 051
466 MHz
H-PLANE
0°
4-9-70
RELATIVE POWER db
REMARKS
ENGR
PROJECT
DATE
TERN NO.
XMT H-PLANE
90°
REF 0°
BIP
AXIS OF ROTATION
FIGURE 4-12



D-2077
BIP ANTENNA
SER. NO. 001
406 MHz
H-PLANE
45°
4-9-70
RELATIVE POWER db
XMT H PLANE
90°
45°
REF
0°
BIP
AXIS OF ROTATION

FIGURE 4-13


BIP ANTENNA
466 MHz
H-PLANE
90°
4-9-70
RELATIVE POWER - db
XMT H-PLANE
REF
BIP
AXIS OF ROTATION
FIGURE

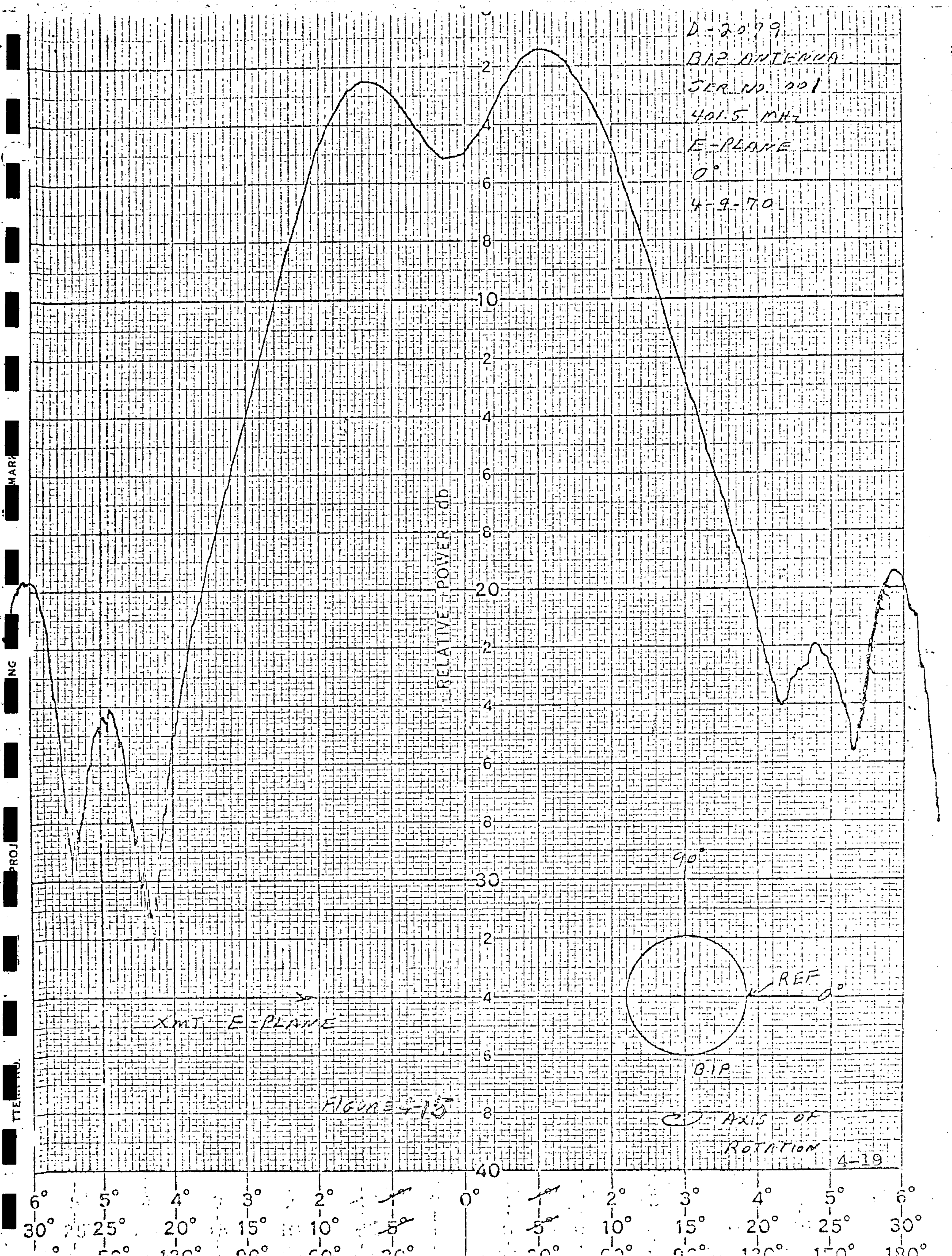
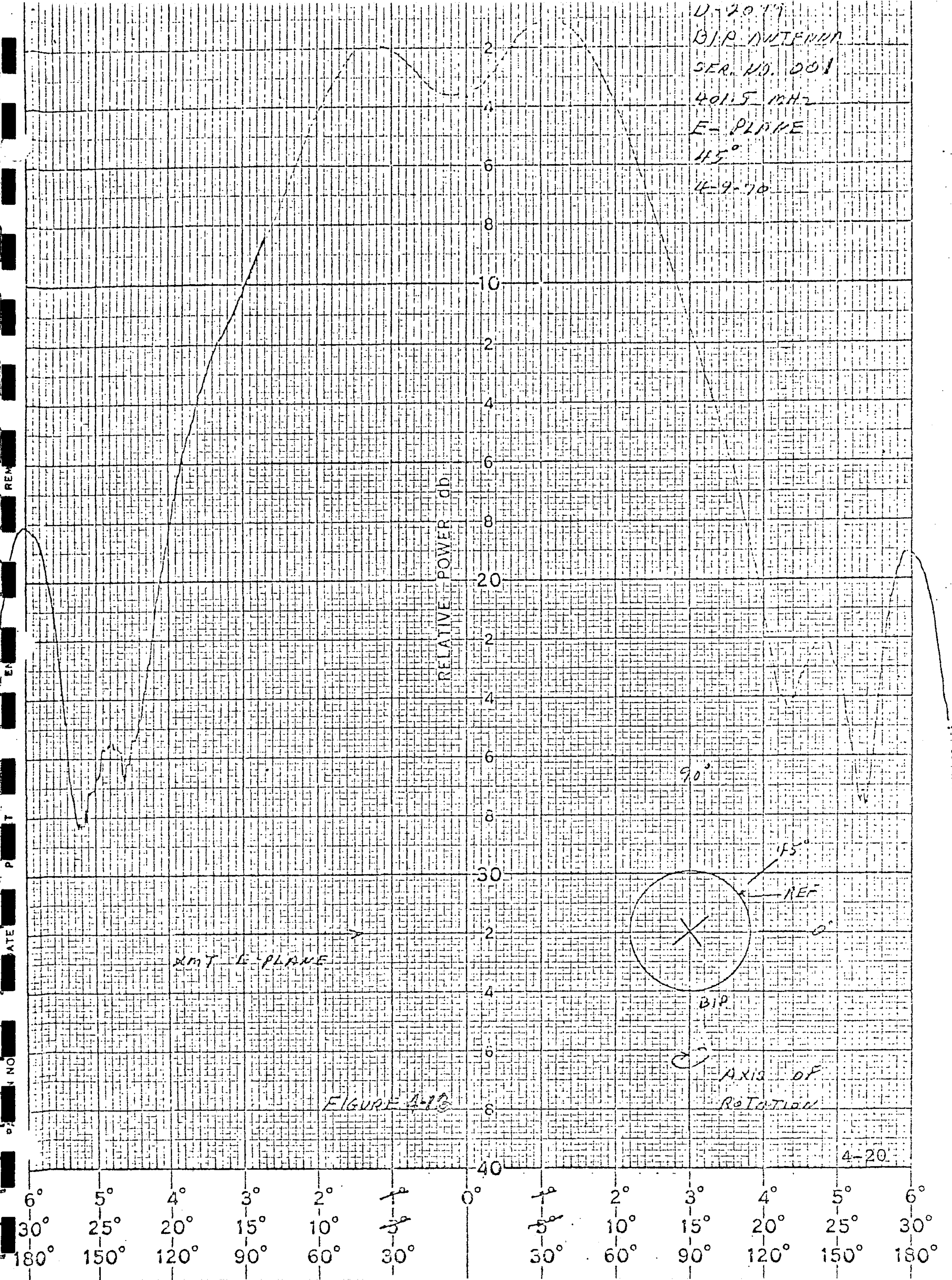
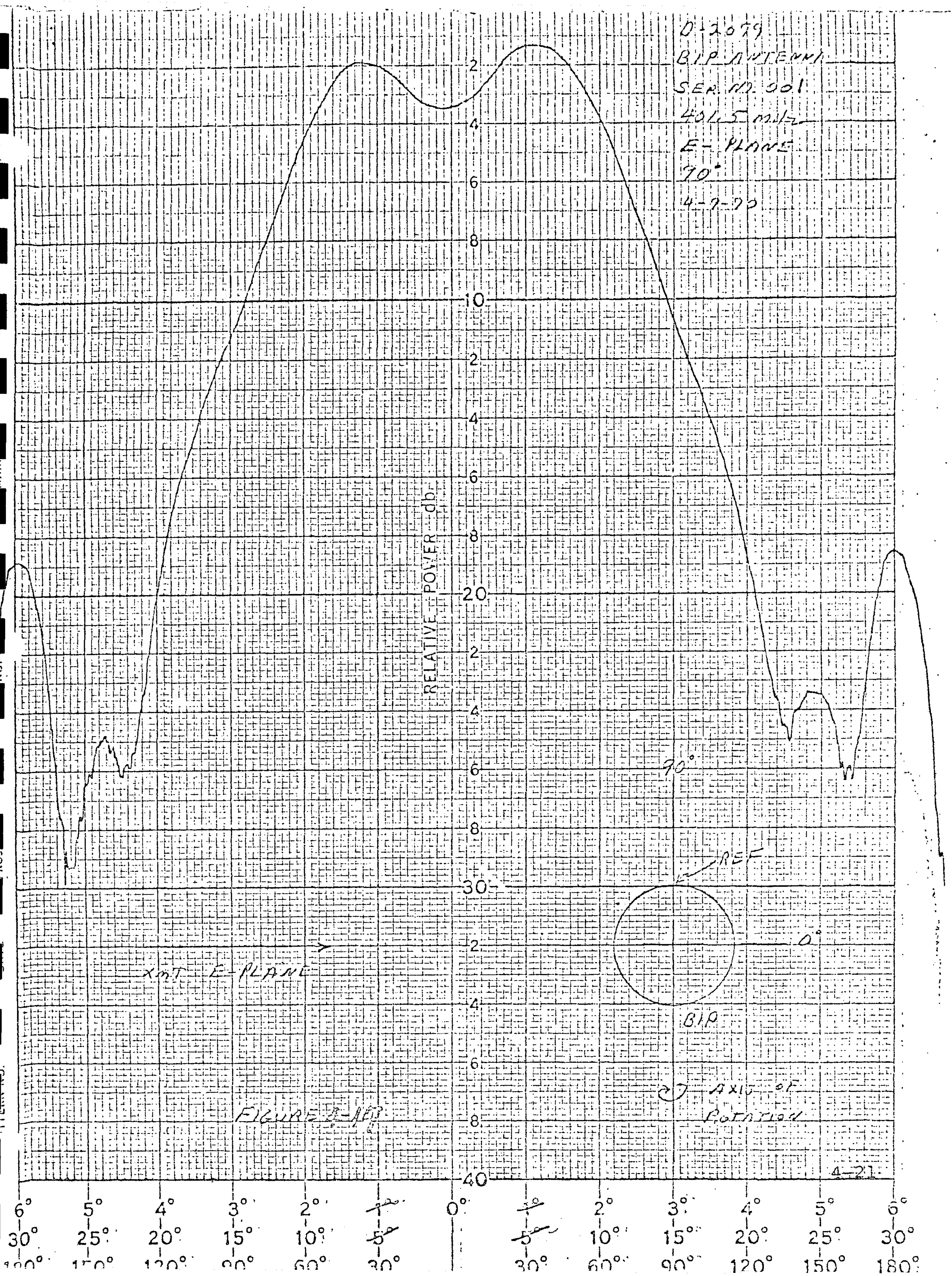

D-2079
BIP ANTENNA
SER NO. 001
401.5 MHz
E-PLANE
0°
4-9-70
RELATIVE POWER db
90°
REF
0°
XMT E-PLANE
BIP
AXIS OF ROTATION

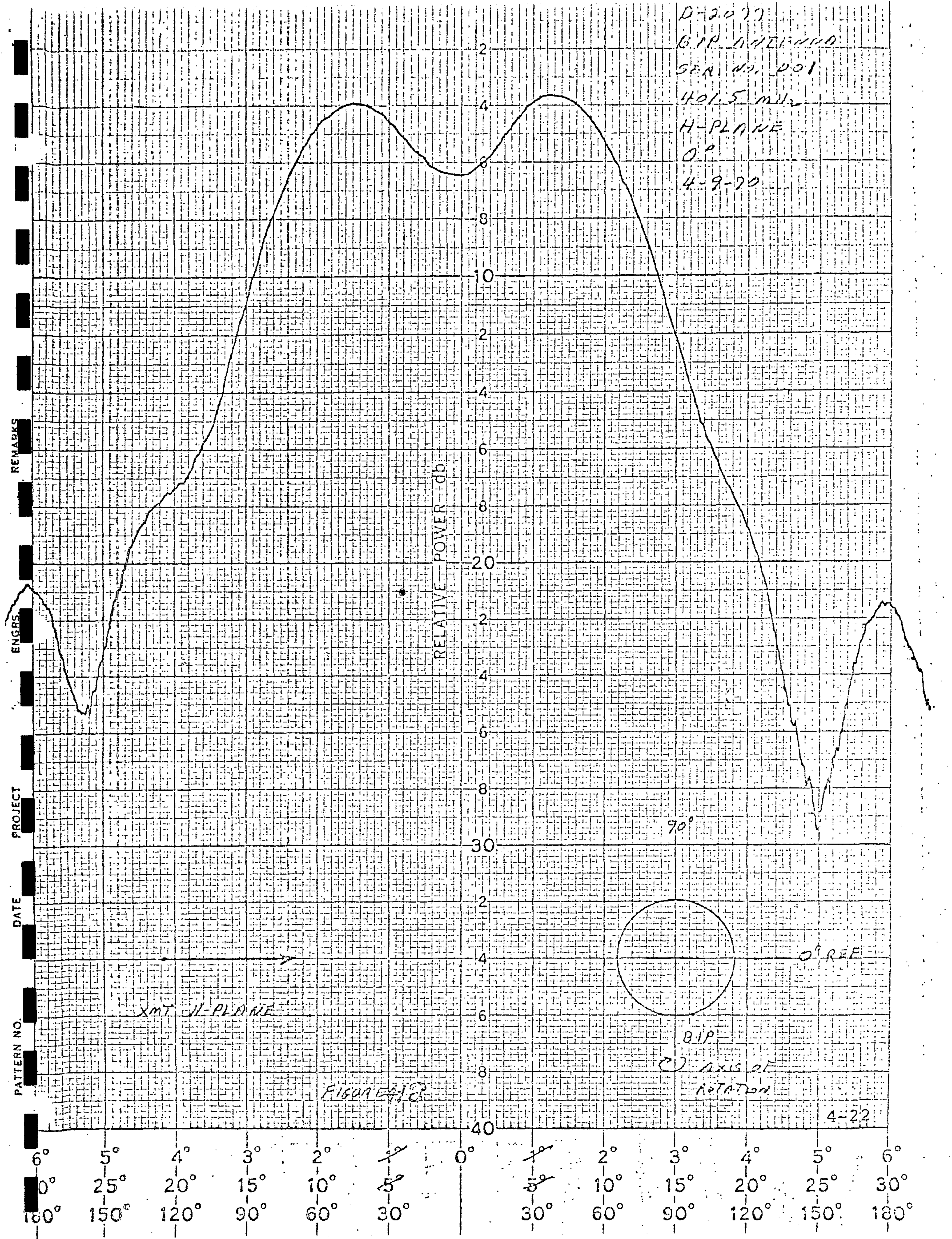
FIGURE 4-15



D-2079
BIP ANTENNA
SER. NO. 001
401.5 MHz
E- PLANE
45°
4-9-70
RELATIVE POWER db
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
90°
45°
REF
0°
BIP
AXIS OF
ROTATION
XMT E-PLANE
6° 5° 4° 3° 2° 1° 0° 1° 2° 3° 4° 5° 6°
30° 25° 20° 15° 10° 5° 5° 10° 15° 20° 25° 30°
180° 150° 120° 90° 60° 30° 30° 60° 90° 120° 150° 180°

FIGURE 4-13


D-2079
BIP ANTENNA
SER. NO. 001
401.5 mHz
E-PLANE
90°
4-7-70
RELATIVE POWER db
REF
0°
XMT E-PLANE
BIP
AXIS OF ROTATION
4-21


SER. NO. 001
401.5 MHz
H-PLANE
0°
4-9-70
RELATIVE POWER db
90°
0° REF
XMT H-PLANE
BIP
AXIS OF ROTATION
REMARKS
ENGRS.
PROJECT
DATE
PATTERN NO.
4-22

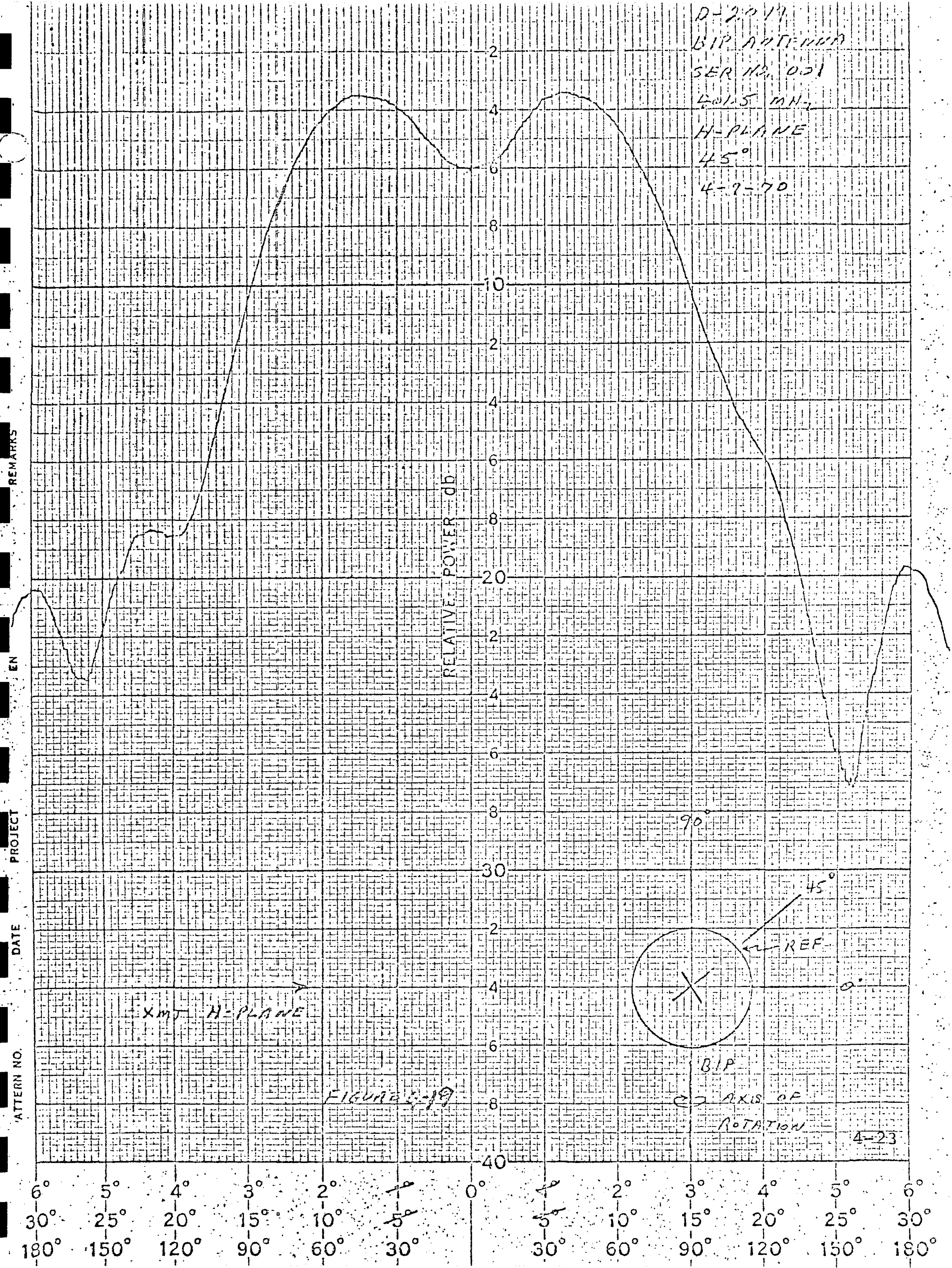
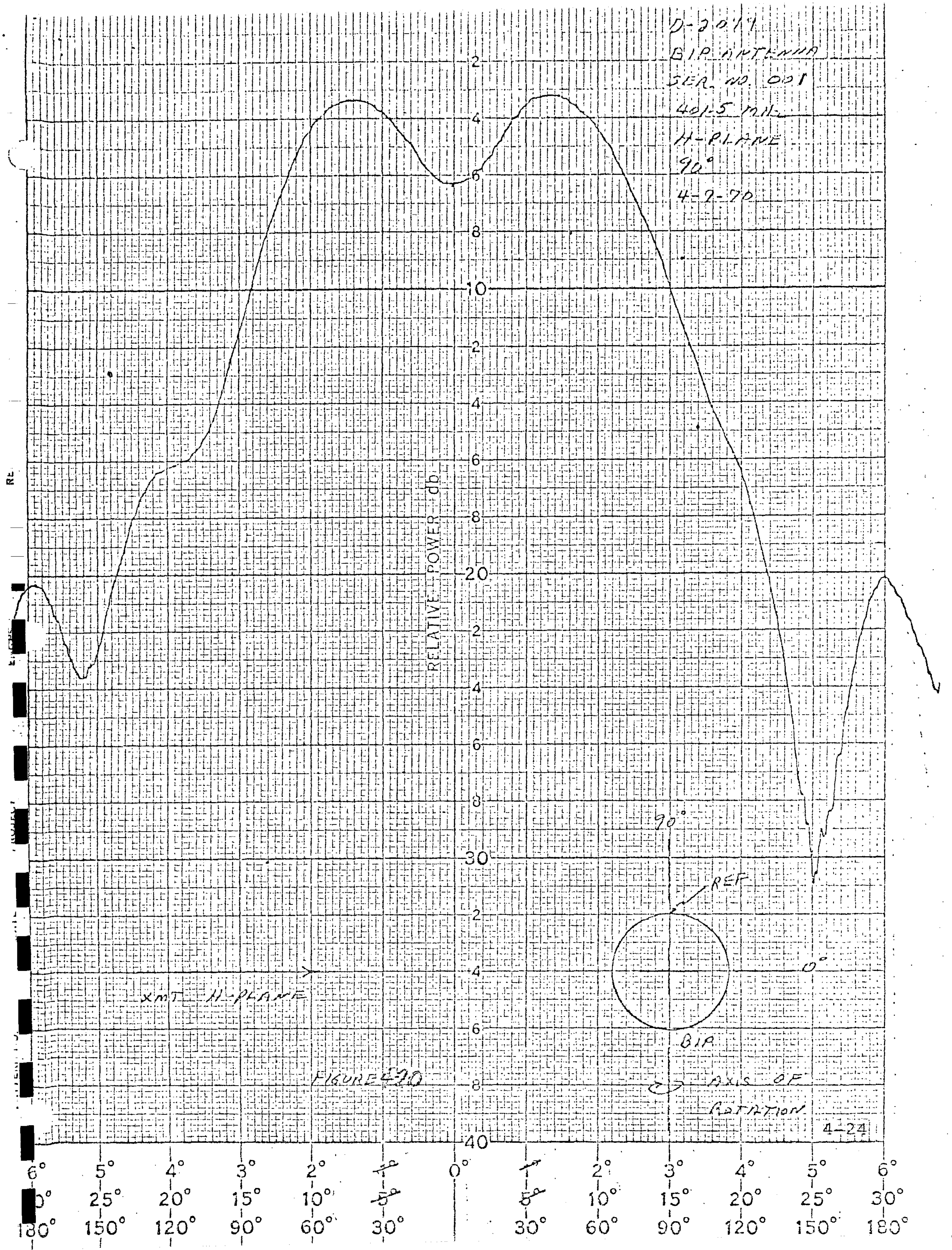

BIP ANTENNA
SER NO. 001
401.5 MHz
H-PLANE
45°
4-7-70
RELATIVE POWER db
XMT H-PLANE
90°
45°
REF
0°
BIP
AXIS OF ROTATION
REMARKS
PROJECT
DATE
PATTERN NO.

FIGURE 4-19


D-2019
BIR ANTENNA
SER. NO. 001
401.5 MHz
H-PLANE
90°
4-2-70
RELATIVE POWER - db
XMT H-PLANE
FIGURE 4-20
90°
REF
0°
BIR
AXIS OF ROTATION

5.0 ELECTRONICS SUB-ASSEMBLY, WATER BAGS, AND BATTERY PACK

A sub-contract was placed with Radiation, Inc., in November 1969 to provide the electronics sub-assembly (ESA) the water bags, and the battery pack assembly. Figure 5-1 is a photograph which shows the components of the BIP electronics unit. Schematic diagrams of the five printed circuit boards that comprise the ESA are shown in Figures 5-2 to 5-6.

5.1 Electronics Sub-Assembly

In March of 1969, Radiation Inc., notified General Instrument Corporation that they had successfully completed the Electrical Performance Test of specification 121765 and were now ready to perform the Qualification Test. Appendix II describes specification 121765.

The first test was aborted during the 10 hour day portion of the test due to a failure in the Power Control PC board. The failure burnt away some of the artwork on the board. Radiation's explanation was that the board was not properly cleaned before the protective coating was applied to this section of the board. Moisture caused an electrical short across the artwork causing it to be destroyed. After the concurrence of General Instrument Corporation and NASA a new Power Control board was installed in the electronic sub-assembly.

After this board was installed two wires going to the Voltage Regulator PC board had to be replaced. A feed-thru and

Fig. 5-1

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a piece of artwork was inadvertently lifted while soldering these two wires. General Instrument Corporation and NASA, in the interest of saving time without jeopardy to the test, gave Radiation permission to rework the board using a jumper to replace the lifted artwork.

Test 2 was completed with one apparent abnormality (the solar current switched to a value of 34 mA, not 25 mA as is normal; this switching occurred during the 10 hour day and not the 14 hour day as is expected).

Upon visual inspection of the electronic sub-assembly printed circuit boards an obvious failure was noted on the voltage regulator board. The printed circuit board and some components were blackened. Electrical troubleshooting found Q10, Q12, and CR 38 components of the water heater control, differential amplifier circuit to be damaged (see Figure 5-6). Radiation Inc. felt that the failure resulted from an opening of the heater load (pin no. 1 of the voltage regulator board that had been previously reworked). Further investigation by General Instrument Corporation engineers indicated that there was no permanent open, however, it was agreed, after circuit analysis, that even a momentary discontinuity at pin no. 1 would cause these components to fail. A new Voltage Regulator card was installed in the electronic sub-assembly and the third test was performed. No failures occurred, the qualification test was concluded, and Section II, the electrical performance test, was successfully performed.

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The 14 hour night test was repeated three times, and in all cases the unit shut off early. The results of these tests are summarized below in Table I. The second test, which is the closest to meeting the design goal, was the only one packaged by the Radiation Inc. engineer who did the thermal design of the BIP package. General Instrument Corporation carefully documented this procedure for both future tests and balloon launches. General Instrument, at NASA's request, directed Radiation Inc. to have the thermostat manufacturer adjust his units to operate at a temperature of -10° ± 1.5°C. This change increased the operating temperature range making the BIP system less sensitive to short term temperature fluctuations that occur as the water bags freeze.

TABLE I

Test No.	Unit turned off (time after start of test)	Unit turned off (time after start of test)	Unit turned off (time after start of test)
1	8 hours	13 hours	--
2	7 hours 50 min.	7 hours 55 min.	13 hours 22 min.
3	4 hours 35 min.	7 hours 45 min.	11 hours 37 min.

In the production testing and field use of the electronics sub-assembly, two major problem areas have arisen. The first is the result of a poor choice of protective coating for the printed circuit boards.A ureathane or epoxy conformal coating should be used for future procurements. The second problem area was numerous broken leads on the wires that are attached to the printed circuit boards. The obvious way of eliminating this is to use connectors, but another means would be to prevent flexing of the cable harness to each board. This could be accomplished by anchoring the cable harness to each board.

5.2 Water Bags

A small percentage of water bag failures did occur. Some of the units that failed had leaky seams, others had small holes in the sides of the plastic bag. The leaky seams can be attributed to improper sealing, while side holes were probably caused by mishandling. The last seventeen production BIP assemblies were vacuum tested to an altitude of 80,000 feet minimum in order to ensure that all water bags were intact. One or two of the 102 water bags were found to be defective by this altitude test.

5.3 Battery Pack

The initial series of battery packs as shipped by Radiation Inc. were all improperly assembled. Heat shrinkable tubing was placed around each individual cell to prevent shorting

6.0 BIP HOUSING

A photograph of the assembled BIP Electronics Unit is shown in Figure 6-1.

After the March 1970 qualification test for the Radiation supplied hardware, it was determined that the end wall thickness of the foam housing was incorrectly specified on the supplied drawings. Both end wall thickness measurements should have been 3 inches; instead they were 3 inches for one wall and 2-3/4 inches for the other wall. The thick wall would, of course, reduce the system "OFF" time during the longest night. A decision was then made to increase the wall thickness and scrap the molds that the supplier had fabricated for the foam housing and cover. Instead, the supplier machined the cover and the housing from a solid block of foam. No other changes were made to the foam housing and cover.

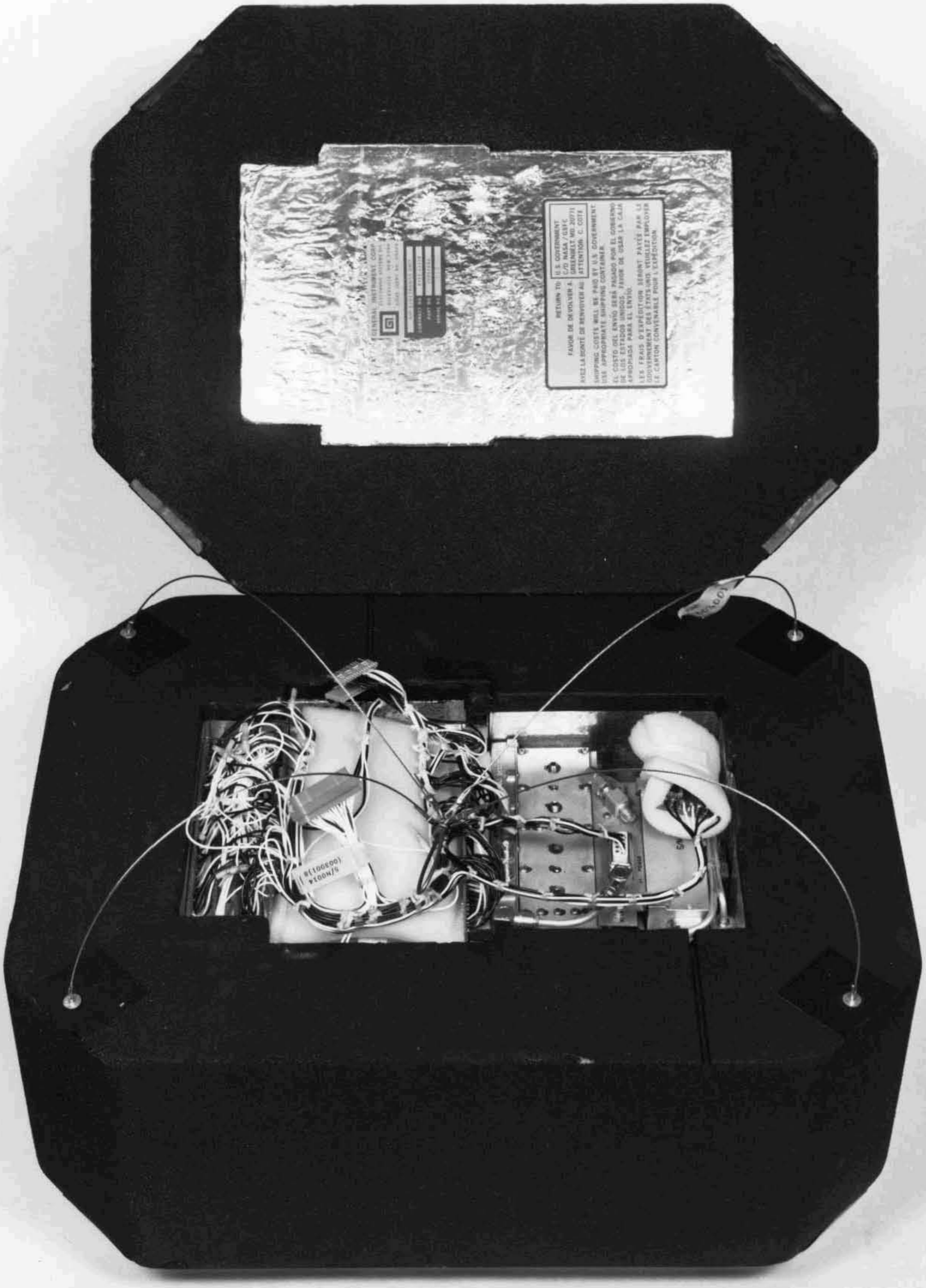


Fig. 6-1

7.0 ENVIRONMENTAL TESTS

Each production receiver and transmitter was tested over a temperature range of -20°C to +30°C a minimum of three times. The first production receiver and transmitter were tested to -30°C with no degradation in performance.

The first production BIP Electronics Unit, as per the contract, was hand carried to Radiation, Inc., for the thermal-altitude test on April 13, 1970. The unit successfully passed the electrical performance test of Specification 121765 and was then made ready for the qualification test by Radiation, Inc., mechanical engineer R. Clark (Appendix II describes these tests). Thermocouples were attached to each water bag and to strategic locations in the interior of the housing. The BIP was then placed into the temperature altitude chamber in preparation for the 14 hour night test.

During the first few hours of the 14 hour night portion of the qualification test a system abnormality occurred. The problem manifested itself in an apparent loss of receiver sensitivity and oscillations on the receiver video output at intermediate signal levels. During this period the transmitter remained energized. After a few hours the receiver sensitivity gradually improved and normal operation was resumed. The qualification test was completed with no additional system difficulties. The electrical performance test was again performed and all parameters were within the prescribed tolerances. A decision was made at this point to rerun the 14 hour night portion of the qualification test to see if this system problem could be repeated. This time the receiver second IF test point was monitored with a sensitive oscilloscope. Also provision was made through a patch cable to externally control the DC power to the transmitter. Unfortunately, the problem did not occur, and the unit was accepted by NASA with the understanding that ESD would investigate the problem further at their facility.

At the conclusion of the tests at Radiation, ESD believed that this problem was due either to an oscillation in the receiver itself or to an oscillation in another part of the system that was conducted through the DC supply lines to the receiver. During the failure, there appeared to be 50 kHz riding on the raw video output of the receiver. Therefore, it was believed that this external oscillation could have occurred in the bit synchronizer of the electronic sub-assembly. The transmitter stay-on problem, it was believed, resulted from not generating an end of two second signal, as the two second timer was not real time and only operated when the system operation was normal.

Tests at ESD revealed that the receiver could only be made to oscillate if long leads were connected between the DC power supply and the receiver. It was found during the ESD tests that the receiver was unstable only near the high voltage extreme of the input DC voltage range at room temperature. However, at $-20^{\circ}C$ the receiver was unstable over most of the input DC voltage range. This problem was corrected by placing a 0.001 μf capacitor (C53) from the collector of Q5 to ground in the receiver power input circuit (Figure 3-3). This transistor is connected as an emitter follower and the capacitor reduces the high frequency gain, thus making the circuit more stable. Since long power leads were used in the tests at Radiation it was felt that this was the cause of the difficulties encountered in the first test at Radiation. That no problem was encountered in the second test could have been due to the addition of the patch cable to externally control the transmitter. After addition of this capacitor no combination of temperature, input DC voltage, and length of power leads could induce a receiver oscillation.

Realizing that the system reliability would be enhanced by using a real time two second timer to limit the transmitter on time and prevent possible failure, ESD proposed to NASA a real time two second timer that could easily be added to the BIP system. NASA accepted the ESD recommendation and the circuit was designed and added to five BIP systems of the first launch. The second launch had real time two second timers in all of the BIP systems. Section 11 of this report details the circuit and system operation of the real time two second timer.

8.0 BALLOON LAUNCH SERIES NO. 1 (MAY, JUNE, AND JULY 1970)

Table 7-1 shows the pertinent BIP and balloon information for the first series of the Ascension Island launches.

Launch No. 1 - Only first response had telemetry data, subsequent responses had all zeros. After five days, interrogation ceased. It was believed that the battery pack was inadvertently shorted before launch. Most probably the battery was damaged and thus would not accept the solar panel charge.

Launch No. 2 - Satisfactory operation for thirty (30) days, with the exception that the strain gauge reading began to steadily decrease. BIP operation and GHOST operation ceased on the same date. Therefore, a balloon failure most probably occurred.

Launch No. 3 - Balloon failure occurred after the launch and all systems fell into the ocean.

Launch No. 4 - Satisfactory BIP and GHOST operations for 105 days, at which time the balloon failed.

Launch No. 5 - After 25 days of satisfactory operation, telemetry sensor information was lost. At this time the balloon was over New Guinea. Channel 5 went to zero while Channel 6 went to approximately 1/2 its normal value. Channels 1 through 4 began tracking one another. The BIP ranging systems continued to operate satisfactorily for another 103 days, at which time the balloon failed.

Launch No. 6 - After 10 days of satisfactory operations, telemetry sensor information was lost. At the time of failure, the balloon was just east of New Guinea. Channel 5 went to zero and Channel 6 went to 1/2 its normal value. Channel 1 through 4 went near full scale. A second telemetry sensor abnormality occurred 23 days after launch, at which time the balloon was over the northern part of Brazil. BIP ranging information was obtained for another 47 days. The balloon floated for a total of 107 days.

Launch No. 7 - All telemetry sensor information was lost at launch. The BIP ranging system operated satisfactorily for 123 days, at which time the balloon failed.

Launch No. 8 - After 15 days of satisfactory operation, telemetry sensor information was lost. Channels 1 thru 4 went to zero and Channel 6 to 1/2 of its normal value. The channels recovered and again went bad on July 23rd, 1970. Again they recovered until all channels went to zero on July 27th, 1970. The BIP ranging system was operational for a total of 62 days, while the balloon floated for 126 days.

Launch No. 9 - After 5 days of satisfactory operation, telemetry sensor information was lost. Channels 5 and 6 went to zero and Channels 1 through 4 began to track each other. The BIP ranging system was operational for a total of 47 days, at which time the balloon failed.

Launch No. 10 - Two successful interrogations were made, after launch, which indicated low battery voltages. Either the solar panel was damaged at launch or the battery pack was defective. The balloon floated for 190 days.

Launch No. 11 - After 25 days of satisfactory operation, telemetry sensor information went to zero and the balloon failed.

Launch No. 12 - After 51 days of satisfactory operation, telemetry sensor information was lost. The BIP ranging system was operational for a total of 120 days, while the balloon floated for 128 days.

Launch No. 13 - After 9 days of satisfactory operation, telemetry sensor information was lost. Channel 5 went to 1/2 scale and Channel 6 went to zero. Channels 1 through 4 began to track. The BIP ranging system was operational for a total of 126 days, while the balloon floated for 135 days.

TABLE 8-1 BALLOON LAUNCH SERIES NO. 1 (May, June, July 1970)

	Address	Platform No.	GI S/N	Launch Date	Days After Launch: First TLM Loss	Days After Launch: BIP Failure	Days After Launch: GHOST Failure	Days After Launch: Balloon Failure	Balloon Height, mb	Two Second Timer	Battery Rewrap	Notes
1.	040300	P26	4	5-27-70	2	5	83	83	30	No	No	
2.	020500	P23	3	6-1-70	-	29	29	29	50	No	No	Balloon Leak
3.	022020	P24	6	6-8-70	-	-	-	-	-	Yes	No	Balloon Failure at Launch
4.	000122	P07	8	6-11-70	-	105	105	105	30	Yes	No	
5.	001404	P11	12	6-22-70	25	128	128	128	50	No	No	
6.	000031	P03	11	6-23-70	10	70	107	107	30	Yes	No	
7.	000141	P02	10	6-24-70	1	123	123	123	50	Yes	No	
8.	002204	P12	13	6-29-70	14	62	126	126	50	No	No	
9.	010410	P20	16	6-30-70	5	47	47	47	30	No	No	
10.	011100	P21	5	7-1-70	-	1	190	190	50	No	Yes	
11.	000064	P06	9	7-3-70	25	25	25	25	50	No	Yes	
12.	001202	P10	15	7-6-70	51	120	128	128	50	No	Yes	
13.	000114	P05	7	7-8-70	10	126	135	135	50	Yes	Yes	

9.0 BALLOON LAUNCH SERIES NO. 2 (Oct., Nov., 1970)

Table 8-1 shows the pertinent BIP and balloon information for the second series of the Ascension Island launches.

Before each BIP system is launched a noon and a midnight series of satellite interrogations are performed. Unfortunately, the first ten launches did not have ground checkouts of the BIP antenna and solar panel before the launch. Therefore, the two early BIP failures might have been prevented if this final checkout was performed.

All of the BIP systems that were launched in October and November have had the below special tests or equipment installed.

1. Two second timer.

2. All battery packs were rewrapped to prevent accidental tab shorting to case. Also, each battery pack was charged at the prescribed rate for 16 hours, then discharged for 1 hour at its full rating. Thus, full battery pack capacity was assured.

3. All water bags were subjected to an altitude of 80,000 feet to check for leaks.

Launch No. 1 - Satisfactory BIP and GHOST operation for 9 days at which time the balloon failed.

Launch No. 2 - After 13 days of satisfactory operation telemetry sensor information was lost over New Guinea. Channels 5, 6, and 7 went to zero at this time. BIP ranging information was obtained for an additional 7 days at which time the balloon failed while over Africa. Recovery of this system was made at Lumbumbashi, in the Congo. This BIP was returned to GI/ESD in February 1971 and is discussed in Section 10.0 of this report.

Launch No. 3 - Satisfactory operation of BIP and GHOST for 159 days, at which time the system was cut-down.

Launch No. 4 - After two days of satisfactory operation, the balloon failed.

Launch No. 5 - Satisfactory operation of BIP for 55 days. The GHOST system has operated satisfactorily for 213 days.

Launch No. 6 - No BIP response after launch. Since this BIP system was not checked out on the ground with the antenna and solar panel that were launched, the antenna could have been defective. Satisfactory GHOST operation for 100 days, at which time the balloon failed.

Launch No. 7 - Satisfactory operation of BIP and GHOST for 97 days , at which time the system was cut-down.

Launch No. 8 - One day of BIP operation. GHOST operation for 64 days.

Launch No. 9 - Balloon failure after launch at an altitude of 20,000 feet. The BIP system was recovered by NCAR. The receiver/transmitter operation was normal, however, the printed circuit boards of the electronic subassembly had salt deposits and corrosion build-up.

Launch No. 10 - This system was launched during adverse weather conditions as both rain and high winds (28 MPH with gusts to 35 MPH) were present. Channels 1 and 3 were full scale after launch which indicated probable solar panel damage at launch. After 2 days of operation, telemetry sensor information was lost. The BIP ranging system continued to operate satisfactorily for 41 days at which time the BIP failed. During the 41 days of operations the number of interrogations per orbit was limited. Most probably this was caused by launch damage to the BIP antenna. After 47 days from launch the balloon failed over South America. The BIP system was recovered in Columbia and is presently at the NCAR facility in Boulder, Colorado.

Launch No. 11 - Satisfactory operation of BIP and GHOST for seven days, at which time the balloon failed.

Launch No. 12 - Satisfactory operation of BIP system for 16 days. The GHOST system was operational for an additional 56 days, at which time the balloon failed.

Launch No. 13 - Satisfactory operation of BIP system for 24 days. The GHOST system was operational for an additional 12 days, at which time the balloon failed.

Launch No. 14 - Satisfactory operation for two days, at which time the balloon failed.

TABLE 9-1 BALLOON LAUNCH SERIES NO. 2 (OCT., NOV. 1970)

	Address	Platform No.	GI S/N	Launch Date	Days After Launch: First TLM Loss	Days After Launch: BIP Failure	Days After Launch: GHOST Failure	Days After Launch: Balloon Failure	Balloon Height, mb	Chan. 4 Connection	Notes
1.	005040	P17	23	10-20-70	-	9	9	9	50	+4.8V(c)	Balloon Leak
2.	004210	P15	17	10-21-70	12	20	20	20	50	+4.8V(c)	Recovered at Lumbumbashi, Congo, Africa
3.	050002	P08	30	10-22-70	-	159	159	159	50	10K ohms	Cut-down
4.	041020	P28	25	10-23-70	-	2	2	2	50	Open	Balloon Leak
5.	004200	P16	20	10-24-70	-	55	213	213	50	Open	
6.	000052	P04	29	10-29-70	-	0	100	100	50	10K ohms	No BIP Response
7.	042010	P29	18	10-30-70	-	97	97	97	50	Relay	Cut-down
8.	044004	P30	26	10-31-70	-	2	64	64	50	Open	
9.	003001	P14	24	11-1-70	-	-	-	-	-	+4.8V(c)	Balloon Failure at Launch
10.	000007	P01	1	11-2-70	3	43	47	47	50	Relay	Recovered at Columbia, South America
11.	002402	P13	27	11-9-70	-	7	7	7	30	Open	Balloon Leak
12.	000601	P09	22	11-10-70	-	16	72	72	30	Relay	
13.	024002	P25	14	11-12-70	-	24	36	36	30	Relay	
14.	020240	P22	28	11-16-70	-	2	2	2	30	Open	Balloon Leak

10.0 LOSS OF EXTERNAL TELEMETRY SENSOR INFORMATION

As mentioned in Section 8, loss of external telemetry sensor information occurred in many of the BIP systems after launch from Ascension Island. Most of the initial anomalies occurred over South America and New Guinea. Since these two areas have severe thunderstorms and very high clouds, a theory was proposed that upper atmospheric electricity was responsible for the data loss. The three external telemetry sensor channels, namely, channel 1 - atmospheric temperature, channel 3 - solar panel temperature, and channel 4 - balloon over pressure, all have very long lengths of wire between the sensor and the BIP electronics unit assembly. Thus, a very good receptor for static electricity was provided. The cloud cover at the location of the first loss of telemetry information was checked for a number of the BIP flights and in all cases the correlation was positive.

10.1 Test Program

After Balloon Launch No. 1, a test program was begun to try to simulate the loss of external telemetry sensor information. Environmental tests of the BIP electronics unit assembly at altitude and low temperature were conducted, but no abnormalities were found. Next, a series of tests were performed whereby shorts were placed in various parts of the analog multiplexer printed circuit board. It was found that the actual failure mode could most closely be simulated by connecting shorts between the gate and source of the input field effect transistors (FET's). The conditions under which this test was performed are described below.

1. A 56 ohm resistor was connected between the gate and source of the input FET.(Figure 10-1 shows this connection).

2. Only single FET failures were simulated.

3. Channels 2, 5 and 6 were connected in the normal operational mode.

4. Channels 1, 3 and 4 had resistors of 43K ohm, 100K ohm, and 10K ohm, respectively, connected between the FET source and analog psc. These resistors were used to simulate the flight impedances that are normally present on these channels.

5. Channel 7 FET source was connected to +6.4 volts.

6. All tests were performed at room temperature.

7. Channel data was observed on the bench check-out equipment display unit.

The results and conclusions of these tests are outlined below:

1. A channel with the short simulation (56 ohm resistor) always has the correct data.

2. A short in channels 1, 2, and 3 will cause channels 5, 6, and 7 data to read zero or very low.

3. A short in channel 4 will cause channels 6 and 7 to read a count of 76 and channel 5 to read zero. Also, channels 1, 2, and 3 track channel 4. This was a mode of operation that occurred many times in the balloon launch no. 1 data. Channel 4 dominates since its source impedance is much lower than any of the other channels.

Using the equivalent circuit of each channel and the superposition theorem, close correlation was obtained between calculations and the experimental results described above for a one channel FET failure. Multiple channel FET failures, however, made calculations more difficult since the source impedance connected to each FET varies considerably during normal operation. A computer program, where the source impedances could be varied in increments would have been necessary to complete the calculations in a reasonable time period. Additional calculations, however, were not necessary since the failure mode had been isolated to channel FET shorts.

10.2 Balloon Launch Series No. 2

For the second series of balloon launches (Oct - Nov 1970), some modifications of the BIP system were made to reduce the effects of this suspected phenomena. Namely, channel 4 - balloon over-pressure, which had over 90 feet of wire between the sensor and the BIP was removed from ten of the fourteen systems that were launched. For these ten BIP systems, three different types of internal channel 4 BIP connections were used. Three BIP systems had channel 4 connected to +4.8 volt "C" power. Channel 4 was terminated in 10K ohm for two other BIP systems. Five BIP systems had channel 4 open.

The remaining four BIP systems that were launched in October and November 1970 employed two relays in parallel that would operate only when +12 volt "C" power was energized. Figure 10-2 shows the schematic of the electrical circuit and connections. Telemetry channels 1, 3 and 4 were connected to the external sensors, through the relay contacts, only during the satellite interrogations, thus minimizing the probability of BIP damage. The resistor and zener diode were placed in the circuit to prevent damage if a high voltage spike occurred at the time when the relay was energized.

These precautions for Balloon Launch No. 2 significantly reduced the loss of external telemetry sensor information as evidenced by the comparison between Table 8-1 and Table 9-1. Coincidentally, the two BIP's that experienced a loss of telemetry information were recovered. P15, recovered at Lumbumbashi, Congo, Africa, was returned to GI/ESD and analyzed, the results of which are detailed in Section 10.3. The second recovered BIP, P01, has not been returned and analyzed to date. P01, which had the relay modifications, experienced a complete loss of telemetry information over South America a few days after a launch during a storm.

10.3 P15, BIP Recovered from Africa

BIP P15, launched from Ascension Island on October 21st, 1970, floated in a westerly direction over South America and the South Pacific Ocean. On November 2nd, 1970 the telemetry data readout indicated that an external telemetry sensor loss had occurred. The balloon position at this time was New Guinea. Channels 3 and 4 had reduced pcm count data, channels 5, 6, and 7 were reading zero, and channel 1 appeared to have the correct reading. From the simulation test program data described in section 10.1, it appeared that a channel 1 failure had occurred. Using source impedances calculated from previous good data, the equivalent circuit, and the superposition theorem, a good correlation was made between the actual and calculated data. The results of these calculations for day 11/2/70 orbit 2794 are tabulated below.

Channel	Actual (Volts)	Calculated (Volts)
2	3.225	3.332
3	3.825	4.04
4	4.625	4.639

The details of these calculations are shown in Appendix I of this report. Data from subsequent orbits did not correlate. This appeared to indicate that another channel FET failure had occurred. Calculations of multiple channel failures were not attempted because of their tedious, time-consuming nature. It was proposed that a computer program be written to perform these calculations, but at this time it was believed not to be warranted.

The balloon system of P15 failed over Africa and was recovered at Lumbumbashi, Congo, Africa. Figures 10-3 and 10-4 are photographs, taken after the African recovery, of the electronics unit and the solar panel, respectively, of P15. The BIP was returned to General Instrument in February of 1970. First, the system was checked for possible damage, then connected to the BCE (Bench Check-out Equipment) where the telemetry sensor data loss mode was verified. The channel FET's were then checked with an ohmmeter and chennel 1 and 3 were found to have gate-to-source and gate-to-drain shorts. These two FET's were replaced and normal operation was verified on the BCE display.

Subsequent visual analysis of the damaged FET's, under a microscope, showed black spots at the shorted junctions. Discussions with Motorola, Inc., indicated that this failure was due to a high voltage, low current transient. Since the header had not arced over, Motorola felt that the voltage was less than 600 or 700 volts. A high voltage, high current transient would have, obviously, destroyed the chip.

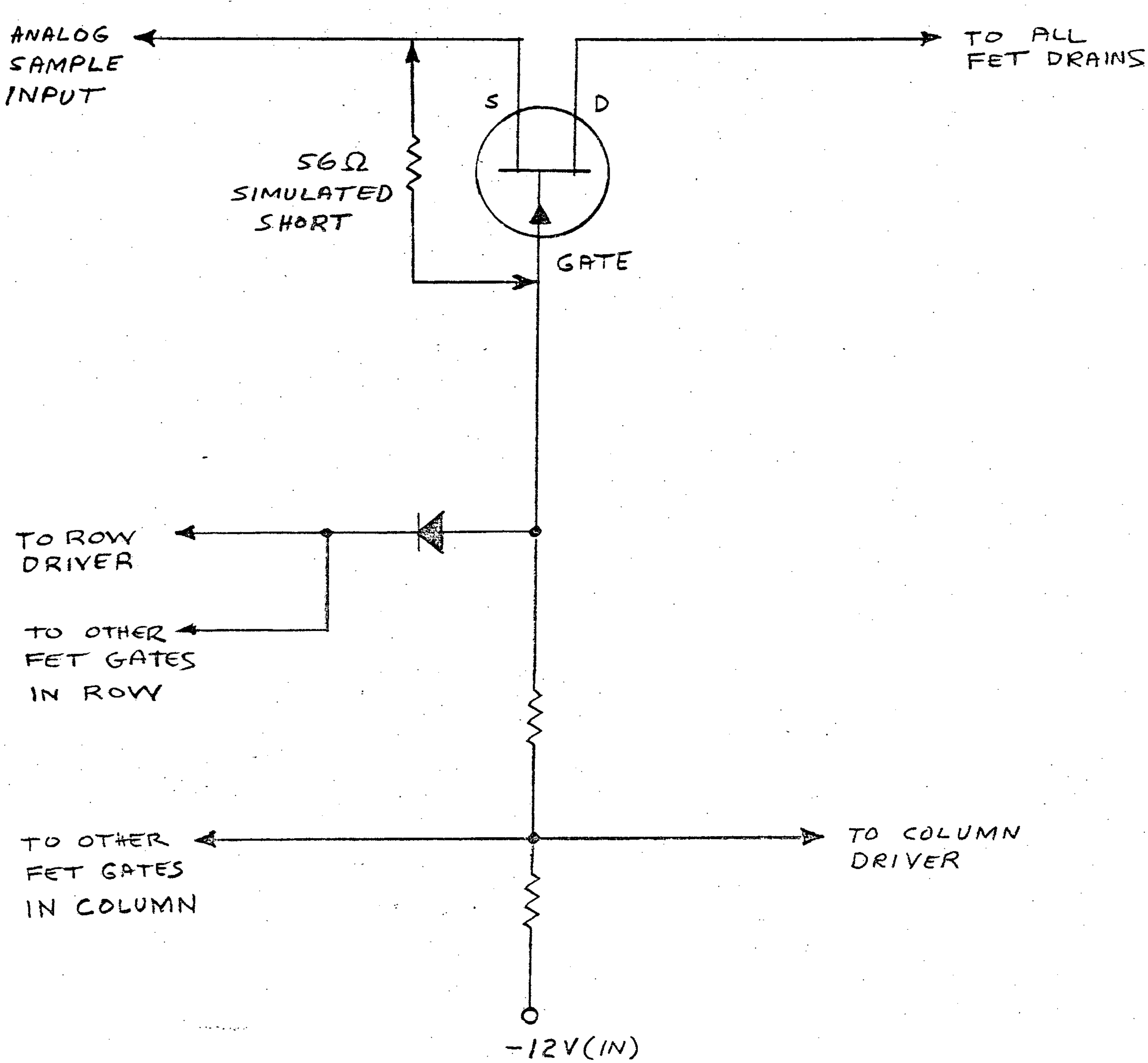


FIG. 10-1 - TYPICAL MULTIPLEXER FET

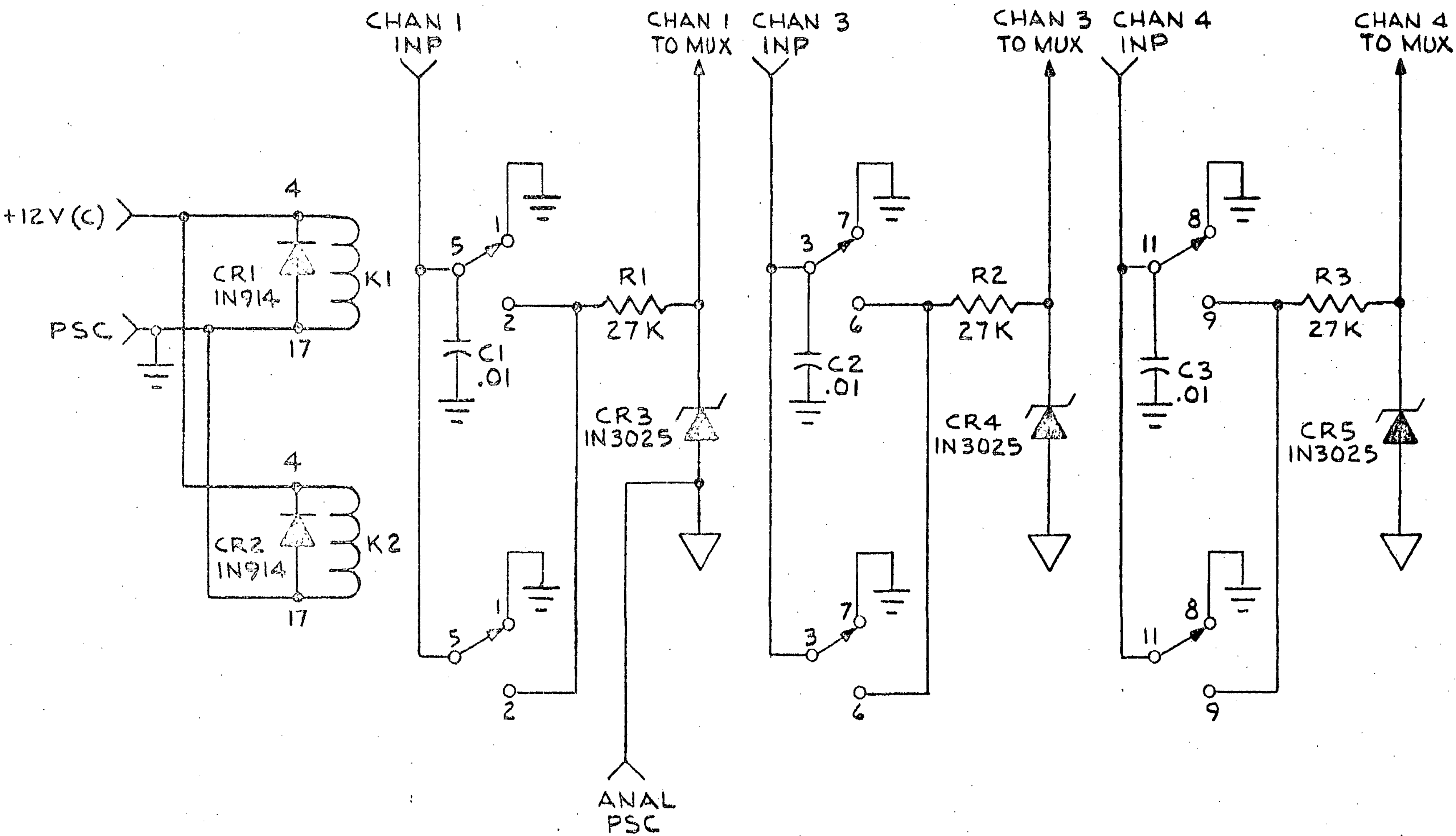


FIGURE 10-2 EXTERNAL TELEMETRY SENSOR RELAY BOARD SCHEMATIC

Fig. 10-3

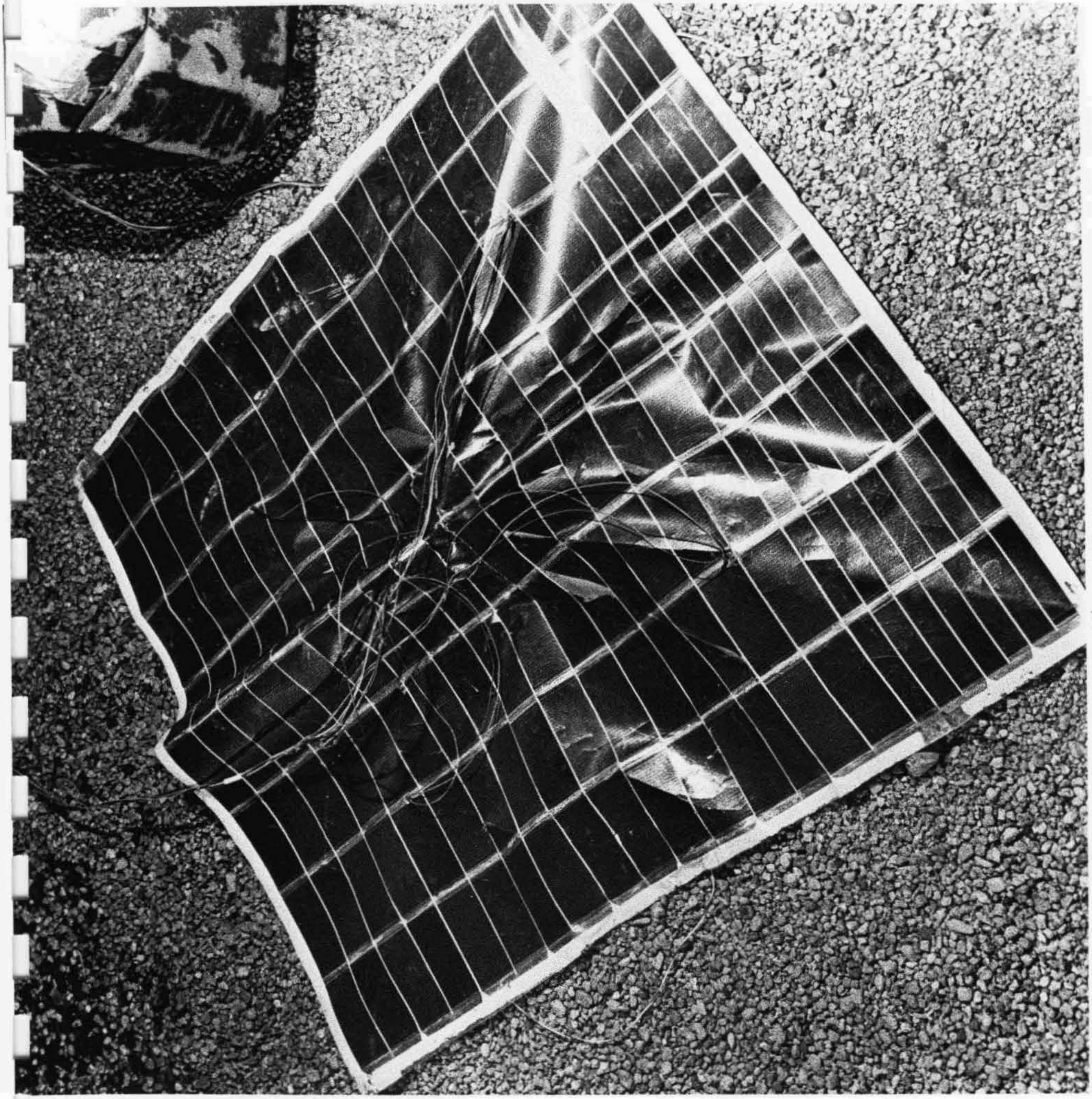


Fig. 10-4

11.0 REAL TIME TWO SECOND TIMER

The two second timer located on printed circuit board A2A3 is not a real time indicator, but measures the interval of time when "C" power is on, when the BIP system is operating normally. Thus, in order to preclude a potential system catastrophic failure, namely, a system malfunction where "C" power remains on, a real time two second timer (A2A10) was designed and incorporated into the BIP system. Figure 11-1is the logic schematic of A2A10. A photograph of the assembled printed circuit board is shown in Figure 11-2.

U1 is biased in the off state (0 volts output) when power is applied to the circuit. This signal is applied to U2 causing pin 11 of U2 to a logic "1", enabling the end of two second (old) to be gated through U2 pin 6 as the end of 2 second (new) signal. This signal turns off all power except stand-by power. When this end of two seconds (old) signal is not generated, the time constant of R1 and C1 will enable pin 2 of U1 to exceed the voltage at pin 3 of U1, causing a positive transition (logic "1") at pin 6 of U1. This signal will now be gated through U2 to become the end of 2 second (new) signal. Thus, the maximum amount of time for "C" power to be on will be limited under all conditions.

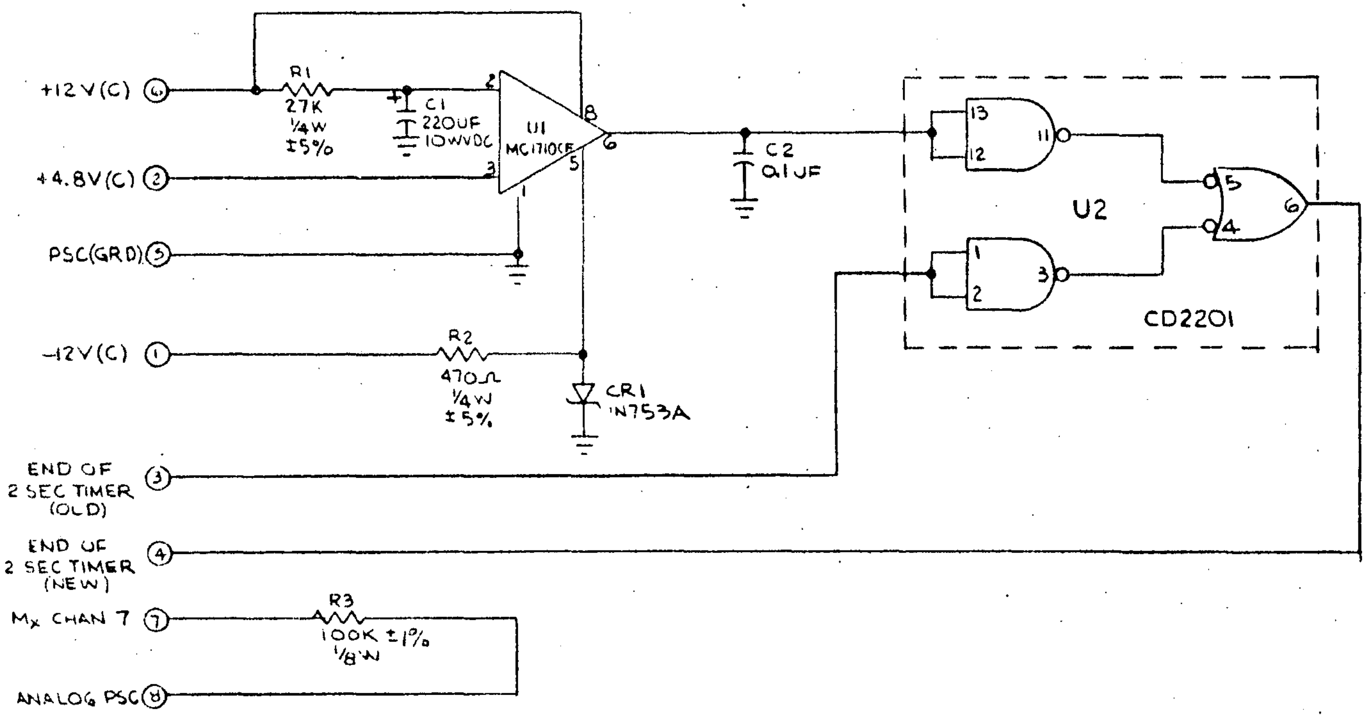


FIGURE 11-1 - TWO SECOND TIMER, SCHEMATIC DIAGRAM - A2A10

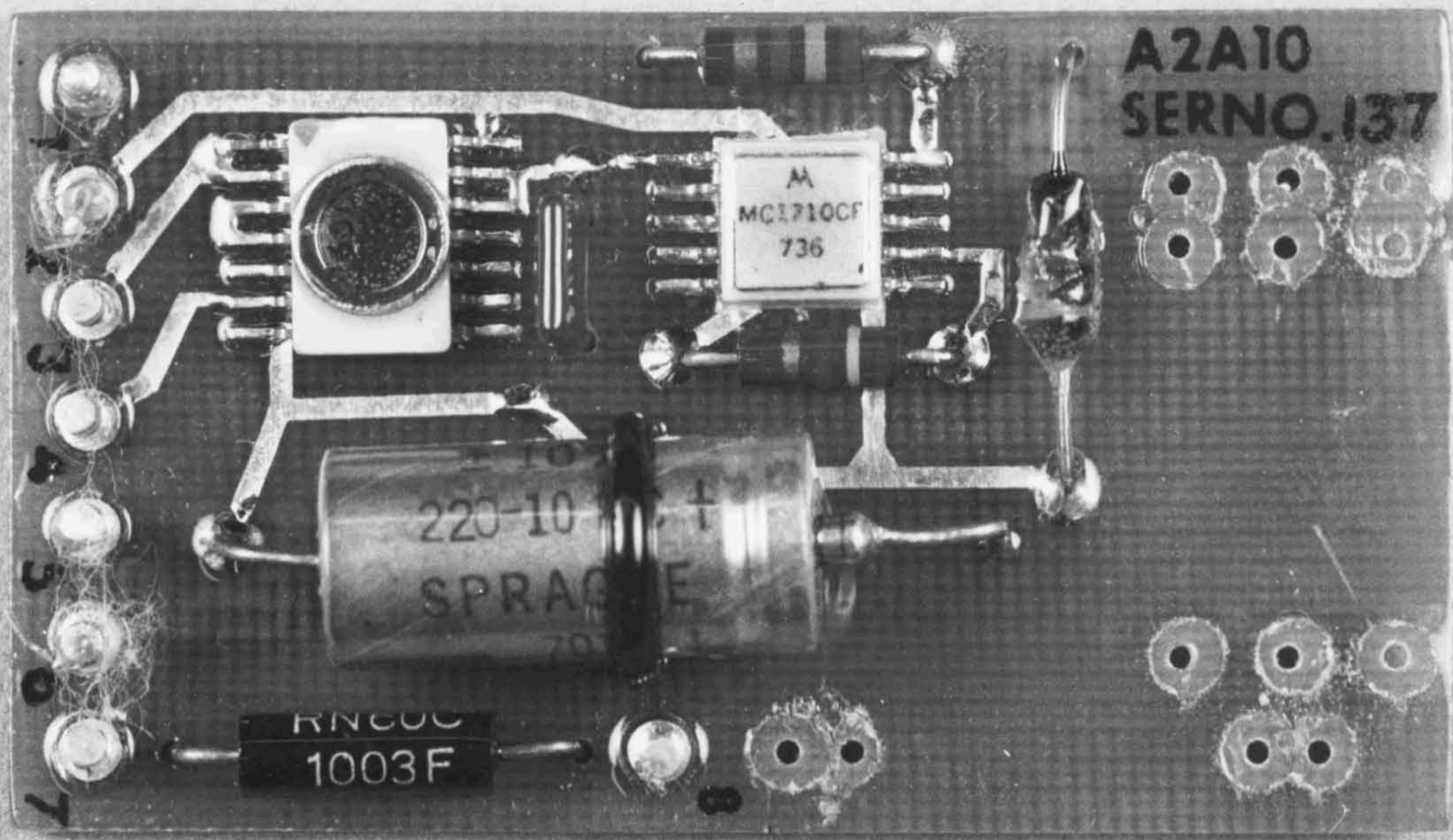


Fig. 11-2

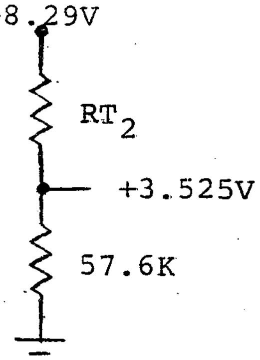
APPENDIX I

Calculation of P15 Channels 2, 3 and 4 Voltages for Day 11/2/70, Orbit 2794.

1. Calculate Thevenin Equivalent for Channels 2 through 4 when operation is normal. Data from Orbit 2781 will be used since Orbit 2794 was a noon time interrogation.

Channel	PCM Count	Voltage
1	73	3.675
2	70	3.525
3	127	≥6.375
4	107	5.375
5	109	5.475
6	109	5.475
7	81	4.075

Channel 2



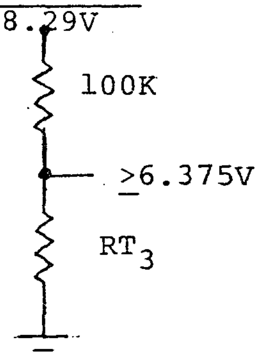
$$3.525 = \frac{8.29 \times 57.6}{RT_2 + 57.6}$$

$$R_{T_2} = 77.8\text{K ohms}$$

$$R_{Thev_2} = \frac{77.8+57.6}{77.8 \times 57.6} = 33.1\text{K ohms}$$

$$V_{Thev_2} = +3.525\text{V}$$

Channel 3



Assume RT_3 open since Channel 3 has consistently read 127.

$$R_{Thev_3} = 100\text{K ohms}$$

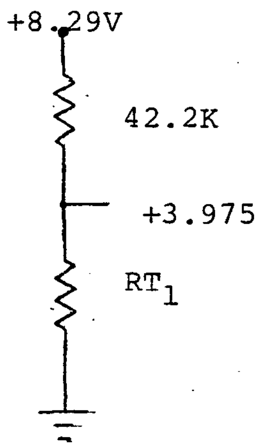
$$V_{Thev_3} = +8.29\text{V}$$

Channel 4 — This Channel was connected to +4.8V. "C" power through a 10K resistor, therefore,

$$R_{Thev_4} = 10K \text{ ohms}$$

$$V_{Thev_4} = +5.375V$$

2. If a Channel 1 failure is assumed, then Channel 1 is reading correctly.



$$3.975 = \frac{8.29\ RT_1}{42.2+RT_1}$$

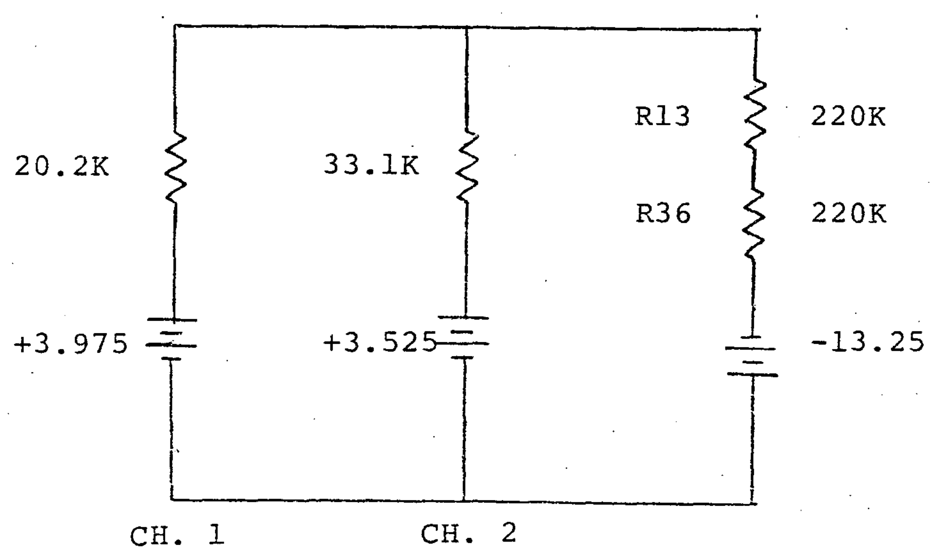
$$RT_1 = 38.8K \text{ ohms}$$

$$R_{Thev_1} = \frac{42.2 \times 38.8}{42.2+38.8} = 20.2K \text{ ohms}$$

$$V_{Thev_1} = +3.975V$$

3. Calculation of Channel 2 voltage for a Channel 1 failure.

Equivalent Circuit:



Using the Superposition Theorem.

$$V = V_1 + V_2 + V_3$$

$$V_1 = \frac{3.975x(33.1x440)/(33.1+440)}{20.2+(33.1x440)/(33.1+440)} = +2.40V$$

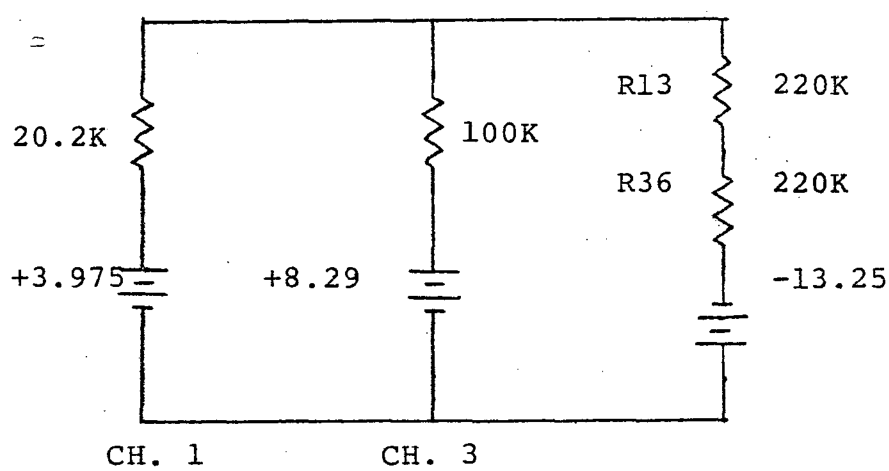
$$V_2 = \frac{3.525x(20.2x440)/(20.2+440)}{33.1+(20.2x440)/(20.2+440)} = +1.30V$$

$$V_3 = \frac{-13.25x(20.2x33.1)/(20.2+33.1)}{440+(20.2x33.1)/(20.2+33.1)} = -0.368V$$

$$V = 2.40 + 1.30 - 0.368 = 3.332V$$

4. Calculation of Channel 3 voltage for a Channel 1 failure.

Equivalent Circuit:



Using the Superposition Theorem.

$$V = V_1 + V_2 + V_3$$

$$V_1 = \frac{3.975x(100x440)/(100+440)}{20.2+(100x440)/(100+440)} = +3.19V$$

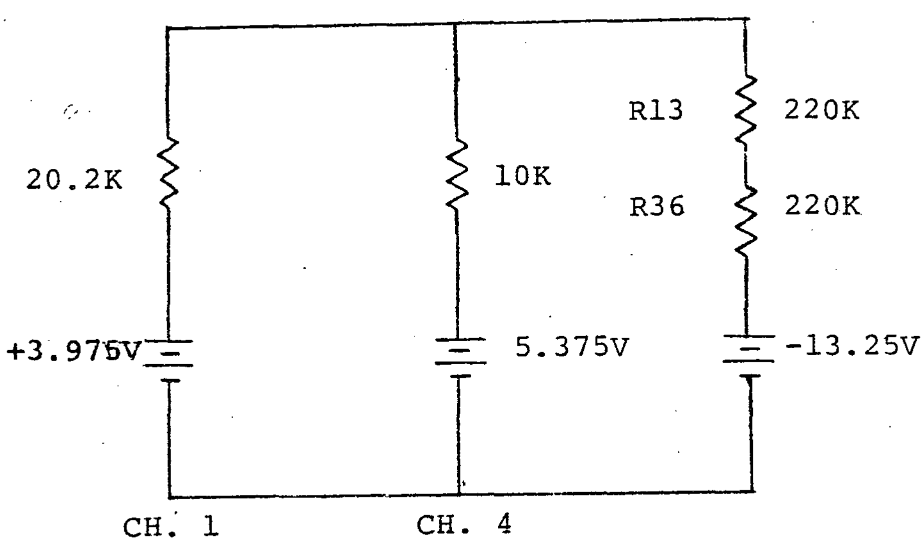
$$V_2 = \frac{8.29x(20.2x440)/(20.2+440)}{100+(20.2x440)/(20.2+440)} = +1.34V$$

$$V_3 = \frac{-13.25x(20.2x100)/(20.2+100)}{440+(20.2x100)/(20.2+100)} = -0.487V$$

$$V = 3.19 + 1.34 - 0.487 = 4.04V$$

5. Calculation of Channel 4 voltage for a Channel 1 failure.

Equivalent Circuit:



Using the Superposition Theorem.

$$V = V_1 + V_2 + V_3$$

$$V_1 = \frac{3.975x(10x440)/(10+440)}{20.2+(10x440)/(10+440)} = +1.297V$$

$$V_2 = \frac{5.375x(20.2x440)/(20.2+440)}{10+(20.2x440)/(20.2+440)} = 3.54V$$

$$V_3 = \frac{-13.25x(20.2x10)/(20.2+10)}{440+(20.2x10)/(20.2+10)} = -0.198V$$

$$V = 1.297 + 3.54 - 0.198 = 4.639V$$

APPENDIX II - SPECIFICATION 121765

1.0 ELECTRICAL PERFORMANCE TEST

Verifies operations of all BIP functions at room temperature. Each of the tests are briefly described in the following sections.

1.1 Address and Address Recognition Test

Verifies that the BIP will recognize its own address and will not respond to 16-bit address code transmissions differing by one or more bits from its hard-wired address.

1.2 Correct Frame Generation Test

Verifies that the BIP, upon interrogation, will transmit a frame consisting of two address complements followed by 7 lines of data followed by one address complement. (3½ of the 7 lines are unused).

1.3 Coder Accuracy Test

Verifies that the BIP analog-to-digital converter will convert analog input data in the range to zero to +6.4v to corresponding 7-bit binary words with an error ±70 millivolts or less.

1.4 Multiplexer and Coder Input Impedance Test

Verifies that the operation of the BIP multiplexer is correct by demonstrating the one-to-one correspondence between analog inputs and digital data word locations in the format. It also verifies that the BIP input impedance at each analog input is greater than 100K ohms during the encoding time for that input.

1.5 Transmitter Carrier Frequency and Output Power Test

Verifies that the BIP transmitter carrier frequency and output power are correct and within tolerance.

1.6 Transmitter Turn-On/Turn-Off Verification

Verifies that BIP is turned off by the End of Frame signal.

1.7 Transmitter Turn-Off Redundancy Test

Verifies that the redundant 2-second clock turn-off signal generated will turn off the transmitter a maximum of 2 seconds after it has been turned on in the event that an end of frame pulse does not occur.

1.8 Transmitter Modulation Test

Verifies that the transmitter is properly modulated by the 12.5 kHz data.

1.9 Address Recognition Test

Verifies that the BIP will recognize its address within 100 milliseconds 90% of the time.

1.10 12.5 KB Bit Error Rate Test

Verifies that the 12.5 KB/sec error rate will be less than 62.5/sec at a signal level of -112 dbm.

1.11 1 KB Bit Error Rate Test

Verifies that the 1.0417KB/sec error rate will be less than 10^{-5} at a signal level of -112 dbm.

1.12 Input Voltage Variation Test

Verifies that the BIP will operate as required over specified input voltage excursions.

1.13 Sensor Output Verification Test

Verifies that the user outputs supplied by the BIP are as required.

1.14 BIP Delay Measurement Test

Determines the delay through the platform system, using the ranging feature of the satellite.

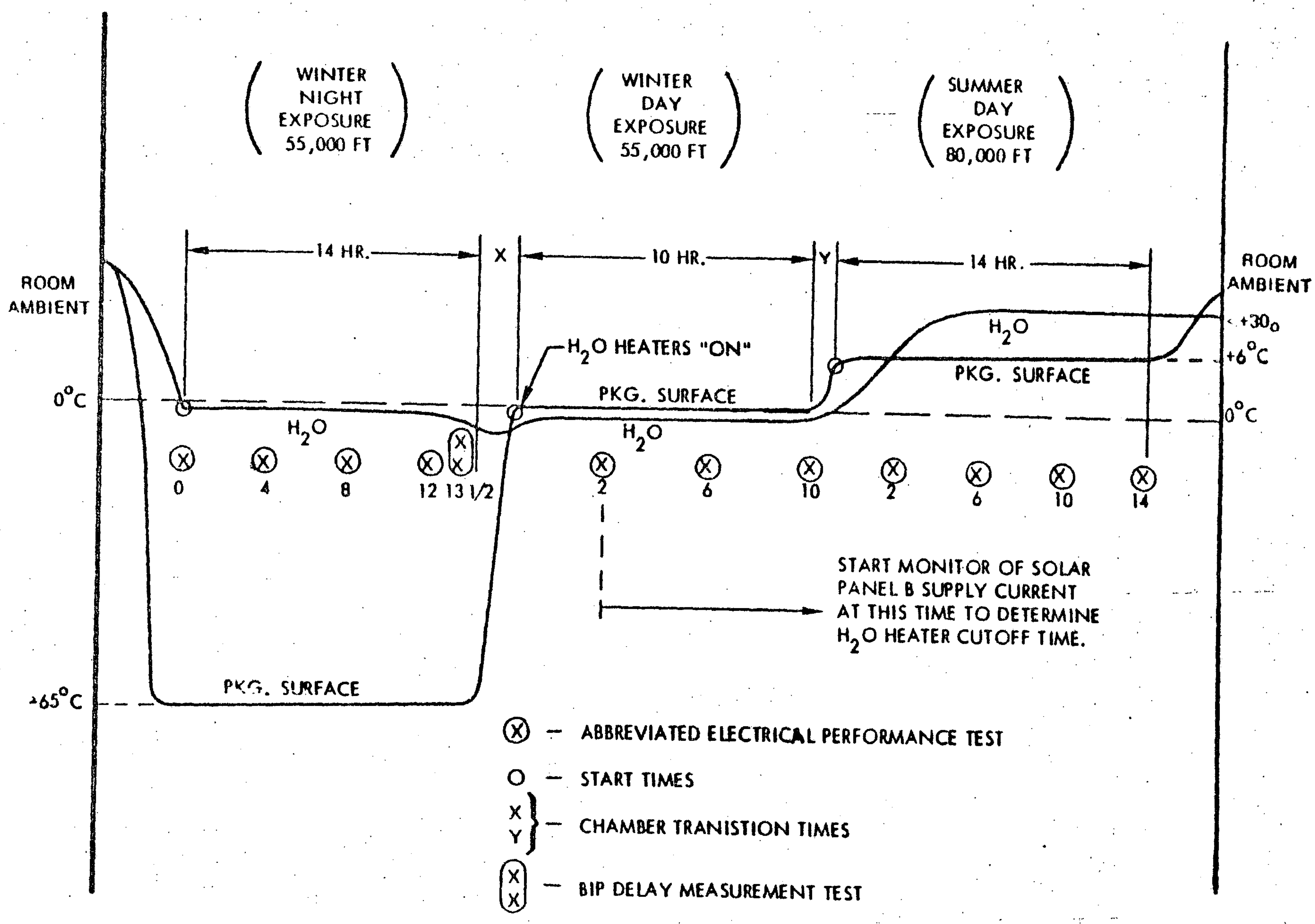
2.0 Qualification Test

This test is designed to simulate the altitude temperature environment that BIP packages are exposed to in actual flight. Figure 2-1 illustrates the test conditions.

2.1 During the qualification test the following parameters are monitored:

- Transmitter RF power output and frequency
- The complete data frame is viewed on a storage oscilloscope to ensure correct address, address complement, data, and parity.

At the conclusion of the qualification test the BIP package is brought back to room temperature and to ensure no degradation a complete electrical performance test is retaken.



WINTER NIGHT EXPOSURE 55,000 FT
WINTER DAY EXPOSURE 55,000 FT
SUMMER DAY EXPOSURE 80,000 FT
14 HR.
X
10 HR.
Y
14 HR.
ROOM AMBIENT
0°C
-65°C
ROOM AMBIENT
+30°
+6°C
0°C
H2O HEATERS "ON"
PKG. SURFACE
H2O
0
4
8
12 13 1/2
2
6
10
2
6
10
14
START MONITOR OF SOLAR PANEL B SUPPLY CURRENT AT THIS TIME TO DETERMINE H2O HEATER CUTOFF TIME.
ⓧ – ABBREVIATED ELECTRICAL PERFORMANCE TEST
O – START TIMES
X Y } – CHAMBER TRANISTION TIMES
BIP DELAY MEASUREMENT TEST
75272

FIG.-2-1