The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

MRT-4-045
QM-66-071

OPERATIONAL PROCEDURE FOR PROJECT PANDORA MICROWAVE TEST FACILITY

#175

Prepared by
E. V. Byron
October 1966

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

MRT-4-045
QM-66-071

ABSTRACT

This report describes the operational procedure for the Project Pandora microwave test facility. It is intended primarily for non-microwave oriented technical personnel to enable them to operate the facility with a minimum of training. Included is the Turn-On, Turn-Off Procedure, the procedure for measuring transmitted power and power density, and a description of the power monitors.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

I. INTRODUCTION

This report describes the operational procedure for the Project Pandora microwave test facility. It is intended primarily for non-microwave oriented technical personnel, to enable them to operate the facility with a minimum of training. Section II of this report delineates the basic turn-on, turn-off procedure for the equipment. Section III describes the procedure for determining which of the "add-on" sections of the expandable conical horn to use, and the power requirements for a desired power density. Section IV describes the power monitors in the microwave anechoic chamber.

The microwave equipment for Project Pandora is assembled in the four equipment racks illustrated in figure 1. Rack No. 1 contains the Spectrum Analyzer R.F. and Display sections. Rack No. 2 contains the auxiliary low-power microwave generation and modulation equipment. The equipment in this rack is not interconnected (nor is the spectrum analyzer). Rack No. 3 contains the primary low power microwave generation and modulation equipment, and the necessary monitoring and recording equipment. Rack No. 4 contains the high power microwave amplifier and power supplies. The interconnection of these two racks, with the "expandable horn" transmitting antenna in the anechoic chamber, is shown in figure 2 which is a functional block diagram of the microwave system.

II. EQUIPMENT OPERATION

The following instructions pertain to the operation of the equipment assembled in equipment racks 3 and 4 with reference to figures 1 and 2.

<u>Note</u>: For operation of the various individual pieces of equipment, refer to the manufacturers' operation manuals which are available at the test facility.

A. Preliminary Turn On Procedure

Note: Connect the proper transmitting horn section for the required frequency and power density as outlined in Section III of this procedure.

1. Equipment Rack Number 4

a. Turn on water supply. Pressure should be between 15 and 50 psi.

b. Turn on low voltage A.C. power supply. Set Heater Voltage to 6.3 volts.

c. Turn on D.C. power supply (solenoid power). Set to 33 volts.

Note: Under no circumstances should the solenoid be operated without water cooling or permanent damage will result. If the over current light is energized, the door interlock is open or there is insufficient water pressure or solenoid current.

d. Set the Cathode Voltage switch on the high voltage power supply to the Burn-in position and turn on the high voltage.

Note: There is a 3 minute delay before the high voltage comes on. Allow 15 minutes warm-up.

2. Equipment Rack Number 3

a. Turn on A.C. power to rack number 3.

b. Turn the Grid Control on the Alfred 5-6868, 10 watt TWT amplifier to -250 volts. Turn Helix Control completely CCW.

c. Turn HP692C Sweep Oscillator to Standby position.

d. Turn on power to all equipment, allow 15 minute warm-up.

e. Zero all HP431C power meters. For maximum accuracy, the power meters should be "re-zeroed" periodically. Refer to the HP431C instruction manual.

f. Turn Sweep Oscillator Output Attenuator and TWT Output Attenuator completely CW (max. attenuation).

g. Set HP692C to desired frequency and connect for desired modulation.

<u>Note</u>: Refer to the instruction manuals of the HP692, HP8403A, and the HP3300A for the possible modulation options and their settings. If the auxiliary low power R.F. generation and modulation equipment is to be used, refer to the appropriate instruction manuals for possible interconnections and operating instructions.

h. Turn HP692C to Operate position.

B. <u>Operational Turn On Procedure</u>

1. <u>Equipment Rack Number 4</u>

a. Set Cathode Voltage switch to the .1/3.3KV position and observe high voltage and current meters.

<u>Note</u>: Do not allow high voltage to exceed 3250 volts and the current to exceed 560 ma.

b. If necessary, adjust high voltage screwdrive adjustment for high voltage meter reading of 3250 volts. DO NOT EXCEED 560 MA. CURRENT.

2. <u>Equipment Rack Number 3</u>

a. Turn Helix Control on Alfred 5-6868 TWT completely CW.

b. Turn Grid Control on Alfred 5-6868 TWT completely CW.

c. Adjust Sweep Oscillator Output Attenuator for maximum power output as observed on TWT Monitor Power Meter. Lock in position.

d. Adjust TWT Output Attenuator for the required transmitted power as observed on the TWT Monitor Power Meter. Lock in position.

Note: The transmitted power required for a desired power density can be determined from figure 3 and Section III of this procedure.
The transmitted power can be determined from the meter reading and figure 4; (High Power Monitor, - Meter Reading vs. Output Power).
DO NOT EXCEED 250 WATTS TRANSMITTED POWER FOR EXTENDED PERIODS OF TIME WITH THE INITIAL TUBE SUPPLIED.

e. Set the monitor switches on the monitor switch panel to connect the desired function to be monitored to the strip chart recorder. The normal setting of these switches is TWT Monitor to the recorder channel No. 2, and Monitor Channel No. 1 to recorder channel No. 1.

f. Connect "Available Inputs" to the scope or the HP415 as required.

C. Turn Off Procedure

1. Equipment Rack Number 3

a. Turn 10 W TWT Output Attenuator max. CW (max. attenuation).

b. Turn Sweep Oscillator Output Attenuator max. CW.

c. Turn Grid Control on Alfred 5-6868 10 Watt TWT to -250 volts. Turn Helix Control completely CCW.

d. Turn HP692C Sweep Oscillator to Standby position.

e. Rack power may now be turned off.

2. Equipment Rack Number 4

a. Set the Cathode Voltage switch on high voltage power supply to Burn-in position.

b. Turn off high voltage.

c. Turn off low voltage A.C. power supply.

d. Turn off D.C. power supply.

e. Turn off water supply.

III. PROCEDURE FOR SELECTING HORN SECTION AND OUTPUT POWER FOR DESIRED POWER DENSITY

A. Design Frequency Range for "Expandable" Conical Horn

The microwave facility was designed such that a suitable quiet zone - minimum dimension, 3' wide by 2' high by 1' deep for two "test samples" side by side - would be illuminated uniformly a $\pm$ 1.0db power variation in the quiet zone was the design goal. The quiet zone, as discussed in this report, starts at a transmission length of 23.0 feet and is symmetric about the chambers horizontal and vertical axis. These quiet zone dimensions, therefore, set the beamwidth characteristics of the transmitting horn; and a conical transmitting horn with "add-on" section was designed to give maximum gain with the required beamwidth over the S-Band frequency range. Under these conditions, figure 3 shows the "design frequency range" for the appropriate sections (D_1 through D_6). This figure is a plot of power density (in mw/cm^2) per watt transmitted - Pd/W - versus frequency, for each of the horn sections. It can be seen that, for the design frequency ranges, Pd/W is $1.6 \times 10^{-2} \frac{mw/cm^2}{watt} \pm 10\%$.

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Thus, for 250 watts transmitted, the power density in the quiet zone is 4.0 mw/cm^2 ± 10%.

1. To determine specifically the transmitted power required for a desired power density (at a given frequency in the design range):

   a. Determine Pd/W for the known frequency and horn section from figure 3.

   b. Solve: Pd/W x Power = Power density

   $$\text{Power} = \frac{\text{Power density}}{\text{Pd/W}}$$

   c. Example: At 3.0 GHz, a power density of 2mw/cm^2 is required. (Horn Section D_4)

   Pd/W = $1.58\text{x}10^{-2}$ from figure 4.

   $$\text{Power} = \frac{2}{1.58\text{x}10^{-2}} = 126 \text{ watts}$$

2. To determine power density from a known transmitted power:

   a. Determine Pd/W for the known frequency and horn section from figure 3.

   b. Solve: Power density = Pd/W x Power

   c. Example: At 3.5 GHz, 200 watts are transmitted (Horn Section D_2).

   Pd/W = $1.56\text{x}10^{-2}$ from figure 3.

   Power density = $1.56\text{x}10^{-2}\text{x}200 = 3.13$ mw/cm^2

B. Horn Section for a Reduced Quiet Zone

To increase the versatility of the test facility, additional "add-on" horn sections were designed to uniformally illuminate successively smaller quiet zone volumes with increased gain. The determination of the quiet zone volume is dependent upon the beamwidth of the various sections and is beyond the scope of this report. Suffice it to say that, at the upper end of the frequency band (3.95 GHz) horn section D_{10} will essentially illuminate uniformly a quiet zone large enough for a single test sample - 1.5'W x 1'H x 1'D. At this frequency, D_{10} gives the maximum power density obtainable for the system. As the frequency is decreased, horn section D_{10} will uniformally illuminate a proportionately larger volume with reduced gain.

1. The power required for a desired power density can be determined as in A1 above.

   a. Example: 10 mw/cm^2 power density is desired at 3.95 GHz (Horn Section D_{10})

   $$\text{Power} = \frac{\text{Power Density}}{\text{Pd/W}}$$

   $$\text{Pd/W} = 3.83 \times 10^{-2} \text{ from figure 3}$$

   $$\text{Power} = \frac{10}{3.83 \times 10^{-3}} \cong 260 \text{ watts}$$

IV. MICROWAVE POWER MONITORS

In addition to the high power TWT monitor, there are 3 power monitors in the anechoic chamber. Two of these, Monitor #1, a standard gain horn, and Monitor #2, a sleeve dipole, are connected to the HP431C power meters in rack number 3. These two monitors may be switched to the Mosley 7100B strip-chart recorder (see figure 2). The third monitor, alternate monitor number 1, is a sleeve dipole and has an available output as shown in figure 2.

A. Monitor Number 1

Monitor number 1, the standard gain horn, is the primary "down stream" power density monitor. Power readings on the Channel No. 1 power meter can be converted to power density <u>at the point of measurement</u> with reference to figure 5.

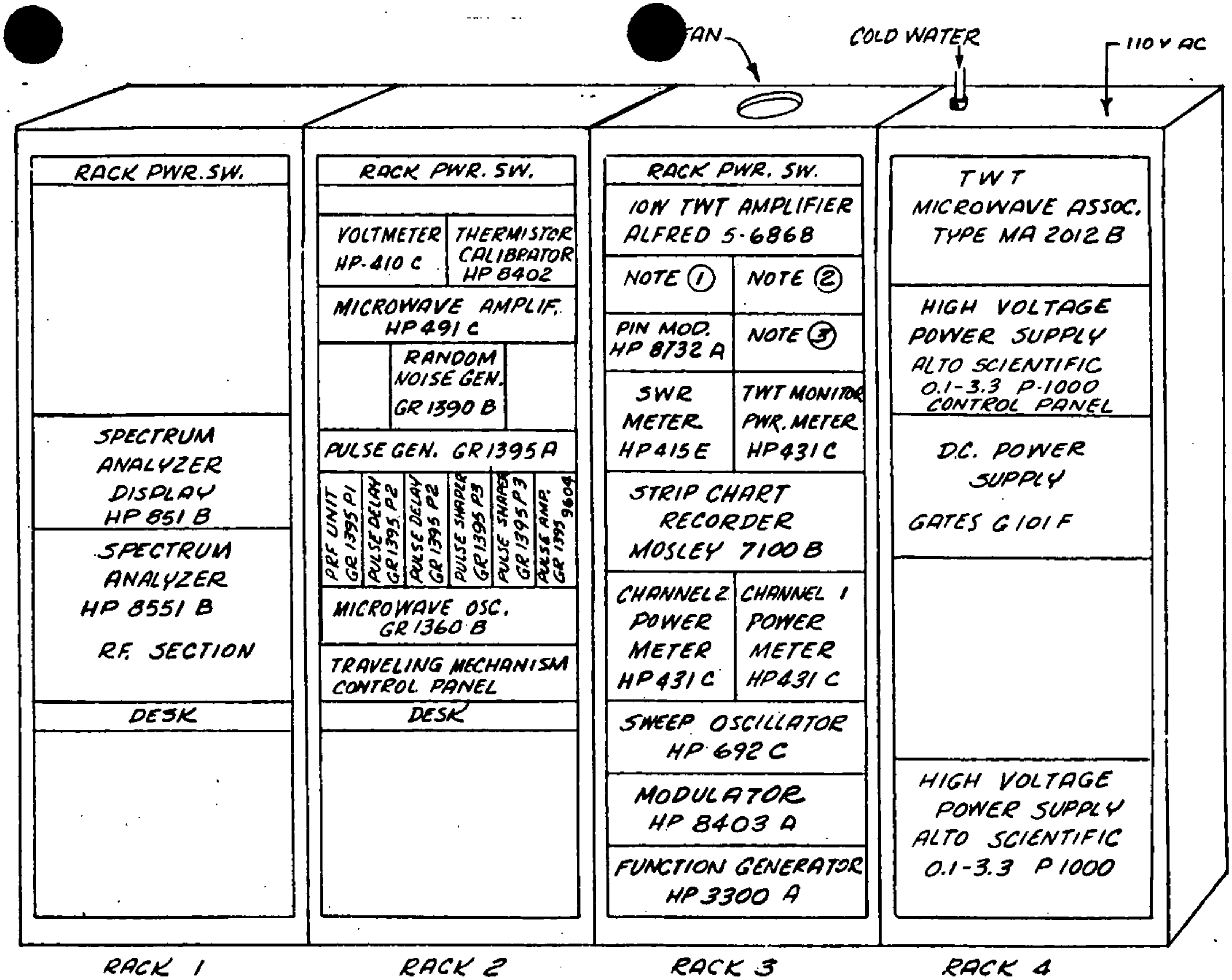
<u>Note</u>: It must be reemphasized that this monitor, in conjunction with figure 5, measures the power density <u>at the point where the monitor is placed in the chamber</u>, and not the power density at the center of the quiet zone as determined in Section III.

B. Monitor Number 2 and Alternate Monitor No. 1

These monitors are available to measure relative power density and for the observation of signal waveforms at any point in the chamber.

By placing monitor number 2, with its alternate monitor line connected, at a point of known power density (previously determined as in Section III or IV A above), and placing alternate monitor number 1, at any other point in the chamber; a gross measurement of power density can be made by observing the relative readings. Due to the nature of the chamber reflections, the power density measured in this manner can be in error by ± 2 db; however, as a "gross" power density measurement technique, these monitors are useful since they are lightweight and easily movable.

RACK ARRANGEMENT OF PANDORA MICROWAVE EQUIPMENT



NOTE (1) PANEL CONTAINS SWITCHES WHICH CONNECT VARIOUS MONITORED FUNCTIONS TO THE STRIP CHART RECORDER. BEHIND PANEL, BAND PASS FILTER (HP 8431 A), 20db DIRECTIONAL COUPLER (HP 797D), 10db FIXED ATTEN. (WEINCHEL 1-10N), XTAL DETECTOR (HP 423A).

NOTE (2) ALFRED 5-686B OUTPUT VARIABLE ATTENUATOR (NARDA 792).

NOTE (3) HP692C SWEEP OSC. OUTPUT VARIABLE ATTENUATOR (NARDA 792).

PANDORA MICROWAVE EQUIPMENT
FUNCTIONAL BLOCK DIAGRAM
FIGURE 2

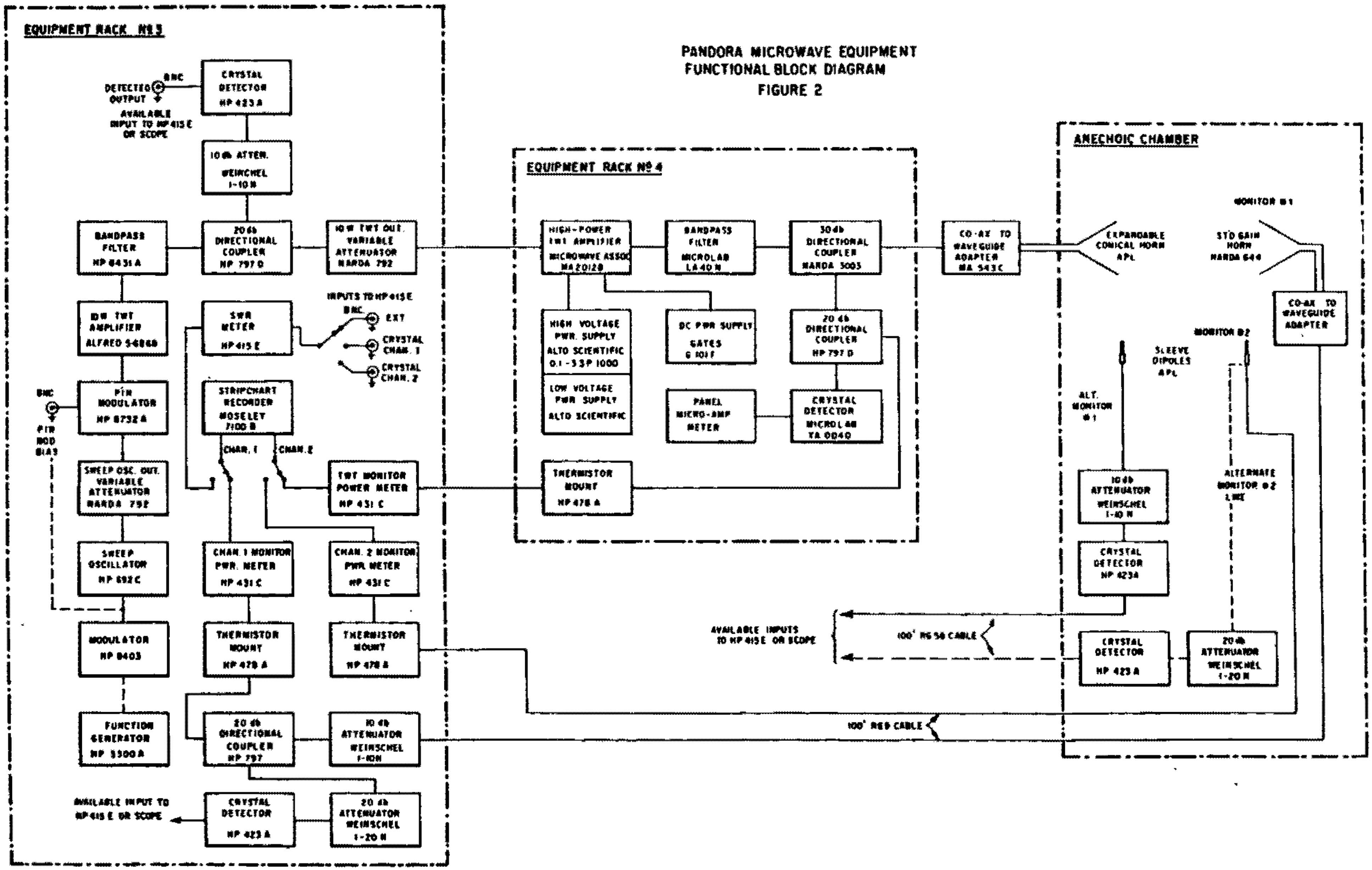
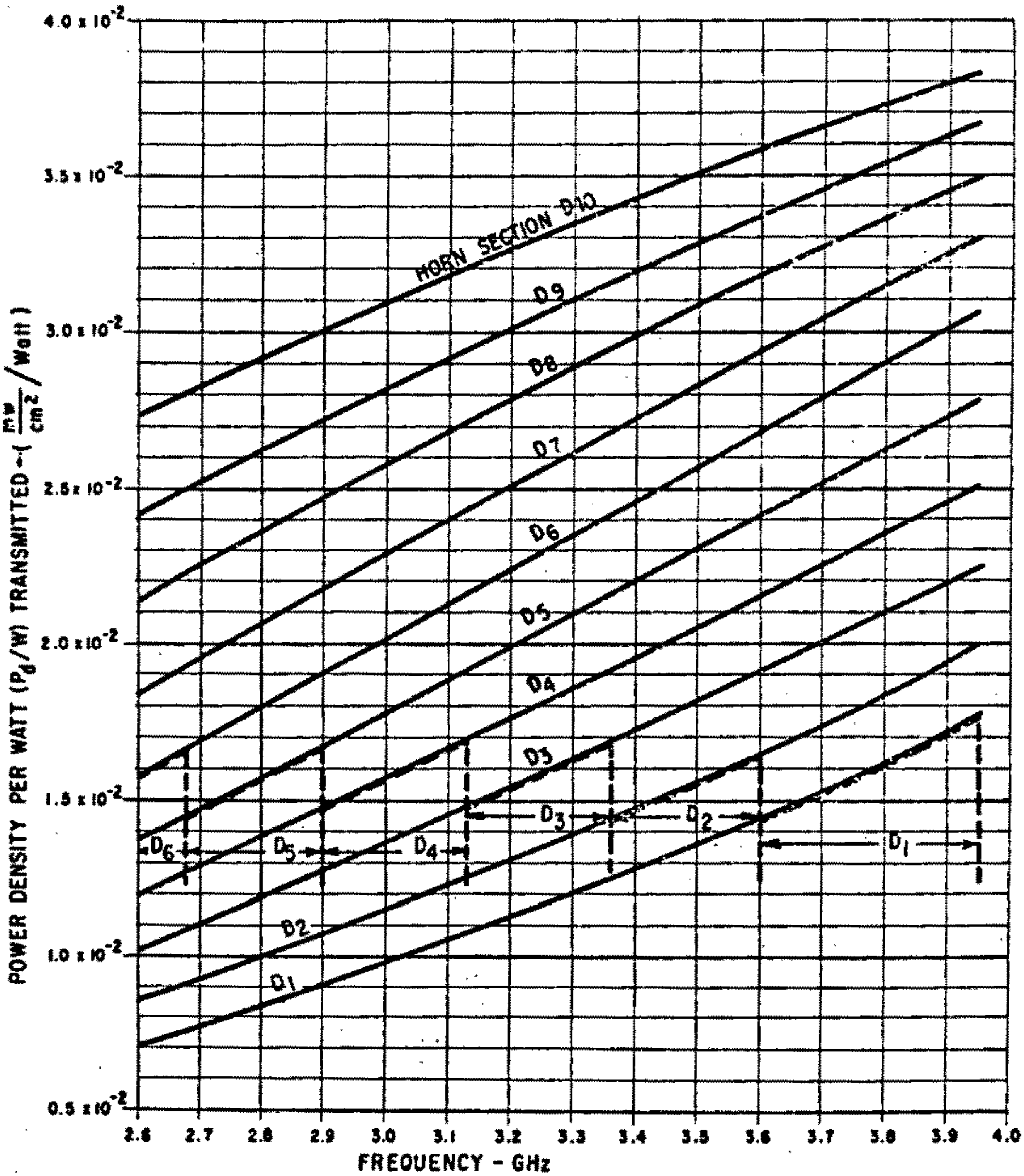
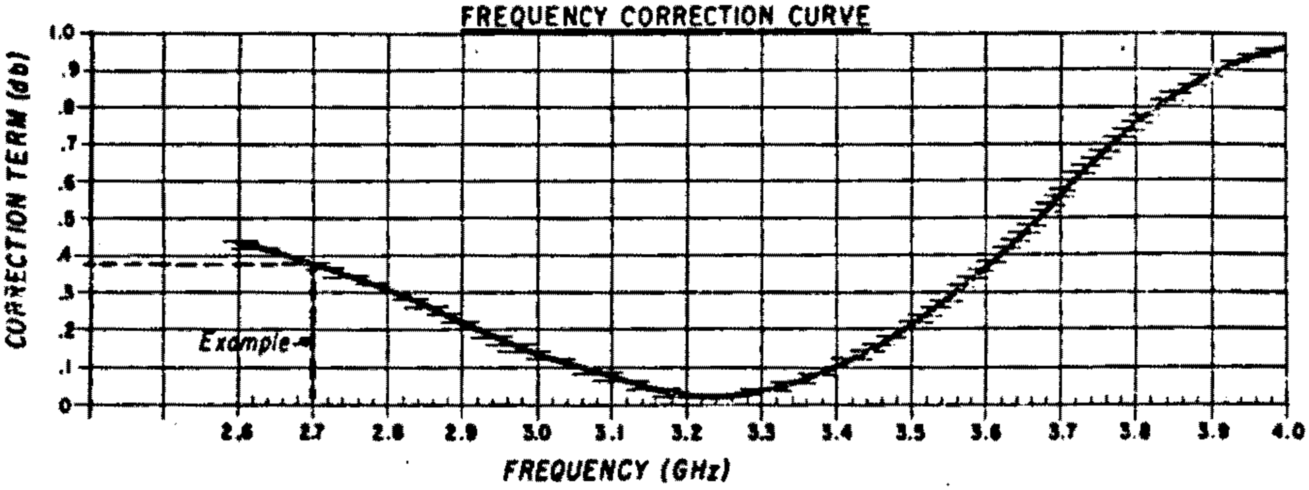


Fig. 3 POWER DENSITY PER WATT TRANSMITTED FOR EACH HORN SECTION



ARROWS SHOW FREQUENCY RANGES

Fig.4 HIGH POWER TWT MONITOR - METER READING Vs TRANSMITTED POWER



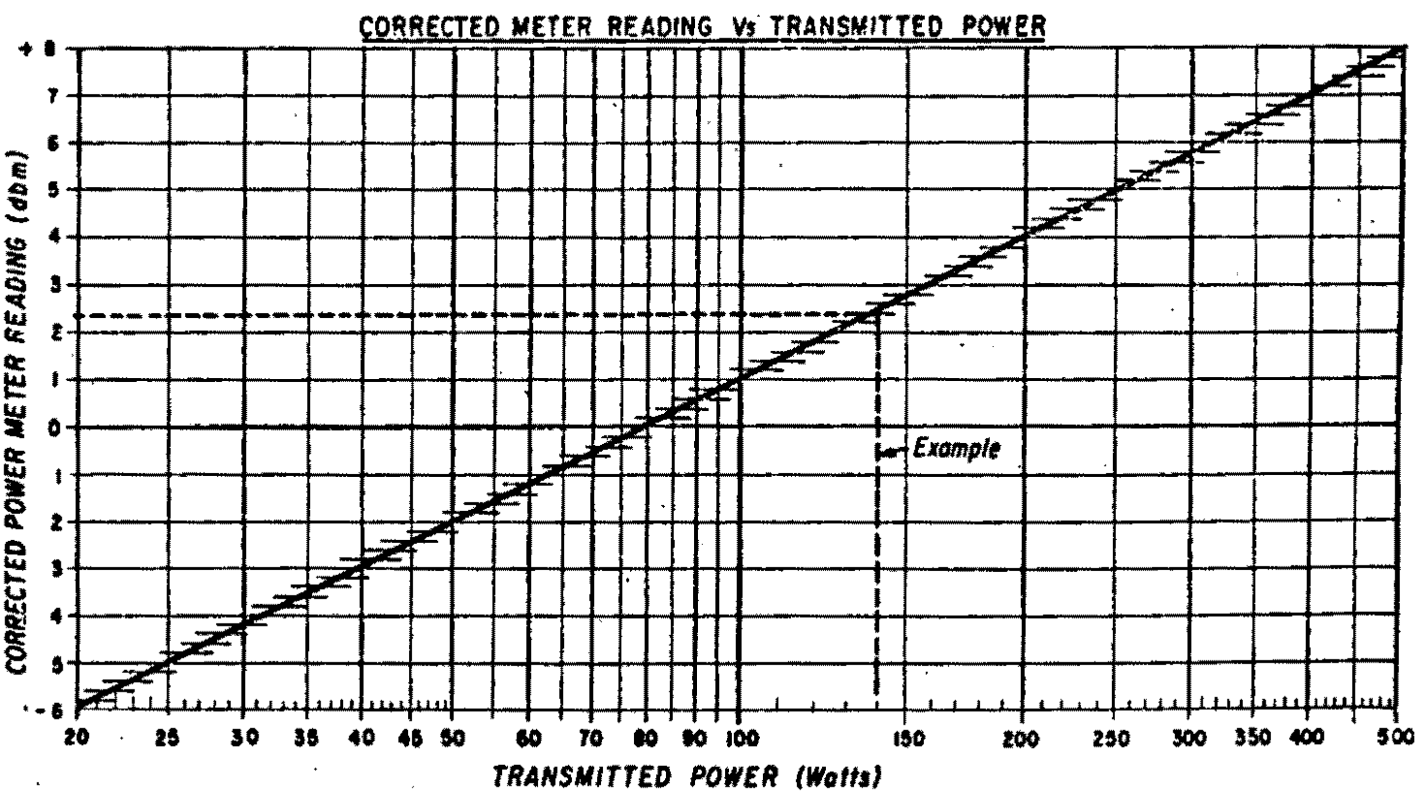
TO MEASURE TRANSMITTED POWER:

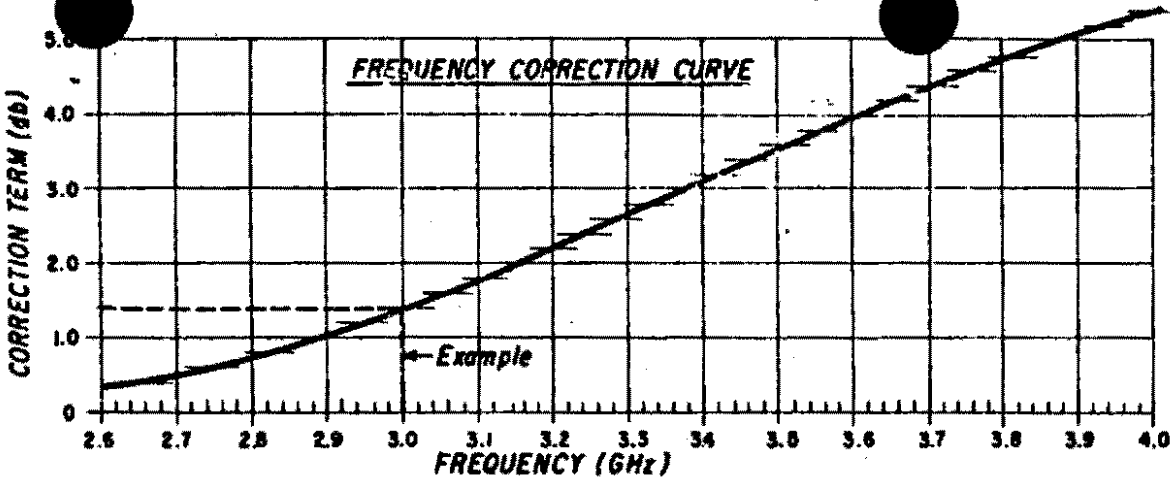
ADD CORRECTION TERM TO TWT MONITOR POWER METER READING.

Example:	AT 2.7 GHz, THE CORRECTION TERM =	.38
	POWER METER READING =	2.00
	CORRECTED METER READING	2.38 dbm ⇐ 140 Watts P_T

TO SET TRANSMITTED POWER:

SUBTRACT CORRECTION TERM FROM CORRECTED METER READING WHICH CORRESPONDS TO DESIRED POWER. ADJUST POWER TO OBTAIN THIS VALUE ON TWT MONITOR POWER METER.





TO MEASURE POWER DENSITY:

ADD CORRECTION TERM TO METER READING.

Example: AT 3.0 GHz, CORRECTION TERM = 1.4 db
METER READING = 3.0 dbm
CORRECTED METER READING = 4.4 dbm
4.4dbm ⇔ 3.0 Milliwatts/cm²

TO SET POWER DENSITY:

SUBTRACT CORRECTION TERM FROM METER READING WHICH CORRESPONDS TO REQUIRED POWER DENSITY. ADJUST POWER TO OBTAIN THIS VALUE ON MONITOR CHANNEL № 1 POWER METER.

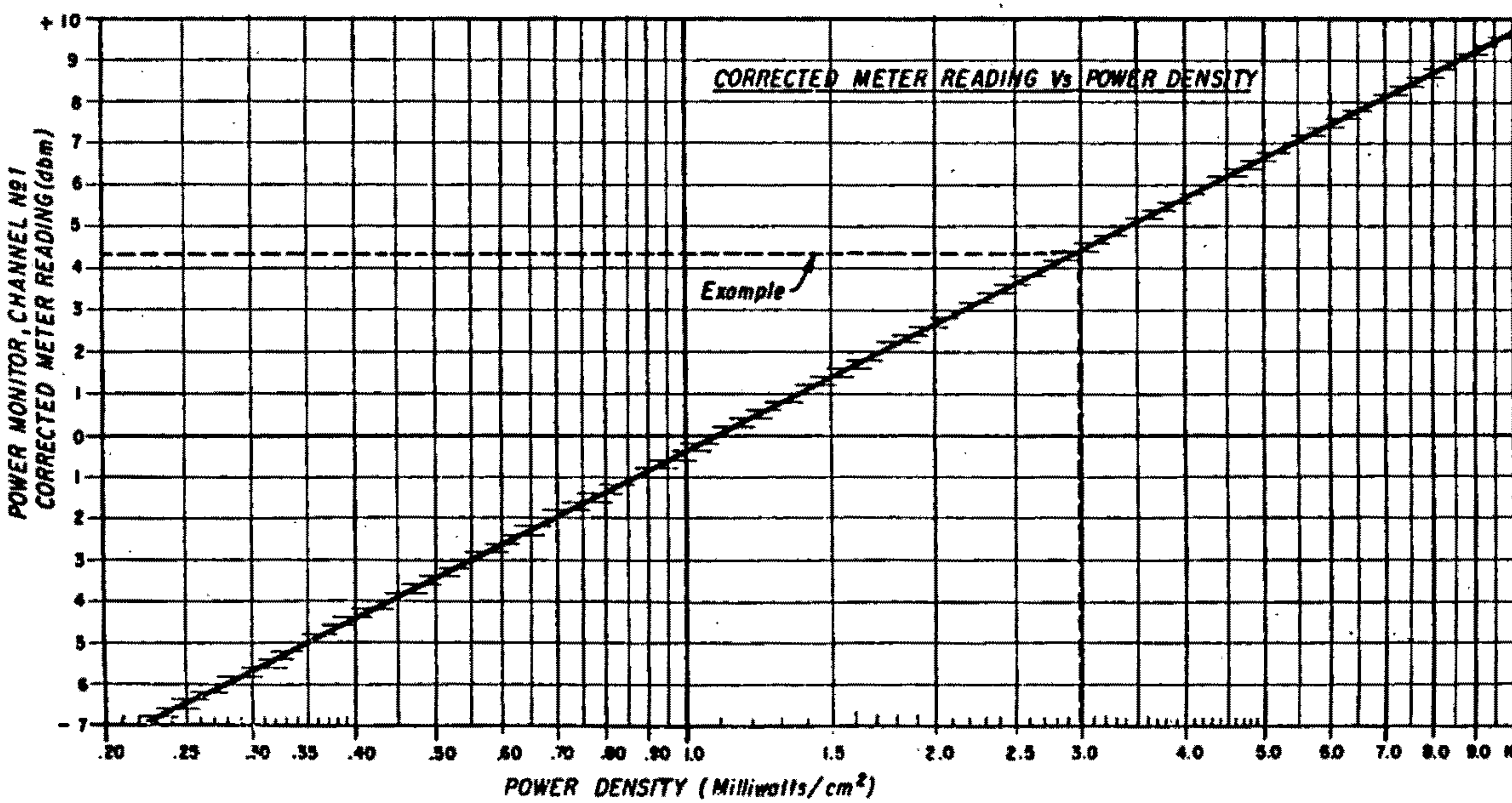


FIGURE 6

Horn Section Dimension

Horn Section	Diameter (inches)
D_1	10.75
D_2	11.75
D_3	13.00
D_4	14.00
D_5	15.25
D_6	16.75
D_7	18.25
D_8	20.00
D_9	22.25
D_{10}	24.5

External Distribution:

P. Tamarkin

R. S. Cesaro/5

H. M. Grove

R. W. Beard

F. Koether

J. Sharp

Internal Distribution:

R. E. Gibson/2

A. Kossiakoff

A. M. Stone

J. W. Follin/2

J. L. Queen

T. C. Cheston

E. V. Byron

Archives/2

MRT-4 File

FINAL REPORT

"EFFECTS OF LOW - LEVEL MICROWAVE IRRADIATION ON

HEART RATE IN RABBITS"

This research was supported by the Advanced Research Project Agency of the Department of Defense and was monitored by U.S. Army Medical Research and Development Command, under Grant No. DADA 17 - 69-G - 9288

by

The Zaret Foundation, Inc.
1230 Post Road
Scarsdale, New York 10583

A number of Soviet studies have reported that low-level microwave irradiation, at or below 10 mW/cm^2, alters the heart rate of humans and animals. In one of the best controlled and most fully reported of these studies, Presman and Levitina[1] irradiated various parts of the body of rabbits with continuous microwaves at intensities of 7 to 12 mW/cm^2. The largest effect observed was an increase in heart rate during and after irradiation of the dorsal aspect of the head. The next largest effect was a decrease in rate during and after irradiation of the whole ventral surface of the body. Smaller changes in rate accompanied irradiation of the back, of the total dorsal surface, of the ventral aspect of the head, and of the abdomen.

The purpose of the present study was to replicate the procedure used by Presman and Levitina for dorsal irradiation of the head, in order to collect enough additional data either to confirm their results or to establish that the differences in heart rate are a manifestation of variability rather than a consequence of irradiation.

Method

Subjects The subjects were 12 albino male rabbits weighing 2.0 to 3.0 kg.

Apparatus Microwave power was obtained from a CW, air-cooled magnetron with an output of 1.3 kW, an anode voltage of 2 kV, and an operating frequency of 2.409 GHz (λ = 12.5 cm). This tube, manufactured by Deutsche Mikrowellen Gesellschaft, exhibited exceptional stability during the exposures. Power from the tube was conducted through a waveguide to the irradiating horn (Fig. 1). Most of the magnetron output was dissipated in a high-power load, and only about 10% was used to irradiate the animal.

The microwave horn was placed in an anechoic chamber with its main lobe directed downward, so that the animal was irradiated from

1 A.S. Presman and N.A. Levitina, Byull. Eksp. Biol. Med. 53, No. 1, 41-44 (1962); Engl. Transl., Bull. Exptl. Biol. Med. 53, 36-39

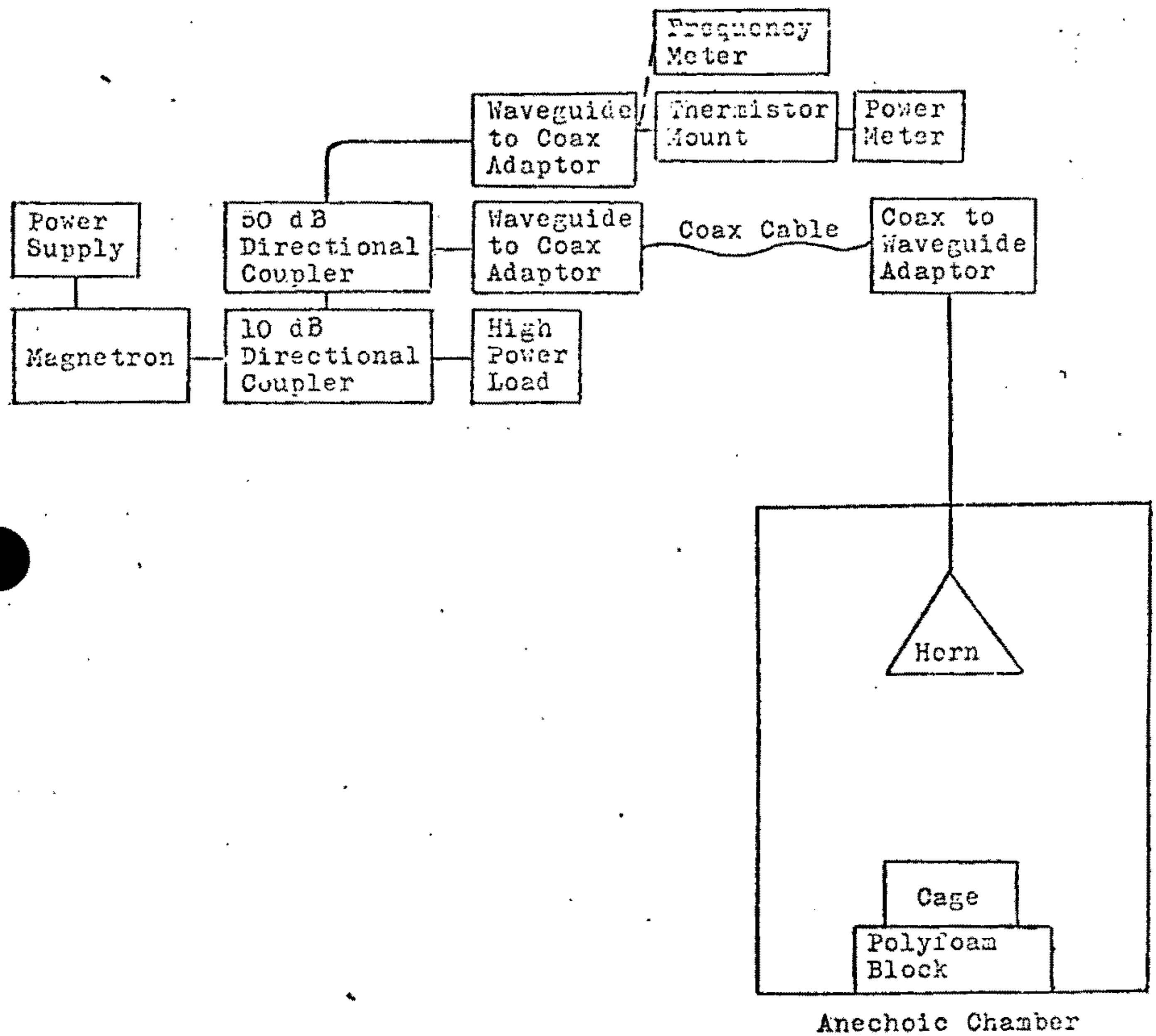


Fig. 1. Schematic diagram of the apparatus.

above. The horn's aperture was $7 \frac{31}{32}$ in. by $5 \frac{7}{8}$ in., its axial length was 15 in., and its estimated power gain was 19.54. The animal's head was 29 in. from the horn. This distance was well within the far-field region, which began at about 12.9 in. from the horn. From the estimated gain of the horn, it was calculated that a total of 35 W leaving the horn produced the measured power density of 10 mW/cm^2 in the vicinity of the animal's head.

The power density was measured with a Ramcor 1250 A densiometer with a calibrated low-gain rectangular horn antenna. A Hewlett Packard Model 431-B power-meter was connected to the waveguide to monitor the power during irradiation. The power-meter reading corresponding to 10 mW/cm^2 at the animal's head was determined and used for setting the magnetron anode current. This calibration procedure was conducted with the cage and animal not present in the anechoic chamber. It was observed that the region of uniform power density was sufficiently large that considerable variation in the placement of the cage would still give the same power density.

The anechoic chamber had interior dimensions of 40 in. by 40 in. by 64 in., and was lined with type CV-4 microwave absorber panels manufactured by Emerson-Cuming. This material is rated to have reflections less than 20 db below the incident power level at 2.0 GHz; at 2.4 GHz the reflection is even lower. A plate of this material was used to shield the animal's back during irradiation of its head.

Procedure The rabbit was restrained in a wooden box, which was placed below the horn antenna in the anechoic chamber. Needle electrodes were inserted for EKG recording. After the animal had been in position for 15 min., its EKG was recorded once each minute for 10 min. before the onset of irradiation. Then the rabbit's head was irradiated from above with continuous 12.5 cm microwaves at a power density of 10 mw/cm^2 for 20 min. During irradiation the EKG was recorded every 2 min. After the power was turned off, the EKG was recorded every minute for 10 min. Each EKG trace was recorded for a 20 sec duration. Exactly the same procedure was followed during the control sessions, except that the animal was not irradiated. Each animal was irradiated twice and served as a control twice: once before and once after irradiation.

Results

Changes in heart rate were calculated in the manner described by Presman and Levitina as follows: (a)For each trace recorded during and after irradiation, the deviation from the mean heart rate before irradiation was calculated. (b)The corresponding deviations were calculated for the data from the control sessions. (c)The relative change in rate for each recording period was obtained by subtracting the mean deviation for the control condition from the corresponding deviation for the irradiation condition.

Each of the three graphs in Fig. 2 represent the mean differences in heart rate between eight irradiation sessions and eight control sessions. The results for the first four rabbits that were exposed show a relative increase in heart rate both during and after irradiation. The average data for the next four rabbits show a decrease during the first 10 min of irradiation and no consistent change thereafter. The last four animals exhibited a decrease during the first 8 min followed by an increase over the last 18 min of the session. All 12 animals received the same dorsal irradiation of the head, and the division into three groups is entirely arbitrary.

The average results for all 12 animals are summarized in Fig. 3. The dots represent the data of the present experiment, based on 24 irradiation and 24 control sessions. A small decrease in heart rate during the first 8 min was followed by a larger increase over the remaining 22 min. The crosses in Fig. 3 indicate the results of Presman and Levitina, based on 16 irradiation and 16 control trials with 8 rabbits. The relative change in heart rate was generally positive, and this increase was both larger and more variable than the results in our experiment.

Table 1 lists the mean number of beats per 20 sec during successive 10 min periods of the control and the irradiation sessions. The animals were irradiated during the middle 20 min of the irradiation condition. Each entry in the table is based on the results of 24 sessions. Heart rate was highest during the first 10 min of both conditions and generallly decreased over time. The analysis of variance summarized in Table 2 shows that the variation over time was statistically significant, as were individual differences and the interaction between radiation and time. The difference between irradiation and control conditions, however, was generally less than 2 beats per 20 sec, and this difference was not statistically significant.

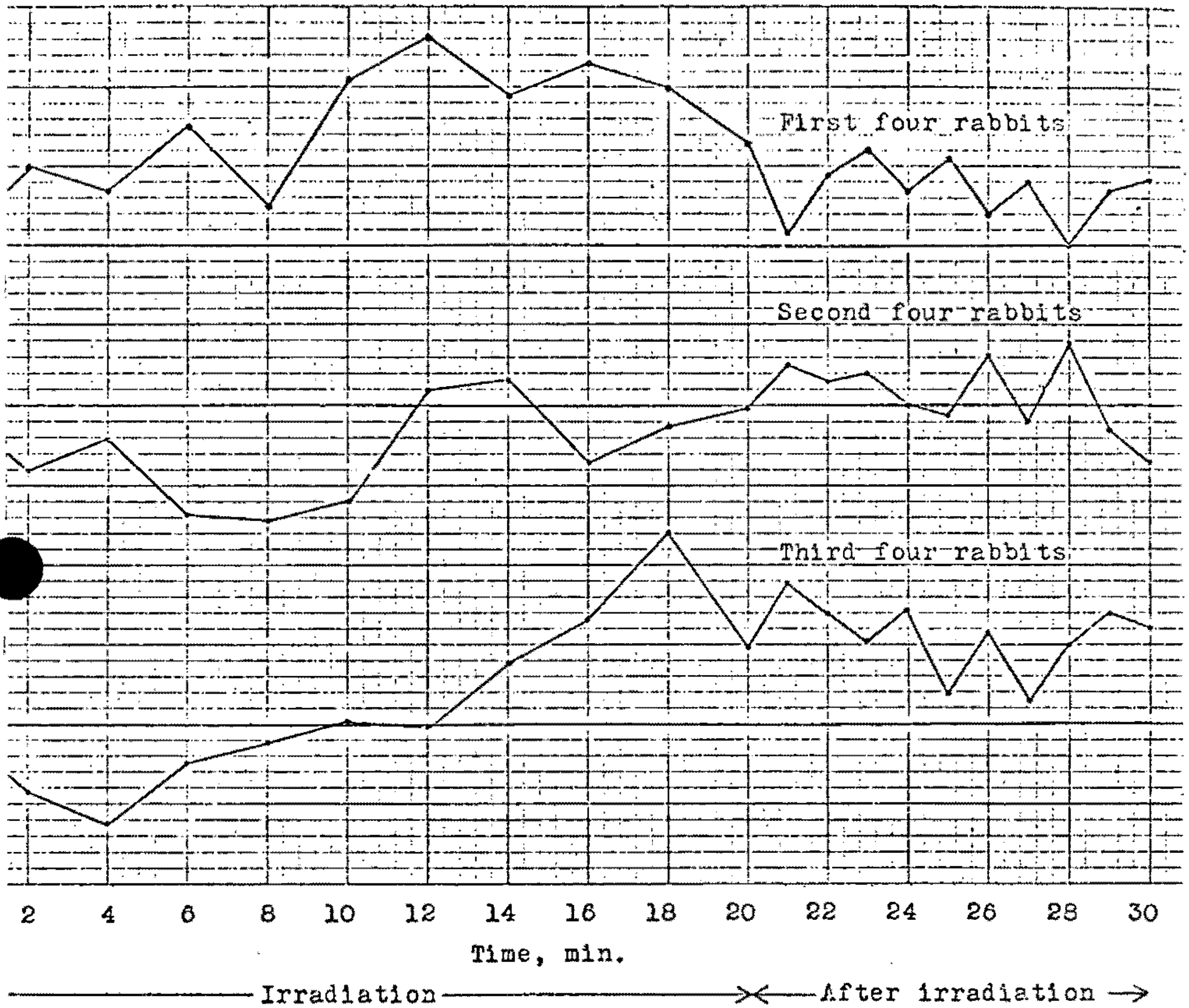


Fig. 2. Relative change in heart rate of rabbits irradiated on the dorsal aspect of the head with continuous microwaves of 12.5 cm wavelength at 10 mw/cm^2. Each point represents the mean difference between 8 exposures and 8 control sessions.

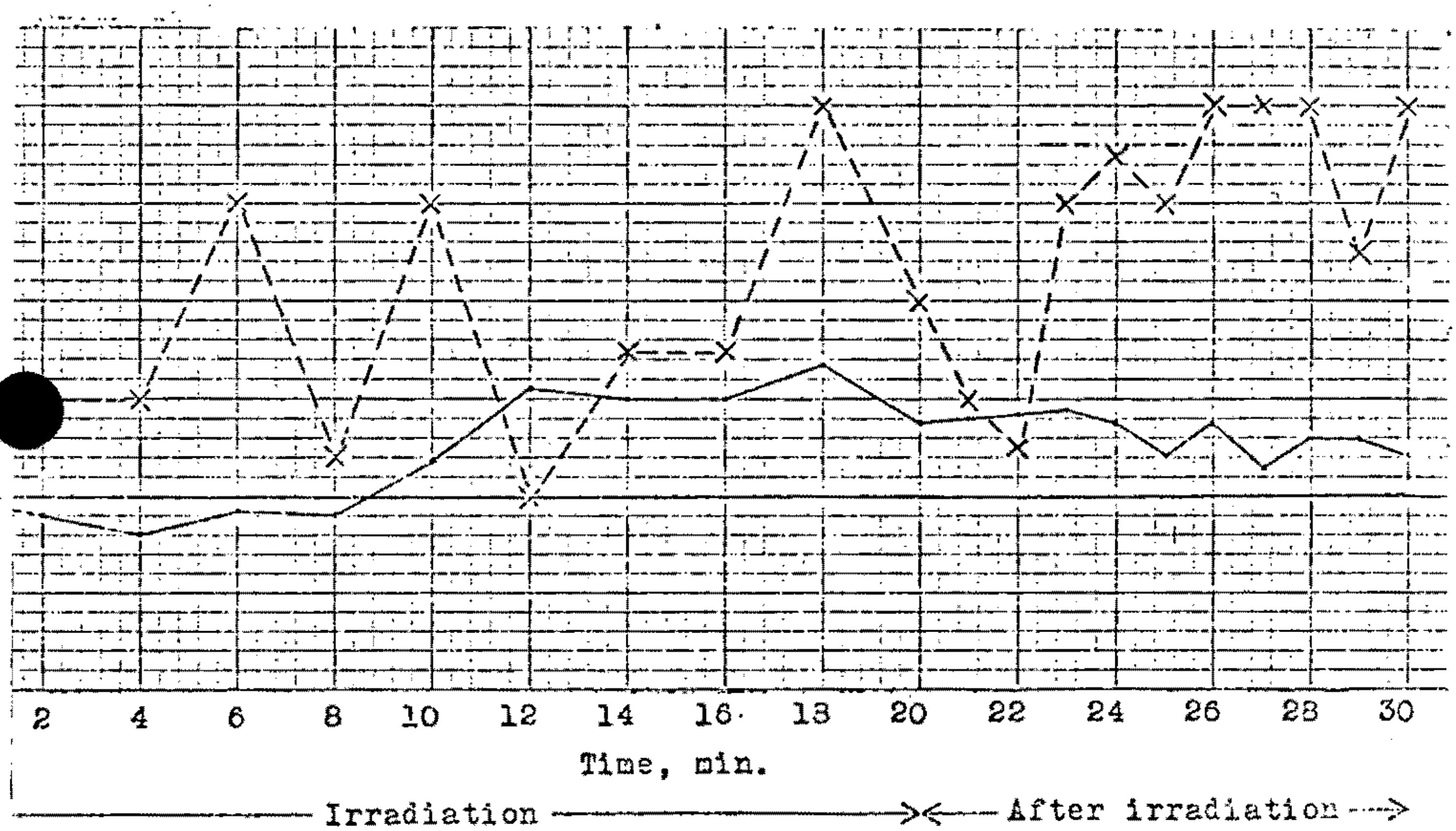


Fig. 3. Relative change in heart rate of rabbits irradiated on the dorsal aspect of the head with continuous microwaves of 12.5 cm wavelength at 10 mw/cm^2. Each dot represents the mean difference between 24 exposures and 24 control sessions of the present experiment. The crosses represent the results of Presman and Levitina based on 16 exposures and 16 controls.

Table 1

Mean Number of Beats per 20 Sec

	1st 10 min	2nd 10 min	3rd 10 min	4th 10 min
Control	63.94	63.79	61.73	61.95
Irradiation	63.56	63.31	63.34	62.83

Table 2

Analysis of Variance

Source of Variation	SS	df	MS	F
Radiation	7.80	1	7.80	< 1
Time	69.07	3	23.02	7.99*
Subjects	10,507.23	11	955.20	25.04*
R x T	36.89	3	12.23	4.66*
R x S	113.96	11	10.36	< 1
T x S	95.12	33	2.88	< 1
R x T x S	86.98	33	2.64	< 1
Error	3,661.43	96	38.14	

* Significant at the .01 level

Presman and Levitina devised the ratio K, which they called the co-efficient of the chronotropic effect, to describe the effect of irradiation on heart rate.

$$K = \frac{100 + m_i}{100 + m_d},$$

where m_i and m_d are the respective changes in the percentage of cases with rates increased or decreased from the control values. An increase in rate is indicated by $K > 1$, and a decrease by $K < 1$. Their results for dorsal irradiation of the head were $K = 1.3$ during irradiation, and $K = 1.42$ after irradiation. The present results were $K = .84$ during irradiation and $K = 1.19$ after irradiation.

Discussion

There were six conditions in the experiment of Presman and Levitina, in each of which a different part of the body was irradiated. One condition (dorsal aspect of the head) produced a relative increase in heart rate during and after irradiation. Another condition (whole ventral surface) showed a decrease during and after irradiation. The other four conditions were accompanied by smaller and less consistent changes in rate. The results of the present experiment suggest that such effects are due to chance variation from one set of trials to another.

The variation from one sample to another under the same conditions of radiation is illustrated in Fig. 2. One set of data shows an increase in relative heart rate; another shows a decrease followed by no consistent change; the third, a decrease followed by an increase. When these three sets of data were averaged, as in Fig. 3, the variability from minute to minute became less, and the relative change in heart rate became smaller. The largest change in the averaged data is about 2 beats per 20 sec, which is only 3 % of the average heart rate of 63 beats per 20 sec.

It is our tentative conclusion that the changes in heart rate that Presman and Levitina attributed to irradiation of different parts of the body were simply due to the variation from one small sample of trials to another. We are still collecting data on the effect of dorsal irradiation of the head at 10 mW/cm^2. If the effect continues to approach zero as our sample size increases, this conclusion will be confirmed.

Future Research

We plan to run four more rabbits under the conditions of the present experiment. If we still observe no effect of radiation at 10 mW/cm^2, we shall proceed to higher power densities, in order to determine the minimum levels at which effects are observable.

We are presently developing procedures for recording body temperature and respiration rate, simultaneously with heart rate, while the animal is irradiated. Temperature will be recorded with a needle thermistor probe inserted subcutaneously just outside the area that is irradiated. Respiration rate will be recorded by means of a sensor that detects changes in chest circumference. We anticipate that these recording procedures should be standardized by 1 September 1969, whereupon we shall begin a series of exposures to determine irradiation thresholds for all three indicators.

The first power density in the series will be 100 mW/cm^2, a level which should produce evidence of thermal stress, such as hyperventilation or hyperthermia. On subsequent exposures we shall decrease the power level until no effect is produced, i.e., until heart rate, respiration rate and temperature are the same during irradiation as during the control sessions. If respiration or temperature is affected at lower power levels than heart rate, that would constitute further evidence against the thesis that low-power microwave fields produce non-thermal effects on cardiac activity via direct action on the central nervous system.

APPENDIX I

Summary of Raw Data

Number of Beats per 20 Sec.

	RABBIT 1				RABBIT 2				RABBIT 3				RABBIT 4			
IMENT	1		2		1		2		1		2		1		2	
(MIN)	C	R	C	R	C	R	C	C	C	R	C	R	C	R	C	R
1	60	63	62	62	64	63	54	54	62	59	61	60	59	57	59	50
2	57	64	53	52	65	61	58	59	61	63	60	59	57	59	56	52
3	59	58	51	53	63	56	58	56	62	61	61	60	57	61	59	48
4	56	58	51	56	63	59	62	54	59	61	62	62	62	58	56	55
5	60	57	56	59	63	58	60	57	59	64	62	60	60	58	57	49
6	59	54	57	54	61	59	62	55	61	63	62	62	59	60	57	62
7	55	57	51	56	62	61	60	56	62	62	62	62	57	59	57	58
8	55	57	65	53	64	62	60	60	60	62	61	60	56	59	55	59
9	56	57	55	58	68	64	60	54	62	62	61	61	58	59	57	59
10	55	60	56	58	66	60	58	57	59	61	62	60	58	62	57	56
[illegible]	58	62	62	63	66	63	59	63	59	60	61	62	52	59	61	56
14	54	62	59	58	63	64	64	70	59	60	62	62	54	62	61	53
16	51	64	59	53	60	60	60	65	59	60	59	62	55	59	58	56
18	61	61	53	56	62	60	58	60	60	59	62	62	52	62	57	49
20	58	61	50	56	63	63	57	61	59	60	61	63	52	61	54	61
22	54	62	52	64	58	67	58	56	59	60	60	62	54	61	54	54
24	59	58	55	66	56	64	57	57	59	60	60	61	57	61	54	54
26	53	61	58	55	55	72	57	52	58	61	58	61	52	60	56	55
28	56	60	57	63	64	77	56	54	58	62	58	61	55	60	52	45
30	55	57	55	62	60	66	64	55	62	61	59	62	57	62	56	56
31	63	61	60	59	63	67	64	53	61	59	61	64	55	59	55	56
32	64	59	59	58	61	74	68	53	60	63	60	64	53	58	52	56
33	58	58	58	56	56	65	67	52	60	64	59	64	55	58	50	58
34	58	63	56	54	59	60	63	54	62	65	59	60	56	60	54	55
35	57	61	58	58	58	64	62	53	62	62	58	61	52	59	61	61
36	54	56	56	53	59	63	61	52	60	62	58	62	52	60	64	56
37	57	63	53	54	61	63	62	56	60	60	58	62	54	58	58	53
38	57	59	53	54	62	62	62	54	63	60	58	59	57	60	58	55
39	57	60	56	56	64	65	60	52	61	58	58	62	57	60	51	56
40	60	58	54	53	60	61	60	54	60	60	58	59	56	58	48	60

C=Control
R=Radiation

APPENDIX I

Summary of Raw Data

Number of Beats per 20 Sec.

	RABBIT 5				RABBIT 6				RABBIT 7				RABBIT 8			
[illegible]MENT (MIN)	1		2		1		2		1		2		1		2	
	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R
1	68	64	70	68	50	42	62	69	76	82	68	75	69	68	62	63
2	66	62	69	67	48	46	61	70	76	80	69	74	69	68	64	61
3	66	62	69	67	51	40	62	68	76	78	72	74	70	70	62	60
4	62	62	68	68	47	40	63	67	74	77	69	74	65	71	63	60
5	62	65	57	68	47	44	61	67	75	77	71	76	69	68	63	62
6	63	62	64	68	46	43	62	67	75	73	70	76	69	69	64	62
7	64	62	70	66	44	43	62	67	76	76	77	74	70	66	66	60
8	62	60	66	69	44	41	64	70	75	77	70	78	73	72	65	62
9	62	61	70	69	43	42	60	68	76	77	72	74	72	71	64	58
[illegible]	60	64	68	65	46	47	62	69	75	76	71	74	71	78	62	62
[illegible]	67	60	68	66	44	41	61	66	75	74	71	73	70	72	67	63
4	66	58	65	67	43	43	61	69	75	71	69	74	71	71	66	61
6	65	59	66	63	47	41	63	68	75	71	70	73	71	69	65	62
8	67	59	65	70	52	40	61	66	75	71	69	72	73	70	67	62
0	64	62	67	66	46	42	61	64	77	74	71	73	73	68	66	62
2	62	61	65	68	44	44	63	69	75	76	70	73	74	70	62	62
4	62	62	63	65	43	41	60	65	73	73	66	74	73	69	61	62
6	62	61	73	65	43	39	63	64	74	74	65	75	74	69	63	64
8	60	61	67	65	41	39	63	63	75	79	68	71	72	68	61	62
0	64	58	63	66	40	40	60	62	75	78	69	73	71	70	60	59
1	64	59	65	66	42	41	57	68	76	78	68	74	70	68	57	58
2	62	58	66	66	46	44	57	64	74	80	68	76	72	68	62	61
3	62	58	64	66	40	40	57	64	75	80	74	74	70	68	57	60
4	62	58	64	65	40	40	57	62	74	78	72	74	74	68	57	60
5	65	57	64	66	44	40	57	60	74	79	68	74	75	69	56	61
6	62	58	65	70	43	38	58	65	74	76	71	80	70	69	58	60
7	62	60	67	67	43	38	58	62	75	75	70	73	72	70	58	62
8	60	58	64	66	41	46	57	66	80	74	72	75	68	69	56	61
9	61	59	60	64	42	40	63	62	76	74	67	71	72	71	64	64
0	64	59	68	64	47	44	61	63	71	72	68	70	73	70	61	65

C=Control
R=Radiation

APPENDIX I

Summary of Raw Data

Number of Beats per 20 Sec.

ERIMENT	RABBIT 9.				RABBIT 10.				RABBIT 11				RABBIT 12			
	1		2		1		2		1		2		1		2	
E (MIN)	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R
1	76	78	76	76	80	75	73	77	60	69	56	44	64	59	64	64
2	77	78	75	73	80	75	74	78	58	63	56	44	63	59	65	68
3	80	80	74	73	79	72	72	76	62	64	56	44	64	63	59	67
4	78	80	74	75	80	75	72	76	62	60	61	43	62	63	59	62
5	77	77	71	78	81	84	72	78	62	61	58	52	62	62	64	66
6	78	72	75	76	80	68	72	77	64	64	58	46	59	64	62	68
7	76	72	69	77	79	74	74	78	58	62	54	54	57	60	64	68
8	77	70	74	77	79	72	74	76	59	67	54	40	58	58	58	54
9	80	76	73	68	79	75	74	77	60	60	52	42	61	59	57	64
10	83	72	70	77	73	74	74	76	60	68	52	41	62	60	60	65
[illegible]	78	67	75	75	79	72	74	77	60	59	48	44	61	58	66	67
[illegible]	80	78	79	75	80	74	74	74	63	60	50	42	62	57	64	64
[illegible]6	75	76	76	76	80	72	70	73	61	58	52	50	61	54	62	61
18	74	79	73	75	80	72	75	73	62	62	51	48	62	61	63	66
20	70	79	75	78	79	68	74	73	61	60	50	43	59	72	68	56
2	69	77	75	75	78	70	75	74	61	63	56	42	57	65	60	56
4	71	78	75	75	78	73	74	72	64	62	43	42	56	59	60	64
6	73	77	76	74	78	74	71	75	57	64	44	43	56	60	63	64
8	72	78	76	73	77	73	72	74	50	64	44	45	59	68	60	64
0	77	79	73	73	76	72	67	74	61	61	41	41	57	59	58	58
1	73	82	72	74	78	72	68	74	61	64	41	42	57	58	62	66
2	71	78	72	72	77	72	69	74	60	63	42	42	55	57	62	64
3	71	77	70	70	78	70	76	74	56	63	43	41	58	58	62	70
4	69	75	68	76	78	72	75	72	60	62	40	46	59	56	61	65
5	69	76	75	74	79	70	71	72	60	62	48	45	62	56	62	68
5	66	76	69	72	80	71	70	72	59	60	46	50	63	59	64	67
7	76	76	71	67	76	70	72	72	60	62	46	42	58	60	62	69
3	76	76	65	74	76	76	70	73	61	60	46	46	64	60	64	65
7	79	76	69	77	76	74	68	71	61	58	38	44	64	64	64	69
)	80	78	70	76	76	75	66	71	64	62	38	38	64	66	60	63

=Control
=Radiation

C. TRANSMITTING HORN

The transmitting horn characteristics were dictated by the dimensions of the quiet zone to be uniformly illuminated. This design rationale and the test results are discussed in Appendix A of this report. In order to provide a constant gain and beamwidth over the desired frequency band, "add-on" sections were provided as depicted in figure 5.

The first section of this "expandable" conical horn incorporates a rectangular to circular transition obviating the need for a separate rectangular to circular waveguide transition.

Gain measurements and antenna patterns were taken for each horn section at the center, and at the low and high ends of the S-Band frequency range. The results of these measurements are summarized in figures 6, 7, 8, and 9. Figure 6 shows the absolute gain of each of the sections across the frequency band. Also shown, is the design frequency range for each section. Figures 7 and 8 show the E and H plane 3 db beamwidth respectively, and figure 9 is a typical E and H plane pattern (section D3) in its design frequency range.

D. POWER MONITORING

One of the prime requirements for the microwave test facility was the ability to accurately determine the power density in the quiet zone of the anechoic chamber and to observe the transmitted signal, within the limits afforded by commercially available test equipment.

Three monitoring channels were incorporated in the system, and several coupled outputs are available for observing signal wave form, either on an oscilloscope (detected outputs), or directly on the spectrum analyzer (see figure 4).

1. Transmitted Power Monitor

To measure the transmitted power, two coaxial directional couplers and a thermistor mount were installed in the high power equipment rack (figure 4). The thermistor output is connected to the HP 431C power meter in rack number three. The loss in this coupled transmission path was measured over the S-Band frequency range. The resultant calibration was incorporated with the measured loss of the output cable and the waveguide to coax adapter on the transmitter horn, to plot the transmitted power curve shown in figure 10. This curve is a plot of corrected power meter reading versus transmitted power. Included in this figure is the legend for determining transmitted power from the corrected meter reading, and conversely, the method for setting the transmitted power by observing the meter reading. This figure in conjunction with figure 11 (Power Density per Watt Transmitted for Each Horn Section) can be used to determine the on boresight power density in the quiet zone. This is explained in greater detail in section II E.

2. Standard Gain Horn Monitor

The standard gain horn monitor (monitor number 1 in figure 4), is the primary "downstream" power density monitor. The gain deviation versus frequency curve of the standard gain horn, and the measured loss of the connecting cable and waveguide to coaxial adapter were incorporated into one frequency correction curve, shown in figure 12. This figure is a plot of the power density as a function of the corrected power meter reading. The power density thus measured is the power density at the position where the standard gain horn is placed in the chamber, and not the on boresight power density alluded to in the section above. It is possible to measure the power density in the anechoic chamber directly, only if the horn monitor can be physically placed at the desired position without interfering with the experiment in progress. If this is not possible, then the power density can be determined by extrapolating the measured power density, to the power density at any other position in the quiet zone by using the known gain-beamwidth characteristics of the transmitting horn section. In a similar fashion, the on boresight power density determined from the measured transmitted power can be extrapolated to any point in the quiet zone. The determination of power density for other than on boresight (and measured) conditions is discussed in Section II F.

3. Monitor Dipoles

In addition to the standard gain horn monitor, two sleeve dipole monitors are available in the chamber for the observation of signal waveforms. These dipole monitors are shown in figure 13. The design dimensions and the measured results are discussed in Appendix B.

It was originally intended that these dipoles would be calibrated and used to measure the absolute power density at any position in the chamber. Unfortunately, the rather large amplitude ripples caused by the reflections from the chamber walls, precluded this possibility. (The standard gain horn integrates the ripples over its considerably larger area and, consequently, was substituted as the prime power density monitor.) However, since the dipoles are light-weight and easily movable, they were retained for signal waveform observation, and for the "gross measure" of power density. Since the two monitors have identical characteristics, by placing one at a region of known power density, and placing the other at any desired position, the power density at any position can be determined. This is a "gross measurement" because the amplitude ripples can cause an error as great as 2.0 db.

E. SELECTION OF TRANSMITTING HORN SECTIONS

As stated previously, the microwave facility was designed such that a suitable quiet zone - minimum dimensions, 3' wide by 2' high by 1' deep for two test samples side by side - would be uniformly illuminated; a ± 1.0 db power variation in the quiet zone was the design goal. The quiet zone starts at a transmission length of 23.0' and is symmetric about the chamber horizontal and vertical axis.

1. Design Frequency Range

As discussed in Appendix A, the quiet zone dimensions set the beamwidth characteristics of the transmitting horn; and a conical transmitting horn with "add-on" sections was designed to give maximum gain with the required beamwidth over the S-Band frequency range. Under these conditions, figure 11 shows the "design frequency range" for the appropriate sections (D1 through D6). This figure is a plot of power density (in mw/cm^2) per watt transmitted - Pd/W - versus frequency for each of the horn sections at a transmission length of 23.0 feet. These curves are obtained by plotting the expression:

$$\frac{P_r}{A_r} \times \frac{1}{P_T} = \frac{G_T}{4\pi R^2} \equiv \frac{Pd}{W} \quad \text{as a function of frequency,}$$

where G_T is the measured gain of each of the transmitting horn sections, and R = 23.0 feet is the transmission length. Thus $\frac{P_r}{A_r} \times \frac{1}{P_T}$ is the power density per watt transmitted when P_T is the transmitted power.

It can be seen from figure 11 that, for the design frequency ranges, Pd/W is $1.6 \times 10^{-2}\ \frac{mw/cm^2}{watt} \pm 10\%$. For 250 watts of transmitted power - the recommended upper limit for continuous operation of the high power TWT - the power density is 4.0 $mw/cm^2 \pm 10\%$, which adequately meets the design goal of 2 mw/cm^2 in the quiet zone.

Neglecting reflections in the chamber, the power density variation for angles off boresight is dependent upon the transmitting horn section used (the gain), the frequency, the angle, and the transmission length. The change in relative amplitude versus frequency for angles of 2, 4, and 6 degrees for each of the horn sections is shown in figures 14 and 15. The change in relative amplitude is defined as the maximum relative power amplitude at a designated frequency (the gain at boresight), minus the relative amplitude at the off boresight angle indicated, at the same frequency. The curves were obtained from the measured antenna patterns. Thus, the curves in figures 14 and 15 show the change in power density, for a fixed transmitted power and transmission length, at the angles indicated for each of the horn sections. For the minimum quiet zone dimensions, starting at a transmission length of 23', the maximum off boresight angle, in the H plane (vertical polarization) is:

$\theta_H = \pm \tan^{-1} \frac{1.5}{23} = \pm 3.75^\circ$, and in the E plane $\theta_E = \pm \tan^{-1} \frac{1}{23} = \pm 2.5^\circ$.

It can be seen from figure 14 that in the design frequency range, the maximum change in relative amplitude is 0.75 db, which occurs for horn section D1 at frequency 4.0 GHz, (H plane, 4 degrees). Adding another 0.4 db due to the change in transmission length in the quiet zone (one foot deep), the total change in relative amplitude, and hence the change in power density for a fixed power transmitted, is 1.15 db ($\approx \pm .6$ db) which is well within the $\pm$ 1.0 db goal set for the quiet zone.

For a quiet zone 4' wide x 3' high x 1' deep ($\theta_H \cong \pm 5^{\circ}$, $\theta_E \cong \pm 4.0^{\circ}$), the power density would be within $\pm$ 1.0 db (neglecting reflections). This was borne out by the chamber evaluation discussed in Section III.

2. Horn Sections for Higher Power Densities

To increase the versatility of the facility, additional "add-on" horn sections were designed to uniformly illuminate successively smaller quiet zone volumes with increased gain. Thus, at the upper end of the frequency band (3.95 GHz) horn section D10 will illuminate uniformly ($\approx \pm .5$ db) a quiet zone large enough for a single test sample - 1.5' wide x 1' high x 1' deep. This can be determined from figure 15 where for D10 and $\theta_H = \pm 2^{\circ}$, $\theta_E = \pm 1^{\circ}$, $\Delta A = .5$ db. At this frequency, D10 gives the maximum power density obtainable for the system. From figure 11, for horn section D10 at 3.95 GHz, $Pd/W = 3.83 \times 10^{-2}$, and the power required for a power density of 10 mw/cm^2 is: $\frac{10}{3.83 \times 10^{-2}} = 260$ watts which is obtainable from the high power TWT in the system.

F. DETERMINATION OF POWER DENSITY

As discussed in Section II D, the power density can be determined by direct measurement using the standard gain horn monitor and figure 12, if the monitor can be physically placed at the desired position. The on boresight power density can also be determined from the measured transmitted power and figure 11. From the discussion in Section E above, it can be seen that this value will be correct to better than $\pm$ 1.0 db for any point in the quiet zone in the design ranges.

In using the larger section to illuminate the 3' wide by 2' high by 1' deep quiet zone, the power density at any position can be determined from the on boresight power density/watt transmitted curve (figure 11), and the ΔA curves given in figures 14 and 15.

As an example, for horn section D10 with 200 watts transmitted at 3.95 GHz, the power density at boresight is Pd = Pd/W x power transmitted. Pd/W = 3.83×10^{-2} from figure 11, therefore, Pd = 7.66 mw/cm^2. At the edge of the 3' quiet zone, $\theta_H = \pm \tan^{-1} 1.5/23 = \pm 3.75^o$. Interpolating from figure 15 for D10, $\theta_H = \pm 3.75$; ΔA is approximately - 2.25 db = 60% of the maximum amplitude, and the power density is approximately 7.66 x 60% = 4.56 mw/cm^2 at the quiet zone edge.

In a similar manner, the on boresight power density can be determined from the measured power density at any point in the quiet zone. Actual values measured during a preliminary experiment are used as an example. The standard gain horn monitor was placed 2.5' off boresight in azimuth, and its meter reading was 2.4 dbm. From figure 12, at 3.2 GHz (the transmitted frequency) the frequency correction term is 2.2 db. Thus, the corrected meter reading is + 2.4 dbm + 2.2 db = 4.6 dbm, which (from figure 12) corresponds to a power density of 3.1 mw/cm^2 at the point of measurement. The monitor horn position gives a $\theta_H = \pm \tan^{-1} 2.5/23 = \pm 6.1^o$, and from figure 14 for $\theta_H = 6^o$ and horn section D6 (the horn section used) ΔA = 1.9 db = 65%. Therefore, the on boresight power density is 3.1 $mw/cm^2 \times \frac{1}{65\%} = 4.78\ mw/cm^2$. For this experiment, the measured transmitted power (210 watts) gives an on boresight power density of 4.72 mw/cm^2 (from figure 11) which is in good agreement with the above calculated value (4.78 mw/cm^2).

III. EVALUATION: PROCEDURE AND RESULTS

The evaluation of the microwave test facility was divided in three phases: (1) the evaluation of the reflection from the walls and ceiling of the empty microwave chamber as measured with an absorber backed dipole and a standard gain horn, (2) the measurement of the reflections from a single sample container (both occupied and unoccupied) in the quiet zone and (3) the measurement of the power density in the chamber using the high power source and the various horn sections.

A. MICROWAVE CHAMBER EVALUATION

The results of the evaluation of the microwave anechoic chamber are summarized in Table I. It can be seen from this tabulation, that for the required minimum quiet zone dimensions - 3' Wide x 2' High x 1' Deep, - a total power variation of ± 1.75 db is possible over the frequency band of interest. At selected frequencies, adequate quiet zones with ± 1.25 db variations are possible. The measurements, performed with an absorber backed dipole, indicate that the power variations are primarily due to "amplitude ripples" caused by reflections from the chamber walls. Maximum ripples as great as ± 1.0 db were observed. Figure 16 is a typical example of the power variation due to reflections. This data is for a 25' transmission length at F = 3.25 GHz.

The values obtained with a standard gain horn at 3.25 GHz (gain = 16.5 db) are also shown in Table I, (from figure 21) as an example of the optimistic conclusions resulting from the use of a large area receiving antenna. The horn integrates the reflected ripples over a receiving area considerably larger than that of the dipole. Maximum ripples as observed with the standard gain horn were less than ± 0.25 db.

The chamber was evaluated by taking horizontal cuts, through the 4 foot cubic quiet zone which is centered equidistant between the side walls, and the floor and ceiling; a distance 25.0' from the transmitting end wall. The horizontal cuts extending ± 2.0' from this quiet zone center, were taken at elevation increments of ± 1.0', ± 1.5', and ± 2.0' for each transmission length increment of ± 1.0', ± 1.5', and ± 2.0' from the 25.0' center point. These measurements were repeated at each of the six different frequencies in the design range of each of the horn sections. Relative power as a function of horizontal distance was recorded on an X-Y recorder, equipped with a roll chart adapter, for each of the measurement increments.

TABLE I

Quiet Zone Volumes and Power Variations

SECRET

Frequency (Horn Section)	Volume Dimensions for Power Variations of:					
	±1.0db	±1.25db	±1.5db	±1.75db	±2.0db	≥±2.2
2.6GHz (D6)	None	None	2'Wx2'Hx3'D	4'Wx3'Hx1'D 3'Wx3'Hx3'D	4'Wx4'Hx1'D 4'Wx3'Hx2'D 4'Wx2'Hx3½'D 3'Wx4'Hx2'D	4'Wx4'H (2.75
2.8GHz (D5)	2'Wx3'Hx1'D	4'Wx3'Hx1'D 3'Wx2'Hx2'D 2'Wx3'Hx2'D 2'Wx4'Hx½'D	4'Wx3'Hx2'D 3'Wx4'Hx1'D 3'Wx3'Hx3½'D 2'Wx4'Hx2'D	4'Wx3'Hx3'D 3'Wx4'Hx3½'D 3'Wx3'Hx4'D 2'Wx4'Hx4'D	4'Wx4'Hx4'D	
3.0GHZ (D4)	3'Wx2'Hx½'D	4'Wx2'Hx1'D 3'W'3'Hx1'D 3'Wx2'Hx3'D	4'Wx3'Hx1'D 3'Wx3'Hx2'D 3'Wx2'Hx4'D 2'Wx4'Hx2'D	4'Wx3'Hx2'D 3'Wx4'Hx3½'D 3'Wx3'Hx4'D	4'Wx4'Hx1'D 3'Wx4'Hx4'D	4'Wx4'H (2.5d
3.25GHz (D3)	3'Wx2'Hx1'D	4'Wx2'Hx2'D	4'Wx3'Hx1'D 4'Wx2'Hx3'D 3'Wx2'Hx3½'D	4'Wx4'Hx1'D 4'Wx3'Hx3'D 4'Wx2'Hx4'D 3'Wx3'Hx4'D	4'Wx4'Hx2'D 4'Wx3'Hx4'D 3'Wx4'Hx3'D	4'Wx4'H (2.25
3.25GHz (D3) Standard Gain Horn	4'Wx3'Hx1'D 3'Wx2'Hx2	4'Wx4'Hx1'D 4'Wx3'Hx3'D Many others	Great many options	4'Wx4'Hx4'D		
3.45GHz (D2)	None	None	2'Wx4'Hx1'D 2'Wx2'Hx2'D	3'Wx4'Hx1'D 3'Wx2'Hx3½'D 2'Wx4'Hx2'D 2'Wx3'Hx4'D	4'Wx4'Hx2'D 4'Wx2'Hx3'D 3'Wx3'Hx4'D	4'Wx4'H (2.25
3.8GHz (D1)	2'Wx2'Hx½'D	3'Wx2'Hx½'D 2'Wx3'Hx2'D	4'Wx2'Hx1'D 3'Wx2'Hx3'D 2'Wx3'Hx4'D	4'Wx4'Hx½'D 4'Wx3'Hx4'D	4'Wx4'Hx4'D	

W = Width H = Height D = Depth

Notes:
(1) All quiet zone volumes start at a transmission length of 23 feet and are symmetric about the chamber width and height center points.
(2) Underlined are the volumes with minimum variations whose dimensions are ≥minimum required values (3'Wx2'Hx1'D)

[redacted]

SECRET

At each frequency, the measured power is relative to the horizontal and vertical center points, at a transmission length of 23.0 feet. Relative power levels were not maintained from frequency to frequency.

The resulting reams of data are summarized in seven tables, based on frequency, shown as Figures 16 through 22. Analysis of the seven tables, using the crosshatch patterns shown in the NOTES section of these figures, resulted in the summary presented in Table I.

The chamber evaluation, using a standard gain horn instead of the absorber backed dipole, was performed in an identical manner. These results from figure 21, are also summarized in Table I.

The aforementioned crosshatch patterns, and the summarized results in Table I, are subject to the following arbitrary rules and definitions in order to keep the analysis manageable and to not unduly complicate the resulting quiet zone options.

1. All summarized quiet zone volumes start at 23.0' and are symmetric about the chamber vertical and horizontal center points.
2. The lowest minimum power level in the vertical distances symmetric about the center point determines the crosshatch pattern. For example: in figure 16 for a transmission length of 23.0' in a horizontal distance of ± 2.0', the minimum power levels for the symmetric distances UP 1.0' and DOWN 1.0' are -2.25 db and -0.75 db, respectively. Both of these points, then, are assigned the crosshatch pattern associated with -2.25 db, which is the minimum power level in the vertically symmetric distance of ± 1.0' (UP 1.0' and DOWN 1.0').
3. The maximum ripple is the maximum positive and negative perturbation (in db) from the average power level curve (the "smoothed" curve) in a horizontal traverse.
4. The underlined volumes in Table I are dictated by the minimum volume required for two test samples in containers placed side-by-side (3'Wx2'Hx1'D).
5. All power level values are rounded off to the nearest 0.25 db. Although the data taking procedure does not preclude the possibility

of missing "worst point" cases, it is felt that the very large number of data points measured represents a good statistical sampling, and the conclusions summarized in Table I are representative of the chamber behavior.

B. EVALUATION OF TEST SAMPLE CONTAINER AND TEST SAMPLE IN THE CONTAINER

1. Test Sample Container

Tests were conducted with a single test sample container in the quiet zone. For the container having no microwave absorbing liner, fairly large amplitude ripples resulted (greater than ± 5.0 db). With the container almost completely lined with a microwave absorber (the "radiation window" excepted), these variations are reduced to approximately ± 3.5 db. Removing the plexiglass back that was on the container (the container is irradiated from the back) and replacing it with a thin plexiglass back (1/16" thick) further reduced these variations to approximately ± 2.5 db. By absorber lining certain braces that are within the radiation window (and cannot be removed), the perturbations are reduced still further, to approximately ± 2.0 db, however, portions of the radiation window are blocked. In any event, the test sample in the container perturbs the field in some different manner and the question arises as to what constitutes a valid set of measurements: the sample and container immersed into an unperturbed field, or the sample placed in an unperturbed field within the container (if this were possible). In either case (the test sample and container, or the sample alone), complex multiple reflections result.

Consideration should be given to the possibility of constructing a suitably lossy microwave container with a radiation window of the desired dimensions.

2. Evaluation Procedure

The evaluation of the test sample container in the microwave chamber was performed by mounting the container in the center of the four foot cubic quiet zone (at a transmission length of 25.0 feet) on the horizontal traversing mechanism. A monitor dipole was placed at a transmission length of 23.0' on the horizontal and vertical center point. Received power was recorded as a function of the horizontal traverse of the container in the quiet zone. The dipole was then moved toward the container in 3-inch increments and the measurement repeated. This procedure was repeated for several different elevations of the monitor dipole and several different frequencies. The test sample container was moved behind the dipole monitor, rather than the monitor being moved in front of the container, because, in the latter case, the traversing mechanism would "shadow" the container. Typical results of the container evaluation are shown in figure 24.

To mount the container at the proper elevation level, the traversing mechanism was fitted with an absorber pedestal, upon which the container was placed. The pedestal by itself (and the traversing mechanism) was evaluated as described above with negligible perturbations of the R. F. field resulting.

3. Test Sample

The evaluation of a single test sample in the test sample container was performed in a manner identical to the procedure described above. Results of these tests show that the sample in the container does not greatly increase the magnitude of the field perturbations over those observed for the container alone - ± 2.88 db versus ± 2.63 for the two cases respectively - however, the phase of the reflections is changed such that where a maximum was observed without the test sample, a minimum might now exist. Table II, below, is a summary of the evaluation of the test sample and the test sample container.

TABLE II

Summary of Sample Container and Sample-in-Container Measurements

Test Condition	Field Variation (Worst Case*)
A. Sample Container Alone	
Absorber Lined Container (3/8' plexiglass back)	± 3.63 db
" " " (no back)	± 4.88 db
" " " (1/16" plexiglass back)	± 2.63 db
B. Sample in Sample Container	
Absorber Lined Container (1/16" plexiglass back)	± 2.88 db
C. Sample Alone**	± .88 db

* Worst Case = greatest maximum to greatest minimum power variation in the quiet zone, for all positions of dipole monitor (see figure 24).

** Perturbations due to Sample movement alone, container and dipole monitor stationary.

C. POWER DENSITY

The final evaluation phase of the microwave test facility was the measurement of the power density in the quiet zone, utilizing the complete microwave chain.

The power density was measured with the standard gain horn monitor as outlined in Section II F, for various frequencies, and for values of transmitted power between 200 and 300 watts with the appropriate horn sections. These measured values were compared with the power density calculated from the measured transmitted power and the gain of the horn sections. The results are summarized in Table III.

TABLE III

Measured versus Calculated Power Densities

Freq. (GHz)	Tx. Horn Section	Tx. Horn Gain	Measured Tx. Power (Watts)	Calc. Power Density -mw/cm^2 ($P_T G_T / 4\pi R^2$)	Measured Power Density mw/cm^2	Δ = Calc.-Meas.
2.6	D6	99.6	228	3.40	3.70	-0.30
2.7	D6	105.0	226	3.55	3.90	-0.35
2.7	D5	91.2	220	3.0	3.0	0.00
2.8	D5	95.6	216	3.09	3.2	-0.11
2.9	D5	102.0	210	3.20	2.9	+0.30
2.9	D4	89.0	236	3.14	2.85	+0.29
3.0	D4	93.5	234	3.27	3.1	+0.17
3.1	D4	100.0	232	3.47	3.35	+0.12
3.2	D3	93.5	226	3.16	3.0	+0.16
3.3	D3	100.0	232	3.47	3.45	+0.02
3.4	D2	91.2	232	3.17	3.0	+0.17
3.6	D2	102.0	236	3.61	3.6	+0.01
3.6	D1	89.0	245	3.27	3.6	-0.33
3.7	D1	95.6	260	3.71	3.6	+0.11
3.8	D1	100.0	278	4.16	4.15	+0.01
3.9	D1	105.0	250	3.93	4.0	-0.07
3.95	D1	110.0	250	4.12	4.35	-0.23
4.0	D1	112.0	250	4.19	4.25	-0.06

NOTE: For these measurements R = 24.0'

D. CONCLUSION

The microwave equipment at the Walter Reed facility is capable of producing a power density of approximately 4.0 mw/cm^2 in a quiet zone adequate for two test samples side-by-side (3'W x 2'H x 1'D) over the S-band frequency range, with a transmitted power of 250 watts - the recommended upper limit for continuous operation of the high powered traveling wave amplifier.

For reduced quiet zone volumes, a power density of 10 mw/cm^2 is possible.

When evaluated with an absorber backed dipole, total power variations of $\pm$ 1.75 db were observed in the 3'W x 2'H x 1'D quiet zone over the S-Band frequency range, primarily due to reflections from the chamber walls ($\pm$ 1.0 db). Using a standard gain horn as the field probe reduces the observed "ripples" to less than $\pm$ 0.25 db.

For a single test sample in an absorber lined test sample container, field variations of $\pm$ 2.63 db were measured. The movement of the sample alone produced variation of $\pm$ 0.88 db in the power measured with the dipole antenna.

SECRET

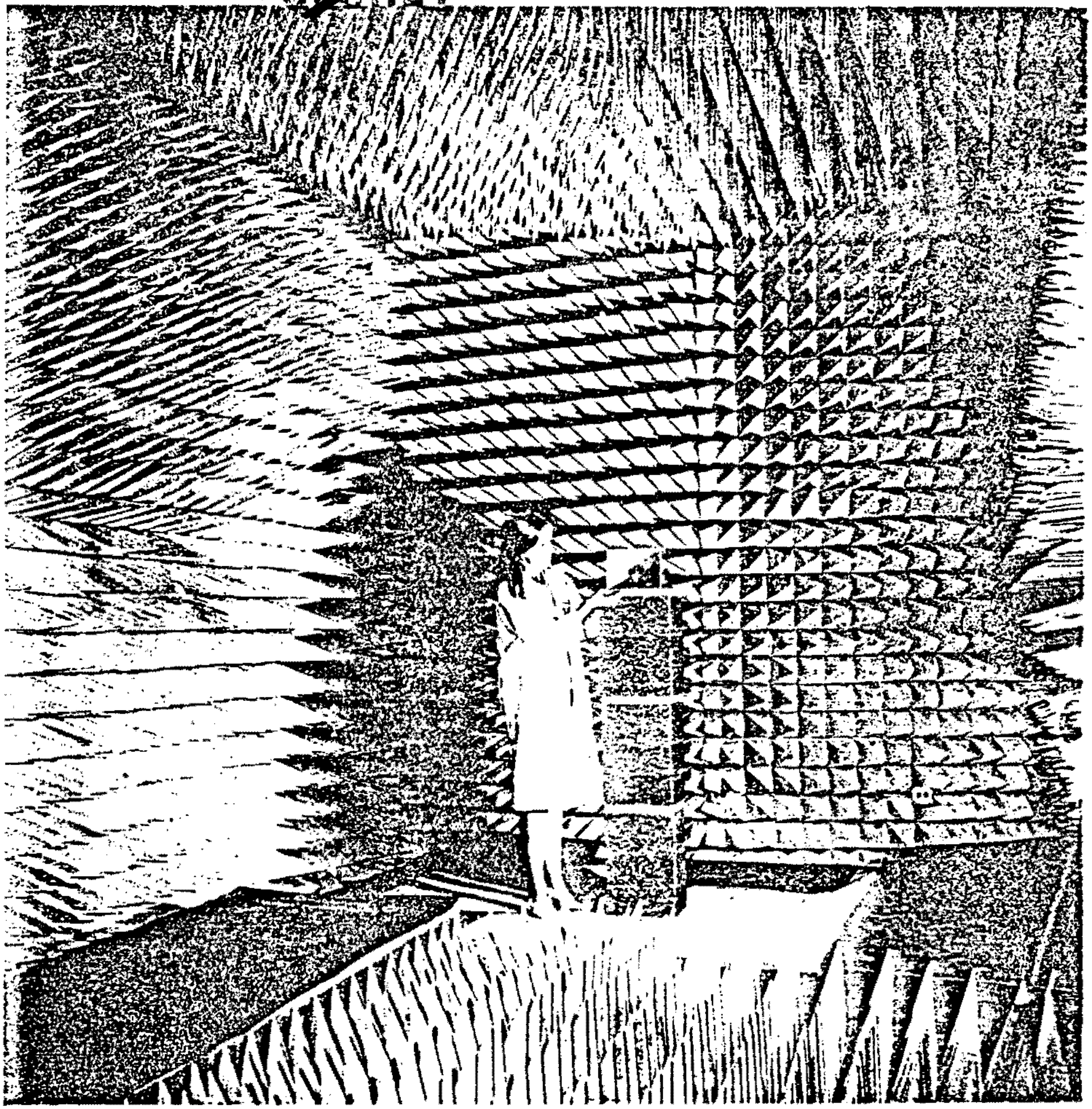


Fig. 1 MICROWAVE ANECHOIC CHAMBER

SECRET

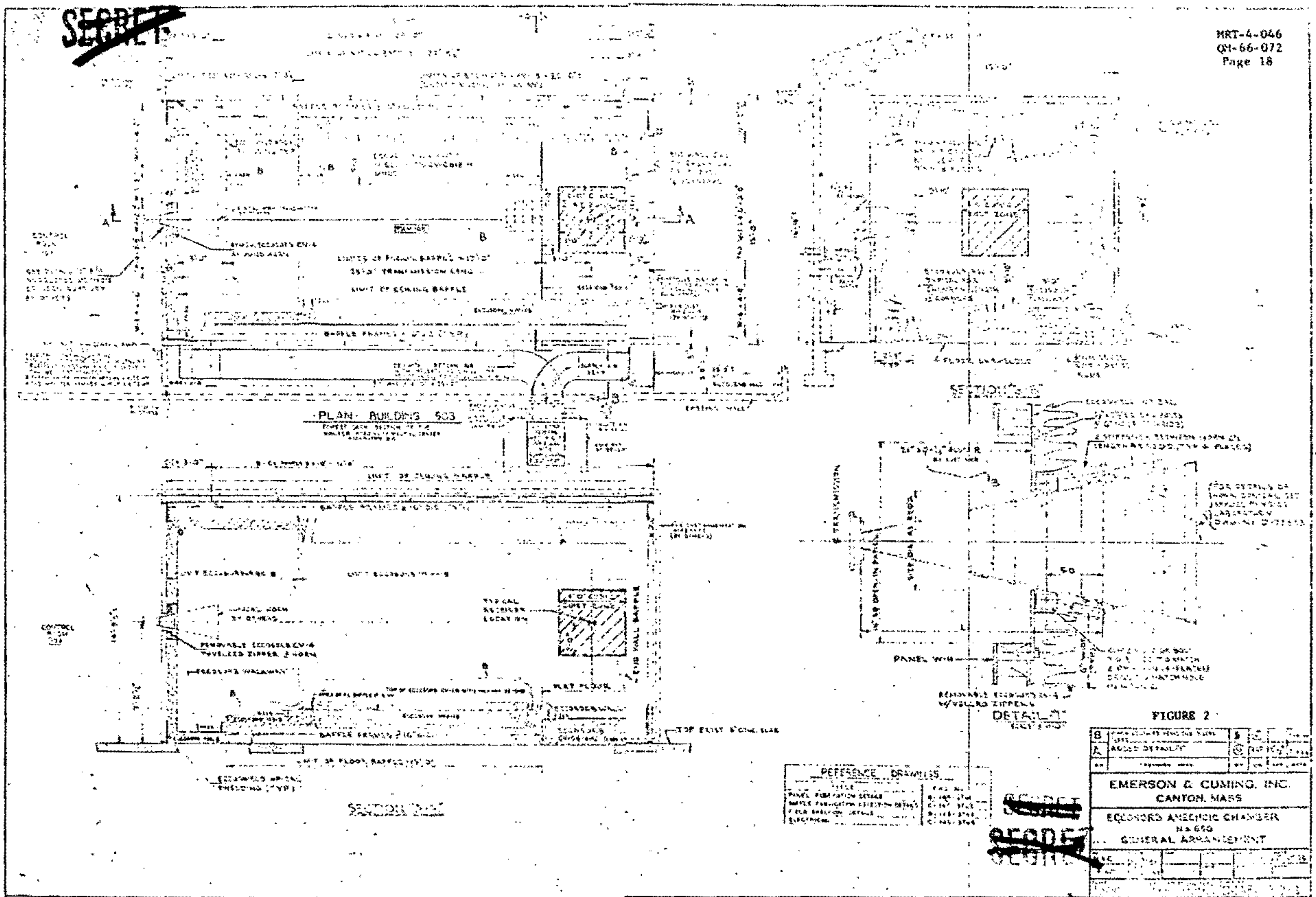

SECRET
PLAN BUILDING 503
SECTION "A-A"
SECTION "B-B"
DETAIL "1"
PANEL W/H
REFERENCE DRAWINGS
EMERSON & CUMING, INC.
CANTON, MASS.
GENERAL ARRANGEMENT
SECRET

FIGURE 2

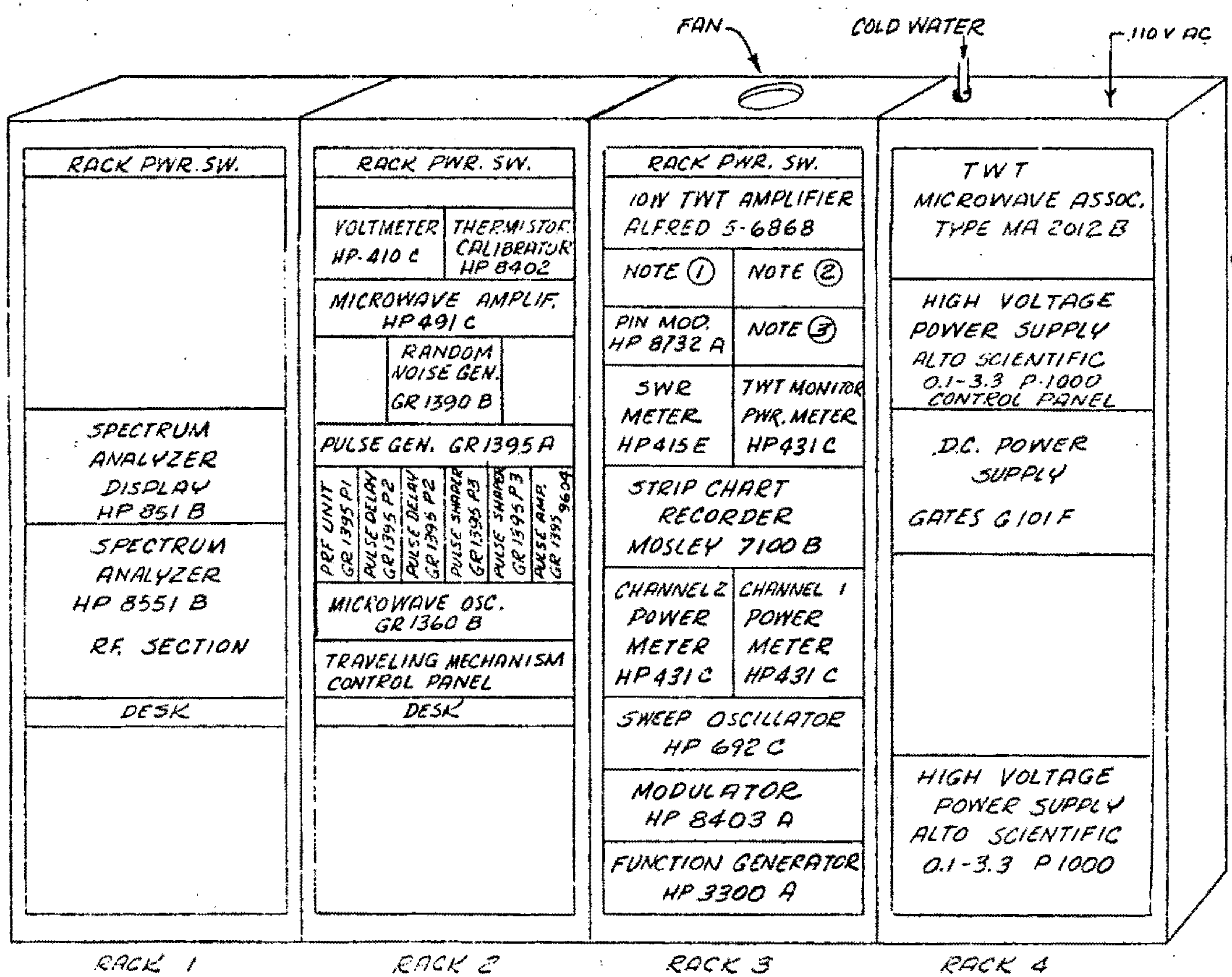
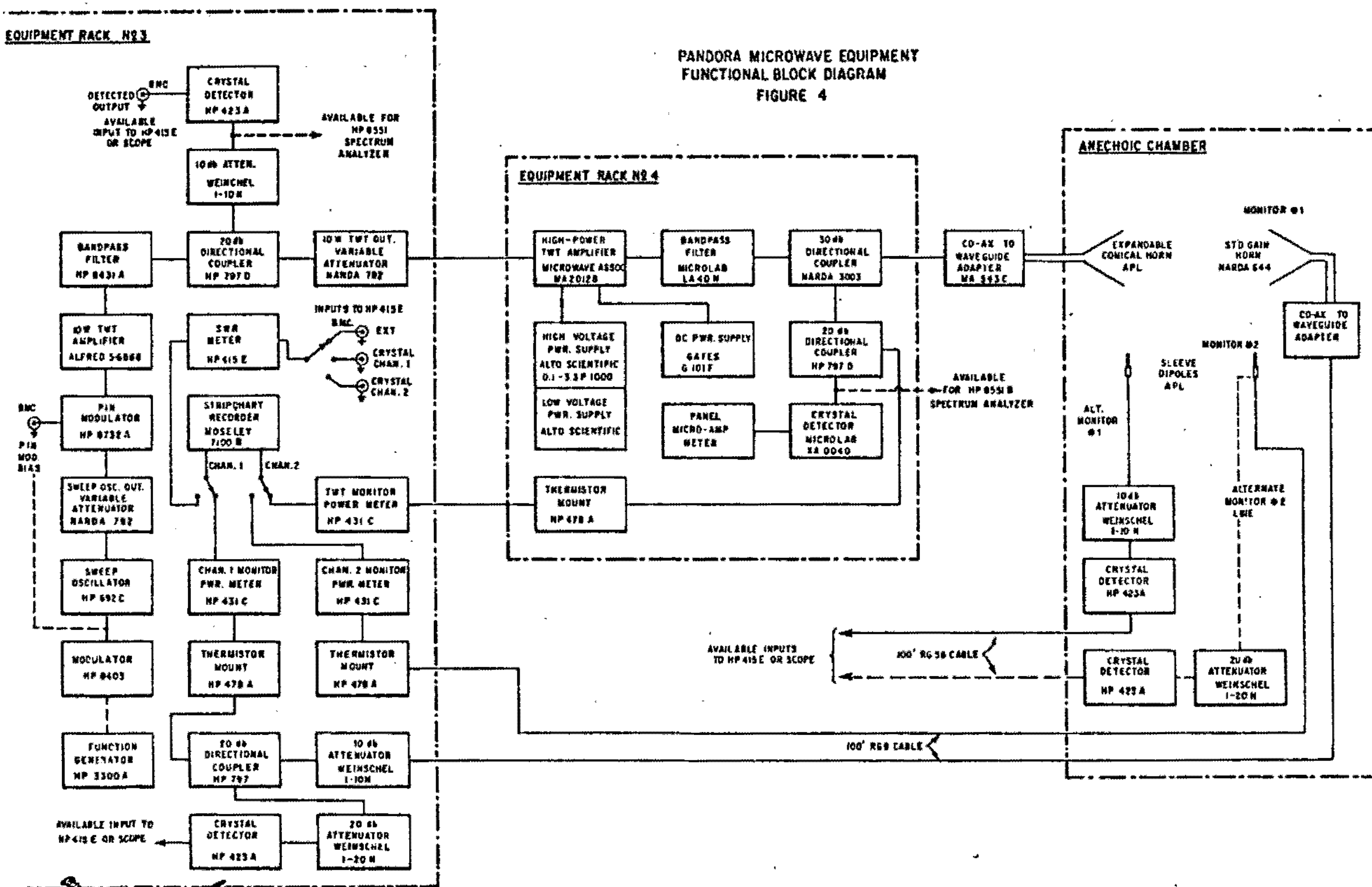


FIGURE 3
RACK ARRANGEMENT OF
PANDORA MICROWAVE EQUIPMENT

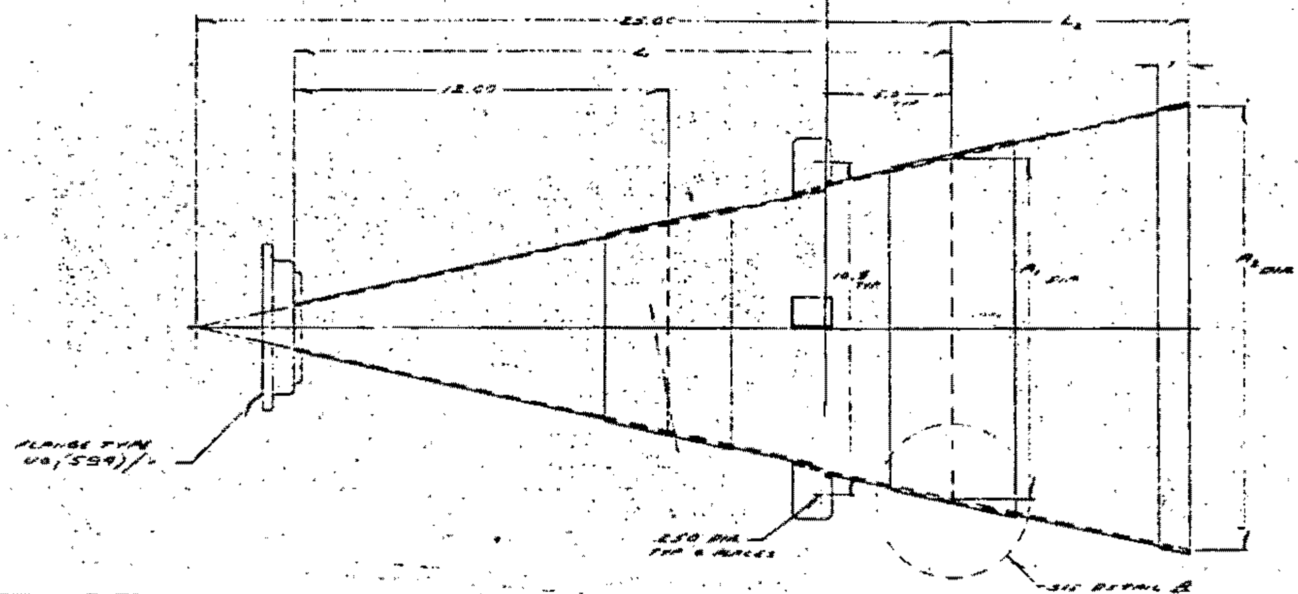
NOTE ① PANEL CONTAINS SWITCHES WHICH CONNECT VARIOUS MONITORED FUNCTIONS TO THE STRIP CHART RECORDER. BEHIND PANEL, BAND PASS FILTER (HP 8431 A), 20 db DIRECTIONAL COUPLER (HP 777D), 10 db FIXED ATTEN. (WEINCHEL 1-10N), XTAL DETECTOR (HP 423

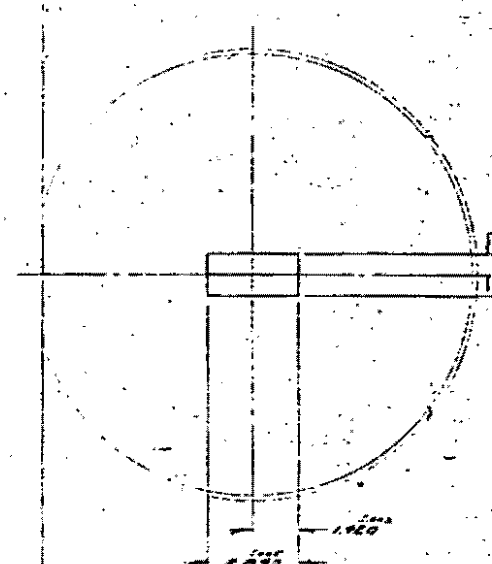


PANDORA MICROWAVE EQUIPMENT
FUNCTIONAL BLOCK DIAGRAM
FIGURE 4

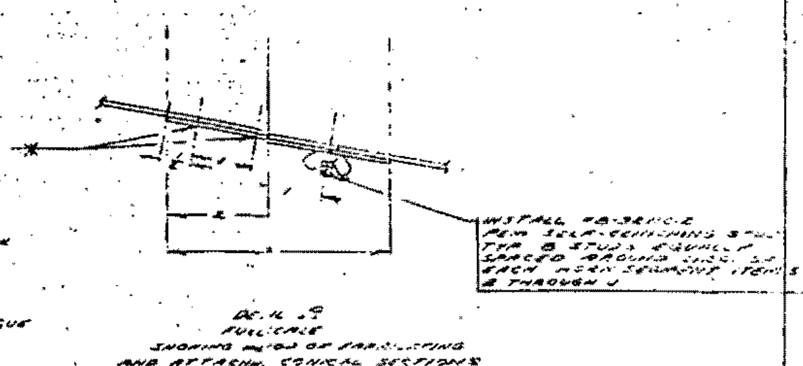
~~SECRET~~

DO NOT SCALE





ITEM	NO. REQ'D	LENGTHS L_1	LENGTHS L_2	DIAMETERS A_1	DIAMETERS A_2
A	1	21.87		10.75	
B	1		2.25	10.75	11.75
C	1		3.25	"	13.00
D	1		7.50	"	14.00
E	1		10.25	"	15.50
F	1		14.00	"	16.75
G	1		17.25	"	18.25
H	1		21.50	"	20.00
I	1		24.75	"	22.25
J	1		31.75	"	25.50



CONSTRUCTION NOTES

1. FABRICATE HORN SEGMENTS FROM .050 NOM. THK ALUMINUM BY SPOT WELDING TECHNIQUES ITEM A MAY BE CONSTRUCTED IN TWO SECTIONS PROVIDING MATE WITH FLANGE UG(599)/U IS NO LESS THAN 12.00 LG.
2. ATTACH FLANGE VIA HELI-ARC WELDING TECHNIQUE METHOD

~~SECRET~~

FIGURE 5

HORN CONICAL

APPLIED PHYSICS LABORATORY

D 73328

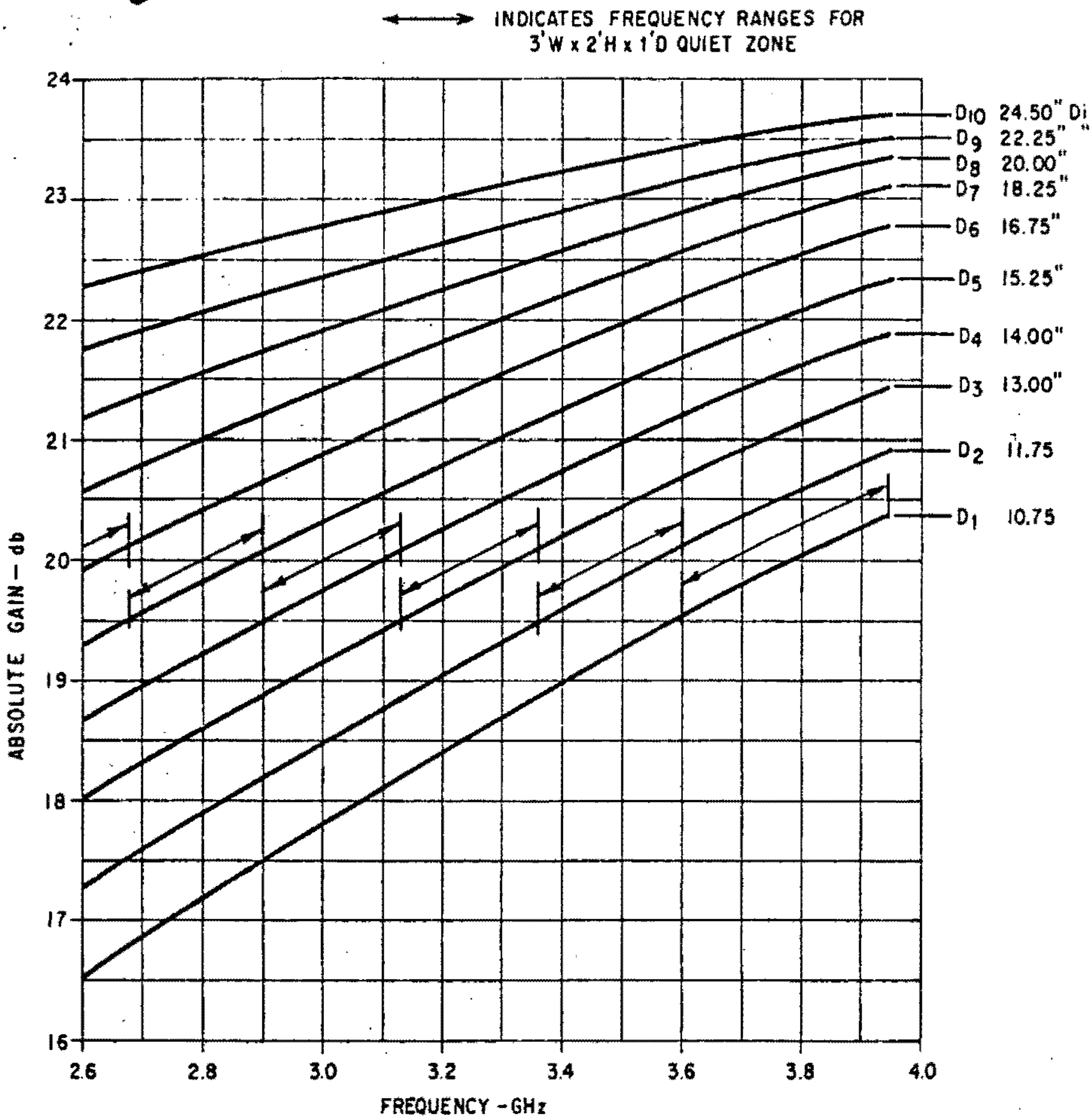


Fig. 6 ABSOLUTE GAIN, EXPANDABLE CONICAL HORN

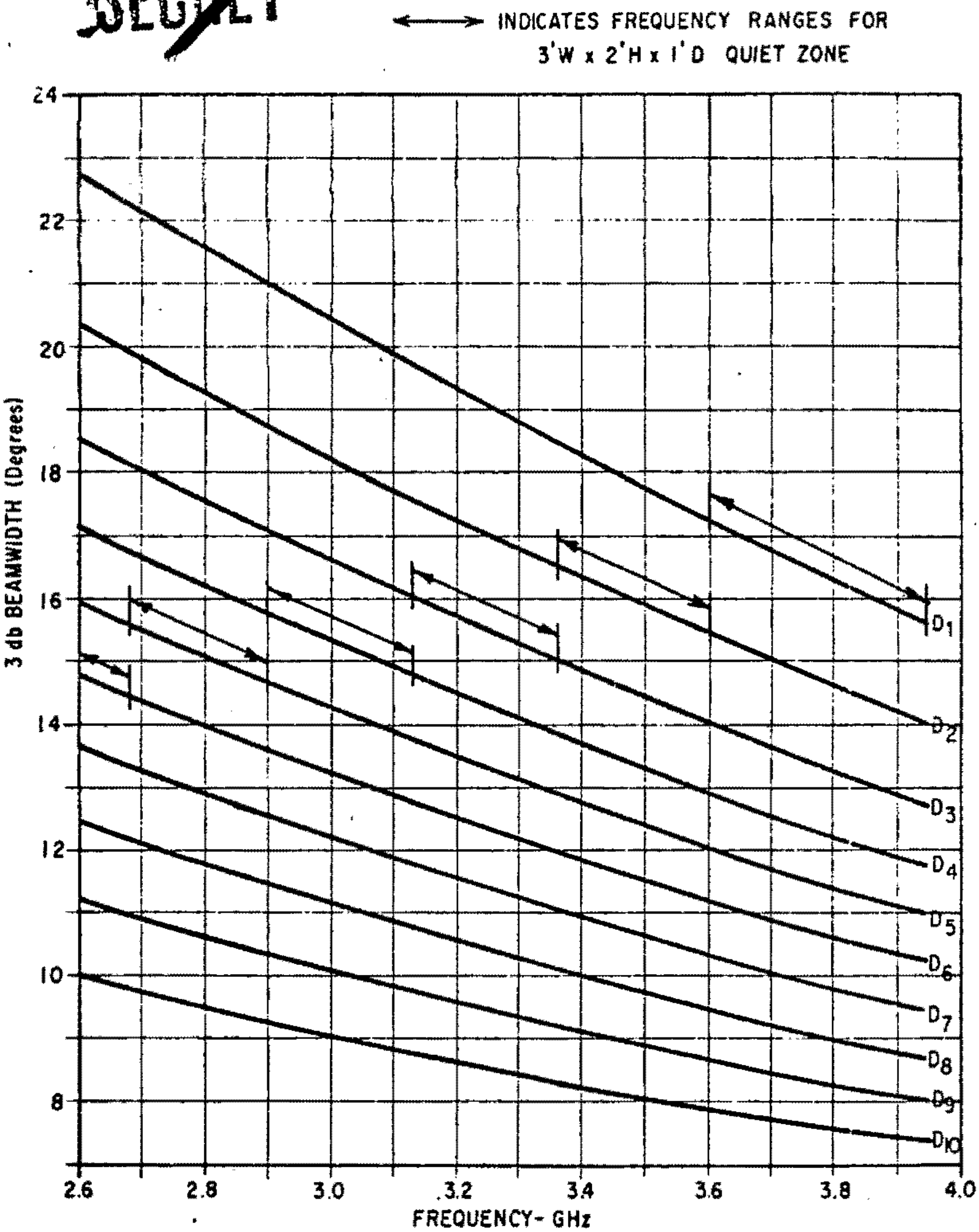


Fig.7 E PLANE 3db BEAMWIDTH, EXPANDABLE CONICAL HORN

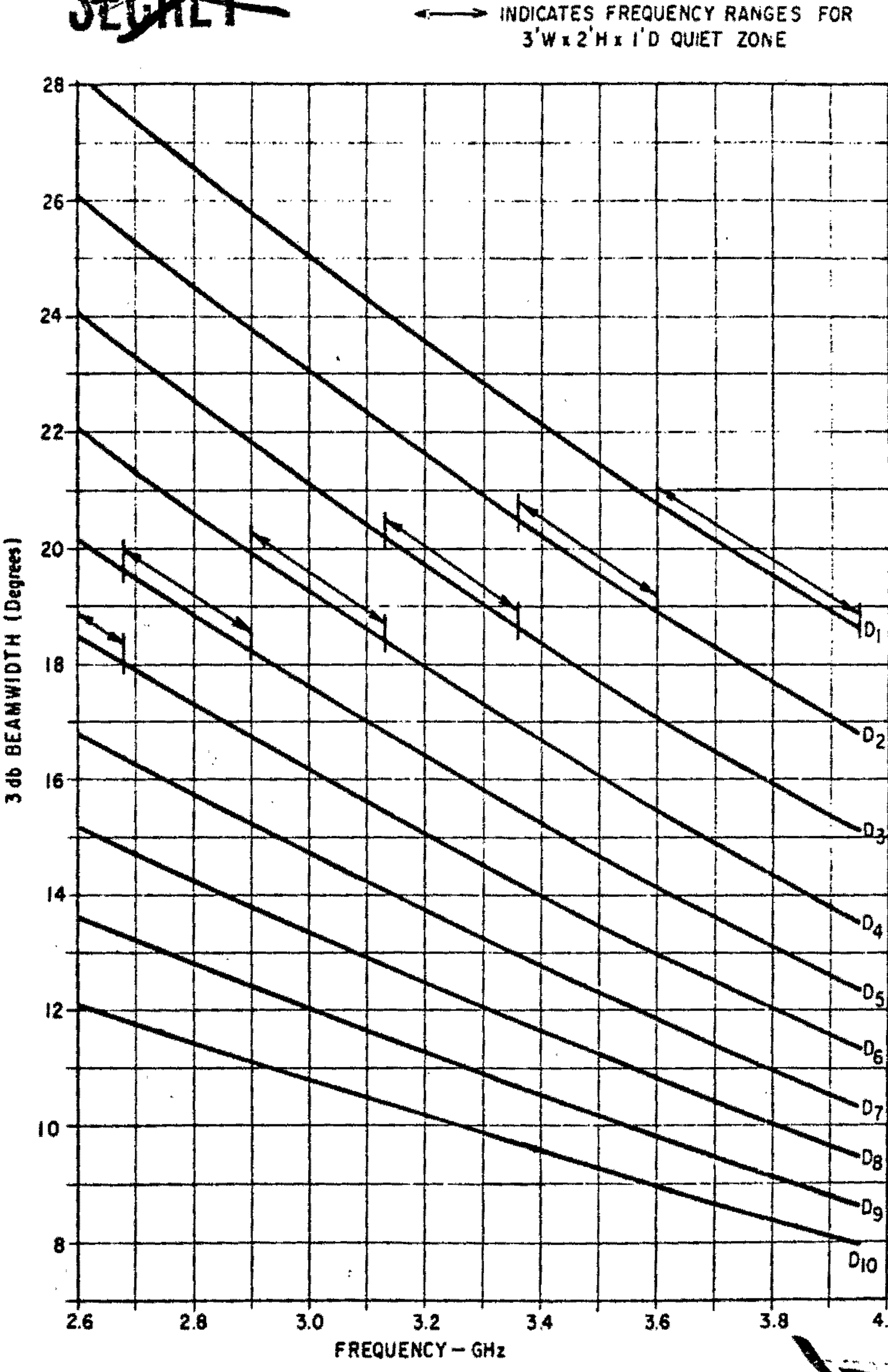


Fig. 8 H PLANE 3db BEAMWIDTH, EXPANDABLE CONICAL HORN

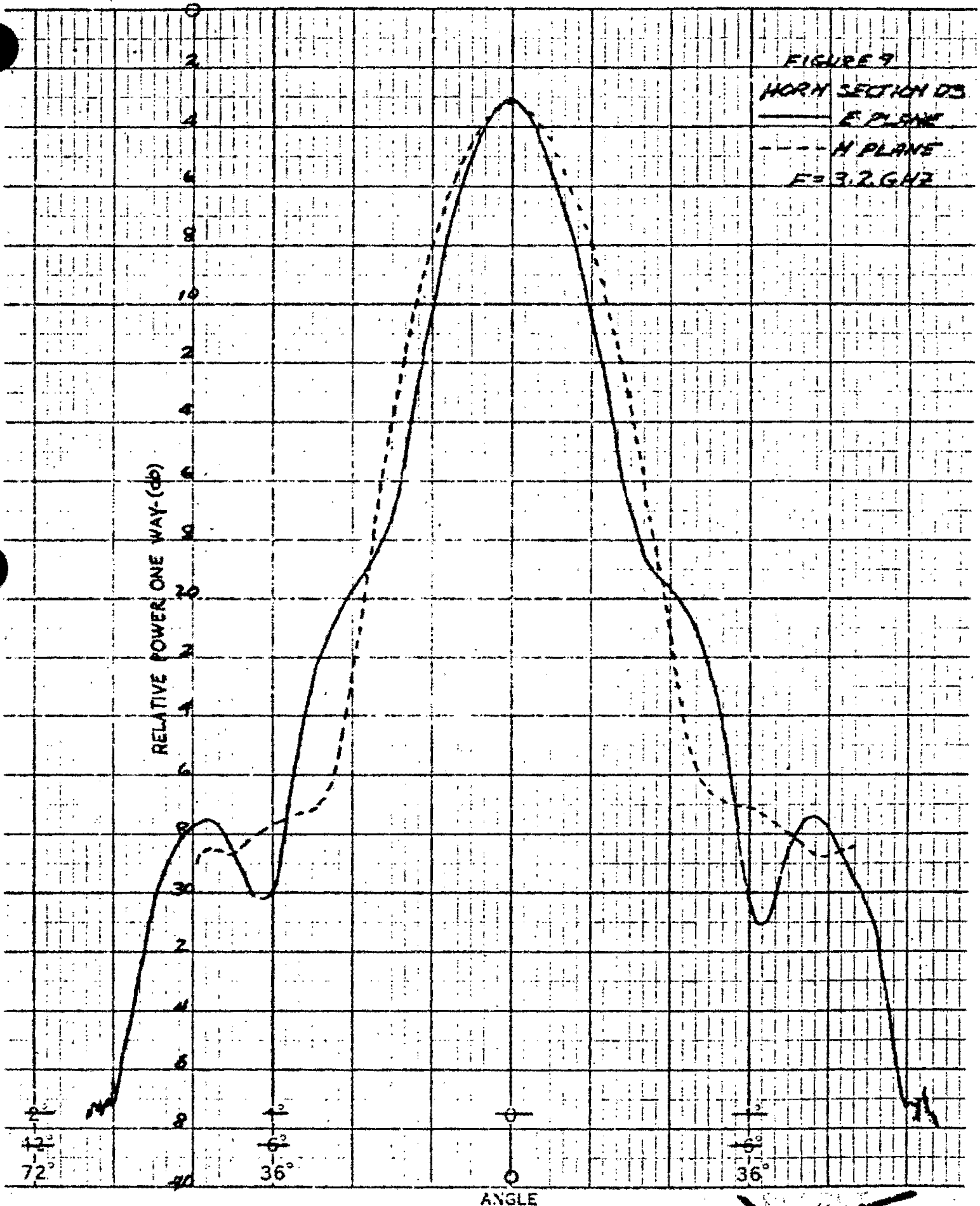
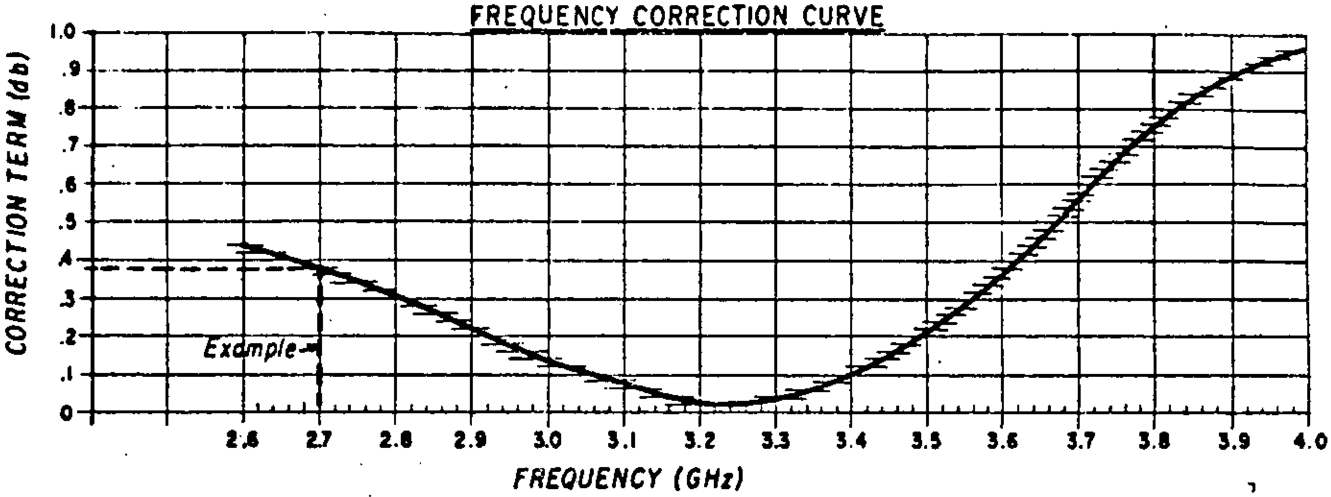


FIGURE 9
HORN SECTION D3
E PLANE
H PLANE
F=3.2 GHZ
RELATIVE POWER ONE WAY-(db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
72°
36°
0
36°
ANGLE

~~SECRET~~

Fig. 10 HIGH POWER TWT MONITOR - METER READING Vs TRANSMITTED POWER

FREQUENCY CORRECTION CURVE



TO MEASURE TRANSMITTED POWER:

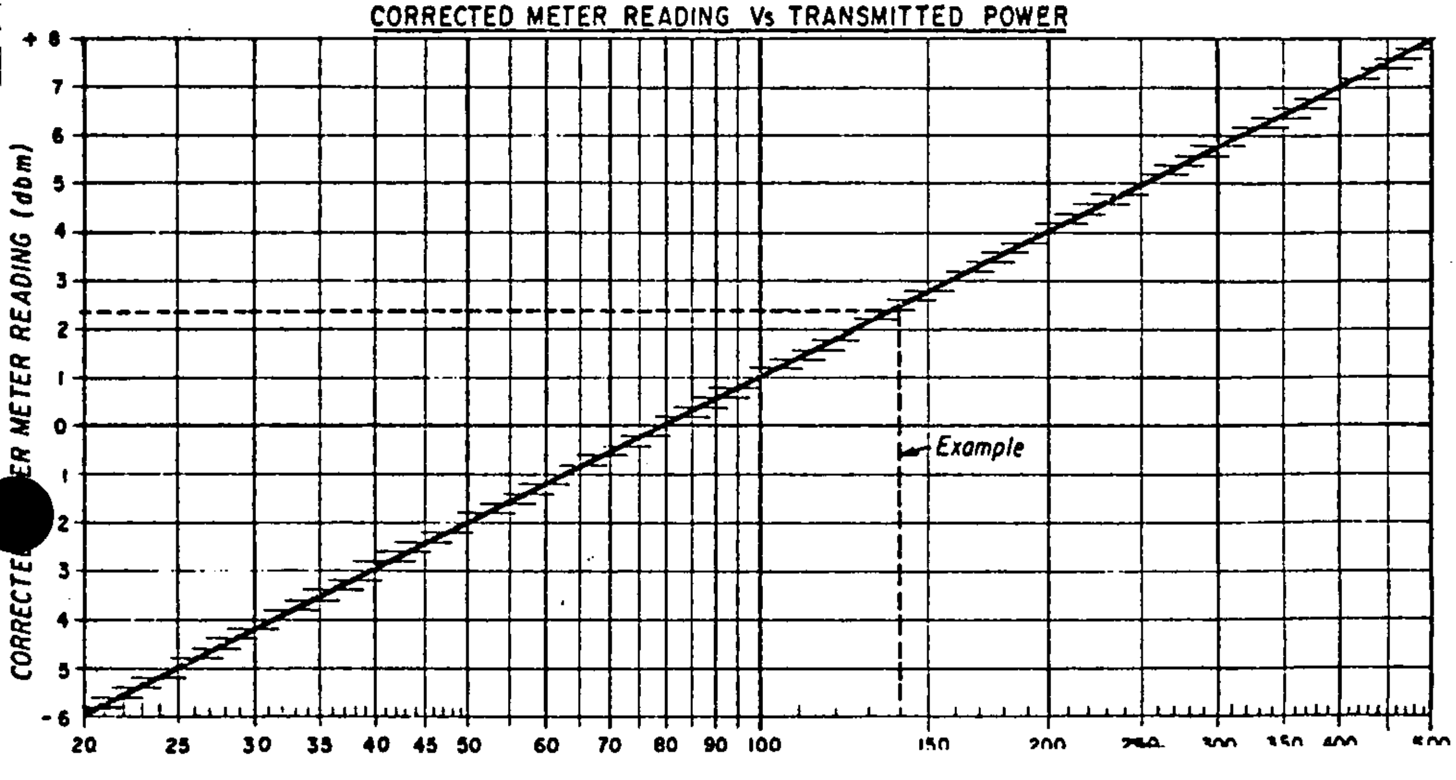
ADD CORRECTION TERM TO TWT MONITOR POWER METER READING.

Example: AT 2.7 GHz, THE CORRECTION TERM = .38
POWER METER READING = 2.00
CORRECTED METER READING 2.38 dbm ≈ 140 Watts P_T

TO SET TRANSMITTED POWER:

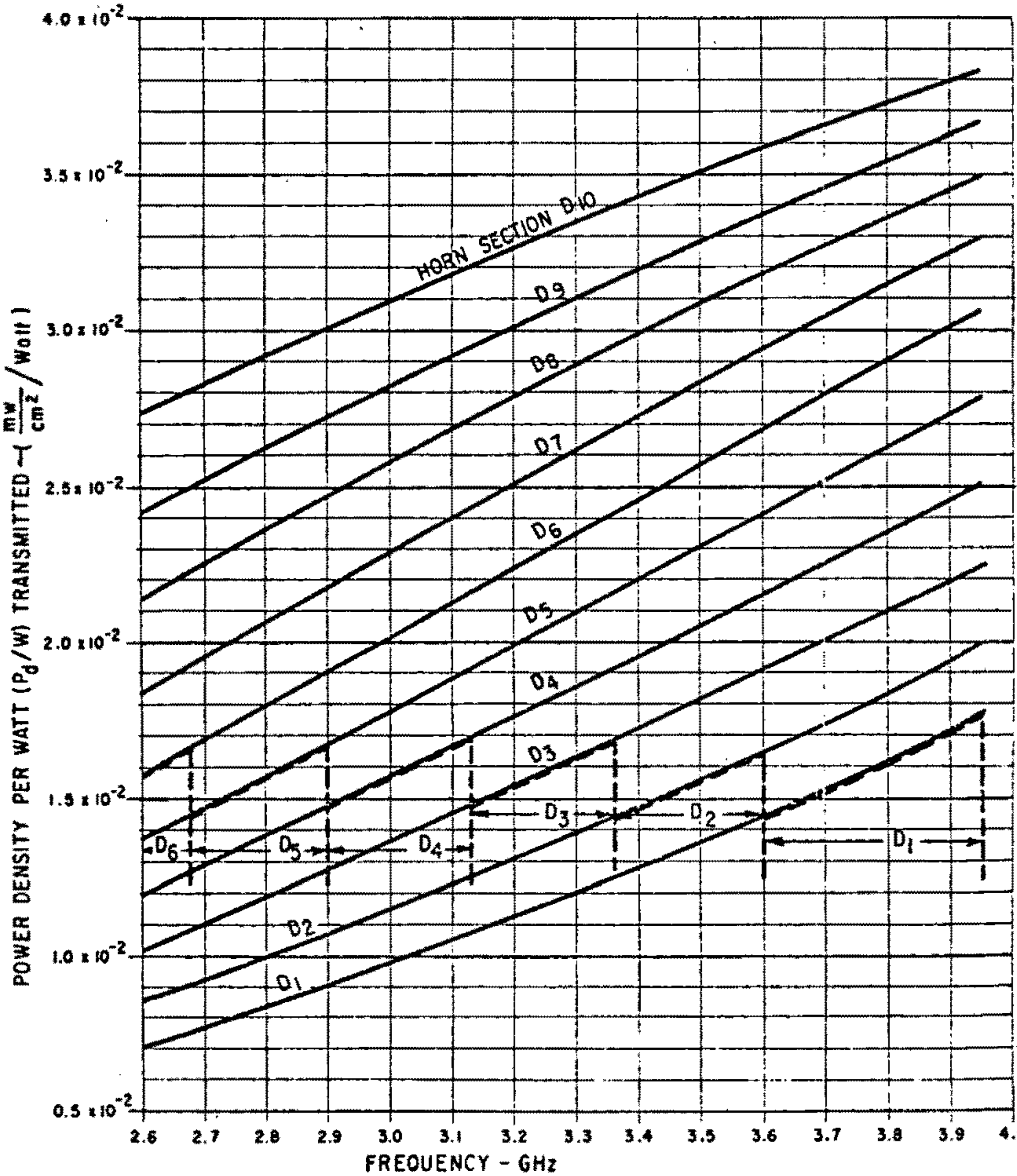
SUBTRACT CORRECTION TERM FROM CORRECTED METER READING WHICH CORRESPONDS TO DESIRED POWER. ADJUST POWER TO OBTAIN THIS VALUE ON TWT MONITOR POWER METER.

CORRECTED METER READING Vs TRANSMITTED POWER



SECRET

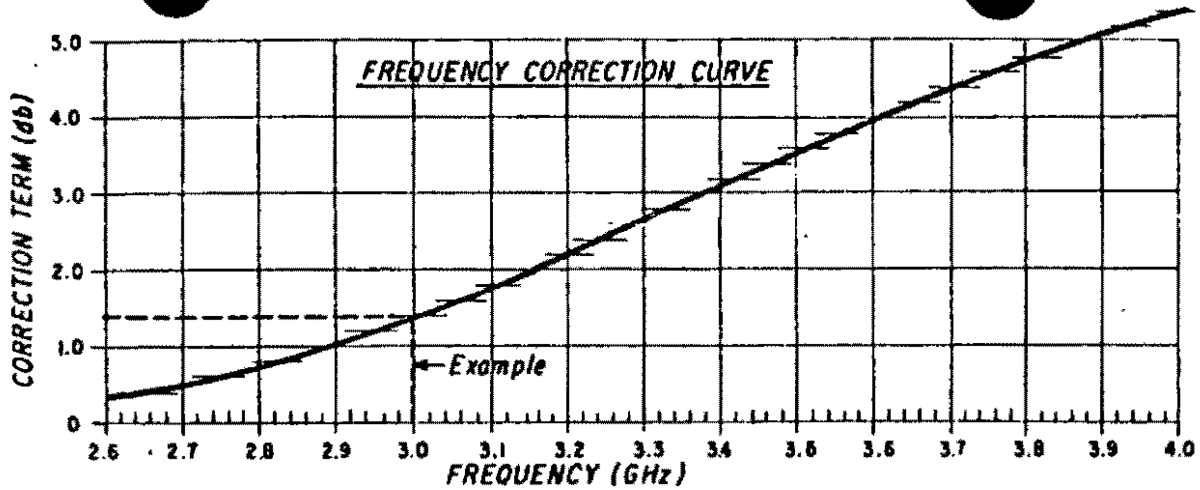
Fig. 11 POWER DENSITY PER WATT TRANSMITTED FOR EACH HORN SECTION (FOR TRANSMISSION LENGTH = 23.0')



ARROWS SHOW FREQUENCY RANGES

SECRET

EFFECTIVE AREA-289 CM



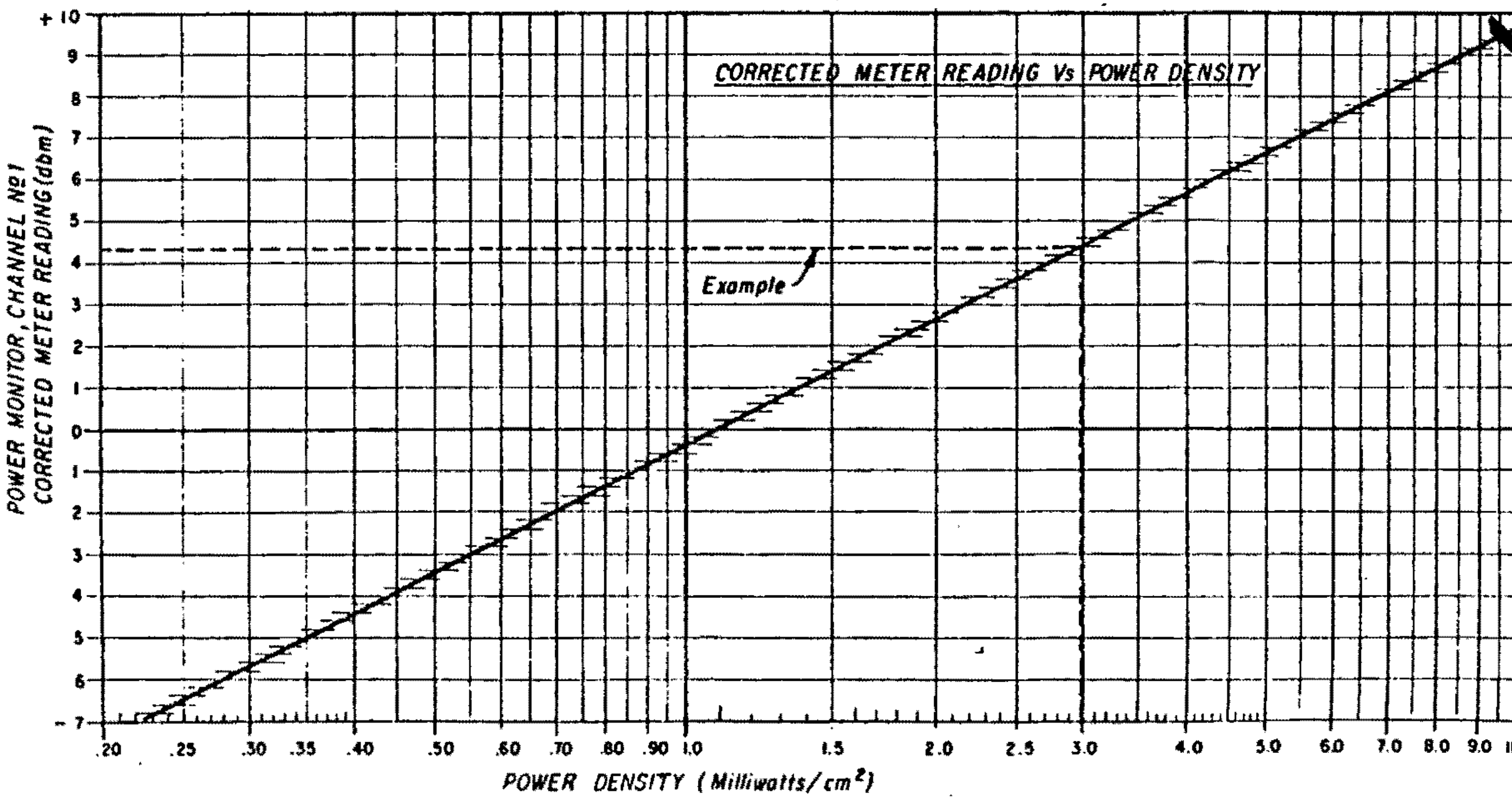
TO MEASURE POWER DENSITY:

ADD CORRECTION TERM TO METER READING.

Example: AT 3.0 GHz, CORRECTION TERM = 1.4 db
METER READING = 3.0 dbm
CORRECTED METER READING = 4.4 dbm
4.4 dbm ⇔ 3.0 Milliwatts/cm²

TO SET POWER DENSITY:

SUBTRACT CORRECTION TERM FROM METER READING WHICH CORRESPONDS TO REQUIRED POWER DENSITY. ADJUST POWER TO OBTAIN THIS VALUE ON MONITOR CHANNEL Nº 1 POWER METER.



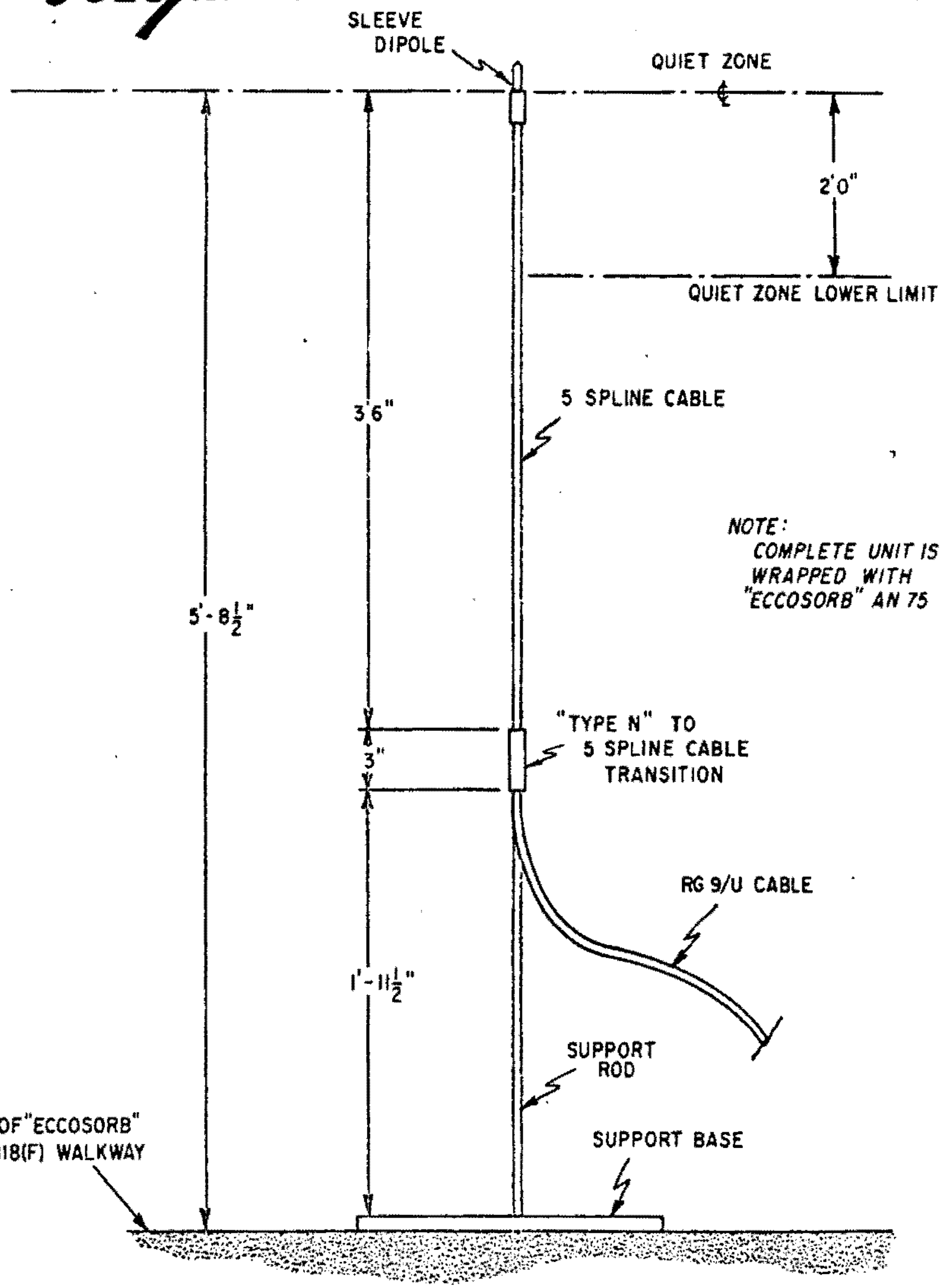


Fig. 13 FIXED DIPOLE MONITOR, STRAIGHT DIPOLE

SECRET

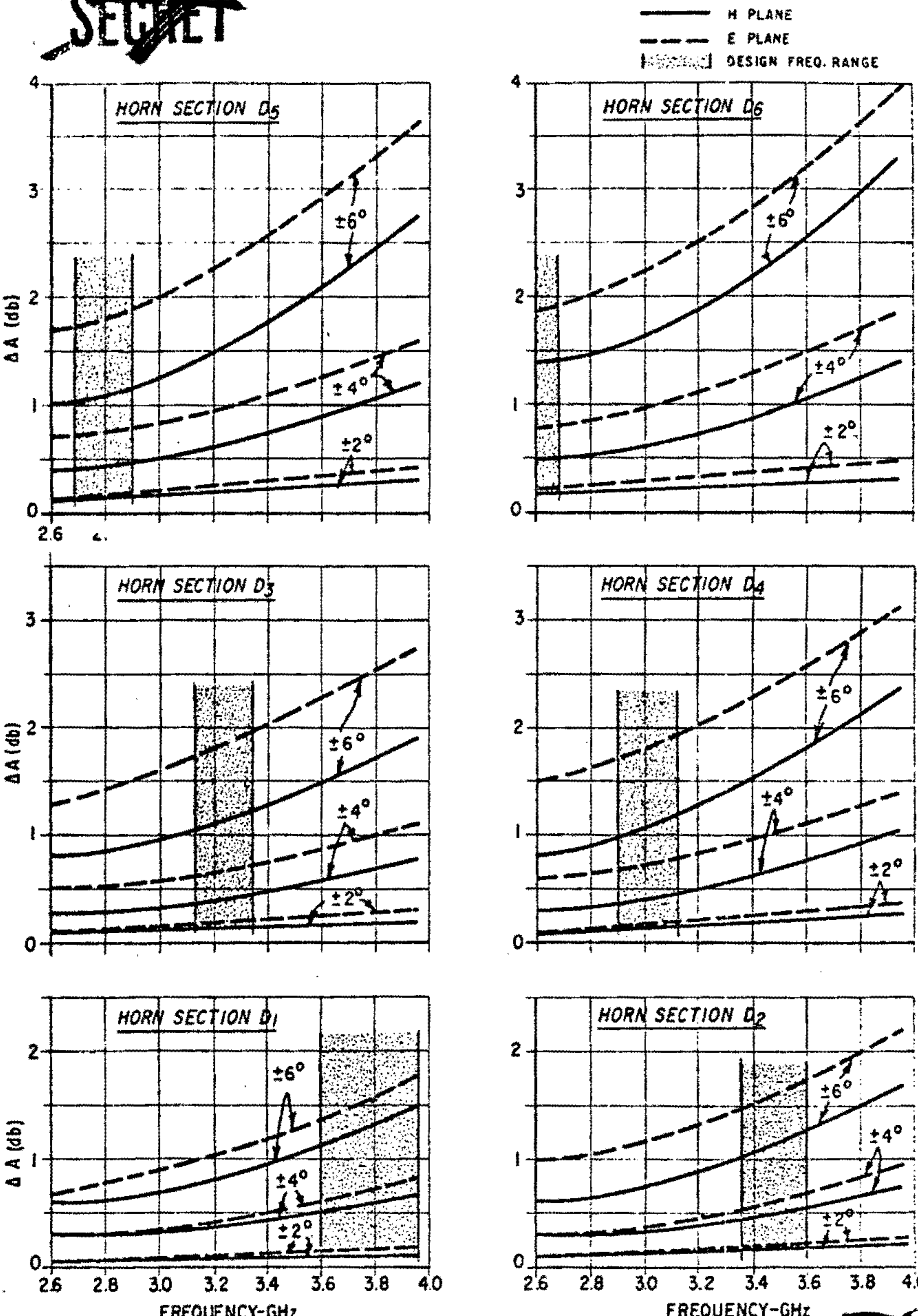
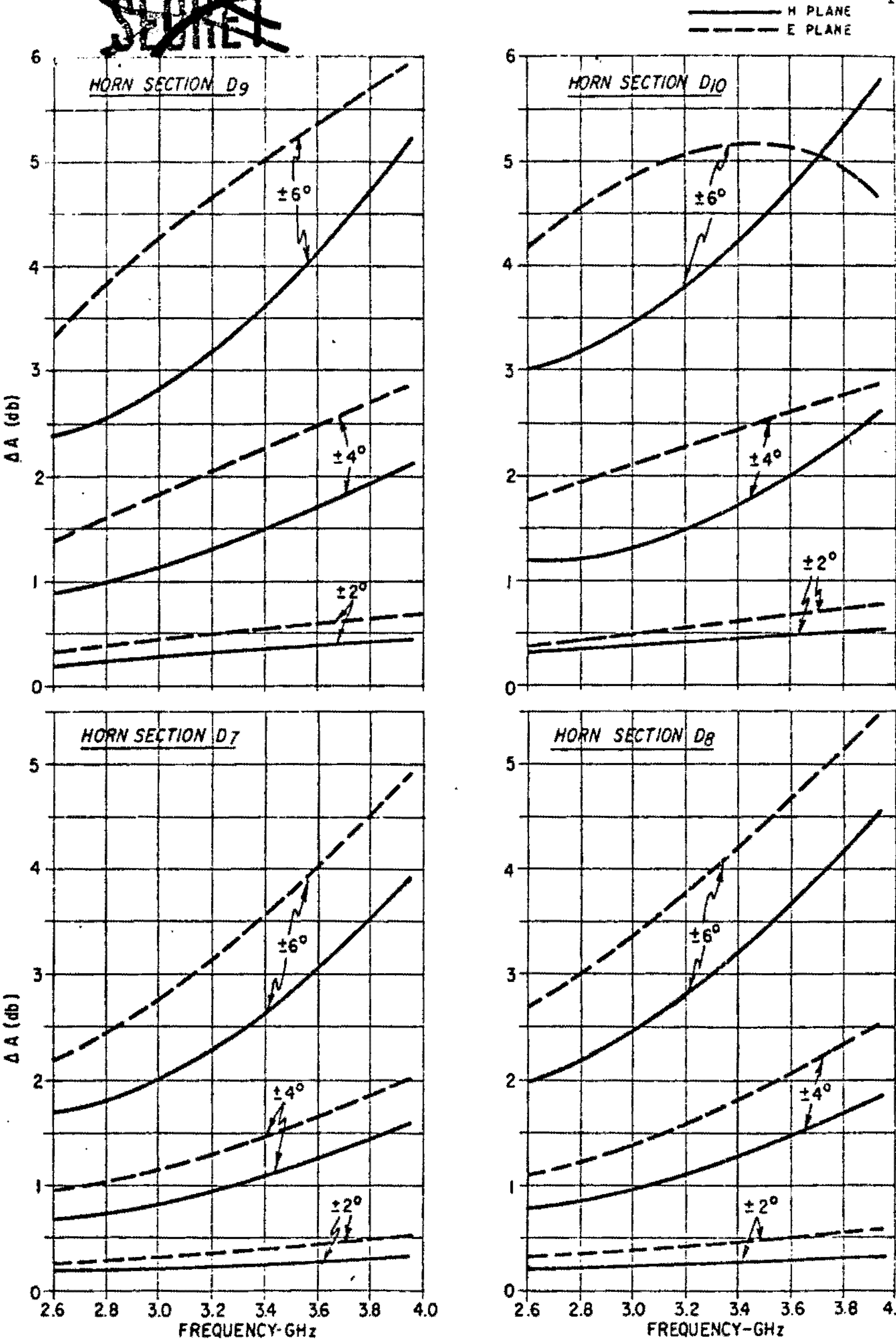


Fig. 14 CHANGE IN RELATIVE AMPLITUDE (ΔA) FOR VARIOUS FIXED ANGLE


H PLANE
E PLANE
HORN SECTION D9
HORN SECTION D10
HORN SECTION D7
HORN SECTION D8
±6°
±4°
±2°
ΔA (db)
0
1
2
3
4
5
6
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
FREQUENCY-GHz

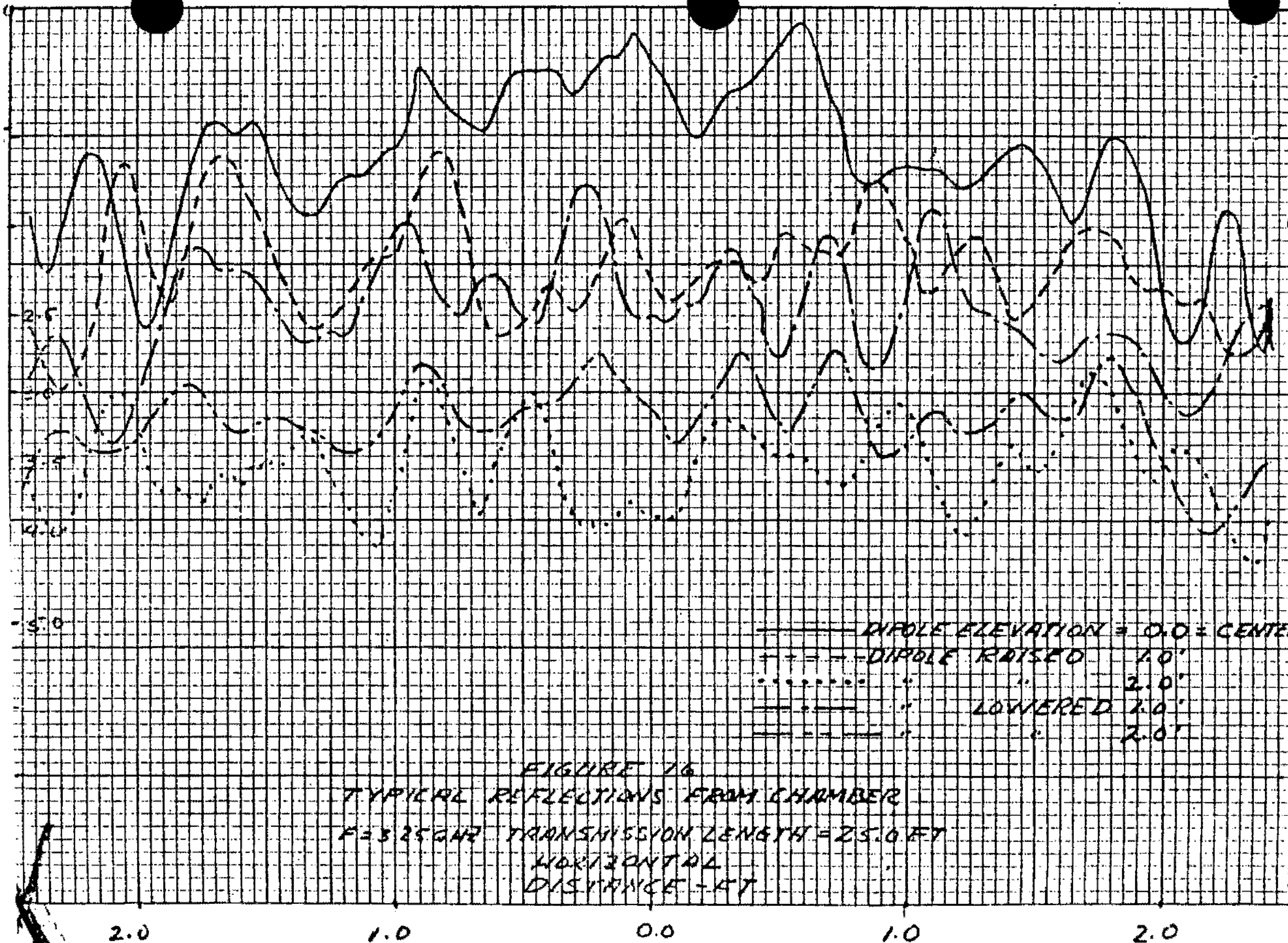


FIGURE 16
TYPICAL REFLECTIONS FROM CHAMBER
F = 3.25 GHZ TRANSMISSION LENGTH = 25.0 FT
HORIZONTAL
DISTANCE - FT

TICAL TANCE		TRANSMISSION LENGTH = 23.0' ±2.0'	±1.5'	±1.0	MAX. RIPPLE
2.0'	MAX	-1.0	-1.0	-1.0	+1.0
	MIN	-3.5	-3.25	-3.75	-1.0
1.5'	MAX	-1.0	-1.0	-1.0	+1.0
	MIN	-2.75	-2.75	-2.75	-0.75
1.0'	MAX	-0.5	-0.5	-0.75	+0.5
	MIN	-2.25	-2.25	-2.25	-0.5
ER 0.0	MAX	0.0	0.0	0.0	+0.5
	MIN	-2.0	-2.0	-2.0	-0.5
1.0'	MAX	+0.5	+0.5	+0.5	+0.5
	MIN	-0.25	-0.25	-0.25	-0.5
1.5'	MAX	0.0	0.0	0.0	+0.5
	MIN	-1.5	-1.25	-1.25	-0.5
2.0'	MAX	-0.25	-0.25	-0.25	+0.5
	MIN	-1.25	-1.25	-1.25	-0.0

RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:

	TRANSMISSION LENGTH = 23.5' ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-1.75	-1.25	-1.75	+0.75
2.0' MIN	-3.0	-2.75	-2.75	-0.75
1.5' MAX	-1.25	-1.25	-1.25	+0.5
1.5' MIN	-3.0	-2.5	-2.5	-0.5
1.0' MAX	-0.75	-1.0	-1.0	+0.5
1.0' MIN	-3.0	-2.5	-2.25	-0.5
0.0 MAX	-0.25	-0.25	-0.25	+0.5
0.0 MIN	-1.75	-1.75	[illegible]	-0.5
1.0' MAX	0.0	0.0	0.0	+0.5
1.0' MIN	-1.0	-1.0	-1.0	-0.5
1.5' MAX	0.0	0.0	0.0	+0.5
1.5' MIN	-2.0	-1.75	-1.0	-0.75
2.0' MAX	0.0	0.0	0.0	+0.5
2.0' MIN	-1.75	-1.25	-1.25	-0.5

	TRANSMISSION LENGTH = 24.0' ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-1.25	-1.25	-1.50	+1.0
2.0' MIN	-3.0	-3.0	-3.0	-0.75
1.5' MAX	-1.5	-1.5	-1.5	+0.5
1.5' MIN	-3.0	-2.5	-2.5	-0.5
1.0' MAX	-1.0	-1.0	-1.0	+0.75
1.0' MIN	-2.5	-2.25	-2.25	-0.5
0.0 MAX	-0.25	-0.25	-0.25	+0.5
0.0 MIN	-1.5	-1.5	-1.5	-0.5
1.0' MAX	-0.25	-0.25	-0.25	+0.5
1.0' MIN	-1.5	-1.0	-1.0	-0.75
1.5' MAX	-0.25	-0.25	-0.25	+0.5
1.5' MIN	-1.75	-1.25	-1.25	-0.5
2.0' MAX	-0.25	-0.25	-0.25	+0.5
2.0' MIN	-1.25	-1.25	-1.25	-0.5

	TRANSMISSION LENGTH = 25.0' ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	[illegible]	-1.75	-1.75	+1.0
2.0' MIN	[illegible]	-3.5	-3.5	-1.0
1.5' MAX	-2.0	-2.0	-2.0	+0.5
1.5' MIN	-3.25	-3.25	-3.25	-0.5
1.0' MAX	-1.0	-1.0	-1.0	+0.5
1.0' MIN	-3.25	-2.75	-3.25	-1.25
0.0 MAX	-0.25	-0.25	-0.25	+0.75
0.0 MIN	-1.75	-1.75	-2.25	-0.75
1.0' MAX	0.0	0.0	0.0	+0.5
1.0' MIN	-1.5	-1.25	-1.25	-0.75
1.5' MAX	-0.75	-0.75	-0.75	+0.75
1.5' MIN	-2.0	-2.0	-2.0	-0.50
2.0' MAX	[illegible]	0.0	0.0	+0.5
2.0' MIN	[illegible]	-1.75	-1.75	-1.0

Figure 17
CHAMBER EVALUATION

ICAL ANCE		TRANSMISSION LENGTH = 26.0' ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.25	-2.25	[illegible]	+0.75
	MIN	-4.25	-4.25	[illegible]	-1.00
1.5'	MAX	[illegible]	[illegible]	[illegible]	+0.5
	MIN	[illegible]	[illegible]	[illegible]	-1.5
1.0'	MAX	-1.5	-1.75	-1.75	+0.75
	MIN	-2.75	-2.75	-2.75	-0.25
ER 0.0	MAX	-0.75	-0.75	-1.0	+0.5
	MIN	-2.0	-2.0	-1.5	-0.75
1.0'	MAX	0.0	0.0	0.0	+1.0
	MIN	-1.75	-1.75	-1.75	-0.5
1.5'	MAX	[illegible]	-0.5	-0.5	+1.0
	MIN	[illegible]	-2.25	-2.25	-0.75
2.0'	MAX	-0.25	-0.25	[illegible]	+0.5
	MIN	-1.75	-1.75	[illegible]	-0.5

	TRANSMISSION LENGTH = 26.5' ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-2.5	-2.5	-2.5	+1.0
2.0' MIN	-4.75	-4.75	-4.5	-1.0
1.5' MAX	[illegible]	-2.0	-2.0	+0.75
1.5' MIN	[illegible]	-3.5	-3.25	-1.00
1.0' MAX	-2.0	-2.0	-2.0	+0.5
1.0' MIN	-3.5	-3.5	-3.5	-0.75
0.0 MAX	-0.5	-0.5	-0.5	+1.0
0.0 MIN	-2.25	-2.25	-2.25	-0.75
1.0' MAX	-0.5	-0.5	-0.5	+0.5
1.0' MIN	-2.25	-2.25	-1.75	-0.5
1.5' MAX	[illegible]	-0.75	-0.75	+0.75
1.5' MIN	[illegible]	-2.25	-2.25	-0.75
2.0' MAX	-0.5	-0.5	-0.5	+0.75
2.0' MIN	-2.0	-2.0	-2.0	-0.75

	TRANSMISSION LENGTH = 27.0' ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-3.0	-3.0	-3.0	+0.75
2.0' MIN	-4.5	-4.5	-4.5	-0.75
1.5' MAX	[illegible]	[illegible]	[illegible]	+0.75
1.5' MIN	[illegible]	[illegible]	[illegible]	-0.50
1.0' MAX	[illegible]	[illegible]	[illegible]	+0.75
1.0' MIN	[illegible]	[illegible]	[illegible]	-0.75
0.0 MAX	[illegible]	[illegible]	[illegible]	+0.75
0.0 MIN	[illegible]	[illegible]	[illegible]	-0.75
1.0' MAX	[illegible]	[illegible]	[illegible]	+0.75
1.0' MIN	[illegible]	[illegible]	[illegible]	-0.75
1.5' MAX	[illegible]	[illegible]	[illegible]	+0.75
1.5' MIN	[illegible]	[illegible]	[illegible]	-1.0
2.0' MAX	-0.75	-0.75	-0.75	+0.0
2.0' MIN	-2.25	-2.25	-2.25	-0.0

FREQUENCY: 2.6 GHz

TRANSMITTING HORN SECTION: 06

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8-22-66

NOTES:

- = +0.5 to -1.5 = ±1.0db
- = +0.5 to -2.0 = ±1.25db
- = +0.5 to -2.5 = ±1.5db
- = +0.5 to -3.0 = ±1.75db
- = +0.5 to -3.5 = ±2.0db
- = +0.5 to -4.0 = ±2.25db
- = +0.5 to -5.0 = ±2.75db

TRANSMISSION LENGTH = 23.0'

ICAL ANCE		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0	MAX. RIPPLE
2.0'	MAX	-1.25	-1.25	[illegible]	+0.25
	MIN	-3.5	-2.75	[illegible]	-0.25
1.5'	MAX	[illegible]	[illegible]	-0.0	+0.5
	MIN	[illegible]	[illegible]	-1.5	-0.5
1.0'	MAX	[illegible]	[illegible]	-0.0	+0.5
	MIN	[illegible]	[illegible]	-1.0	-0.5
ER 0.0	MAX	[illegible]	[illegible]	-0.0	+0.5
	MIN	[illegible]	[illegible]	-1.0	-0.5
1.0'	MAX	[illegible]	[illegible]	-0.5	+0.5
	MIN	[illegible]	[illegible]	-1.5	-0.5
.1.5'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	[illegible]	[illegible]	-1.5	-0.25
2.0'	MAX	-1.5	-1.5	[illegible]	+0.5
	MIN	-3.5	-2.75	[illegible]	-0.5

TRANSMISSION LENGTH = 23.5'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.25	-1.25	[illegible]	+0.75
	MIN	[illegible]	-2.75	[illegible]	-0.5
1.5'	MAX	[illegible]	-0.75	-0.75	+0.5
	MIN	[illegible]	-1.75	-1.75	-0.5
1.0'	MAX	[illegible]	[illegible]	-0.0	+0.5
	MIN	[illegible]	[illegible]	-1.5	-0.5
ER 0.0	MAX	-0.0	-0.0	-0.0	+0.5
	MIN	[illegible]	[illegible]	-1.25	-0.25
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	[illegible]	[illegible]	-2.0	-0.5
1.5'	MAX	[illegible]	-0.5	-0.5	+0.25
	MIN	[illegible]	-1.75	-1.75	-0.25
2.0'	MAX	[illegible]	-1.5	[illegible]	+0.5
	MIN	[illegible]	-2.5	[illegible]	-0.5

TRANSMISSION LENGTH = 24.0'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.5	-3.0	-2.25	-0.5
1.5'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.0	-2.0	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.25
	MIN	[illegible]	-1.5	-1.0	-0.25
ER 0.0	MAX	-0.25	-0.25	-0.25	+0.5
	MIN	[illegible]	-1.5	-1.25	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	[illegible]	-2.0	-1.5	-0.5
1.5'	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	[illegible]	-2.0	-2.0	-0.5
2.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-3.0	-2.75	-0.75

TRANSMISSION LENGTH = 25.0'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.0	-2.5	-2.5	-0.5
1.5'	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	-3.0	-3.0	-2.25	-0.75
1.0'	MAX	-0.5	[illegible]	[illegible]	+0.5
	MIN	-2.25	[illegible]	[illegible]	-0.75
ER 0.0	MAX	-0.75	-0.75	-0.75	+0.75
	MIN	-2.25	[illegible]	[illegible]	-0.75
1.0'	MAX	-1.5	[illegible]	[illegible]	+0.5
	MIN	-3.0	[illegible]	[illegible]	-0.5
1.5'	MAX	-1.0	-1.0	-1.0	+0.25
	MIN	-3.0	-2.25	[illegible]	-0.5
2.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.5	-3.25	-3.0	-0.5

TRANSMISSION LENGTH = 26.0'

ICAL ANCE		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	[illegible]	-3.25	-3.0	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-2.75	-2.5	-2.5	-0.5
1.0'	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	-2.5	-2.25	-2.0	-0.75
ER 0.0	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-3.0	-2.25	-2.0	-0.75
1.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-2.75	-2.75	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.5	-3.0	-2.5	-0.75
2.0'	MAX	[illegible]	-2.5	-2.5	+0.5
	MIN	[illegible]	-3.5	-3.5	-0.5

TRANSMISSION LENGTH = 26.5'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	[illegible]	-2.5	-2.5	+0.75
	MIN	-4.0	-3.25	-3.25	-0.75
1.5'	MAX	[illegible]	-1.75	-1.75	+0.25
	MIN	-3.25	-2.75	-2.50	-0.25
1.0'	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-2.5	-2.5	-2.0	-0.5
ER 0.0	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	[illegible]	-2.75	-2.75	-0.75
1.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	[illegible]	-3.0	-3.0	-0.25
1.5'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-4.0	-3.0	-2.5	-0.75
2.0'	MAX	-2.5	-2.5	-2.5	+0.5
	MIN	[illegible]	-3.5	-3.5	-0.5

TRANSMISSION LENGTH = 27.0'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.5	-2.5	-2.5	+0.25
	MIN	[illegible]	-3.25	-3.25	-0.25
1.5'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.5	-3.50	-2.75	-0.5
1.0'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-2.75	-2.50	-2.50	-0.75
ER 0.0	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-2.5	-2.5	-0.5
1.0'	MAX	-2.0	-2.0	-2.0	+0.5
	MIN	-3.5	-3.25	-3.25	-0.5
1.5'	MAX	-1.5	-1.5	-1.5	+1.0
	MIN	-3.5	-3.0	-2.75	-1.0
2.0'	MAX	-2.25	[illegible]	-2.25	+0.5
	MIN	[illegible]	[illegible]	-3.5	-0.5

Figure 18
CHAMBER EVALUATION

FREQUENCY: 2.8 GHZ

TRANSMITTING HORN SECTION: D5

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8/23/66

NOTES:

Shading	Range
(light stipple)	= 0.0 - 2.0 db = ± 1.0 db
(cross-hatch)	= 0.0 - 2.5 db = ± 1.25 db
(blank)	= 0.0 - 3.0 db = ± 1.5 db
(dense stipple)	= 0.0 - 3.5 db = ± 1.75 db
(diagonal hatch)	= 0.0 - 4.0 db = ± 2.0 db

SECRET

SECRET

ICAL ANCE		TRANSMISSION LENGTH = 23.0' — RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0	MAX. RIPPLE
2.0'	MAX	-1.0	-2.0	-2.0	+0.5
	MIN	-3.75	-3.5	-4.25	-0.5
1.5'	MAX	?	?	?	
	MIN	?	?	?	
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.0	-1.75	-0.25
ER 0.0	MAX	-0.25	-0.25	-0.25	+0.5
	MIN	-2.00	-1.5	-1.0	-0.5
1.0'	MAX	-0.25	-0.25	-0.25	+0.5
	MIN	-2.0	-1.25	-0.75	-0.5
1.5'	MAX	?	?	?	
	MIN	?	?	?	
2.0'	MAX	-1.75	-1.75	-2.25	+0.5
	MIN	-3.0	-3.0	-3.5	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 23.5' — RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.75	-2.25	-1.75	+0.5
	MIN	-4.0	-3.25	-3.0	-0.5
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.0	-2.75	-2.5	-0.5
1.0'	MAX	-1.5	-1.5	-1.5	+0.25
	MIN	-2.75	-2.25	-2.0	-0.25
ER 0.0	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-2.0	-1.75	-1.5	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.25
	MIN	-1.75	-1.50	-1.0	-0.25
1.5'	MAX	-0.25	-0.25	-0.25	+0.75
	MIN	-3.25	-1.50	-1.5	-0.5
2.0'	MAX	-1.75	-2.25	-2.25	+0.5
	MIN	-3.5	-3.75	-3.50	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 24.0' — RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.75	-1.75	-2.25	+0.5
	MIN	-4.25	-3.5	-3.25	-0.5
1.5'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.5	-2.5	-2.5	-0.25
1.0'	MAX	-1.5	-1.5	-1.5	+0.25
	MIN	-2.75	-2.5	-2.0	-0.25
ER 0.0	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-2.25	-1.75	-1.75	-0.75
1.0'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.0	-1.75	-1.5	-0.5
1.5'	MAX	-0.75	-0.75	-0.75	+0.25
	MIN	-2.5	-1.75	-1.5	-0.25
2.0'	MAX	-1.50	-1.50	-1.80	+0.5
	MIN	-3.25	-3.25	-2.25	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 25.0' — RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	[illegible]	-2.25	-2.25	+0.5
	MIN	[illegible]	-3.5	-3.25	-0.5
1.5'	MAX	-2.25	-3.25	-2.25	+0.5
	MIN	-3.50	-3.25	-3.25	-0.25
1.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-2.5	-2.5	-0.5
ER 0.0	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-3.0	-2.5	-2.0	-0.5
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.25	-2.25	-0.5
1.5'	MAX	-0.5	-0.5	-0.5	+0.75
	MIN	-2.5	-2.0	-2.25	-0.50
2.0'	MAX	[illegible]	-1.75	-1.75	+0.5
	MIN	[illegible]	-3.25	-2.75	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 26.0' — RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.25	-1.75	-1.75	+0.5
	MIN	-4.25	-3.75	-3.5	-0.5
1.5'	MAX	-2.5	-2.5	-2.5	+0.5
	MIN	-4.0	-3.5	-3.5	-0.5
1.0'	MAX	-1.5	-1.5	-1.5	+0.25
	MIN	-3.25	-2.75	-2.75	-0.5
ER 0.0	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.25	-2.75	-2.75	-0.5
1.0'	MAX	-0.75	-0.75	-0.75	+0.75
	MIN	-3.0	-2.5	-2.0	-0.5
1.5'	MAX	-1.75	-1.75	-1.75	+0.25
	MIN	-2.75	-2.5	-2.5	-0.25
2.0'	MAX	-1.75	-1.75	-1.75	+0.25
	MIN	-3.50	-2.75	-2.25	-0.25

ICAL ANCE		TRANSMISSION LENGTH = 26.5' — RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	[illegible]	-2.0	-2.5	+0.5
	MIN	[illegible]	-3.75	-4.25	-0.5
1.5'	MAX	-2.5	-2.5	-2.5	+0.75
	MIN	-4.25	-4.25	-4.25	-1.0
1.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.25	-3.0	-2.75	-0.5
ER 0.0	MAX	-2.25	-2.25	-2.25	+0.25
	MIN	-2.75	-3.5	-3.25	-0.5
1.0'	MAX	-1.0	-1.0	-1.0	+0.25
	MIN	-2.75	-2.5	-2.75	-0.5
1.5'	MAX	-2.0	-2.0	-2.0	+0.5
	MIN	-3.25	-3.0	-3.0	-0.5
2.0'	MAX	[illegible]	-1.5	-1.5	+0.5
	MIN	[illegible]	-2.75	-2.5	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 27.0' — RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.75	-2.75	-2.75	+1.0
	MIN	-5.0	-4.0	-4.0	-1.25
1.5'	MAX	-3.0	-2.0	-2.0	+0.25
	MIN	-4.5	-3.75	-3.5	-0.5
1.0'	MAX	-2.0	-2.0	-2.0	+0.5
	MIN	-3.5	-3.0	-3.75	-0.5
ER 0.0	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.75	-2.75	-2.25	-0.5
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.25	-2.0	-0.5
1.5'	MAX	-2.5	-2.5	-2.5	+0.5
	MIN	-3.5	-3.5	-3.0	-0.5
2.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.5	-3.0	-2.75	-0.5

Figure 19
CHAMBER EVALUATION

FREQUENCY: 3.0 GHz

TRANSMITTING HORN SECTION: D4

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8/22/66

NOTES:

- ± 0.25 – 2.25 = ± 1.0db
- ± 0.25 – 2.75 = ± 1.25db
- ± 0.25 – 3.25 = ± 1.5db
- ± 0.25 – 3.75 = ± 1.75db
- ± 0.25 – 4.25 = ± 2.0db
- ± 0.25 – 4.75 = ± 2.25db
- ± 0.25 – 5.25 = ± 2.5db

SECRET

ICAL ANCE		TRANSMISSION LENGTH = 23.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0	MAX. RIPPLE
2.0'	MAX	-1.75	-1.75	-1.25	+0.75
	MIN	-3.75	-3.0	-3.0	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-2.5	-2.25	-2.25	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-1.75	-1.25	-1.0	-0.5
ER 0.0	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-1.50	-1.25	-1.0	-0.25
1.0'	MAX	-0.25	-0.75	-0.75	+0.5
	MIN	-2.25	-2.75	-2.0	-0.75
1.5'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.0	-3.0	-2.75	-0.5
2.0'	MAX	-2.0	-2.0	-2.0	+0.25
	MIN	-3.0	[illegible]	[illegible]	-0.50

ICAL ANCE		TRANSMISSION LENGTH = 23.5' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.25	[illegible]	-2.25	+0.5
	MIN	-4.25	-3.50	[illegible]	-0.5
1.5'	MAX	-1.75	-1.25	-1.25	+0.5
	MIN	[illegible]	[illegible]	-2.25	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-2.0	-1.75	-1.5	-0.5
ER 0.0	MAX	-1.0	-1.0	-1.0	+.25
	MIN	-1.75	-1.75	-1.75	-.5
1.0'	MAX	-1.25	-1.25	-1.25	+0.25
	MIN	-2.0	-1.5	-1.75	-0.25
1.5'	MAX	-2.0	-2.0	-2.0	+0.5
	MIN	-3.25	[illegible]	-3.0	-0.5
2.0'	MAX	-1.75	-1.75	-1.75	+0.75
	MIN	-3.0	[illegible]	[illegible]	-.5

ICAL ANCE		TRANSMISSION LENGTH = 24.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.25	-2.25	-2.25	+0.75
	MIN	-3.75	-3.75	-3.75	-0.75
1.5'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-3.25	-2.75	-2.5	-1.00
1.0'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.0	-2.0	-1.75	-0.5
ER 0.0	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-2.0	-1.75	-1.5	-0.25
1.0'	MAX	-1.75	-1.25	-1.25	+0.5
	MIN	-3.0	-2.5	-2.25	-0.5
1.5'	MAX	[illegible]	-3.0	-3.0	+0.5
	MIN	-4.0	-4.0	-3.75	-0.5
2.0'	MAX	-2.0	-2.0	-2.25	+0.5
	MIN	-3.0	[illegible]	-3.0	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 25.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.75	-3.0	-3.0	+0.75
	MIN	-4.25	-4.25	-4.0	-0.75
1.5'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-2.75	-2.75	-2.75	-0.75
1.0'	MAX	-1.5	-1.0	-1.5	+0.5
	MIN	-2.0	-2.5	-2.5	-0.5
ER 0.0	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.0	-1.75	-0.5
1.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.0	-2.75	-2.75	-0.5
1.5'	MAX	-2.0	-2.0	-2.0	+0.5
	MIN	-3.75	-3.75	-3.75	-0.75
2.0'	MAX	-2.5	-2.5	-2.5	+.25
	MIN	-3.5	-3.5	-3.5	-.25

ICAL ANCE		TRANSMISSION LENGTH = 26.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.75	-2.75	-2.75	+0.75
	MIN	-4.5	-4.5	-4.5	-0.75
1.5'	MAX	-2.25	-2.25	-2.25	+0.5
	MIN	-3.25	-3.75	-2.75	-0.5
1.0'	MAX	-2.0	-2.0	-2.0	+0.5
	MIN	-3.0	-3.0	-3.0	-0.5
ER 0.0	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-2.75	-2.75	-2.75	-0.5
1.0'	MAX	-2.25	-2.25	-2.25	+0.5
	MIN	-3.25	-3.25	-3.25	-0.5
1.5'	MAX	-2.5	[illegible]	-2.5	+0.5
	MIN	-4.0	-3.5	-3.5	-0.5
2.0'	MAX	-2.75	-2.75	-2.75	+0.5
	MIN	-5.0	-4.25	-4.25	-1.0

ICAL ANCE		TRANSMISSION LENGTH = 26.5' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.5	-2.5	-2.5	+0.75
	MIN	-4.5	-4.0	-4.0	-0.5
1.5'	MAX	-2.25	-2.25	-2.25	+0.75
	MIN	-3.5	-3.5	-3.5	-0.50
1.0'	MAX	-3.25	-3.25	-3.25	+0.5
	MIN	-4.25	[illegible]	-4.25	-0.5
ER 0.0	MAX	-3.25	-3.0	-3.0	+0.75
	MIN	-3.75	-4.25	-4.25	-0.75
1.0'	MAX	-2.25	-2.25	-2.25	+0.75
	MIN	-3.75	-3.5	-3.5	-0.75
1.5'	MAX	-2.25	-2.25	-2.25	+0.75
	MIN	-4.25	-3.75	-3.75	-0.75
2.0'	MAX	-2.75	-2.75	-2.75	+0.5
	MIN	-4.75	-4.75	-4.0	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 27.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.0	-2.0	-2.25	+0.5
	MIN	-3.25	-3.0	-3.0	-0.5
1.5'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.5	-3.0	-2.75	-0.75
1.0'	MAX	-2.00	-2.00	-2.00	+0.75
	MIN	-3.5	-3.5	-3.25	-0.75
ER 0.0	MAX	-2.00	-4.00	-2.25	+0.5
	MIN	-3.25	-3.0	-3.0	-0.5
1.0'	MAX	-2.75	-2.75	-2.75	+0.5
	MIN	-4.0	-3.75	-3.75	-0.5
1.5'	MAX	-2.75	-2.75	-2.75	+0.75
	MIN	-4.25	-4.0	-4.0	-0.50
2.0'	MAX	-2.75	-2.75	-2.75	+0.75
	MIN	-5.0	-4.5	-4.0	-0.75

Figure 20
CHAMBER EVALUATION

FREQUENCY: 3.25 GHZ

TRANSMITTING HORN SECTION: D3

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8/22/66 8/23/66

NOTES:

- = 0.5 - 2.5 = ± 1.0 db
- = 0.5 - 3.0 = ± 1.25 db
- = 0.5 - 3.5 = ± 1.5 db
- = 0.5 - 4.0 = ± 1.75 db
- = 0.5 - 4.5 = ± 2.0 db
- = 0.5 - 5.0 = ± 2.25 db

SECRET

SECRET

TRANSMISSION LENGTH = 23.0'

...AL ...CE		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0	MAX. RIPPLE
2.0'	MAX	[illegible]	-3.25	[illegible]	
	MIN	-3.0	[illegible]	-2.50	
1.5'	MAX	-1.75	-1.75	-1.75	
	MIN	-2.5	-2.5	-2.25	
1.0'	MAX	-1.0	-1.0	-1.0	
	MIN	-1.75	-2.0	-1.5	
0.0	MAX	-0.5	-0.5	-0.5	+.125
	MIN	-1.25	-1.5	-1.0	-.125
1.0'	MAX	-1.0	-1.0	-1.0	+.125
	MIN	-1.75	-1.75	-1.25	-.125
1.5'	MAX	-1.5	-1.5	-1.5	
	MIN	-2.25	-2.25	-1.75	
2.0'	MAX	-3.0	-3.0	-3.0	
	MIN	-3.75	[illegible]	[illegible]	

TRANSMISSION LENGTH = 23.5'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	[illegible]	-2.25	-2.25	
	MIN	[illegible]	-2.5	-2.50	
1.5'	MAX	-1.75	-1.75	-1.75	
	MIN	-2.25	-2.25	-1.75	
1.0'	MAX	-1.0	-1.0	-1.0	
	MIN	-2.25	-1.75	-1.25	
0.0	MAX	-0.5	-0.5	-0.5	+0.125
	MIN	-1.75	-1.5	-1.0	-0.125
1.0'	MAX	-0.75	-0.75	-0.75	+.125
	MIN	-2.25	-1.75	-1.25	-.125
1.5'	MAX	-1.5	-1.5	-1.5	
	MIN	-2.0	-2.0	-1.75	
2.0'	MAX	[illegible]	-2.0	-2.0	
	MIN	[illegible]	-2.25	-2.25	

TRANSMISSION LENGTH = 24.0'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	[illegible]	[illegible]	[illegible]	
	MIN	[illegible]	-3.0	[illegible]	
1.5'	MAX	-1.75	-1.75	-1.75	
	MIN	-2.5	-2.5	-2.0	
1.0'	MAX	-1.0	-1.0	-1.0	
	MIN	-2.5	-2.0	-1.5	
0.0	MAX	-0.75	-0.75	-0.75	
	MIN	-2.0	-1.75	-1.25	
1.0'	MAX	-1.0	-1.0	-1.0	+0.125
	MIN	-2.5	-2.0	-1.5	-0.125
1.5'	MAX	-1.5	-1.5	-1.5	
	MIN	-2.25	-2.25	-2.0	
2.0'	MAX	-2.25	-2.25	-2.25	
	MIN	[illegible]	[illegible]	[illegible]	

TRANSMISSION LENGTH = 25.0'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-3.0	-3.0	-3.0	
	MIN	[illegible]	-3.25	-3.25	
1.5'	MAX	-2.25	[illegible]	-2.25	
	MIN	-2.0	[illegible]	-2.5	
1.0'	MAX	-2.0	-2.0	-2.0	
	MIN	-3.0	-2.5	-2.25	
0.0	MAX	[illegible]	-1.25	-1.25	
	MIN	[illegible]	-2.25	-1.75	
1.0'	MAX	[illegible]	-1.5	-1.5	+0.125
	MIN	-2.25	-2.25	-2.0	-0.125
1.5'	MAX	-2.0	[illegible]	-2.0	+.125
	MIN	[illegible]	[illegible]	-2.5	-.125
2.0'	MAX	-2.75	[illegible]	-2.75	
	MIN	-3.25	-3.0	[illegible]	

TRANSMISSION LENGTH = 26.0'

...AL ...CE		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-3.0	[illegible]	-3.0	
	MIN	-3.5	-3.5	-3.25	
1.5'	MAX	-2.25	-2.25	-2.25	
	MIN	-2.75	-2.75	-2.50	
1.0'	MAX	-2.25	-2.25	-2.25	
	MIN	[illegible]	-2.75	-2.50	
0.0	MAX	-1.25	-1.25	-1.75	
	MIN	-2.25	[illegible]	-2.00	
1.0'	MAX	-2.0	[illegible]	-2.0	+.125
	MIN	-3.0	[illegible]	-2.25	-.125
1.5'	MAX	-2.25	-2.50	-2.25	
	MIN	[illegible]	[illegible]	-2.5	
2.0'	MAX	-3.0	-3.0	-3.0	+.125
	MIN	-3.5	-3.75	-3.0	-.125

TRANSMISSION LENGTH = 26.5'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX				
	MIN				
1.5'	MAX				
	MIN				
1.0'	MAX				
	MIN				
0.0	MAX				
	MIN				
1.0'	MAX				
	MIN				
1.5'	MAX				
	MIN				
2.0'	MAX				
	MIN				

TRANSMISSION LENGTH = 27.0'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-3.0	-3.0	-3.0	
	MIN	-3.75	-3.5	-3.25	
1.5'	MAX	-2.5	[illegible]	-2.5	
	MIN	-3.5	-3.25	-2.75	
1.0'	MAX	-2.25	[illegible]	-2.25	
	MIN	-3.5	[illegible]	-2.5	
0.0	MAX	-2.0	[illegible]	-2.0	+.250
	MIN	-3.0	[illegible]	-2.5	-.250
1.0'	MAX	-2.25	[illegible]	-2.25	+.125
	MIN	-3.25	-2.25	-2.50	-.125
1.5'	MAX	-2.75	[illegible]	-2.25	+.125
	MIN	-3.5	-2.75	[illegible]	-.125
2.0'	MAX	-3.0	-3.0	-3.0	+.125
	MIN	-3.5	-3.25	-3.25	-.125

Figure 21
CHAMBER EVALUATION

FREQUENCY: 3.25 GHZ

TRANSMITTING HORN SECTION: D3

RECEIVING ANTENNA: Standard Gain Horn (Narda Model 644)

DATE: 8/23/66

NOTES:

Shading	Range	Ripple
(dotted)	= 0.5 - 2.5	= ± 1.0 db
(cross-hatched)	= 0.5 - 3.00	= ± 1.25 db
(diagonal)	= 0.5 - 3.5	= ± 1.5 db
(light)	= 0.5 - 4.0	= ± 1.75 db

SECRET

SECRET

TICAL TANCE		TRANSMISSION LENGTH = 23.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0	MAX. RIPPLE
P 2.0'	MAX	-0.5	-0.5	[illegible]	+0.75
	MIN	-2.75	-2.25	[illegible]	-0.5
P 1.5'	MAX	-0.5	-0.5	[illegible]	+0.75
	MIN	-2.5	-2.0	[illegible]	-0.75
P 1.0'	MAX	-0.75	-0.75	[illegible]	+0.75
	MIN	-2.5	-2.5	[illegible]	-0.75
TER 0.0	MAX	-0.0	-0.5	[illegible]	+0.5
	MIN	-2.25	-1.5	[illegible]	-0.5
N 1.0'	MAX	-0.0	-0.0	[illegible]	+0.5
	MIN	-1.75	-1.75	[illegible]	-0.75
N 1.5'	MAX	+0.25	+0.25	[illegible]	+0.5
	MIN	-2.25	-1.75	[illegible]	-0.5
N 2.0'	MAX	-0.0	-0.0	[illegible]	+0.5
	MIN	-1.5	-1.5	[illegible]	-0.5

TICAL TANCE		TRANSMISSION LENGTH = 23.5' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
P 2.0'	MAX	[illegible]	-1.0	-1.0	+1.0
	MIN	[illegible]	-3.25	-2.25	-1.0
P 1.5'	MAX	-0.75	-0.75	-1.0	+0.75
	MIN	-3.0	-3.0	-2.5	-0.75
P 1.0'	MAX	[illegible]	-1.5	-1.5	+0.5
	MIN	[illegible]	-3.0	-2.75	-0.75
TER 0.0	MAX	-0.0	-0.0	-0.0	+0.5
	MIN	-1.5	-1.5	-1.0	-0.5
N 1.0'	MAX	-0.0	-0.0	-0.0	+0.75
	MIN	-2.0	-1.25	-1.25	-0.75
N 1.5'	MAX	[illegible]	-0.0	-0.0	+0.5
	MIN	-1.0	-1.0	-1.0	-0.5
N 2.0'	MAX	-0.25	-0.25	-0.25	+0.5
	MIN	[illegible]	-2.0	-1.75	-0.5

TICAL TANCE		TRANSMISSION LENGTH = 24.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
P 2.0'	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	-3.0	-2.75	-2.25	-0.75
P 1.5'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-3.0	-2.75	-2.75	-0.5
P 1.0'	MAX	[illegible]	-1.0	-1.0	+0.75
	MIN	-3.5	-2.75	-2.5	-0.5
TER 0.0	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	[illegible]	-2.5	-2.25	-0.5
N 1.0'	MAX	-0.25	-0.25	-0.25	+0.5
	MIN	[illegible]	-1.5	-1.5	-0.5
N 1.5'	MAX	-1.25	-0.25	-0.25	+0.25
	MIN	-1.5	-1.5	-1.0	
N 2.0'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-2.5	-1.75	-1.75	-0.5

TICAL TANCE		TRANSMISSION LENGTH = 25.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
P 2.0'	MAX	-1.0	-1.0	-1.0	+1.0
	MIN	-3.25	[illegible]	-2.75	-0.75
P 1.5'	MAX	[illegible]	-1.5	-1.5	-1.0
	MIN	[illegible]	[illegible]	-3.0	+1.0
P 1.0'	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.0	-2.25	-2.25	-0.5
TER 0.0	MAX	-1.50	-1.50	-1.50	+0.5
	MIN	-3.0	-2.5	-2.5	-0.5
N 1.0'	MAX	-0.75	-0.75	-0.75	+1.0
	MIN	-3.0	-2.5	-2.0	-1.0
N 1.5'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	[illegible]	-1.75	-1.75	-0.5
N 2.0'	MAX	-0.5	-0.5	-0.5	+1.0
	MIN	-2.5	-2.25	-1.75	-1.0

TICAL TANCE		TRANSMISSION LENGTH = 26.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
P 2.0'	MAX	-1.75	-1.75	-1.75	+0.75
	MIN	[illegible]	-3.5	-3.5	-0.75
P 1.5'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-4.0	-3.5	-1.0	-1.0
P 1.0'	MAX	-1.75	-1.75	-1.75	+0.75
	MIN	-3.0	-3.0	-3.0	-0.50
TER 0.0	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.0	-2.75	-2.25	-0.5
N 1.0'	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	-2.25	-2.75	-2.25	-0.75
N 1.5'	MAX	-1.0	[illegible]	-1.0	+0.5
	MIN	-2.5	[illegible]	-2.0	-0.5
N 2.0'	MAX	-1.25	-1.25	-1.5	+0.75
	MIN	[illegible]	-2.25	-2.25	-0.75

TICAL TANCE		TRANSMISSION LENGTH = 26.5' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
P 2.0'	MAX	[illegible]	-2.25	[illegible]	+1.0
	MIN	-4.25	-4.25	-4.25	-1.0
P 1.5'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	[illegible]	-3.0	-3.0	-0.5
P 1.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-4.0	-3.0	-3.0	-1.0
TER 0.0	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-2.75	-2.75	-2.5	-0.25
N 1.0'	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-2.5	-2.5	-2.25	-0.5
N 1.5'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.5	-2.25	-1.75	-0.5
N 2.0'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-4.0	-4.0	-4.0	-0.75

TICAL TANCE		TRANSMISSION LENGTH = 27.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
P 2.0'	MAX	-2.0	-2.0	-2.0	+0.5
	MIN	-4.25	[illegible]	-3.25	-0.5
P 1.5'	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	[illegible]	[illegible]	-3.0	-0.75
P 1.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.75	-3.5	-2.75	-0.5
TER 0.0	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.0	-3.0	-2.5	-0.5
N 1.0'	MAX	-2.0	[illegible]	-2.0	+0.5
	MIN	[illegible]	[illegible]	-2.75	-0.5
N 1.5'	MAX	[illegible]	[illegible]	-0.5	+0.75
	MIN	[illegible]	[illegible]	-2.25	-0.75
N 2.0'	MAX	-1.5	[illegible]	-1.5	+0.5
	MIN	-3.25	[illegible]	-2.75	-0.5

Figure 22

CHAMBER EVALUATION

FREQUENCY: 3.45 GHZ

TRANSMITTING HORN SECTION: D2

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8/22/66

NOTES:

= +0.25 - 2.25 = ± 1.25 db
= +0.25 - 2.75 = ± 1.5 db
= +0.25 - 3.25 = ± 1.75 db
= +0.25 - 3.75 = ± 2.0 db
= +0.25 - 4.25 = ± 2.25 db

SECRET

ICAL ANCE		TRANSMISSION LENGTH = 23.0' +2.0'	+1.5'	+1.0'	MAX. RIPPLE
2.0'	MAX	-2.0	-2.0	-2.0	+0.5
	MIN	-3.5	-2.5	-2.5	-0.75
1.5'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-3.25	-2.25	-2.5	-0.75
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-3.0	-2.5	-2.0	-0.5
ER 0.0	MAX	-0.0	-0.0	0.0	+0.25
	MIN	-2.0	-1.0	-0.5	-0.5
1.0'	MAX	-0.0	-0.0	-0.0	+0.25
	MIN	-0.5	-1.5	-1.25	-0.25
1.5'	MAX	-0.5	-0.8	-0.5	+0.25
	MIN	-2.0	-1.75	-1.25	-0.25
2.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-3.5	-2.0	-2.0	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 23.5' +2.0'	+1.5'	+1.0'	MAX. RIPPLE
2.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.75	-2.75	-2.5	-0.5
1.5'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.5	-2.0	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-2.25	-2.25	-2.0	-0.5
ER 0.0	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-2.75	-2.25	-2.25	-0.75
1.0'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.26	-2.0	-1.75	-0.25
1.5'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.25	-2.0	-1.5	-0.5
2.0'	MAX	-1.75	-1.25	-1.75	+0.25
	MIN	-3.25	-3.0	-2.5	-0.25

ICAL ANCE		TRANSMISSION LENGTH = 24.0' +2.0'	+1.5'	+1.0'	MAX. RIPPLE
2.0'	MAX	-1.75	-1.75	-1.75	+1.0
	MIN	-4.0	-4.0	-3.75	-0.75
1.5'	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.5	-2.75	-2.0	-0.5
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.0	-2.25	-2.25	-0.5
ER 0.0	MAX	-0.25	-0.25	-0.25	+0.25
	MIN	-2.25	-2.0	-1.75	-0.25
1.0'	MAX	-1.0	-1.0	-1.0	+0.25
	MIN	-2.25	-2.25	-1.75	-0.50
1.5'	MAX	-0.75	-0.75	-0.75	+0.25
	MIN	-2.5	-2.0	-2.0	-0.25
2.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-3.0	-3.0	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 25.0' +2.0'	+1.5'	+1.0'	MAX. RIPPLE
2.0'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-4.0	-3.75	-2.5	-1.0
1.5'	MAX	-0.75	-0.75	-0.75	+0.75
	MIN	-3.5	-2.25	-2.25	-0.75
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.25	-2.5	-2.0	-0.25
ER 0.0	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.5	-2.0	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-3.25	-2.0	-1.75	-0.75
1.5'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.8	-2.5	-1.5	-0.75
2.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.0	-2.75	-2.75	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 26.0' +2.0'	+1.5'	+1.0'	MAX. RIPPLE
2.0'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-3.0	-2.75	-2.75	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.0	-3.5	-2.5	-0.75
1.0'	MAX	-0.75	-0.75	-0.75	+0.75
	MIN	-3.5	-2.75	-2.5	-0.50
ER 0.0	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	-3.0	-2.75	-2.75	-0.75
1.0'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-2.25	-2.5	-2.5	+0.50
1.5'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.75	-2.5	-2.5	-0.5
2.0'	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.25	-3.5	-3.0	-0.75

ICAL ANCE		TRANSMISSION LENGTH = 26.5' +2.0'	+1.5'	+1.0'	MAX. RIPPLE
2.0'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.75	-3.25	-3.25	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-2.75	-2.75	-1.0
1.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.25	-3.25	-2.75	-0.5
ER 0.0	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-2.75	-2.5	-2.75	-0.5
1.0'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.0	-3.0	-2.8	-0.50
1.5'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.5	-2.5	-0.5
2.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.5	-3.25	-3.5	-0.5

ICAL ANCE		TRANSMISSION LENGTH = 27.0' +2.0'	+1.5'	+1.0'	MAX. RIPPLE
2.0'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.25	-3.0	-3.0	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-2.75	-2.75	-2.75	-0.5
1.0'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-3.0	-2.75	-2.25	-0.75
ER 0.0	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.0	-2.75	-2.5	-0.5'
1.0'	MAX	-1.0	-1.5	-1.5	+0.5
	MIN	-3.5	-2.5	-2.5	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.25	-2.75	-3.0	-0.5
2.0'	MAX	-2.25	-2.25	-2.25	+0.5
	MIN	-3.75	-3.75	-3.0	-0.5

Figure 23
CHAMBER EVALUATION

FREQUENCY: 3.8 GHz

TRANSMITTING HORN SECTION: D1

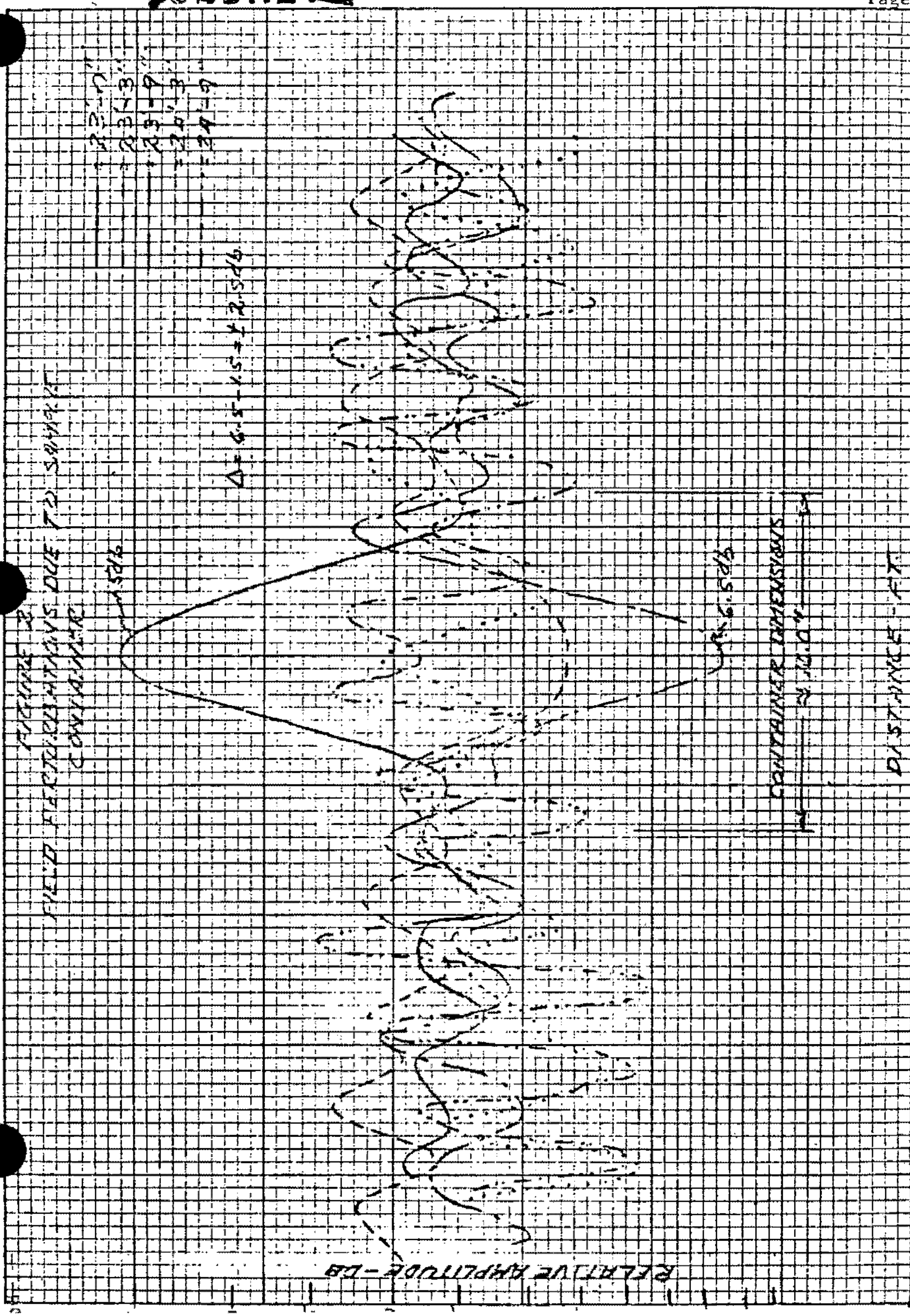
RECEIVING ANTENNA: Absorber backed dipole

DATE: 8/23/66

NOTES:

(dotted)	= 0.0 - 2.0 = ± 1.0db
(hatched)	= 0.0 - 2.5 = ± 1.25db
(stippled)	= 0.0 - 3.0 = ± 1.5db
(cross-hatched)	= 0.0 - 3.5 = ± 1.75db
(light dotted)	= 0.0 - 4.0 = ± 2.0db

~~SECRET~~



~~SECRET~~

APPENDIX A

Transmitting Horn, Design and Test Results

INTRODUCTION

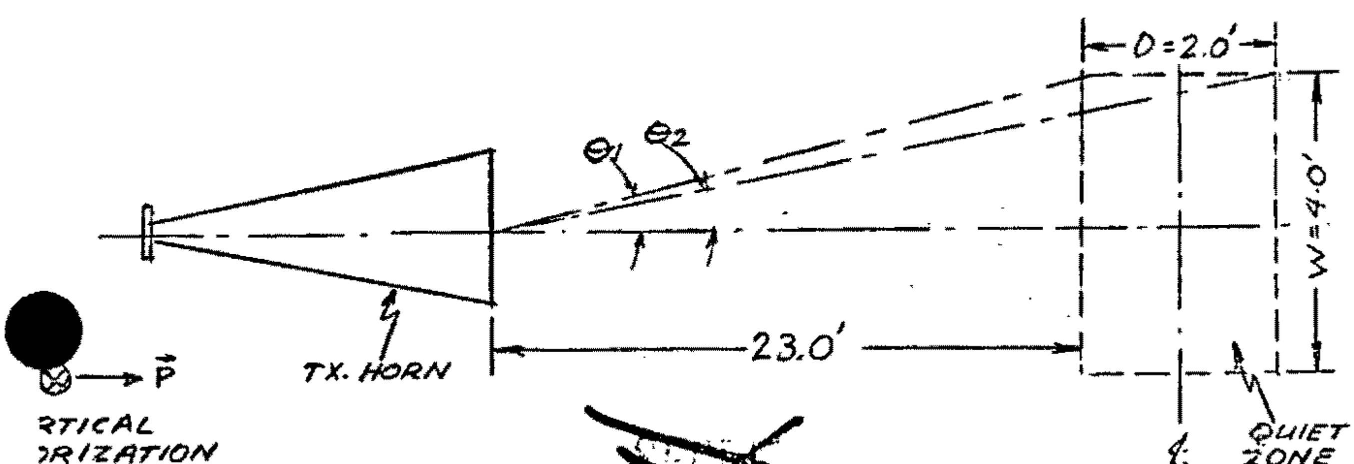
The anechoic chamber specifications originally called for a four foot cubic quiet zone; however, it was determined that a quiet zone 3' wide x 2' high x 1' deep would be suitable for two test samples in containers side-by-side. With a minimum transmitted power of 200 watts, a power density of 2 mw/cm^2 $\pm$ 1.0 db was required in the quiet zone. To allow for a margin of safety, a uniform illumination (within $\pm$ 1.0 db) in a 4'W x 3'H x 2'D quiet zone was the design goal for the transmitting horn antenna.

A conical transmitting horn antenna design was chosen because it has an H plane to E plane beamwidth ratio close to that required (4 to 3), without the narrower beam in the intercardinal planes associated with the pyramidal horn antenna.

Because gain and beamwidth vary with the wavelength, the horn design incorporates "add-on" sections for the various incremental bandwidths. This is discussed further under beamwidth considerations. The first section includes a built-in rectangular to circular transition obviating the need for a separate waveguide transition. Figure 5 in the main section of this report is an illustration of the transmitting horn.

BEAMWIDTH CONSIDERATIONS

The geometry for the horn illumination of the quiet zone is shown in the following sketch.



The chamber specifications called for a maximum of .5 db ($\pm$ .25 db) change in amplitude due to reflections from the walls. This value, added to the .75 db ($\pm$ .37 db) change in amplitude due to the change in transmission length ($\frac{1}{R^2}$ loss), dictated that the change in amplitude due to the beamwidth of the transmitting horn could not exceed .75 db in order to meet the design goal of $\pm$ 1.0 db change in power density in the quiet zone volume. From the above sketch, then, the .75 db beamwidth is $2\,\theta_2 = 2\,\tan^{-1}\frac{2}{25} = 9.2^\circ$. From the figure in reference 3, the ratio of the .75 db beamwidth to the 3 db beamwidth is .5. Thus,

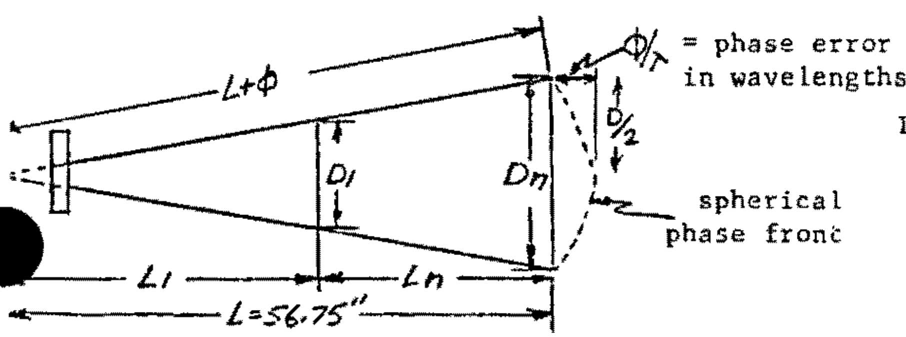
$$\frac{\theta_H(.75\text{ db})}{\theta_H(3\text{ db})} = .5 \qquad \theta_H(3\text{ db}) = \frac{\theta_H(.75\text{ db})}{.5} = \frac{9.2}{.5} = \underline{\underline{18.4^\circ}}$$

The S-Band frequency range from 2 to 4 GHz was divided into eight increments, each representing approximately 10% of the band, in order to keep the beamwidth (and gain) nearly constant. To compensate for this ten percent bandwidth, the design beamwidth was increased by ten percent, resulting in a desired H plane 3 db beamwidth of 20°.

The horn aperture diameter in wavelengths (D/λ) was determined from the approximate expression from the H plane beamwidth [(4)].

$$\theta_H(3\text{ db}) \cong \frac{70}{D/\lambda}$$

For $\theta_H(3\text{ db}) = 20^\circ$, $D/\lambda = 3.5$. Starting at 2.0 GHz, the approximate 10% incremental frequencies, wavelengths, and the diameter of the horn section computed from $D/\lambda = 3.5$ are shown in Table A1. Also shown in this table are the lengths of the various sections computed from the geometry in the following sketch.



$$L \approx \left(\frac{D}{2}\right)^2 \times \frac{1}{2\phi}$$

For $D \approx 4\lambda$ $\quad \phi = \frac{\lambda}{4}$ (chosen)

$$L = 8\lambda$$

---

(3) The Microwave Engineers Handbook and Buyers Guide 1966, Page 174

(4) <u>Antennas</u> J. D. Kraus McGraw Hill 1950, Page 381

Thus $L \cong 8\lambda$ determined the lengths of the various sections as tabulated.

TABLE AI

Horn Dimensions

Freq.	λ(in.)	Diameter (in.) D = 3.5λ	Section Designation	L_n (in.)
2.00	5.8	20.00	D8	21.5
2.20	5.35	18.75	D7	17.5
2.45	4.80	16.75	D6	14.0
2.70	4.35	15.25	D5	10.5
2.95	4.00	14.0	D4	7.50
3.20	3.70	13.0	D3	5.25
3.55	3.35	11.75	D2	2.25
3.90	3.05	10.75	D1	0

The recommended frequency range for S-Band WR 284 waveguide is 2.6 to 3.95 GHz, therefore horn sections larger than D6 may not be required. However, should higher power densities be needed (over smaller areas) horn sections D7 and D8, and two additional sections, D9 and D10 were constructed. The diameters for D9 and D10 are 22.5 "and 24.5", and the lengths are 26.75" and 31.75" respectively, based on the same criteria as the other sections.

GAIN REQUIREMENTS

The above analysis assumes an aperture with sufficient gain to provide a power density of 2 mw/cm^2 for a minimum of 200 watts of transmitted power. Reference 5 gives the gain of a conical horn as $G\ (db) = 10 \log \left(\frac{4\pi A}{\lambda^2}\right) - L$, where L is the loss term (in the reference figure) versus the phase deviation at the aperture edge. For the selected phase deviation of λ/4, L = 1.5 db; and for D/λ = 3.5

$$G = \left(\frac{\pi D}{\lambda}\right)^2 - 1.5\ db = 20.85 - 1.5 \doteq 19.4\ db$$

(5) Antenna Engineers Handbook H. Jasik, Ed. McGraw Hill (1961) Chap 10-4

The power density is

$$Pd = \frac{P_r}{A_r} = \frac{P_T G_T}{4\pi R^2} \quad \text{where } P_T = 200 \text{ watts (min)}$$

$$G_T = 19.4 \text{ db} = 87$$

$$R = 24 \text{ ft}$$

$Pd = 2.6\ mw/cm^2$, which is adequate.

MEASURED VERSUS CALCULATED VALUES

The calculated gain (above) was 19.4 db at the design frequencies, which included a 1.5 db loss due to efficiency and phase error. The measured gains at the design frequencies are tabulated below along with the difference between the measured and calculated gain (ΔG).

TABLE A2

Measured versus Calculated Gain

Horn Section	Design Frequency	Measured Gain	Calculated Gain	ΔG
D1	3.9	20.3	19.4	+0.9
D2	3.55	20.0	19.4	+0.6
D3	3.20	19.7	19.4	+0.3
D4	2.95	19.7	19.4	+0.3
D5	2.7	19.6	19.4	+0.2
D6	2.45	19.4(est)	19.4	+0.0

From this table, it can be seen that the measured gain is very slightly higher than calculated. This is due in part to the beamwidth being slightly narrower than the design value; and in part to the phase deviation at the aperture edge being less than $\lambda/4$, and consequently, the loss due to phase error and efficiency being slightly less than the 1.5 db allotted.

Table A3 below compares the measured and calculated 3 db beamwidths, which again are in good agreement. These values indicate that the expression for the H plane 3 db beamwidth is more nearly $\theta_H\ (3\ db) \cong \frac{68}{D/\lambda}$ and for the E plane $\theta_E \cong 55/D\lambda$.

TABLE A3

Measured versus Calculated E & H Plane Beamwidths

Horn Section	Frequency (GHz)	Measured H Plane 3dbB.W (Degrees)	Calculated $\theta_H (3db) = \frac{70}{D/\lambda}$	Measured E Plane 3dbB.W (Degrees)	Calculated $\theta_E (3db) = \frac{60}{D/\lambda}$
D1	3.9	18.9	20°	15.8	17°
D2	3.55	19.3	20°	15.7	17°
D3	3.2	19.7	20°	15.7	17°
D4	2.95	19.6	20°	15.5	17°
D5	2.7	19.5	20°	15.5	17°
D6	2.45	19.5	20°	15.5	17°

APPENDIX B

Sleeve Dipole Antenna

A dipole was chosen as the field probe antenna for the chamber evaluation in order to observe virtually all of the reflections from the walls (and the ceiling and floor), which contribute to the perturbation of the field in the chamber. The sleeve (or skirt) dipole design was selected because of its natural configuration for an upright power monitor of a vertically polarized field, and because of its ease in construction utilizing the APL 5-spline semirigid coaxial cable which was available; the dipole probe tip simply screws into the cables hollow center conductor. The dipole is illustrated in figure B1 . This figure gives the pertinent design dimensions which were arrived at empirically using the basic tenets set forth by Silver[6].

Figure 13, in the main section of this report, illustrated the fixed monitor version of the sleeve dipole used as a power monitor in the chamber.

Figure B2 illustrates the "gooseneck" version used to evaluate the chamber.

The VSWR of both versions is shown in figure B3. These values include the mismatch from the Type N to 5-spline cable transition. A surprising feature of these dipoles is that the VSWR was less than 2:1 from 2.6 GHz to 11.4 GHz (the limits of the then available equipment).

---

(6) Microwave Antenna Theory and Design S. Silver, Ed. MIT Rad Lab Series, Vol 12 McGraw Hill (1949) Chap 8.2

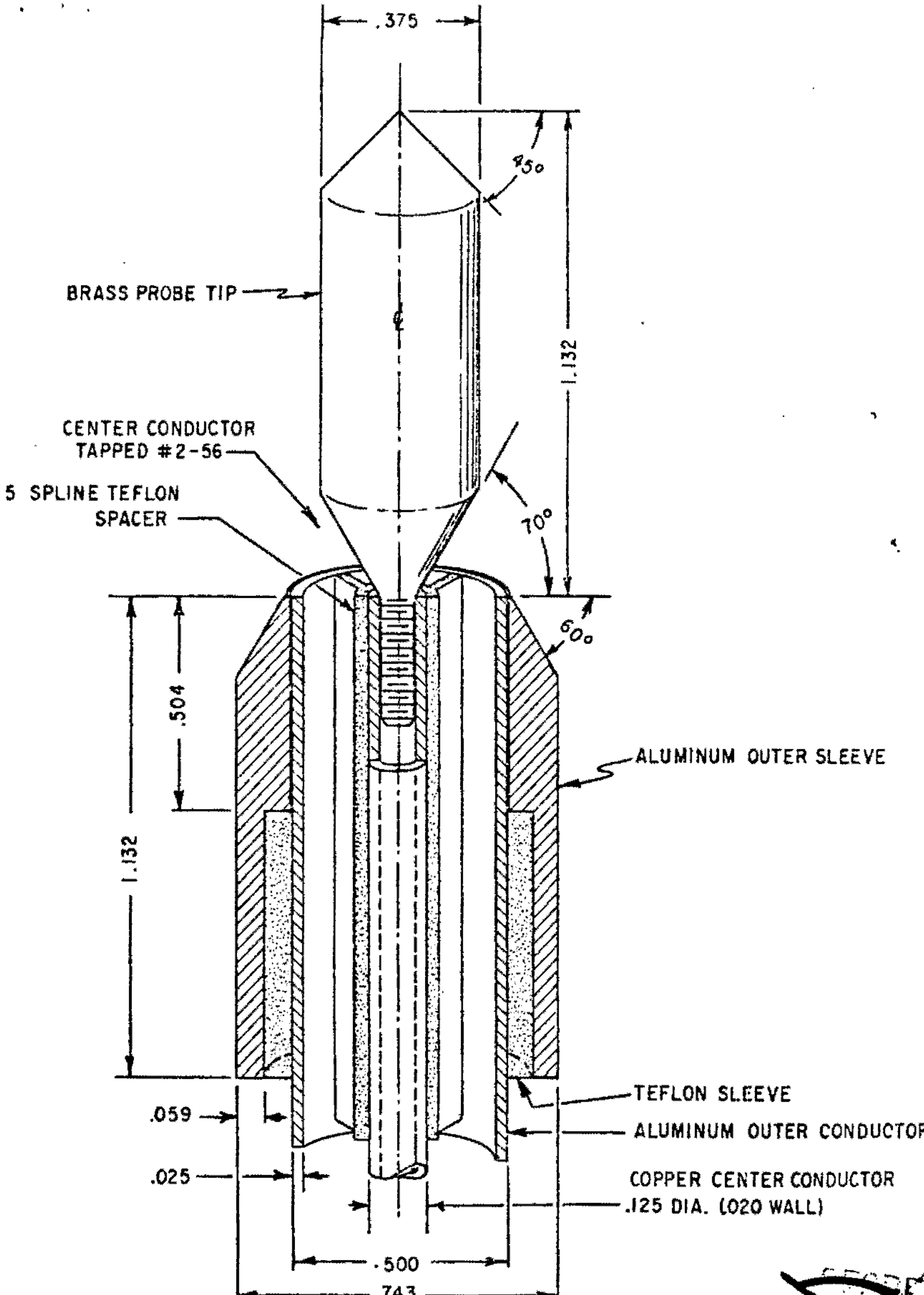


Fig. B1 DIMENSIONS OF "S" BAND SLEEVE DIPOLE

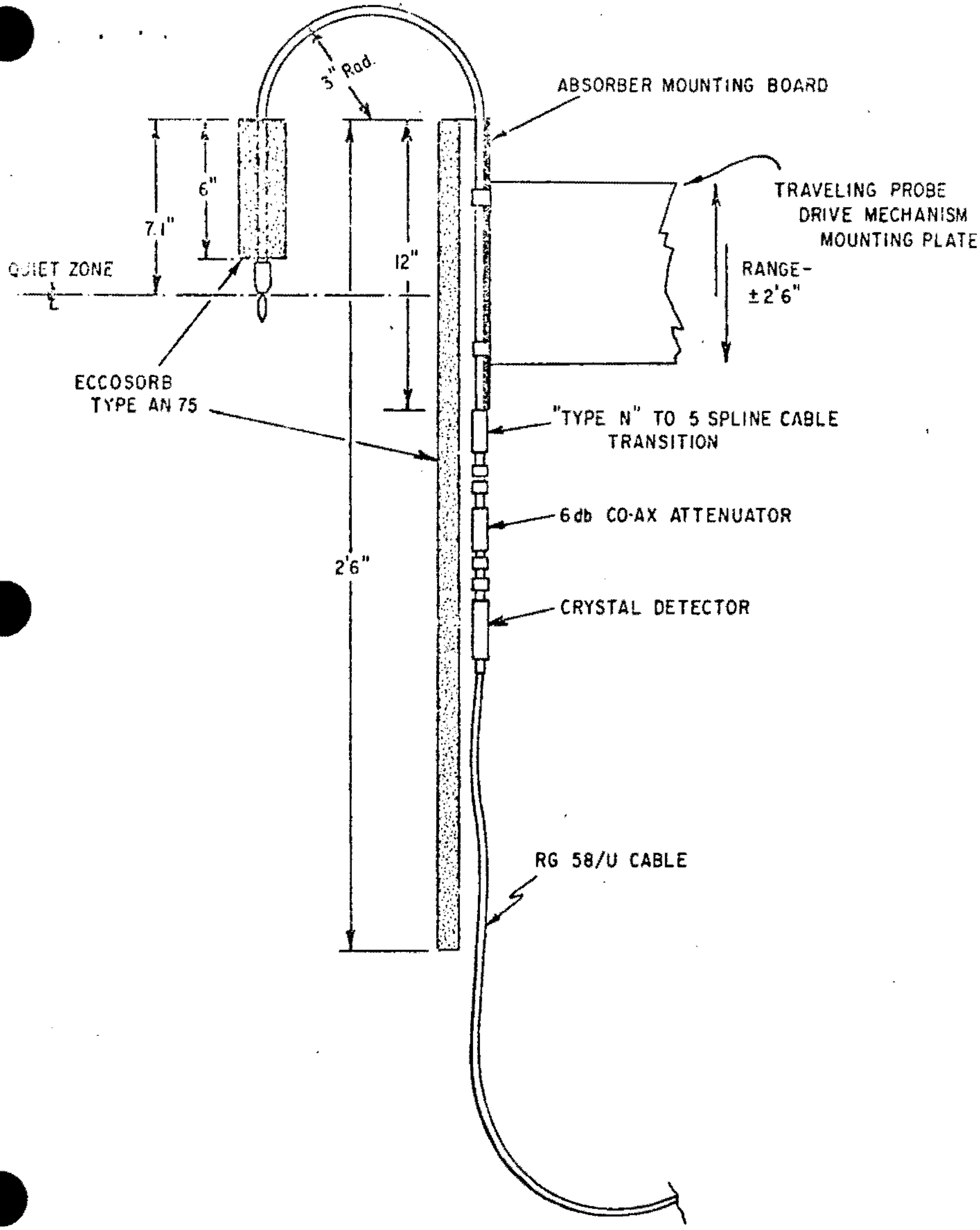
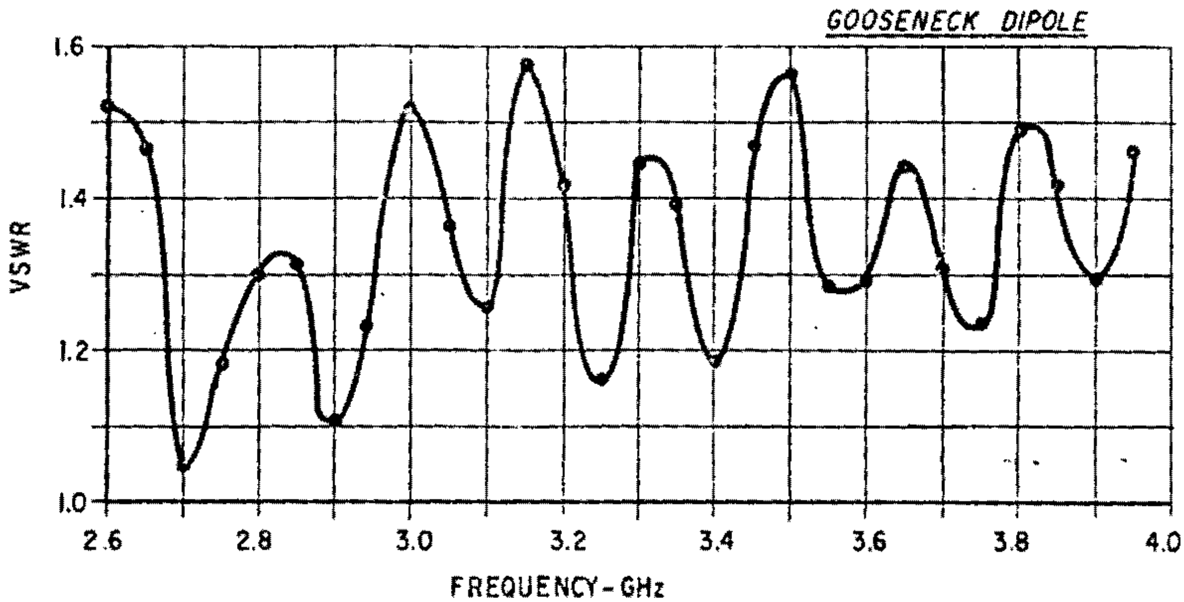


Fig. B2 MOVEABLE GOOSENECK DIPOLE MONITOR

~~SECRET~~



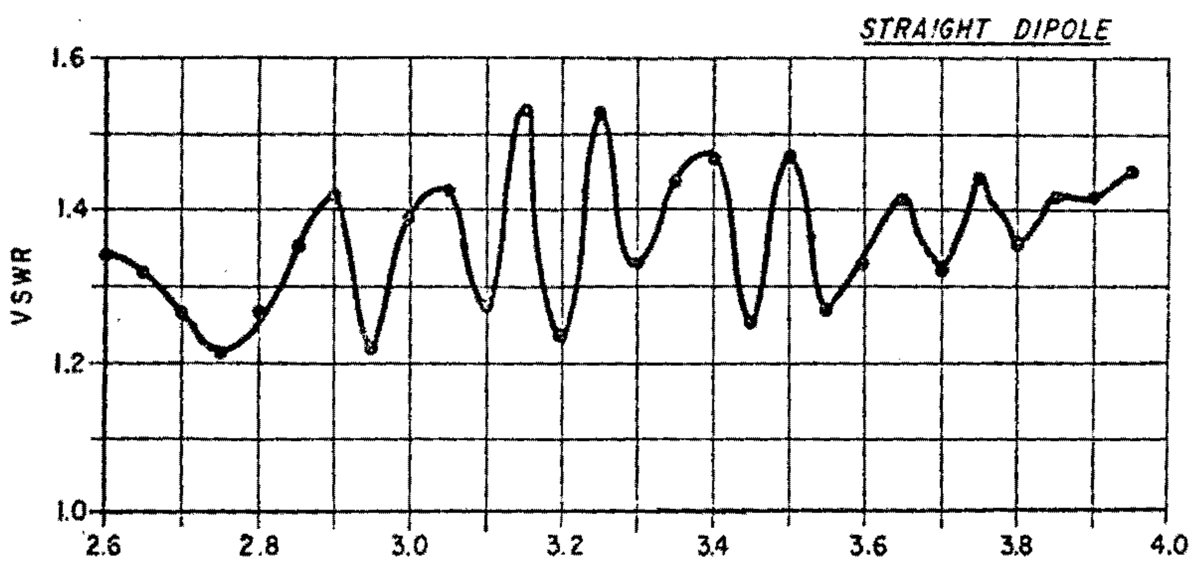
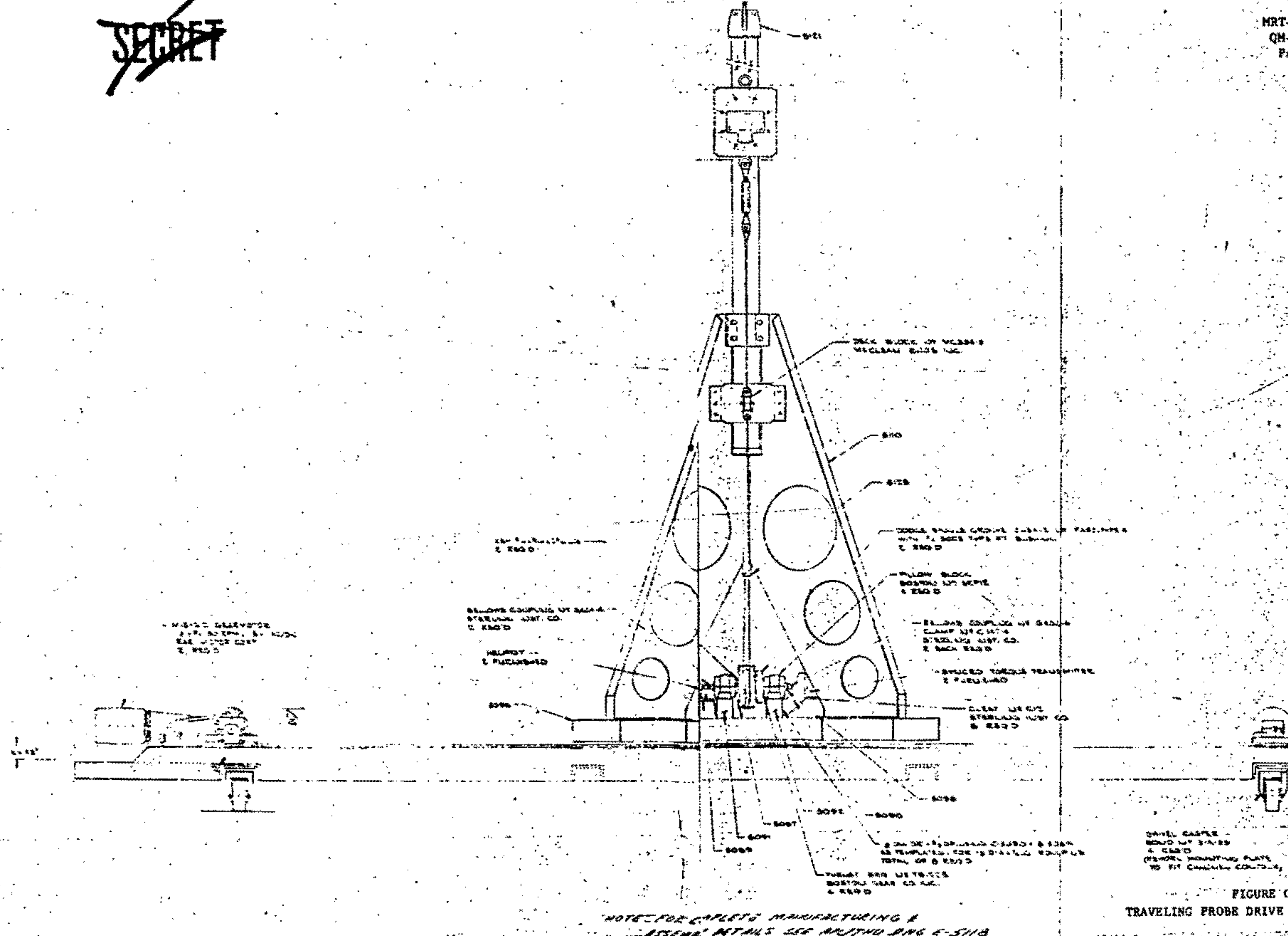


Fig. B3 DIPOLE VSWR Vs FREQUENCY (With S-Band 5 Spline Cable to "Type N" Transition)

~~SECRET~~

SECRET



SECRET

FIGURE C1
TRAVELING PROBE DRIVE MECHANISM

APPENDIX C

Field Traversing Mechanism

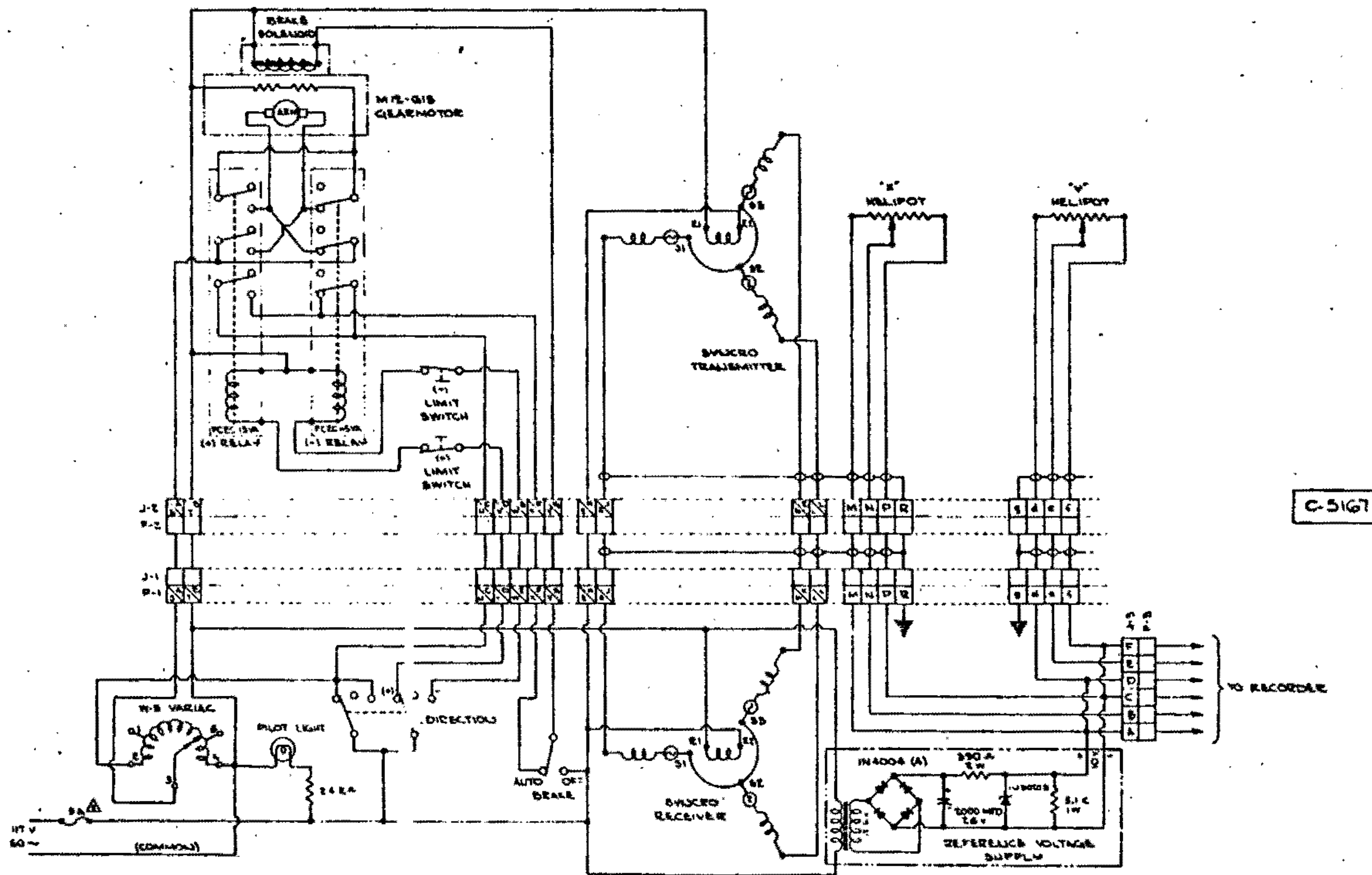
The field traversing mechanism used to evaluate the anechoic chamber is shown in figure C1. It is capable of moving the probe antenna (either the dipole or the standard gain horn) in azimuth and in elevation a distance of $\pm$ 2.5' from the center at variable speeds. The entire mechanism was moved manually along the transmission length of the chamber during the evaluation.

Incorporated in the mechanism are voltage readouts proportional to the distance (in both azimuth and elevation) which are used to drive an X-Y recorder. Also included are syncro position indicators on the remote control panel. Limit switches at the azimuth and elevation extremes set the motor brake until the movement direction is reversed. Figure C3 is a wiring diagram of the mechanism and its control panel.

The "mast" is readily removable for ease in transportation and storage. For the "sample container" measurements, the mast and its "super structure", and the entire elevation drive mechanism were removed, and an absorber pedestal was placed on the movable azimuth base. The sample container was placed on this absorber pedestal and moved $\pm$2.0 feet in azimuth behind the fixed dipole monitor. During all measurements, the exposed superstructure is absorber lined.

Figure C2 is the wiring diagram for the Field Traversing Mechanism.

DO NOT SCALE



NOTES:

1. CIRCUIT SHOWN TYP FOR BOTH X-AXIS (HORIZONTAL) & Y-AXIS (VERTICAL); ☒ DENOTES CIRCUIT DUPLICATIONS

2. 5 AMP CIRCUIT BREAKER SUPPLIED WITH VARIAC.

WIRING DIAGRAM - TRAVELLING HORNS

C-5167

C-5167

SECRET

MRT-4-046
QM-66-072
Page C3

External Distribution:

P. Tamarkin	Copy No.	1
R. S. Cesaro		2
R. S. Cesaro		3
R. S. Cesaro		4
R. S. Cesaro		5
R. S. Cesaro		6
H. M. Grove		7
R. W. Beard	W/o enclosures	
F. Koether	W/o enclosures	

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

UNCLASSIFIED

[redacted]

MRT-4-046
QM-66-072
DRC-H-9331-002

PROJECT PANDORA (U)

Final Report

24 FEB ..

THIS DOCUMENT HAS BEEN DOWNGRADED
TO UNCLASSIFIED
Per Director DARPA/TIO

EX[redacted]
[redacted]PLY

Prepared by
Eugene V. Byron
November 1966

UNCLASSIFIED

[redacted]

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18 U.S.C. [illegible]

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

ABSTRACT

This is the final report on the Applied Physics Laboratory's contribution to Project PANDORA - specifically, aid in the implementation, and the evaluation of a microwave test facility at Walter Reed Army Institute of Research. An "expandable" conical horn transmitting antenna, and monitor dipole receiving antennas were designed for use in the anechoic chamber constructed by Emerson and Cuming, Inc. A mechanical field traversing mechanism was designed and constructed for the chamber evaluation, the microwave equipment was functionally assembled, and the completed facility was thoroughly evaluated. The evaluation included the measurement of power variations in the quiet zone with and without the sample container (with and without the test sample) in the required position, and the measurement of the power density in the quiet zone using the Microwave Associates high power TWT and the appropriate transmitting horn sections.

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS
(continued)

LIST OF TABLES

I. INTRODUCTION

This is the final report on the contribution of the Johns Hopkins University Applied Physics Laboratory, to Project PANDORA - specifically, aid in the implementation and the evaluation of a microwave test facility at the Walter Reed Army Institute of Research, Forest Glen Section. APL's responsibilities were divided into roughly three areas: (1) aid in determining the suitability of the microwave equipment to be procured, and the functional assembly of this equipment (2) the design and fabrication of necessary specialized equipment, - transmitting horn, monitoring dipole antennas, a field traversing mechanism, etc., and (3) the evaluation of the microwave anechoic chamber, the calibration of the measurement equipment, and the test of the completed facility. The test and evaluation of the completed facility included the measurement of the power variations in the quiet zone of the anechoic chamber with and without the sample container (with and without the test sample) in the required position, and the measurement of the power density in the quiet zone.

In addition, a familiarization session was conducted for Army personnel scheduled to operate the facility. A companion report [(1)] describes the operational procedure, the procedure for determining the power requirements and which "add-on" section of the expandable conical horn to use for a desired power density, and a description of the monitoring equipment.

The commerically available microwave equipment was specified and purchased by the Air Force Avionics Laboratory (AFAL), Wright-Patterson AFB, Columbus, Ohio - the program managers. The microwave anechoic chamber was designed and constructed by Emerson and Cuming, Inc., Canton, Mass. The high power microwave traveling wave tube was designed and built by Microwave Associates, Burlington, Mass., with the associated power supplies furnished by Alto Scientific, Inc., Palo Alto, California.

---

(1) "Operational Procedure for Project PANDORA Microwave Test Facility" APL/JHU Report MRT-4-045; (QM-66-071) dated October 1966 (U)

II. DESCRIPTION OF THE MICROWAVE FACILITY

The microwave test facility implemented at Walter Reed consists of a microwave anechoic chamber, an expandable conical transmitting horn attached to one end wall of the chamber, and the microwave control and monitoring equipment installed in four equipment racks which are housed in the control room adjacent to the transmission end of the chamber. Also, a standard gain horn power monitor, and two sleeve dipole monitoring antennas are installed in the microwave chamber.

The facility was designed to operate at S-Band, with conversion potential through X-Band, such that a suitable quiet zone - minimum dimensions, 3' wide x 2' high x 1' deep, for two test samples side by side - would be illuminated uniformly; a power density of 2 mw/cm^2 $\pm$ 1.0 db over the frequency band was the design goal, with a potential for a power density of 10 mw/cm^2 over a reduced volume and a fixed frequency.

A. MICROWAVE ANECHOIC CHAMBER

The microwave anechoic chamber (Eccosorb Anechoic Chamber No. 650) is approximately 15' wide by 15' high by 35' long. The proposed four foot cubic quiet zone is symmetric about a point 25 feet from the transmitting end wall, and equidistant between the floor, ceiling and side walls. Figure 1 is a photograph of the chamber; figure 2 is the general arrangement drawing, and also shows the mounting detail for the transmitting horn.

The design requirements for the chamber specified that the power variations should not exceed $\pm$ .25 db superimposed on the transmitted gain "droop" measured in the quiet zone with an absorber backed dipole over the frequency band of interest. As noted in Section III of this report, these values were not realized, and power "amplitude ripples" as great as $\pm$ 1.0 db were observed. The chamber evaluation showed that for the minimum quiet zone dimensions - 3' wide x 2' high x 1' deep, - power variations of

± 1.75 db were possible over the S-Band frequency range. When a standard gain horn was used as the field probe instead of the absorber backed dipole, considerable improvement was observed; amplitude ripples were less than ± 0.25 db. This is discussed further in Section III.

B. MICROWAVE EQUIPMENT

The microwave equipment is assembled in the four racks shown in figure 3. Equipment rack number one contains the Spectrum Analyzer R. F. and Display sections. Rack number two contains the auxiliary low power microwave generation and modulation equipment, and some ancillary equipment, in addition to the control panel for the field traversing mechanism. Rack number three contains the primary low-power microwave generation and modulation equipment, and the necessary monitoring and recording equipment. Rack number four contains the high power microwave amplifier and associated power supplies and R. F. power monitors.

The equipment in rack number two is not interconnected (nor is the spectrum analyzer). The interconnection of racks number three and four with the expandable conical horn is shown in figure 4 which is a functional block diagram of the microwave system. Also shown in this figure are the "downstream" power monitors in the anechoic chamber.

All of the equipment assembled in racks number two and three are commercial "off the shelf" units (traveling mechanism control panel excepted) and constitutes the best and most versatile, in terms of possible R. F. modulations, microwave equipment available. This was particularly necessitated by the unknown nature of the desired signal for an experimental facility. These units were specified and purchased by the program managers (AFAL). Compatability and suitability of this equipment was monitored by APL and the equipment was functionally assembled and tested at APL and delivered as a unit to Walter Reed.

The high power microwave amplification equipment in rack four was purchased under separate contract (from AFAL) to Microwave Associates and was delivered as a unit.

UNCLASSIFIED

[redacted]

APPENDIX I

CALIBRATED MICROWAVE FACILITY AT WALTER REED ANECHOIC CHAMBERS

Irradiated Test Section 4' X 2' X 1½'

BASIC SIGNAL

S-Band - Consists of Signal I and II operating at the same time and superimposed.

Signal I

1. Carrier - 3.03 GHz

2. Noise - FM-Modulation - "white" noise band limited - 0-500 Hz
20% of total energy is in the modulation products.

3. 1 and 2 above are swept with a 440 cycle square wave at
± 2 MHz bandwidth.

Signal II

1. Carrier - 3.06GHz

2. Noise - FM-Modulation as above except 80% instead of 20%
in the modulation products.

3. Sinewave - FM-Modulation 25KHz single frequency, a small amount
of this signal is in the modulation products.

4. 1, 2 and 3 above, are swept with a 440 cycle triangular wave
form ± 10 megacycles from center frequency carrier
(3.06 GHz).

The total average power per unit area arriving in the test region where the specimens are placed is about 5 milliwatts per square centimeter.

UNCLASSIFIED

EXCLUDED FROM AUTOMATIC REGRADING DOD DIR 5200.10 DOES NOT APPLY

[redacted]

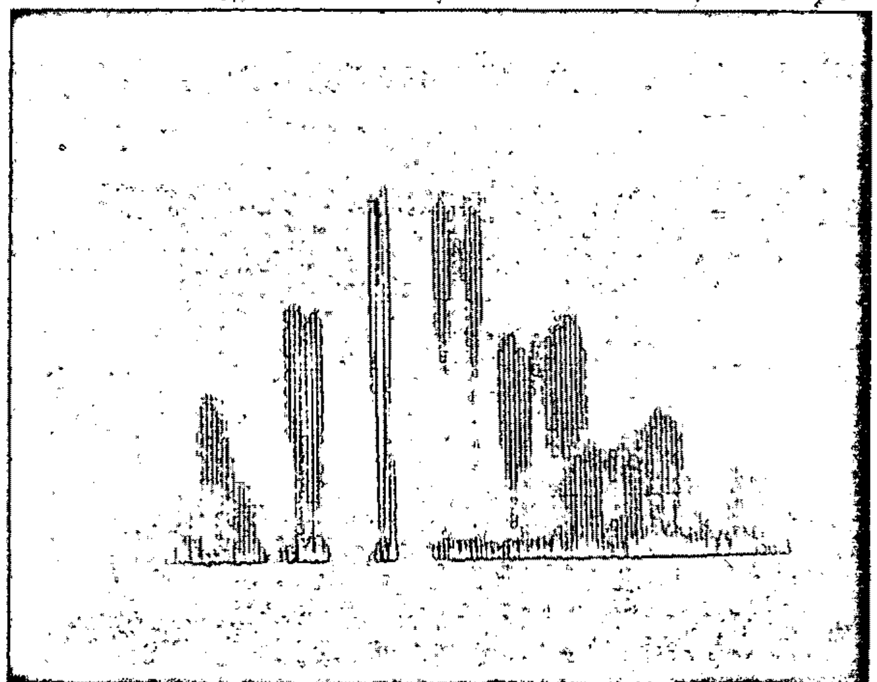
DECLASSIFIED BY DARPA/TIO 5 DEC 1977

UNCLASSIFIED

[redacted]

Appendix I - continued

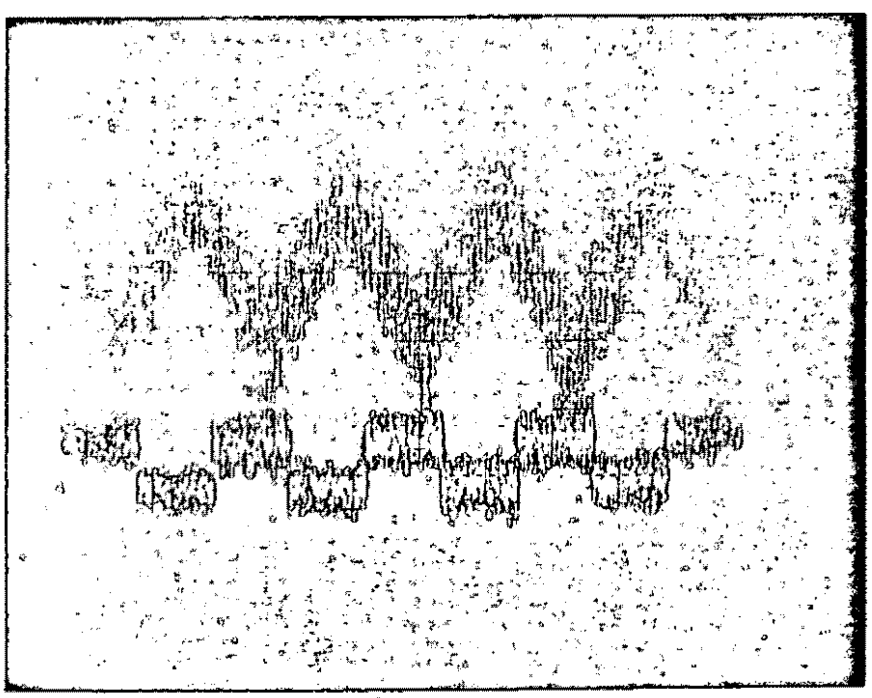
Typical Spectrum of Signal



30 mc/cm
100 kc IF BW
30 msec/cm
log.

QUALITATIVE ONLY
DO NOT USE FOR
QUANTITATIVE PURPOSES

MODULATION



SWEEP TIME = 1 msec/cm
UPPER = 0.2
LOWER = 0.2 V/CM

[redacted]

TABLE I

Monkey working 7 days/week; 10 hrs/day for 79 days prior to radiation.
ALL TESTS conducted on one monkey.

DATE	RADIATION	NO RADIATION	EFFECT NOTED	
29 Oct	x			
30 Oct	x			
31 Oct	x			
1 Nov	x			
2 Nov	x			
3 Nov	x		No effects to this point	
	6			
4 Nov		x		
5 Nov	x			
6 Nov	x			
7 Nov	x			
8 Nov	x			
	4			
9 Nov		x		
10 Nov		x		
11 Nov	x			
12 Nov	x		Yes	Function "A"
13 Nov	x		Yes	Complete stoppage in all functions, monkey in sleep
14 Nov	x		Yes	"
15 Nov	x		Yes	"
	5			

TABLE I - continued

16 Nov		x	Yes	Stoppage same as during radiation. Stoppage of monkey work.
17 Nov		x	Yes	"
18 Nov		x	Returns to normal	
19 Nov		x		
20 Nov		x		
21 Nov		x		
22 Nov		x		
23 Nov		x 8		
24 Nov	x			
25 Nov	x			
26 Nov	x			
27 Nov	x			
28 Nov	x			
29Nov	x			
30 Nov	x			
1 Dec	x 8			
2 Dec		x		
3 Dec		x		
4 Dec		x		
5 Dec		x		
6 Dec		x		

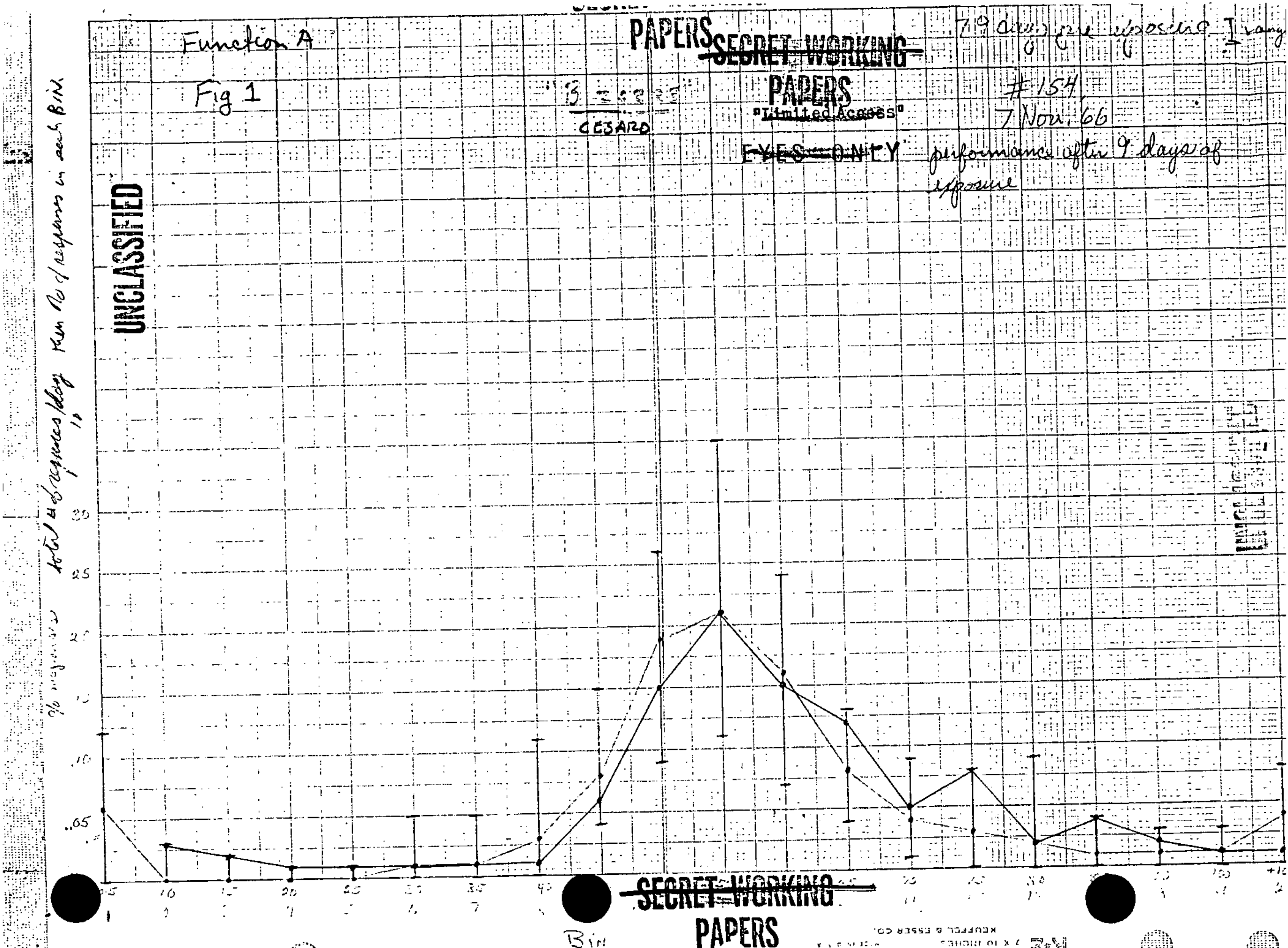
TABLE I - continued

7 Dec		x		
8 Dec		x		
9 Dec	x		Yes	Function "A" - slowed down rapidly
10 Dec	x		Yes	Complete stoppage of monkey - all functions
11 Dec	x		Yes	"
12 Dec	X		Yes	"
13 Dec	x / 5		Yes	"
14 Dec		x	Yes	"
15 Dec End reporting period		x	No recovery as yet	

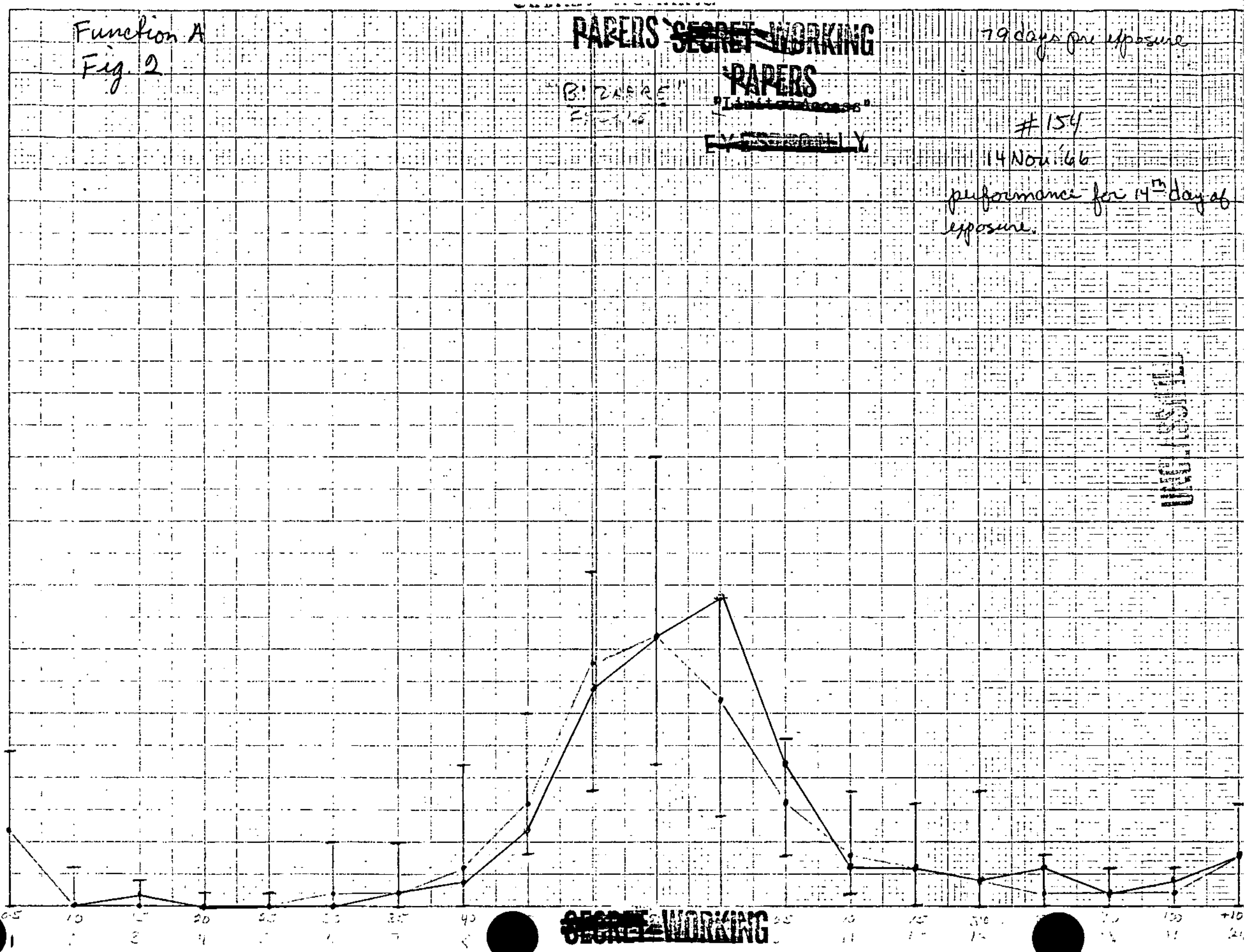
Total number of radiation days - 28

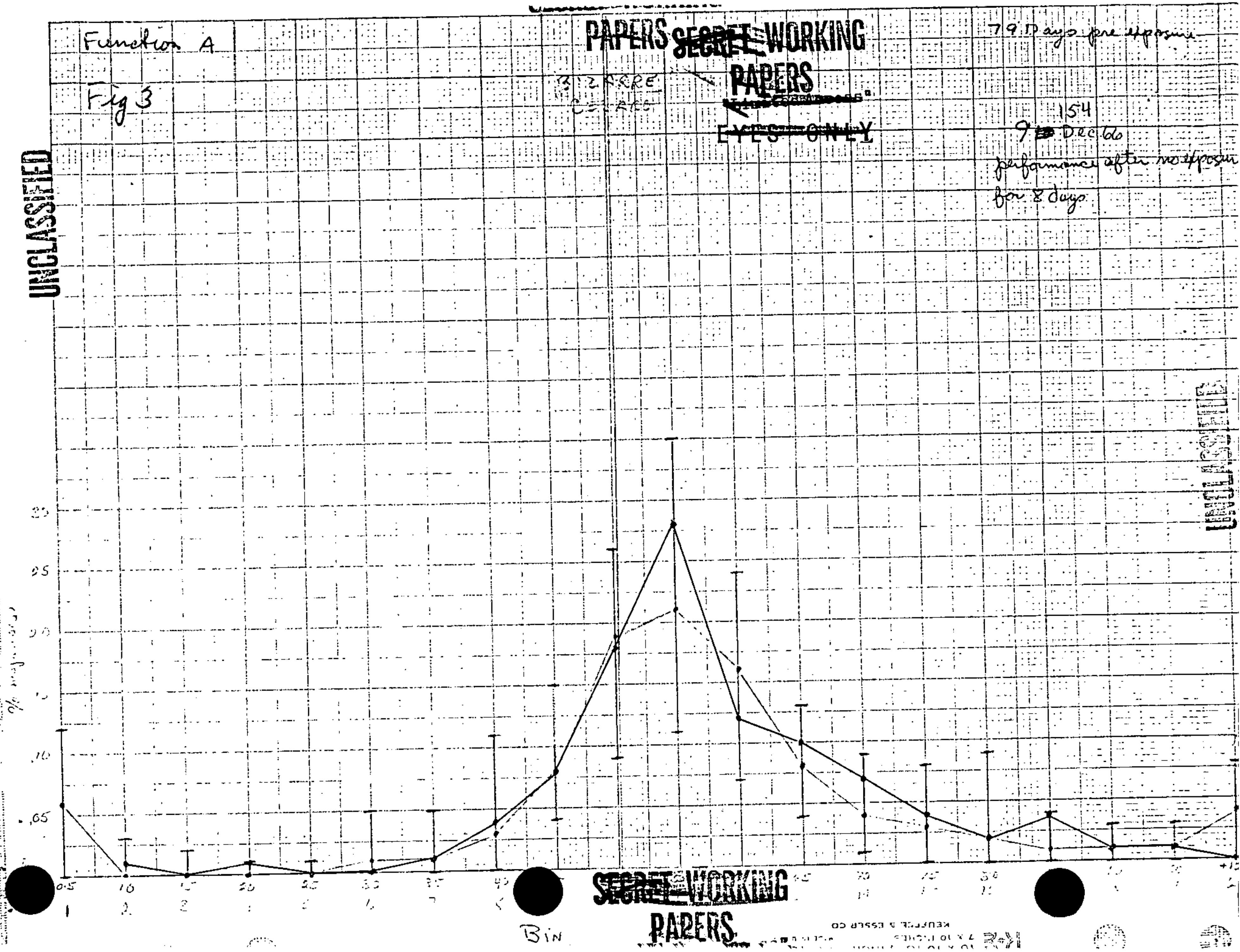
Two complete cycles of stoppage:

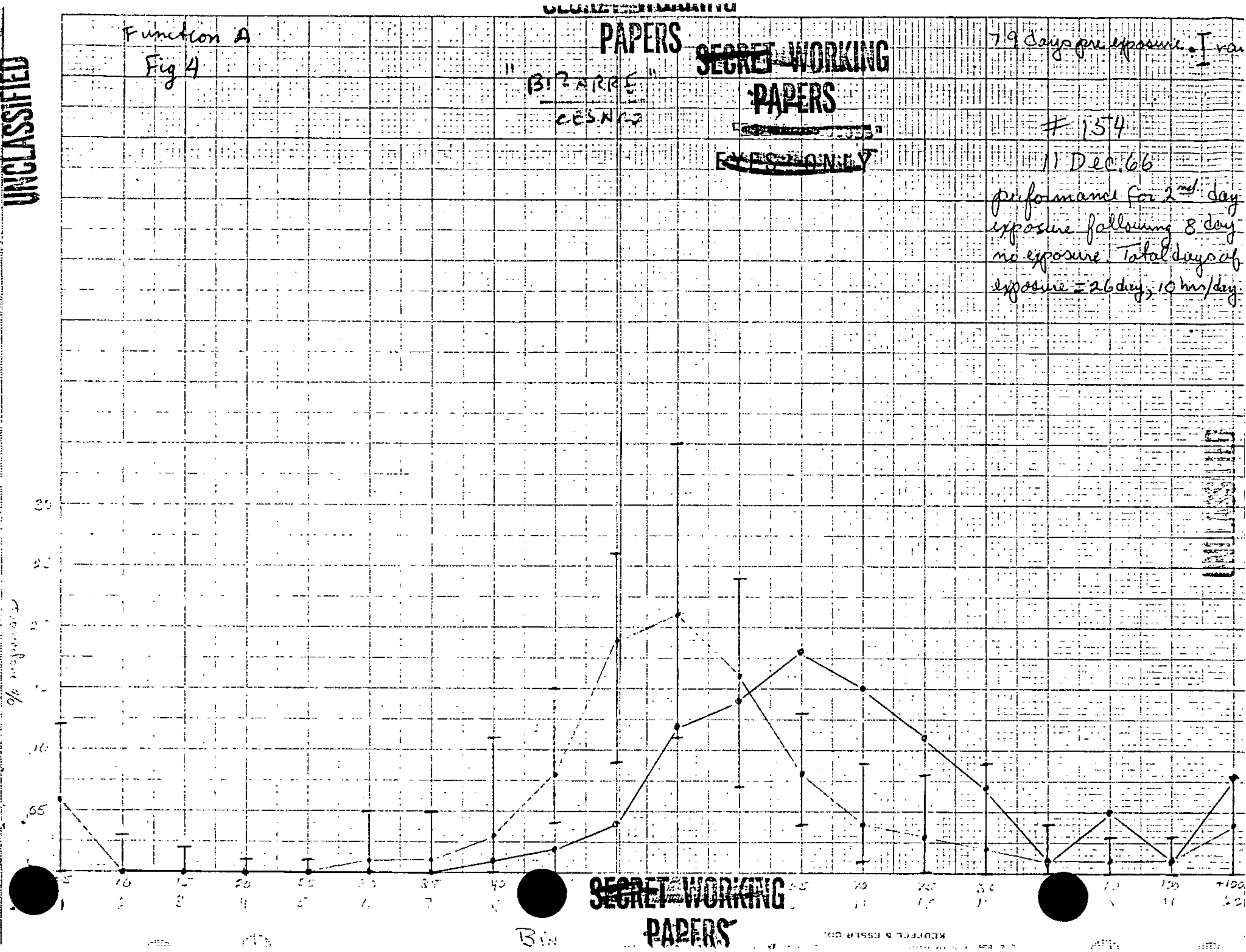
One - recovering is normal
One - not yet recovered


Function A
Fig 1
PAPERS SECRET WORKING
PAPERS
"Limited Access"
EYES ONLY
CESARO
79 days pre exposure I
#154
7 Nov. 66
performance after 9 days of exposure
UNCLASSIFIED
% responses
total # of responses/day
Num No of responses in each BIN
30
25
20
.10
.05
10
20
25
40
Bin
SECRET WORKING
PAPERS
KEUFFEL & ESSER CO.

UNCLASSIFIED




Function A
Fig 3
79 Days pre exposure
154
9 Dec 66
performance after no exposure for 8 days
Bin


Function A
Fig 4
"BIZARRE"
CESNR
79 days pre exposure. I ran
154
11 Dec. 66
performance for 2nd day exposure following 8 day no exposure. Total days of exposure = 26 day, 10 hrs/day.
% response
.05
.10
Bin
+100

PANDORA

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
1400 WILSON BOULEVARD
ARLINGTON, VA 22209-2308

HOLD AS REFERENCE.

MEMORANDUM FOR OASD(PA) FOIA
ATTN: CDR. LANGERMAN

SUBJECT: 89-FOI-2208 (PROJECT PANDORA)

AS YOU REQUESTED DURING OUR MEETING ON 21 DEC 1989, THE FOLLOWING INFORMATION IS FURNISHED, IN ADDITION TO THE DOCUMENTS CONCERNING PROJECT PANDORA, FOR RELEASE TO MICHAEL DROSNIN TO SATISFY HIS REQUEST UNDER SUBJECT CASE. (ATTACH A)

THE TERM PROJECT BIZARRE IS NOT A SEPARATE PROJECT, BUT WAS A CODE NAME FOR A SPECIAL ACCESS CATEGORY WITHIN THE PANDORA PROJECT.

ALL OTHER DOCUMENTATION RELATING TO THE PROJECT WAS TRANSFERRED TO THE ARMY (WRAIR) AS OUTLINED IN THE "AGREEMENT TRANSFER OF PROJECT PANDORA." (ATTACH B)

ALSO FORWARDED IS A COPY OF DARPA LETTER DATED 15 SEP 1977 IN RESPONSE TO SENATOR MAGNUSON'S LETTER, WHICH MIGHT FURTHER SATISFY MR. DROSNIN'S REQUEST. (ATTACH C)

FRED KOETHER

Memorandum for OASD (PA) FOIA
Cdr. Langerman

Subject: 89-FOI-2208 (Project PANDORA)

1. As ~~of~~ you requested during our meeting on 21 Dec 89, the following information is furnished, in addition to the documents concerning Project PANDORA, for release to Michael Dronin to satisfy his request under subject case. (Attach. A)

2. The term Project BIZARRE ~~was~~ not a separate project, but was a code name for a special access category within the PANDORA project.

3. All other documentation relating to the project were transferred to the Army (WRAIR) as outlined in the "Agreement Transfer of Project PANDORA". (Attach. B)

4. Also forwarded is a copy of DARPA letter dated 15 Sept 1977 in response to Senator Magnuson's letter, which ~~would~~ might further satisfy Mr. Dronin's request. (Attach. C)

FOIA CASE NO. 89-FOI-2208

ATTACH A:

1) MEMO FROM B. W. AUGENSTEIN TO DR. BROWN & DR. FUBINI, 13 MAY 65

2) MEMO FROM R. S. CESARO, A/DIR., ADV SENSORS TO DIR., ARPA, 15 OCT 65

3) MEMO FROM R. S CESARO, TO DIR., ARPA, 15 DEC 66

4) MEMO FROM R. S. CESARO FOR RECORD, 20 DEC 66

5) REPORT BY E. V. BYRON, JOHNS HOPKINS UNIV, OPERATIONAL PROCEDURE FOR PROJECT PANDORA MICROWAVE, OCT 66

6) REPORT BY E. V. BYRON, JOHNS HOPKINS UNIV., PROJECT PANDORA, NOV 66

7) MEMO FROM R. S. CESARO, TO DIR., DEF R&D, 27 SEP 67

8) MEMO FROM HERBERT POLLACK TO R. S. CESARO, 2 JAN 69

9) REPORT BY J. F. KUBIS, THE SARATOGA STUDY, 8 MAY 69

10) MINUTES OF PANDORA MEETING OF 17 JAN 69

11) MINUTES OF PANDORA MEETING OF 21 APR 69

12) MINUTES OF PANDORA MEETING OF 12 MAY 69

13) MINUTES OF PANDORA MEETING OF 18 JUN 69

14) MINUTES OF PANDORA MEETING OF 16 JUL 69

15) MINUTES OF PANDORA MEETING OF 12 & 13 AUG 69

16) LTR FROM RAND, REVIEW OF PANDORA EXPERIMENTS, 4 NOV 69

17) PRELIMINARY REPORT ON THE EVALUATION OF DATA ASSOCIATED WITH PANDORA BY J. F. KUBIS, 4 DEC 69

18) MEMO FROM IDA REVIEW PANEL TO R. S. CESARO, 14 JAN 69

19) LETTER REPORT ON AO 791, 15 FEB 69

20) PROGRESS REPORT BY B. H. COHEN, JOHNS HOPKINS UNIV., 28 FEB 70

21) FINAL REPORT BY K. R. BRIZZEE, TULANE UNIV., 16 SEP 70

22) REPORT BY R. J. GAVALAS, UNIV OF CALIF AND D. O. WALTER, ET AL, EFFECT OF LOW LEVEL, LOW-FREQUENCY ELECTRIC FIELDS ON EEG AND BEHAVIOR IN MACACA NEMESTRINA

23) MINUTES OF PANDORA MEETING, 12 JAN 70

24) FINAL REPORT BY ZARET FOUNDATION, INC.

ATTACH B:

AGREEMENT TRANSFER OF PROJECT PANDORA

ATTACH C:

LETTER FROM DR. HEILMEIER TO WARREN G. MAGNUSON, 15 SEP 77

Ref: 89-FOI-2208/L

Mr. Michael Drosnin
458 West Broadway, 5th Floor
New York, NY 10012

Dear Mr. Drosnin:

This responds to your December 5, 1989, Freedom of Information Act (FOIA) request to the Office of the Secretary of Defense which was received in this Directorate on December 12, 1989. Our interim response of December 21, 1989, refers.

The Defense Advanced Research Projects Agency (DARPA) has determined that the documents at enclosure 1 are responsive to your request pertaining to Project Pandora and have been granted in full. Project Bizarre was not a separate project, rather, it was a code name for a special category within the Pandora Project. All other documentation relating to Project Pandora was transferred to the Walter Reed Army Institute of Research (WRAIR) per enclosure 2. The letter to Senator Magnuson at enclosure 3 may serve to answer any further questions you may have.

This office referred your request to the Services as previously indicated in our interim response. The Department of the Navy response of January 10, 1990, and the Department of the Air Force response of January 4, 1990, both correctly inform you that they are unable to assist you in your search for documents. WRAIR, under the Department of the Army, now has cognizance of this information as indicated in the previous paragraph and should be able to provide you a more substantive response.

After deleting 100 pages as an "other" requester, the chargeable costs of processing your FOIA request consisted of 365 pages of office machine reproduction (with the documents provided in our interim response and this final response) at $0.15 per page.

Please indicate the FOIA reference number above on a check or money order made payable to the U.S. Treasurer in the amount of $54.75. Send the payment within 30 days to this office at the following address:

Office of the Assistant Secretary of Defense
(Public Affairs)
Directorate for Freedom of Information
and Security Review
Pentagon, Room 2C757
Washington, DC 20301-1400

Sincerely,

W. M. McDonald
Director
Freedom of Information
and Security Review

Enclosures:
As stated

CYT:LANGERMAN:mml:89-2208 ltr:900117: gr___pk___ye___ wh___

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

89-2208

13 May 65

MEMORANDUM FOR DR. BROWN
DR. FUBINI

SUBJECT: ARPA and Moscow Embassy Radiation

In the advanced sensor program, ARPA is entertaining proposals to investigate possible clinical effects, primarily neurological, of continuous microwave radiation with either CW or pulsed wave forms.

The CIA and a special USIB Subcommittee have become interested in this problem for the following reason. The radiation intensity on our Moscow Embassy exceeds, by a factor of about 100, the safety level specified in Soviet microwave specification standards. These Soviet standards are considerably more stringent than ours. Specifically, the Soviet standards are: to not exceed 10 microwatts continuously and, in no case, to exceed 1 milliwatt for even very short periods of time.

I understand that the average radiation intensity inside the windows of our Moscow Embassy is on the order of 1 milliwatt. Consequently, a considerable amount of interest has been generated by the CIA and by the USIB in reviewing existing data in this field, which is very scanty at these radiation levels, even though the possibility that the radiation is intended to produce neurological effects on embassy personnel is probably relatively low. On the other hand, since we have no real idea of what the radiation is intended for, it has been the feeling, in the USIB and the CIA, that this possibility should not go unexplored. Unfortunately, there is some past unsavory history of experiments of this kind in this country which has made a number of people rather leery of further experiments in this field, and which has resulted in the setting of standards of safety which are approximately 1,000 times looser in this country than in the Soviet Union, with our standards being set primarily by thermal damage thresholds. Effort has been going on by the Director of Clinical Research, Neurology, in NIH on lower level radiation to see if neurological effects can be detected but, even in this case, the effort has not been apparently officially sanctioned as a NIH project because of the circumstances noted earlier.

ARPA now has some proposals to conduct meaningful experiments in this range in which the intent would ultimately be to experiment not only with the average intensity of the Moscow radiation but also with a close simulation of the wave forms used. However, there seems to be some internal resistance in ARPA to the suggestion that ARPA proceed with these experiments, probably because there is a feeling that at one time it certainly attracted a number of crack pots. The proposal which makes considerable sense now is a proposal to use Air Force primates as subjects in a carefully controlled series of experiments, with the intent being to detect neurological or synergistic effects. My feeling is that we should carry through these experiments, if these can be accomplished at reasonable cost, because of the following considerations:

a. There is definite USIB and CIA interest in this proposition, and I believe that a USIB recommendation that such research be carried on can, or will, be generated.

b. The existing U.S. experience in this particular energy range does not seem to be very satisfactory in quality of research.

c. The pragmatic fact exists that the Soviet Union is irradiating our embassy in Moscow with radiation which exceeds by a factor of 100 their own safety standards, and which would give us a lever for protest if we wished.

d. Unless, and until, other explanations are found for the purposes of the Embassy radiation, this should not be left an unexplored possibility.

For these reasons, I believe that ARPA should be encouraged to do this research as part of the advanced sensor program under the assumption that a reasonably contained, high quality, and not unduly expensive program can be formulated. I do not think that the past history of this particular subject, which apparently makes many people suspicious about the scientific content of such experiments, should be allowed to impede a sound research program in this area, for the reasons mentioned earlier.

B. W. Augenstein

[redacted]

UNCLASSIFIED

A.0.791

ADVANCED RESEARCH PROJECTS AGENCY
WASHINGTON, D. C. 20301

THIS DOCUMENT HAS BEEN DOWNGRADED
TO UNCLASSIFIED 5 - DEC 1977
Per Director DARPA/TIO

15 October 1965

MEMORANDUM FOR THE DIRECTOR, ADVANCED RESEARCH PROJECTS AGENCY

SUBJECT: Justification Memorandum for Project PANDORA

The purpose of this memorandum is to explain some of the background requirements and justification for the ARPA Program Plan 562 relating to Project PANDORA.

Background. For several years it has been noted that the American Embassy in Moscow has been radiated with low level electromagnetic signals on a more or less continuous basis. These emitting signals, in the "S" and "L" band spectrum, have been of complex modulation with seemingly random variations.

The White House has directed through USIB that intensive investigative research be conducted within the State Department, CIA and DOD to attempt to determine what the actual threat is and stop it. The National program has been coordinated by the State Department under code name project "TUMS." ARPA is represented and has been requested to initiate a selective portion of the overall program concerned with one of the potential threats, that of radiation effects on man.

Discussion. A program has been outlined to irradiate a group of primates under carefully controlled conditions simulating the dosages and complex modulation of the threat. This effort is known as Project PANDORA. The trained primates will be carefully observed under varying and controlled irradiated conditions in an attempt to determine if any changes in their behavior or physiological condition can be detected. This effort will be carried out on behalf of ARPA by the following organizations.

1. The Air Force will select, procure, and monitor the electromagnetic generating equipment and control the environment thus produced. An initial study of equipment was made under ARPA Order #757. They will integrate above resources into a system and provide an aerospace medical doctor to assist the other medical team members in the test program.

2. The Applied Physics Laboratory will provide scientific consulting services and technical assistance in the design and fabrication of the laboratory, its electromagnetic environment and test facilities pertaining thereto.

Copy 1 of 3 copies.

[redacted]

[redacted]

[redacted]

ARPA-AS-TS-65-23a

[redacted]

3. The Walter Reed Army Institute of Research will provide laboratory quarters, primates, biological monitoring and data reduction capabilities.

4. In addition, Mr. Mark Groves, of the Wright Patterson Avionics Laboratory will act as ARPA monitor and coordinator for this project. Additionally, other consultants which will be utilized include Drs. Nat Baldwin, NIH; Ross Adey, UCLA; Milton Zaret, Zaret Foundation; J. Johnson, CIA; and H. Pollack, IDA.

Recommended Action. It is recommended that ARPA initiate the required ARPA Orders as covered in the Program Plan attached. This memorandum, being of a sensitive nature, will be retained in the Office of Advanced Sensors and act as justification in depth for above referenced future Program Plan and ARPA Order.

Richard S. Cesaro
Acting Director
Advanced Sensors

[redacted]

"Limited Access"

EYES ONLY

UNCLASSIFIED

ADVANCED RESEARCH PROJECTS AGENCY

WASHINGTON 25, D.C.

1 5 DEC 1965

MEMORANDUM FOR THE DIRECTOR, ARPA

THIS DOCUMENT HAS BEEN DOWNGRADED TO UNCLASSIFIED For Director, DARPA/TIO 8 - DEC 197

SUBJECT: Project PANDORA - Initial Test Results

I. BACKGROUND

In excess of five years, the American Embassy in Moscow has been radiated with low level electromagnetic signals (the Moscow Signal) on a more or less continuous basis. These signals, in the "S" and "L" band spectrum, have been of complex modulation with seemingly random variations.

The White House has directed, through USIB, that intensive investigative research be conducted within the State Department, CIA and DOD to attempt to determine what the actual threat is and stop it. The National Program has been coordinated by the State Department, under code name, "TUMS." ARPA is represented and is conducting research on a selective portion of the overall program concerned with one of the potential threats, that of the effects of low level electromagnetic radiation on man. This memorandum summarizes the initial test results obtained from this program called PANDORA. The extremely sensitive nature of the results obtained to date, and their impact on National Security, has resulted in establishing a special access category for all data results and analysis, under code name "BIZARRE." The code name is unclassified. Results can only be discussed with or conveyed to individuals cleared for this special access through Mr. Daniel J. Sullivan, ARPA.

II. SUMMARY

The most important results obtained to date, after 28 days (not continuous) of radiation of a primate at 5 milliwatts/cm^2 with a simulated Moscow Signal, have been two repetive, complete slowdowns and stoppages of the monkey in carrying out his test work functions. The monkey works 10 hrs/day, 7 days/week. At stoppage, the data strongly suggests the monkey went into deep sleep. The second breakdown occurred sooner than the first, indicating that pre-stressing due to the radiation environment had occurred. There is no question that penetration of the central nervous system has

UNCLASSIFIED

"Limited Access"

EYES ONLY

PB-66-1

copy 1 of 4

been achieved, either directly or indirectly into that portion of the brain concerned with the changes in the work functions and the effects observed.

Events leading to these breakdowns were as follows: On the 12th day of radiation (10 hrs/day), a definite slowdown was recorded in the monkey's ability to time his work functions. On the 13th day of radiation, the monkey further degraded and finally stopped working. For the next two days of radiation, the monkey's condition remained unchanged - complete stoppage - at which time the radiation was terminated. Three days later (without radiation) the monkey returned to normal operation in his work functions. For five additional days (without radiation) the monkey maintained a normal work pattern. Radiation was turned on after this period and after eight days of radiation slowdown in work functions was again recorded. On the 10th day of radiation, complete stoppage occurred. The stoppage continued for the next three days at which time radiation was terminated. The next two days of recordings, up to 15 December 1966, reveal the monkey had not returned to normal.

At all times when the monkey ceased to respond, the measured deep core temperature dropped 1.2 to 1.5°F from normal with a latency of 30 to 60 minutes. It stayed at this level for the remainder of the 10 hr/day. This data and direct observations on a TV monitor strongly suggest the monkey was in deep sleep.

III. DETAILED TECHNICAL DISCUSSIONS

A. Signal

1. The radiation intensity on our Moscow Embassy exceeds, by a factor of about 100, the safety level specified in Soviet microwave specification standards; specifically, 10 microwatts/cm^2 - not to exceed 1 milliwatt/cm^2 for short periods of time (15-20 minutes). The average steady level within the Moscow Embassy has been measured at values in excess of 1 milliwatt/cm^2. The U.S. safety standard is 10 milliwatts/cm^2. Large amounts of Soviet technical literature discuss non-thermal neurophysiological and neuro-circulatory effects of microwave radiation at levels below the U.S. accepted standard of 10 milliwatts/cm^2. There has been essentially no U.S. data covering this Soviet area of investigation.

2. The signal used in the PANDORA radiation experiments is a simulated portion of the Moscow Signal and its complete characteristics are shown in Appendix I, including a photograph of a spectrum analyzer display of the complete signal and an oscilloscope recording of the modulation signal amplitude characteristics. Generally, the signal is centered around 3.0 GHz (S-band) and is frequency modulated. The average power density impinging on the monkey is approximately 5 milliwatts/cm^2.

B. Animal Test Mode [redacted]

1. All testing, to date, has been conducted on one monkey. The monkey established a base of performance over 79 days prior to testing in the radiation environment. A male rhesus monkey was restrained in a chair in the anechoic chamber and trained in place to establish his base level performance without the radiation environment. Monkey work functions are broken down into a three-part schedule: (1) Function "A" - is cued to the monkey by a tone of 3300 cps. This function is designed to establish a base level of time response dependent upon internal clock, or the ability of the animal to estimate time. The monkey is required to wait for a period in excess of 50 seconds after the auditory cue then respond by closing a switch. A response before 50 seconds requires the monkey to re-cycle. The monkey is rewarded with a food pellet upon correct delayed response interval; (2) Function "B" - is cued to the monkey by a tone of 1450 cps. In this mode the monkey must sense change in tone from 3300 cps to the new signal of 1450 cps which results in the monkey carrying out a new function. This new function is to delay response until the tone goes off; (3) Function "C" - starts when the tone of 1450 cps stops and the monkey now must press a lever for each food pellet which is delivered only after the appropriate geometric progressions in number of switch closings.

2. The progression is as follows:

Step	No. of Switch Closings	Pellets Delivered
1	40	1
2	80	1
3	160	1
4	320	1
5	640	1

At the end of Step 5, the program is re-cycled.

IV. TEST RESULTS

A. Function "A" - Results presented in Figures 1 through 4 show the following: In all figures, the black curves represent the normal average response for this animal with time, without the radiation environment. The vertical black lines with horizontal "pips" represent the entire date point range of 79 days of pre-exposure results. The red line indicates the performance level for the day indicated. Figure 1 represents

[redacted]

performance after nine days of accumulative radiation exposure. This curve does not deviate from normal. Figure 2 presents results after fourteen days of accumulative radiation exposure. The red line shows a slowdown in the animal's timing behavior. Figure 3 presents results after eight days of no exposure preceded by twenty-three days of exposure, sequenced as shown in Table I. This data indicates the monkey returned to normal performance. Figure 4 presents results after twenty-six days of cumulative exposure and shows a marked decrease in the timing behavior (red curve).

B. Function "B" - Essentially no change observed in all of the data reported above.

C. Function "C" - After twelve days of radiation exposure, the time for completing the geometric progression showed a tendency to increase (slowdown). On the thirteenth day, the time to completion was clearly greater than normal and 5 hours and 29 minutes from the start of this session, the monkey stopped responding altogether at the progression function requiring 640 responses. The next two days (14 and 15), the same pattern was seen with the monkey stopping 5 hours and 56 minutes into the 10 hour session. The next two days, because of equipment failure, no radiation of the monkey occurred - although the monkey stopped working completely (all functions) and did not recover until the third day of no radiation. Complete cessation of all work function occurred for a total of five consecutive days during this run.

D. Function "D" - The same effect was repeated on the 24th, 25th and 26th day of radiation. At this reporting, recovery is not established.

V. <u>OTHER EFFECTS</u>

At all times, when the monkey ceased to respond, the measured deep core temperature dropped 1.2 to 1.5°F from normal with a latency of 30 to 60 minutes and stayed at this level for the remainder of the 10 hours. This data and observations on a TV monitor strongly suggest the monkey was in deep sleep.

The next key step in the program will involve repeating these experiments with a new monkey. Confirming previous results at this stage will next require extremely careful experimentation and measurements to begin to understand the mechanism involved and identify supporting laboratory research that must be conducted.

Richard S. Cesaro
Deputy Director
Advanced Sensors

[redacted]

UNCLASSIFIED

ADVANCED RESEARCH PROJECTS AGENCY
WASHINGTON, D. C. 20301

20 December 1966

MEMORANDUM FOR THE RECORD

SUBJECT: Project PANDORA - Initial Test Results

Reference: PANDORA-BIZARRE Test Results - Memo dated 15 Dec 66

I. <u>BACKGROUND</u>

For more than five years, the American Embassy in Moscow has been radiated with low level electromagnetic signals (the Moscow Signal) on a more or less daily basis for several hours a day. These signals, in the "S" and "L" band spectrum, have been in part recorded and are of complex modulation with a pattern of variation, some of which seems to be random.

The White House has directed, through USIB, that intensive investigative research be conducted within the State Department, CIA and DOD to attempt to determine what the threat is. The National Program has been coordinated by the State Department, under code name, "TUMS." ARPA is represented and is conducting research on a selective portion of the overall program concerned with one of the potential threats, that of the effects of low level electromagnetic radiation on man. This memorandum summarizes the initial test results obtained from this program called PANDORA.

II. <u>SUMMARY</u>

The most important results obtained to date, after 28 days (not continuous) of radiation of a primate at 5 milliwatts/cm^2 with a simulated Moscow Signal, have been two repetitive, complete slowdowns and stoppages of the monkey in carrying out his test work functions. The monkey normally works 10 hrs/day, 7 days week. At stoppage, the data strongly suggests the monkey went into deep sleep. The second breakdown occurred sooner than the first, suggesting that pre-stressing due to the radiation environment had occurred. There is no question that penetration of the central nervous system has been achieved, either directly or indirectly into that portion of the brain concerned with the changes in the work functions and the effects observed.

[redacted]

[redacted]

PB-66-2
cy 1 of 4 cys

Events leading to these breakdowns were as follows: On the 12th day of radiation (10 hrs/day), a definite slowdown was recorded in the monkey's ability to time his work functions. On the 13th day of radiation, the monkey further degraded and finally stopped working. For the next two days of radiation, the monkey's condition remained unchanged - complete stoppage - at which time the radiation was terminated. Three days later (without radiation) the monkey returned to normal operation in his work functions. For five additional days (without radiation) the monkey maintained a normal work pattern. Radiation was turned on after this period and after eight days of radiation slowdown in work functions was again recorded. On the 10th day of radiation, complete stoppage occurred. The stoppage continued for the next three days at which time radiation was terminated. The next two days of recordings, up to 15 December 1966, reveal the monkey had not returned to normal.

At all times when the monkey ceased to respond, the measured deep core temperature dropped 1.2 to 1.5°F from normal with a delay of 30 to 60 minutes. It stayed at this level for the remainder of the 10 hr/day. This data and direct observations on a TV monitor strongly suggest the monkey was in deep sleep. Detailed results of tests contained in Ref 1.

III. STATUS

Only one monkey has, so far, been tested. It cannot be stressed too strongly that, at this time, conclusions as to what may generally be expected cannot be drawn until at least another monkey has been subjected to the same sequence of radiation and normal environments, and has shown similar effects.

IV. PRESENT ARPA PROGRAM

A. Repeat test on second monkey which will be instrumented to detect various body changes.

B. Based on these results, a new design of tests will be constructed to determine the gross mechanisms involved in producing the effect observed.

V. IMPLICATIONS

The central nervous system of one monkey has been affected by low level microwave radiation. If tests on another monkey display similar results then:

1. Attention must begiven to initiating a National Program to investigate thoroughly these effects, since only isolated investigations have heretofore been carried on in the U.S. By contrast, the USSR

[redacted]

"Limited Access"

[redacted]

UNCLASSIFIED

has had an intensive national program in this area for more than 10 years.

2. The U.S. microwave radiation safety standards should be examined and overhauled to take account of the non-thermal damage potential.

3. The potential of exerting a degree of control on human behavior by low level microwave radiation must be carefully investigated.

Richard S. Cesaro
Deputy Director
Advanced Sensors

[redacted]

"Limited Access"

[redacted]

UNCLASSIFIED

Hopkins University
HYSICS LABORATORY
Spring, Maryland

MRT-4-045
QM-66-071

OPERATIONAL PROCEDURE FOR PROJECT PANDORA MICROWAVE TEST FACILITY

Prepared by
E. V. Byron
October 1966

T Hopkins University
AP YSICS LABORATORY
pring, Maryland

MRT-4-045
QM-66-071

ABSTRACT

This report describes the operational procedure for the Project Pandora microwave test facility. It is intended primarily for non-microwave oriented technical personnel to enable them to operate the facility with a minimum of training. Included is the Turn-On, Turn-Off Procedure, the procedure for measuring transmitted power and power density, and a description of the power monitors.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

I. INTRODUCTION

This report describes the operational procedure for the Project Pandora microwave test facility. It is intended primarily for non-microwave oriented technical personnel, to enable them to operate the facility with a minimum of training. Section II of this report delineates the basic turn-on, turn-off procedure for the equipment. Section III describes the procedure for determining which of the "add-on" sections of the expandable conical horn to use, and the power requirements for a desired power density. Section IV describes the power monitors in the microwave anechoic chamber.

The microwave equipment for Project Pandora is assembled in the four equipment racks illustrated in figure 1. Rack No. 1 contains the Spectrum Analyzer R.F. and Display sections. Rack No. 2 contains the auxiliary low-power microwave generation and modulation equipment. The equipment in this rack is not interconnected (nor is the spectrum analyzer). Rack No. 3 contains the primary low power microwave generation and modulation equipment, and the necessary monitoring and recording equipment. Rack No. 4 contains the high power microwave amplifier and power supplies. The interconnection of these two racks, with the "expandable horn" transmitting antenna in the anechoic chamber, is shown in figure 2 which is a functional block diagram of the microwave system.

II. EQUIPMENT OPERATION

The following instructions pertain to the operation of the equipment assembled in equipment racks 3 and 4 with reference to figures 1 and 2.

Note: For operation of the various individual pieces of equipment, refer to the manufacturers' operation manuals which are available at the test facility.

A. Preliminary Turn On Procedure

Note: Connect the proper transmitting horn section for the required frequency and power density as outlined in Section III of this procedure.

1. Equipment Rack Number 4

a. Turn on water supply. Pressure should be between 15 and 50 psi.

b. Turn on low voltage A.C. power supply. Set Heater Voltage to 6.3 volts.

c. Turn on D.C. power supply (solenoid power). Set to 33 volts.

Note: Under no circumstances should the solenoid be operated without water cooling or permanent damage will result. If the over current light is energized, the door interlock is open or there is insufficient water pressure or solenoid current.

d. Set the Cathode Voltage switch on the high voltage power supply to the Burn-in position and turn on the high voltage.

Note: There is a 3 minute delay before the high voltage comes on. Allow 15 minutes warm-up.

2. Equipment Rack Number 3

a. Turn on A.C. power to rack number 3.

b. Turn the Grid Control on the Alfred 5-6868, 10 watt TWT amplifier to -250 volts. Turn Helix Control completely CCW.

c. Turn HP692C Sweep Oscillator to Standby position.

d. Turn on power to all equipment, allow 15 minute warm-up.

e. Zero all HP431C power meters. For maximum accuracy, the power meters should be "re-zeroed" periodically. Refer to the HP431C instruction manual.

f. Turn Sweep Oscillator Output Attenuator and TWT Output Attenuator completely CW (max. attenuation).

g. Set HP692C to desired frequency and connect for desired modulation.

<u>Note</u>: Refer to the instruction manuals of the HP692, HP8403A, and the HP3300A for the possible modulation options and their settings. If the auxiliary low power R.F. generation and modulation equipment is to be used, refer to the appropriate instruction manuals for possible interconnections and operating instructions.

h. Turn HP692C to Operate position.

B. <u>Operational Turn On Procedure</u>

1. <u>Equipment Rack Number 4</u>

a. Set Cathode Voltage switch to the .1/3.3KV position and observe high voltage and current meters.

<u>Note</u>: Do not allow high voltage to exceed 3250 volts and the current to exceed 560 ma.

b. If necessary, adjust high voltage screwdrive adjustment for high voltage meter reading of 3250 volts. DO NOT EXCEED 560 MA. CURRENT.

2. <u>Equipment Rack Number 3</u>

a. Turn Helix Control on Alfred 5-6868 TWT completely CW.

b. Turn Grid Control on Alfred 5-6868 TWT completely CW.

c. Adjust Sweep Oscillator Output Attenuator for maximum power output as observed on TWT Monitor Power Meter. Lock in position.

d. Adjust TWT Output Attenuator for the required transmitted power as observed on the TWT Monitor Power Meter. Lock in position.

Note: The transmitted power required for a desired power density can be determined from figure 3 and Section III of this procedure.
The transmitted power can be determined from the meter reading and figure 4; (High Power Monitor, - Meter Reading vs. Output Power).
DO NOT EXCEED 250 WATTS TRANSMITTED POWER FOR EXTENDED PERIODS OF TIME WITH THE INITIAL TUBE SUPPLIED.

e. Set the monitor switches on the monitor switch panel to connect the desired function to be monitored to the strip chart recorder. The normal setting of these switches is TWT Monitor to the recorder channel No. 2, and Monitor Channel No. 1 to recorder channel No. 1.

f. Connect "Available Inputs" to the scope or the HP415 as required.

C. Turn Off Procedure

1. Equipment Rack Number 3

a. Turn 10 W TWT Output Attenuator max. CW (max. attenuation).

b. Turn Sweep Oscillator Output Attenuator max. CW.

c. Turn Grid Control on Alfred 5-6868 10 Watt TWT to -250 volts. Turn Helix Control completely CCW.

d. Turn HP692C Sweep Oscillator to Standby position.

e. Rack power may now be turned off.

2. Equipment Rack Number 4

a. Set the Cathode Voltage switch on high voltage power supply to Burn-in position.

b. Turn off high voltage.

c. Turn off low voltage A.C. power supply.

d. Turn off D.C. power supply.

e. Turn off water supply.

III. PROCEDURE FOR SELECTING HORN SECTION AND OUTPUT POWER FOR DESIRED POWER DENSITY

A. Design Frequency Range for "Expandable" Conical Horn

The microwave facility was designed such that a suitable quiet zone - minimum dimension, 3' wide by 2' high by 1' deep for two "test samples" side by side - would be illuminated uniformly a $\pm$ 1.0db power variation in the quiet zone was the design goal. The quiet zone, as discussed in this report, starts at a transmission length of 23.0 feet and is symmetric about the chambers horizontal and vertical axis. These quiet zone dimensions, therefore, set the beamwidth characteristics of the transmitting horn; and a conical transmitting horn with "add-on" section was designed to give maximum gain with the required beamwidth over the S-Band frequency range. Under these conditions, figure 3 shows the "design frequency range" for the appropriate sections (D_1 through D_6). This figure is a plot of power density (in mw/cm^2) per watt transmitted - Pd/W - versus frequency, for each of the horn sections. It can be seen that, for the design frequency ranges, Pd/W is $1.6x10^{-2} \frac{mw/cm^2}{watt} \pm 10\%$.

Thus, for 250 watts transmitted, the power density in the quiet zone is 4.0 $mw/cm^2 \pm 10\%$.

1. To determine specifically the transmitted power required for a desired power density (at a given frequency in the design range):

   a. Determine Pd/W for the known frequency and horn section from figure 3.

   b. Solve: Pd/W x Power = Power density

   $$\text{Power} = \frac{\text{Power density}}{\text{Pd/W}}$$

   c. Example: At 3.0 GHz, a power density of $2 mw/cm^2$ is required. (Horn Section D_4)

   $Pd/W = 1.58 \times 10^{-2}$ from figure 4.

   $$\text{Power} = \frac{2}{1.58 \times 10^{-2}} = 126 \text{ watts}$$

2. To determine power density from a known transmitted power:

   a. Determine Pd/W for the known frequency and horn section from figure 3.

   b. Solve: Power density = Pd/W x Power

   c. Example: At 3.5 GHz, 200 watts are transmitted (Horn Section D_2).

   $Pd/W = 1.56 \times 10^{-2}$ from figure 3.

   Power density = $1.56 \times 10^{-2} \times 200 = 3.13 \ mw/cm^2$

B. Horn Section for a Reduced Quiet Zone

To increase the versatility of the test facility, additional "add-on" horn sections were designed to uniformally illuminate successively smaller quiet zone volumes with increased gain. The determination of the quiet zone volume is dependent upon the beamwidth of the various sections and is beyond the scope of this report. Suffice it to say that, at the upper end of the frequency band (3.95 GHz) horn section D_{10} will essentially illuminate uniformly a quiet zone large enough for a single test sample - 1.5'W x 1'H x 1'D. At this frequency, D_{10} gives the maximum power density obtainable for the system. As the frequency is decreased, horn section D_{10} will uniformally illuminate a proportionately larger volume with reduced gain.

1. The power required for a desired power density can be determined as in A1 above.

   a. Example: 10 mw/cm^2 power density is desired at 3.95 GHz (Horn Section D_{10})

   $$\text{Power} = \frac{\text{Power Density}}{\text{Pd/W}}$$

   $$\text{Pd/W} = 3.83 \times 10^{-2} \text{ from figure 3}$$

   $$\text{Power} = \frac{10}{3.83 \times 10^{-3}} \cong 260 \text{ watts}$$

IV. MICROWAVE POWER MONITORS

In addition to the high power TWT monitor, there are 3 power monitors in the anechoic chamber. Two of these, Monitor #1, a standard gain horn, and Monitor #2, a sleeve dipole, are connected to the HP431C power meters in rack number 3. These two monitors may be switched to the Mosley 7100B strip-chart recorder (see figure 2). The third monitor, alternate monitor number 1, is a sleeve dipole and has an available output as shown in figure 2.

A. Monitor Number 1

Monitor number 1, the standard gain horn, is the primary "down stream" power density monitor. Power readings on the Channel No. 1 power meter can be converted to power density at the point of measurement with reference to figure 5.

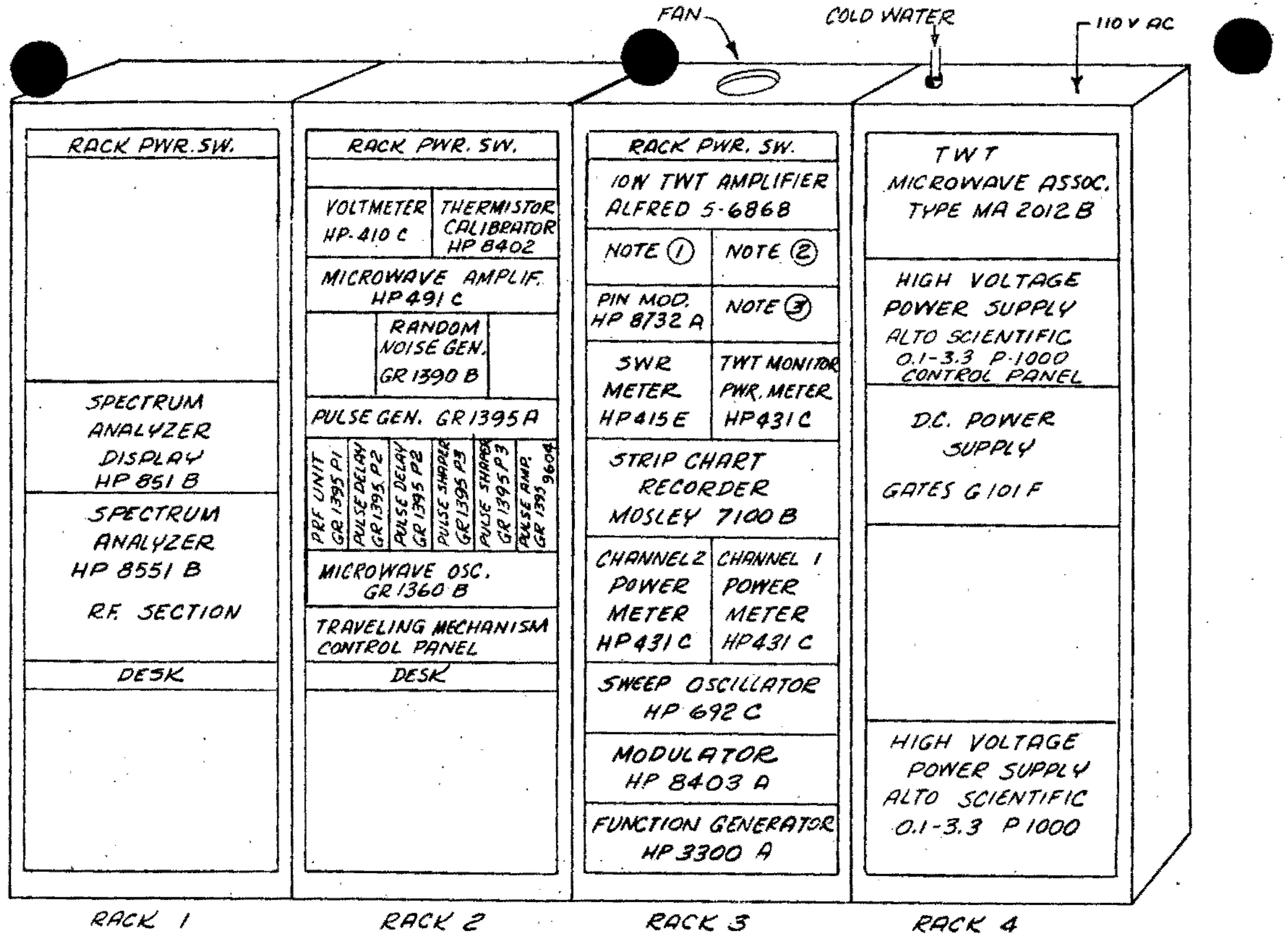
Note: It must be reemphasized that this monitor, in conjunction with figure 5, measures the power density at the point where the monitor is placed in the chamber, and not the power density at the center of the quiet zone as determined in Section III.

B. Monitor Number 2 and Alternate Monitor No. 1

These monitors are available to measure relative power density and for the observation of signal waveforms at any point in the chamber.

By placing monitor number 2, with its alternate monitor line connected, at a point of known power density (previously determined as in Section III or IV A above), and placing alternate monitor number 1, at any other point in the chamber; a gross measurement of power density can be made by observing the relative readings. Due to the nature of the chamber reflections, the power density measured in this manner can be in error by $\pm$ 2 db; however, as a "gross" power density measurement technique, these monitors are useful since they are lightweight and easily movable.

RACK ARRANGEMENT OF PANDORA MICROWAVE EQUIPMENT



NOTE (1) PANEL CONTAINS SWITCHES WHICH CONNECT VARIOUS MONITORED FUNCTIONS TO THE STRIP CHART RECORDER. BEHIND PANEL, BAND PASS FILTER (HP 8431 A), 20 db DIRECTIONAL COUPLER (HP 797D), 10 db FIXED ATTEN. (WEINCHEL 1-10N), XTAL DETECTOR (HP 423A).

NOTE (2) ALFRED 5-6868 OUTPUT VARIABLE ATTENUATOR (NARDA 792).

NOTE (3) HP 692 C SWEEP OSC. OUTPUT VARIABLE ATTENUATOR (NARDA 792).

PANDORA MICROWAVE EQUIPMENT
FUNCTIONAL BLOCK DIAGRAM
FIGURE 2

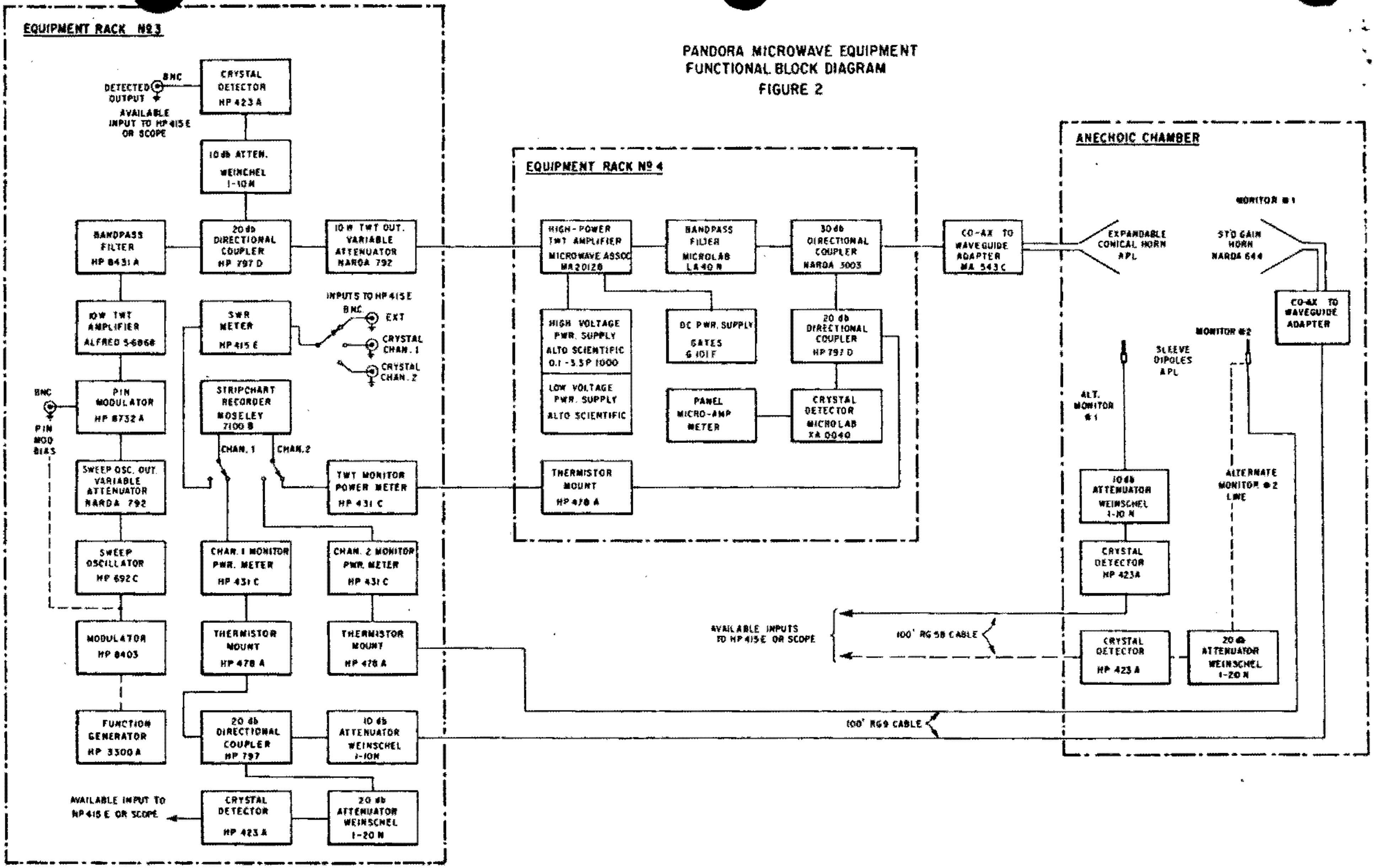
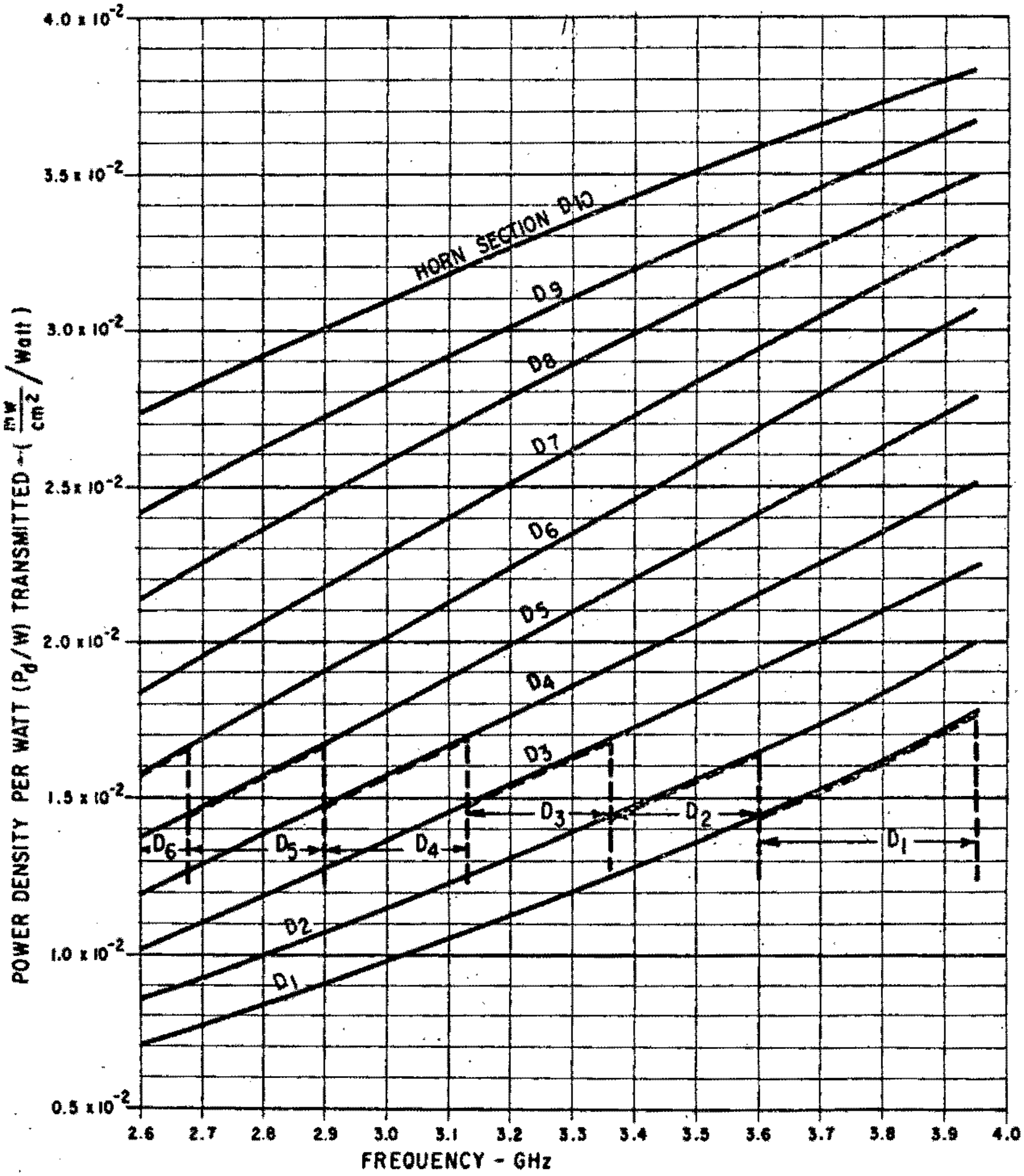


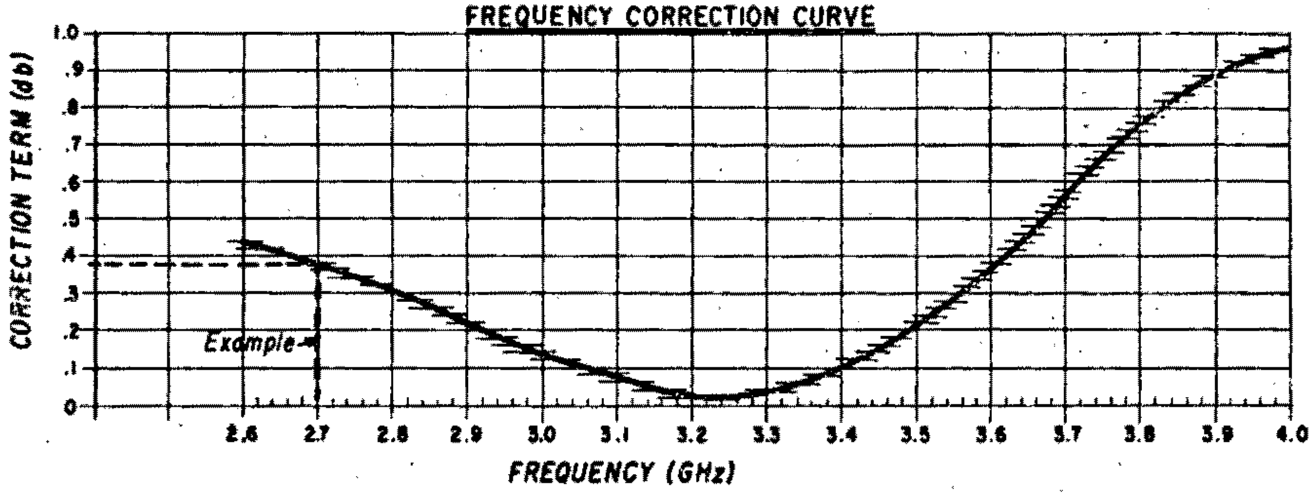
Fig. 3 POWER DENSITY PER WATT TRANSMITTED FOR EACH HORN SECTION



ARROWS SHOW FREQUENCY RANGES

Fig.4 HIGH POWER TWT MONITOR - METER READING Vs TRANSMITTED POWER

FREQUENCY CORRECTION CURVE



TO MEASURE TRANSMITTED POWER:

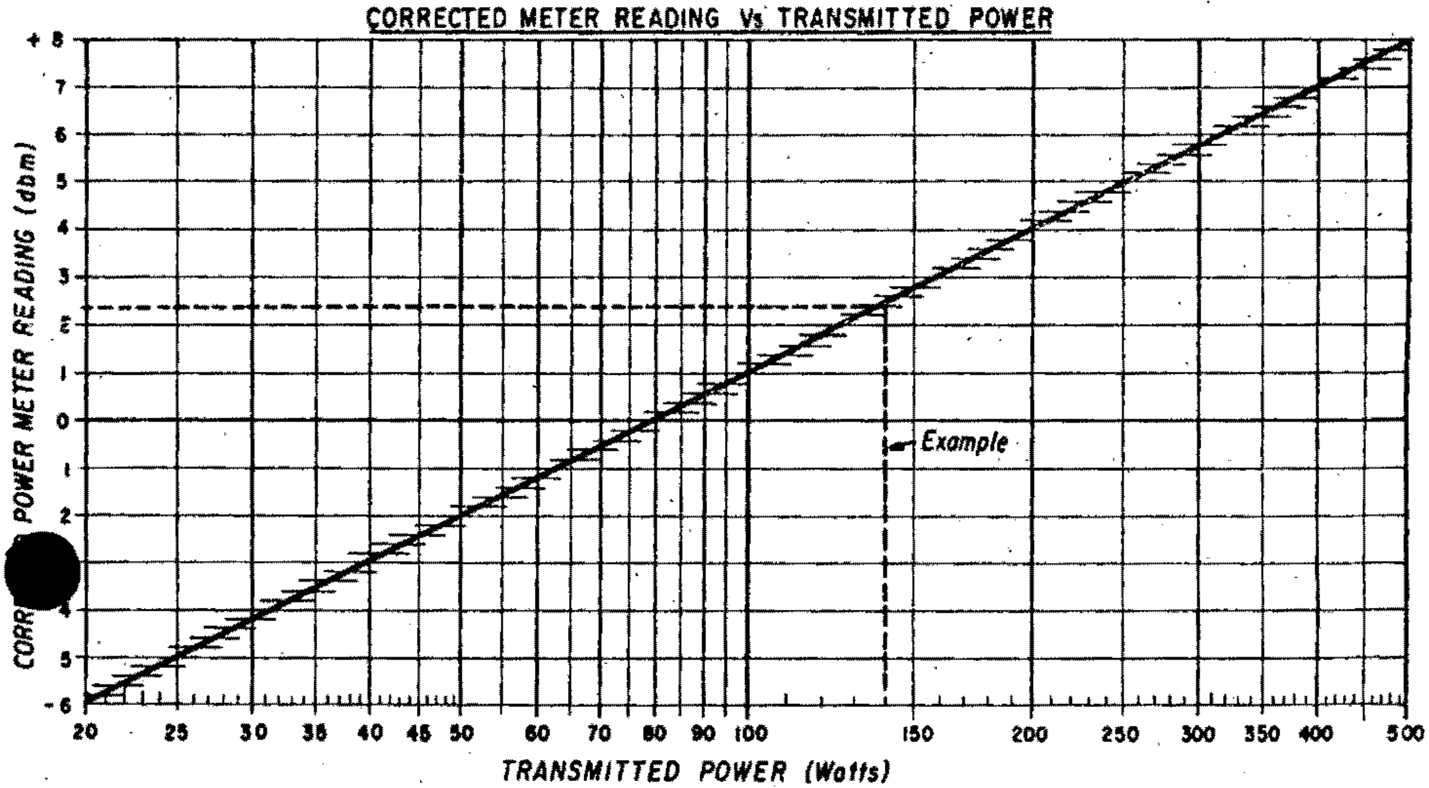
ADD CORRECTION TERM TO TWT MONITOR POWER METER READING.

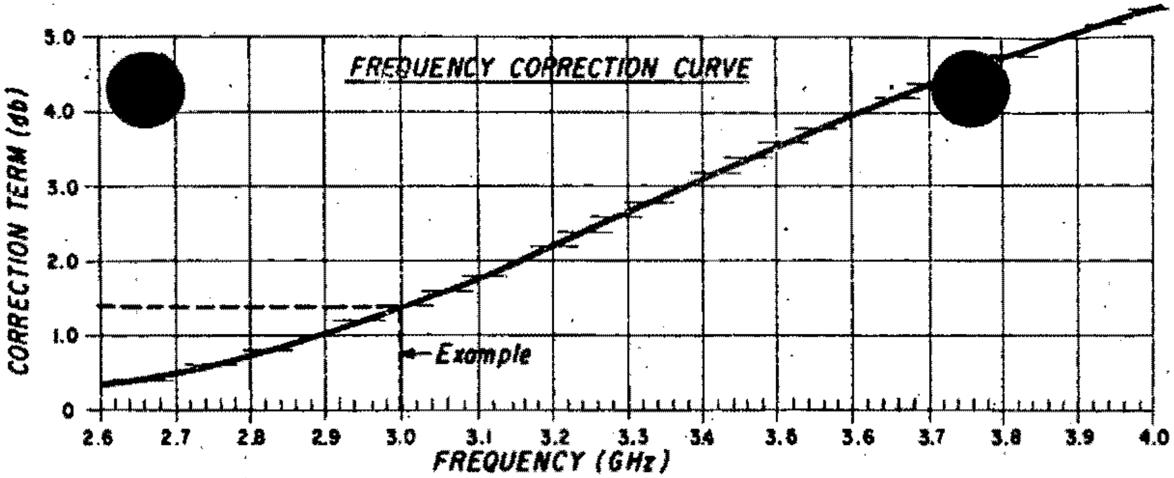
Example: AT 2.7 GHz, THE CORRECTION TERM = .38
POWER METER READING = 2.00
CORRECTED METER READING 2.38 dbm ≈ 140 Watts P_T

TO SET TRANSMITTED POWER:

SUBTRACT CORRECTION TERM FROM CORRECTED METER READING WHICH CORRESPONDS TO DESIRED POWER. ADJUST POWER TO OBTAIN THIS VALUE ON TWT MONITOR POWER METER.

CORRECTED METER READING Vs TRANSMITTED POWER





TO MEASURE POWER DENSITY:

ADD CORRECTION TERM TO METER READI

Example: AT 3.0 GHz, CORRECTION TERM [illegible] db
METER READING = 3.0 dbm
CORRECTED METER READING = 4.4 dbm
4.4dbm ⇔ 3.0 Milliwatts/cm²

TO SET POWER DENSITY:

SUBTRACT CORRECTION TERM FROM METER READING WHICH CORRESPONDS TO REQUIRED POWER DENSITY. ADJUST POWER TO OBTAIN THIS VALUE ON MONITOR CHANNEL № 1 POWER METER.

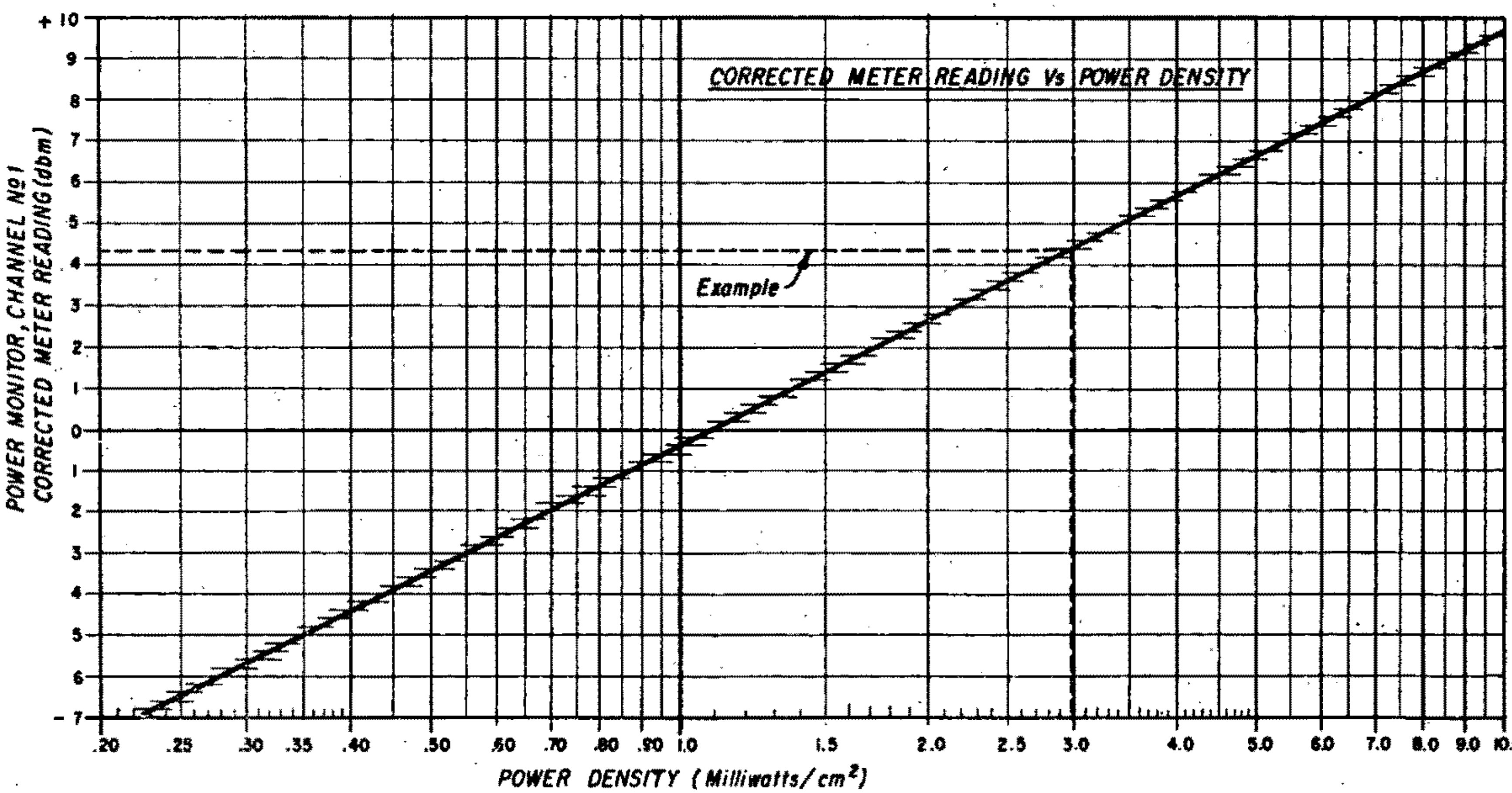


FIGURE 6

Horn Section Dimension

Horn Section	Diameter (inches)
D_1	10.75
D_2	11.75
D_3	13.00
D_4	14.00
D_5	15.25
D_6	16.75
D_7	18.25
D_8	20.00
D_9	22.25
D_{10}	24.5

External Distribution:

P. Tamarkin

R. S. Cesaro/5

H. M. Grove

R. W. Beard

F. Koether

J. Sharp

Internal Distribution:

R. E. Gibson/2

A. Kossiakoff

A. M. Stone

J. W. Follin/2

J. L. Queen

T. C. Cheston

E. V. Byron

Archives/2

MRT-4 File

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

~~SECRET~~

MRT-4-046
QM-66-072
DRC-H-9331-002

PROJECT PANDORA (U)

Final Report

2 4 FEB 1977

THIS DOCUMENT HAS BEEN DOWNGRADED
TO "UNCLASSIFIED"
Per Director DARPA / TIO

~~EXCLUDED FROM AUTOMATIC REGRADING~~
~~DOD DIR 5200.10 DOES NOT APPLY~~

Prepared by
Eugene V. Byron
November 1966

[redacted]
~~SECRET~~

e Johns Hopkins University
LIED PHYSICS LABORATORY
Silver Spring, Maryland

SECRET
MRT-4-046
QM-66-072

ABSTRACT

This is the final report on the Applied Physics Laboratory's contribution to Project PANDORA - specifically, aid in the implementation, and the evaluation of a microwave test facility at Walter Reed Army Institute of Research. An "expandable" conical horn transmitting antenna, and monitor dipole receiving antennas were designed for use in the anechoic chamber constructed by Emerson and Cuming, Inc. A mechanical field traversing mechanism was designed and constructed for the chamber evaluation, the microwave equipment was functionally assembled, and the completed facility was thoroughly evaluated. The evaluation included the measurement of power variations in the quiet zone with and without the sample container (with and without the test sample) in the required position, and the measurement of the power density in the quiet zone using the Microwave Associates high power TWT and the appropriate transmitting horn sections.

[redacted]

SECRET

TABLE OF CONTENTS

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

TABLE OF CONTENTS
(continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS
(continued)

Figure No.	Title	Page

LIST OF TABLES

I. INTRODUCTION

This is the final report on the contribution of the Johns Hopkins University Applied Physics Laboratory, to Project PANDORA - specifically, aid in the implementation and the evaluation of a microwave test facility at the Walter Reed Army Institute of Research, Forest Glen Section. APL's responsibilities were divided into roughly three areas: (1) aid in determining the suitability of the microwave equipment to be procured, and the functional assembly of this equipment (2) the design and fabrication of necessary specialized equipment, - transmitting horn, monitoring dipole antennas, a field traversing mechanism, etc., and (3) the evaluation of the microwave anechoic chamber, the calibration of the measurement equipment, and the test of the completed facility. The test and evaluation of the completed facility included the measurement of the power variations in the quiet zone of the anechoic chamber with and without the sample container (with and without the test sample) in the required position, and the measurement of the power density in the quiet zone.

In addition, a familiarization session was conducted for Army personnel scheduled to operate the facility. A companion report [(1)] describes the operational procedure, the procedure for determining the power requirements and which "add-on" section of the expandable conical horn to use for a desired power density, and a description of the monitoring equipment.

The commerically available microwave equipment was specified and purchased by the Air Force Avionics Laboratory (AFAL), Wright-Patterson AFB, Columbus, Ohio - the program managers. The microwave anechoic chamber was designed and constructed by Emerson and Cuming, Inc., Canton, Mass. The high power microwave traveling wave tube was designed and built by Microwave Associates, Burlington, Mass., with the associated power supplies furnished by Alto Scientific, Inc., Palo Alto, California.

---

(1) "Operational Procedure for Project PANDORA Microwave Test Facility" APL/JHU Report MRT-4-045; (QM-66-071) dated October 1966 (U)

II. DESCRIPTION OF THE MICROWAVE FACILITY

The microwave test facility implemented at Walter Reed consists of a microwave anechoic chamber, an expandable conical transmitting horn attached to one end wall of the chamber, and the microwave control and monitoring equipment installed in four equipment racks which are housed in the control room adjacent to the transmission end of the chamber. Also, a standard gain horn power monitor, and two sleeve dipole monitoring antennas are installed in the microwave chamber.

The facility was designed to operate at S-Band, with conversion potential through X-Band, such that a suitable quiet zone - minimum dimensions, 3' wide x 2' high x 1' deep, for two test samples side by side - would be illuminated uniformly; a power density of 2 mw/cm^2 $\pm$ 1.0 db over the frequency band was the design goal, with a potential for a power density of 10 mw/cm^2 over a reduced volume and a fixed frequency.

A. MICROWAVE ANECHOIC CHAMBER

The microwave anechoic chamber (Eccosorb Anechoic Chamber No. 650) is approximately 15' wide by 15' high by 35' long. The proposed four foot cubic quiet zone is symmetric about a point 25 feet from the transmitting end wall, and equidistant between the floor, ceiling and side walls. Figure 1 is a photograph of the chamber; figure 2 is the general arrangement drawing, and also shows the mounting detail for the transmitting horn.

The design requirements for the chamber specified that the power variations should not exceed $\pm$ .25 db superimposed on the transmitted gain "droop" measured in the quiet zone with an absorber backed dipole over the frequency band of interest. As noted in Section III of this report, these values were not realized, and power "amplitude ripples" as great as $\pm$ 1.0 db were observed. The chamber evaluation showed that for the minimum quiet zone dimensions - 3' wide x 2' high x 1' deep, - power variations of

$\pm$ 1.75 db were possible over the S-Band frequency range. When a standard gain horn was used as the field probe instead of the absorber backed dipole, considerable improvement was observed; amplitude ripples were less than $\pm$ 0.25 db. This is discussed further in Section III.

B. MICROWAVE EQUIPMENT

The microwave equipment is assembled in the four racks shown in figure 3. Equipment rack number one contains the Spectrum Analyzer R. F. and Display sections. Rack number two contains the auxiliary low power microwave generation and modulation equipment, and some ancillary equipment, in addition to the control panel for the field traversing mechanism. Rack number three contains the primary low-power microwave generation and modulation equipment, and the necessary monitoring and recording equipment. Rack number four contains the high power microwave amplifier and associated power supplies and R. F. power monitors.

The equipment in rack number two is not interconnected (nor is the spectrum analyzer). The interconnection of racks number three and four with the expandable conical horn is shown in figure 4 which is a functional block diagram of the microwave system. Also shown in this figure are the "downstream" power monitors in the anechoic chamber.

All of the equipment assembled in racks number two and three are commercial "off the shelf" units (traveling mechanism control panel excepted) and constitutes the best and most versatile, in terms of possible R. F. modulations, microwave equipment available. This was particularly necessitated by the unknown nature of the desired signal for an experimental facility. These units were specified and purchased by the program managers (AFAL). Compatability and suitability of this equipment was monitored by APL and the equipment was functionally assembled and tested at APL and delivered as a unit to Walter Reed.

The high power microwave amplification equipment in rack four was purchased under separate contract (from AFAL) to Microwave Associates and was delivered as a unit.

C. TRANSMITTING HORN

The transmitting horn characteristics were dictated by the dimensions of the quiet zone to be uniformly illuminated. This design rationale and the test results are discussed in Appendix A of this report. In order to provide a constant gain and beamwidth over the desired frequency band, "add-on" sections were provided as depicted in figure 5.

The first section of this "expandable" conical horn incorporates a rectangular to circular transition obviating the need for a separate rectangular to circular waveguide transition.

Gain measurements and antenna patterns were taken for each horn section at the center, and at the low and high ends of the S-Band frequency range. The results of these measurements are summarized in figures 6, 7, 8, and 9. Figure 6 shows the absolute gain of each of the sections across the frequency band. Also shown, is the design frequency range for each section. Figures 7 and 8 show the E and H plane 3 db beamwidth respectively, and figure 9 is a typical E and H plane pattern (section D3) in its design frequency range.

D. POWER MONITORING

One of the prime requirements for the microwave test facility was the ability to accurately determine the power density in the quiet zone of the anechoic chamber and to observe the transmitted signal, within the limits afforded by commercially available test equipment.

Three monitoring channels were incorporated in the system, and several coupled outputs are available for observing signal wave form, either on an oscilloscope (detected outputs), or directly on the spectrum analyzer (see figure 4).

1. Transmitted Power Monitor

To measure the transmitted power, two coaxial directional couplers and a thermistor mount were installed in the high power equipment rack (figure 4). The thermistor output is connected to the HP 431C power meter in rack number three. The loss in this coupled transmission path was measured over the S-Band frequency range. The resultant calibration was incorporated with the measured loss of the output cable and the waveguide to coax adapter on the transmitter horn, to plot the transmitted power curve shown in figure 10. This curve is a plot of corrected power meter reading versus transmitted power. Included in this figure is the legend for determining transmitted power from the corrected meter reading, and conversely, the method for setting the transmitted power by observing the meter reading. This figure in conjunction with figure 11 (Power Density per Watt Transmitted for Each Horn Section) can be used to determine the on boresight power density in the quiet zone. This is explained in greater detail in section II E.

2. Standard Gain Horn Monitor

The standard gain horn monitor (monitor number 1 in figure 4), is the primary "downstream" power density monitor. The gain deviation versus frequency curve of the standard gain horn, and the measured loss of the connecting cable and waveguide to coaxial adapter were incorporated into one frequency correction curve, shown in figure 12. This figure is a plot of the power density as a function of the corrected power meter reading. The power density thus measured is the power density at the position where the standard gain horn is placed in the chamber, and not the on boresight power density alluded to in the section above. It is possible to measure the power density in the anechoic chamber directly, only if the horn monitor can be physically placed at the desired position without interfering with the experiment in progress. If this is not possible, then the power density can be determined by extrapolating the measured power density, to the power density at any other position in the quiet zone by using the known gain-beamwidth characteristics of the transmitting horn section. In a similar fashion, the on boresight power density determined from the measured transmitted power can be extrapolated to any point in the quiet zone. The determination of power density for other than on boresight (and measured) conditions is discussed in Section II F.

3. Monitor Dipoles

In addition to the standard gain horn monitor, two sleeve dipole monitors are available in the chamber for the observation of signal waveforms. These dipole monitors are shown in figure 13. The design dimensions and the measured results are discussed in Appendix B.

It was originally intended that these dipoles would be calibrated and used to measure the absolute power density at any position in the chamber. Unfortunately, the rather large amplitude ripples caused by the reflections from the chamber walls, precluded this possibility. (The standard gain horn integrates the ripples over its considerably larger area and, consequently, was substituted as the prime power density monitor.) However, since the dipoles are light-weight and easily movable, they were retained for signal waveform observation, and for the "gross measure" of power density. Since the two monitors have identical characteristics, by placing one at a region of known power density, and placing the other at any desired position, the power density at any position can be determined. This is a "gross measurement" because the amplitude ripples can cause an error as great as 2.0 db.

E. SELECTION OF TRANSMITTING HORN SECTIONS

As stated previously, the microwave facility was designed such that a suitable quiet zone - minimum dimensions, 3' wide by 2' high by 1' deep for two test samples side by side - would be uniformly illuminated; a $\pm$ 1.0 db power variation in the quiet zone was the design goal. The quiet zone starts at a transmission length of 23.0' and is symmetric about the chamber horizontal and vertical axis.

1. Design Frequency Range

As discussed in Appendix A, the quiet zone dimensions set the beamwidth characteristics of the transmitting horn; and a conical transmitting horn with "add-on" sections was designed to give maximum gain with the required beamwidth over the S-Band frequency range. Under these conditions, figure 11 shows the "design frequency range" for the appropriate sections (D1 through D6). This figure is a plot of power density (in mw/cm^2) per watt transmitted - Pd/W - versus frequency for each of the horn sections at a transmission length of 23.0 feet. These curves are obtained by plotting the expression:

$$\frac{P_r}{A_r} \times \frac{1}{P_T} = \frac{G_T}{4\pi R^2} \equiv \frac{Pd}{W} \quad \text{as a function of frequency,}$$

where G_T is the measured gain of each of the transmitting horn sections, and R = 23.0 feet is the transmission length. Thus $\frac{P_r}{A_r} \times \frac{1}{P_T}$ is the power density per watt transmitted when P_T is the transmitted power.

It can be seen from figure 11 that, for the design frequency ranges, Pd/W is $1.6 \times 10^{-2}\ \frac{mw/cm^2}{watt} \pm 10\%$. For 250 watts of transmitted power - the recommended upper limit for continuous operation of the high power TWT - the power density is 4.0 $mw/cm^2 \pm 10\%$, which adequately meets the design goal of 2 mw/cm^2 in the quiet zone.

Neglecting reflections in the chamber, the power density variation for angles off boresight is dependent upon the transmitting horn section used (the gain), the frequency, the angle, and the transmission length. The change in relative amplitude versus frequency for angles of 2, 4, and 6 degrees for each of the horn sections is shown in figures 14 and 15. The change in relative amplitude is defined as the maximum relative power amplitude at a designated frequency (the gain at boresight), minus the relative amplitude at the off boresight angle indicated, at the same frequency. The curves were obtained from the measured antenna patterns. Thus, the curves in figures 14 and 15 show the change in power density, for a fixed transmitted power and transmission length, at the angles indicated for each of the horn sections. For the minimum quiet zone dimensions, starting at a transmission length of 23', the maximum off boresight angle, in the H plane (vertical polarization) is:

$\theta_H = \pm \tan^{-1} \frac{1.5}{23} = \pm 3.75^\circ$, and in the E plane $\theta_E = \pm \tan^{-1} \frac{1}{23} = \pm 2.5^\circ$.

It can be seen from figure 14 that in the design frequency range, the maximum change in relative amplitude is 0.75 db, which occurs for horn section D1 at frequency 4.0 GHz, (H plane, 4 degrees). Adding another 0.4 db due to the change in transmission length in the quiet zone (one foot deep), the total change in relative amplitude, and hence the change in power density for a fixed power transmitted, is 1.15 db ($\approx \pm .6$ db) which is well within the $\pm$ 1.0 db goal set for the quiet zone.

For a quiet zone 4' wide x 3' high x 1' deep ($\theta_H \cong \pm 5^o$, $\theta_E \cong \pm 4.0^o$), the power density would be within $\pm$ 1.0 db (neglecting reflections). This was borne out by the chamber evaluation discussed in Section III.

2. Horn Sections for Higher Power Densities

To increase the versatility of the facility, additional "add-on" horn sections were designed to uniformly illuminate successively smaller quiet zone volumes with increased gain. Thus, at the upper end of the frequency band (3.95 GHz) horn section D10 will illuminate uniformly ($\approx \pm .5$ db) a quiet zone large enough for a single test sample - 1.5' wide x 1' high x 1' deep. This can be determined from figure 15 where for D10 and $\theta_H = \pm 2^o$, $\theta_E = \pm 1^o$, $\Delta A = .5$ db. At this frequency, D10 gives the maximum power density obtainable for the system. From figure 11, for horn section D10 at 3.95 GHz, $Pd/W = 3.83 \times 10^{-2}$, and the power required for a power density of 10 mw/cm² is: $\frac{10}{3.83 \times 10^{-2}} = 260$ watts which is obtainable from the high power TWT in the system.

F. DETERMINATION OF POWER DENSITY

As discussed in Section II D, the power density can be determined by direct measurement using the standard gain horn monitor and figure 12, if the monitor can be physically placed at the desired position. The on boresight power density can also be determined from the measured transmitted power and figure 11. From the discussion in Section E above, it can be seen that this value will be correct to better than $\pm$ 1.0 db for any point in the quiet zone in the design ranges.

In using the larger section to illuminate the 3' wide by 2' high by 1' deep quiet zone, the power density at any position can be determined from the on boresight power density/watt transmitted curve (figure 11), and the ΔA curves given in figures 14 and 15.

As an example, for horn section D10 with 200 watts transmitted at 3.95 GHz, the power density at boresight is Pd = Pd/W x power transmitted. Pd/W = 3.83×10^{-2} from figure 11, therefore, Pd = 7.66 mw/cm^2. At the edge of the 3' quiet zone, $\theta_H = \pm \tan^{-1} 1.5/23 = \pm 3.75^{\circ}$. Interpolating from figure 15 for D10, $\theta_H = \pm 3.75$; ΔA is approximately - 2.25 db = 60% of the maximum amplitude, and the power density is approximately 7.66 x 60% = 4.56 mw/cm^2 at the quiet zone edge.

In a similar manner, the on boresight power density can be determined from the measured power density at any point in the quiet zone. Actual values measured during a preliminary experiment are used as an example. The standard gain horn monitor was placed 2.5' off boresight in azimuth, and its meter reading was 2.4 dbm. From figure 12, at 3.2 GHz (the transmitted frequency) the frequency correction term is 2.2 db. Thus, the corrected meter reading is + 2.4 dbm + 2.2 db = 4.6 dbm, which (from figure 12) corresponds to a power density of 3.1 mw/cm^2 at the point of measurement. The monitor horn position gives a $\theta_H = \pm \tan^{-1} 2.5/23 = \pm 6.1^{\circ}$, and from figure 14 for $\theta_H = 6^{\circ}$ and horn section D6 (the horn section used) ΔA = 1.9 db = 65%. Therefore, the on boresight power density is 3.1 mw/cm^2 x $\frac{1}{65\%}$ = 4.78 mw/cm^2. For this experiment, the measured transmitted power (210 watts) gives an on boresight power density of 4.72 mw/cm^2 (from figure 11) which is in good agreement with the above calculated value (4.78 mw/cm^2).

III. EVALUATION: PROCEDURE AND RESULTS

The evaluation of the microwave test facility was divided in three phases: (1) the evaluation of the reflection from the walls and ceiling of the empty microwave chamber as measured with an absorber backed dipole and a standard gain horn, (2) the measurement of the reflections from a single sample container (both occupied and unoccupied) in the quiet zone and (3) the measurement of the power density in the chamber using the high power source and the various horn sections.

A. MICROWAVE CHAMBER EVALUATION

The results of the evaluation of the microwave anechoic chamber are summarized in Table I. It can be seen from this tabulation, that for the required minimum quiet zone dimensions - 3' Wide x 2' High x 1' Deep - a total power variation of ± 1.75 db is possible over the frequency band of interest. At selected frequencies, adequate quiet zones with ± 1.25 db variations are possible. The measurements, performed with an absorber backed dipole, indicate that the power variations are primarily due to "amplitude ripples" caused by reflections from the chamber walls. Maximum ripples as great as ± 1.0 db were observed. Figure 16 is a typical example of the power variation due to reflections. This data is for a 25' transmission length at F = 3.25 GHz.

The values obtained with a standard gain horn at 3.25 GHz (gain = 16.5 db) are also shown in Table I, (from figure 21) as an example of the optimistic conclusions resulting from the use of a large area receiving antenna. The horn integrates the reflected ripples over a receiving area considerably larger than that of the dipole. Maximum ripples as observed with the standard gain horn were less than ± 0.25 db.

The chamber was evaluated by taking horizontal cuts, through the 4 foot cubic quiet zone which is centered equidistant between the side walls, and the floor and ceiling; a distance 25.0' from the transmitting end wall. The horizontal cuts extending ± 2.0' from this quiet zone center, were taken at elevation increments of ± 1.0', ± 1.5', and ± 2.0' for each transmission length increment of ± 1.0', ± 1.5', and ± 2.0' from the 25.0' center point. These measurements were repeated at each of the six different frequencies in the design range of each of the horn sections. Relative power as a function of horizontal distance was recorded on an X-Y recorder, equipped with a roll chart adapter, for each of the measurement increments.

TABLE I

Quiet Zone Volumes and Power Variations

que Sec	Volume Dimensions for Power Variations of: ±1.0db	±1.25db	±1.5db	±1.75db	±2.0db	≥±2.25db
6GHz D6)	None	None	2'Wx2'Hx3'D	4'Wx3'Hx1'D 3'Wx3'Hx3'D	4'Wx4'Hx1'D 4'Wx3'Hx2'D 4'Wx2'Hx3½'D 3'Wx4'Hx2'D	4'Wx4'Hx4'D (2.75db)
8GHz D5)	2'Wx3'Hx1'D	4'Wx3'Hx1'D 3'Wx2'Hx2'D 2'Wx3'Hx2'D 2'Wx4'Hx½'D	4'Wx3'Hx2'D 3'Wx4'Hx1'D 3'Wx3'Hx3½'D 2'Wx4'Hx2'D	4'Wx3'Hx3'D 3'Wx4'Hx3½'D 3'Wx3'Hx4'D 2'Wx4'Hx4'D	4'Wx4'Hx4'D	
0GHZ D4)	3'Wx2'Hx½'D	4'Wx2'Hx1'D 3'W'3'Hx1'D 3'Wx2'Hx3'D	4'Wx3'Hx1'D 3'Wx3'Hx2'D 3'Wx2'Hx4'D 2'Wx4'Hx2'D	4'Wx3'Hx2'D 3'Wx4'Hx3½'D 3'Wx3'Hx4'D	4'Wx4'Hx1'D 3'Wx4'Hx4'D	4'Wx4'Hx4'D (2.5db)
25G D3)	3'Wx2'Hx1'D	4'Wx2'Hx2'D	4'Wx3'Hx1'D 4'Wx2'Hx3'D 3'Wx2'Hx3½'D	4'Wx4'Hx1'D 4'Wx3'Hx3'D 4'Wx2'Hx4'D 3'Wx3'Hx4'D	4'Wx4'Hx2'D 4'Wx3'Hx4'D 3'Wx4'Hx3'D	4'Wx4'Hx4'D (2.25db)
25GHz D3) rd Gain rn	4'Wx3'Hx1'D 3'Wx2'Hx2	4'Wx4'Hx1'D 4'Wx3'Hx3'D Many others	Great many options	4'Wx4'Hx4'D		
45GHz D2)	None	None	2'Wx4'Hx1'D 2'Wx2'Hx2'D	3'Wx4'Hx1'D 3'Wx2'Hx3½'D 2'Wx4'Hx2'D 2'Wx3'Hx4'D	4'Wx4'Hx2'D 4'Wx2'Hx3'D 3'Wx3'Hx4'D	4'Wx4'Hx4'D (2.25db)
8GHz D1)	2'Wx2'Hx½'D	3'Wx2'Hx½'D 2'Wx3'Hx2'D	4'Wx2'Hx1'D 3'Wx2'Hx3'D 2'Wx3'Hx4'D	4'Wx4'Hx½'D 4'Wx3'Hx4'D	4'Wx4'Hx4'D	

= Width H = Height D = Depth

otes:

All quiet zone volumes start at a transmission length of 23 feet and are symmetric about the chamber width and height center points.

(2) Underlined are the volumes with minimum variations whose dimensions are ≥minimum required values (3'Wx2'Hx1'D)

of missing "worst point" cases, it is felt that the very large number of data points measured represents a good statistical sampling, and the conclusions summarized in Table I are representative of the chamber behavior.

B. EVALUATION OF TEST SAMPLE CONTAINER AND TEST SAMPLE IN THE CONTAINER

1. Test Sample Container

Tests were conducted with a single test sample container in the quiet zone. For the container having no microwave absorbing liner, fairly large amplitude ripples resulted (greater than ± 5.0 db). With the container almost completely lined with a microwave absorber (the "radiation window" excepted), these variations are reduced to approximately ± 3.5 db. Removing the plexiglass back that was on the container (the container is irradiated from the back) and replacing it with a thin plexiglass back (1/16" thick) further reduced these variations to approximately ± 2.5 db. By absorber lining certain braces that are within the radiation window (and cannot be removed), the perturbations are reduced still further, to approximately ± 2.0 db, however, portions of the radiation window are blocked. In any event, the test sample in the container perturbs the field in some different manner and the question arises as to what constitutes a valid set of measurements: the sample and container immersed into an unperturbed field, or the sample placed in an unperturbed field within the container (if this were possible). In either case (the test sample and container, or the sample alone), complex multiple reflections result.

Consideration should be given to the possibility of constructing a suitably lossy microwave container with a radiation window of the desired dimensions.

2. Evaluation Procedure

The evaluation of the test sample container in the microwave chamber was performed by mounting the container in the center of the four foot cubic quiet zone (at a transmission length of 25.0 feet) on the horizontal traversing mechanism. A monitor dipole was placed at a transmission length of 23.0' on the horizontal and vertical center point. Received power was recorded as a function of the horizontal traverse of the container in the quiet zone. The dipole was then moved toward the container in 3-inch increments and the measurement repeated. This procedure was repeated for several different elevations of the monitor dipole and several different frequencies. The test sample container was moved behind the dipole monitor, rather than the monitor being moved in front of the container, because, in the latter case, the traversing mechanism would "shadow" the container. Typical results of the container evaluation are shown in figure 24.

To mount the container at the proper elevation level, the traversing mechanism was fitted with an absorber pedestal, upon which the container was placed. The pedestal by itself (and the traversing mechanism) was evaluated as described above with negligible perturbations of the R. F. field resulting.

3. Test Sample

The evaluation of a single test sample in the test sample container was performed in a manner identical to the procedure described above. Results of these tests show that the sample in the container does not greatly increase the magnitude of the field perturbations over those observed for the container alone - ± 2.88 db versus ± 2.63 for the two cases respectively - however, the phase of the reflections is changed such that where a maximum was observed without the test sample, a minimum might now exist. Table II, below, is a summary of the evaluation of the test sample and the test sample container.

TABLE II

Summary of Sample Container and Sample-in-Container Measurements

	Test Condition	Field Variation (Worst Case*)
A.	Sample Container Alone	
	Absorber Lined Container (3/8' plexiglass back)	± 3.63 db
	" " " (no back)	± 4.88 db
	" " " (1/16" plexiglass back)	± 2.63 db
B.	Sample in Sample Container	
	Absorber Lined Container (1/16" plexiglass back)	± 2.88 db
C.	Sample Alone**	± .88 db

* Worst Case = greatest maximum to greatest minimum power variation in the quiet zone, for all positions of dipole monitor (see figure 24).

** Perturbations due to Sample movement alone, container and dipole monitor stationary.

C. POWER DENSITY

The final evaluation phase of the microwave test facility was the measurement of the power density in the quiet zone, utilizing the complete microwave chain.

The power density was measured with the standard gain horn monitor as outlined in Section II F, for various frequencies, and for values of transmitted power between 200 and 300 watts with the appropriate horn sections. These measured values were compared with the power density calculated from the measured transmitted power and the gain of the horn sections. The results are summarized in Table III.

TABLE III

Measured versus Calculated Power Densities

Freq. (GHz)	Tx. Horn Section	Tx. Horn Gain	Measured Tx. Power (Watts)	Calc. Power Density -mw/cm² ($P_T G_T / 4\pi R^2$)	Measured Power Density mw/cm²	Δ = Calc.-Meas.
2.6	D6	99.6	228	3.40	3.70	-0.30
2.7	D6	105.0	226	3.55	3.90	-0.35
2.7	D5	91.2	220	3.0	3.0	0.00
2.8	D5	95.6	216	3.09	3.2	-0.11
2.9	D5	102.0	210	3.20	2.9	+0.30
2.9	D4	89.0	236	3.14	2.85	+0.29
3.0	D4	93.5	234	3.27	3.1	+0.17
3.1	D4	100.0	232	3.47	3.35	+0.12
3.2	D3	93.5	226	3.16	3.0	+0.16
3.3	D3	100.0	232	3.47	3.45	+0.02
3.4	D2	91.2	232	3.17	3.0	+0.17
3.6	D2	102.0	236	3.61	3.6	+0.01
3.6	D1	89.0	245	3.27	3.6	-0.33
3.7	D1	95.6	260	3.71	3.6	+0.11
3.8	D1	100.0	278	4.16	4.15	+0.01
3.9	D1	105.0	250	3.93	4.0	-0.07
3.95	D1	110.0	250	4.12	4.35	-0.23
4.0	D1	112.0	250	4.19	4.25	-0.06

NOTE: For these measurements R = 24.0'

D. CONCLUSION

The microwave equipment at the Walter Reed facility is capable of producing a power density of approximately 4.0 mw/cm^2 in a quiet zone adequate for two test samples side-by-side (3'W x 2'H x 1'D) over the S-band frequency range, with a transmitted power of 250 watts - the recommended upper limit for continuous operation of the high powered traveling wave amplifier.

For reduced quiet zone volumes, a power density of 10 mw/cm^2 is possible.

When evaluated with an absorber backed dipole, total power variations of $\pm$ 1.75 db were observed in the 3'W x 2'H x 1'D quiet zone over the S-Band frequency range, primarily due to reflections from the chamber walls ($\pm$ 1.0 db). Using a standard gain horn as the field probe reduces the observed "ripples" to less than $\pm$ 0.25 db.

For a single test sample in an absorber lined test sample container, field variations of $\pm$ 2.63 db were measured. The movement of the sample alone produced variation of $\pm$ 0.88 db in the power measured with the dipole antenna.

SECRET

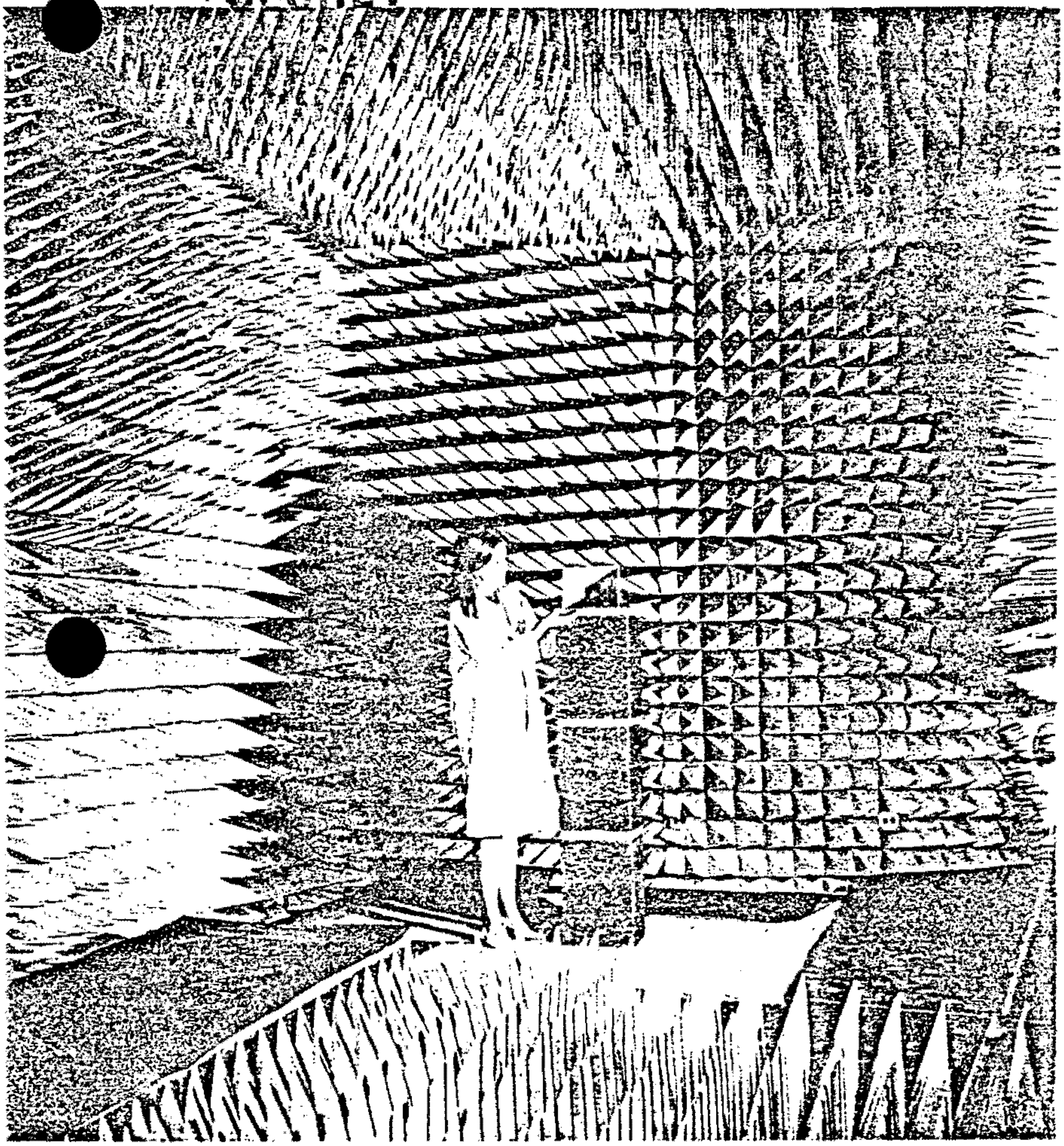


Fig. 1 MICROWAVE ANECHOIC CHAMBER

SECRET

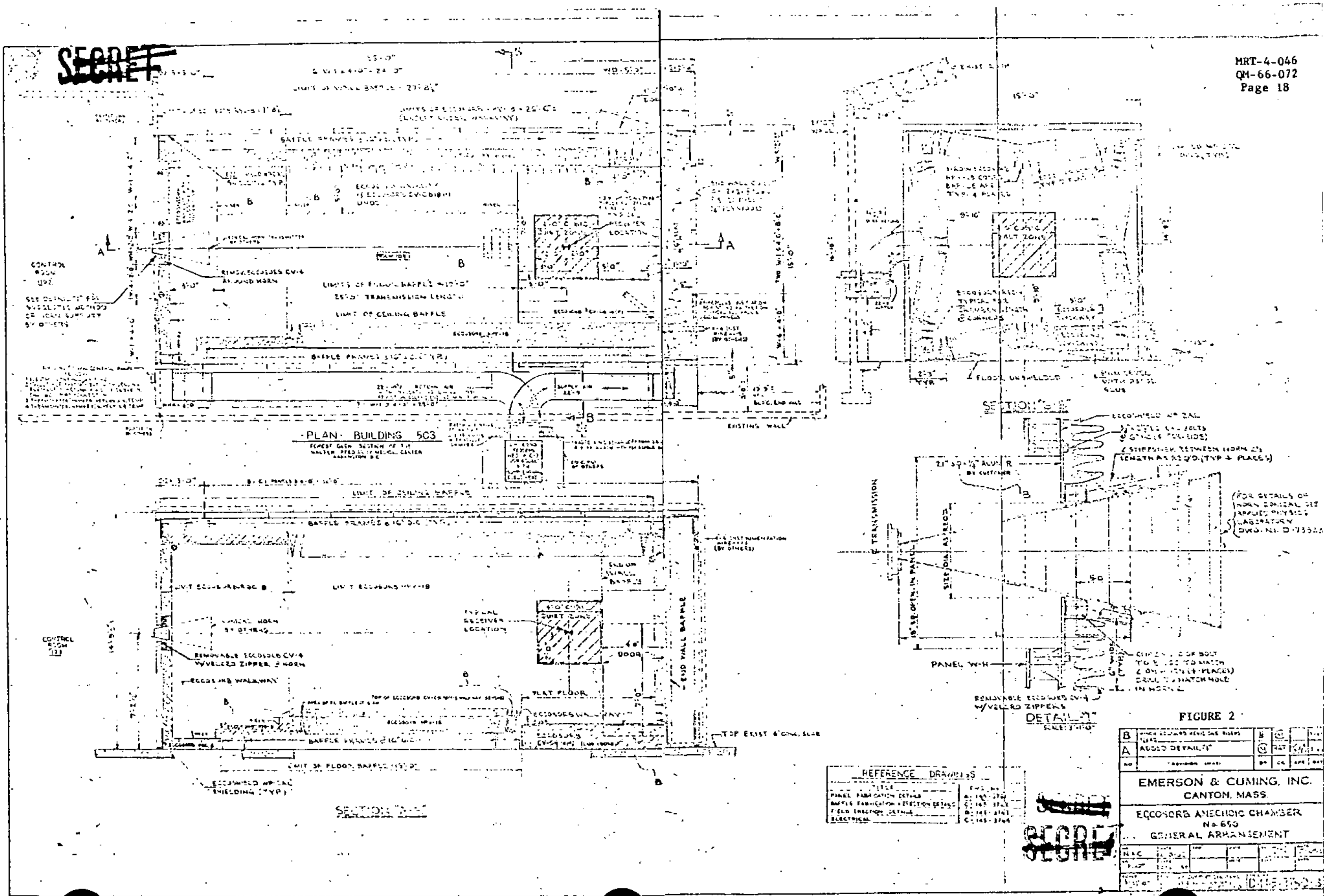

SECRET
PLAN BUILDING 503
SECTION "B-B"
SECTION "A-A"
DETAIL "Y"
REFERENCE DRAWINGS
EMERSON & CUMING, INC.
CANTON, MASS.
ECCOSORB ANECHOIC CHAMBER
No. 650
GENERAL ARRANGEMENT
SECRET

FIGURE 2

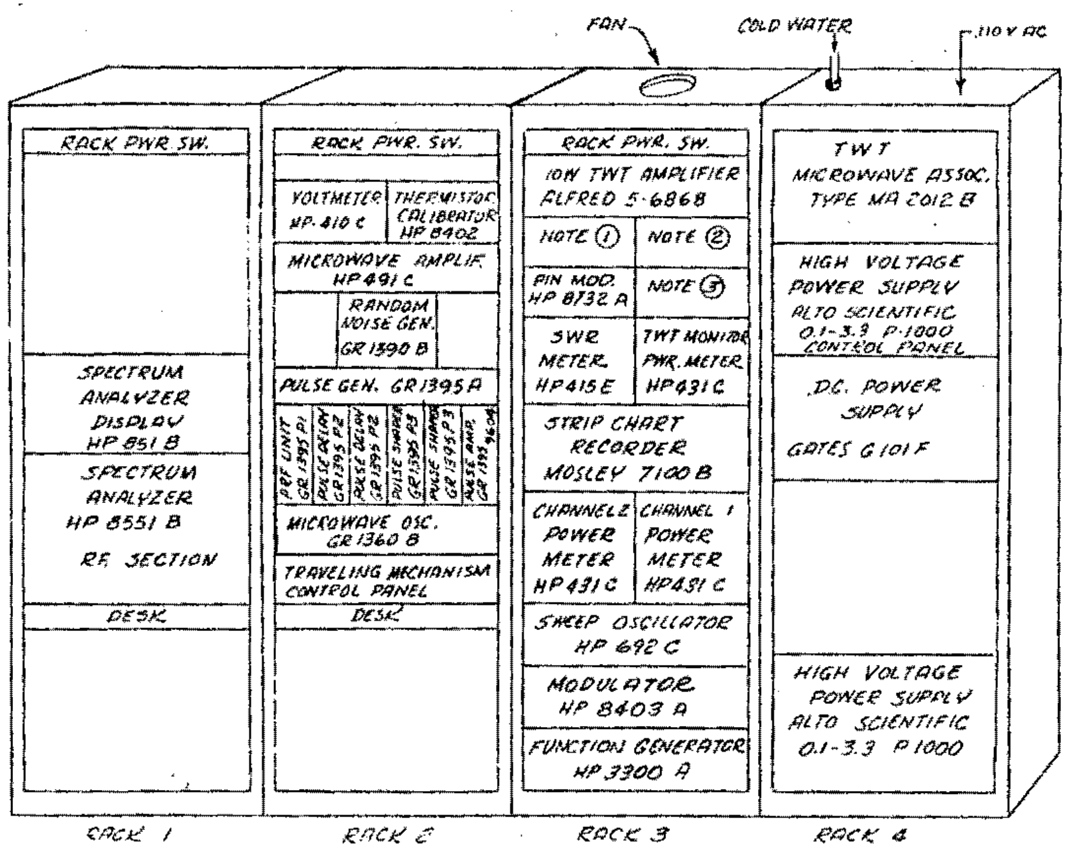


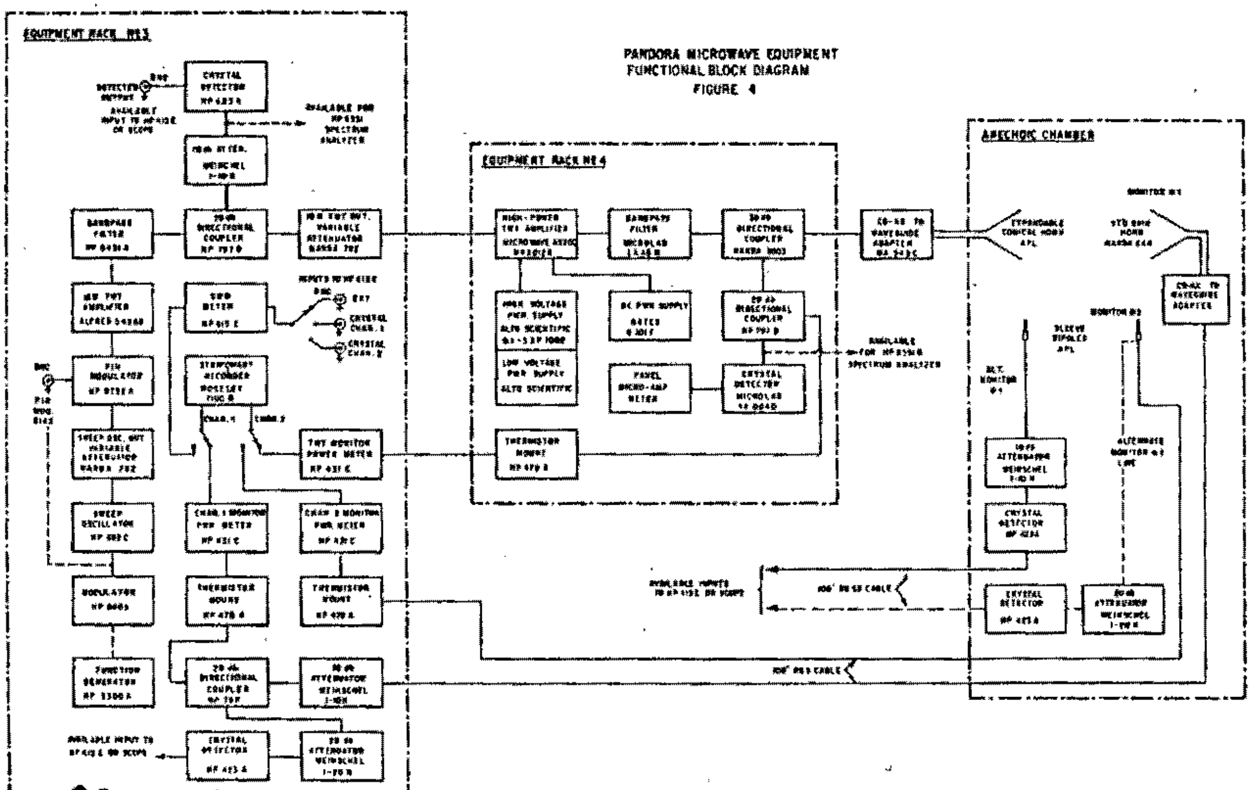
FIGURE 3
RACK ARRANGEMENT OF PANDORA MICROWAVE EQUIPMENT

NOTE ① PANEL CONTAINS SWITCHES WHICH CONNECT VARIOUS MONITORED FUNCTIONS TO THE STRIP CHART RECORDER. BEHIND PANEL, BAND PASS FILTER (HP 8431 A), 20 db DIRECTIONAL COUPLER (HP 7770), 10 db FIXED ATTEN. (WEINCHEL 1-10N), XTAL DETECTOR (HP 423A).
NOTE ② ALFRED 5-6868 OUTPUT VARIABLE ATTENUATOR (NARDA 792).
NOTE ③ HP 692 C SWEEP OSC. OUTPUT VARIABLE ATTENUATOR (NARDA 792).

SECRET

SECRET

PANDORA MICROWAVE EQUIPMENT
FUNCTIONAL BLOCK DIAGRAM
FIGURE 4

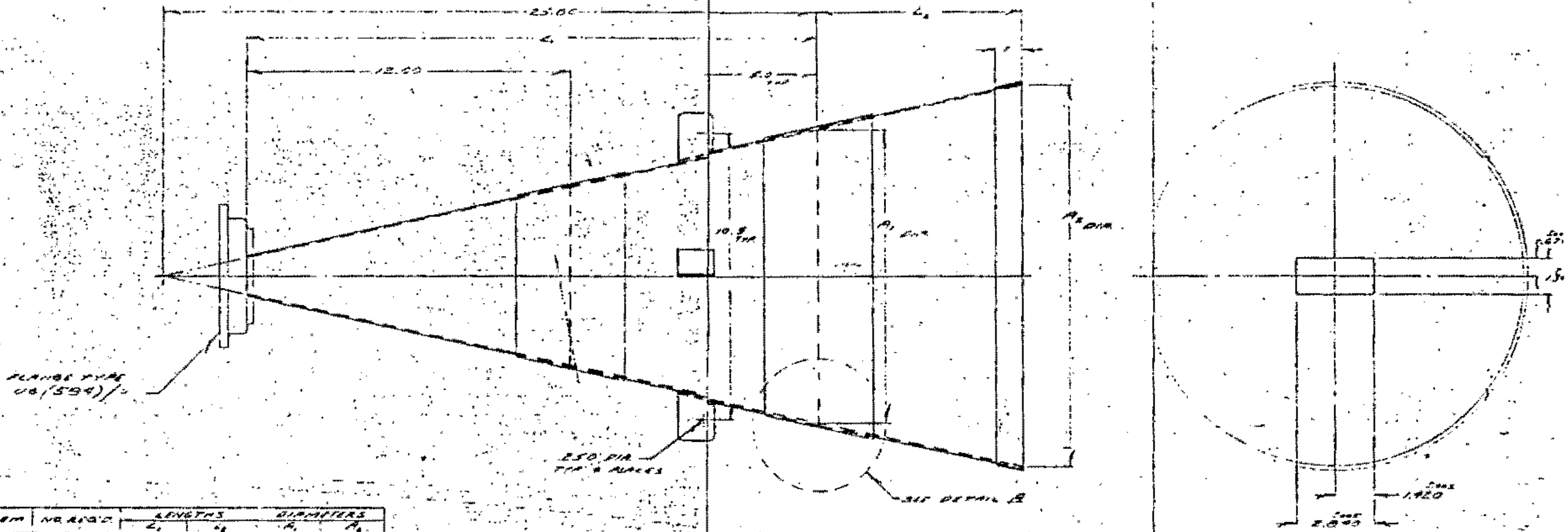


SECRET

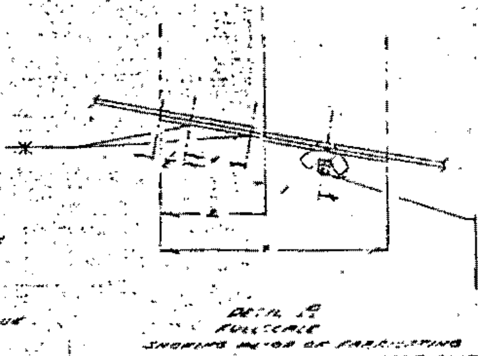
SECRET

SECRET

DO NOT SCALE



ITEM	NO. REQ'D.	LENGTHS L_1	LENGTHS L_2	DIAMETERS A_1	DIAMETERS A_2
A	1	21.87		10.75	
B	1		2.25	10.75	11.75
C	1		5.25	"	13.00
D	1		7.50	"	14.00
E	1		10.25	"	15.25
F	1		14.00	"	16.75
G	1		17.25	"	18.25
H	1		21.50	"	20.00
I	1		24.75	"	22.25
J	1		31.75	"	25.50



CONSTRUCTION NOTES

1. FABRICATE HORN SEGMENTS FROM .050 ALUMINUM THRU ALUMINUM BY SPOT WELDING TECHNIQUES ITEM A MAY BE CONSTRUCTED IN TWO SECTIONS PROVIDING HALF WITH FLANGE UG(594)/U IS NO LESS THAN 12.00 LG
2. ATTACH FLANGE VIA "HELI-ARC" WELDING TECHNIQUE METHOD

SECRET

FIGURE 5

HORN CONICAL

ALUMINUM

APPLIED PHYSICS LABORATORY

D 73828

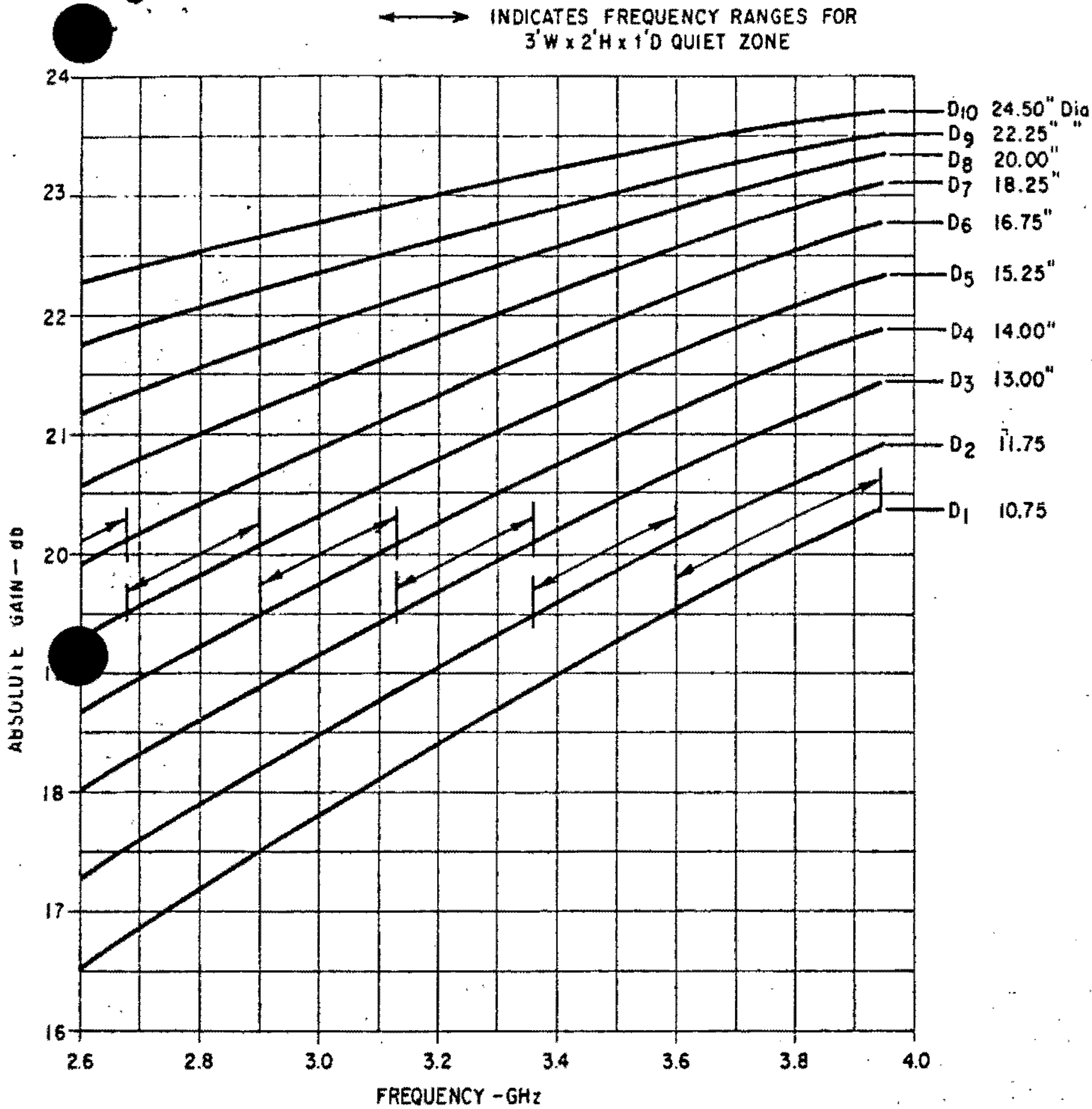


Fig. 6 ABSOLUTE GAIN, EXPANDABLE CONICAL HORN

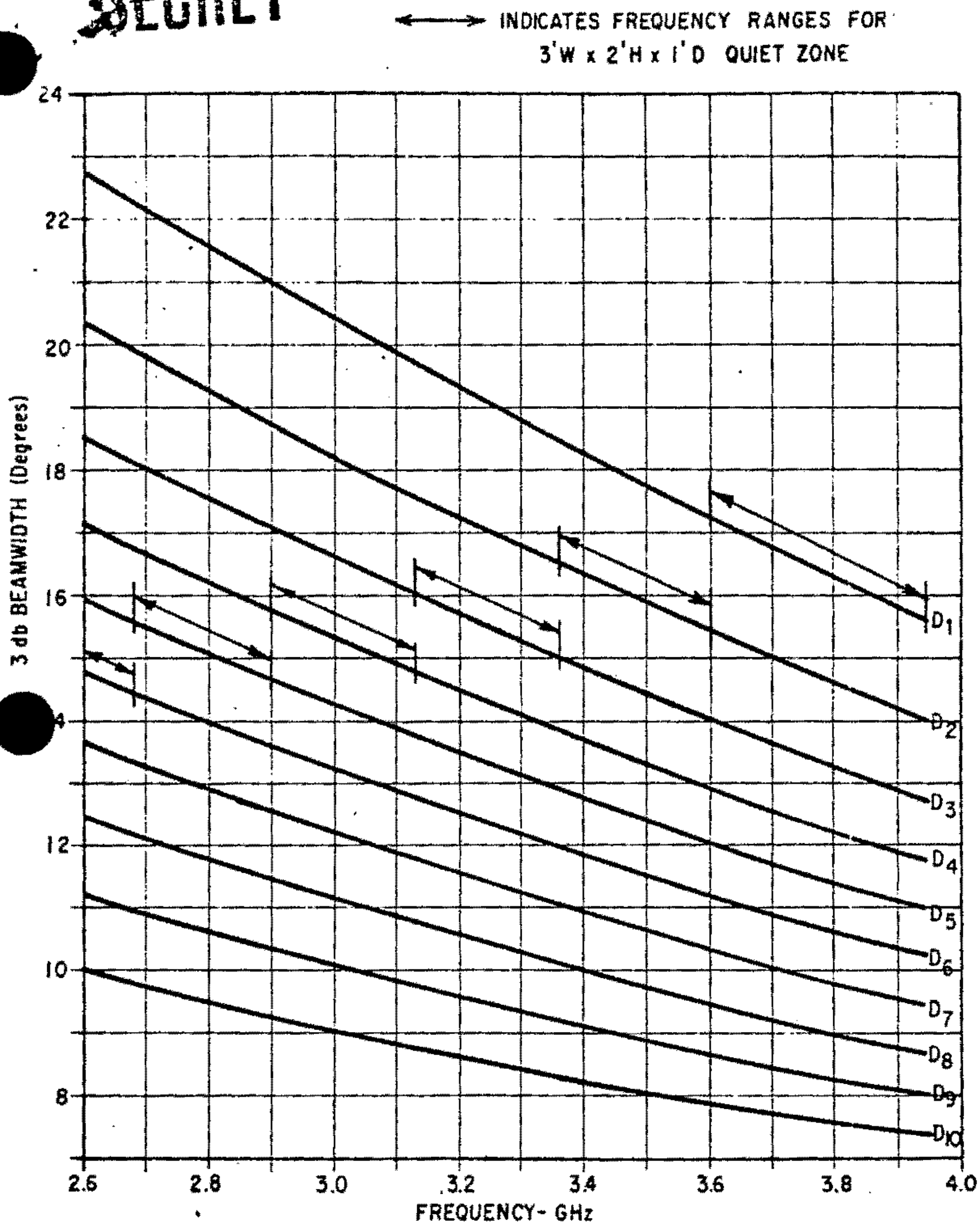


Fig.7 E PLANE 3db BEAMWIDTH, EXPANDABLE CONICAL HORN

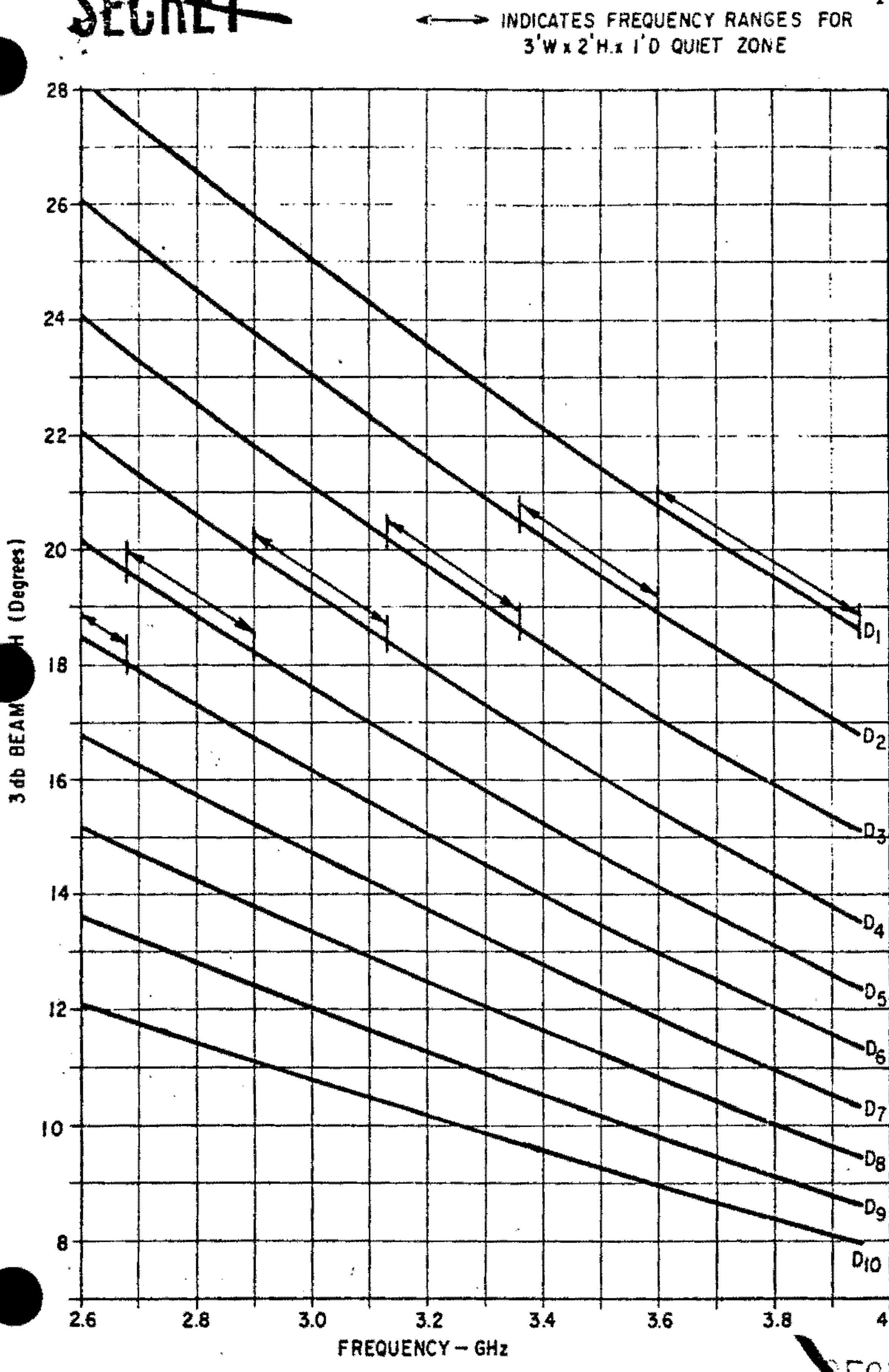


Fig.8 H PLANE 3db BEAMWIDTH, EXPANDABLE CONICAL HORN

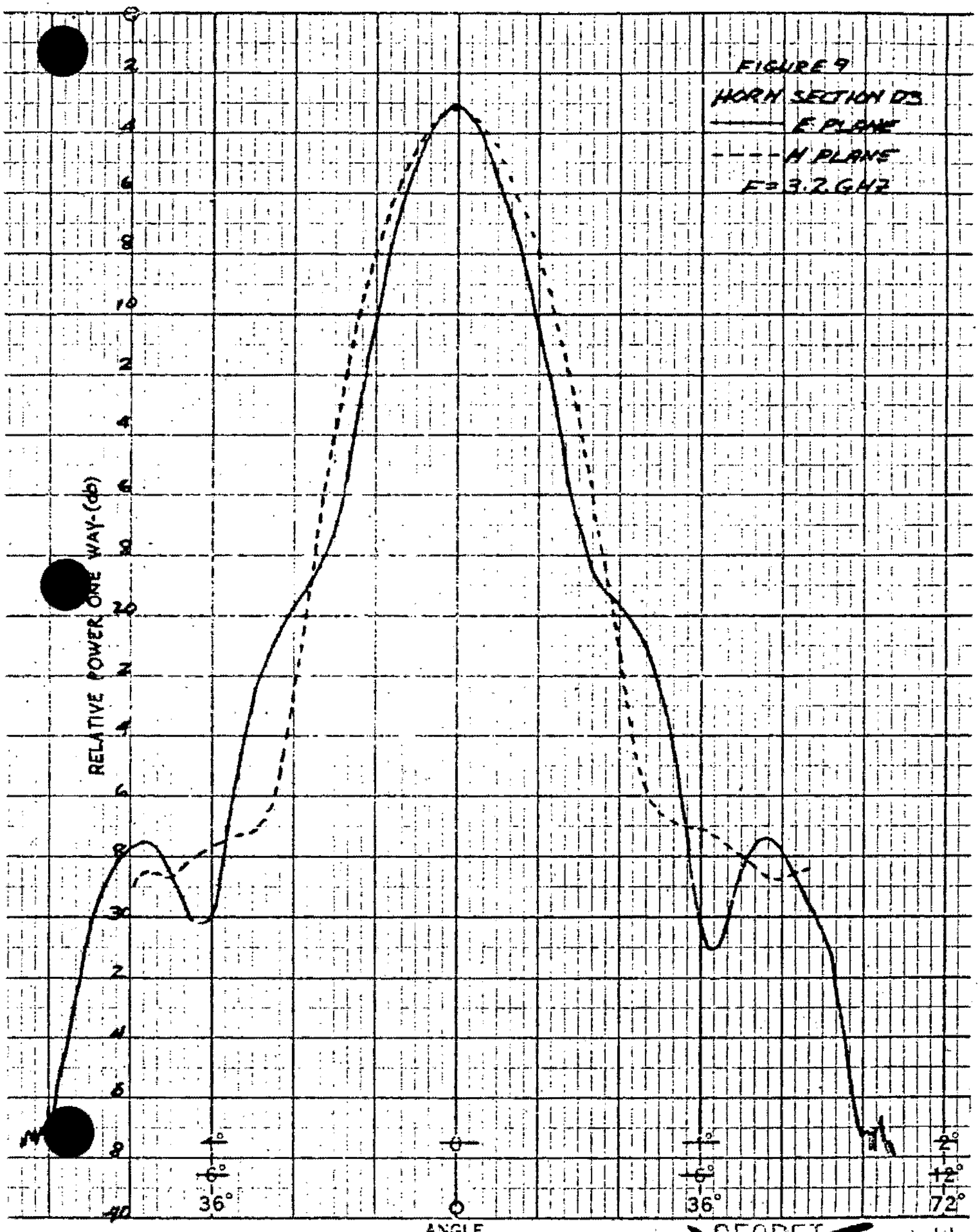
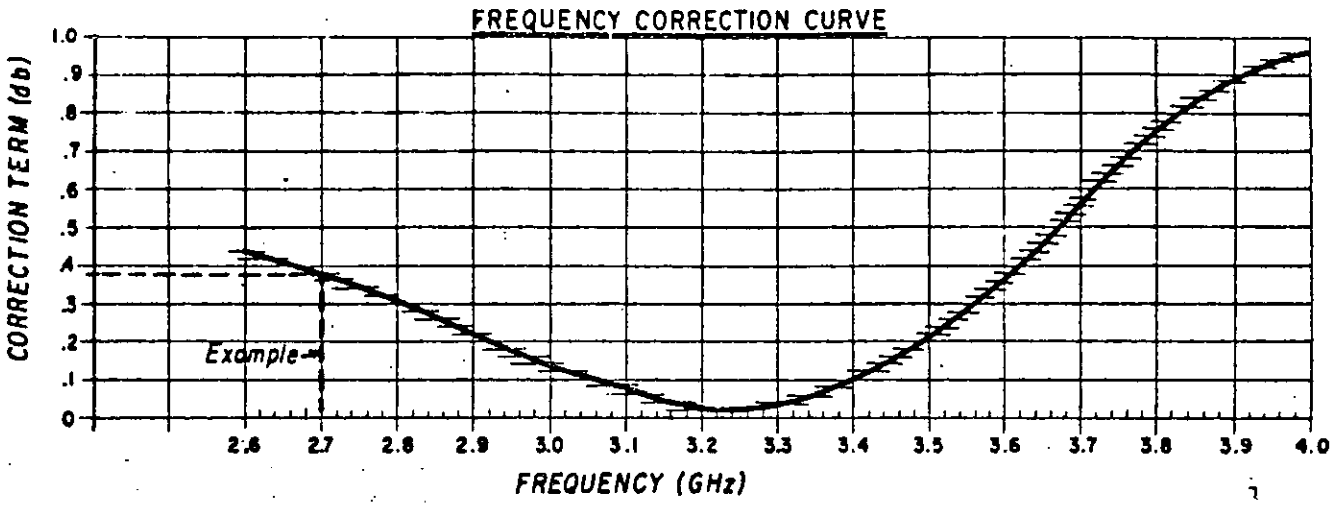


FIGURE 9
HORN SECTION D3
——— E PLANE
- - - - H PLANE
F = 3.2 GHZ
RELATIVE POWER ONE WAY-(db)
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
4°
6°
36°
0
0
4°
6°
36°
2°
12°
72°
ANGLE

Fig. 10 HIGH POWER TWT MONITOR - METER READING Vs TRANSMITTED POWER



TO MEASURE TRANSMITTED POWER:

ADD CORRECTION TERM TO TWT MONITOR POWER METER READING.

Example: AT 2.7 GHz, THE CORRECTION TERM = .38
POWER METER READING = 2.00
CORRECTED METER READING 2.38 dbm ⇒ 140 Watts P_T

TO SET TRANSMITTED POWER:

SUBTRACT CORRECTION TERM FROM CORRECTED METER READING WHICH CORRESPONDS TO DESIRED POWER. ADJUST POWER TO OBTAIN THIS VALUE ON TWT MONITOR POWER METER.

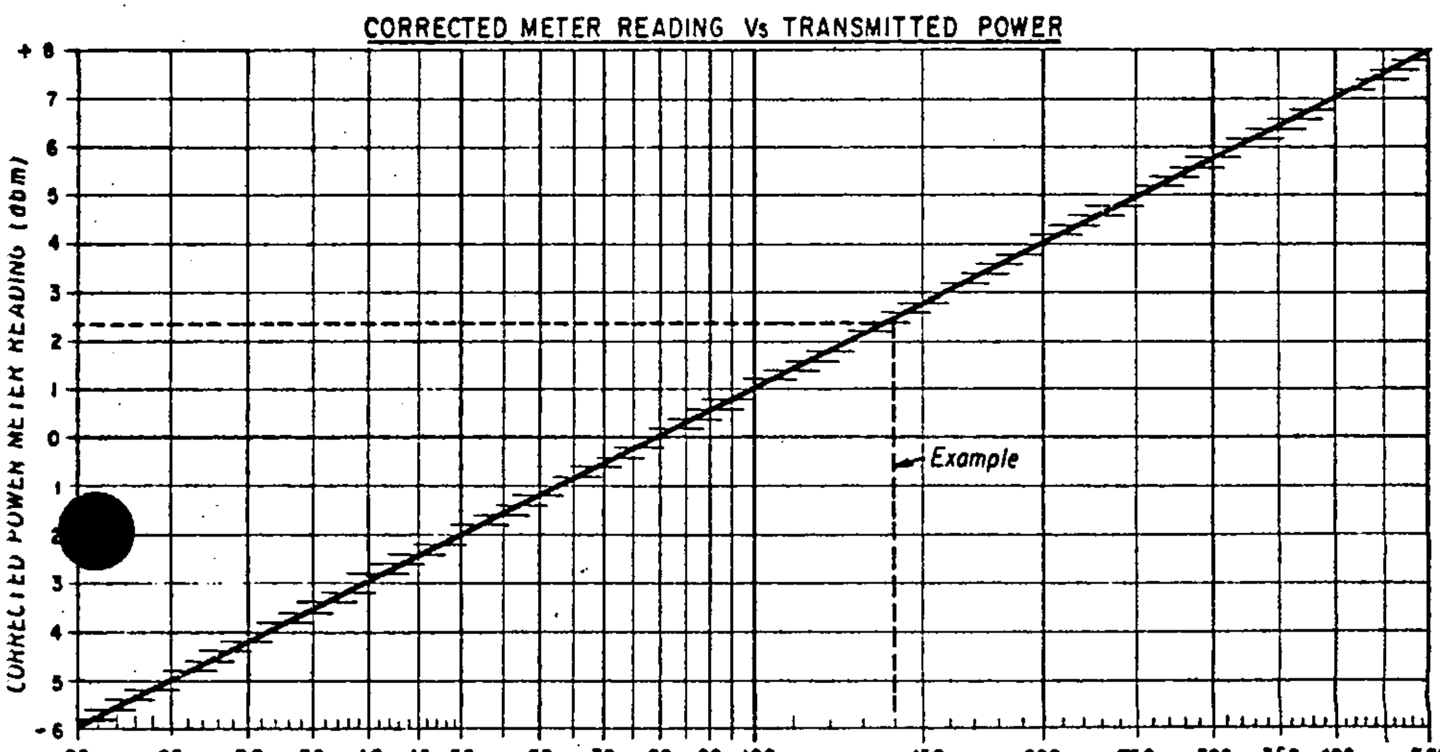
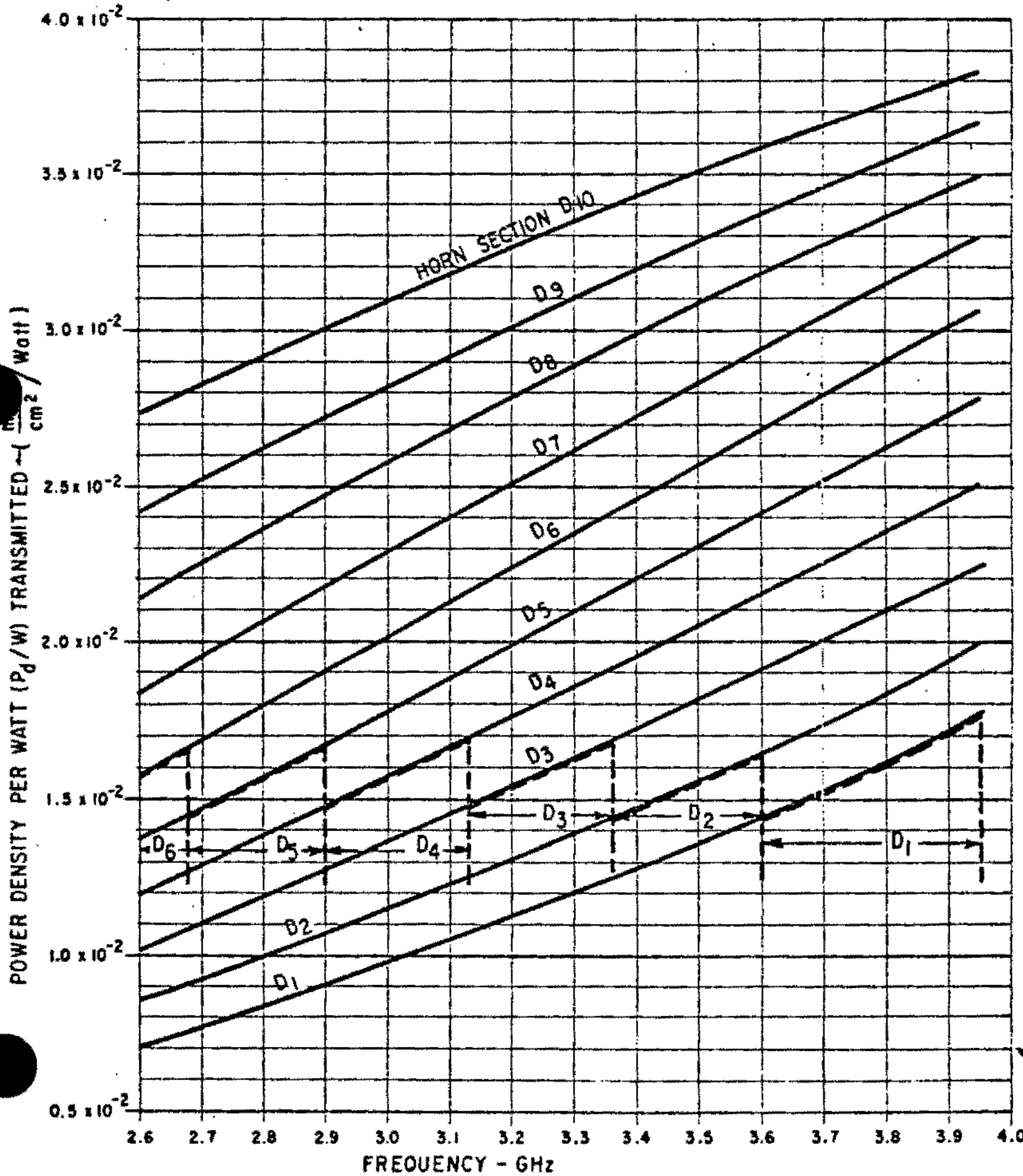
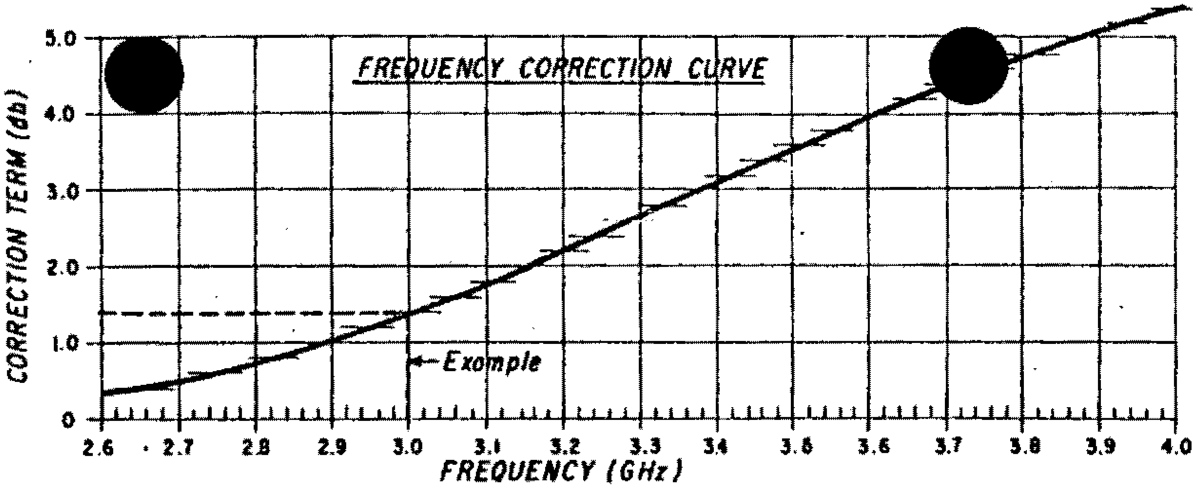


Fig. 11 POWER DENSITY PER WATT TRANSMITTED FOR EACH HORN SECTION (FOR TRANSMISSION LENGTH = 23.0')



ARROWS SHOW FREQUENCY RANGES

EFFECTIVE AREA-289 CM²



TO MEASURE POWER DENSITY:

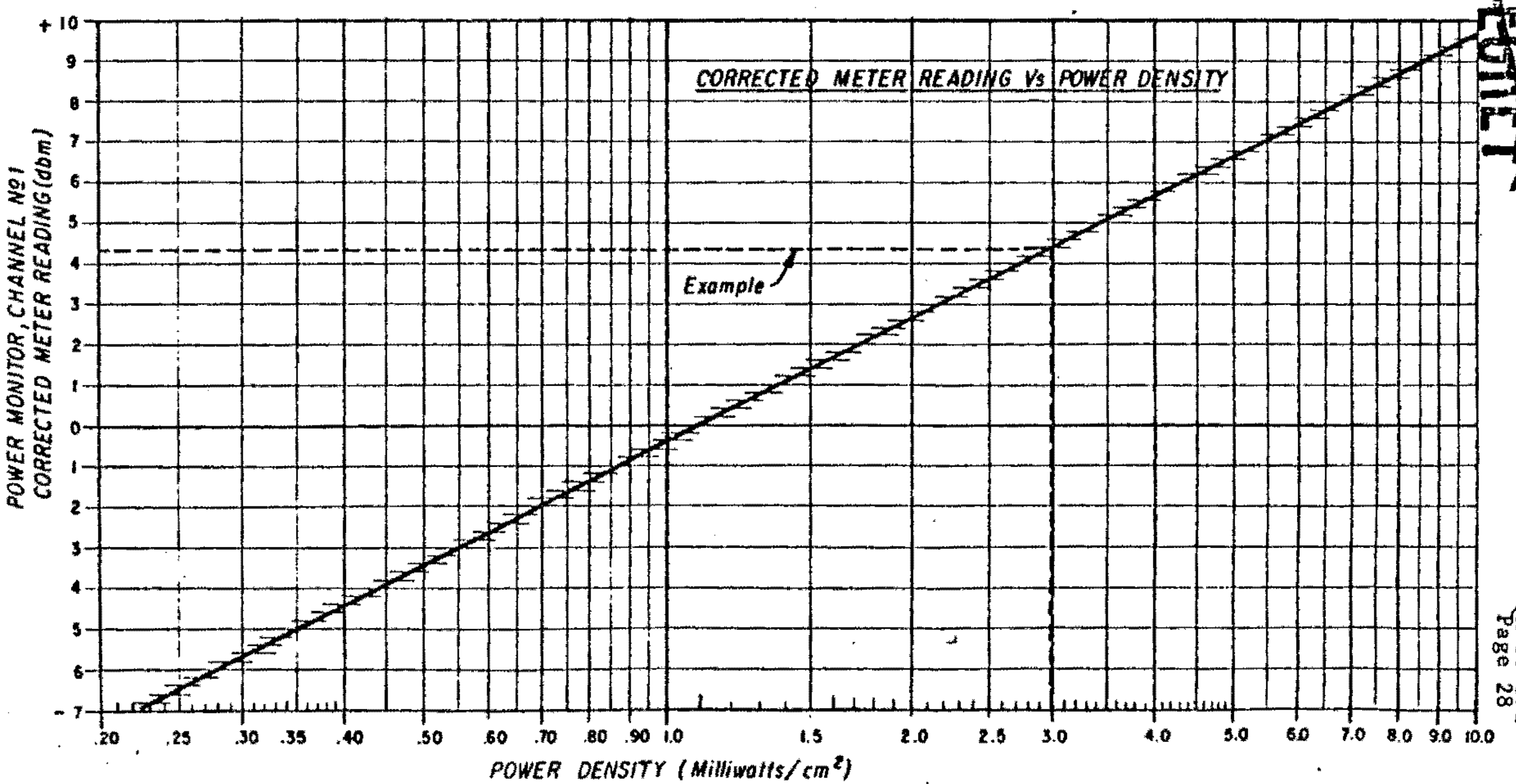
ADD CORRECTION TERM TO METER READING.

Example: AT 3.0 GHz, CORRECTION TERM	=	1.4 db
METER READING	=	3.0 dbm
CORRECTED METER READING	=	4.4 dbm

4.4dbm ⇔ 3.0 Milliwatts/cm²

TO SET POWER DENSITY:

SUBTRACT CORRECTION TERM FROM METER READIN WHICH CORRESPONDS TO REQUIRED POWER DENSIT ADJUST POWER TO OBTAIN THIS VALUE ON MONITO CHANNEL № 1 POWER METER.



SECRET

SECRET

SECRET

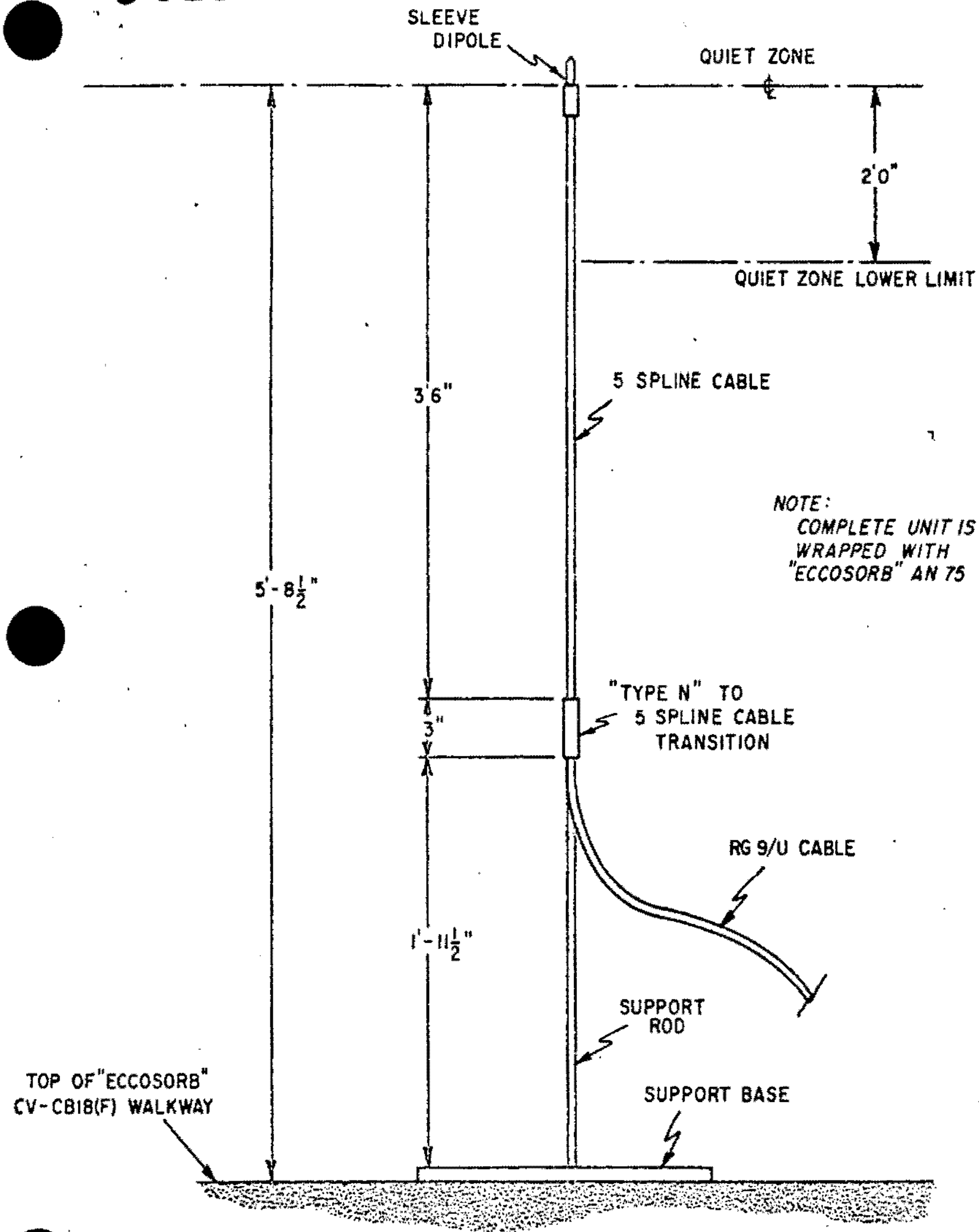


Fig. 13 FIXED DIPOLE MONITOR, STRAIGHT DIPOLE

SECRET

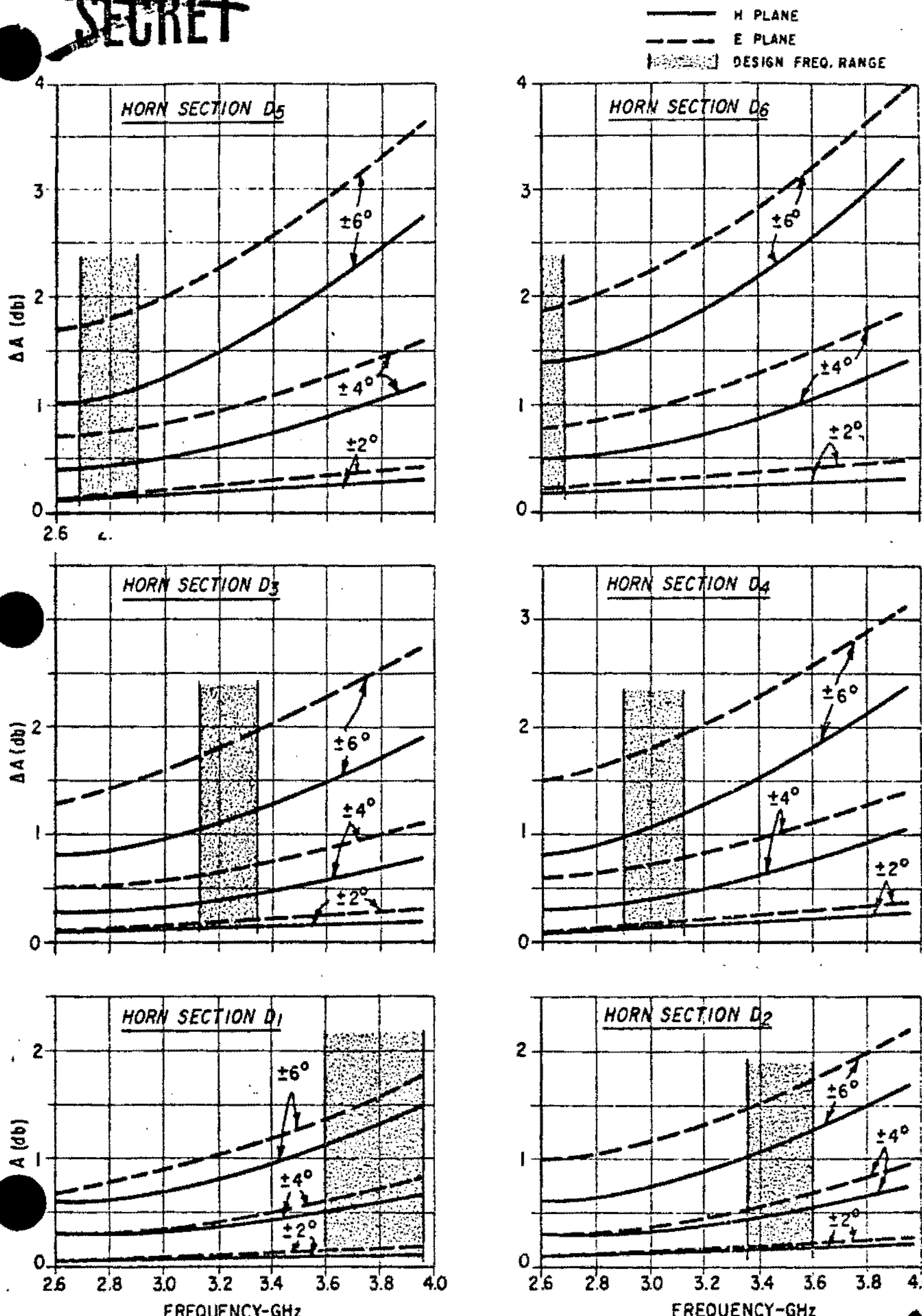
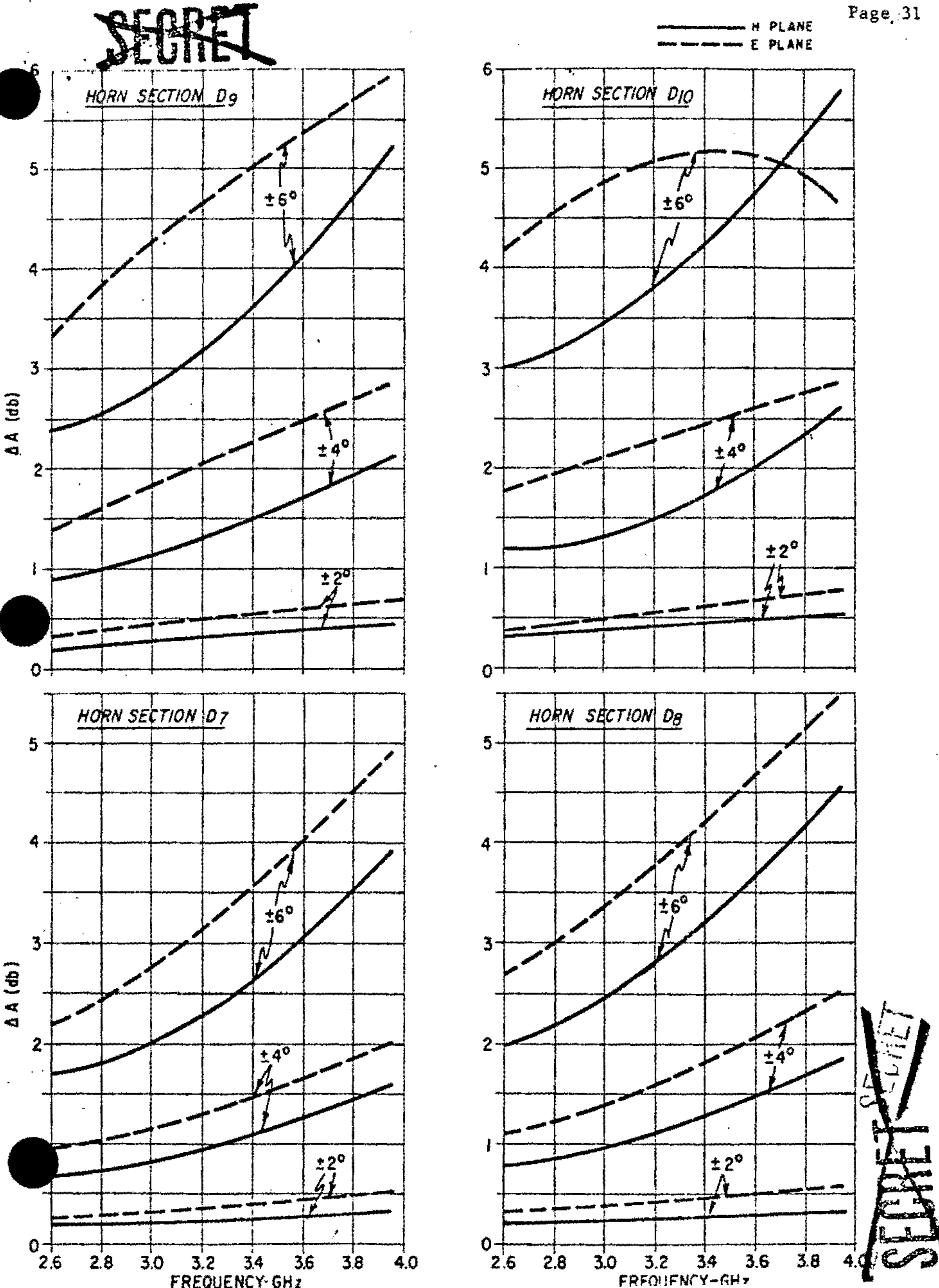


Fig 14 CHANGE IN RELATIVE AMPLITUDE (ΔA) FOR VARIOUS FIXED ANGLE


H PLANE
E PLANE
HORN SECTION D9
HORN SECTION D10
HORN SECTION D7
HORN SECTION D8
±6°
±4°
±2°
ΔA (db)
FREQUENCY-GHz
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0

SECRET

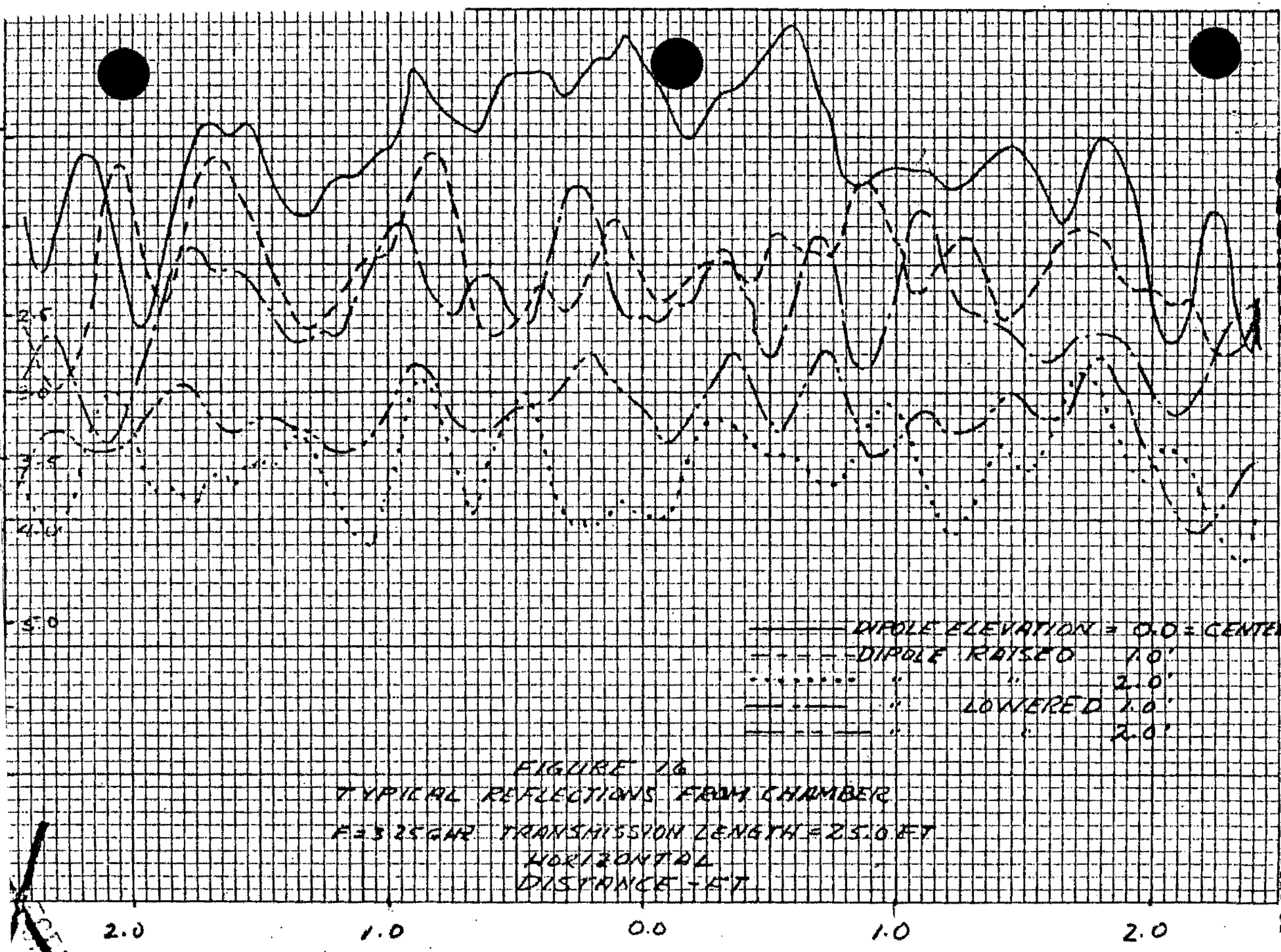


FIGURE 16
TYPICAL REFLECTIONS FROM CHAMBER
F=3.25GHZ TRANSMISSION LENGTH = 25.0 FT

(VERTIC)AL (DISTAN)CE		TRANSMISSION LENGTH = 23.0'				TRANSMISSION LENGTH = 23.5'				TRANSMISSION LENGTH = 24.0'				TRANSMISSION LENGTH = 25.0'			
		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE	RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE	RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE	RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE
		±2.0'	±1.5'	±1.0		±2.0'	±1.5'	±1.0'		±2.0'	±1.5'	±1.0'		±2.0'	±1.5'	±1.0'	
2.0'	MAX	-1.0	-1.0	-1.0	+1.0	-1.25	-1.25	-1.25	+0.75	-1.25	-1.25	-1.50	+1.0	-0.75	-1.75	-1.75	+1.0
	MIN	-3.5	-3.25	-3.75	-1.0	-3.0	-2.75	-2.75	-0.75	-3.0	-3.0	-3.0	-0.75	-3.75	-3.5	-3.5	-1.0
1.5'	MAX	-1.0	-1.0	-1.0	+1.0	-1.25	-1.25	-1.25	+0.5	-1.5	-1.5	-1.5	+0.5	-2.0	-2.0	-2.0	+0.5
	MIN	-2.75	-2.75	-2.75	-0.75	-2.0	-2.5	-2.5	-0.5	-3.0	-2.5	-2.5	-0.5	-3.25	-3.25	-3.25	-0.5
1.0'	MAX	-0.5	-0.5	-0.75	+0.5	-0.75	-1.0	[illegible]	+0.5	-1.0	-1.0	-1.0	+0.75	-1.0	-1.0	-1.0	+0.5
	MIN	-1.75	[illegible]	-1.75	-0.5	-3.0	-2.5	-1.75	-0.5	-2.5	-2.25	-2.25	-0.5	-3.25	-2.75	-2.25	-1.25
0.0	MAX	0.0	-1.0	0.0	+0.5	-0.25	-0.25	-0.25	+0.5	-0.25	-0.25	-0.25	+0.5	-0.25	-0.25	-0.0	+0.75
	MIN	[illegible]	[illegible]	[illegible]	-0.5	-1.75	-1.75	-1.0	-0.5	-1.5	-1.5	-1.5	-0.5	-1.75	-1.75	-2.25	-0.75
1.0'	MAX	-0.5	-0.5	-0.5	+0.5	0.0	0.0	0.0	+0.5	-0.25	-0.25	-0.25	+0.5	0.0	0.0	0.0	+0.5
	MIN	-0.25	-0.25	-0.25	-0.5	-1.0	-1.0	-1.0	-0.5	-1.5	-1.5	-1.5	-0.75	-1.5	-1.25	-1.25	-0.75
1.5'	MAX	0.0	0.0	0.0	+0.5	0.0	0.0	0.0	+0.5	-0.25	-0.25	-0.25	+0.5	-0.75	-0.75	-0.75	+0.75
	MIN	-1.5	-1.25	-1.25	-0.5	-1.0	-1.75	-1.0	-0.75	-1.75	-1.25	-1.25	-0.5	-2.0	-2.0	-2.0	-0.50
2.0'	MAX	-0.25	-0.25	-0.25	+0.5	0.0	0.0	0.0	+0.5	-0.25	-0.25	-0.25	+0.5	0.0	0.0	0.0	+0.5
	MIN	-1.25	-1.25	-1.25	-0.0	-1.75	-1.25	-1.25	-0.5	-1.25	-1.25	-1.25	-0.5	[illegible]	-1.75	-1.75	-1.0

(VERTIC)AL (DISTA)NCE		TRANSMISSION LENGTH = 26.0'				TRANSMISSION LENGTH = 26.5'				TRANSMISSION LENGTH = 27.0'			
		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE	RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE	RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE
		±2.0'	±1.5'	±1.0'		±2.0'	±1.5'	±1.0'		±2.0'	±1.5'	±1.0'	
2.0'	MAX	-2.25	-2.25	-2.75	+0.75	-2.5	-2.5	-2.5	+1.0	-3.0	-3.0	-3.0	+0.75
	MIN	-4.25	-4.25	-4.0	-1.00	-4.75	-4.75	-4.5	-1.0	-4.5	-4.5	-4.5	-0.75
1.5'	MAX	-2.25	-2.25	-1.5	+0.5	-2.0	-2.0	-2.0	+0.75	-1.75	-1.75	-0.75	+0.75
	MIN	-4.00	-3.75	-3.75	-1.5	-4.0	-3.5	-3.25	-1.00	-3.0	[illegible]	-3.0	-0.50
1.0'	MAX	-1.5	-1.75	-1.75	+0.75	-2.0	-2.0	-2.0	+0.5	-2.0	-2.0	-2.0	+0.75
	MIN	-2.75	-2.75	-2.75	-0.25	-3.5	-3.5	-3.5	-0.75	-4.0	-3.75	-3.75	-0.75
0.0	MAX	-0.75	-0.75	-1.0	+0.5	-0.5	-0.5	-0.5	+1.0	-1.0	-1.0	-1.0	+0.75
	MIN	-2.0	-2.0	-1.5	-0.75	-2.25	-2.25	-2.25	-0.75	-3.0	-2.75	-2.75	-0.75
1.0'	MAX	0.0	0.0	0.0	+1.0	-0.5	-0.5	-0.5	+0.5	-0.75	-0.75	-0.75	+0.75
	MIN	-1.75	-1.75	-1.75	-0.5	-2.25	-2.25	-1.75	-0.5	-2.25	-2.75	-2.75	-0.75
1.5'	MAX	-0.5	-0.5	-0.5	+1.0	-0.75	-0.75	-0.75	+0.75	-0.75	-0.75	-0.75	+0.75
	MIN	-2.5	-2.25	-2.25	-0.75	-2.25	-2.25	-2.25	-0.75	-2.5	-2.5	-2.5	-1.0
2.0'	MAX	-0.25	-0.25	-0.25	+0.5	-0.5	-0.5	-0.5	+0.75	-0.75	-0.75	-0.75	+0.0
	MIN	-1.75	-1.75	[illegible]	-0.5	-2.0	-2.0	-2.0	-0.75	-2.25	-2.25	-2.25	-0.0

Figure 17
CHAMBER EVALUATION

FREQUENCY: 2.6 GHz

TRANSMITTING HORN SECTION: D6

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8-22-66

NOTES:

- = +0.5 to -1.5 = ±1.0db
- = +0.5 to -2.0 = ±1.25db
- = +0.5 to -2.5 = ±1.5db
- = +0.5 to -3.0 = ±1.75db
- = +0.5 to -3.5 = ±2.0db
- = +0.5 to -4.0 = ±2.25db
- = +0.5 to -5.0 = ±2.75db

CAL NCE		TRANSMISSION LENGTH = 23.0'			
		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE
		±2.0'	±1.5'	±1.0	
2.0'	MAX	-1.25	-1.25	[illegible]	+0.25
	MIN	-3.5	-2.75	[illegible]	-0.25
1.5'	MAX	[illegible]	[illegible]	-0.0	+0.5
	MIN	[illegible]	-1.5	-1.5	-0.5
1.0'	MAX	[illegible]	-0.0	-0.0	+0.5
	MIN	[illegible]	-1.5	-1.0	-0.5
0.0	MAX	[illegible]	[illegible]	-0.0	+0.5
	MIN	[illegible]	-1.5	-1.0	-0.5
1.0'	MAX	[illegible]	-0.5	-0.5	+0.5
	MIN	[illegible]	-2.25	-1.5	-0.5
1.5'	MAX	[illegible]	-0.5	-0.5	+0.5
	MIN	[illegible]	[illegible]	-1.5	-0.25
2.0'	MAX	-1.5	-1.5	[illegible]	+0.5
	MIN	-3.5	-2.75	[illegible]	-0.5

		TRANSMISSION LENGTH = 23.5'			
		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE
		±2.0'	±1.5'	±1.0'	
2.0'	MAX	-1.25	-1.25	[illegible]	+0.75
	MIN	[illegible]	-2.75	[illegible]	-0.5
1.5'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	[illegible]	-1.25	-1.75	-0.5
1.0'	MAX	[illegible]	-0.0	-0.0	+0.5
	MIN	[illegible]	-1.75	-1.5	-0.5
0.0	MAX	[illegible]	-0.0	-0.0	+0.5
	MIN	[illegible]	-1.25	-1.25	-0.25
1.0'	MAX	[illegible]	-1.0	-1.0	+0.5
	MIN	[illegible]	-1.25	-2.0	-0.5
1.5'	MAX	[illegible]	[illegible]	-0.5	+0.25
	MIN	[illegible]	-1.25	-1.75	-0.25
2.0'	MAX	-1.5	-1.5	[illegible]	+0.5
	MIN	-1.75	-2.5	[illegible]	-0.5

		TRANSMISSION LENGTH = 24.0'			
		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE
		±2.0'	±1.5'	±1.0'	
2.0'	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.5	-3.0	-2.25	-0.5
1.5'	MAX	[illegible]	-1.0	-1.0	+0.5
	MIN	-2.5	-2.0	-2.0	-0.5
1.0'	MAX	[illegible]	-0.5	-0.5	+0.25
	MIN	[illegible]	-1.5	-1.0	-0.25
0.0	MAX	-0.25	-0.25	-0.25	+0.5
	MIN	[illegible]	-1.5	-1.25	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	[illegible]	-2.0	-1.5	-0.5
1.5'	MAX	[illegible]	-1.0	-1.0	+0.75
	MIN	[illegible]	-2.0	-2.0	-0.5
2.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-3.0	-2.75	-0.75

		TRANSMISSION LENGTH = 25.0'			
		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE
		±2.0'	±1.5'	±1.0'	
2.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.0	-2.5	-2.5	-0.5
1.5'	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	-3.0	-3.0	-2.25	-0.75
1.0'	MAX	-0.5	[illegible]	[illegible]	+0.5
	MIN	-2.25	-1.75	[illegible]	-0.5
0.0	MAX	-0.75	-0.75	-0.75	+0.75
	MIN	-2.25	[illegible]	[illegible]	-0.75
1.0'	MAX	-1.5	[illegible]	[illegible]	+0.5
	MIN	-3.0	-2.5	[illegible]	-0.5
1.5'	MAX	-1.0	-1.0	-1.0	+0.25
	MIN	-3.0	-2.25	[illegible]	-0.5
2.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.5	-2.25	-3.0	-0.5

Figure 18
CHAMBER EVALUATION

CAL NCE		TRANSMISSION LENGTH = 26.0'			
		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE
		±2.0'	±1.5'	±1.0'	
2.0'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.5	-3.25	-3.0	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-2.75	-2.5	-2.5	-0.5
1.0'	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	-2.5	-2.25	-2.0	-0.75
0.0	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-3.0	-2.25	-2.0	-0.75
1.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-2.75	-2.75	-0.75
1.5'	MAX	[illegible]	-1.5	-1.5	+0.75
	MIN	-3.5	-3.0	-2.5	-0.75
2.0'	MAX	[illegible]	-2.5	-2.5	+0.5
	MIN	-3.75	-3.5	-3.5	-0.5

		TRANSMISSION LENGTH = 26.5'			
		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE
		±2.0'	±1.5'	±1.0'	
2.0'	MAX	-2.5	-2.5	-2.5	+0.75
	MIN	-4.0	-3.25	-3.25	-0.75
1.5'	MAX	-1.75	-1.75	-1.75	+0.25
	MIN	-3.25	-2.75	-2.50	-0.25
1.0'	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-2.5	-2.5	-2.0	-0.5
0.0	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-3.0	-2.75	-2.75	-0.75
1.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-4.0	-3.0	-3.0	-0.25
1.5'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-4.0	-3.0	-2.5	-0.75
2.0'	MAX	-2.5	-2.5	-2.5	+0.5
	MIN	-4.0	-3.5	-3.5	-0.5

		TRANSMISSION LENGTH = 27.0'			
		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF:			MAX. RIPPLE
		±2.0'	±1.5'	±1.0'	
2.0'	MAX	-2.5	-2.5	-2.5	+0.25
	MIN	-3.5	-3.25	-3.25	-0.25
1.5'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.5	-3.50	-2.75	-0.5
1.0'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-2.75	-2.50	-2.50	-0.75
0.0	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-2.5	-2.5	-0.5
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-3.5	-3.25	-3.25	-0.5
1.5'	MAX	-1.5	-1.5	-1.5	+1.0
	MIN	-3.5	-3.0	-2.75	-1.0
2.0'	MAX	-2.25	-2.25	-2.25	+0.5
	MIN	-3.75	-3.75	-3.5	-0.5

FREQUENCY: 2.8 GHZ

TRANSMITTING HORN SECTION: DS

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8/23/66

NOTES:

= 0.0 - 2.0 db = ± 1.0 db
= 0.0 - 2.5 db = ± 1.25 db
= 0.0 - 3.0 db = ± 1.5 db
= 0.0 - 3.5 db = ± 1.75 db
= 0.0 - 4.0 db = ± 2.0 db

SECRET

SECRET

...ICAL ...ANCE		TRANSMISSION LENGTH = 23.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0	MAX. RIPPLE
2.0'	MAX	-1.0	-2.0	-3.0	+0.5
	MIN	-3.75	-3.5	-2.25	-0.5
1.5'	MAX	?	?	?	
	MIN	?	?	?	
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.0	-1.75	-0.25
...ER 0.0	MAX	-0.25	-0.25	-0.25	+0.5
	MIN	-2.00	-1.5	-1.0	-0.5
1.0'	MAX	-0.25	-0.25	-0.25	+0.5
	MIN	-2.0	-1.25	-0.75	-0.5
1.5'	MAX	?	?	?	
	MIN	?	?	?	
2.0'	MAX	-1.75	-1.75	-3.25	+0.5
	MIN	-3.0	-3.0	-3.0	-0.5

	TRANSMISSION LENGTH = 23.5' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-1.75	-1.75	-1.75	+0.5
2.0' MIN	-4.0	-3.25	-3.0	-0.5
1.5' MAX	-1.5	-1.5	-1.5	+0.5
1.5' MIN	-3.0	-2.75	-2.5	-0.5
1.0' MAX	-1.5	-1.5	-1.5	+0.25
1.0' MIN	-2.75	-2.25	-2.0	-0.25
0.0 MAX	-0.5	-0.5	-0.5	+0.5
0.0 MIN	-2.0	-1.75	-1.5	-0.5
1.0' MAX	-0.5	-0.5	-0.5	+0.25
1.0' MIN	-1.75	-1.50	-1.0	-0.25
1.5' MAX	-0.75	-0.25	-0.25	+0.75
1.5' MIN	-2.25	-1.50	-1.5	-0.5
2.0' MAX	-1.75	-1.75	-1.75	+0.5
2.0' MIN	-3.5	-2.75	-2.50	-0.5

	TRANSMISSION LENGTH = 24.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-1.75	-1.75	-1.75	+0.5
2.0' MIN	-4.25	-3.0	-2.25	-0.5
1.5' MAX	-0.75	-0.75	-0.75	+0.5
1.5' MIN	-2.5	-2.5	-2.5	-0.25
1.0' MAX	-1.5	-1.5	-1.5	+0.25
1.0' MIN	-2.75	-2.5	-2.0	-0.25
0.0 MAX	-0.5	-0.5	-0.5	+0.5
0.0 MIN	-2.25	-1.75	-1.75	-0.75
1.0' MAX	-0.75	-0.75	-0.75	+0.5
1.0' MIN	-2.0	-1.75	-1.5	-0.5
1.5' MAX	-0.75	-0.75	-0.75	+0.25
1.5' MIN	-2.5	-1.75	-1.5	-0.25
2.0' MAX	-1.50	-1.50	-1.50	+0.5
2.0' MIN	-3.25	-3.25	-2.25	-0.5

	TRANSMISSION LENGTH = 25.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-2.75	-2.25	-2.25	+0.5
2.0' MIN	[illegible]	-3.5	-3.5	-0.5
1.5' MAX	-2.25	-2.25	-2.25	+0.5
1.5' MIN	-3.50	-3.25	-3.25	-0.25
1.0' MAX	-1.5	-1.5	-1.5	+0.5
1.0' MIN	-3.0	-2.5	-2.5	-0.5
0.0 MAX	-1.0	-1.0	-1.0	+0.5
0.0 MIN	-3.0	-2.5	-2.0	-0.5
1.0' MAX	-1.0	-1.0	-1.0	+0.5
1.0' MIN	-2.5	-2.25	-2.25	-0.5
1.5' MAX	-0.5	-0.5	-0.5	+0.75
1.5' MIN	-1.5	-2.0	-2.25	-0.50
2.0' MAX	-1.75	-1.75	-1.75	+0.5
2.0' MIN	-3.75	-3.25	-2.25	-0.5

...ICAL ...ANCE		TRANSMISSION LENGTH = 26.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.25	-2.25	-2.25	+0.5
	MIN	-4.25	-3.75	-3.0	-0.5
1.5'	MAX	-2.5	-2.5	-2.5	+0.5
	MIN	-4.0	-3.5	-3.5	-0.5
1.0'	MAX	-1.5	-1.5	-1.5	+0.25
	MIN	-3.25	-2.75	-2.75	-0.5
...ER 0.0	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.25	-2.25	-2.25	-0.5
1.0'	MAX	-0.75	-0.75	-0.75	+0.75
	MIN	-3.0	-2.5	-2.0	-0.5
1.5'	MAX	-1.75	-1.75	-1.75	+0.25
	MIN	-2.75	-2.5	-2.5	-0.25
2.0'	MAX	-1.75	-1.75	-1.75	+0.25
	MIN	-3.50	-2.75	-2.75	-0.25

	TRANSMISSION LENGTH = 26.5' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-2.5	-2.0	-2.5	+0.5
2.0' MIN	-4.5	-3.25	-3.75	-0.5
1.5' MAX	-2.5	-2.5	-2.5	+0.75
1.5' MIN	-4.25	-4.25	-4.25	-1.0
1.0' MAX	-1.75	-1.75	-1.75	+0.5
1.0' MIN	-3.25	-3.0	-2.75	-0.5
0.0 MAX	-2.25	-1.25	-2.25	+0.25
0.0 MIN	-2.75	-2.5	-2.25	-0.5
1.0' MAX	-1.0	-1.0	-1.0	+0.25
1.0' MIN	-2.25	-2.5	-1.75	-0.5
1.5' MAX	-2.0	-2.0	-2.0	+0.5
1.5' MIN	-3.25	-3.0	-3.0	-0.5
2.0' MAX	-1.5	-1.5	-1.5	+0.5
2.0' MIN	-3.5	-2.75	-2.5	-0.5

	TRANSMISSION LENGTH = 27.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-2.75	-2.75	-2.75	+1.0
2.0' MIN	-5.0	-4.0	-4.0	-1.25
1.5' MAX	-3.0	-3.0	-3.0	+0.25
1.5' MIN	-4.5	-3.75	-3.5	-0.5
1.0' MAX	-1.0	-2.0	-2.0	+0.5
1.0' MIN	-3.5	-3.0	-2.75	-0.5
0.0 MAX	-1.0	-2.0	-1.0	+0.5
0.0 MIN	-2.75	-2.75	-2.5	-0.5
1.0' MAX	-1.0	-2.0	-1.0	+0.5
1.0' MIN	-2.5	-2.75	-2.0	-0.5
1.5' MAX	-2.5	-2.5	-2.5	+0.5
1.5' MIN	-3.5	-3.5	-3.0	-0.5
2.0' MAX	-1.75	-1.75	-1.75	+0.5
2.0' MIN	-3.5	-3.0	-2.75	-0.5

Figure 19
CHAMBER EVALUATION

FREQUENCY: 3.0 GHz

TRANSMITTING HORN SECTION: D4

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8/22/66

NOTES:

- (dotted) = 0.25 - 2.25 = ± 1.0db
- (back-hatched) = 0.25 - 2.75 = ± 1.25db
- (cross-hatched) = 0.25 - 3.25 = ± 1.5db
- (forward-hatched) = 0.25 - 3.75 = ± 1.75db
- (light dotted) = 0.25 - 4.25 = ± 2.0db
- (vertical lines) = 0.25 - 4.75 = ± 2.25db
- (blank) = 0.25 - 5.25 = ± 2.5db

MRT--4-046
QM-66-072
Page 35

SECRET

TRANSMISSION LENGTH = 23.0'

ICAL ANCE		±2.0'	±1.5'	±1.0	MAX. RIPPLE
2.0'	MAX	-1.75	-1.75	-1.25	+0.75
	MIN	-2.75	-2.0	-2.0	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-2.5	-2.25	-2.25	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-1.75	-1.25	-1.0	-0.5
ER 0.0	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-1.50	-1.25	-1.0	-0.25
1.0'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.75	-2.75	-2.0	-0.75
1.5'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.0	-3.0	-2.75	-0.5
2.0'	MAX	-2.0	-2.0	-2.0	+0.25
	MIN	-3.0	-2.75	-2.75	-0.50

Relative power level (db) in horizontal distances of: ±2.0', ±1.5', ±1.0'

TRANSMISSION LENGTH = 23.5'

	±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-2.25	-2.25	-2.25	+0.5
2.0' MIN	-3.25	-3.00	-3.25	-0.5
1.5' MAX	-1.75	-1.20	-1.25	+0.5
1.5' MIN	-3.00	-3.0	-2.5	-0.5
1.0' MAX	-0.5	-0.5	-0.5	+0.5
1.0' MIN	-2.0	-1.75	-1.5	-0.5
0.0 MAX	-1.0	-1.0	-1.0	+.25
0.0 MIN	-1.75	-1.25	-1.75	-.5
1.0' MAX	-1.25	-1.25	-1.25	+0.25
1.0' MIN	-2.5	-2.5	-1.75	-0.25
1.5' MAX	-2.0	-2.0	-2.0	+0.5
1.5' MIN	-3.25	-3.25	-3.0	-0.5
2.0' MAX	-1.75	-1.75	-1.75	+0.75
2.0' MIN	-3.0	-3.0	-3.25	-.5

TRANSMISSION LENGTH = 24.0'

	±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-2.25	-2.25	-2.25	+0.75
2.0' MIN	-3.75	-3.75	-3.75	-0.75
1.5' MAX	-1.25	-1.25	-1.25	+0.75
1.5' MIN	-4.25	-2.25	-2.5	-1.00
1.0' MAX	-0.75	-0.75	-0.75	+0.5
1.0' MIN	-2.0	-2.0	-1.75	-0.5
0.0 MAX	-0.5	-0.5	-0.5	+0.5
0.0 MIN	-2.0	-1.75	-1.5	-0.25
1.0' MAX	-1.25	-1.25	-1.25	+0.5
1.0' MIN	-3.0	-2.5	-2.25	-0.5
1.5' MAX	-2.0	-2.0	-2.0	+0.5
1.5' MIN	-4.0	-4.0	-3.75	-0.5
2.0' MAX	-2.0	-2.0	-2.25	+0.5
2.0' MIN	-3.0	-3.0	-3.0	-0.5

TRANSMISSION LENGTH = 25.0'

	±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-2.75	-3.0	-3.0	+0.75
2.0' MIN	-4.25	-4.25	-4.0	-0.75
1.5' MAX	-1.75	-1.75	-1.75	+0.75
1.5' MIN	-2.75	-2.25	-2.25	-0.75
1.0' MAX	-1.5	-1.5	-1.5	+0.5
1.0' MIN	-2.0	-2.5	-2.5	-0.5
0.0 MAX	-1.0	-1.0	-1.0	+0.5
0.0 MIN	-2.5	-2.0	-1.75	-0.5
1.0' MAX	-1.75	-1.75	-1.75	+0.5
1.0' MIN	-3.0	-2.75	-2.25	-0.5
1.5' MAX	-2.0	-2.0	-2.0	+0.5
1.5' MIN	-3.75	-3.75	-3.75	-0.75
2.0' MAX	-2.5	-2.5	-2.5	+.25
2.0' MIN	-3.5	-3.5	-3.5	-.25

TRANSMISSION LENGTH = 26.0'

ICAL ANCE		±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.75	-2.25	-2.75	+0.75
	MIN	-4.5	-4.5	-4.5	-0.75
1.5'	MAX	-2.25	-2.25	-2.25	+0.5
	MIN	-3.75	-3.25	-2.75	-0.5
1.0'	MAX	-2.0	-2.0	-2.0	+0.5
	MIN	-3.0	-3.0	-3.0	-0.5
IR 0.0	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-2.75	-2.75	-2.25	-0.5
1.0'	MAX	-3.25	-3.5	-3.25	+0.5
	MIN	-4.5	-4.25	-4.25	-0.5
1.5'	MAX	-2.5	-2.5	-2.5	+0.5
	MIN	-4.0	-3.5	-3.5	-0.5
2.0'	MAX	-2.75	-2.75	-2.75	+0.5
	MIN	-5.0	-4.25	-4.25	-1.0

TRANSMISSION LENGTH = 26.5'

	±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-2.5	-2.5	-2.5	+0.75
2.0' MIN	-4.5	-4.0	-4.0	-0.5
1.5' MAX	-2.25	-2.25	-2.25	+0.75
1.5' MIN	-3.5	-3.5	-3.5	-0.50
1.0' MAX	-2.25	-2.25	-2.25	+0.5
1.0' MIN	-3.25	-3.25	-3.25	-0.5
0.0 MAX	-1.75	-2.0	-2.0	+0.75
0.0 MIN	-3.75	-3.25	-3.25	-0.75
1.0' MAX	-2.25	-2.25	-2.25	+0.75
1.0' MIN	-3.75	-3.5	-3.5	-0.75
1.5' MAX	-2.25	-2.25	-2.25	+0.75
1.5' MIN	-4.25	-3.75	-3.75	-0.75
2.0' MAX	-2.75	-2.75	-2.75	+0.5
2.0' MIN	-4.75	-4.75	-4.0	-0.5

TRANSMISSION LENGTH = 27.0'

	±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0' MAX	-2.0	-2.0	-2.25	+0.5
2.0' MIN	-3.25	-3.0	-3.0	-0.5
1.5' MAX	-1.5	-1.5	-1.5	+0.75
1.5' MIN	-3.5	-3.0	-2.75	-0.75
1.0' MAX	-2.00	-2.00	-2.00	+0.75
1.0' MIN	-3.5	-3.5	-3.25	-0.75
0.0 MAX	-2.00	-2.00	-2.25	+0.5
0.0 MIN	-3.25	-3.0	-3.0	-0.5
1.0' MAX	-2.25	-2.75	-2.75	+0.5
1.0' MIN	-4.0	-3.75	-3.75	-0.5
1.5' MAX	-2.75	-2.75	-2.75	+0.75
1.5' MIN	-4.25	-4.0	-4.0	-0.50
2.0' MAX	-2.75	-2.75	-2.75	+0.75
2.0' MIN	-5.0	-4.5	-4.0	-0.75

Figure 20
CHAMBER EVALUATION

FREQUENCY: 3.25 GHZ

TRANSMITTING HORN SECTION: DJ

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8/22/66 8/23/66

NOTES:

- = 0.5 - 2.5 = ± 1.0 db
- = 0.5 - 3.0 = ± 1.25 db
- = 0.5 - 3.5 = ± 1.5 db
- = 0.5 - 4.0 = ± 1.75 db
- = 0.5 - 4.5 = ± 2.0 db
- = 0.5 - 5.0 = ± 2.25 db

SECRET

SECRET

...CAL ...NCE		TRANSMISSION LENGTH = 23.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0	MAX. RIPPLE
2.0'	MAX	[illegible]	-2.25	-2.0	
	MIN	-3.0	-2.75	-2.60	
1.5'	MAX	-1.75	-1.75	-1.75	
	MIN	-2.5	-2.5	-2.25	
1.0'	MAX	-1.0	-1.0	-1.0	
	MIN	-1.75	-2.0	-1.5	
...R 0.0	MAX	-0.5	-0.5	-0.5	+.125
	MIN	-1.25	-1.5	-1.0	-.125
1.0'	MAX	-1.0	-1.0	-1.0	+.125
	MIN	-1.75	-1.75	-1.25	-.125
1.5'	MAX	-1.5	-1.5	-1.5	
	MIN	-2.25	-2.25	-1.75	
2.0'	MAX	[illegible]	-3.0	-3.0	
	MIN	-2.75	-2.75	-2.25	

...CAL ...NCE		TRANSMISSION LENGTH = 23.5' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-2.75	-2.25	-2.25	
	MIN	-2.70	-2.5	-2.50	
1.5'	MAX	-1.75	-1.75	-1.75	
	MIN	-2.25	-2.25	-1.75	
1.0'	MAX	-1.0	-1.0	-1.0	
	MIN	-2.25	-1.75	-1.25	
...R 0.0	MAX	-0.5	-0.5	-0.5	+0.125
	MIN	-1.75	-1.5	-1.0	-0.125
1.0'	MAX	-0.75	-0.75	-0.75	+.125
	MIN	-2.25	-1.75	-1.25	-.125
1.5'	MAX	-1.5	-1.5	-1.5	
	MIN	-2.0	-2.0	-1.75	
2.0'	MAX	-3.0	-2.0	-2.0	
	MIN	[illegible]	-2.75	-2.25	

...CAL ...NCE		TRANSMISSION LENGTH = 24.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	[illegible]	[illegible]	[illegible]	
	MIN	-3.0	-3.0	[illegible]	
1.5'	MAX	-1.75	-1.75	-1.75	
	MIN	-2.5	-2.5	-2.0	
1.0'	MAX	-1.0	-1.0	-1.0	
	MIN	-2.5	-2.0	-1.5	
...R 0.0	MAX	-0.75	-0.75	-0.75	
	MIN	-2.0	-1.75	-1.25	
1.0'	MAX	-1.0	-1.0	-1.0	+0.125
	MIN	-2.5	-2.0	-1.5	-0.125
1.5'	MAX	-1.5	-1.5	-1.5	
	MIN	-2.25	-2.25	-2.0	
2.0'	MAX	-3.25	[illegible]	-2.25	
	MIN	[illegible]	[illegible]	[illegible]	

...CAL ...NCE		TRANSMISSION LENGTH = 25.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-3.0	-3.0	-3.0	
	MIN	-3.5	-3.25	-3.25	
1.5'	MAX	-2.25	-2.25	-2.25	
	MIN	-3.0	-2.75	-2.5	
1.0'	MAX	-3.0	-2.0	-2.0	
	MIN	-3.0	-2.5	-2.25	
...R 0.0	MAX	[illegible]	-1.25	-1.25	
	MIN	[illegible]	[illegible]	-1.75	
1.0'	MAX	[illegible]	-1.5	-1.5	+0.125
	MIN	[illegible]	-2.25	-2.0	-0.125
1.5'	MAX	-2.0	[illegible]	-2.0	+.125
	MIN	-3.5	[illegible]	[illegible]	-.125
2.0'	MAX	-2.75	-2.75	-2.75	
	MIN	-3.25	-3.0	-3.25	

...CAL ...NCE		TRANSMISSION LENGTH = 26.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-3.0	[illegible]	-3.0	
	MIN	-3.5	-3.5	-3.75	
1.5'	MAX	-2.25	[illegible]	-2.25	
	MIN	-2.75	-2.75	-2.50	
1.0'	MAX	-2.25	-2.20	-2.25	
	MIN	-3.0	-2.75	-2.50	
...R 0.0	MAX	-1.75	-1.75	-1.75	
	MIN	-2.25	-2.20	-2.00	
1.0'	MAX	-3.0	-3.0	-2.0	+.125
	MIN	-3.0	[illegible]	-2.25	-.125
1.5'	MAX	-2.75	-3.50	-2.25	
	MIN	-3.0	-3.0	-2.5	
2.0'	MAX	-3.0	-3.0	-3.0	+.125
	MIN	[illegible]	-3.25	-3.0	-.125

...CAL ...NCE		TRANSMISSION LENGTH = 26.5' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX				
	MIN				
1.5'	MAX				
	MIN				
1.0'	MAX				
	MIN				
...R 0.0	MAX				
	MIN				
1.0'	MAX				
	MIN				
1.5'	MAX				
	MIN				
2.0'	MAX				
	MIN				

...CAL ...NCE		TRANSMISSION LENGTH = 27.0' RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-3.0	-3.0	-3.0	
	MIN	-3.75	-3.5	-3.25	
1.5'	MAX	-3.5	-3.5	-2.5	
	MIN	-3.5	-3.25	-2.75	
1.0'	MAX	-2.75	-2.25	-2.25	
	MIN	-3.0	-2.5	-2.5	
...R 0.0	MAX	-3.0	-2.0	-2.0	+.250
	MIN	-3.0	[illegible]	-2.5	-.250
1.0'	MAX	-3.25	-2.25	-2.25	+.125
	MIN	-3.25	-2.75	-2.50	-.125
1.5'	MAX	-3.25	-3.25	-3.25	+.125
	MIN	-3.5	-3.25	-3.0	-.125
2.0'	MAX	-3.0	-3.0	-3.0	+.125
	MIN	-3.5	-3.75	-3.25	-.125

Figure 21
CHAMBER EVALUATION

FREQUENCY: 3.25 GHZ

TRANSMITTING HORN SECTION: D3

RECEIVING ANTENNA: Standard Gain Horn (Narda Model 644)

DATE: 8/23/66

NOTES:

Pattern	Range	Ripple
Dotted	= 0.5 - 2.5	= ± 1.0 db
Cross-hatched	= 0.5 - 3.00	= ± 1.25 db
Diagonal hatched	= 0.5 - 3.5	= ± 1.5 db
Light dotted	= 0.5 - 4.0	= ± 1.75 db

SECRET

TRANSMISSION LENGTH = 23.0'

TICAL ANCE		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0	MAX. RIPPLE
2.0'	MAX	-0.5	-0.5	-1.5	+0.75
	MIN	-2.75	-2.25	-1.75	-0.5
1.5'	MAX	-0.5	-0.5	-0.5	+0.75
	MIN	-2.5	-2.0	-1.75	-0.75
1.0'	MAX	-0.75	-0.75	-1.0	+0.75
	MIN	-2.5	-2.5	-2.25	-0.75
ER 0.0	MAX	-0.0	-0.5	-0.0	+0.5
	MIN	-2.25	-1.5	-1.5	-0.5
1.0'	MAX	-0.0	-0.0	-0.0	+0.5
	MIN	-1.75	-1.75	-1.75	-0.75
1.5'	MAX	+0.25	+0.25	+0.25	+0.5
	MIN	-2.25	-1.75	-1.5	-0.5
2.0'	MAX	-0.0	-0.0	-0.0	+0.5
	MIN	-1.5	-1.5	-1.25	-0.5

TRANSMISSION LENGTH = 23.5'

RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
-1.0	-1.0	-1.0	+1.0
-3.5	-3.25	-2.75	-1.0
-0.75	-0.75	-1.0	+0.75
-3.0	-3.0	-3.5	-0.75
-1.5	-1.5	-1.5	+0.5
-3.5	-3.0	-2.75	-0.75
-0.0	-0.0	-0.0	+0.5
-1.5	-1.5	-1.0	-0.5
-0.0	-0.0	-0.0	+0.75
-3.0	-1.25	-1.25	-0.75
-0.0	-0.0	-0.0	+0.5
-1.0	-1.0	-1.0	-0.5
-0.25	-0.25	-0.25	+0.5
[illegible]	-2.0	-1.75	-0.5

TRANSMISSION LENGTH = 24.0'

RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
-1.0	-1.0	-1.0	+0.75
-3.0	-2.75	-2.25	-0.75
-1.0	-1.0	-1.0	+0.5
-3.0	-2.75	-2.75	-0.5
-1.0	-1.0	-1.0	+0.75
-3.5	-2.75	-2.5	-0.5
-1.25	-1.25	-1.25	+0.5
-3.5	-2.5	-2.25	-0.5
-0.75	-0.25	-0.75	+0.5
-3.25	-1.5	-1.5	-0.5
-0.25	-0.25	-0.25	+0.25
-1.5	-1.5	-1.0	
-0.5	-0.5	-0.5	+0.5
-2.5	-1.75	-1.75	-0.5

TRANSMISSION LENGTH = 25.0'

RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
-1.0	-1.0	-1.0	+1.0
-3.25	-2.75	-2.75	-0.75
-1.5	-1.5	-1.5	-1.0
-3.75	-3.25	-3.0	+1.0
-1.25	-1.25	-1.25	+0.5
-3.0	-2.25	-2.25	-0.5
-1.50	-1.50	-1.50	+0.5
-3.0	-2.5	-2.5	-0.5
-0.75	-0.75	-0.75	+1.0
-3.0	-2.5	-2.0	-1.0
-0.75	-0.25	-0.75	+0.5
-2.25	-1.75	-1.75	-0.5
-0.5	-0.5	-0.5	+1.0
-2.25	-2.25	-1.75	-1.0

Figure 22

CHAMBER EVALUATION

TRANSMISSION LENGTH = 26.0'

TICAL ANCE		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.75	-1.25	-1.75	+0.75
	MIN	-4.5	-3.5	-3.5	-0.75
1.5'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-4.0	-3.5	-3.0	-1.0
1.0'	MAX	-1.75	-1.75	-1.75	+0.75
	MIN	-3.0	-3.0	-3.0	-0.50
ER 0.0	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.0	-2.75	-2.25	-0.5
1.0'	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	-2.75	-2.75	-2.25	-0.75
1.5'	MAX	-1.0	[illegible]	-1.0	+0.5
	MIN	-2.5	[illegible]	-2.0	-0.5
2.0'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-3.75	-2.75	-2.25	-0.75

TRANSMISSION LENGTH = 26.5'

RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
-2.25	-2.25	-2.25	+1.0
-4.25	-4.25	-4.25	-1.0
-1.5	-1.5	-1.5	+0.75
-3.5	-3.0	-3.0	-0.5
-1.75	-1.75	-1.75	+0.5
-4.0	-3.0	-3.0	-1.0
-1.25	-1.25	-1.25	+0.5
-2.75	-2.75	-2.5	-0.25
-1.25	-1.25	-1.25	+0.5
-2.5	-2.5	-2.25	-0.5
-0.75	-0.75	-0.75	+0.5
-2.5	-2.25	-1.75	-0.5
-1.25	-1.25	-1.25	+0.75
-3.0	-3.0	-3.0	-0.75

TRANSMISSION LENGTH = 27.0'

RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
-2.0	-2.0	-2.0	+0.5
-4.25	[illegible]	-3.25	-0.5
-1.0	-1.0	-1.0	+0.75
-3.5	-3.25	-3.0	-0.75
-1.75	-1.75	-1.75	+0.5
-3.75	-3.5	-2.75	-0.5
-1.25	-1.25	-1.25	+0.5
-3.0	-3.0	-2.5	-0.5
-1.0	-1.0	-1.0	+0.5
-3.5	-3.5	-2.25	-0.5
-0.5	-0.5	-0.5	+0.75
-3.5	-3.5	-2.25	-0.75
-1.5	-1.5	-1.5	+0.5
-3.75	-3.5	-2.75	-0.5

FREQUENCY: 3.45 GHZ

TRANSMITTING HORN SECTION: D2

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8/22/66

NOTES:

- = +0.25 - 2.25 = ± 1.25 db
- = +0.25 - 2.75 = ± 1.5 db
- = +0.25 - 3.25 = ± 1.75 db
- = +0.25 - 3.75 = ± 2.0 db
- = +0.25 - 4.25 = ± 2.25 db

SECRET

SECRET SECRET

TRANSMISSION LENGTH = 23.0'

L E		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0	MAX. RIPPLE
2.0'	MAX	-2.0	-2.0	-2.0	+0.5
	MIN	-3.5	-3.8	-3.5	-0.75
1.5'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-1.75	-1.25	-2.5	-0.75
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-3.0	-2.5	-2.0	-0.5
0.0	MAX	0.0	0.0	0.0	+0.25
	MIN	-2.0	-1.0	-0.5	-0.5
1.0'	MAX	-0.0	-0.0	-0.0	+0.25
	MIN	-1.5	-1.5	-1.25	-0.25
1.5'	MAX	-0.5	-0.5	-0.5	+0.25
	MIN	-2.0	-1.75	-1.25	-0.25
2.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-3.5	-2.0	-2.0	-0.5

TRANSMISSION LENGTH = 23.5'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-2.75	-2.25	-2.0	-0.5
1.5'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.5	-2.0	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-2.25	-2.25	-2.0	-0.5
0.0	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-2.25	-2.25	-2.25	-0.75
1.0'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.25	-2.0	-1.75	-0.25
1.5'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.25	-2.0	-1.5	-0.5
2.0'	MAX	-1.75	-1.25	-1.25	+0.25
	MIN	-3.25	-3.0	-2.5	-0.25

TRANSMISSION LENGTH = 24.0'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.75	-1.75	-1.75	+1.0
	MIN	-4.0	-4.0	-3.75	-0.75
1.5'	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.5	-2.75	-2.0	-0.5
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-3.0	-2.75	-2.25	-0.5
0.0	MAX	-0.25	-0.25	-0.25	+0.25
	MIN	-1.25	-1.0	-0.75	-0.25
1.0'	MAX	-1.0	-1.0	-1.0	+0.25
	MIN	-2.5	-2.25	-1.75	-0.50
1.5'	MAX	-0.75	-0.75	-0.75	+0.25
	MIN	-2.5	-2.0	-2.0	-0.25
2.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-3.0	-3.0	-0.5

TRANSMISSION LENGTH = 25.0'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.25	-0.25	-0.25	+0.75
	MIN	-4.0	-2.75	-2.5	-1.0
1.5'	MAX	-0.75	-0.75	-0.75	+0.75
	MIN	-1.0	-2.25	-2.25	-0.75
1.0'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.25	-2.0	-2.0	-0.25
0.0	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-1.5	-2.0	-0.5
1.0'	MAX	-0.5	-0.5	-0.5	+0.5
	MIN	-3.25	-2.0	-1.75	-0.75
1.5'	MAX	-0.75	-0.75	-0.75	+0.5
	MIN	-2.5	-2.5	-1.5	-0.75
2.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.0	-2.75	-2.75	-0.5

TRANSMISSION LENGTH = 26.0'

L E		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-3.0	-2.25	-2.25	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.0	-2.5	-2.5	-0.75
1.0'	MAX	-0.75	-0.75	-0.75	+0.75
	MIN	-3.0	-2.75	-2.75	-0.50
0.0	MAX	-1.0	-1.0	-1.0	+0.75
	MIN	-3.0	[illegible]	[illegible]	-0.75
1.0'	MAX	-1.25	-1.5	-1.25	+0.75
	MIN	-2.75	-2.5	-2.25	+0.50
1.5'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.75	-2.5	-2.5	-0.5
2.0'	MAX	-1.25	-1.25	-1.25	+0.5
	MIN	-3.25	-3.0	-3.0	-0.75

TRANSMISSION LENGTH = 26.5'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.75	-3.25	-3.25	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.5	-3.25	-2.5	-1.0
1.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.25	-3.25	-2.75	-0.5
0.0	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.25	-3.5	-2.25	-0.5
1.0'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.0	-3.0	-2.5	-0.50
1.5'	MAX	-1.0	-1.0	-1.0	+0.5
	MIN	-2.5	-2.5	-2.5	-0.5
2.0'	MAX	-1.75	-1.75	-1.75	+0.5
	MIN	-3.5	-3.25	-2.5	-0.5

TRANSMISSION LENGTH = 27.0'

		RELATIVE POWER LEVEL (db) IN HORIZONTAL DISTANCES OF: ±2.0'	±1.5'	±1.0'	MAX. RIPPLE
2.0'	MAX	-1.5	-1.5	-1.5	+0.75
	MIN	-3.25	-3.0	-3.0	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-2.75	-2.0	-2.75	-0.5
1.0'	MAX	-1.25	-1.25	-1.25	+0.75
	MIN	-3.0	-2.75	-2.5	-0.75
0.0	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-3.0	-2.75	-2.5	-0.5'
1.0'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-2.5	-2.5	-2.5	-0.75
1.5'	MAX	-1.5	-1.5	-1.5	+0.5
	MIN	-2.25	-3.5	-2.5	-0.5
2.0'	MAX	-2.25	-2.25	-2.75	+0.5
	MIN	-3.75	-3.75	-3.0	-0.5

Figure 23
CHAMBER EVALUATION

FREQUENCY: 3.8 GHz

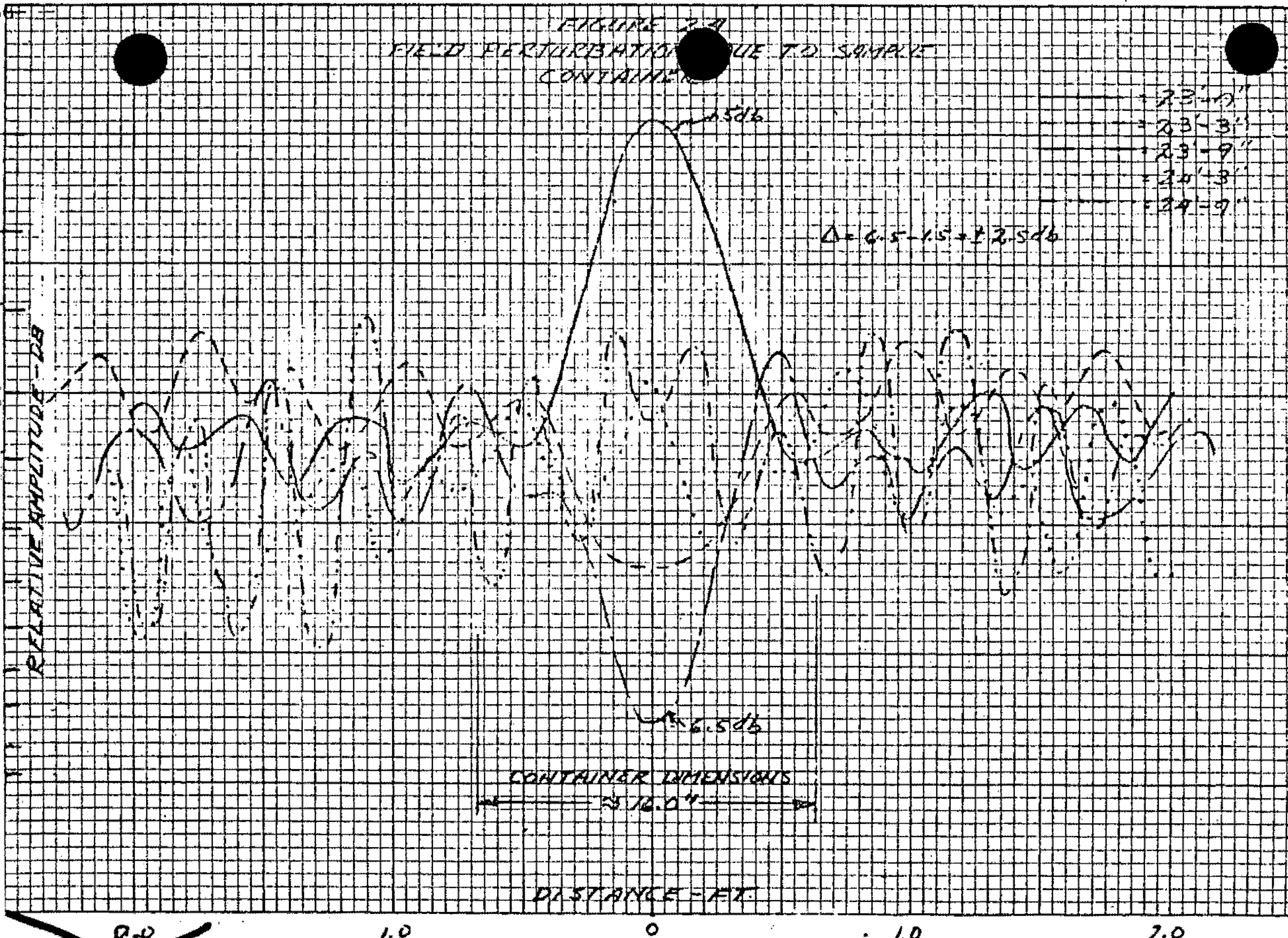
TRANSMITTING HORN SECTION: 01

RECEIVING ANTENNA: Absorber backed dipole

DATE: 8/23/66

NOTES:

- = 0.0 - 2.0 = ± 1.0db
- = 0.0 - 2.5 = ± 1.25db
- = 0.0 - 3.0 = ± 1.5db
- = 0.0 - 3.5 = ± 1.75db
- = 0.0 - 4.0 = ± 2.0db



SECRET SECRET SECRET

APPENDIX A

Transmitting Horn, Design and Test Results

INTRODUCTION

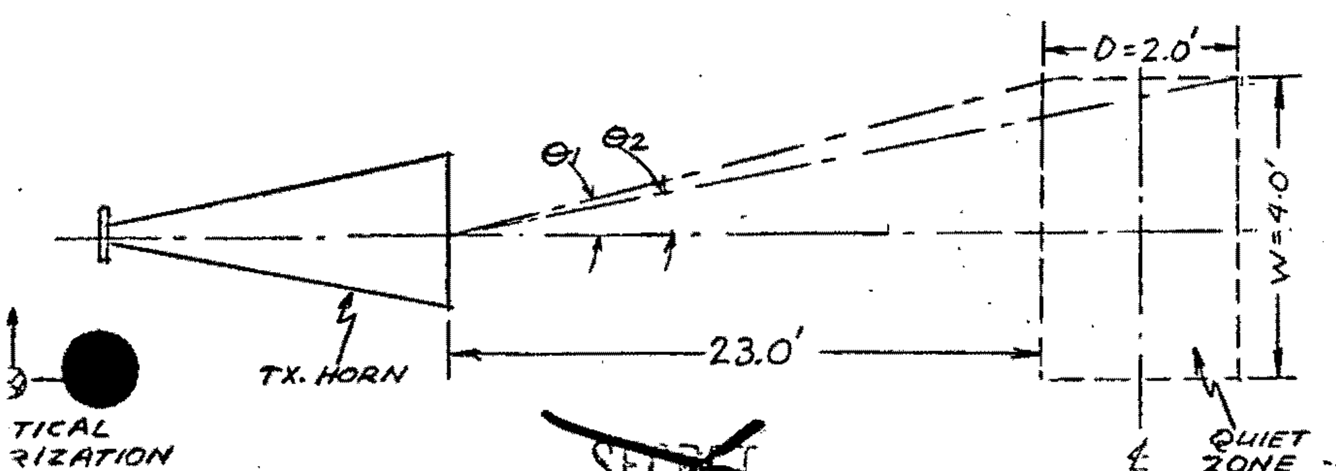
The anechoic chamber specifications originally called for a four foot cubic quiet zone; however, it was determined that a quiet zone 3' wide x 2' high x 1' deep would be suitable for two test samples in containers side-by-side. With a minimum transmitted power of 200 watts, a power density of 2 mw/cm^2 $\pm$ 1.0 db was required in the quiet zone. To allow for a margin of safety, a uniform illumination (within $\pm$ 1.0 db) in a 4'W x 3'H x 2'D quiet zone was the design goal for the transmitting horn antenna.

A conical transmitting horn antenna design was chosen because it has an H plane to E plane beamwidth ratio close to that required (4 to 3), without the narrower beam in the intercardinal planes associated with the pyramidal horn antenna.

Because gain and beamwidth vary with the wavelength, the horn design incorporates "add-on" sections for the various incremental bandwidths. This is discussed further under beamwidth considerations. The first section includes a built-in rectangular to circular transition obviating the need for a separate waveguide transition. Figure 5 in the main section of this report is an illustration of the transmitting horn.

BEAMWIDTH CONSIDERATIONS

The geometry for the horn illumination of the quiet zone is shown in the following sketch.



The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

The chamber specifications called for a maximum of .5 db (± .25 db) change in amplitude due to reflections from the walls. This value, added to the .75 db (± .37 db) change in amplitude due to the change in transmission length ($\frac{1}{R^2}$ loss), dictated that the change in amplitude due to the beamwidth of the transmitting horn could not exceed .75 db in order to meet the design goal of ± 1.0 db change in power density in the quiet zone volume. From the above sketch, then, the .75 db beamwidth is $2\,\theta_2 = 2.\tan^{-1}\frac{2}{25} = 9.2^\circ$. From the figure in reference 3, the ratio of the .75 db beamwidth to the 3 db beamwidth is .5. Thus,

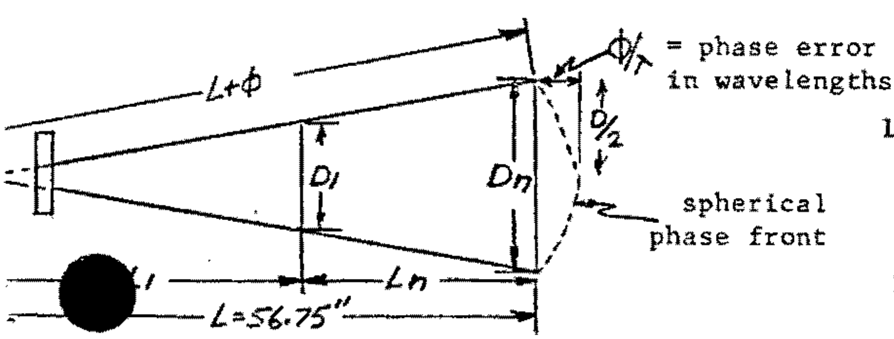
$$\frac{\theta_H(.75\text{ db})}{\theta_H(3\text{ db})} = .5 \qquad \theta_H(3\text{ db}) = \frac{\theta_H(.75\text{ db})}{.5} = \frac{9.2}{.5} = \underline{\underline{18.4^\circ}}$$

The S-Band frequency range from 2 to 4 GHz was divided into eight increments, each representing approximately 10% of the band, in order to keep the beamwidth (and gain) nearly constant. To compensate for this ten percent bandwidth, the design beamwidth was increased by ten percent, resulting in a desired H plane 3 db beamwidth of 20°.

The horn aperture diameter in wavelengths (D/λ) was determined from the approximate expression from the H plane beamwidth [(4)].

$$\theta_H(3\text{ db}) \cong \frac{70}{D/\lambda}$$

For $\theta_H(3\text{ db}) = 20^\circ$, $D/\lambda = 3.5$. Starting at 2.0 GHz, the approximate 10% incremental frequencies, wavelengths, and the diameter of the horn section computed from $D/\lambda = 3.5$ are shown in Table A1. Also shown in this table are the lengths of the various sections computed from the geometry in the following sketch.



$$L \approx \left(\frac{D}{2}\right)^2 \times \frac{1}{2\phi}$$

For $D \approx 4\lambda$ $\quad \phi = \frac{\lambda}{4}$ (chosen)

$L = 8\lambda$

(3) The Microwave Engineers Handbook and Buyers Guide 1966, Page 174
(4) *Antennas* J. D. Kraus McGraw Hill 1950, Page 381

Thus $L \cong 8\lambda$ determined the lengths of the various sections as tabulated.

TABLE AI

Horn Dimensions

Freq.	λ(in.)	Diameter (in.) $D = 3.5\lambda$	Section Designation	L_n (in.)
2.00	5.8	20.00	D8	21.5
2.20	5.35	18.75	D7	17.5
2.45	4.80	16.75	D6	14.0
2.70	4.35	15.25	D5	10.5
2.95	4.00	14.0	D4	7.50
3.20	3.70	13.0	D3	5.25
3.55	3.35	11.75	D2	2.25
3.90	3.05	10.75	D1	0

The recommended frequency range for S-Band WR 284 waveguide is 2.6 to 3.95 GHz, therefore horn sections larger than D6 may not be required. However, should higher power densities be needed (over smaller areas) horn sections D7 and D8, and two additional sections, D9 and D10 were constructed. The diameters for D9 and D10 are 22.5" and 24.5", and the lengths are 26.75" and 31.75" respectively, based on the same criteria as the other sections.

GAIN REQUIREMENTS

The above analysis assumes an aperture with sufficient gain to provide a power density of 2 mw/cm^2 for a minimum of 200 watts of transmitted power. Reference 5 gives the gain of a conical horn as

$G\ (db) = 10 \log \left(\frac{4\pi A}{\lambda^2}\right) - L$, where L is the loss term (in the reference figure) versus the phase deviation at the aperture edge. For the selected phase deviation of $\lambda/4$, $L = 1.5$ db; and for $D/\lambda = 3.5$

$$G = \left(\frac{\pi D}{\lambda}\right)^2 - 1.5 \text{ db} = 20.85 - 1.5 \doteq 19.4 \text{ db}$$

(5) Antenna Engineers Handbook H. Jasik, Ed. McGraw Hill (1961) Chap 10-4

The power density is

$$Pd = \frac{P_r}{A_r} = \frac{P_T G_T}{4\pi R^2} \qquad \text{where } P_T = 200 \text{ watts (min)}$$

$$G_T = 19.4 \text{ db} = 87$$

$$R = 24 \text{ ft}$$

$Pd = 2.6\ \text{mw/cm}^2$, which is adequate.

MEASURED VERSUS CALCULATED VALUES

The calculated gain (above) was 19.4 db at the design frequencies, which included a 1.5 db loss due to efficiency and phase error. The measured gains at the design frequencies are tabulated below along with the difference between the measured and calculated gain (ΔG).

TABLE A2

Measured versus Calculated Gain

Horn Section	Design Frequency	Measured Gain	Calculated Gain	ΔG
D1	3.9	20.3	19.4	+0.9
D2	3.55	20.0	19.4	+0.6
D3	3.20	19.7	19.4	+0.3
D4	2.95	19.7	19.4	+0.3
D5	2.7	19.6	19.4	+0.2
D6	2.45	19.4(est)	19.4	+0.0

From this table, it can be seen that the measured gain is very slightly higher than calculated. This is due in part to the beamwidth being slightly narrower than the design value; and in part to the phase deviation at the aperture edge being less than λ/4, and consequently, the loss due to phase error and efficiency being slightly less than the 1.5 db allotted.

Table A3 below compares the measured and calculated 3 db beamwidths, which again are in good agreement. These values indicate that the expression for the H plane 3 db beamwidth is more nearly $\theta_H\ (3\ \text{db}) \cong \frac{68}{D/\lambda}$ and for the E plane $\theta_E \cong 55/D\lambda$.

TABLE A3

Measured versus Calculated E & H Plane Beamwidths

Horn Section	Frequency (GHz)	Measured H Plane 3dbB.W (Degrees)	Calculated $\theta_H(3db)=\frac{70}{D/\lambda}$	Measured E Plane 3dbB.W (Degrees)	Calculated $\theta_E(3db)=\frac{60}{D/\lambda}$
D1	3.9	18.9	20°	15.8	17°
D2	3.55	19.3	20°	15.7	17°
D3	3.2	19.7	20°	15.7	17°
D4	2.95	19.6	20°	15.5	17°
D5	2.7	19.5	20°	15.5	17°
D6	2.45	19.5	20°	15.5	17°

APPENDIX B

Sleeve Dipole Antenna

A dipole was chosen as the field probe antenna for the chamber evaluation in order to observe virtually all of the reflections from the walls (and the ceiling and floor), which contribute to the perturbation of the field in the chamber. The sleeve (or skirt) dipole design was selected because of its natural configuration for an upright power monitor of a vertically polarized field, and because of its ease in construction utilizing the APL 5-spline semirigid coaxial cable which was available; the dipole probe tip simply screws into the cables hollow center conductor. The dipole is illustrated in figure B1. This figure gives the pertinent design dimensions which were arrived at empirically using the basic tenets set forth by Silver[6].

Figure 13, in the main section of this report, illustrated the fixed monitor version of the sleeve dipole used as a power monitor in the chamber.

Figure B2 illustrates the "gooseneck" version used to evaluate the chamber.

The VSWR of both versions is shown in figure B3. These values include the mismatch from the Type N to 5-spline cable transition. A surprising feature of these dipoles is that the VSWR was less than 2:1 from 2.6 GHz to 11.4 GHz (the limits of the then available equipment).

---

[6] Microwave Antenna Theory and Design S. Silver, Ed. MIT Rad Lab Series, Vol 12 McGraw Hill (1949) Chap 8.2

[redacted] S[redacted] [redacted]

[redacted]

"UNCLASSIFIED"

IDA

January 2, 1969

THIS DOCUMENT HAS BEEN DOWNGRADED TO "UNCLASSIFIED" 9 - OCT 1979 Per Director DARPA/TIO

MEMORANDUM TO: Mr. R. S. Cesaro, ARPA

FROM: Herbert Pollack

SUBJECT: Report of Visit to U.S.S. Saratoga, December 31, 1968 (U)

1. The visit to the Aircraft Carrier Saratoga was accomplished on December 31, 1968. The personnel were most cordial and cooperative.

2. The Chief Medical Officer is an alert, well informed, and effective physician. We discussed the possibility of a retrospective study of the health records of deck personnel as compared to other groups of sailors.

3. The engine room crew, because of constant exposure to high temperatures, have a specialized series of complaints that make it difficult to evaluate their health against deck crews. Sailors in the supply division would serve as better controls.

4. The medical records while adequate for the routine health supervision may not be complete enough for our purposes. Commander Pratt, the C.M.O. of the Saratoga, has offered to try to get a comparison of sick call rates between deck crews and other divisions and to list the frequency of various complaints or presenting symptoms.

5. The Operations Officer in charge of radar pointed out that the "lookouts" are in the direct line of sight of the search radars for four hours at a time. These men are selected from the gunnery crews.

6. The executive officer speaking for the Captain expressed their interest in the problems and will extend all help if the CNO or CINCATLAN approves a request to have two observers aboard the Saratoga to get base line readings on selected members of the crew. The carrier is scheduled for a training cruise in the Carribean for February and it was suggested that the last part of that month would be most convenient for them.

"UNCLASSIFIED"

[redacted] Copies

[redacted]

[redacted] ~~SECRET~~ [redacted]

[redacted]

"UNCLASSIFIED"

7. It is suggested that a protocol be developed for the purpose of making measurements of "vigilance" reactions on selected members of the crew. These measurements will be repeated on the same people after several months of operational activities. It should be pointed out that the Saratoga has just undergone extensive rehabilitation and has been tied to the docks for one year. Hence none of the ship's complement have had any exposure to micro-waves during this time. The subjects selected for the study should be divided into two groups: a. veteran members of the crew whose duties allowed them to be radiated by the micro-waves and b. new recruits with no history of previous exposure to micro-waves. A log will be kept of the duty stations and hours of the selected subjects.

HP/nr

"UNCLASSIFIED"

[redacted]

THE SARATOGA STUDY (U)

THIS DOCUMENT HAS BEEN DOWNGRADED
TO "UNCLASSIFIED" 9 - OCT 1979
Per Director, DARPA / TIO

Joseph F. Kubis

(5-8-69)

"UNCLASSIFIED"

Copy 16 of 20 Copies

IDA HQ 69-10

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U.S. Code, Sections 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is

EXCLUDED FROM AUTOMATIC REGRADING; DOD DIR 5200.10 DOES NOT APPLY

TABLE OF CONTENTS

SARATOGA REPORT

Presents the rationale, results and recommendations of the Saratoga Study.

APPENDIX A

Issues in this report prepared by Dr. Kubis were presented verbally in a meeting (2-18-69) at Walter Reed Hospital called by Mr. Cesaro.

APPENDIX B

The reduced data and analytic summaries were prepared by Captain James P. Flanders with the assistance of Ensign Loren Appelbaum and Captain J. Ronald Gentile. Methods of scoring, reducing, and analyzing the data were established in meetings (2-20 and 2-24-69) held by Dr. Kubis at Walter Reed Hospital (Forest Glen). The analytic summaries and other data necessary for completing the Saratoga report were received by Dr. Kubis on March 18, April 2, and April 15, 1969.

THE SARATOGA REPORT

PURPOSE

1. To determine if seamen, grouped according to amount of exposure experienced during work schedules, would differ in performance on a broad battery of cognitive, sensory-perceptual, and psychomotor tests.
2. To provide baseline performance data for seamen under dockside and at-sea conditions.
3. To establish the reliability of the measures used under the ordinary working conditions of a seaman.

RATIONALE

It was anticipated that sailors working on the Flight Deck would receive more exposure than sailors working below deck (specifically, the Hangar Deck). Though differing in exposure, these two groups are relatively equivalent in terms of work loads and work schedules, and could be made equivalent on a number of background variables such as age, education, and general ability.

Lookouts at the 09 Deck Level were considered to be highly exposed. On the basis of conversations with the personnel in the CS and OI groups, both involved in lookout operations, the former (CS) was judged to be more exposed than the latter (OI). Sailors from the 4th Division were selected as a control for both the CS and OI groups. These sailors had no exposure of the sort experienced at the 09 Deck Level, but their work duties were similar to those of the CS and OI groups.

Three sets of analyses were suggested: (1) to evaluate the differences in test performance between the Flight Deck (exposed) and the Hangar Deck (non-exposed) crew; (2) to evaluate the differences among the CS, OI, and 4th Division groups, which represent a gradient of exposure from maximal to minimal; (3) to evaluate the test performance of the CS, OI, and 4th Division groups immediately after a work assignment. Since each of these groups were to be tested during a non-work (i.e. non-exposed) period, the retesting immediately following a work assignment (during which the CS and OI groups are subject to exposure) would test for immediate exposure effects.

FUNCTIONS MEASURED -- TESTS USED

A broad spectrum of human functions was selected on the basis of potential sensitivity to the exposure conditions anticipated aboard the Saratoga. These are categorized below.

A. Psychomotor

1. Choice Reaction Time
   (Lafayette device)

2. Rotary Pursuit
   (Lafayette photoelectric apparatus)

B. Sensory-Perceptual

1. Visual Acuity (Far and Near)
   (Vision Tester - Titmus)

2. Vertical and Lateral Imbalance
   (Vision Tester - Titmus)

3. Stereo-Depth
   (Vision Tester - Titmus)

4. Color Weakness
   (Vision Tester - Titmus)

5. Flicker Fusion
   (Lafayette apparatus)

C. Cognitive

1. Word Fluency
   (Word Endings Test)

2. Number Facility
   (Addition Test)

3. Memory
   (Auditory Number Span Test)

4. Speed of Closure
   (Concealed Words Test)

5. Perceptual Speed
   (Number Comparison Test)
   (Identical Picture Test)

In addition, a hand dynamometer was used to test hand grip. This test provided superficial face validity to a procedure which, in its directions, emphasized "fatigue" as an important factor under study (cf. Appendix A).

SUBJECTS

Subjects were selected for membership in each of the experimental and control groups on the basis of educational level, prior test performance, and time remaining in service.

The minimum educational requirement was completion of the 12th grade. In a few instances a 12th grade equivalency diploma was substituted for the high school graduate requirement.

Prior testing on the GCT and ARI provided an added check on the educational criterion. A combined score of 95 on these two tests was the cut-off score, with neither the GCT nor ARI below 45. The educational requirement and the test criterion filtered out those subjects who would have difficulty in reading or understanding the directions in the experimental test battery.

Finally, no seaman was selected who was due to leave the service in less than 12 months. This criterion made it possible to retest subjects after an extended tour of duty and, therefore, after extended exposure.

METHODOLOGY

The conditions under which the tests were administered are described in Appendix A.

STATISTICAL CONSIDERATIONS

The data were considered to meet the requirements of classical tests of significance. Analyses of variance of single and multiple classification and repeated measures designs were utilized. Pearson product-moment correlation coefficients were used to estimate test-retest reliability.

RESULTS

As indicated in the summary table of Appendix B, the statistical analysis presents a picture of overall insignificance. The few significant results (test-retest situation) present no meaningful pattern.

In particular

1. There are no meaningfully significant differences between the test performances of the Flight Deck and the Hangar Deck crews. The one significant difference is in the Reaction Time score which lacks adequate reliability.
2. There are no significant differences in performance among the Lookout groups: CS, OI, and 4th Division.
3. There are no significant differences in performance among the Lookout groups when tested immediately after a work (exposure) session.
4. The reliability of most of the test instruments proved to be adequate for the conditions under which they were used. Reaction Time measures, however, were unreliable. Memory Span appears to be an inadequate as well as an unreliable measure of the memory function. Word Endings,

Far Acuity (Both eyes), and Flicker Fusion have yielded reliabilities lower than expected.

CONCLUSIONS

1. No exposure effect was demonstrated.
2. Reliability is adequate for most test measures.

DISCUSSION

In view of the short period of exposure during the sea trials of the Saratoga, the Flight Deck, the CS, and the OI groups were not expected to differ significantly in test performance from their control groups. Consequently the obtained results, which indicated general non-significance, were not surprising.

However, upon careful check, considerable doubt now exists as to whether any exposure differences (as assumed by prior considerations) actually existed aboard the Saratoga during the sea trials. In view of the strong probability for this position, the obtained negative results tend to generate confidence in the adequacy of the test procedures and the care with which the criteria of selection were applied.

The adequate reliability of most test measures obtained during the ordinary work day of the seaman and under actual operating conditions (eg. ambient noise, vibration, and motion aboard a ship in restless seas) gives further confidence in the use of such test procedures aboard vessels during routine sea operations.

RECOMMENDATIONS

1. Reaction Time, Memory Span, Far Acuity, Word Endings, and Flicker Fusion should be reexamined and appropriately modified to meet higher reliability standards.
2. An ongoing search program should be undertaken to identify behavioral functions potentially susceptible to the exposures alluded to in this study.

3. Exposure situations or sites of the type alluded to in this study should be examined to see if

   a. they produce exposure of sufficient intensity

   b. the exposure intensities can be monitored so as to provide a record of any changes in rate of exposure

   c. a sufficient number of subjects are subjected to the exposure intensity

   d. a measure of subject-exposure-time can be developed.

4. In view of the difficulties experienced in this study relative to the use of external electric power (cf. Appendix A), instruments for the evaluation of psychomotor functions should be supplied with independent power sources where feasible.

APPENDIX A

[illegible]

[illegible]

FATIGUE STUDY

UNCLASSIFIED

[illegible]

I. PREPARATORY STAGE

A. Selection of Abilities to be Tested

Aiming
Depth-Perception
Memory Span
Perceptual Speed
Response Orientation
Speed of Closure
Static Strength
Visual Acuity
Word Fluency

B. Contracted Services with BioTechnology Inc.

1. To obtain tests
2. To duplicate test materials
3. To prepare direction and recording forms
4. To train a field team in the use of the test battery

C. Training Program

1. At BioTechnology Inc.
2. 1-23-69 through 1-24-69

D. Personnel

1. Preparatory Stage

Dr. Joseph V. Brady
Dr. Thomas W. Frazier
Dr. Joseph F. Kubis
Dr. Herbert Pollack

2. Training Stage

ENS. Loren Appelbaum
CPT. James P. Flanders
CPT. J. Ronald Gentile
Dr. Joseph F. Kubis
CDR. Thomas J. Sullivan

E. Directions and Questionnaire

Confer Appendix

II. TESTING STAGE

A. On Board - Dockside (1-27-69 through 1-30-69)

1. Facilities

a. Initially, Ward 2 and the Quiet Room
b. Later, because of blood work and TB examinations, testing was conducted in the Isolation Ward and the Quiet Room

UNCLASSIFIED

[illegible]

2. Personnel and Duties

a. ENS Appelbaum, CPT Flanders, and CPT Gentile -- testing
b. CDR Sullivan -- liaison and scheduling
c. Dr. Kubis -- liaison, personnel records analysis, coordination

3. Work Completed

67 individuals were tested

B. On Board - At Sea (1-31-69 to 2-10-69)

1. Facilities

a. Initially, the Isolation Ward and the Quiet Room
b. Later, because an active case of TB had to be isolated, testing was limited to the Quiet Room

2. Personnel and Duties

a. ENS Appelbaum and R. Deimel -- testing
b. Dr. Kubis -- liaison, scheduling, and coordination
c. (Note: R. Deimel was trained in test procedure by ENS Appelbaum.)

3. Work Completed*

a. 92 persons were tested
b. 47 of these were retests
   i. to obtain a reliability estimate
   ii. to evaluate the effects of watch or lookout duty

* To be rechecked during reduction and analysis of data

C. Acknowledgments

To CDR H. Pratt for outstanding cooperation and help in providing testing and living space; and for laying the groundwork for the genuine acceptance of the project.

To CDR T. Sullivan for outstanding cooperation in keeping the testing program moving smoothly and for providing Robert W. Deimel as psychometrist for testing at sea.

To ENS Appelbaum, R. Deimel, CPT Flanders, and CPT Gentile for enthusiastic devotion to the demands of arduous duty.

To all officers and to the men who were tested for their wholehearted participation in the program.

D. Problems

1. Noise level -- since continuous, probably not a critical factor

2. Occasional announcements over public-address system

3. General quarters

4. Occasional intrusion into testing room

5. Variable line power

6. Breakdown in the controls on the timer for the rotary pursuit and reaction time apparatus

E. Resolution of Problems

1. Data influenced by extraneous and undesired intrusions will be analyzed separately.

2. The apparatus for the rotary pursuit and reaction time tests was to be returned to BioTechnology for repair. These units were removed from the Saratoga, January 30, 1969, by CPT Flanders and CPT Gentile.

F. Disposition of Apparatus and Test Material

All remaining apparatus and test materials were to be removed from the Saratoga, Monday Feb. 10, 1969, by ENS Appelbaum and R. Deimel, to be returned to Dr. T. Frazier. Apparatus should be rechecked by BioTechnology.

III. RECOMMENDATIONS

A. All apparatus to be rechecked and recalibrated, if necessary, before any additional testing is to be done. This task should be referred to BioTechnology.

B. Scoring of tests. Since "local" problems can be best interpreted by the men who did the testing and since there are not too many tests involved, it might be most economical to have ENS Appelbaum, R. Deimel, CPT Flanders, and CPT Gentile do the scoring or to closely supervise it. Recording format should be compatible with card punching requirements.

C. Reduction and Analysis of Results. Some preliminary analysis should be completed before further retesting is undertaken. The first phase of the retesting should be scheduled sometime within the period of April 15 to April 30, 1969 during which the Saratoga will presumably be in Mayport. It is recommended that the personnel involved in the Dockside testing in Philadelphia conduct the testing at Mayport.

D. Blood on a limited sample should again be taken at Mayport during the April 15-30 period.

E. M. Grove should continue his work by rechecking his readings at Mayport. Other aspects related to these readings, should be discussed by the present group.

F. The problem of variable power on the Saratoga in relation to the rotary pursuit and reaction time tests should be discussed with BioTechnology Inc.

J.F.K. - (2-18-69)
Walter Reed Hospital

APPENDIX

GENERAL INSTRUCTIONS

When men are tired, sleepy, or work under heavy stress loads, their performance usually suffers and they tend to make more errors.

We want to measure how human efficiency is affected by long working hours, hard work, and different work-rest schedules.

We will do this by giving you a number of tasks and activities that will involve sensory, perceptual, and motor functions.

Accuracy and time will be measured.

Make sure you understand the instructions before you begin. Instructions for each task will be given by the examiners.

The results of these tests will have no bearing on your naval career and will not become a part of your service record.

Thank you for your cooperation.

FATIGUE-SLEEP

1. How tired do you feel?

   Very ______ Moderately ______ Slightly ______ Not at all ______

2. How sleepy do you feel?

   Very ______ Moderately ______ Slightly ______ Not at all ______

3. How long did you sleep? ________ hours

4. When did you awake? __________AM (PM)

5. What activity were you engaged in just before coming here for testing?

6. How long were you involved in this activity? __________ hours

7. Have you ever worked around X-ray machines? ____________

8. Have you had any X-ray examinations in the last year? ___________

   If so, was it Stomach
   Chest
   Head
   Arm or leg

9. Are you taking any drugs regularly? _____________

   Which? ____________________________________

10. Are you taking aspirin? __________________________

    How much? __________________ How often? _______________

Data Collection Form

Name ______________________ Date ______________________

Service No. ______________________ Time ______________________

Rate ______________________ Examiner ______________________

Division ______________________

Critical Flicker Frequency (in flashes per second)

1A ________ 2D ________ 3A ________ 4D ________ 5A ________

6D ________ 7A ________ 8D ________ 9A ________ 10D ________

Choice Reaction Time (practice 3 each color) (in milliseconds)

1R ________ 2B ________ 3B ________ 4G ________ 5R ________

6G ________ 7B ________ 8G ________ 9R ________

Rotary Pursuit Test (30-second trials) (time on target in seconds)

1. ________ 2. ________ 3. ________ 4. ________ 5. ________

Grip Strength (kilograms)

R ________ L ________ R ________ L ________ R ________ L ________

Comments:

APPENDIX B

SUMMARY OF ANALYSES

I. Key to Summary Sheet
   A. Sources of variance
      1. Treatments(Tmts)
         a. 2x2: Flight vs hangar
         b. 3x2: OI vs CS vs Fourth
      2. Testing occasions (TO)
      3. Tmts x TO interaction
   B. Only Fs greater than 1 are shown
   C. Dependent measures with retests available were analyzed using ANOVA with repeated measures and test-retest reliabilities
   D. Dependent measures without retest, namely reaction time and pursuit rotor, were available only on Flight and Hangar treatments, and thus were analyzed using one-way ANOVA and between-trial reliabilities
   E. Table showing p-values for all relevant Fs is given for convenience in lower left corner

II. ANOVA results
   A. Treatment effects were not found in 2x2 or 3x2 ANOVAs. One treatment effect was found in overall [illegible] of [illegible] reaction time measure, indicating shorter reaction times for flight than hangar deck members. Because there was only one significant treatment effect of 24, the most reasonable interpretation is that the solitary finding is a chance finding. Thus the data can be interpreted as indicating no differences exist between treatment groups on these tests.
   B. Interaction effects were not found, indicating that all treatment groups were affected in the same way by the two test occasions. That is, test-retest difference scores were of the same magnitude and direction for all treatment groups.
   C. Five significant test occasion effects were found. The following arguments support the proposition that meaningful interpretation of these five effects is not possible.
      1. Argument against strong TO effects. Only five of 22 TO effects were significant. In all five cases the significant effects found in the 2x2 ANOVAs failed to obtain in the 3x2 ANOVAs, with F less than 1 in three of the five cases.
      2. Argument against a general consistent TO effect. No general consistent effect of being at sea occurred, since a significant performance increment occurred on three of the tests while a significant performance decrement occurred on two tests.
      3. Argument against meaningful differentiated interpretation. Since being at sea hindered performance on three paper-and-pencil tests and improved performance on two other tests, it might be argued (differentiating between kind of test) that the results can meaningfully be interpreted using paper-and-pencil vs non-paper-and-pencil kind of test. Meaningful differentiated interpretation requires a reasonable a priori reason for the two kinds of tests to be affected differently by being at sea. No such reason is apparent. However, one's desire to go out on a limb to interpret these findings is

weakened with the realization that all five findings failed to obtain in the 3x2 analyses.

4. Argument against meaningfulness on the basis of significance. It might be argued that because the five effects were significant, they are meaningful to some degree. However, being neither strong nor consistent, the significant findings are most parsimoniously interpreted as chance findings, possibly Type I errors. Going out on a limb to create an explanation for these findings viewed in proper context would violate common sense, and whenever there is a conflict between methodological rules and common sense, common sense must prevail.

D. Summary of ANOVA results. ANOVA yielded five significant findings of 68 possible significant findings. Being neither strong nor consistent, these findings are best interpreted as chance effects, possibly Type I errors.

III. Reliabilities. For subtests of WAIS or other relatively "pure" tests, reliabilities of .65 and up are about all that can be expected at present. If the reliability of a given test is less than this figure, recommend rejecting it unless reliability can be raised, possibly using recommendations below.

IV. Recommendations

A. Paper-and-pencil tests

1. Identical pictures, number comparisons, concealed word, and addition test reliabilities are adequate for parallel forms with test and retest 1-2 weeks apart.
2. Word endings test reliability is low. No suggestions for improvement.
3. Number span is too unreliable for future use in present form. However, since most subjects recalled very few sequences, it is recommended that items be presented in order of increasing difficulty. WAIS digit span subtest of this kind is reliable.

B. Electrical apparatus. Recommend no testing with electrical apparatus be initiated until line voltage fluctuations have been checked before testing and found to meet with approval. Checking throughout testing also necessary. Recommend use of "Amp-probe" a-c line monitor.

C. Vision tests

1. CFF and vision test reliabilities are quite low by physiologic test standards. Recommend eliminating tests where reliabiliti cannot be raised to .80 by checking line voltage and standardizing wearing of glasses for the tests.
2. Flanders recommends eliminating vision tests 2, 3, 5, 6, 10, and 11, which do not seem to yield different (qualitatively) information in addition to tests 1, 4, 7, 9, and 12.
3. Recommend eliminating non-preferred grip test. Reliability is lower than preferred grip test and there seems nothing which non-preferred indicates in addition to preferred.

5. Recommend deciding whether complex judgement-reaction time or simple reaction time measure is desired. If a simple reaction time to a stimulus is desired, recommend reaction time task with single bright light and single key. If complex judgement-reaction time measure desired, recommend keeping present reaction time task, which requires several different responses to be made. The disadvantage with the present task is that color perception, key position, color perception of key, and probably some judgmental factors are confounded. Thus even significant results with the present task would be uninterpretable without extensive other investigations. Advantage of the present method is that it might be more sensitive since one of the processes involved might be more sensitive, but etiology would be obscured since the processes are confounded. Obviously different processes are involved in reacting to the different colors. Unless strong justification exists for a complex task here (none should, since complex tasks are present elsewhere in the battery), recommend using simple reaction time task.

D. Pursuit rotor tracking has good reliability. Recommend keeping it.

E. General recommendations

1. Recommend specific factors upon which tests load to be enumerated.
2. Recommend considering using both speed and power tests on at least one factor. Prominent theories of [illegible] hypothesize different effects upon [illegible], depending upon task difficulty and characteristics of subject. In paper-and-pencil tests, identical pictures, number comparison, and addition are speed, while number span and possibly word endings and confounded words are substantially power, thus confounding test difficulty with factor loaded upon.

DEPENDENT VARIABLES ON SUMMARY SHEET

1. Identical pictures. Scores were corrected for guessing using Nunnally formula (Nunnally, J.C. Tests and Measurements. New York; McGraw-Hill, 1959, p. 55).

$$\text{Number corrected} = \frac{\text{Number correct} - p\ (\text{number tried})}{q}$$

"UNCLASSIFIED"

Where p = 1/number alternatives = .2

and q = 1 - p = .8

2. Number comparison. Number correct - (number tried - number correct)
Number correct - (number incorrect) = score.
3. Number span. Number correct.
4. Word endings. Number correct.
5. Concealed words. Number correct.
6. Addition. Number correct.
7. Sum CFF ascending. Eliminated trials 1 and 2. Eliminated scores over 59. Eliminated aberrant score for subjects with range of ascending scores over 9. Then Sum CFF ascending = 3+7+5+9.
8. Sum CFF descending = 4+8+6+10, after eliminations as above.
9-14. Vision test scores recorded straight from sheets, i.e. difference scores not taken for tests 6,7, and 12.
15. Sum grip preferred. Eliminated lowest score for each hand. Identified preferred hand as hand with greater of two remaining sum scores.
16. Sum grip non-preferred.
17-19, 21 are not variables but reliabilities.
17. Correlation of mdn red with mdn blue.
18. Correlation of mdn red with mdn green.
19. Correlation of mdn green with mdn blue.
20. Median of medians for reaction time.
21. Correlation of trials (2+4) with trials (3+5).
22. Pursuit rotor sum trials (2+4+3+5).

Row	Stat	Eidetic pictures	Number [illegible]	[illegible] span	Word [illegible]	[illegible]	[illegible]	CTT [illegible]	CTT [illegible]	Vis. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Equip. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(N=44) reliability, test-retest		.744	.743	.455	.597	.742	.917	.650	.552	.558	.77-	.866	.929										
(N=15) reliability, test-retest														.762	.810	.878	.742						
(N=15) reliability, alternate trials																		.260	.108	.581		.856	
ANOVAs																							
2 X 2 N=24 Bet. Ss, Tmt	F	<1	<1	1.0910	2.7910	<1	<1	<1		<1	<1				1.5178	<1							
	p			>.05	>.05										>.05								
Wth Ss, Test occ.	F	11.7596	<1	2.108	<1	7.0191	14.5811?	2.3891		<1	<1				4.5087	12.1036							
	p	<.01		>.05		<.01	<.01	>.15							<.05	<.01							
	interpretation	T>RT				T>RT	T>RT								RT>T	RT>T							
TmtxTO	F	<1	<1	<1	<1	<1	<1	<1		<1	1.2?				1.0250	<1							
	p										>.[illegible]				>.05								
3x2 N=17 Bet Ss Tmt	F	2.2506	2.5918?	3.457?	[illegible]	1.9057	4.1566?	1.1971?		1.3?16	2.[illegible]				<1	<1							
	p	>.05	>.05	>.05	>.[illegible]	>.05	>.05	>.05		>.05	>.[illegible]												
Wth Ss TO	F	<1	<1	2.5417	<1	4.4003	2.1900?	<1		<1	<1				<1	<1							
	p			>.05		>.05	>.05																
	Interp					T>RT	T>RT?																
TmtxTO	F	3.2197	<1	1.0852	<1	<1	<1	<1		2.0327	<1				<1	<1							
	p	>.05		>.05						>.05													
Normal ESS, FH vs. hangar																					7.189 <.01 F<H		<1

F	p <.05	<.025	<.01
$F_{1,24}$	4.26	5.72	7.82
$F_{2,16}$	3.63	4.69	6.23
$F_{1,16}$	4.49	6.12	8.53

[illegible]

			Embedded Pictures	Number comparison	Number span	Word endings	Concealed words	Addition	N	Score Accuracy	Score Speed	Visual [illegible]	Vis[illegible]
[illegible]	Flight	[illegible]	24.270	21.000	2.959	12.[illegible]	11.500	19.7[illegible]	22	1[illegible]	113.[illegible]	16.9[illegible]	7.
	[illegible]	[illegible]	4.245	3.651	1.014	4.425	[illegible].345	6.179	22	16.[illegible]	16.761	[illegible]	2.
[illegible]	[illegible]	[illegible]	28.300	20.900	3.4[illegible]	9.[illegible]	13.133	19.[illegible]	30	190.3[illegible]	118.8[illegible]	11.5[illegible]	6.
	[illegible]	[illegible]	7.197	5.000	1.716	4.5[illegible]	3.4[illegible]	5.[illegible]	30	12.6[illegible]	23.7[illegible]	2.177	2.
	[illegible]	[illegible]	29.769	20.961	3.0[illegible]	10.[illegible]	12.423	[illegible]	26	189.5[illegible]	112.1[illegible]	11.500	7.
	short	[illegible]	6.58[illegible]	4.8[illegible]	1.356	4.981	3.336	5.7[illegible]	[illegible]	14.083	19.1[illegible]	2.[illegible]	3.
	relat	[illegible]	25.981	20.923	3.500	11.192	11.[illegible]	18.461	26	193.[illegible]	119.7[illegible]	11.6[illegible]	7.
	relat	[illegible]	7.351	4.117	1.699	4.[illegible]	2.[illegible]	6.211	26	14.344	23.[illegible]	2.7[illegible]	2.
Flight	short	[illegible]	28.545	21.181	2.545	12.[illegible]	12.090	20.727	11	192.5[illegible]	107.909	11.[illegible]	7.
Flight	short	[illegible]	6.234	4.423	1.213	4.631	2.[illegible]	6.117	11	14.985	15.[illegible]	[illegible]	2.
Flight	relat	[illegible]	26.[illegible]	20.[illegible]	3.363	12.454	10.[illegible]	18.818	[illegible]	193.263	116.[illegible]	10.[illegible]	7.
Flight	relat	[illegible]	8.237	2.591	1.119	4.435	1.9[illegible]	6.384	[illegible]	1[illegible].112	17.[illegible]	[illegible].311	2.
[illegible]	short	[illegible]	30.666	20.[illegible]	3.333	9.113	12.[illegible]	19.933	[illegible]	190.93[illegible]	115.[illegible]	11.[illegible]	7.
[illegible]	short	[illegible]	6.870	5.361	1.377	4.[illegible]	2.[illegible]	5.939	[illegible]	13.8[illegible]	21.3[illegible]	1.9[illegible]	2.
[illegible]	relat	[illegible]	25.933	21.0[illegible]	3.[illegible]	10.[illegible]	11.600	18.200	[illegible]	193.8[illegible]	[illegible]	11.[illegible]	6.
[illegible]	relat	[illegible]	6.933	4.9[illegible]	2.02[illegible]	4.333	2.[illegible]	6.0[illegible]		11.[illegible]	[illegible]	2.[illegible]	2.
[illegible]	[illegible]	[illegible]	33.275	27.[illegible]	3.950	17.[illegible]	15.125	27.375	8	18[illegible]	113.[illegible]	12.[illegible]	4.
	[illegible]	[illegible]	8.[illegible]	4.659	1.[illegible]	5.175	3.181	7.5[illegible]	8	21.4[illegible]	14.[illegible]	2.[illegible]	[illegible]
	[illegible]	[illegible]	33.[illegible]	24.35[illegible]	4.9[illegible]	12.785	12.857	20.[illegible]	14	[illegible]	112.0[illegible]	12.[illegible]	7.
	[illegible]	[illegible]	5.954	3.[illegible]	1.859	4.775	3.0[illegible]	4.[illegible]	14	16.180	12.[illegible]	1.[illegible]	[illegible]
	[illegible]	[illegible]	26.875	20.[illegible]	3.[illegible]	11.187	11.375	20.125	16	190.375	101.812	11.5[illegible]	7.
	[illegible]	[illegible]	6.936	5.585	1.[illegible]	4.[illegible]	3.667	4.014	16	11.218	13.7[illegible]	3.117	[illegible]
	short	[illegible]	31.[illegible]	21.[illegible]	3.684	12.684	13.[illegible]	20.152	19	193.5[illegible]	116.[illegible]	11.473	6.
	short	[illegible]	7.1[illegible]	5.[illegible]	1.[illegible]	4.831	3.336	5.690	19	16.[illegible]	11.[illegible]	3.[illegible]	2.
	relat	[illegible]	30.184	24.213	4.[illegible]	13.421	12.057	21.157	19	193.[illegible]	101.157	11.131	6.
	relat	[illegible]	8.327	4.773	1.694	5.[illegible]	3.763	5.737	19	12.760	15.[illegible]	2.137	[illegible]
CS	short	[illegible]	31.250	24.[illegible]	3.[illegible]	16.[illegible]	15.500	27.750	4	186.25[illegible]	113.5[illegible]	12.75[illegible]	4.
CS	short	[illegible]	9.464	5.[illegible]	1.414	3.162	2.081	7.320	4	11.644	15.545	1.872	2.
CS	relat	[illegible]	35.500	25.[illegible]	4.500	18.5[illegible]	14.750	37.000	4	18[illegible]	113.[illegible]	11.25[illegible]	4.
CS	relat	[illegible]	9.110	4.242	6.577	6.952	4.347	8.831	4	30.572	16.713	[illegible]	2.
CSE	short	[illegible]	34.714	27.[illegible]	4.857	12.[illegible]	13.285	20.428	7	2[illegible]	113.714	12.[illegible]	7.
CSE	short	[illegible]	5.774	2.129	1.011	4.953	3.039	4.236	7	18.873	11.8[illegible]	[illegible]	1.
CSE	relat	[illegible]	33.142	24.[illegible]	5.[illegible]	13.[illegible]	12.428	19.571	7	[illegible]	[illegible]	12.714	7.
CSE	relat	[illegible]	6.465	3.690	2.417	4.854	3.309	4.835	7	18.[illegible]	13.[illegible]	[illegible]	2.
[illegible]	short	[illegible]	27.625	21.875	3.[illegible]	11.375	12.375	20.625	8	19[illegible]	119.[illegible]	13.125	7.
[illegible]	short	[illegible]	6.112	6.[illegible]	1.[illegible]	5.152	3.829	4.627	8	15.163	9.4[illegible]	3.75[illegible]	[illegible]
[illegible]	relat	[illegible]	26.125	20.[illegible]	3.5[illegible]	11.[illegible]	16.375	19.625	8	190.5[illegible]	1[illegible]	11.875	7.
[illegible]	relat	[illegible]	7.989	5.[illegible]	0.925	3.[illegible]	3.377	3.543	7	6.301	17.357	[illegible]	3.
[illegible]	[illegible]		[illegible]			[illegible]	[illegible]		10.[illegible]				

"UNCLASSIFIED"

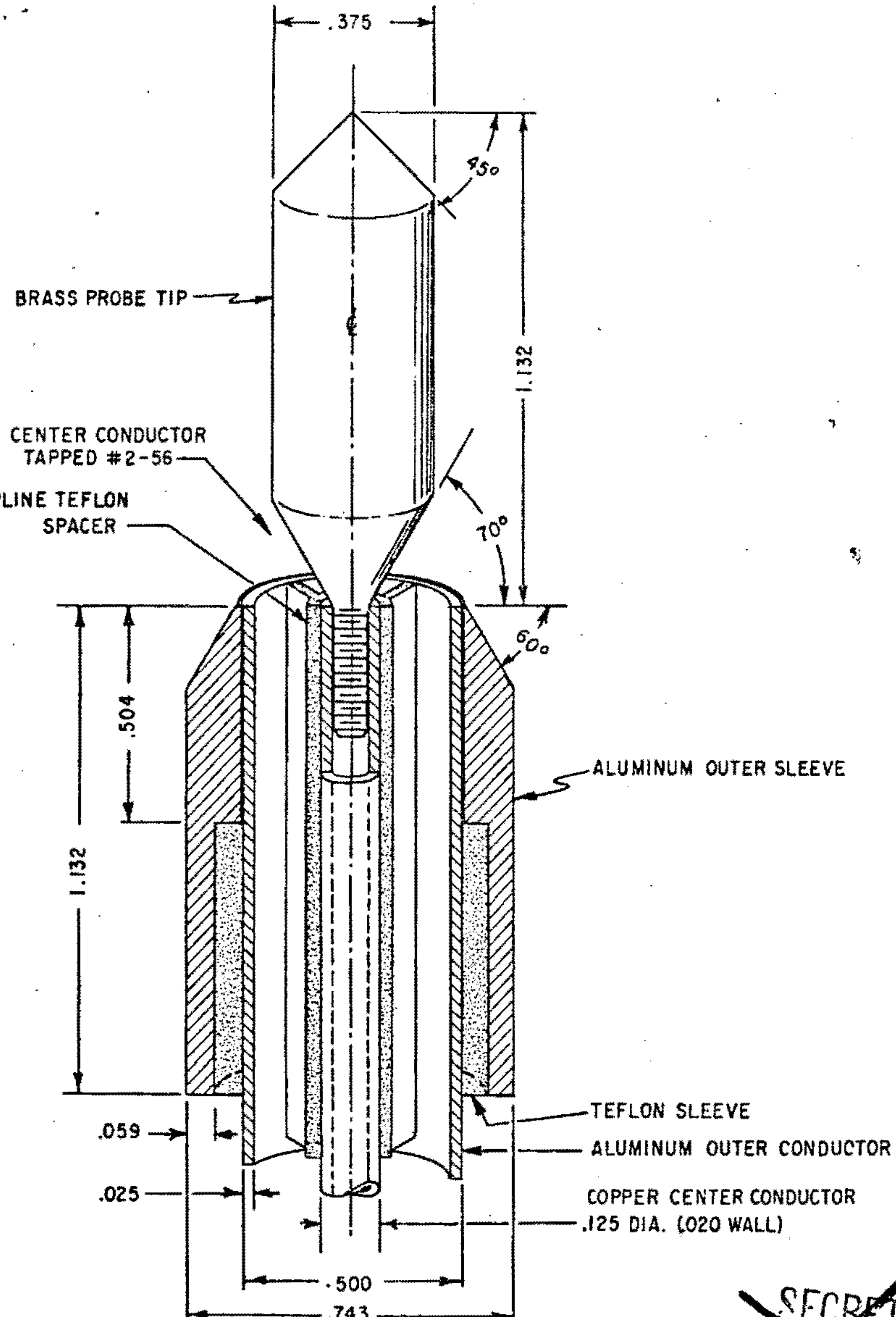


Fig. B1 DIMENSIONS OF "S" BAND SLEEVE DIPOLE

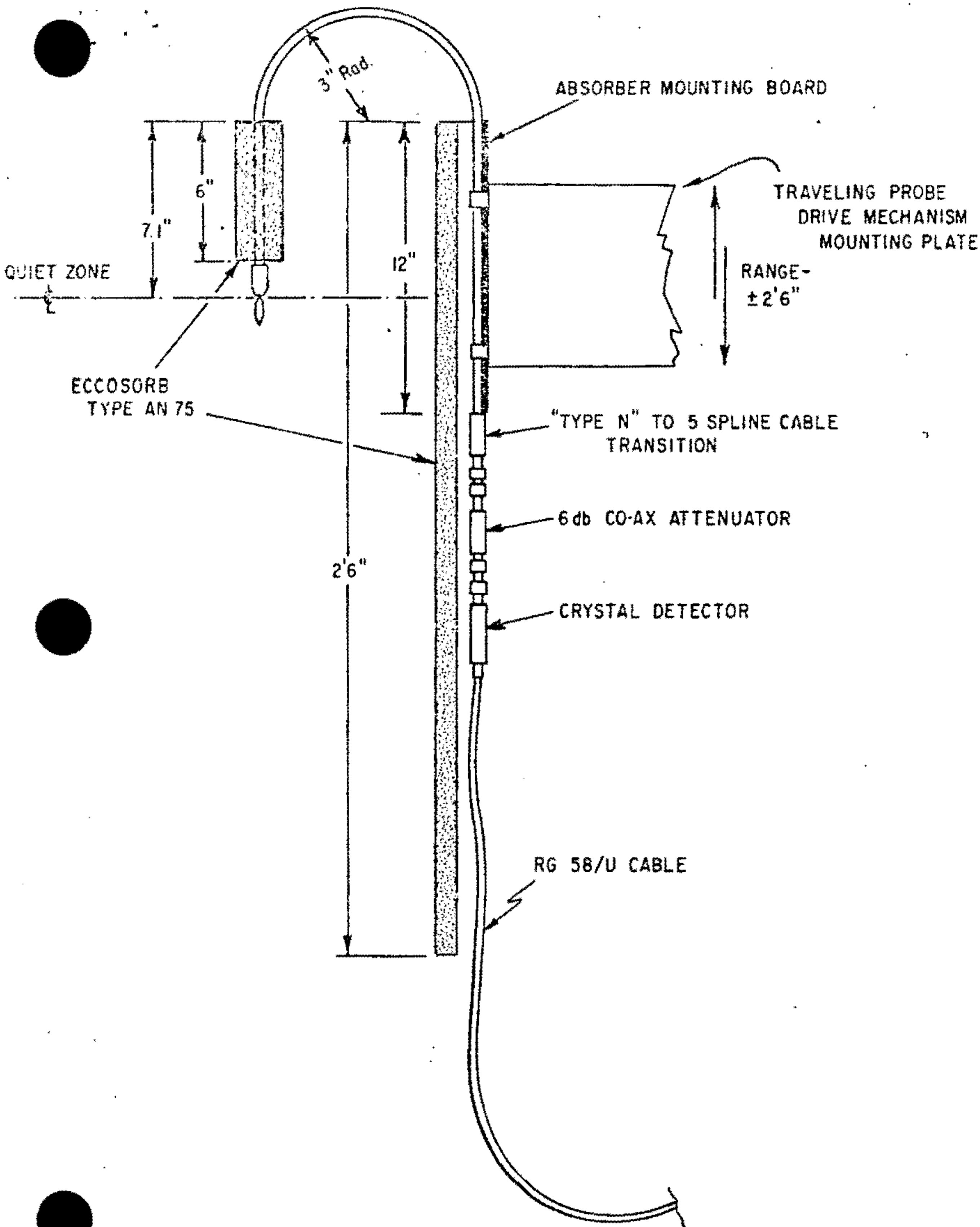
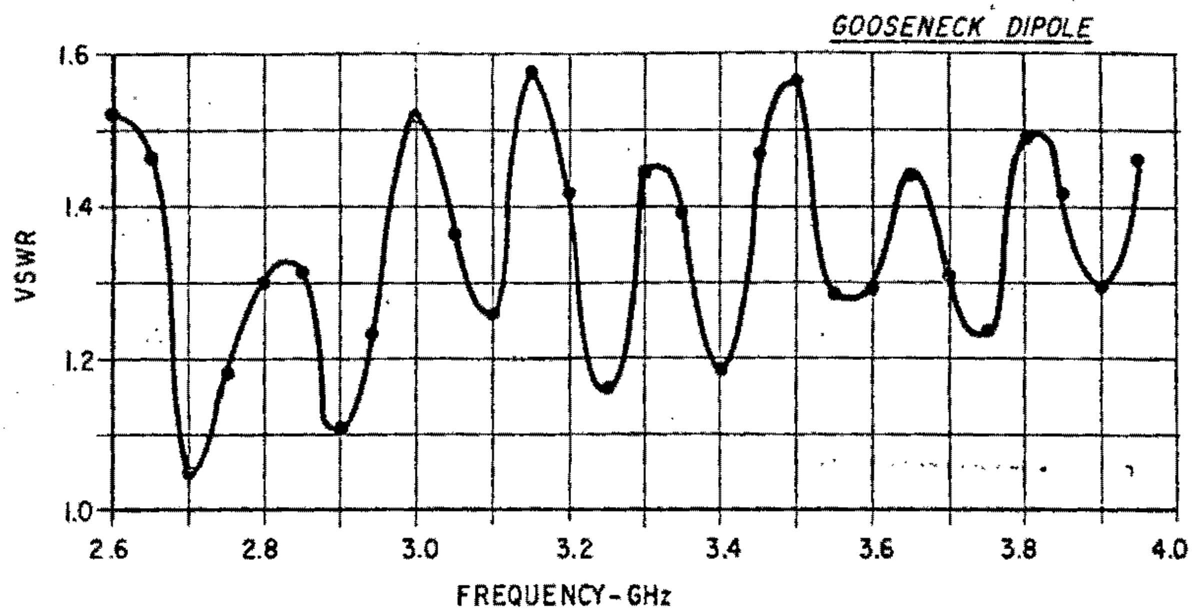


Fig. B2 MOVEABLE GOOSENECK DIPOLE MONITOR

SECRET



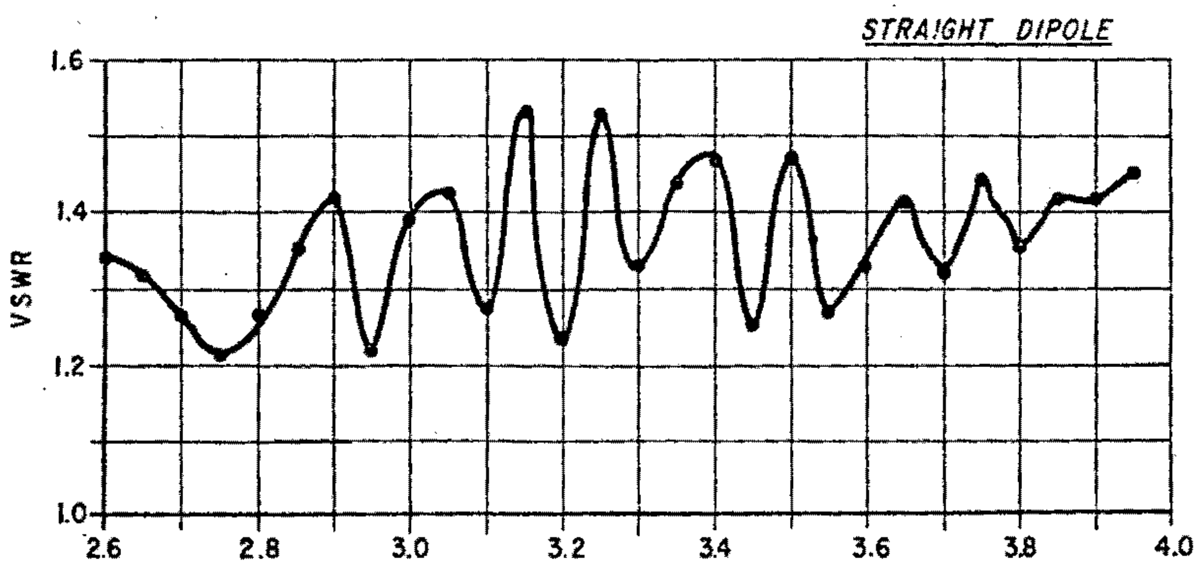
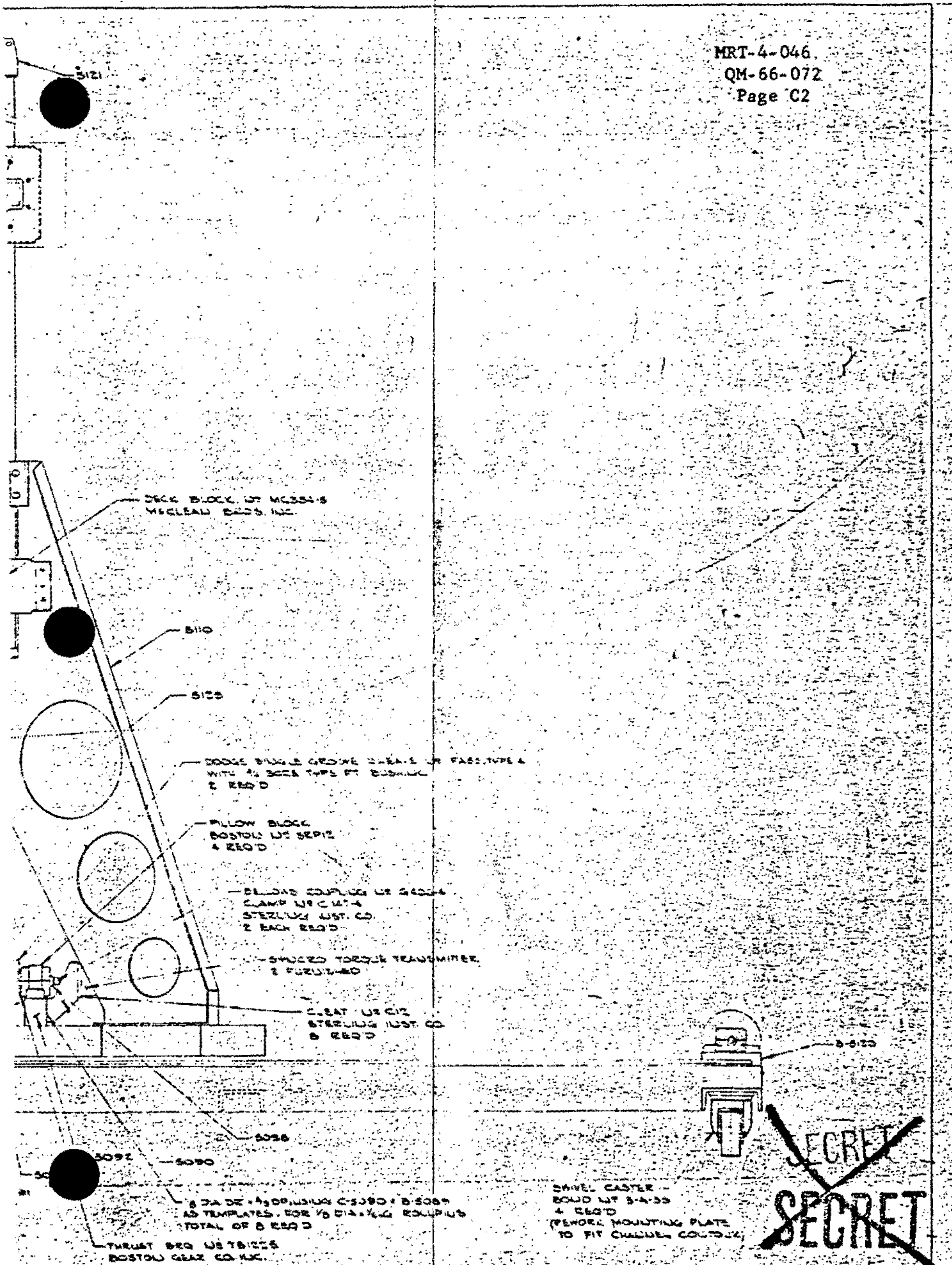


Fig. B3 DIPOLE VSWR Vs FREQUENCY (With S-Band 5 Spline Cable to "Type N" Transition)

SECRET



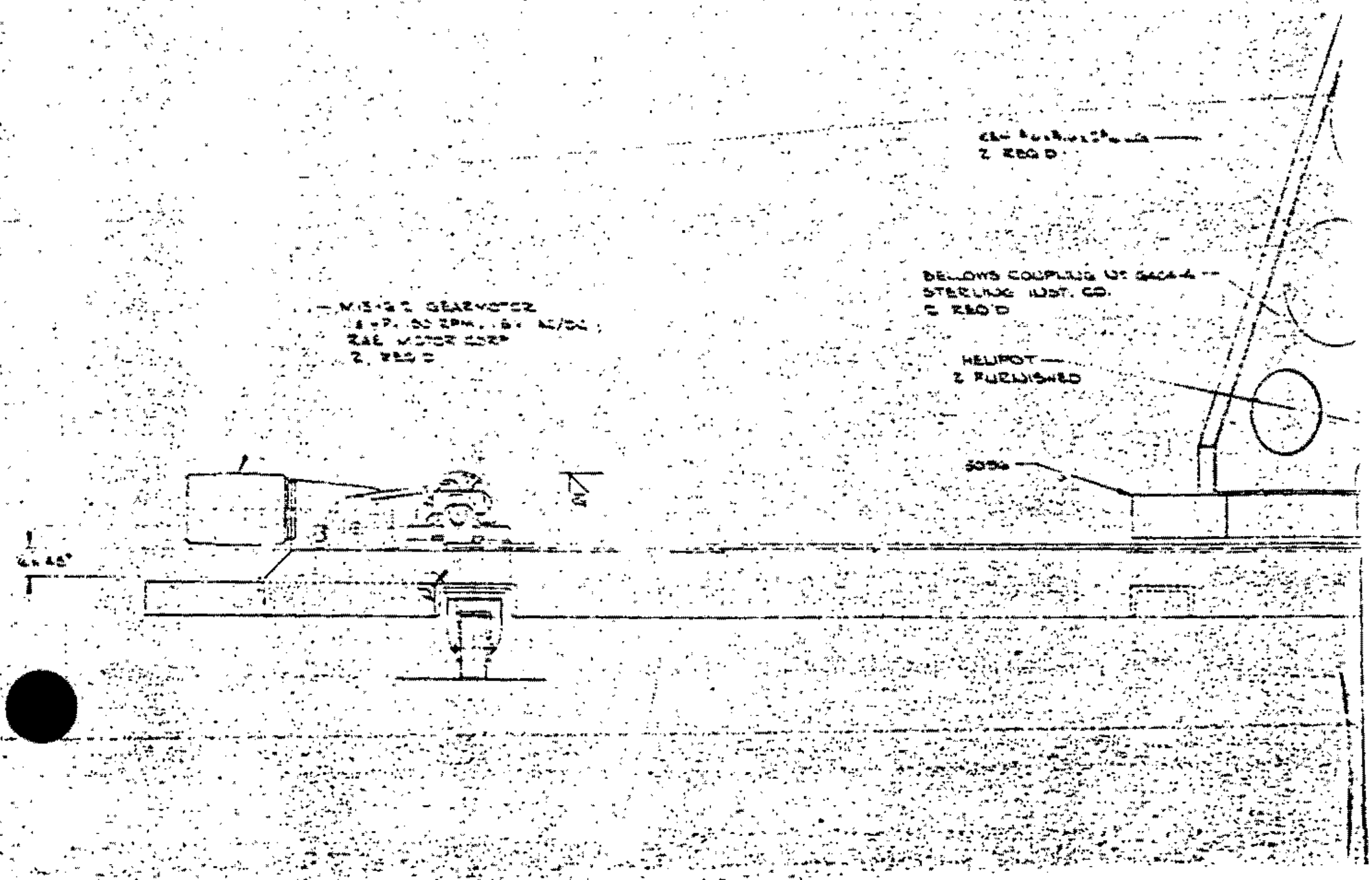
SECRET

SECRET

FIGURE C1

TRAVELING PROBE DRIVE MECHANISM

SECRET



APPENDIX C

Field Traversing Mechanism

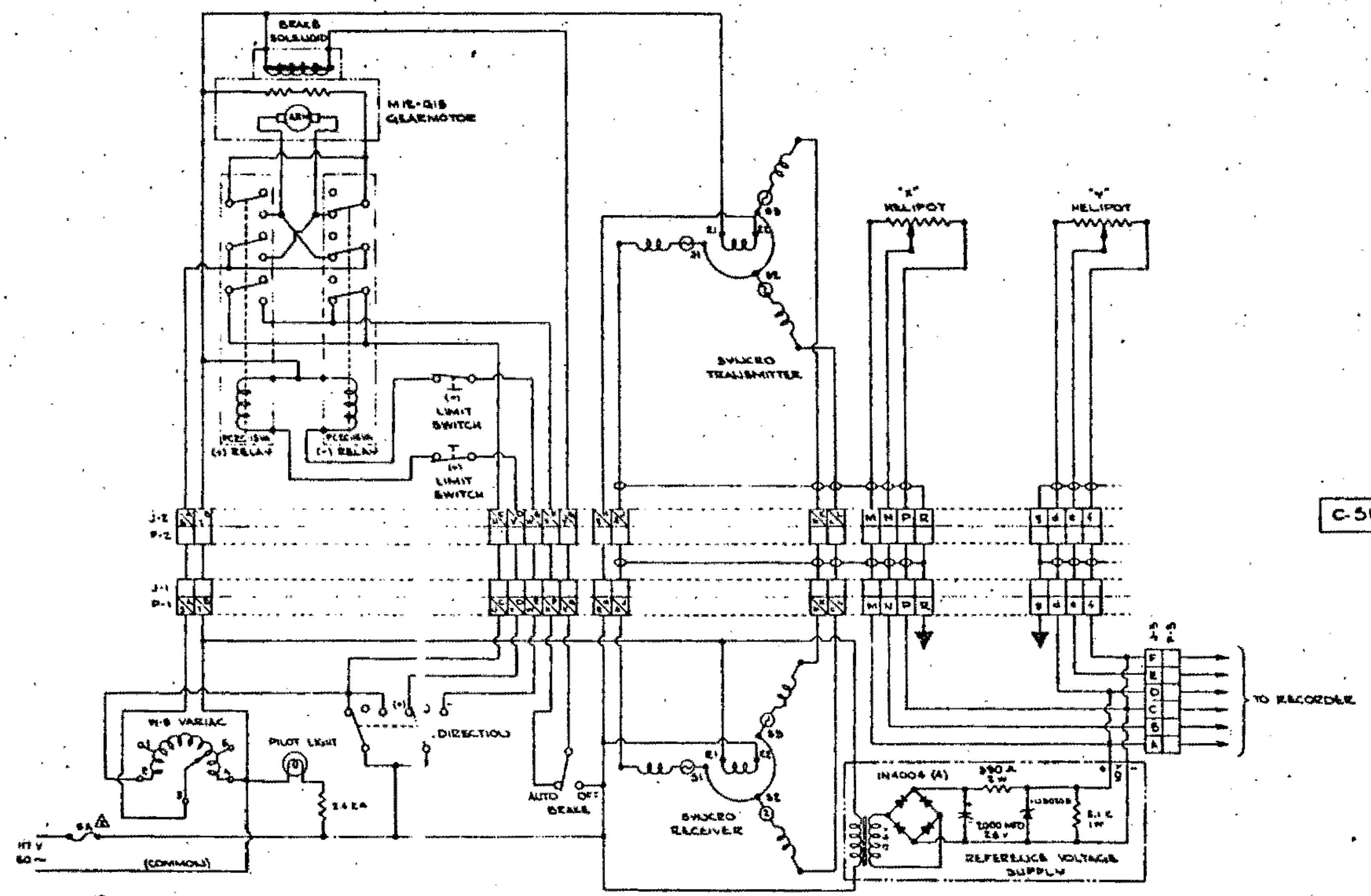
The field traversing mechanism used to evaluate the anechoic chamber is shown in figure C1. It is capable of moving the probe antenna (either the dipole or the standard gain horn) in azimuth and in elevation a distance of ± 2.5' from the center at variable speeds. The entire mechanism was moved manually along the transmission length of the chamber during the evaluation.

Incorporated in the mechanism are voltage readouts proportional to the distance (in both azimuth and elevation) which are used to drive an X-Y recorder. Also included are syncro position indicators on the remote control panel. Limit switches at the azimuth and elevation extremes set the motor brake until the movement direction is reversed. Figure C3 is a wiring diagram of the mechanism and its control panel.

The "mast" is readily removable for ease in transportation and storage. For the "sample container" measurements, the mast and its "super structure", and the entire elevation drive mechanism were removed, and an absorber pedestal was placed on the movable azimuth base. The sample container was placed on this absorber pedestal and moved ±2.0 feet in azimuth behind the fixed dipole monitor. During all measurements, the exposed superstructure is absorber lined.

Figure C2 is the wiring diagram for the Field Traversing Mechanism.

DO NOT SCALE



C-5167

NOTES:

1. CIRCUIT SHOWN TYP FOR BOTH X-AXIS (HORIZONTAL) & Y-AXIS (VERTICAL); [X] DENOTES CIRCUIT DUPLICATIONS

⚠2 5 AMP CIRCUIT BREAKER SUPPLIED WITH VARIAC

WIRING DIAGRAM - TRAVELLING WORD

SECRET

Page C3

Johns Hopkins University
[illegible]IED PHYSICS LABORATORY
Silver Spring, Maryland

External Distribution:

P. Tamarkin	Copy No.	1
R. S. Cesaro		2
R. S. Cesaro		3
R. S. Cesaro		4
R. S. Cesaro		5
R. S. Cesaro		6
H. M. Grove		7
R. W. Beard	W/o enclosures	
F. Koether	W/o enclosures	

External Distribution:

P. Tamarkin	Copy No.	1
R. S. Cesaro		2
R. S. Cesaro		3
R. S. Cesaro		4
R. S. Cesaro		5
R. S. Cesaro		6
H. M. Grove		7
R. W. Beard	W/o enclosures	
F. Koether	W/o enclosures	

[redacted]

L[redacted]

ADVANCED RESEARCH PROJECTS AGENCY

WASHINGTON, D. C. 20301

[redacted]

4

Seen by Mr Nitze.

THIS DOCUMENT HAS BEEN DOWNGRADED
TO UNCLASSIFIED
Per Director, DARPA / TIO
5 - DEC 1977

27 SEP 1967

MEMORANDUM FOR DIRECTOR, DEFENSE RESEARCH & ENGINEERING

SUBJECT: Project BIZARRE

References:
1. Memorandum to Director, ARPA, from Deputy Director, Advanced Sensors, dated 15 December 1966, subject: Project PANDORA - Initial Test Results. (Top Secret)

2. Memorandum for Record, signed by Deputy Director, Advanced Sensors, dated 20 December 1967, subject: Project PANDORA - Initial Test Results. (Top Secret)

3. Memorandum for Director, R&E, from Deputy Director, Advanced Sensors, dated 28 June 1967, concerning Projects PANDORA and BIZARRE. (Top Secret)

4. CIA Memorandum for Deputy Director, R&D, dated 13 September 1967, subject: Summary of TUMS Power Density Measurements - 13 September 1967. (Secret)

5. Memorandum from AF Avionics Laboratory to Mr. Cesaro, dated 15 August 1967, subject: Power Level Measurements - TUMS Radiation. (Secret)

SUMMARY

1. The central nervous system of primates has been penetrated directly or indirectly by non-thermal modulated microwave radiation at power density levels from 4.0 milliwatts per square centimeter down to 1.0 mw/cm^2 (these levels are below present U. S. safety standards).

2. At similar radiation power densities and non-modulated low microwave radiation the primates performed normally.

[redacted]

ARPA-AS-TS-67-20
Copy #1

[redacted]N

[redacted]

[redacted]

3. The recent low level BIZARRE tests at .008, .05, .01 mw/cm^2 power densities under <u>modulated</u> microwave radiation did not cause the primate to degrade in conducting his work tasks.

4. The latest data collected on the Moscow data indicates energy densities no greater than .05 mw/cm^2 in the Moscow Signal

DISCUSSION

This memorandum is a progress report on Project BIZARRE. References 1, 2, and 3 report in detail on the ARPA experimental results of primate tests in Project BIZARRE and related research and development. The tests so far have established that the central nervous system of primates was disrupted directly or indirectly after exposure to low level (non-thermal) 4-5 mw/cm^2 <u>modulated</u> "S" band microwave radiation for periods between 10 and 19 days. When the primate tests were conducted at the same low level (4-5 mw/cm^2) radiation, <u>without modulation,</u> the central nervous system was not disrupted for test periods up to 30 days as reflected by overt performance measurements (references 1 and 2). The electromagnetic frequency and modulation used for these preliminary tests simulated a portion of the "Moscow Signal." The intent of the "Moscow Signal" has not been established by the experiments conducted to date.

New measurements with ARPA instrumentation of the "Moscow Signal" on site has now been completed. These data of the "Moscow Signal" cover a recorded bandwidth of 50 mc as opposed to the original bandwidth data recordings of 3 mc. Also, a partial mapping of the power density has been completed (references 4 and 5). A thorough analysis of this new signal data should now be undertaken to define the "Moscow Signal" characteristics. No further "on-site" electromagnetic measurements seem to be ~~are~~ required.

The latest data on power levels recorded in the Moscow Embassy were always below 50 microwatts/cm^2 (.05 mw/cm^2). The recent BIZARRE tests have completed one experiment on primate behavior at power levels of .008, .05, .01, and 4.6 mw/cm^2. These data showed no overt primate performance degradation at levels below 1.0 mw/cm^2. It must be emphasized that these initial investigations were only concerned with

[redacted]

the overt primate performance measurement. Information on other biological indicators such as EEG, EKG, genitic effects, anatomical abnormalities, neuro chemistries, or sophisticated blood chemistries (endocrine, steroid levels, chromasomal abberations, etc.) will be obtained in the next program phase of BIZARRE.

The Soviets have reported in the open literature that humans subjected to low level (non-thermal) modulated microwave radiation, show adverse clinical and physiological effects. The experiments with modulated microwaves on primates conducted by ARPA show repeatable histories of measured degradation of primate performance under laboratory conditions. In the United States there have been no experiments with microwaves which directly relate primate performance with human behavior. In certain other types of experimental medicine (e.g., blood chemistry, drug screening, etc.) effects which show up on Rhesus monkeys bear a strong relationship to effects observed in humans. The ARPA BIZARRE program will establish methods which should permit us to relate the behavior of sub-human primates to man under conditions of microwave exposure. This may require direct testing with humans under controlled conditions.

Serious impact of this research centers around the following general considerations:

1. Hazards to humans from low level microwave radiation may exist below the present U. S. safety limits. These hazards must be carefully explored and established. Latent, long term effects on biological systems must be investigated.

2. The ARPA test results have demonstrated the feasibility of causing adverse biological effects on the central nervous system of primates. The potential of exerting a degree of control on human behavior by low level selectively modulated microwave radiation should be investigated for potential weapon applications.

Significant results obtained from the BIZARRE experimental effort will be periodically reported as soon as these are available.

Richard S. Cesaro
Acting Director
Advanced Sensors

~~SECRET~~
~~SECRET~~

~~LIMITED DISTRIBUTION~~

~~ADVANCED SENSOR RESTRICTED~~

Minutes of Pandora Meeting of January 17, 1969 (u)

2 4 FEB 1977

THIS DOCUMENT HAS BEEN DOWNGRADED
TO UNCLAS
Per Director, DARPA/TIO

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

Cont. No.

~~SECRET~~
~~SECRET~~

IDA HQ 69- 10,071

ADVANCED SENSOR RESTRICTED

MINUTES OF PANDORA MEETING OF JANUARY 17, 1969

Meeting Convened: 0945

IDA Rm. No.: 10K5

Present a.m. and p.m.:

Science Advisory Committee	Walter Reed Army Institute of Research
General Frederic J. Hughes, Jr.	Colonel Joseph V. Brady
Dr. Joseph F. Kubis	Dr. Thomas W. Frazier
Dr. Lysle H. Peterson, Chairman	Major Joseph C. Sharp
Dr. Herbert Pollack	

Dr. Joseph E. Barmack absent due to illness
Mr. H. Mark Grove, Wright-Patterson AFB
Commander Hugh S. Pratt, MC, USN
(C.M.D. USS Saratoga)
Rear Admiral Frank Voris, MC, USN

Present p.m. only:

Dr. Joseph M. Aein, IDA
Mr. Richard S. Cesaro, OSD/ARPA/AS
Dr. James T. McIlwain, MC, USA, WRAIR
Mr. A. Rubenstein, OSD/ARPA/AS

1. Dr. Pollack reviewed considerations relative to the USN-ARPA study to be carried out aboard the USS Saratoga currently in Philadelphia Naval Yard in preparation to join fleet operations.

2. Rear Admiral Voris and Commander Pratt commented on operational considerations of the study from money point of view.

3. Colonel Brady, Dr. Frazier, and Dr. Sharp commented regarding Walter Reed army considerations.

4. Mr. Grove commented regarding physical measurements and engineering considerations of shipboard radar measurements and monitoring.

Summary of Discussions:

Dr. Pollack reviewed need for definitive data on effects of radiation on physiological and psychological (particularly behavioral) functions in man. Primary areas to be looked at appeared to be (a) physiological, (i) formed blood elements, i.e., genetic alterations, (ii) cardiovascular and (iii) neurological and (b) psychological regarding task performance and group behavior. Regarding general plan involved selecting a population of ship's crew subjected to shipboard radiation (radar) and to

SECRET

re them with a group below decks and not exposed to radia-[redacted]n. It appeared that plane handling crews on the hanger decks and flight decks involved similar enough tasks and living conditions that comparisons could be made so as to reveal any major or gross differences. Dr. Kubis and his team with the support of Commander Pratt and his staff aboard ship would review the personnel records of the two crew populations and select from them appropriate groups. They would receive physical and psychological tests during the approximately two weeks that the ship was scheduled to be docked in Philadelphia. Repeat tests would be made at intervals while the ship was underway and at certain scheduled ports-of-call during the following six weeks, a specific protocol was to be developed.

Discussion centered on selection criteria and upon what tests would be given to the selected groups.

Physical examination (including a general physical exam):

1. Blood specs for leucocyte genetic evolution
2. Blood pressure and pulse rate (on arising and after work cycle)
3. Discussion related to sending selected representation to the Philadelphia Naval Hospital for EEG evaluations. Also, a "microneurological exam" was described which might be included

Psychological examination was designed by Dr. Kubis and associates. Dr. Kubis indicated procedures would relate to cognitive, psychomotor, physical efficiency and sensory perception testing.

Three phases to protocol:

I. Dockside - two weeks
II. Toward end of ten day shakedown
III. Three to six months later

Meeting adjourned at 4:30 p.m. on January 17, 1969.

Minutes respectfully submitted by Lysle Peterson, Chairman

mc

Date Typed - May 15, 1969

SECRET

SPECIAL HANDLING

TED STRIBUTION

ADVANCED SENSOR RESTRICTED

17. The need for information on humans in addition to the accelerated animal studies at Walter Reed was emphasized. Therefore, it was urged that the Walter Reed facility develop a human program and start immediately to develop Phase 1, i.e., to develop a plan and protocols.

    a) Suggested putting the human aspect into the Pandora program rather than in the Walter Reed stress program.

    b) Estimated that human subjects would be required for six to eight months and that they could be obtained from Ft. Dietrich.

    c) Controls should also include as many variables as possible including IQ, memory and performance testing. Control period should be less than sixty days. One or more should go through the entire procedure without exposure, and one or more with alternating exposure plan. Study should be double-blind with protection of eyes and gonads. Shielding of testicles is recommended.

    d) Panel would like to review protocol before enactment.

18. Land-based radar station human study program should be developed to replace or supplement any on-board studies at sea.

Respectfully submitted by Lysle Peterson, Chairman

mc

Date Typed - May 16, 1969

~~SECRET~~

~~SECRET~~

~~LIMITED DISTRIBUTION~~

~~SPECIAL HANDLING~~ ~~ADVANCED SENSOR-RESTRICTED~~

Minutes of Pandora Meeting of April 21, 1969 (U)

This document contains information [illegible] the [illegible] of the United States within the meaning of the [illegible], Title 18, U.S. Code, Sections [illegible] and 794. The transmission or the [illegible] of its contents in any manner to an unauthorized person is prohibited by law.

[illegible]

24 FEB 1977

THIS DOCUMENT HAS BEEN DOWNGRADED

TO [illegible]

Per Director [illegible]

IDA NO. 69- 10,076

~~SECRET~~

~~SECRET~~

Copy 15 ... 18

~~SECRET SECRET~~ ~~LIMITED DISTRIBUTION~~

~~HANDLING~~ ~~ADVANCED SENSOR RESTRICTED~~

SUMMARY OF PANDORA MEETING

HELD: April 21, 1969

I. Detailed minutes attached. Same classification and instructions:

II. Meeting organized in three parts:

1. Review of "Big Boy":

A. Purpose: Elucidate effects on man of microwave radiation (radar) by comparing ship's crew groups apparently exposed to radiation to groups protected from radiation (below deck and remote stations). Studies on USS Saratoga in two stages (i) dock side in preparation for shakedown and (ii) shakedown, i.e., underway and operational.

B. Findings: No significant differences in psychological tests performed on the apparently exposed and control groups. Also, no apparently significant differences on genetic (leucocyte) and physical findings. Thus, studies generally proved negative. Detailed report due from Dr. Kubis.

C. Radiation Findings: Detailed survey of on-board radiation levels revealed that levels were considerably lower than anticipated, i.e., in most cases levels varied from 0.3 to 0.03 mw/cm^2 and in no case greater than 1 mw/cm^2. Radars were operating 80 to 90 percent capacity.

D. Summary and Conclusions To Date: Saratoga study verified testing procedures and provided useful information for developing human radar-field testing. However, studies were negative since exposures were very low.

2. General discussion of ARPA contracts relative to biomedical effects of microwave:

A. Dr. Brazies' studies of CNS tissue exposed to microwave radiation reviewed. Recommendations: to accelerate contractor's efforts as urgent and to extend samples. Attempt to get reports from

~~SECRET~~

contractor for inclusion in general report to panel as soon as possible.

B. Contract with Dr. Ross Adey reviewed. <u>Recommendations</u>: Although Dr. Adey's efforts bear on the general problem of the effects of radiation and fields on CNS functions, they are not directly contributory to priority ARPA questions. Since he is furnishing valuable EEG evaluation services as well as contributing to the general field, it was suggested that he be encouraged to deal more directly with priority questions and also to continue support for present. As Walter Reed capability developes, if contractors interests tend away from ARPA interests, support should be phased out.

C. New England Institute for Medical Research (Dr. Heller) program regarded as not contributing directly to ARPA high priority question although the contractor has capabilities in the area.

D. Work at Milton Zaret Foundation attempting to confirm or reproduce U. S. S. R. work. Review for information to panel.

E. The Lilienfeld studies conducted several years ago were reviewed, since a new proposal was being developed to extend the earlier studies. It was concluded that, due to the size of the Baltimore area mongoloid population and incidence, the scope of the study could probably not be increased by more than 50 percent. It was recommended that (i) scope not be extended beyond the Baltimore region, e.g., Washington area, (ii) that the program be regarded as a multiphase effort and that Phase 1 should be funded. If findings of Phase 1 indicated that further studies would be promising, then later phases could be considered for funding. Thus, proposal should include in-depth follow-up of original cases as well as new cases uncovered. See detailed minutes.

F. Studies of Dr. Dordano (Johns Hopkins), Dr. Sol Snyder, and Dr. Justison were reviewed for information.

3. <u>General Discussion</u>

A. Priorities of ARPA interests in the microwave field were reviewed. High priority still assigned to evaluating the significance of Moscow Signal and also, in the general context, the biomedical effects of microwave radiation on humans such that meaningful safety standards can be set.

B. It was agreed that there is at present insufficient evidence to draw conclusions. In answer to questions about whether or not other studies (aside from those supported by ARPA) are likely to or have shed light on the problem, it was concluded that the only known study not included herein was that of Dr. Jacobson (George Washington School of Medicine) on young women exposed to Moscow Signal. Findings may indicate abnormal genetic activities in some of the women. Significance is not established. There was general discussion of chromosomal aberrations and its causes.

C. It was recommended that further studies be developed:

1. Walter Reed facility and program advancement be encouraged. Extend animal studies and initiate human studies. Suggestions for protocols were made, e.g., study include four men involved for six to eight months. Study to be in two groups and double-blind.

2. Programs to be developed to take advantage of land-based radar installations.

4. It was recommended that the Walter Reed group prepare and present a detailed review of the field, i.e., their activities with reports of their findings, protocols, etc., since projects were begun. Also, a review of relative contract work supported by ARPA and related to Walter Reed efforts as well as any related studies of others in field.

Respectfully submitted by Lysle Peterson, Chairman

mc

Date Typed - May 15, 1969

SECRET

LIMITED DISTRIBUTION

ADVANCED SENSOR RESTRICTED

DETAILED MINUTES OF PANDORA MEETING OF APRIL 21, 1969

Meeting Convened: 0930

IDA Rm. No.: 10K5

Present:

Science Advisory Committee

Dr. Joseph E. Barmack
*Dr. H. Allen Ecker
General Frederic J. Hughes, Jr.
Dr. Joseph F. Kubis
Dr. Lysle H. Peterson, Chairman
Dr. Herbert Pollack

Walter Reed Army Institute of Research

Colonel Joseph V. Brady
Dr. Thomas W. Frazier
*Mr. T. Daryl Hawkins
Colonel Merrill C. Johnson
Major James T. McIlwain

*Mr. John F. Collins (CNO), USN
Mr. H. Mark Grove, Wright-Patterson AFB
Mr. Albert Rubenstein, ARPA
Mr. Harris B. Stone (CNO), USN

*First Attendance

Dr. Pollack reviewed events since previous meeting. He noted the formation and meeting of a new committee (ERMAC**) from the Office of Emergency Planning and chaired by General James D. O'Connell to consider microwave radiation. This panel resulted from legislation setting HEW as the responsible agent for microwave radiation health considerations. He also noted that a document had appeared by Mr. Rexford Daniels under contract to the Office of Telecommunications Management. This document has been classified. He then noted that "Big Boy" shipboard exercize had been completed insofar as the dock-side and shakedown cruise activities aboard the Saratoga. Dr. Kubis would be submitting a report of activities and findings to date.

Dr. Kubis reviewed "Big Boy" objectives and events to date:

A. Objective: To study certain behavioral and physical functions of selected crew aboard the Saratoga in order to ascertain effects of microwave radiation on man regarding shedding light on effects of Moscow Signal, i.e., nonthermal effects (if any) of radiation of radar origin.

**Electromagnetic Radiation Management Advisory Council

SECRET

B. Procedures

1. Three groups of ship's crew were selected:

   a) Flight deck crew (eight in number). Highest levels of exposure expected.

   b) Hangared deck crew (fifteen in number). Low levels expected.

   c) Look-out crews (eight in number). No exposure expected.

2. Dock-side control tests conducted from Jan. 27 through Jan. 30, 1969. Five-man team under Kubis with excellent cooperation of naval medical personnel. (Details will be included in Dr. Kubis' report.) Batteries of tests included performance (e.g., aiming, depth perception, etc.) and written procedures. Also, base-line physical exams were given.

3. Seagoing tests were performed while ship was under way for shakedown cruise Jan. 30, 1969, through Feb. 10, 1969.

4. Summary: Sixty-seven tests were performed in three days at dock-side, and ninety-two tests were performed at sea. Forty-seven tests represented retesting of control material. There were a number of disturbances regarding shipboard routine, etc., e.g., high noise levels, P-A system interrupted activities in "quiet room," general quarters, intrusions into test areas due to routines, variable line voltage which affected equipment. Three dock-side test days conducted by five-man team; eight sea test days conducted by three-man team. It was regarded by Dr. Kubis that the testing was satisfactory and that the interruptions were not significant. Most test procedures were good (0.9); some were poor (greater than 0.1).

5. Findings: There were no significant differences in the dock-side tests, i.e., among groups, and there were no significant differences among groups in the under-way tests, i.e., about 50 percent showed some increases in performance scores and about 50 percent showed some decreases. It was recommended that isolated power supply for instrumentation be developed if further work is to be done aboard ship.

SECRET

LIMITED DISTRIBUTION

SPECIAL HANDLING

ADVANCED SENSOR RESTRICTED

Mr. Mark Grove reviewed the measurements and monitoring of shipboard radar levels. The ship was swept re two primary radiation sources, i.e., SPS-30 (S-band radar) and SPS-43 (UHF) search radar. It was expected from a naval electronics lab report that there might be greater than 10 m w/cm^2 on at least 80 percent of the surface of the deck (data from destroyers). Mr. Grove and Dr. Kubis were on ship at the same time but worked independently. Used RAMCORE dosimeter, HP power meter with thermistor bridge (re S-band) from island to bow, 9 decks.

Findings: In no case did measured levels exceed 1 mw/cm^2 with radar operations at 80 to 90 percent of utilization rate. Ranges of findings were in most cases less than 0.3 to 0.03 mw/cm^2. It was noted that verbal reports from shipboard engineers, i.e., engineering center and ship's hazards group, had indicated these findings. It was suggested that such reports had been made to the SEC.

C. Discussion:

1. Cover story considered appropriate and worked well (Robert Stone).

2. Aircraft radar and HERO effects were discussed. Effects and indications were insignificant.

3. Radiation from radar generators considered, i.e., 50 to 100 KV X-ray generation from tubes. Considered that lead shielding was adequate.

4. Mr. Rubenstein indicated that there were several excellent land-based radar sites which might be appropriate as study sites.

5. Blood studies from Saratoga crew were discussed. Colonel Johnson reported that twenty-one samples were recovered at San Juan. Seventeen successful cultures obtained with 288 spreads photographed. These were coded for double-blind studies. Code not yet revealed. Although two abnormalities were found, they were regarded as in normal range.

6. Several discussions of genetic aberrations of leucocyte nuclei covered several areas:

a) Colonel Brady's three monkeys exposed to date at Walter Reed (thirty days) to special signals. One of these was the initial one showing abnormal chromosomal changes. Plan now is to get samples during exposure and with larger group of animals.

SECRET

b) Dr. Pollack reported the studies of Dr. Jacobson at George Washington University who has studied young women returning from embassy in Moscow (State Dept. contract). One hundred forty blood samples were examined over a four-year period of time. These specimens were identified only by code numbers. Four of these reportedly showed serious chromosomal abnormalities. Colonel Johnson reviewed these reported findings with Dr. Bender of Oakridge. The latter expressed the opinion that the evidence was based upon weighted data which may not be acceptable to all experts in the field.

c) Dr. Johnson described the general character of chromosomal abnormalities re probabilities, stillborns, mongolism, chemicals, and drugs, etc. It was described that while bone marrow, testicular tissue, etc., might be better tissue to study (higher rates of replication), most knowledge is based upon leucocyte studies.

d) The older Lilienfeld (Johns Hopkins) studies were of Korean and WW II veterans relative to the incidence of mongoloid children born to them. It was concluded that the earlier study was not well designed to reveal data regarding current interest. Study indicated that eighteen of twenty-five mongoloid children had fathers who had been exposed to radar. It is now proposed to expand the study in Baltimore and possibly in Washington. It is likely from the incidence and population of mongolism that the number cannot be increased beyond 50 percent, i.e., from twenty-five to about thirty-six. It was suggested that the original twenty-five and additional cases should be studied in detail, i.e., cytogenetic studies of testicles and lymphocytes. It is also concluded that the study may not answer the question. It was proposed that the study should cost $100,000; $50,000 from ARPA and $50,000 from NIH. The objective should be to validate the earlier study, i.e., cross-validation seems appropriate. The study may be regarded as in three phases. Phase 1 may be supported. Later phases should not be funded unless Phase 1 defines an appropriate study, i.e., a milestone decision should be made.

7. General discussion concluded that additional work is required to investigate whether or not appropriate radiation levels and type have genetic effects on man. Shipboard versus land-based studies were discussed. It was concluded that land-based radar studies should be seriously considered and planned if appropriate. Details of George Washington University study were lacking to the group.

8. Dr. Brazies' (New Orleans) studies on material sent from Walter Reed are not completed as yet. Contractor does not know what the exposure is nor in which animals. (Does know that it is microwave.) He reported that one monkey (exposed to special signal) showed significant changes in the auditory and visual cortex but not in deeper structures. He is now studying two other monkeys and four dogs. These reports are due this year.

It was concluded that the contractor should be urged to proceed as rapidly as possible, i.e., with urgency.

9. It was concluded that more animals should be exposed and studied. There was discussion of the new facilities developing at Walter Reed. They are expected to be completed soon.

10. Contract with Dr. Ross Adey reviewed. Adey's studies have been concerned with modulated A. M. (3 to 10 cps) and C. W. (4.6, 2 v/meter) and S-band radar modulated with EEG. He is continuing monkey studies regarding EEG and reaction time. He has a contract with Northrup for the study of reaction times in electrostatic fields. It is felt that, although Dr. Adey's work is not directly concerned with the important questions of the effects of VHF on CNS function and that of excluding the electrical effects as artifacts, his work is related to the general field of the effects of radiation and CNS function. Also, he is assisting Walter Reed with EEG evaluation and data processing. Current level of support is about $135,000 annually. It was concluded that Dr. Adey should be informed that his own priorities and work trends are not entirely matched with those of ARPA. Although his work is related to the general field and is of considerable assistance to the Walter Reed effort, it is thought that his support might be phased out in a year or two after the Walter Reed facility is better developed.

11. A contract already funded by ONR with New England Institute for Medical Research (Dr. Heller) was reviewed. It was suggested that the content of this work is not directly appropriate to this subject although that institute has a microwave facility.

12. A contract with the Milton Zaret Foundation of Scarsdale, New York, was reviewed. Contractor also uses facilities of Brooklyn Polytechnical Institute. Work primarily in 700 p.p.s. (1-10 u. sec.) range. Is attempting to confirm or reproduce Myrra, Czechoslovakia, work, i.e., production of differences in heart rate at subthermal levels. This review was for information.

13. Other contracts were also reviewed:

a) Dr. Dordano of Johns Hopkins in A. M., F. M., C. W., S-band frequency work on monkeys.

b) Dr. Sol Snyder of Johns Hopkins is studying neuropharmacological effects, e.g., turn-over rates of norepinephrine and serotonin.

c) Dr. Justison (Kansas City, Missouri) using microwave Tappin oven is studying hypnotic and soporific effects of low power level microwaves. It is thought that the geometry of the oven may provide higher power levels than predicted.

14. It was estimated that current funding in the area is $500,000 outside and $200,000 in-house (does not include reconstruction and development costs at Walter Reed or computer facility).

15. It is regarded that the new facility providing three chambers and data processing including (Hewell Packard) general purpose computing, record and reproduce capability for time series, coherence, cross- and auto-correlations, etc., and real time capability will be ready between mid-June and August.

16. The priority of questions of interest to ARPA was discussed. It was reiterated that the elucidation of the Moscow Signal remains as a high priority question within the general field of the effects of microwave radiation on man in order that safety standards may be rationally developed. It was also noted that, aside from the work of Dr. Jacobson, there was apparently no other relative work being conducted by Federal Agencies.

(S) Although the panel expressed some concern that the experiment, as defined by the protocol, might result in findings which would be difficult to characterize as definite indications of effects of the signal on man, i.e., the problems of characterizing changes in each individual and as his own control and of satisfying criteria of group statistics. It was recommended that at least one of the subjects and perhaps two go through the entire procedure except that they not be exposed to the signal. The fact that there are to be two rooms would facilitate this approach.

(S) There was also continuing concern expressed regarding the effects of the signal on the measuring system itself, i.e., signal artifacts. The panel recommended continued scrutiny of this problem. The panel requested an up-to-date bibliography of the effects of microwaves on biological systems. It was noted that there is a recent article in the Canadian JOURNAL OF MICROWAVES.

Respectfully submitted by Lysle Peterson, Chairman

mc

Date Typed - June 4, 1969

SECRET

LIMITED DISTRIBUTION

Minutes of Pandora Meeting of May 12, 1969 (U)

24 FEB 1977

Per Director DARPA/TIO

This document contains information affecting the [redacted] of the [redacted] States within the meaning of the Espionage Laws, Title 18, U.S. Code, Sections 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

DOWN[redacted]
VALS; NOT AUTOMATICALLY
DECLASS[redacted]

SECRET

IDA HQ 69-10119

SECRET

Copy 11 of 14 Copies

SECRET

LIMITED DISTRIBUTION

[illegible] [illegible]

MINUTES OF PANDORA MEETING OF MAY 12, 1969

Meeting Convened: 0930

IDA Rm. No.: 10K5

Present:

Science Advisory Committee

Dr. Joseph E. Barmack
Dr. H. Allen Ecker
General Frederic J. Hughes, Jr.
Dr. Joseph F. Kubis
Dr. Lysle H. Peterson, Chairman
Dr. Herbert Pollack

Walter Reed Army Institute of Research

Colonel Joseph V. Brady
Dr. Thomas W. Frazier
Mr. T. Daryl Hawkins
Colonel Merrill C. Johnson
Major James T. McIlwain

Dr. John F. Collins (CNO), USN
Mr. H. Mark Grove, Wright-Patterson AFB
Mr. Albert Rubenstein, ARPA

(S) The primary order of business was the preliminary protocol proposal for human studies which was requested at the previous meeting on April 21, 1969. The protocol had been distributed toward the end of the previous week and, therefore, had not been received by many of the panel. Time to pursue the proposal was taken before discussion began.

(S) Dr. Brady noted that the proposal had been the combined effort of himself, Thomas Frazier, Merrill Johnson, and Daryl Hawkins and desired the advice of the committee on the ninety-day protocol. Dr. Brady noted that they had considered two basic strategies: (i) assumes that there is an effect of the signal (based upon previous experience) and the protocol is designed to maximize the yield and (ii) assumes that there may or may not be an effect (nue hypothesis) and the protocol would include "extreme" operations, i.e., high-forcing functions and large "n"s. If an effect is seen, then fine responses are defined.

(S) In view of previous experiences and evidence available, the first alternative was chosen, i.e., based upon the assumption that there *is* an effect. Therefore, protocol is an attempt to optimize economic considerations, use small "n"s and primarily to define the effects of the signal.

(S) The panel discussed the over-all strategy and alternatives and agreed with Dr. Brady. Also, re human experiments, this approach regarded most defensible as a prerequisite to more demanding studies, if needed.

SECRET

(S) It was noted that a major question regarding any such study relates to the evaluation of behavioral effects since the spectrum of possibilities is so broad compared to physical evaluation. Thus, the major part of the discussion related to behavioral aspects of the program. It was also noted that any energy form, if large enough, will produce biological effects. It was agreed that the signal used would be the special signal at the levels developed and used with the primates, i.e., between 4.5 and 5 mw/cm^2. Discussion revealed several distinct questions:

(i) Because the "n" is small (eight subjects) there, the question was raised as to whether the protocol will permit the characterization of the individual, i.e., the individual as his own control and at the same time to also permit the characterization of the group, i.e., significance of the findings in individuals in a small "n" group.

(ii) To what extent is the instrumentation appropriate to carry out the objectives of the experiment, e.g., signal beam incidence, range of power levels, polarization, etc. The protocol had not detailed the electromagnetic aspects of the experimental design. Also, what are the effects, if any, of the signal on the instrumentation, e.g., EEG electrodes?

(iii) What are the dependent variables re behavior?

(iv) What are the considerations relative to monitoring the physical (biomedical) parameters re two purposes: as a monitor of the subject's general health and as scientific data re effects of signal?

(v) What are the classification considerations of the program re its management and scientific effectiveness?

(S) The discussion provided consensus regarding these points as follows:

DOD regards the general line of effort to aquire human-based data on effects of the signal, with appropriate safeguards, as a high priority. ARPA believes that the entire effort should be classified for several reasons. <u>It was urged that DOD provide written security specifications and guide for the program.</u>

(S) An appropriate cover relates to the purpose of the program to evaluate the validity of U. S. S. R. reports that nonthermal effects of nonionizing radiation are significant.

(S) It is urged that the special signal (or any improved signal, i.e., to better simulate the Moscow signal) be used. Currently, special signal-producing available equipment can develop less than 10 or 20 mw/cm^2. Monkey studies have been done at 4.6 mw/cm^2. Also recommendation to use same carrier frequency. While polarization can be varied, it was urged that the same polarization (radiation beam toward back of animal and vertical) be used in humans but that absorbent seat and gonadal protection be provided. While posterior presentation is utilized, protection of eyes should be considered.

(S) It was recommended that a medical examination function be established as a separate entity from the research function. Thus, the physical well-being of the subjects would be ascertained and reviewed periodically by medical expertise, which is not directly associated with the purpose of the effort. This medical examining function would not be privy to Pandora but would be given the cover story. It was noted that this separate examination procedure, if properly defined, could provide useful data as well as a safety check for the program. General Hughes thought that such a medical evaluation function could be arranged through the new commander of Walter Reed. In view of the fact that the morphological changes (cytological) which have been found in the CNS of animals exposed to the signal appeared in the visual cortex (as well as other areas), flicker fusion studies should be incorporated into the medical examination. Also, slit lamp and visual field checks should be made and audiograms done. It was also recommended that a separate psychiatric evaluation should be accomplished before and after the study. It was not resolved as to whether there should be separate psychiatric screening in addition to the research program screening procedures. This separate medical function or task force may be referred to as the "medical monitoring task force." It was recommended that a specific chain-of-command be established to be certain that in the changing personnel structure of Walter Reed, the appropriate responsibilities are established, and thus, the research team will know whom to work through re the medical monitoring function. It was recommended that the medical monitoring procedure include:

slit lamp examination: initially 90 days, 180 days
visual fields examination: initially 90 days, 180 days
*audiogram: initially 90 days, 180 days
ECG: once per week
**Physician perform general check-up once per week

*At end of day
**Have responsibility to be certain that all data are entered on record

SECRET SECRET

SPECIAL HANDLING

LIMITED DISTRIBUTION

ADVANCED SENSOR RESTRICTED

IDA

Minutes of Pandora Meeting of June 18, 1969 (U)
(Final)

Minutes Prepared By: Lysle H. Peterson

24 FEB 1977

THIS DOCUMENT HAS BEEN DOWNGRADED
TO "UNCLASSIFIED"
BY Director, DARPA/TIO

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

DOWNGRADED AT 12 YEAR INTERVALS; NOT AUTOMATICALLY DECLASSIFIED. DOD DIR 5200.10

IDA HQ 69- 10179

SECRET SECRET

Copy 4 of 14 Copies

SECRET

SPECIAL HANDLING

ED-DISTRIBUTION

ADVANCED SENSOR RESTRICTED

MINUTES OF PANDORA MEETING OF JUNE 18, 1969

Meeting Convened: 0930

Meeting Adjourned: 1700

IDA Rm. No.: 10K5

Present:

Science Advisory Committee

Dr. Joseph E. Barmack
*Dr. James N. Brown
Dr. H. Allen Ecker
Dr. Lysle H. Peterson, Chairman
Dr. Herbert Pollack
*Dr. Lawrence Sher

Walter Reed Army Institute of Research

Colonel Joseph V. Brady
Dr. Thomas W. Frazier
Mr. T. Daryl Hawkins
Colonel Merrill C. Johnson
Major James T. McIlwain

Mr. Richard S. Cesaro, ARPA
Dr. John J. Collins, (CNO), USN
Mr. H. Mark Grove, Wright-Patterson AFB
Mr. Albert Rubenstein, ARPA

*First Attendance

Absent: Dr. Joseph Kubis, Science Advisory Committee
Dr. Joseph C. Sharp, N. Y. State Dept. of Health
Mr. Harris B. Stone, (CNO), USN

(S) The minutes of the previous meeting (May 12, 1969) were discussed. Dr. Peterson explained that the questions regarding the WRAIR protocol were stated as those which were raised for discussion at that meeting. The discussion associated with these questions resulted in a general agreement that the protocol in general provided an appropriate initial approach with human subjects. Furthermore, the nature of the problem together with constraints of available time, facilities, personnel and funds, and the scope of the approach result in statistical problems from the use of a small "n." A protocol using significantly more subjects would be more desirable but would delay the program considerably. It was agreed that for the first approach, the small "n" would be acceptable. The primary purpose of this meeting (June 18, 1969) was to consider the approach in more detail and to hear reports from ARPA and WRAIR regarding broad approaches to the solution of the Pandora and related problems:

SECRET

(S) Mr. Cesaro reminded the Committee of the urgency and high priority which ARPA assigns to the Pandora program; it is important to make major advances in solving the problem in FY 70; the Advisory Committee was invited to give as much attention and creative thinking to the problem as it can. He defined the Advisory Committee's role and that its effectiveness would be enhanced by maintaining a close and continuing association with the Walter Reed group. His view of the overall problem was summarized:

1. Investigative programs should be designed to take major bites at the problem to achieve definite indications of whether or not there are effects on humans of microwaves under conditions simulating, as closely as appropriate, the Moscow signal. Furthermore, he urged that the experimental programs be relevant to the Pandora problem and provide significant results, negative or positive. He reminded the Committee that, conversely, it would be inappropriate to follow paths which while they might be interesting scientifically, would not be relevant to the problem.

2. While there is evidence that low energy (less than 10 mw/cm^2) R.F. radiation does penetrate to the CNS in primates, a significant and relevant question is <u>how</u> the penetration occurs, i.e., the mechanism re microwave characteristic and biomedical engineering principles. Such questions relate to whether or not the Moscow signal is unique and to whether the Soviets have special insight into the effects and use of athermal microwave radiation on man. The WRAIR experience indicates that C. W. has no effect, but modulation does.

3. There appears to be interrelationships of signal time and biological effects, which should be evaluated, i.e., biological on-off effects phased to the on-off character of the signal, i.e., short response times, intermediate and long time effects together with intermittent and long exposures, i.e., at least nine combinations possible.

4. The biomedical effects may include (i) physiological, (ii) behavioral, and (iii) genetic. Each general class re short and long time effects should be evaluated.

SECRET

HANDLING

Man should be emphasized as the object in the investigations both because he is the obvious recipient and because he is in many ways a more effective reporter of effects.

6. Behavioral investigations should include attitudinal (subjective) considerations and measures.

(S) Discussion centered next on details of the WRAIR protocol. There was a concensus among the WRAIR and Committee members that the general approach of the protocol is appropriate and that in the initial stages of the effort, many "on-the-spot" decisions would have to be made because of the uncertainty of aspects of the program. As these uncertainties are clarified, the protocol would become better defined. The areas considered which require initial exploration to provide better definition are:

1. Exposure: It was the concensus that the aim should be to duplicate or simulate the Moscow environment as much as appropriate to solve the problem. Since exposure to the Moscow signal tended to be over an eight- to ten-hour period, it is thought that the exposure of subjects to the Special Signal should approximate that time frame. Furthermore, the primate findings were based on a seven-day, ten hours each day, exposure. It is suggested that the protocol indicate exposures up to eight to ten hours each day rather than the one-hour cycle providing four hours total per day.

2. The instrumentation artifact question re possible E. E. G. recordings be explored vigorously. The differences between primate and man with respect to head dimensions, effect of beam incidence, etc., must be reviewed and analyzed.

3. The physiological and medical monitoring include the array noted in the minutes of May 12, the matrix presented by Dr. McIlwain, portable ECG for continuous monitoring and the utilization of lower-body, negative-pressure plethysmography (LBNPP). It is recognized that the Soviet literature refers extensively to cardiovascular effects of microwave radiation. The nature of the reported behavior of the cardiovascular system requires relatively continuous monitoring to characterize significant effects from normal variations. Also, it is recognized that LBNPP is an accepted and relatively sensitive measure

SECRET

ED DISTRIBUTION

of cardiovascular "deconditioning" (in the physiological sense). In addition to the special tests, the medical monitor would be responsible for the routine physical examination, regular daily inspection of subjects and to adhere to the responsibilities associated with AR 70-25. These procedures would be worked out through the Office of the Surgeon General, Dept. of the Army, and jointly with WRAIR operational group and relative to security requirements defined by ARPA. ARPA agreed to present, in writing, the security requirements for the program.

(S) The Committee recognizes that a period of uncertainty exists in the early phases of developing such a program and that the program director will require a degree of latitude in conducting pilot experiments before finalizing a detailed protocol. The Advisory Committee agreed to work closely with WRAIR in considerations of refinements of the protocol.

(S) The Committee agreed to conduct "brainstorming" sessions relative to the general Pandora problem in the context of ARPA's interests and responsibilities. The Committee expressed a need for more, yet manageable, literature review and information relative to the problem especially re the Soviet literature and from whatever sources useful information could be obtained. It was agreed that Dr. Pollack and Dr. McIlwain would assemble a "package" of useful documents to be distributed to the Committee. There was general discussion about various documents known to the attendees. It was agreed that several documents were relevant and appropriate, e.g., the IDA analysis due out soon, a document by Dr. Robert D. Turner, U. S. A. Standards document, the ERMAC report, a report by Castlr and Dodge, one by Castle, one by Thompson, and the Presman summary. It was also agreed that ARPA would make available, to the Committee, any information that is relevant to the problem. It was also agreed that the agenda of the Advisory Committee would automatically include a call for a progress report and new, relevant information from Committee members, WRAIR, and ARPA.

(S) Dr. McIlwain and Data Corporation representatives presented a demonstration of the BEER project and application of a computer-based information storage and retrieval system to provide rapid access to files on microwave related information. It is expected that user needs and responses will soon be tested by ARPA and WRAIR.

(S) A correction of the minutes of May 12 is noted, i.e., that Dr. McIlwain participated as a principal in developing the WRAIR protocol.

(U) The next meeting is scheduled for July 16, 1969.

Respectfully submitted by Lysle Peterson, Chairman

mc

Date Typed: June 30, 1969

SECRET

~~SPECIAL HANDLING~~

LIMITED DISTRIBUTION

~~ADVANCED SENSOR RESTRICTED~~

to the agenda would be invited as early as possible and notified of the material requested. A list of possible agenda items for the future was developed, and it was expected that this list would be considered appraised by Committee members and an agenda for the next meeting defined on or about August 1. It was agreed that the next meeting would be scheduled for August 12 and 13.

(U) The meeting was adjourned at 1700.

Respectfully submitted by Lysle H. Peterson, Chairman

mc

Date Typed: July 31, 1969

SECRET

MINUTES OF PANDORA MEETING OF JULY 16, 1969

Meeting Convened: 0930

Meeting Adjourned: 1700

Meeting Held: 0930 to 1330 at Building 503, Forrest Glen Annex of the Walter Reed Hospital

1400 to 1700 at IDA Rm. No. 10K5

Present:

Science Advisory Committee

Dr. Joseph E. Barmack
Dr. James N. Brown
Dr. H. Allen Ecker
Dr. Joseph Kubis
Dr. Lysle H. Peterson, Chairman
Dr. Herbert Pollack
Dr. Lawrence Sher

Walter Reed Army Institute of Research

Colonel Joseph V. Brady
Dr. Thomas W. Frazier
Mr. T. Daryl Hawkins
Colonel Merrill C. Johnson
Major James T. McIlwain

Mr. Richard S. Cesaro, ARPA
Dr. John J. Collins, (CNO), USN
Mr. H. Mark Grove, Wright-Patterson AFB
Mr. Albert Rubenstein, ARPA
*Dr. Stanley Marder, IDA
Dr. Joseph C. Sharp, N. Y. State Dept. of Health

*First Attendance

Absent: Mr. Harris B. Stone, (CNO), USN

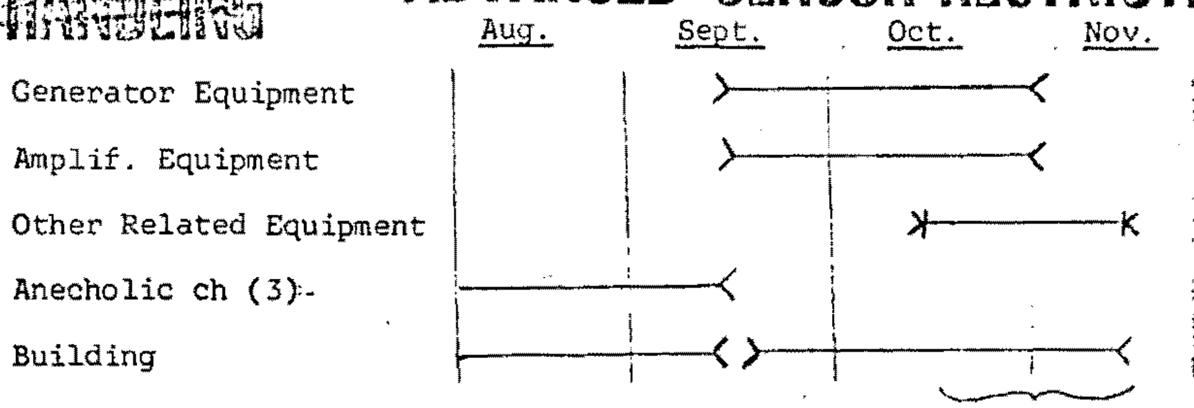
(S) The meeting was convened at 0930 at Building 503, Forrest Glen Annex, Walter Reed Hospital. The purpose of the meeting at Walter Reed was to review the developments of the facilities and programs re site, to review schedule for completion of the program and to give new Committee members the opportunity to see the laboratories.

(S) Major McIlwain and Mr. Grove led a presentation of schedules to complete the development of the facilities:

SECRET

~~LIMITED DISTRIBUTION~~

C[illegible]-HANDLING ~~ADVANCED SENSOR RESTRICTED~~



Delivery (>) H. P. 2116B

In Operation (<)

(S) Discussion included estimates of signal stability, flexibility, and obsolescence of system. Mr. Grove indicated that satisfactory stability could be expected re 15 ft. cube, that the system was modular and could be expanded, and that range extended from 250 megahertz to 10 gigahertz.

(S) Discussion then focused upon the relevance of the signals to the Moscow signal. It was stressed again that the signal used in the forthcoming experiments should (i) be comparable to previous experiments at the laboratory, (ii) be relevant to the Pandora problem, (iii) the signal characteristics be calibrated periodically as referenced to a standardization technique and (iv) possible signal artifacts (i.e., signals recorded from biomedical transducers due to direct effects of the microwave input in contrast to microwave input effects on the biomedical system) should be elucidated and evaluated.

(S) Discussion also focused upon the software program, i.e., the evaluation of data via computer system. Mr. Grove and Major McIlwain defined three software areas: (i) that developed by Ross Adey at U. C. L. A., (ii) that developed for the internal logic of the equipment to be delivered (H.P. 2116B and related system), and (iii) software needed to extend and interface with (i) and (ii). The U. C. L. A. program had been developed to test an array of statistical parameters re EEG signals on the equipment at U. C. L. A. WRAIR has selected from the total U. C. L. A. program certain aspects which were felt necessary for the WRAIR needs, e.g., auto- and cross-correlation, auto- and cross-power spectra, average transients and certain standard statistical processing. These were packaged into the logic of the equipment being delivered by Hewlett Packard. WRAIR felt that there

SECRET

DISTRIBUTION ADVANCED SENSOR RESTRICTED

were aspects of the U. C. L. A. programs (e.g., coherence functions) that were not needed. To duplicate the U. C. L. A. software program would have been too costly and would require too extensive a hardware package. Thus, the special computer package approach was taken. It was not anticipated that extensive, additional software would be needed but that if so, contracting would be more appropriate than developing extensive in-house programming capability.

(S) In summary, the WRAIR presentation concluded that:

1. The facility (at least two chambers operational) would be ready for experimental work by mid-October unless unexpected delays occurred.

2. The signal characteristics would be comparable to previous work and that a calibration procedure would be adopted.

   (<u>NOTE</u>: Discussion indicated that the calibration question related to defining the characteristics to be calibrated rather than to capability to calibrate, i.e., to define spectral and energy characteristics to be measured for calibration and standardization.)

3. With the planned program and facilities, the experimental artifact question could be approached within the inherent uncertainty levels. It is known that EEG experimental artifacts do occur and that the question remains as that in a given experiment how much of the recorded response is artifact, i.e., in levels at different EEG frequencies, to what extent is the living brain required. It is expected that the autospectral analogies will be helpful. A two- or three-month program using monkeys is planned.

(S) The Committee reconvened in executive session after lunch at Room 10K5 in IDA to review the present status of the program in the light of Mr. Cesaro's charge to the Committee. It was agreed that the Committee would participate in certain working sessions devoted to specific problem areas and, whenever appropriate, do so in subgroups relative to the particular expertise involved, would conduct "brainstorming" sessions relative to the overall Pandora question and the various components of the program, and structure agenda for periodic, approximately monthly, meetings such that orderly progress should occur. Furthermore, contributors

SECRET SECRET

SPECIAL HANDLING

DISTRIBUTION

ADVANCED SENSOR RESTRICTED

D R A F T

MINUTES OF THE PANDORA MEETINGS OF AUGUST 12 and 13, 1969 (U)

Minutes Prepared By: Lysle H. Peterson, Chairman

24 FEB 1977

THIS DOCUMENT HAS BEEN DOWNGRADED

TO *UNCL...

Per Director DARPA/TIO

...ins information affecting ...of the United States with... ...he Espionage Laws, Title ...tions 793 and 794. The ...revelation of its contents ...a unauthorized person is

12 YEAR INTER... ...LY ...

IDA HQ 69- ...

SECRET

DISTRIBUTION

~~SPECIAL HANDLING~~

~~ADVANCED SENSOR RESTRICTED~~

D R A F T

MINUTES OF PANDORA MEETINGS OF AUGUST 12 and 13, 1969 (U)

Meeting Convened: 0900 on August 12 and 13

Meeting Adjourned: 1700 on August 12
1300 on August 13

Meeting Held: IDA Room No. 10K5 on August 12 and 13

Present:

Science Advisory Committee

Joseph E. Barmack
James N. Brown
H. Allen Ecker
Joseph Kubis
Lysle H. Peterson, Chairman
Herbert Pollack, Executive Secretary
Lawrence Sher

The following attended Aug. 12 only:

Mr. T. Daryl Hawkins, WRAIR
Major James T. McIlwain, WRAIR
*Mr. Daniel Sullivan, ARPA

*First Attendance

Absent: Colonel Joseph V. Brady, WRAIR
Mr. Richard S. Cesaro, ARPA
Dr. John J. Collins, (CNO), USN
Dr. Thomas W. Frazier, WRAIR
Mr. H. Mark Grove, Wright-Patterson AFB
Colonel Merrill C. Johnson, WRAIR
Mr. Albert Rubenstein, ARPA
Dr. Joseph C. Sharp, N. Y. State Dept. of Health
Mr. Harris B. Stone, (CNO), USN

(S) I. The minutes of the July 16 meeting were approved with minor modifications, such as the omission of the fact that the Committee had requested a written summary of the WRAIR program to date and an oral presentation of the basic data.

(S) II. Dr. Peterson reviewed the purpose of the meetings (August 12 and 13) as principally that defined at the previous

SECRET

LIMITED DISTRIBUTION

ADVANCED SENSOR RESTRICTED

meeting:

A. To have a detailed, full review presented by WRAIR of the background and findings of the Pandora/WRAIR primate studies from their inception to present. Specifically:

(i) A review of the background for the development of the program.

(ii) Considerations of the expected sensitivity and relevance of the tests used in the program.

(iii) Review all findings from all experiments.

(iv) Review current protocol for future program.

B. To hear Dr. Ecker's report on the work of his sub-committee, which was asked to look into the hardware systems being developed for future work in the program at WRAIR.

C. To discuss follow-up of Big Boy project.

The Committee was then, in the remaining time, available to conduct "brain sessions," as requested by Mr. Cesaro.

5) III. Major McIlwain presented his analysis and conclusions of the WRAIR/Pandora program. It is noted that although Colonel Joseph Brady, Dr. Joseph Sharp, and Mr. Mark Grove were invited, they were unable to attend this meeting. Also, Messrs. Cesaro and Rubenstein were unable to attend because of conflicting duties; however, they were represented by Mr. Dan Sullivan. The Committee's summary of Major Mc-Ilwain's review is as follows:

SECRET

ADVANCED SENSOR RESTRICTED

The experimental approach was defined early in 1966 mainly by Drs. Brady and Sharp with Dr. Sharp being assigned primary, direct responsibility for the operational conduct of the experimental program. The earliest studies were pilot studies. The same signal has been used throughout the study except for varied strength. This signal was selected from the "Moscow signal" tapes by a group representing various agencies. Mr. Mark Grove has had a major responsibility for providing the hardware to generate the selected "special" signal for WRAIR. Primate behavior measures were chosen by WRAIR as the primary indicators of an effect of the special signal. Studies comparing exposed and unexposed behavior were divided into three groups: 1. Reaction times, 2. Detection, and 3. Multiple schedule studies.

1. Reaction Time: Two types of experiments were performed on two monkeys at 4.6 mw/cm^2:

   (i) Shock avoidance (No. 682) 250 trials/day in midday period and (Animal No. 683) 500 trials/day; both a.m. and p.m. periods.

   Results:

   (a) No significant differences between experimental (exposed) and nonexposed periods, and no significant differences between a.m. and p.m. trials.

Conclusion: Special signal (in WRAIR program) has no significant effect on reaction time under the shock avoidance test procedures.

(ii) Food Reward: Animals No. 782 with 33 days' exposure and 783 with 30 days' exposure 4.6 mw/cm^2.

Results: No effects on median performance and some tendency for the interquartile range to change. Discussion: Previously the change in the interquartile range was interpreted as an effect which "slowed down" the monkey, presumably due to the special signal. Dr. McIlwain, however, concluded that with a more complete analysis, the finding could be interpreted as an effect of the experimental program itself and not necessarily due to the signal.

Conclusion: The effect of the WRAIR signal on reaction time under the food reward test procedures was indeterminate.

2. Detection: In this stimulus substitution design, the animal, trained to one stimulus, is then trained to respond conditionally to a second stimulus. An attempt was made to train the animal to respond to microwaves as the second stimulus. Shock avoidance was the response. One monkey

ADVANCED SENSOR RESTRICTED

was exposed to 4.6 mw/cm^2 at 11-second intervals. The second monkey was exposed to 20 mw/cm^2 at 60-second intervals.

Results: No significant detection elicited by either monkey.

Conclusion: The animals showed no response to the microwave signal at least in this regimen.

3. Multiple Schedule: This was regarded as the most critical aspect of the experimental program and involved learning performances for nine sessions on four monkeys, using a progressive, fixed ratio reward (PRL) and alternating with a differential reinforcement of low rates (DRL). Six measures were examined using 4.6 mw/cm^2 as average field strength of the signal:

(i) DRL distributions

(ii) Latency of the DRL

(iii) Average number of time-out responses

(iv) Average time per time-out

(v) Average pause time for each ratio step

(vi) Average running time within each ratio step

Of these, the only measure that showed any possible significant effect was the DRL distribution measure, but the data were internally contradictory. A further analysis was made of (i) the number of uninterpreted pauses exceeding ten minutes, (ii) work stoppages for any reason, including equipment malfunction, and (iii) total number of pellets earned.

Results: In two of the nine sessions in which the full-power special signal was used, uninterpretable data were obtained either because of equipment malfunction or the use of reinforcement schedules (which reward certain types of stoppages) were recognized as contributing themselves to work stoppages. In two of the nine sessions, there was no effect of the signal; in three (or four) of the nine sessions, there were effects, but they were not cummulative; in one or possibly two sessions, there were unexplained work stoppages which, in the light of the total experience, appear to be random variations found as often in control as in exposed sessions.

Conclusions: There is no convincing evidence of an effect of the special signal on the performance of monkeys.

In addition, Dr. McIlwain acknowledged that the studies had primarily involved behavioral analysis with little effort made to analyze physiological functions, e.g., cardiovascular.

The Committee was told that Dr. McIlwain had not had the opportunity to present his analysis and conclusions to Drs. Sharp and Brady although he had briefly and informally conferred with Dr. Brady. Although the Committee had not previously had any other detailed consideration related to Dr. McIlwain's presentation as well. The Committee felt strongly that the character of the signal itself should be reviewed in the light of previous events. The Committee thereby requested information concerning the analysis and logic, which led to the selection of the particular "special" signal developed for and utilized by the WRAIR program. It appeared that complete analysis of the Moscow signal had not been accomplished prior to the selection. It was the opinion of the Committee that a thorough spectral analysis of the Moscow signal was technically and economically feasible and should be undertaken for the following reasons:

1. To establish a sounder basis for the design of a signal to be used as the "most significant and relevant" components of the Moscow signal to test the biomedical effects of the signal.
2. To permit proper choice of instrumentation and equipment to simulate the signal in experiments.
3. In the event of negative findings in initial experiments, to provide a basis for defining alternative signals or for reproduction of the Moscow signal itself.

Thus, if there is reason to believe that particular forms of microwave signals hold the "key" to the biomedical effects (if any) of the Moscow signal, then any analysis of the WRAIR program findings, it was apparent that the conclusions presented earlier by Dr. Sharp were significantly different from those of Dr. McIlwain.

The Committee felt that because of the importance of these differences, the WRAIR program principals, Drs. Brady, Sharp, McIlwain, etc., should attempt to resolve the inconsistencies of their conclusions. The significant differences are, of course, whether or not there are established effects of the special signal on primate behavior as evidenced from the WRAIR program. It was also noted that no technical report had been written regarding the program to date. Dr. McIlwain agreed to furnish the Committee with a written summary of his presentation. The Committee expressed the desire to analyze the raw data themselves.

(S) IV. Dr. H. Allen Ecker presented the findings of his subcommittee on the functions and characteristics of the instrumentation being developed for the expanded WRAIR program. (See minutes of July 16.) A written summary of Dr. Ecker's report is appended (Exhibit A). In discussion, it was concluded that the capacity of the instrumentation exceeds present requirements, but the rational that if the program is expanded and extended, that added requirements will develope, is probably sound.

Discussion regarding the special signal was withheld until after Dr. Ecker's presentation although this major attempt to duplicate it must start from a thorough analysis. To date, the analysis has not, apparently, been thorough; a deficiency in the Pandora effort.

Mr. Daniel Sullivan of ARPA was requested to see whether the signal analysis could be made available to the Committee.

(S) V. A brief review of Big Boy reminded the Committee that the results of the Saratoga study were essentially inconclusive although the testing technology and programs were worked out and proved feasible and reliable with certain suggested improvements. (A report has been written of the Saratoga effort.) A possible reason for the inconclusiveness of the Saratoga study was that the levels of microwave radiation measured at sites where tested personnel were located were found to be extremely low and the exposure time very slight. The Committee recommends that the approach of using established, operational radar stations to test the effects of microwaves on humans be followed-up. Dr. McIlwain indicated that he and Mark Grove had looked at the possibilities of several ground-based establishments, such as those at Monmouth, White Sands, Fort Sill, Hawk missile systems (e.g., El Paso), etc. Their conclusions are that populations of men exposed to radiation are too unstable to be effective for tests. It was also noted that the Navy has at least seven communications ships broadcasting in the 10-meter band rather than S-band, i.e., similar in character to the Voice of America station.

The Committee concluded that further consideration be given to the use of ground- and ship-based microwave generators for further studies.

(S) VI. The Committee spent the better part of two days on the subjects noted above and only had time to introduce additional topics. It was again concluded that biochemical, physiological, and "well being" studies should be carried out at WRAIR or elsewhere. These should include cardiovascular responses, morphological and biochemical studies of peripheral blood. It was also concluded that the findings re cytogenetic studies should be carefully reviewed.

(S) VII. The Committee felt that the first order of continued effort by the Committee should be based upon a resolution of the apparent differences in the interpretation and/or analysis of the WRAIR primate program.

Respectfully submitted by Lysle H. Peterson, Chairman

mc

Date Typed: August 27, 1969

Attachment: Exhibit A--Instrumentation Review
by Dr. H. Allen Ecker

SECRET

Exhibit A.

9 August 1969

LIMITED DISTRIBUTION

~~ADVANCED SENSOR-RESTRICTED~~

~~SPECIAL HANDLING~~

INSTRUMENTATION REVIEW

On 31 July 1969 Dr. James N. Brown, Mr. Mark Grove and Dr. H. Allen Ecker met at Georgia Tech to review the planned instrumentation for the new facility at WRAIR. Since the schedule for completion of equipment was discussed at some length at the last Pandora Panel Meeting and is recorded in the minutes of that meeting, further discussion of the schedule did not appear necessary. The two major items that were reviewed are (1) the Signal Generation Equipment and (2) the Data Recording and Processing Equipment. Neither the variables to be measured, the method of their measurement nor software requirements was discussed.

<u>Data Recording and Processing Equipment</u>

A simplified block diagram of the Data Recording and Processing Equipment for the new facility is shown in Figure 1. Hewlett-Packard is the prime contractor for design and installation of this system and a very flexible and well-coordinated system which offers excellent data analysis capability has been designed. The use of pre-programmed analyzers such as the new Hewlett-Packard 5450 Fourier Analyzer provides pre-programmed analysis techniques and; therefore, reduces the initial software requirements. Both analog and digital data storage equipment is included. Care has been taken to provide calibration and monitoring capability throughout the system. Since the variables to be measured and analyzed were not defined at the time of equipment design, it appears that the money available for this instrumentation was used wisely to provide a very flexible data recording and processing system.

A suggestion for increased capability is the use of a Honeywell Visicorder in place of the currently planned HP 7878 Ink Oscillograph. The visicorder offers a bandwidth of 5 KHz with an extension to 10 KHz with reduced amplitude, whereas the HP Ink Recorder has a maximum bandwidth of 150 Hz. In any system in which input variables are unknown, bandwidth can be a limiting factor on the flexibility of the processing system.

~~SECRET~~

Signal Generation Equipment

The task of designing the system to generate the desired RF signal was accomplished in house with Litton Industries providing the special high voltage power supply. A preliminary block diagram of the basic components of the system is shown in Figure 2. The basic RF oscillator is an HP 8690 Sweep Oscillator. The frequency modulation signal is generated by summing the output from two Hewlett-Packard 3300 Function Generators and a General Radio 1390 Noise Generator; current plans do not call for amplitude modulation. However, a PIN modulator could be inserted between the basic oscillator and the first amplifier as indicated by X on the block diagram. A PIN modulator is an easy and flexible way to provide amplitude modulation with minimum interaction with the desired frequency modulation.

A two stage drive section in the form of sequential 1 watt and 10 watt TWT amplifiers is part of the present design. TWT's with 30 dB gain are common; therefore, in a conventional system, drivers separated by only 10 dB in output would not be an efficient system; the desire for extreme linearity prompted the choice of this configuration.

Provisions are made to monitor the power level and the frequency spectrum after the 10 watt TWT. The results of this monitoring will be available to the Data Processing System.

The present plans call for Klystrons to amplify the signal to a 1-to-2 kilowatt level. An amplifier of this type in the frequency range of interest would have only approximately 5 MHz bandwidth with 40 dB of gain. Since only about 23 dB of gain would be required to produce 2 kilowatts from a 10 watt drive, it would be possible to stagger tune the Klystron amplifier sections and increase the bandwidth at the expense of gain; perhaps as much as 15 or 20 MHz bandwidths could be achieved. A major design item of the Signal Generation System is the high voltage power supply and associated protective circuitry for the Klystron amplifier. At present, a 10 kilovolt-1 amp power supply is being designed.

After the Klystron amplifier, monitoring of the output power will be provided as well as isolation from undesired or reflected signals. The transmitting antenna will be a Scientific Atlanta Standard Gain Horn with approximately 18 dB gain. The three dB beamwidths in the E and H planes are 23° and 22° respectively. A probe antenna and associated thermistor mount and power meter are provided down range for monitoring power levels at that point.

The signal generation system as proposed provides a flexible source for a frequency and amplitude modulated RF signal with the exception of the final Klystron amplifier. Octave bandwidths are common practice in TWT amplifiers whereas Klystrons usually exhibit less than a one percent bandwidth. If one is assured that the signal to be simulated will never exceed the bandwidth limitation of the Klystron amplifier, then the proposed system will be adequate. However, if the possibility of a larger bandwidth requirement exists, a search for broader bandwidth and perhaps higher powered output tubes should be made. Both Hughes and Varian advertise 1 KW CW TWT amplifiers in the frequency range of interest. A recent advertisement by Varian in the March 1969 Microwave Journal indicates that 10 KW CW TWT's have been built and delivered. Also, recent developments in CW cross field amplifiers could provide a very efficient and reasonably broadband final transmitter stage. Both Ratheon and SFD have made significant advances in the development of cross field amplifiers. It should be emphasized that the system was originally conceived before the above tubes were catalog items. Also, cost and scheduling can be limiting factors.

The choice of a standard gain horn for the transmitting antenna provides a simple method of coupling to free space. However, the far-field criterion must be satisfied to establish a uniform plane wave over a region in space. If a larger area and a more uniform wave is desired, a large collimating reflector type antenna could be substituted for the standard gain horn. Of course, a large reflector antenna would be much more expensive.

Concluding Remarks

The results of the review of instrumentation indicate that at this point

~~LIMITED DISTRIBUTION~~

~~ADVANCED SENSOR-RESTRICTED~~

both the Data Recording and Processing System and the Signal Generation System have been well planned. However, two pressing issues must be resolved. (1) It is imperative that rapid decisions be made on the variables to be measured and on the desired methods of analyses to permit determination of required software. (2) A more thorough analysis of the RF signal to be simulated is necessary. The bandwidth requirements of the output amplifier hinge on the results of that analysis.

Respectfully submitted,

H Allen Ecker

H. Allen Ecker

~~SPECIAL HANDLING~~

~~SECRET~~

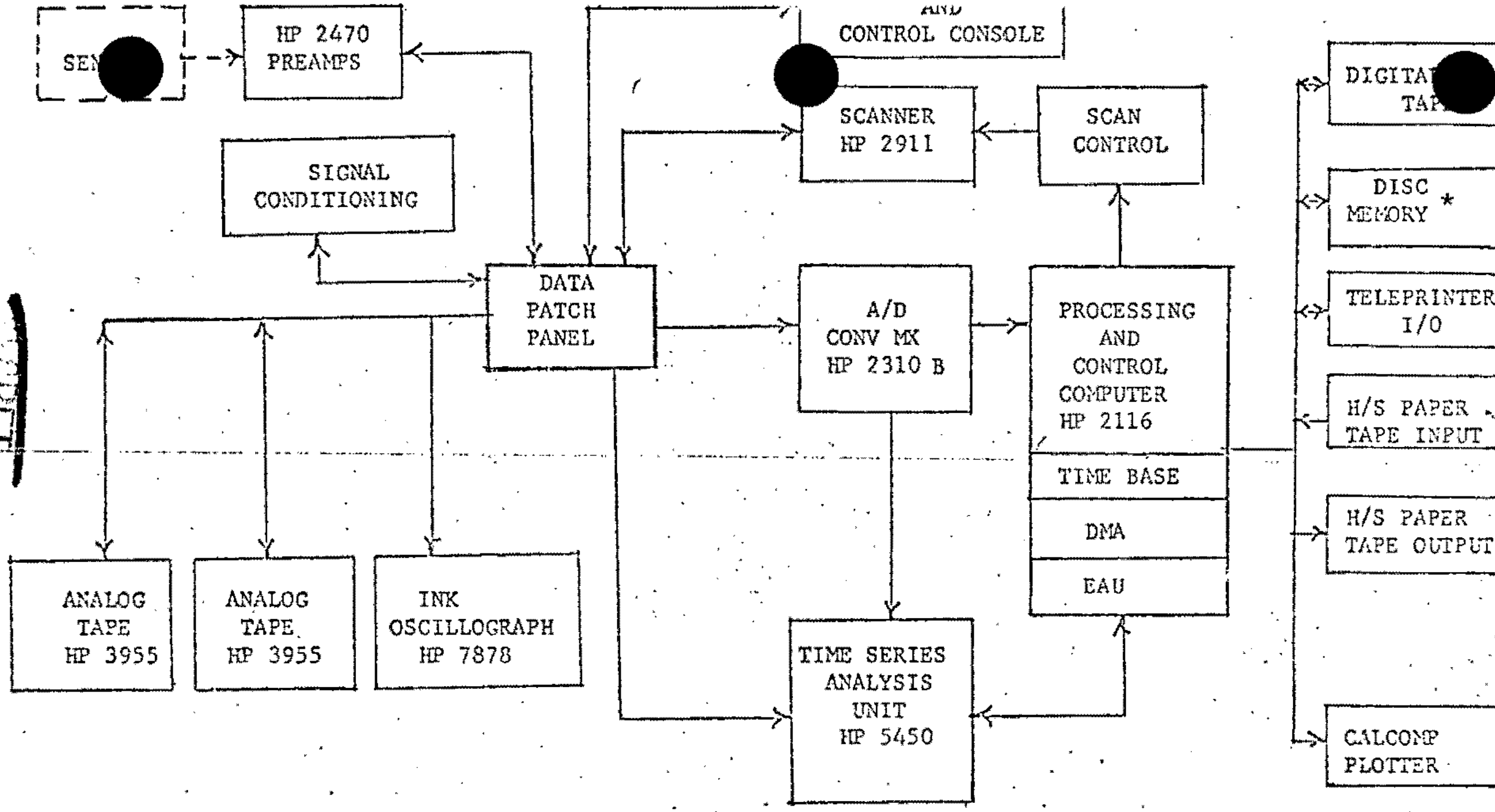
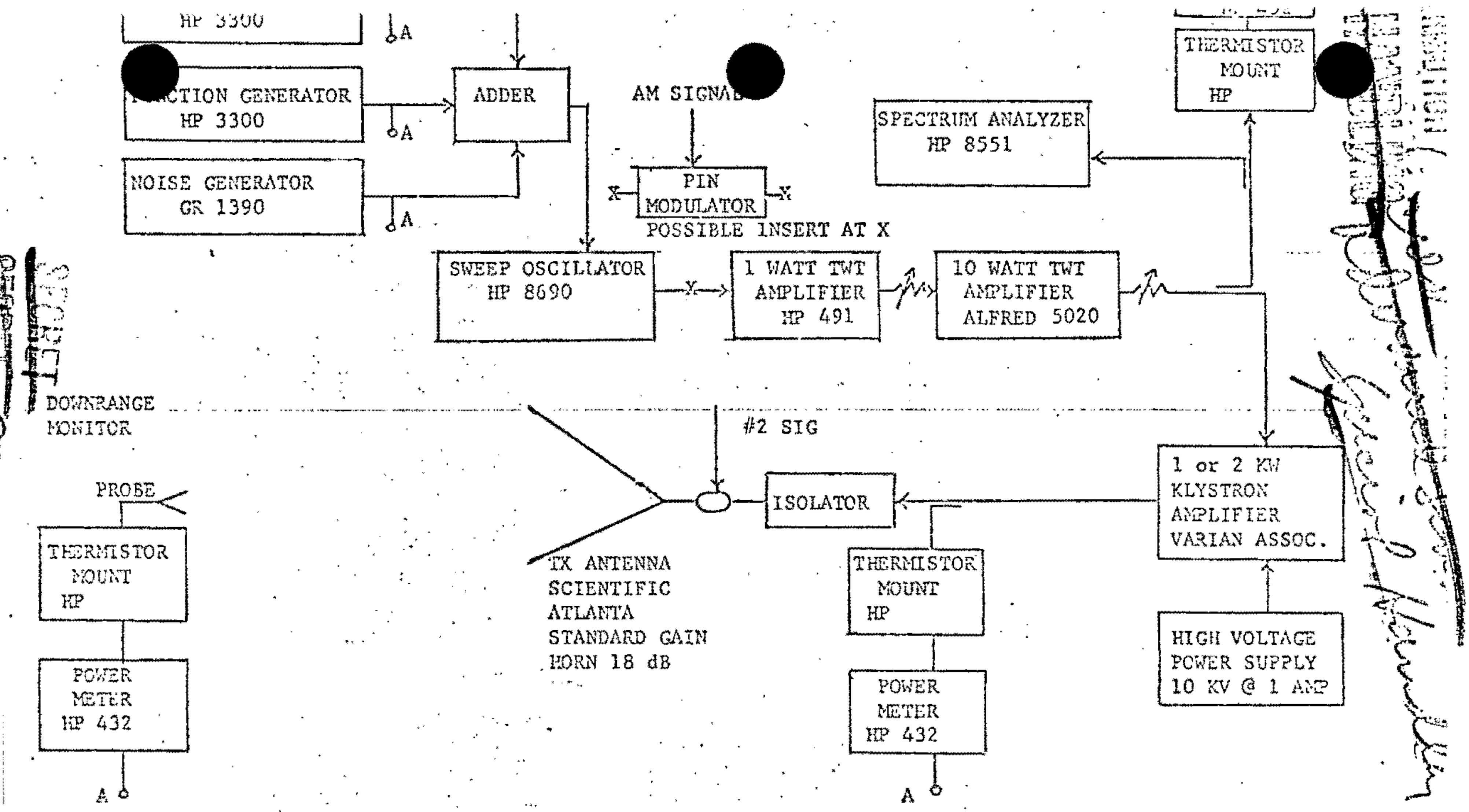


FIGURE 1

9 August 1969

* Not part of original purchase

ADVANCED SENSOR RESTRICTED



A - access to processing system

FIGURE 2

9 August 1969

ADVANCED SENSOR RESTRICTED

[redacted]

Rand
SANTA MONICA, CA. 90406

September 12, 1979

Director
Defense Advanced Research Projects Agency
1400 Wilson Blvd.
Arlington, VA 22209

Attention: Mr. Fred A. Koether
Management Information Systems Division

Dear Fred:

Your request put our Records Vault management to the test with such limited document description but they came through with flying colors. The letter you wished is enclosed.

Please sign and return the enclosed classified material receipt.

Sincerely,

Claude R. Culp

CRC:eh

Enclosure as noted.
(CL2238, Copy 3 dated 4 November 1969
"Review of Pandora Experiments"(U)

[redacted]

[redacted]

The RAND Corporation

1000 CONNECTICUT AVENUE, N.W. • WASHINGTON, D.C. 20036

3

4 November 1969
WL 613

[redacted]Y

Dr. Stephen Lukasik
Deputy Director, ARPA
Office of the Secretary of Defense
Washington, D.C. 20301

THIS DOCUMENT HAS BEEN DOWNGRADED
TO "UNCLASSIFIED" 24 SEP 1979
Per Director, DARPA / TIO

Dear Steve:

REVIEW OF PROJECT PANDORA EXPERIMENTS

Following our recent discussions I have gone through the data on the Pandora Experiment as they have been presented by Major McIlwain. Maj. McIlwain has done a superb job on reassessing the material of the last few years and presenting it in an easily understood form. During the course of this review I spent approximately 8 hours (October 22, 1969) looking at the material and in related discussions. In brief, I am forced to conclude that the data do not present any evidence of a behavioral change due to the presence of the special signal within the limits of any reasonable scientific criteria. There is evidence of behavioral change in some cases but this change could be attributed to a variety of causes or systematic measurement errors all well within the limits of experimental methodology. Evidence of other effects such as EEG, histology, and chromosomal analyses have not accumulated with either adequate detail or control to tell whether effects due to radiation are present.

One should not infer from these statements that there is no value to the work done; there is unquestionably considerable value in development of protocols and facilities and the possibility of extending this to a variety of useful work which I will discuss later.

The primary experiments have been to look for the effect of the special signal on specially trained monkeys at intensity levels comparable

[redacted] AFFECTING THE NATIONAL DEFENSE OF [redacted] UNITED STATES [redacted] THE ESPIONAGE LAWS, TITLE 18 U.S.C. [redacted] 793 AND 794. THE [redacted] OR REVELATION [redacted] IN ANY [redacted] TO AN UNAUTHORIZED PERSON [redacted]

[redacted]

[redacted]
Ex[redacted]
[redacted]

to the special site environment. As I recall the data, there have been four operant conditioned animals which have been exposed in total 7 times to the special signal, 2 times to a square wave, 1 time to a triangular wave, and 1 time to cw. The intensity generally used has been 4.6 mw/cm^2 which, I might point out, is probably in excess of the special site environment. Experiments are not run at higher intensity since this is the maximum possible for the equipment using two carriers. At least one animal was run at very low intensities corresponding perhaps closer to the action site ranging from 8 $\mu w/cm^2$ to 1 mw/cm^2 but I recall nothing particularly significant for this run compared to the others. The basic parameters measured were the PR (prompt response), DRL (differential reinforcement of low rate) and the latency time to go into DRL.

I will not attempt here to detail the various particular runs generally of 20 to 30 or more days in duration but rather give my general impressions. There were certainly individual days where differences were observed which were statistically significant in terms of the individual day's experiment. These behavioral changes, however, were well within the limits of causes other than radiation such as change of the animal from one room to another, day/night variations, or perturbations caused by malfunction of equipment. In particular there seem to be a considerable number of malfunctions in the pellet-feeding gear. In the case of one animal who was exposed at two different times approximately two years apart, it was interesting to note that the variation in his behavior during the 2nd exposure where he had the opportunity for long continued training was much smoother than the first period. It is also important to note that while a large number of performance degradations were noted most of these occurred either in the form of very small variations from a normal count (i.e., number of food pellets obtained) or occurred the day following a significant equipment malfunction. There may have been one case (animal number 673) where there was a performance time-out of some significance.

In general one would consider the unexposed animal or a period of nonexposure to be the control; I would also say that in view of the problem associated with the special signal an equally significant control would be the cw signal. However, as mentioned above there was only one case of this sort of run and this quite a few years ago. It was difficult for me to see how one can have a viable protocol for any stimulus when the stimulus intensity has not been brought to a level which creates a positive effect and this then compared to the required operational level.

For example, such a level might be in excess of 10 mw/cm^2. The equipment used in a combined single-mode manner could certainly produce approximately this level of power.

Another type of experiment that could be classified as behavioral was the reaction time studies. Four animals were used here, two with food reward and two using shock avoidance. The basic concept here is for the animal itself to adjust his reaction time to a comfortable value and to look at changes in this as a result of various stimuli or environmental conditions. Of the four tests run three showed no effect, one did show an effect but this effect could be either eliminated or emphasized by a change of the timing program. I believe, in general, these reaction time studies have been used in the behavioral field primarily for relatively short-term changes. Certainly there was some indication of statistically valid variations over a period of months but this could not be correlated to on/off times of the signal. It might be noted also that negative results were obtained for a tone substitution versus the microwaves for shock avoidance.

In summary, you could say that there are some changes in the distribution of the various parameters at various times but there were few or none uniquely correlated with a special signal. There were certainly no trends observed, any statistically valid changes were single day, and there was certainly no evidence of anything that could be described as a catastrophic effect.

The effect of low frequency modulation on the EEG has been reported a number of times by this project. Implanted electrodes are placed into various brain regions of the monkey and the resulting EEG tapes were analyzed off-line by Dr. Adey's laboratory in California. The time delays intrinsically involved in this process may be significant in explaining some of the experimental procedures followed or not followed. If the animals are irradiated by sine wave modulated at various low frequencies in the alpha region the autocorrelated power spectrum analysis shows reinforcement of the modulation frequency in various portions of the brain. At this date there is no convincing evidence that this effect is not an electrical artifact of the procedure. There are several variations of protocol which could determine this using an on-line system. I believe a fast-Fourier transform analyser is on order for purposes of going on-line. Experiments were run with the animals' head shielded, under anesthesia, killed during the experiment, and even with a perfused brain. However, none of these were satisfactory for positive elimination of the possibility of an artifact. In fact, variations of head position versus autocorrelation spectrum did tend to lend some evidence for an antenna action for the probes.

Additional programs are underway for chromosomal analysis using karotyping of cultured lymphocytes and for testicular and brain histology but no substantive results have been reported yet other than a few isolated observations that cannot be considered significant until placed in the context of systematic data.

As stated earlier, the value of the behavioral protocols, procedures, and equipment should not be summarily dismissed. In addition not only does the present working facility represent a substantial capital equipment investment but also the new facility nearing completion is a magnificent laboratory indeed with three additional exposure chambers and all the various ancillary histological, biochemical, and conditioning laboratories that could be required, at least for studies in the microwave region. The issue of determining whether or not there is a biological effect at relatively low levels below the 50 to 100 mw/cm^2 levels which constitute directly observable hazards is not limited to the question of the special signal. Failure to have absolute scientific evidence of the presence or absence of an effect and its threshold region can leave the U.S. vulnerable to a campaign against the use of surveillance radars foreign and domestic, military and civilian, as well as highpowered communications equipment. A possible public and consequent Congressional reaction on scare material, particularly if encouraged by inimical forces, could result in a catastrophic impediment to the use of various equipments essential for the national security.

It would appear that the problem should be viewed on three security levels. First, the compartmented signal and data derived from it should be put aside under adequate security protection for the present; if there is to be any understanding of this, the present program is probably wrong to start with.

One should start with an examination of various basic wave forms and then the combinations resulting in possible intermodulations and demodulations by biological tissue. A program that might look at possible behavioral implications from the point of view of a weapon or interrogation device could be handled on a SECRET level. The more pressing issue is the safety problem and that could be handled on a CONFIDENTIAL or OUO level during acquisition of data with eventual declassification as the goal.

As an example of a protocol one might consider starting at a fairly high level, 10 or 20 mw/cm^2 then looking at 5 mw/cm^2 and 1 mw/cm^2 for cw, and 50%, 1%, and 0.1% pulsed duty cycles with equivalent average power. I do not mean to imply by this that either I or ARPA should design the experimenter's protocol, but rather that one should start with a level high enough to get some observable effect and then continue to look at real world levels and modulations. The new facility is certainly adequate to handle the microwave problem, still leaving currently urgent problems of ULF and HF/VHF.

The important objective now should be to determine at what level, modulation, and exposure regime (chronic, intermittent, etc.), a biological effect as distinguished from a hazard exists. These two terms should not be confused. If an effect is observed at that time an adjudication of various operational situations should be made to determine what hazard, if any, exists.

Sincerely,

Samuel Koslov
Research Council

SK/bt

cc: Augenstein, McIlwain, Tamarkin

[redacted]

ON THE EVALUATION OF DATA ASSOCIATED WITH PANDORA

(Preliminary Report)

24 FEB 1977

THIS DOCUMENT HAS BEEN DOWNGRADED
TO [illegible]
Per Director DARPA/TIO

Joseph F. Kubis
12/4/69

TABLE OF CONTENTS

ADMINISTRATIVELY CONFIDENTIAL

ON THE EVALUATION OF DATA ASSOCIATED WITH PANDORA

Section 1: Introduction

BACKGROUND

In a letter dated October 29, 1969, Dr. Lysle H. Peterson invited me to help in "developing criteria for the evaluation of data associated with Pandora." I agreed to talk with the project investigators, examine whatever records were available, and prepare a report of my findings and recommendations.

My purpose in meeting with those intimately connected with the project was to solicit ideas on how they felt the data should be evaluated. The examination of basic and derived data was not only to gain an understanding of the analyses already made but also to recommend additional procedures the structure of the data might suggest.

Finally, I suggested that whatever findings and recommendations I would make be reviewed by Dr. Peterson, who with the assistance of Dr. Pollack, would decide whether further effort on my part would be desirable.

THE PROBLEM

The underlying problem which led to this report was the existence of two different approaches to the analysis of Pandora data -- one by Dr. J. Sharp, the other by Maj. J. McIlwain. In Dr. Sharp's view, although most of the experiments produced negative results, certain aspects of the data (IRT changes and work stoppages) are suggestive of an exposure effect due to the WRAIR signal. Admitting that some changes in the animal's behavior could not be explained by artifacts, Maj. McIlwain believes that there is insufficient consistency in the data to seriously entertain the notion of an exposure effect due to the special WRAIR signal.

The evidence adduced by Dr. Sharp was a series of graphs and a cataloguing of the instances of work stoppages attributed to the special signal. Maj. McIlwain's position is that there are clerical errors in one of the graphs and that the sequence showing a shift in the IRT distribution is a function of the days selected for graphing. He has presented graphs from baseline periods that are similar to the graphs in the IRT sequence. As for work stoppages, Maj. Mc.Ilwain noted that a number of them could be associated with mechanical and other failures. Acknowledging that such difficulties limit interpretations, Dr. Sharp believes that there are some runs that are artifact-free and that these should undergo intensive analysis.

[redacted]

VISITS

Appointments were made with the following individuals associated with Pandora:

Col. J. Brady
Col. E. Buescher
Mr. R. Cesaro
Maj. J. McIlwain
Col. W. Meroney
Mr. A. Rubenstein
Dr. J. Sharp

During these visits a number of reports were examined as well as the basic and derived data from the experiments. A description of the visits made and the materials examined may be found in Appendixes A and D.

Section 2: Components of the Problem

As stated in Section 1, the problem seems simple enough. However, it is embedded in a mosaic of components, which, if clearly understood, will place the problem in proper perspective.

PROJECT AS A WHOLE

Essential to a proper evaluation of the problem is the consideration of how the project as a whole was viewed. Dr. Sharp interpreted his task as exploratory in nature -- a series of pilot experiments to search for leads that might prove fruitful in a more extended research effort. An examination of the experiment protocols does support this interpretation: many experiments were tried, many conditions were tested, and many changes in procedure were introduced during the experimental program.

The inevitable outcome of a pilot program is an accumulation of a wide diversity of data, fractionated into blocks obtained under various combinations of conditions. Experimental outcomes, uncontaminated by changes in condition or possible influence of several factors, are hard to come by. A particularly pertinent example from the Pandora experiments may be found in Appendix C.

A second consequence of a pilot program is that conclusions cannot be asserted with great confidence because of the limited number of observations that are available. Statistical tests performed on even promising segments of data might very well lead to insignificant results because the sample size is small.

From the nature of the case, then, the conclusions generated from the Pandora experiments at WRAIR must be considered as tentative and suggestive except for segments of data sufficiently numerous and free from the contaminating effects of changes in condition or intrusion of uncontrolled factors.

ADMINISTRATIVELY CONFIDENTIAL

PROCEDURES UTILIZED [redacted]

The WRAIR experimental program contains an imaginative complex of procedures which tap various behavioral functions that are uniquely packaged into a well-motivated work day for the monkey. A description of the various "jobs" comprising the monkey's work day may be found in Appendix B.

As structured at present, the experimental program generates data from the same monkey exposed to a variety of conditions. At times he is exposed to a variety of conditions. At times he is exposed to a signal, at times not. Each monkey is his own control. This is an efficient design provided that a minimally varying baseline can be achieved, that the baseline is stable over relatively long periods of time, that the behavior observed is sensitive to the experimental "intrusion," and that strict control over most of the confounding conditions can be maintained throughout the experiment. When these conditions cannot be easily met, the design can benefit appreciably from the inclusion of control subjects.

From an interpretative point of view, it is felt that the results of the Pandora experiments would have been more discriminative with the addition of control animals. In particular, it would have been desirable to control for the effects of "isolation" and "confinement." Over a long period of time, say several months, it is possible that continued isolation and confinement could bring about an erratic temporal pattern in the monkey's performance.

One further point about procedure. The complexity of the present task routine makes inevitable a long turn-around-time for a single animal. He requires a long training period and is subjected for a long time to a stimulus whose measurable effect may be long delayed. Inevitably this means that the experiment is based on a small sample with an effect that may be weak or ephemeral. In turn, this leads either to very limited generalizability or to inconclusive statistical results. At worst, it could lead to accepting as significant results that reflect long-range and unknown fluctuations in the animal's condition in no way related to the experimental signal. Expanded facilities, of course, would help since more experimental and more control animals could be used. In addition, the use of tasks or animals with a shorter turn-around-time should also be considered.

CHANGES IN TEST CONDITIONS AND BASELINE

As mentioned earlier, test conditions were changed relatively frequently. Some changes were due to limitations of test facilities, for example, having the animal tested or trained in the "ice box" and then tested in the anechoic chamber. In other cases, changes were introduced to determine if a facilitating or debilitating effect would ensue, as, for example, changing the character or strength of signal exposure. In any event, the greater the number of changes in conditions (especially if used in combination), the smaller the chances that an adequate baseline would be obtained to test for the specific effect under consideration.

[redacted]

As illustrated in Appendix C, the animal was exposed to a number of differing conditions in various combinations within a relatively short period of time. These were: night vs day work, alone vs with another animal, "ice box" vs anechoic chamber, WRAIR signal on vs WRAIR signal off, new chair, new lever, new speaker vs old chair, old lever, old speaker. Good baselines for testing the effects of all these changes might prove impossible of attainment.

Adequacy of baseline is a serious but not hopeless problem in the WRAIR experiments. The basic shortcoming is that the number of observations for the appropriate baseline may be small.

MALFUNCTIONING SYSTEM

The usual mechanical difficulties were experienced during the course of the Pandora experiments: feeder jam, empty feeder, ink failure, etc. Power fluctuations and circuit malfunction also occurred.

One of the obvious results of such malfunction is loss of data. The problem, however, is more complicated. It is very likely that the finely trained animal may have had his habit patterns disturbed because of the inappropriate cues or inadequate food rewards. His "confusion" and altered motivation may have affected his behavior for the remainder of the day and possibly for a day or more after the malfunction. The fundamental questions are: Subsequent to the identified malfunction, how much data should be discarded as unreliable? How reliable is the data immediately before the difficulty was identified?

Relevant criteria for these situations may have been developed by the laboratory in the course of its experience. In any event, an informed opinion to corroborate the adequacy of such criteria should be obtained from an outstanding expert in the field of animal experimentation. It is suggested that such information be obtained from Col. J. Brady.

MODELS AND ANALYTIC PROCEDURES

Interpretation of data is strongly connected to the model assumed to underly the data. Similarly, the model will tend to determine the character and direction of the statistical procedures one would employ to analyze the data. As a simple example, the model may specify that the exposure signal enhances the functioning of the organism, or that it causes a deterioration in its functioning, or that it enhances some functions and brings about a deterioration in others, or that it has no observable effect at all.

The analysis and interpretation of the Pandora experiments will depend, then, on the characteristics of the model one considers appropriate for the data. For example: Is the effect cumulative (or non-cumulative)? Is the effect reversible (or irreversible)? Is the effect ephemeral, so that it is generally observable only under direct exposure?

But as one tests more and more hypotheses with the same set of data, one must take into account that the level of significance for the statistical tests is no longer the conventional one agreed upon. In a similar vein, as one tests more and more relatively independent variables within the same experiment, one is likely to obtain some results that seem to point to a statistically significant effect when, in reality, there is none. This is analogous to the traditional urn problem (containing, for example, 95 white and 5 red balls) in which the probability of picking a red ball in one draw is .05. Yet the probability of obtaining a red ball increases rapidly as I make many successive draws from the urn (replacement model).

The Pandora experiments reflect a multivariate model embedded in a time series. Although the multivariate time series model is not recommended for the present set of Pandora experiments, some thought might be given to its use when a critical and definitive set of experiments is decided upon.

Section 3: Recommendations

THE BASIC ISSUES

Work Stoppage. A relevant scale needs to be developed for the application of this concept. In Maj. McIlwain's analyses an animal who "stopped work and did not recommence within ten minutes of the end of the day" is said to have engaged in a work stoppage. As used in a nominal-scale situation, a work stoppage of 11 minutes is equivalent to one of several hours.

It is recommended that the distribution of the lengths of work stoppages be compiled so that the parameters of the distribution can be estimated. This should help in establishing a weighting procedure which would give more weight to longer than to shorter work stoppages. (Often in the case of time variables, a logarithmic transformation provides an adequate solution.)

IRT Distribution Shift. In his presentation of a series of overlays (exposure data) compared to a distribution of baseline data, Dr. Sharp can be challenged concerning the criterion he used to select his time points. If this criterion had no theoretical justification, then distributions at other time points could have been taken just as well. What Dr. Sharp wanted to show is a global trend of the distributions without the necessity of processing all the data. Maj. McIlwain's "counter examples" taken from baseline data, though pictorially effective, may suffer from a similar selection bias.

Two analytic approaches seem to be feasible: 1) studying the change in the distribution as a whole over time; 2) utilizing several appropriate parameters of the distributions and studying their trend over time.

A first approach towards evaluating the change in the distribution as a whole over time might consider fractionating a time period into successive segments and then constructing an "average" distribution for each segment. The differences between distributions could be tested by a Kolmogorov-Smirnov type of statistic. This test procedure could be improved by the development of a Studentized range type of statistic for total distributions analogous to that developed for the comparisons among treatment means. More generally, a time series solution to problems of total distributions would be required.

In the second approach mentioned above, several basic parameters would be estimated for each distribution at each time point. The median and interquartile range would be appropriate. The distribution of these statistics over time would be available for analysis. Often enough, the hypothesis under test is relatively simple, as, for example, that the median (or interquartile range) increases over time. Curve fitting procedures could be used to test this or more complex functions. Orthogonal polynomials also could be utilized in testing for trend.

Either of the two approaches should be used. Of these, the trend analysis would seem more feasible, at least initially. The statistics (median and interquartile range) are available and the test procedure is characterized by ease of computation and interpretation.

BASELINE PROBLEMS

From an examination of the data and the graphs based on the data, it would be a questionable procedure to use many of the original baselines to evaluate the effects of the WRAIR signal. For example, the baseline developed in the "icebox" is not relevant to test for the effect of the signal in the anechoic chamber. Similarly, a baseline developed on a night "shift" cannot be used to test the effects of the WRAIR signal given during the day. Discouraged by the problem of an adequate baseline, Maj. McIlwain has refrained from using baselines in his analyses of the exposure periods.

It is recommended that the initial period of orientation to any change in condition be considered as a source for baseline data. For example, after transfer from the "icebox" to the anechoic chamber, the animal is usually tested for a number of days without exposure to the WRAIR signal. A portion of this adaptation period, once the perturbations settle down, could be used as the base against which the effects of the signal should be evaluated. Despite the fewer number of points available, they should be used as baseline data for the particular comparison under consideration.

The issue pointed up in this discussion is that there is no general baseline for all combinations of test situations. Changes in test situations seem to produce more pronounced effects than exposure stimuli.

DIVISION OF EXPOSURE PERIOD

In the extant analyses, Maj. McIlwain has divided the exposure period into two equal segments. He has reasoned that if the effect is cumulative, the average value of the two segments should differ -- the greater effect being observed in the second half of the exposure period. This analysis loses some valuable information. In the first place it gives no information about the comparison of the exposure period with the baseline period. Secondly, it masks the trend of the effect over time.

It is recommended that the exposure period be divided into more than two segments. In particular, since it is anticipated that the new baseline periods will not contain many points (confer discussion in the previous section), it would be advantageous to divide the exposure period into segments equal in size to the baseline period. The analyses, non-parametric analogues of analysis of variance, will have the following advantages: (1) a comparison with baseline data will be available, and (2) a trend would be more discernible and easily tested.

STATISTICAL CONSIDERATIONS

Where hypothesis are specific and directional, one-tailed tests should be used. The possibility of an enhancement effect on some functions under exposure should not be discounted. Two-tailed tests in these situations would leave the issue open ended.

It is recommended that the personnel at WRAIR continue using non-parametric statistics wherever feasible. These are the statistics of choice since the distributions of many of the statistics used in behavioral measurements have no known parametric representation. Further, they have good efficiency and they are simply and easily calculated.

It is also recommended that these calculations be done by clerical personnel trained and supervised by Maj. McIlwain.

I[illegible]ITIONS AND CONSULTANTS

It is urged that the operational definitions of relevant concepts (ex. pause), the specification of models, evaluation of effects of malfunction, rejection of inadequate data, and other such problems be discussed with the expertise available in-house at WRAIR. In particular, the services of Col. J. Brady should be secured, since he is an outstanding authority in behavioral matters, especially those pertaining to animal behavior.

APPENDIXES

A. DOCUMENTS AND MATERIALS EXAMINED

B. TASK SEQUENCE DURING ANIMAL'S WORK DAY

C. EXAMPLE ILLUSTRATING CHANGES IN TEST CONDITIONS

D. VISITS AND COMMENTS

[redacted]

APPENDIX A

DOCUMENTS AND MATERIALS EXAMINED

I MR. R. CESARO'S OFFICE

A. Reports of Dr. J. Sharp to ARPA
1. Two basic series of graphs. These were presented at the first briefing Dr. Sharp gave to the Committee late in 1968.
2. Method rationale.
3. Work-stoppage descriptions
4. An overall description of the behavioral program. (Confer section relating to Dr. Sharp).

B. Reports of Mr. Cesaro based on Dr. Sharp's reports
These included reproductions of the graphs and representative summaries of the substantive material in Dr. Sharp's reports.

II WALTER REED - FOREST GLEN

The materials consisted of 8 note books containing original and partially processed data obtained from the various experiments associated with Pandora. These fell into two classes, four notebooks in each: Basic Data Note Books and Data Analysis Note Books. The latter group, prepared by Maj. McIlwain, contain a careful and thorough analysis of much of the basic data in the form of graphs and statistical tests of significance.

Maj. McIlwain is continuing the analysis which, at present, is emphasizing comparisons between the first and second halves of the radiation period. The model under analysis assumes the accumulation of an effect over the radiation period, with the effect increasing as the radiation continues. Maj. McIlwain feels that, because of various technical changes and difficulties, the pre-radiation baselines do not meet stringent criteria for adequacy and, consequently, have not been compared with the radiated periods.

A. Basic Data Note Books

1. D51 Reaction Time
Contains data from monkeys 682, 683, 782, and 783. There is some processing (data reduction) in the form of means, medians, variances, and interquartile ranges.

2. D53 Multiple Schedule (Book 1)
Data book for animals 176, 216, 397, 673, and 948. It is indicated that non-exposed animals 216 and 984 died. There is occasional data reduction in the form of Q.

3. D54 Multiple Schedule (Book 2)
Data book for animals 194, 673, 681, 700 and for the two non-exposed animals, 111 and 675, who died during the experiment. There is some processing of the data in the form of median and Q.

[redacted]

4. 681 Second Run
Reports data obtained during the period 1 April 69 to 13 July 69. Reduced data is presented in the form of Q_1, Q_2, Q_3.

B. Data Analysis Note Books

1. 154
History of monkey from April 66 to May 68. Book contains old data and old graphs together with new graphs and a large number of statistical tests usually comparing the first half with the latter half of the exposure period.

2. 673
History and analyzed data from 3 Feb. 66 to 20 Oct.67. This animal worked under a large number of stimulating conditions: CW, the WRAIR at .008, .01, .1, 1.0, and $5mw/cm^2$.

3. 681
History and analyzed data from 30 Aug.66 to 13 July 69. Dr. Sharp's graphs are compared with overlays prepared by Maj. McIlwain; and Dr. Sharp's overlays are compared with control data.

4. V700
Data, graphs, analyses, and statistical tests for V700. Also contains data from 683; but this data was not subjected to statistical analysis.

II DR. J. SHARP'S OFFICE

The last document prepared for ARPA by Dr. Sharp was completed around October 1969. It gives a succinct and clear summary of the types of experiments he performed, the results he obtained, and the recommendations he made. Most of the results were negative. However, two phenomena -- work stoppage and IRT distribution shift -- were suggestive of an effect due to radiation. "While the earlier stoppages may have been questioned as related to an 'explainable' artifact, the cumulative evidence strongly suggests caution in accepting this interpretation. In addition, an inspection of the then old data strongly suggested to me that the inter-response time (IRT) data from the DRL component was showing a shift from the 'base-line' level to a slower performance pattern followed by a return to 'base-line' upon cessation of exposure."

Dr. Sharp suggests that these preliminary findings be checked out on more monkeys and in other laboratories. For the data at hand he recommends the use of a baseline utilizing "all data generated after training and before exposure ..."

[redacted]

APPENDIX B

TASK SEQUENCE DURING ANIMAL'S WORK DAY

Cycle	Sequence	Task	Time Limits: Minimal	Expected	Cum. Exp.	Reward (Food): Pellets	Cumulated
1	1	TO	10'	12'	12'	--	
	2	PR	10'	15'	27'	5	5
	3	TO	10'	12'	39'	--	
	4	DRL	5'	20'	59'	5	10
2	5	TO	10'	12'	12'	--	
	6	PR	etc...				
	.						
	.						
	etc						

EXPLANATION

1. TO: Time Out Period (with Delay Contingency). The animal's work day begins with the TO period which is characterized by a 3,300 hz tone. His task is not to respond during the 10 minute period. If he does respond (with a bar press), the timer is reset and the 10 minute period begins all over again. If the animal does not respond for a complete 10 minute period, the tone goes off and a red light comes on as a signal. He is then in the PR period.

2. PR: Progressive Ratio Period. The animal now has to complete 40 bar presses to earn one pellet of food. When this pellet is delivered, he has to press 80 times for the next pellet; 160 times for the third pellet; 320 times for the fourth pellet; and 640 times for the fifth and last pellet in this phase. When the animal earns the fifth pellet of food, the red light (PR signal) goes off and the 3,300 hz tone (TO signal) comes on again signalling the animal that he is again in the TO period.

3. TO: Time Out Period (with Delay Contingency). His task, as before, is to refrain from responding (bar presses) for a period of 10 minutes. As he completes this TO phase successfully, the 3,300 hz tone changes to a 1,400 hz tone. This new signal alerts the animal that he is in the DRL period.

4. DRL: Differential Reinforcement (Low Rate) Period. In this phase the animal is to delay his response, a bar press, for a minimum of 50 seconds. A response given before the termination of the 50 second interval would reset the timer, starting a new 50 second interval during which the animal had to refrain from responding.

   If the animal did delay for 50 seconds and then made his response, either of two events occurred: there was a brief flash of light to

[redacted]

indicate that his response was adequate or he received a pellet of food. The relative frequency of light to food was 2:1, programmed by a probability generator. Thus, one third of the correct responses were rewarded with food.

This procedure continued until the animal received a total of 5 pellets in this (DRL) portion of the cycle. On the average, then, there were 15 successful responses during a DRL session and 5 of these were rewarded by food.

After receipt of the fifth pellet the 1,400 hz tone (DRL signal) changed to one of 3,300 hz (TO signal). This signal indicated to the animal that he was then in a TO period.

5. TO: Time Out Period. (This initiated the second cycle, identical to the one completed at Step 4 above. Such cycling continued "until the animal received its daily food ration or until 10 hours had elapsed.")

COMMENTS

1. One cycle is approximately one hour in duration.

2. The monkey's weight determines the number of pellets assigned for his daily ration. These could range, roughly, from 70 to 100 pellets.

3. Thus, the monkey with the heaviest work load (required to earn 100 pellets) could be expected to finish within 10 hours. It also follows that the monkey with the lightest work load (required to earn 70 pellets) would be expected to work about 7 hours per day.

APPENDIX C

EXAMPLE ILLUSTRATING CHANGES IN TEST CONDITIONS

(Animal #681)

Time Epoch	Place of Testing	Time of Testing	Alone or with Others	Other Conditions
11Feb - 11Mar	"Icebox"	Day	Alone	
12Mar - 3Apr	Anechoic	Night	With #673	
4Apr - 1May	Anechoic	Day	Alone	New chair, new lever, new speaker
(11Apr - 11May)				WRAIR Signal
2May - 25May	Anechoic	Night	With #673	
(11May - 6June)				Control
2[illegible] - 6June	"Icebox"		Alone	

COMMENTS

1. In order to indicate the changes made in the environmental conditions, the time epochs, as presented, necessarily overlap.

2. A large number of conditions were varied during the testing of this animal: "icebox" vs anechoic, day vs night, alone vs with another animal, WRAIR signal ON vs WRAIR signal OFF.

3. As a result, one could not attribute an effect to a single factor uncontaminated by changes in test conditions.

APPENDIX D

V[illegible]S AND COMMENTS

3 November 1969 R. Cesaro, A. Rubenstein (Pentagon)

1. Mr. Cesaro urged a thorough examination of the data to determine what additional analyses were necessary to clarify the critical issues in the problem:
   a. whether an effect had been obtained
   b. whether any of the approaches used showed any promise.

2. Mr. Rubenstein suggested a comprehensive analysis of the baseline data and the development of models for the evaluation of an effect.

3. ARPA'S file on Pandora was made available for examination. This included the progress reports and graphs prepared by Dr. Sharp and other administrative reports prepared by Mr. Cesaro utilizing Dr. Sharp's material. (Confer Appendix A)

14 November 1969

1. Col. E. Buescher, A. Rubenstein (Walter Reed)
   a. Col. Meroney could not attend the meeting but appointed Col. Buescher to represent him.
   b. The purpose of my visit was discussed with Col. Buescher who assured me and Mr. Rubenstein that there would be full cooperation from Walter Reed personnel.

2. Col. E. Buescher, A. Rubenstein, Col. J. Brady, Maj. J. McIlwain (Walter Reed)
   Col. Brady and Maj. McIlwain joined the meeting and were briefed on what was discussed. They indicated that they would help in any way they could.

3. Maj. J. McIlwain (Walter Reed, Forest Glen)
   In this meeting, Maj. McIlwain presented the various analyses of the data he had completed.

20 November 1969 (Walter Reed, Forest Glen)

This day was spent examining the data obtained during the various experiments associated with Pandora. The basic data, the derived data, the graphs and tests of significance were included in eight (8) DATA NOTE BOOKS. (Confer Appendix A)

24 November 1969 J. Sharp (Albany)

1. Dr. Sharp stressed the fact that the series of experiments conducted by him were preliminary in nature -- pilot experiments. Consequently he considered his reports on these experiments as indicating provocative not definitive trends.

2. He felt that some of the runs which were free of artifacts pointed to IRT changes and Work Stoppages as possibly due to exposure. These, he suggested should be carefully analyzed and replicated, if possible, by independent investigators.

LIMITED DISTRIBUTION SECRET "UNCLASSIFIED"

Special Handling

AS BEEN DOWNGRADED Advanced Sciences Restricted

9 OCT 1979

DARPA / TIO

January 14, 1969

MEMORANDUM TO: Mr. R. S. Cesaro, ARPA

FROM: IDA Review Panel

SUBJECT: Flash Report of Pandora/Bizarre Briefing (S)

(S) In response to a request from Advanced Research Projects Agency (ARPA), a special panel was convened by the Institute for Defense Analyses (IDA) to review the research techniques, results to-date, and to make recommendations for the future of the Pandora/Bizarre program.

(S) The IDA Panel personnel were as follows:

1. Lysle H. Peterson, M.D., (Chairman) Univ. of Pennsylvania
2. Joseph E. Barmack, PhD, C.C.N.Y.
3. Joseph F. Kubis, PhD, Fordham University, N.Y.
4. BG Frederic J. Hughes, M.C., Walter Reed Gen. Hospital
5. Herbert Pollack, M.D., Institute for Defense Analyses

(S) Observers present were

1. Richard S. Cesaro, OSD/ARPA/AS
2. James P. Deck, Colonel, Wright Patterson AFB, AFAL
3. Daniel J. Sullivan, OSD/ARPA/AS

(S) The briefings were presented by

Col. J. Brady, M.S.C. - WRAIR

Maj. J. Sharp, M.S.C. - WRAIR

Capt. McIlwain, M.C. - WRAIR

Mark Grove, AF Avionics Lab - WPAFB

(S) The panel met at 0900 on Friday, December 20, 1968, in the Forest Glen Annex of the Walter Reed Army Hospital. All persons present who had not done so previously signed the Pandora/Bizarre clearance forms. Briefings and an inspection of the physical plant lasted until 1230. The panel and the briefing team drove to the Institute for Defense Analyses where they reconvened at

Copy 10 of 17 Copies

Advanced Sciences Restricted "UNCLASSIFIED"

1[illegible] hours. Further discussions were carried on until 1500 hours, when the panel thanked the briefing team and went into executive session.

(S) The terms of reference for the review panel as presented by Mr. Cesaro called for an initial flash report based upon the briefings of the day. Mr. Cesaro indicated that he expected the panel to operate on a continuing basis until the project was completed. It is expected that the panel would be enlarged in the near future as soon as clearance procedures permitted.

(S) The flash report was to be the response to the following questions posed by Mr. Cesaro:

1. Does the panel consider the research procedures reported at this briefing scientifically sound and capable of supplying the data required to satisfy the stated objectives?

2. Does the evidence presented support the stated deductions [illegible]r conclusions?

3. What future plans and procedures should be adopted in view of the findingsto-date?

4. Does the panel consider it necessary to develop a "real time" data processing technique to facilitate the identification of those components of the "synthetic signal" which are responsible for the observed biological effects?

5. Does the panel wish to express an opinion as to the mechanism of the action of the electromagnetic radiation on the intact animal?

(S) The panel was unanimous in its opinion that the use of multi-schedule programs for operantly conditioned monkeys was a sound and acceptable technique to assess degradation or acceleration of work patterns. That the monkeys exposed to the specific "synthetic Moscow signal" in field strengths from 1 mw/cm^2 up to 4.6 mw/cm^2 showed degradation of work performance after 10-hours-a-day exposure for from 11 days to 21 days. This degradation in performance may be regarded as a "vigilance function degradation." The effects appear to be grossly functionally reversible. There is some evidence that repeated series of exposures sensitizes the animal and shortens the latent period before signs of vigilance degradation appear.

(S) The WRAIR investigators attempted to develop techniques with more rapid response times in the hopes of being able to facilitate the identification of the elements of the synthetic signal responsible for the bio-medical effects. These took two directions. One was a study of alteration in reaction time response in the primates after exposure to the micro-waves. The other was to implant a series of specially designed electrodes into specific areas of the brains of monkeys and to record the electro encephalographic changes before and after radiation.

(S) The studies on reaction times are inconclusive to-date. More data would be needed to express an opinion as to whether this approach should be pursued further or discarded.

(S) The E.E.G. approach has been carried out in association with The Brain Research Institute at the U.C.L.A. School of Medicine. The problem of artifacts and analysis of wave forms makes interpretation difficult. Further work in this area should be supported. To do this effectively, the analysis of the E.E.G. recordings should be on a "real time" or approximately "on line" analysis. This will require a computer availability and capability. The computer may be an in-house special purpose one, or a connection with a central computer programmed for this analysis. A cost effectiveness assessment of the alternatives should be helpful in the decision.

(S) The panel was of the opinion that the help of Dr. John Tukey of Princeton should be obtained. He is considered an outstanding expert in the field of wave form analysis.

(S) The WRAIR research workers presented two additional facets of the work. These were attempts to determine if there were any detectable morphological changes in the tissues. One effort was directed toward a study of the chromosomes of the circulating blood. The two animals studied to-date were reported as showing no changes.

This phase should be continued until a sufficient number of animals have been studied to give positive assurance that the non-ionizing radiation does not have any effect on chromosomes. The other was the histo pathological studies of the central nervous system tissues taken from animals that had been radiated. This study is being carried out at Tulane under contract. At the time of this briefing only one monkey brain had been studied. The contractor had reported that this brain was "different" from the controls. (The study is a blind one to avoid prejudice.) In view of the suggestive but inadequate evidence, additional effort must be made to further this aspect of the program.

(S) The panel recognizes that Col. Brady is a professional leader in the field of animal behavior studies and has added substantially to the credibility of the work.

(S) The response to Question #3 takes into consideration the total problem, including the animal findings as presented, and the time and cost element in extending animal studies to provide a more complete spectrum of response. In the absence of significant adverse findings in the chromosomal and histo pathological studies mentioned above, the future course of action <u>must</u> include a study of human response to non-ionizing radiation in low level fields and with the specific modulations employed in the primate exposure tests. Animal studies are only able to provide a limited spectrum of responses. The human with his ability to describe subjective changes can extend the response gradient through the levels:

a. Feelings, attitudes, fatigue, moods, etc.

b. Health, physical and mental

c. Performance and stamina

The animal studies are focused on c. but may include b.; they cannot measure a.

(S) Over a period of years humans have been exposed to micro-wave radiations at much higher field strengths than are proposed in this work. The U.S. personnel in the Moscow Embassy have been exposed to the micro-wave signal over a period of many years. The panel were not given any evidence of impaired health of these people.

(S) A protocol should be developed with the following objectives:

1. To determine the immediate or short time effects on humans of the synthetic Moscow signal in use at W.R.A.I.R. on the three aspects mentioned above. This should be given a high priority.

2. To provide for follow-up observations of the subjects.

3. The study should contribute to the understanding of the effects of micro-wave radiation on man in general as well as the specific Moscow signal.

(S) The protocol should be developed by the responsible group. This panel will stand ready to review the proposed protocol and offer such advice as they see indicated when asked to do so.

(S) It is suggested that the program provide for:

a. Biochemical laboratory analysis of blood and urine for a variety of substances including steroids, enzymes, trace metals, etc.

b. Cardiovascular evaluation such as E.C.G., blood pressure, etc.

c. Chromosomal studies of lymphocytes cells

d. Appropriately sensitive and reliable studies on behavior

(S) Subjects selected should be normal, healthy, young male adults. Exposure periods should be at least 90 days unless significant changes occur earlier. Subjects should be divided into 3 groups:

1. Controls

2. Subjects with a history of exposure to micro-waves

3. Subjects with no previous exposure to micro-waves

(S) The panel at this time has no basis upon which to suggest the mechanism involved.

(S) It is recognized that the findings to-date were presented to the panel in an orientative way and the format of the presentation was qualitative. The panel suggests that the data be prepared in a statistical format for better scientific evaluation. The panel would like the opportunity to examine the data in depth.

LIMITED DISTRIBUTION ~~SECRET~~ "UNCLASSIFIED"

~~Special Handling~~

~~Access Restricted~~

Lysle Peterson (signature)
Lysle Peterson

Joseph F. Kubis (signature)
Joseph Kubis

Joseph Barmack

Frederic Hughes Jr. (signature)
Frederic Hughes

Herbert Pollack (signature)
Herbert Pollack

DISTRIBUTION:

- Panel Members
- Briefing Team
- Mr. Albert Rubenstein
- Dr. Robert Fox

ADDENDUM

January 17, 1969

The final results of the examination of the chromosomes obtained from the peripheral blood of one monkey, previously irradiated with the "Moscow signal" at a field strength of 4.6 mw/cm^2, indicate marked aberations in 40 percent of the cells. The tests are being repeated.

~~[illegible] DATA~~

~~LIMITED DISTRIBUTION~~

~~Special Handling~~

~~Access Restricted~~

ALLIED RESEARCH ASSOCIATES
VIRGINIA ROAD, CONCORD, MASSACHUSETTS 01742, TEL. (617)

15 February 1969
Document No. 9G61-2

Director
Advanced Research Projects Agency
Washington, D. C. 20301

Reference:

ARPA Order Number:	791
Program Code Number:	8M10
Name of Contractor:	Allied Research Associates, Inc., Concord, Mass.
Date of Contract:	1 August 1968
Amount of Contract:	$53,899.00
Contract Number:	DADA17-69-C-9021
Principal Investigator:	J. Healer
Contract Expiration Date:	31 June 1969
Short Title of Work:	Review, Analysis, and Classification of Literature on the Biological Effects of Microwave Radiation

Gentlemen:

This letter report is a resume of work performed during the second three months of the referenced contract.

Information Base - Source Material

During this period a continuous search, acquisition and review of pertinent foreign and domestic material on biological effects of radio-frequency radiation has been carried out. Approximately 700 relevant documents have been identified. Bibliographic cards have been prepared for most of these, and those items currently available in this country have been acquired. An unedited preliminary bibliography covering new material added to the system is included as an Appendix to this report.

Approximately 50 requests from Allied Research for information, abstracts and/or translations of foreign reports, and original language sources have been processed in this period by the Aerospace Technology Division of the Library of Congress.

Preparation and Revision of Data Sheets

New data sheets are being continuously prepared, with a total of about 135 completed to date. An additional bioscientist has been recently added to the project staff, in order to facilitate an accelerated rate of data sheet preparation and information processing during the remainder of the contract period. Sixty-two sets of completed data sheets and associated source documents have been forwarded to the contract monitor during this period.

Application of Data System

While as yet not enough material has been fully processed to enable use of the data collection acquired under this contract in its desired final automated form, the information assembled to date, including reports, preliminary computer printouts of bibliographic listings and completed data sheets, has proved exceedingly useful in meeting various requests for information from the project's technical monitor and from other concerned military and civilian activities.

Data System Plans

During the next quarterly period it is intended to accelerate the rate of effort on this project, including more rapid processing of information, preparation of data sheets, and preparation of data cards and citation-index cards. Selected data cards will be prepared to serve as a model for preliminary testing of the data system.

Very truly yours,

Janet Healer

Janet Healer
Biosciences

JH/se

APPENDIX

Bibliographic Listing

The following listing is a preliminary unedited printout of bibliographic information from foreign and domestic articles, books, and reports dealing with the subject of biological effects of radio-frequency radiation, which has been prepared under the subject contract. This listing consists of entries supplementary to the bibliography on this subject prepared under the preceding contract (ARA Document No. 319-3-1). It is a working copy only and has been included as a convenience to potential users in order to make the information available as soon as possible. No items from the previous bibliography are repeated here.

This working bibliography has been printed automatically from punched cards. Each reference bears the document number assigned to it for retrival and identification purposes. References are arranged in alphabetical order according to the name of the first-listed author, then in order of year of publication, and then alphabetically by second author. Each reference contains complete bibliographic information in a format which departs from conventional reference form as follows:

The format is similar for each type of reference. In the case of journal articles, the first line includes the name of the first-listed author and the journal information. The journal title appears as a four-letter code. It is followed by a series of digits separated by commas. The first three digits indicate the volume, the next two are the issue number, and the following four digits are the page number. The page number is followed by the last two digits of the year with no intermediate separation or punctuation. Following the year of publication is a separate notation of total number of pages. The second line of the reference contains co-author's name(s), if any, followed by the article title.

For books, the first line of each reference retains the form previously described with only minor variations. The word BOOK appears in the position allocated to the four-letter journal code and zeros fill the field where volume, number, and page are found in the article references. The year of publication is given by the last two digits of the digit series. The second line contains co-author's name(s), if any. These are followed by the title and publisher.

Reports follow roughly the same format as books. The code REPT replaces BOOK.

Sections of books are identified by the code SECT and a page number may appear in the digit string as well as a the year.

In addition, a separate line with one or more four-digit numbers occurs after many of the references. These number codes represent the affiliations of the authors. Where several authors of an article have different affiliations, the corresponding affiliation codes are presented in the order of the author listing, separated by commas for different authors. Foreign literature references and all reports have one additional line which consists of English translation source(s) and availability information in the case of foreign material, and report identification numbers in the case of reports.

Conversions of the four-letter journal codes and of the four-digit author affiliation codes are presented at the end of this bibliography.

8002A ADDINGTON C H PCMW 002 00 013958 0013P
8002B FISCHER F P NEUBAUER R A OSBORN C SARKEES Y T SWARTZ G
8002B REVIEW OF THE WORK AT UNIVERSITY OF BUFFALO - STUDIES OF THE BIOLOGICAL
8002C EFFECTS OF 200 MEGACYCLES
8002X 0628

8003A ADDINGTON C H PCMW 003 00 000159 0009P
8003B NEUBAUER R A OSBORN C SWARTZ G FISCHER F P SARKEES Y T
8003C BIOLOGICAL EFFECTS OF MICROWAVE ENERGY AT 200 MEGACYCLES UPON THE EYES OF
8003D SELECTED MAMMALS
8003X 0628

8004A ADDINGTON C H PCMW 003 00 001059 0005P
8004B OSBORN C SWARTZ G FISCHER F P SARKEES Y T
8004C THERMAL EFFECTS OF 200 MEGACYCLES (CW) IRRADIATION AS RELATED TO SHAPE,
8004D LOCATION AND ORIENTATION IN THE FIELD
8004X 0628

6119A ANDRIYASHEVA N M MS37 000,00,000037 0000P
6119B OCCUPATIONAL HAZARD OF VHF-HF AND THE PREVENTIVE MEASURES

0357A ANNE A REPT 000,00,000063 0116P
0357B SCATTERING AND ABSORPTION OF MICROWAVES BY DISSIPATIVE DIELECTRIC OBJECTS
0357C THE BIOLOGICAL SIGNIFICANCE AND HAZARDS TO MANKIND
0375D U PENN REPT NO 36 UNDER CONTRACT NONR 551 05
0357X 0645
0357Y AD 408997

0358A ANNE A REPT 000,00,000062 0125P
0358B SAITO M SALATI O M SCHWAN H P PENETRATION AND THERMAL DISSIPATION OF
0358C MICROWAVE IN TISSUES
0358D U PENN REPT NO 62-13 UNDER CONTRACT AF 30(602)-2344
0358X C645
0352Y AD 284981, RADC TDR 62 244

0374A ANON LN37 000 00 000037 0000P
0374B MATERIALS OF THE LENINGRAD CONFERENCE ON VHF-HF WAVES
0374C LENINGRAD 1937

0373A ANON BOOK 000 00 000037 0000P
0373B PROBLEMS OF THE METRICS AND DOSIMETRY OF ULTRAHIGH FREQUENCY IN
0373C BIOLOGY AND MEDICINE MOSCOW 1937

0375A ANON MS57 000,00,000057 0000P
0375B JUBILEE SCIENTIFIC SESSION OF THE INSTITUTE OF LABOR HYGIENE AND
0375C OCCUPATIONAL DISEASES DEDICATED TO THE 40TH ANNIVERSARY OF THE GREAT
0375C OCTOBER SOCIALISTIC REVOLUTION
0375D SUMMARIES OF REPORTS PART 2
0357E MOSCOW 1957

0340A ANON TVMA 073,00,000057 0000P
0340B THE BIOLOGICAL EFFECT OF A SHF-UHF ELECTROMAGNETIC FIELD
0340C LENINGRAD 1957
0340X 0021
0340Y TRANSL AVAIL OF ABSTRACTS OF SOME SECTIONS

6262A ANON REPT 000,00,000059 0045P
6262B INVESTIGATORS CONFERENCE ON BIOLOGICAL EFFECTS OF ELECTRONIC RADIATING
6262C EQUIPMENTS - 14 AND 15 JANUARY 1959
6262X 0622
6262Y AD 214693, RADC TR 59 67

0366A ANON MS59 000,00,000059 0000P
0366B LABOR HYGIENE AND THE BIOLOGICAL EFFECT OF RADIO FREQUENCY
0366C ELECTROMAGNETIC WAVES SUMMARIES OF REPORTS
0366D MOSCOW 1959

0344A ANON TIGT 000,01,012160 0004P
0344B TEMPORARY SANITARY REGULATIONS IN WORK WITH GENERATORS OF CENTIMETER
0344C WAVES APPROVED 26 NOV 1958 NO 273 58
0344Y JPRS 12471, N62 11902

0391A ANON REPT 000,00,000060 0000P
0391B SAFETY PRECAUTIONS RELATING TO INTENSE RADIO-FREQUENCY RADIATION
0391C HER MAJESTY'S STATIONERY OFFICE, LONDON

6269A ANON PICM 003,00,045960 0002P
6269B DISCUSSION ON ULTRASONICS AND MICROWAVE RADIATION (AT 3RD INTERNAT. CONF.
6269C MED. ELECTRONICS)

0364A ANON LN61 000,00,000061 0000P
0364B MATERIALS OF THE SCIENTIFIC SESSION CONCERNED WITH THE RESUL[illegible] OF WORK
0364C CONDUSTED BY THE LENINGRAD INSTITUTE OF INDUSTRIAL HYGIENE A[illegible]
0364C OCCUPATIONAL DISEASES FOR 1959-1960
0364E LENINGRAD 1961
0364X 0032

0343A ANON LN62 000,00,0000 0000P
0343B QUESTIONS OF THE BIOLOGICAL EFFECT OF A SHF-UHF ELECTROMAGNETIC FIELD
0343C SUMMARIES OF REPORTS
0343D KIROV ORDER OF LENIN MILITARY MEDICAL ACADEMY LENINGRAD 1962
0343X 0021

0365A ANON LN63 000,00,000063 0000P
0365B MATERIALS OF THE SCIENTIFIC SESSION CONCERNED WITH THE WORK OF THE
0365C INSTITUTE OF INDUSTRIAL HYGIENE AND OCCUPATIONAL DISEASES FOR 1961-1962
0365D LENINGRAD 1963
0365X 0032

0363A ANON MS63 000,00,000063 0000P
0363B ABSTRACTS OF THE CONFERENCE ON INDUSTRIAL HYGIENE AND THE BIOLOGICAL
0363C ACTION OF RADIO FREQUENCY ELECTROMAGNETIC FIELDS
0363D INST INDUST HYG AND OCCUP DISEASES, ACAD MED SCI, MOSCOW 1963

6028A ANON REPT 000,00,006063 0010P
6028B ARMY MEDICAL BASIC RESEARCH IN LIFE SCIENCES - PROJECT NO 3A012501B813 -
6028C TASK NO 04 - BIOPHYSICS
6028D IN U S ARMY MED RES LAB ANN PROG REPT RCS-MEDDH-288
6028E 1 JULY 1962 - 30 JUNE 1963
6028X 0602
6028Y AD 409892

0268A ANON REPT 000,00,000066 0002P
0268C USA STANDARD SAFETY LEVEL OF ELECTROMAGNETIC RADIATION WITH RESPECT TO
0268C PERSONNEL C95.1-1966
0268C USA STANDARDS INSTITUTE 1966
0268C ALSO IN IEEE TRANS BIO MED ENGR VOL BME 14 NO 2 1967
0268X 0657

6182A ANON REPT 000,00,000068 1596P
6182B RADIATION CONTROL FOR HEALTH AND SAFETY ACT OF 1967
6182C HEARING BEFORE THE COMMITTEE ON COMMERCE, UNITED STATES SENATE,NINETIETH
6182D CONGRESS, SECOND SESSION, ON S.2067, S.3211, AND H.R.10790, TO PROVIDE
6182E FOR THE PROTECTION OF THE PUBLIC HEALTH FROM RADIATION EMISSIONS PART 2
6182F MAY 6,8,9,13 AND 25, 1968 SERIAL NO 90-49
6182Y US GOVT PRINTING OFFICE WASHING D C 1968

6181A ANON REPT 000,00,823168 0004P
6181B THE MICROWAVE OVEN - A BENEFIT AND A POTENTIAL HAZARD
6181C IN CONGRESSIONAL RECORD - SENATE 8 JULY 1968

6114A ASANOVA T P ET AL LN63 000,00,005263 0002P
6114B THE PROBLEM OF THE EFFECT OF HIGH VOLTAGE INDUSTRIAL FREQUENCY ELECTRIC
6114C FREQUENCY FIELD ON THE ORGANISM OF WORKERS
6114X 0032

6149A BACH S A PCMW 004,00,011760 0018P
6149B LUZZIO A J BROWNELL A S EFFECTS OF RADIO FREQUENCY ENERGY ON HUMAN GAMMA
6149C GLOBULIN
6149X 0602

0265A BALDWIN B R REPT 000,00,000061 0084P
0265B CONSTANT P C JR FETTER R W JONES B L KLEIN V W MARTIN E J JR RUNGE L
0265C WAIDELICH D L SURVEY OF RADIO FREQUENCY RADIATION HAZARDS
0265C MIDWEST RESEARCH INSTITUTE SUMMARY REPT NO 2 UNDER CONTRACT NOBS 77142
0265D 20 MAY 1960 THRU 19 MAY 1961
0265X 0615
0265Y AD 427612

0280A BARANSKI S LKWO 000,10,090366 0007P
0280B CZERSKI P INVESTIGATION OF THE BEHAVIOR OF CORPUSCULAR BLOOD
0280C CONSTITUENTS IN PERSONS EXPOSED TO MICROWAVES
0280X 0014
0280Y ATD ABSTRACT

0369A BARANSKI S APHP 018,04,051767 0016P
0369B EDELWEJN Z ELECTROENCEPHALOGRAPHICAL AND MORPHOLOGICAL INVESTIGATION
0369C UPON THE INFLUENCE OF MICROWAVES ON THE CENTRAL NERVOUS SYSTEM
0369X 0014
0369Y ATD ABSTRACT

6231A BARRON C I PCMW 002,00,011258 0006P
6231B BARAFF A A MEDICAL CONSIDERATIONS OF EXPOSURE TO MICROWAVES (RADAR)
6231X 0612

6260A BAUS R PCMW 003,00,029159 0023P
6260B FLEMING J D BIOLOGIC EFFECTS OF MICROWAVE RADIATION WITH LIMITED BODY
6260C HEATING
6260X 0635

6078A BAVRO G V LN62 000,00,000362 0002P
6078B KHOLODOV YU A THE CHARACTER OF BIOELECTRIC REACTIONS OF THE RABBIT
6078C CEREBRAL CORTEX DURING THE INFLUENCE OF A SHF-UHF FIELD

6105A BAVRO G V MS63 000 00 010863 0000P
6105B KHOLODOV YU A

6130A BELOVA S F MS57 000,00,006657 0001P
6130B STATE OF THE ORGAN OF SIGHT IN PERSONS SUBJECTED TO THE INFLUENCE OF
6130C ULTRAHIGH FREQUENCY FIELDS

0248A BELOVA S F TIGT 000,02,011964 0003P
0248B RESULTS OF SIGHT ORGAN EXAMINATION IN WORKERS ASSOCIATED WITH MF-LF
0248C GENERATORS (150-600KC)
0248X 0012
0248Y ATD ABSTRACT

0253A BELOVA S F TIGT 000,02,014064 0004P
0253B FUNCTIONAL STATE OF THE VISUAL ANALYZER UNDER THE ACTION OF MICROWAVES
0253X 0012

0348A BENYO I KIOR 007,05,045465 0004P
0348B FUSY F IHASZ M EFFECT OF SHORT-WAVE IRRADIATION OF THE LIVER ON THE
0348C ELIMINATION OF BROMSULPHALEIN FROM THE BLOOD
0348X 0053
Y ATD ABST

0367A BERG A I ED BOOK 000,00,000060 0392P
0367B ELECTRONICS IN MEDICINE
0367C GOSENERGOIZDAT MOSCOW LENINGRAD 1960
0367Y TRANSL AVAIL OF SOME SECTIONS

0386A BERGMAN W BOOK 000,00,000065 0081P
0386B THE EFFECT OF MICROWAVES ON THE CENTRAL NERVOUS SYSTEM
0386Y TRANSL FROM GERMAN BY TECH LIB RES SERVICE, FORD MOTOR CO

6171A BIERMAN W AJMS 187,00,054534 0008P
6171B THE EFFECT OF HYPERPYREXIA INDUCED BY RADIATION UPON THE LEUKOCYTE COUNT
6171X 0665 0666 0667

6172A BOYSEN J E AIOM 007,00,051653 0010P
6172B HYPERTHERMIC AND PATHOLOGIC EFFECTS OF ELECTROMAGNETIC RADIATION (350 MC)
6172X 0668 0686

6009A BILOKRYNYTSKYY V SFZKR 012,01,007066 0009P
6009B CHANGES IN THE TIGROID SUBSTANCE OF NEURONS UNDER THE EFFECT OF
6009C RADIO WAVES
6009X 0015
6009Y ATD REP 67 3 1967, AD 649460, N67 27381

6 A BIRENBAUM L REPT 000,00,014465 0007P
6287B GROSOF G M HAMMOND A H ROSENTHAL S W SCHMIDT H ZARET M M
6287C EFFECTS OF MICROWAVE RADIATION ON THE EYE
6287D IN PROGRESS REPORT NO 28 - 1 APRIL 1965 THRU 30 SEPT 1965 CONTRACT
6287E AF 49 638 1402 A SUMMARY OF CURRENT RESEARCH IN THE MICROWAVE RESEARCH
6287F INSTITUTE PROGRAMS POLYTECH INST BROOKLYN
6287X 0708 ,0639 ,0639 ,0708 ,0639 ,0639
6187Y AD 476288, R 452 28 65

6288A BIRENBAUM L REPT 000,00,012366 0004P
6288B GROSOF G M HAMMOND A H ROSENTHAL S W SCHMIDT H ZARET M M
6288C EFFECTS OF MICROWAVE RADIATION ON THE EYE
6288D IN PROGRESS REPORT NO 29 - 1 OCT 1965 THRU 15 MARCH 1966 CONTRACT
6288E AF 49 638 1402 A SUMMARY OF CURRENT RESEARCH IN THE MICROWAVE RESEARCH
6288F INSTITUTE PROGRAMS POLYTECH INST BROOKLYN
6288X 0708 ,0639 ,0639 ,0708 ,0639 ,0639
6288Y AD 488303, R 452 29 66

6289A BIRENBAUM L REPT 000,00,005067 0002P
6289B KAPLAN I ROSENTHAL S W SCHMIDT H ZARET M M
6289C EFFECTS OF MICROWAVE RADIATION ON THE EYE
6289D IN PROGRESS REPORT NO 32 - 15 MARCH 1966 THRU 14 SEPT 1967 CONTRACT
6289E AF 49 638 1402 A SUMMARY OF CURRENT RESEARCH IN THE MICROWAVE RESEARCH
6289F INSTITUTE PROGRAMS POLYTECH INST BROOKLYN
62 0708 ,0639 ,0708 ,0639 ,0639
6 AD 662885, R 452 32 67, AFOSR 67 2582

6060A BOLSHUKLIN I D MS59 000,00,000059 0000P
6060B RESULTS OF SHIELDING OF CERTAIN KINDS OF MF-LF GENERATORS

6172A BOYSEN J E AIOM 007,00,051653 0010P
6172B HYPERTHERMIC AND PATHOLOGIC EFFECTS OF ELECTROMAGNETIC RADIATION (350 MC)
6172X 0668 0686

6160A BOYSEN J E PCMW 004,00,030960 0010P
6160B A REVIEW OF UNANSWERED BIOLOGICAL HAZARD OPERATIONAL PROBLEMS
6160X 0694

0372A BOZIK L PRLK 019,06,024967 0003P
0372B GRUBEROVA JC INFLUENCE OF ELECTROMAGNETIC WAVES UPON NERVOUS SYSTEM
0372X 0051
0372Y ATD ABSTRACT

6115A BRATKOVSKIY R YE MS37 000,00,022737 0025P
6115B THE INFLUENCE OF AN ULTRAHIGH FREQUENCY ELECTRIC FIELD ON OXIDATION
6115C PROCESSES AND NITROGEN METABOLISM

6278A BREDON A D REPT 000,00,000063 0062P
6278B INVESTIGATION OF DIPLEXING TRANSDUCERS FOR VOICE COMMUNICATIONS
6278X 0705
6278Y AD 400487, ASD TDR 63 157

6267A BROWN G H BOOK 000,00,000047 0384P
6267B HOYLER C N BIERWIRTH R A THEORY AND APPLICATION OF RADIO-FREQUENCY
6267C HEATING
6267D D VAN NOSTRAND CO INC NEW YORK
6267X 0623

6263A BROWN W S JR REPT 000,00,000052 0028P
6263B PHYSIOLOGICAL HAZARD OF NON-IONIZING RADIATION
6263X 0612
6263Y AD 139961, SDR 1072

62[illegible]2A BURGESS J S PCMW 001,00,003257 0003P
6[illegible]B HIGH POWER MICROWAVE FACILITIES
6[illegible]X 0622

6254A BURHAN A S PCMW 003,00,012459 0012P
6254B SOME RECENT DEVELOPMENTS IN PULSED ENERGY SLEEP
6254X 0681

0352A BUSCO R RMAS 030,00,046967 0060P
0352B COMIGNANI L CURRENT KNOWLEDGE REGARDING THE EFFECTS OF RADAR WAVES ON
0352C LIVING ORGANISMS AND THE PROTECTIVE EQUIPMENT INVOLVED I
0352X 0304

0353A BUSCO R RMAS 030,00,071867 0040P
0352B COMIGNANI L PRESENT STATE OF KNOWLEDGE CONCERNING THE EFFECTS OF RADAR
0353C WAVES ON LIVING ORGANISMS AND RELATIVE PROTECTIVE DEVICES II
0353X 0304

6062A BUTKINA T K MS59 000,00,000059 0000P
6062B SANITARY HYGIENIC WORKING CONDITIONS AND THE HEALTH OFINDIVIDUALS EXPOSED
6062C SIMULTANEOUSLY TO X RAYS AND CENTIMETER WAVES

6061A BUTKINA T K MS59 000,00,000059 0000P
6061B VORONTSOVA A S GIRSKAYA E N DUBROVSKAYA L R KLYACHINA I E

0252A BYALKO N K TIGT 000,02,013764 0003P
0252B SADCHIKOVA M A SOME BIOCHEMICAL BLOOD INDICES UNDER THE ACTION OF
0252C CENTIMETER WAVES
0252X 0012
0252Y ATD ABSTRACT

6043A BYCHKOV M S TVMA 073,00,005857 0020P
6043B CHANGES OF ELECTRIC ACTIVITY OF THE CORTEX OF THE LARGE HEMISPHERES IN
6043C ANIMALS EXPOSED TO SHF-UHF ELECTROMAGNETIC FIELDS
6043X 0021

6055A BYCHKOV M S MS59 000,00,004959 0001P
6055B ELECTROPHYSIOLOGICAL CHARACTERISTIC OF THE BIOLOGICAL EFFECT OF
6055C MICROWAVE ELECTROMAGNETIC FIELDS OF VARIOUS PARAMETERS

6063A BYCHKOV M S MS59 000,00,000059 0000P

6079A BYCHKOV M S LN62 000,00,000662 0003P
6079B ON THE MECHANISM OF ACTION OF A SHF-UHF ELECTROMAGNETIC FIELD

6080A BYCHKOV M S LN62 000,00,000862 0002P

6081A BYCHKOV M S LN62 000,00,000962 0003P
6081B SYNGAYEVSKAYA V A DATA ON THE NON THERMAL EFFECT OF SHF-UHF FIELDS ON
6081C THE CHOLINERGIC SYSTEMS OF AN ORGANISM

0380A BYNUM J A THES 000,00,000066 0103P
0380B THE EFFECTS OF UHF FIELDS ON RETENTION IN A VERBAL LEARNING TASK - BAYLOR
0380C UNIVERSITY 1966
0380X 0647

6235A CARPENTER R L PCMW 002,00,014658 0023P
6235B REVIEW OF THE WORK CONDUCTED AT TUFTS UNIVERSITY (USAF SPONSORED)
6235X 0634

6259A CARPENTER R L PCMW 003,00,027959 0012P
6259B STUDIES ON THE EFFECTS OF 2450 MC RADIATION ON THE EYE OF THE RABBIT
6259X 0634

6164A CARPENTER R L REPT 000,00,000062 0057P
6164B AN EXPERIMENTAL STUDY OF THE BIOLOGICAL EFFECTS OF MICROWAVE RADIATION IN
6164C RELATION TO THE EYE
6164X 0634
6164Y AD 275840, RADC TDR 62 131

6162A CARPENTER R L DICM 006,00,057365 0002P
6162B SUPPRESSION OF DIFFERENTIATION IN LIVING TISSUES EXPOSED TO MICROWAVE
6162C RADIATION
6162X 0634

6265A CARPENTER R L ITME 007,03,015260 0006P
6265B BIDDLE D K VAN UMMERSEN C A OPACITIES IN THE LENS OF THE EYE
6265C EXPERIMENTALLY INDUCED BY EXPOSURE TO MICROWAVE RADIATION
6265X 0634

6163A CARPENTER R L PICM 003,00,040160 0008P
6163B BIDDLE D K VAN UMMERSEN C A BIOLOGICAL EFFECTS OF MICROWAVE RADIATION
6163C WITH PARTICULAR REFERENCE TO THE EYE
6163X 0634

0392A CARPENTER R L SECT 000,00,013166 0008P
0392B CLARK V A RESPONSES TO RADIO-FREQUENCY RADIATIONS
0392C IN ALTMAN P L AND DITTMER D S (ED) ENVIRONMENTAL BIOLOGY
0392X 0634
0392Y AD 646890, AMRL TR 66 194

0379A CARPENTER R L JMWP 003,01,000368 0017P
0379B VAN UMMERSEN C A THE ACTION OF MICROWAVE RADIATION ON THE EYE
0379X 0634

6026A CARSTENSEN E L REPT 000,00,000062 0009P
6026B INTERNAL CONDUCTIVITY OF ESCHERICHIA COLI
6026C FT DETRICK TECH MS 23
6026X 0701
6026Y AD 293693

0354A CAZZAMALLI F SECT 000,00,012560 0028P
0354B ON A CEREBRO-PSYCHIC RADIATION PHENOMENON (CEREBRO-PSYCHIC RADIATION
0354C REFLEX) AS A MEANS OF PSYCHOPHYSICAL EXPLORATION
0354D IN THE ITALIAN BOOK IL CERVELLO RADIANTE 1960
0354Y US ARMY ENGR RES DEV LAB T 1695, AD 422217

0355A CAZZAMALLI F SECT 000,00,015360 0042P
0355B ELECTROMAGNETIC PHENOMENA WHICH RADIATES FROM THE HUMAN BRAIN DURING
0355C INTENSE PSYCHOSENSORIAL ACTIVITY FROM DREAMY, HALLUCINATORY AND
0355C TELEPSYCHIC STATES
0355D IN THE ITALIAN BOOK IL CERVELLO RADIANTE 1960
0355Y US ARMY ENGR RES DEV LAB T 1696, AD 422218

0282A CHIZHENKOVA R A ZVND 017,02,031367 0009P
0282B THE ROLE OF VARIOUS BRAIN FORMATIONS IN EEG REATIONS OF RABBITS TO
0282C PERMANENT MAGNETIC FIELD AND VHF-HF AND SHF-UHF
0282C ELECTROMAGNETIC FIELDS
0282X 0009
0282Y ATD ABSTRACT

0281A CHIZHENKOVA R A FZHS 053,05,051467 0006P
0281B BRAIN BIOPOTENTIALS IN THE RABBIT DURING EXPOSURE TO ELECTROMAGNETIC
0281C FIELDS
0281X 0009
0281Y ATD ABSTRACT

6010A CHRISTIANSON C REPT 000,00,000067 0025P
6010B RUTKOWSKI A ELECTROMAGNETIC RADIATION HAZARDS IN THE NAVY
6010C U S NAVAL APPLIED SCIENCE LAB BROOKLYN NEW YORK
6010C TECH MEMO NO 3 PROJ 9400 20 SF 013 15 04 TASK 2162
6010X 0656
6010Y AD 645698, N67 22697

6007A CHUKHLOVIN B A VMZH 000,07,002565 0005P
6007B THE EFFECT OF SHF-UHF ELECTROMAGNETIC RADIATION ON THE IMMUNOBIOLOGICAL
6007C PROPERTIES OF THE ORGANISM
6007Y ATD ABSTRACT

0278A CHUKHLOVIN B A BEBM 061,06,005366 0003P
0278B GRACHEV B N LIKINA I V THE DETECTION OF S- AND SX- REACTIVE PROTEIN IN
0278C THE BLOOD SERUM DURING EXPOSURE OF THE ORGANISM TO SHF-UHF
0278D ELECTROMAGNETIC WAVES
0278Y ATD ABSTRACT

0370A CIECIURA L LKWO 038,06,051962 0012P
0370B MINECKI L PATHOLOGICAL CHANGES IN THE TESTES OF RATS SUBJECTED TO THE
0370C SINGLE OR REPEATED ACTION OF MICROWAVES (S BAND)
0370X 0014
0370Y ATD ABSTRACT

6264A CLARK J W PIRE 000,09,102850 0005P
6264B EFFECTS OF INTENSE MICROWAVE RADIATION ON LIVING ORGANISMS
6264X 0700

6255A CLARK L A PCMW 003,00,023959 0005P
6255B EYE STUDY SURVEY
6255X 0622

6173A CLEARY S F AREH 012,00,002366 0007P
6173B PASTERNACK B S LENTICULAR CHANGES IN MICROWAVE WORKERS
6173X 0620

6176A COGAN D G AAOP 045,00,050851 0015P
6176B DONALDSON D D EXPERIMENTAL RADIATION CATARACTS
6176X 0630 0670

6174A COGAN D G AAIH 018,00,029958 0004P
6174B FRICKER S J LOBIN M DONALDSON D D HARDY H CATARACTS AND ULTRA-HIGH-
6[illegible] FREQUENCY RADIATION
6[illegible]X 0630 0670 ,0613 ,0671 ,0630 0670 ,0671

6175A CONSTANT P C TRFI 005,01,005663 0021P
6175B MARTIN E J THE RADIATION HAZARDS (RAD HAZ) PROGRAM ON THE FORMULATION OF
6175C STANDARDS
6175X 0615

0257A CONSTANT P C JR DICM 007,00,034967 0001P
0257C HEARING EM WAVES
0257X 0615

0398A CUTTER R S REPT 000,00,000060 0020P
0398B BIOLOGICAL EFFECTS OF NON-IONIZING RADIATION ON HUMANS AND HIGHER ANIMALS
0398C SELECTED REFERENCES IN ENGLISH 1916-1959
0398D NAT LIB MED PUBLIC HEALTH SERVICE U S DEPT HEALTH EDUCATION AND WELFARE
0398X 0709

6258A DADIRRIAN A N PCMW 003,00,027159 0008P
6258B A MICROWAVE MEDICAL SAFETY PROGRAM IN AN INDUSTRIAL ELECTRONICS FACILITY
6258X 0626

6179A DAILY L AAOP 033,00,124150 0014P
6179B WAKIM K G HERRICK J F PARKHILL E M BENEDICT W L THE EFFECTS OF MICROWAVE
6[illegible] DIATHERMY ON THE EYE
6[illegible] 0614 0672 ,0614 ,0614 ,0614 ,0614

6177A DAILY L AAOP 035,00,100152 0017P
6177B WAKIM K G HERRICK J F PARKHILL E M BENEDICT W L THE EFFECTS OF
6177C MICROWAVE DIATHERMY ON THE EYE OF THE RABBIT
6177X 0614 0672 ,0614 ,0614 ,0614 ,0614

6274A DAILY L ITME 004,00,002556 0002P
6274B WAKIM K G HERRICK J F PARKHILL E M BENEDICT W L THE EFFECTS OF MICROWAVE
6274C DIATHERMY ON THE EYE
6274X 0614

6178A DAILY L AAOP 034,00,130151 0006P
6178B ZELLER E A WAKIM K G HERRICK J F BENEDICT W L INFLUENCE OF MICROWAVES ON
6178C CERTAIN ENZYME SYSTEMS IN THE LENS OF THE EYE
6178X 0614 0672 ,0614 ,0614 ,0614 ,0614

6223A DAVIS H PCMW 002,00,001958 0014P
6223B DISCUSSION OF LONG RANGE DEVELOPMENT PLANS IN THE AIR FORCE
6223X 0622

6249A DEICHMANN W B PCMW 003,00,007259 0003P
6249B RESULTS OF STUDIES IN MICROWAVE RADIATION
6249X 0632

62[illegible] DEICHMANN W B PCMW 003,00,006259 0009P
6247B BERNAL E KEPLINGER M EFFECTS OF ENVIRONMENTAL TEMPERATURE AND AIR VOLUME
6247C EXCHANGE ON SURVIVAL OF RATS EXPOSED TO MICROWAVE RADIATION OF 24,000 MC
6247X 0632

6276A DEICHMANN W B JOMD 005,09,041863 0008P
6276B BERNAL E STEPHENS F LANDEEN K EFFECTS ON DOGS OF CHRONIC EXPOSURE TO
6276C MICROWAVE RADIATION
6276X 0632

6180A DEICHMANN W B INMS 028,00,021259 0002P
6 B KEPLINGER M BERNAL E RELATION OF INTERRUPTED PULSED MICROWAVES TO
6 C BIOLOGICAL HAZARDS
6180X 0632

6250A DEICHMANN W B PCMW 003,00,007759 0005P
6250B KEPLINGER M BERNAL E RELATION OF INTERRUPTED PULSED MICROWAVES TO
6250C BIOLOGICAL HAZARDS
6250X 0632

6293A DEICHMANN W B JOMD 001,00,036959 0013P
6293B STEPHENS F H KEPLINGER M LAMPE K F ACUTE EFFECTS OF MICROWAVE RADIATION
6293C ON EXPERIMENTAL ANIMALS (24,000 MEGACYCLES)
6293X 0632

0261A DINKLOH H WMED 004,00,012366 0009P
0261B HEALTH DAMAGE CAUSED BY MICROWAVES, ESPECIALLY RADAR WAVES

0262A DODGE C REPT 000,00,000066 0037P
0262B KASSEL S SOVIET RESEARCH ON THE NEURAL EFFECTS OF MICROWAVES
0262C ATD REP 66 133

6053A DOLINA L A MS59 000,00,004459 0002P

03 DOLINA L A ARPT 023,01,005161 0007P
0 MORPHOLOGICAL CHANGES IN THE CENTRAL NERVOUS SYSTEM UNDER THE EFFECT OF
03 C CENTIMETER WAVES ON THE ORGANISM
0393X 0016 0052
0393Y JPRS 9118

6030A DOOLEY E S REPT 000,00,000063 0023P
6030B GILLENWATER J Y FROHLICH E D ALTERED RENOPRESSOR RESPONSE-PATTERN TO
6030C ENDOTOXIN RADIATED WITH RADIO-FREQUENCY ENERGY
6030X 0602
6030Y AD 411221, U S ARMY MED RES LAB REPT 565

0285A DROGICHINA E A GTPZ 010,07,001366 0004P
0285B KONCHALOVSKAYA N M GLOTOVA K V SADCHIKOVA M A SNEGOVA G V
0285C ON THE PROBLEM OF VEGETATIVE AND CARDIOVASCULAR DISTURBANCES SUBSEQUENT
0285D TO CHRONIC EXPOSURE TO MICROWAVE FREQUENCY ELECTROMAGNETIC FIELDS
0285X 0012
0285Y JFRS 38663

6087A DROGICHINA E A LN62 000,00,002262 0001P
6087B SADCHIKOVA M A GINZBURG D A CLINIC OF ACUTE PHASES OF A CONTINUOUS
6087C ACTION OF CENTIMETER WAVES

0284A DROGICHINA E A GTPZ 006,01,002862 0007P
0284B SADCHIKOVA M A GINZBURG D A CHULINA N A CERTAIN CLINICAL MANIFESTATIONS
02 FROM CHRONIC EXPOSURE TO CENTIMETER WAVES
02 0012
028 JPRS 13157

6108A DROGICHINA E A MS63 000 00 002963 0000P
6108B SADCHIKOVA M A

0245A DROGICHINA E A   TIGT 000,02,010564   0005P
0245B SADCHIKOVA M A CLINICAL SYNDROMES DURING THE ACTION OF VARIOUS
0245C RADIO-FREQUENCY RANGES
0245X 0012
0245Y ATD ABSTRACT

0283A DROGICHINA E A   GTPZ 009,01,001765   0005P
0283B SADCHIKOVA M A CLINICAL SYNDROMES ARISING UNDER THE EFFECT OF VARIOUS
0283C RADIO FREQUENCY BANDS
0283X 0012
0283Y JPRS 29694, N65 21573

0286A EAKIN S K   PSRT 011,00,019262   0001P
0286B THOMPSON W D EFFECTS OF MICROWAVE RADIATION ON ACTIVITY LEVEL OF RATS
0286X 0647

0297A EAKIN S K   PSRT 017,00,059565   0008P
0297B THOMPSON W D BEHAVIORAL EFFECTS OF STIMULATION BY UHF RADIO FIELDS
0297X 0647

0368A EDELWEJN Z   APHP 013,03,043162   0005P
0368B HADUCH S ELECTROENCEPHALOGRAPHIC STUDIES ON PERSONS WORKING WITHIN THE
0368C REACH OF MICROWAVES
0368X 0014
0368Y ATD ABSTRACT

6230A ELY T S   PCMW 002,00,009758   0008P
6230B FIELD TRIAL OF RICHARDSON MICROWAVE DOSIMETER
6230X 0689

6285A ELY T S   REPT 015,00,007757   0062P
6285B GOLDMAN D E HEARON J Z WILLIAMS R B CARPENTER H M HEATING
6285D CHARACTERISTICS OF LABORATORY ANIMALS EXPOSED TO TEN-CENTIMETER MICROWAVES
6285C NAVAL MEDICAL RES INST BETHESDA MD RESEARCH REPT PROJ NM 001 056 13 02
6285X 0618
6285Y AD 136077

6216A ELY T S   PCMW 001,00,006457   0013P
6216B GOLDMAN D E HEATING CHARACTERISTICS OF LABORATORY ANIMALS EXPOSED TO
6216C TEN CENTIMETER MICROWAVES - SUMMARY
6216X 0633U,0618

6286A ELY T S   ITBE 011,04,012364   0015P
6286B GOLDMAN D E HEARON J Z HEATING CHARACTERISTICS OF LABORATORY ANIMALS
6286C EXPOSED TO TEN-CENTIMETER MICROWAVES
6286X 0633 ,0618 ,0710

6146A ENGELBRECHT R S   PCMW 004,00,005560   0016P
6146B MUMFORD W W SOME ENGINEERING ASPECTS OF MICROWAVE RADIATION HAZARDS
6146X 0606

0287A EYDELMAN F M   LKWO 000,09,078166   0006P
0287B BARANSKI S EFFECTS OF IRRADIATION ON THE NERVOUS SYSTEM OF PERSONNEL
0287C EXPOSED TO MICROWAVE-RANGE FIELDS
0287X 0014
0287Y ATD ABSTRACT

6183A ESSMAN L   ARPM 031,00,050250   0006P
6183B WISE C S LOCAL EFFECTS OF MICROWAVE RADIATION ON TISSUES IN THE ALBINO
6183C RAT
6183X 0673 ,0674

0345A FATTELSERO BLANK PZHS [illegible]
0345B ABSORPTIVE GASTRIC AND INTESTINAL ACTIVITY UNDER THE INFLUENCE OF THE
0345C MICROWAVE ELECTRIC FIELD

8013A FIDELMAN F M GTPZ 000,08,005667 0002P
8013B RASINA G YA SANITARY-HYGENIC ESTIMATE OF INTENSITY LEVELS FOR
[illegible]C MF-LF ELECTROMAGNETIC FIELDS OF CHELYABINSK ENTERPRISES AND THE
8[illegible] MEANS OF PROTECTION
8013C PROTECTION
8013X 0039

6243A FISCHER F P PCMW 003,00,001559 0007P
6243B NEUBAUER R A SARKEES Y T ADDINGTON C H OSBORN C SWARTZ G ELECTRICAL
6243C INSTRUMENTATION OF BIOELECTRIC HAZARDS AT 200 MC AND THE DEVELOPMENT OF A
6243D MINIATURE HAZARD METER
6243X 0628

6155A FLEMING J D PCMW 004,00,022960 0022P
6155B PINNEO C R BAUS R MCAFEE R D MICROWAVE RADIATION IN RELATION TO
6155C BIOLOGICAL SYSTEMS AND NEURAL ACTIVITY
6155X 0635

0288A FOFANOV P N KLME 044,04,001866 0005P
0288B FEATURES PECULIAR TO HEMODYNAMICS IN PERSONS WORKING IN CONDITIONS OF
0288C PROTRACTED ELECTROMAGNETIC HIGH FREQUENCY RADIATION
0288X 0021
0288Y JPRS 36301,TT 66 32733

6292A FRANK KAMENETSKII DANP 136,02,047661 0003P
6292B PLASMA EFFECT IN SEMICONDUCTORS AND BIOLOGICAL EFFECT OF RADIOWAVES
6[illegible]Y AM INST PHYS TRANSL VOL 6 NO 1 PP 91-92

6064A FRANKE V A MS59 000,00,000059 0000P
6064B DEPENDENCE OF THE ABSORPTION OF ENERGY BY A HUMAN IN AN ELECTROMAGNETIC
6064C FIELD ON FREQUENCY

6120A FRENKEL G L MS37 000,00,011537 0023P
6120B SOME CHARACTERISTICS OF THE BIOLOGICAL EFFECT OF HF/VHF

6121A FRENKEL G L MS37 000,00,041037 0000P

6217A FRICKER S J PCMW 001,00,007957 0010P
6217B MICROWAVE EXPOSURE DISCUSSION (AT FIRST TRISERVICE CONFERENCE)
6217X 0613

0258A FREY A H AERM 032,12,114061 0003P
0258B AUDITORY SYSTEM RESPONSE TO RADIO FREQUENCY ENERGY
0258X 0649

0259A FREY A H JAPP 017,04,068962 0004P
0259B HUMAN AUDITORY SYSTEM RESPONSE TO MODULATED ELECTROMAGNETIC ENERGY
0259X 0649

0260A FREY A H JAPP 023,06,098467 0005P
0260B BRAIN STEM EVOKED RESPONSES ASSOCIATED WITH LOW-INTENSITY PULSED UHF
0[illegible]C ENERGY
[illegible]X 0661

0289A FROLOVA L T GTPZ 000,02,002763 0003P
0289B HYGIENIC EVALUATION OF WORKING CONDITIONS IN WORK WITH HIGH-FREQUENCY
0289C CURRENTS
0289X 0040
0289Y N64 11855

6102A FUKALOVA P P LN62 000,00,005762 0002P
6102B SMUROVA YE I CHANGES IN THE FUNCTIONAL CONDITION OF SOME ANALYZERS IN
6102C PERSONS EXPOSED TO SHF-UHF FIELDS

0[illegible] FUKALOVA P P TIGT 000,02,014464 0005P
0[illegible] SENSITIVITY OF OLFACTORY AND VISUAL ANALYZERS IN INDIVIDUALS EXPOSED TO
0254C CONTINUOUSLY GENERATED SHORT AND ULTRASHORT WAVES
0254X 0012
0254Y ATD ABSTRACT

0241A FUKALOVA P P TIGT 000,02,007864 0002P
0241B THE EFFECT OF SHORT AND ULTRASHORT WAVES ON BODY TEMPERATURE AND THE RATE
0241C OF SURVIVAL OF EXPERIMENTAL ANIMALS
0241X 0012
0241Y ATD ABSTRACT

8001A FUKALOVA P P TIGT 000,02,015864 0006P
8001B HYGIENIC CHARACTERISTIC OF WORKING CONDITIONS NEAR THE SOURCES OF SHORT
8001C AND ULTRASHORT WAVES AT RADIO AND TV STATIONS
8001X 0012
8001Y ATD ABSTRACT

8006A FUKALOVA P P GISA 031,02,000066 0003P
8006B EFFECTIVENESS OF PROTECTION AGAINST SW AND USW ELECTROMAGNETIC FIELDS AT
8006C RADIO AND TV STATIONS
8006X 0012
8006Y TT 66 51160/4-6

8[illegible]A FUKALOVA P P GTPZ 000,07,000566 0005P
8[illegible] TOLGSKAYA M S NIKOGOSYAN S V KITSOVSKAYA I A ZENINA I N
8007C RESEARCH DATA ON THE STANDARDIZATION OF ELECTROMAGNETIC FIELDS IN THE
8007D SHORT AND ULTRASHORT WAVE RANGES
8007X 0012
8007Y ATD REPT 66 126, AD 644537

6042A GAPEYEV P I TVMA 073,00,015257 0000P
6042B THE EFFECT OF UHF/SHF FIELDS ON SIGHT ORGANS
6042X 0021

6125A GATEV S , VMDE 020 03 003065 0006P
6125B TREATMENT OF TENOVAGINITIS WITH MICROWAVE (RADAR) AND HYDROCORTISONE
6125C PHONOPHORESIS
6125X 0042

0238A GELFON I A TIGT 000,02,006864 0002P
0238B EFFECTS OF 10 CM WAVES OF LOW INTENSITY ON HISTAMINE CONTENT
0238C IN THE BLOOD OF ANIMALS
0238X 0012
0238Y ATD ABSTRACT

0251A GELFON I A TIGT 000,02,013364 0004P
0251B SADCHIKOVA M A PROTEIN FRACTURES AND BLOOD HISTAMINE UNDER THE ACTION OF
0251C RADIO WAVES OF VARIOUS RANGES
0[illegible] 0012
0[illegible] ATD ABSTRACT

6039A GELFON I A GTPZ 009,05,002865 0006P
6039B FEDOROVA V I PATUSHINSKII G I EFFECT OF HF/VHF (UVCH) THERAPY ON
6039C CONNECTIVE TISSUE PROTEINS OF THE LUNGS IN EXPERIMENTAL SILICOSIS
6039Y ENGLISH SUMMARY

6082A GEMBITSKY YE V LN62 000,00,001462 0002P
6082B MATERIAL ON THE CLINICAL ASPECTS OF CHRONIC MICROWAVE EFFECTS

0250A GINZBURG D A TIGT 000,02,012664 0007P
0250B SADCHIKOVA M A CHANGES OF THE ELECTROENCEPHALOGRAM UNDER CONTINUOUS
02[illegible]C ACTION OF RADIO WAVES
0[illegible] 0012
02[illegible] ATD ABSTRACT

6136A GLEZER D YA LN37 000,00,000537 0014P

6135A GOLYSHEVA K P SECT 000 00 0063 0012P
6135B IN PROBS METRICS AND DOSIMETRY OF ULTRAHIGH FREQ IN BIOL AND MEDICINE
6135C MOSCOW 1937

6116A GOLYSHEVA K P MS37 000,00,030937 0016P
6116B ANDRIYASHEVA N M INFLUENCE OF ULTRAHIGH FREQUENCY ON THE GROWTH OF WHITE
6116C MICE

6117A GOLYSHEVA K P MS37 000,00,000037 0000P
6117B ANDRIYASHEVA N M THE EFFECT OF ULTRAHIGH FREQUENCY ON EMBRYONIC
6117C DEVELOPMENT

8008A GONCHAROVA N N GTPZ 010,07,001066 0004P
8008B KARAMYSHEV V B MAKSIMENKO N V PROBLEMS OF OCCUPATIONAL HYGIENE IN WORK
8008C WITH ULTRASHORT-WAVE TRANSMITTERS USED IN TV AND RADIO BROADCASTING
8008X 0041
8008Y JPRS 38663, ATD REP 66 125

61[illegible] GORDON Z V MS57 000,00,006757 0002P

6077A GORDON Z V SECT 000,00,013560 0000P
6077D IN LETAVET A A PHYSICAL FACTORS OF THE ENVIRONMENT MOSCOW 1960

6083A GORDON Z V LN62 000,00,001562 0002P
6083B CERTAIN FEATURES OF THE BIOLOGICAL EFFECT OF MICROWAVES OF VARIOUS RANGES

0227A GORDON Z V TIGT 000,02,000364 0007P
0227B RESULTS OF A COMPREHENSIVE STUDY OF THE BIOLOGICAL EFFECTS OF RADIO
0227C FREQUENCY ELECTROMAGNETIC WAVES AND THE OUTLOOK FOR FURTHER RESEARCH
0227X 0012
0227Y ATD ABSTRACT

0235A GORDON Z V TIGT 000,02,005764 0004P
0235B EFFECTS OF MICROWAVES ON THE LEVEL OF BLOOD PRESSURE IN EXPERIMENTS ON
0235C ANIMALS
0235X 0012
0235Y ATD ABSTRACT

0270A GORDON Z V BOOK 000,00,000066 0164P
0270B PROBLEMS OF INDUSTRIAL HYGIENE AND THE BIOLOGICAL EFFECT OF SHF/UHF
0270C ELECTROMAGNETIC FIELDS
0270D MEDITSINA, LENINGRAD, 1966
0270X 0012
02[illegible] ABSTRACT IN FOREIGN SCI BULL VOL 3 NO 1 JAN 1967 OR AD 646634

0290A GORDON Z V GTPZ 010,10,000366 0004P
0290B ELECTROMAGNETIC RADIOFREQUENCY FIELDS AS A HEALTH FACTOR
0290X 0012
0290Y JPRS 39820

6138A GORDON Z V ET AL MS57 000,00,000057 0000P
6138B MORPHOLOGICAL CHANGES IN ANIMALS UNDER THE ACTION OF ULTRAHIGH
6138C FREQUENCIES

60 A GORDON Z V MS59 000 00 000759 0002P
6 BELITSKIY B M

6109A GORDON Z V MS63 000 00 002363 0000P
6109B TOLGSKAYA M S ALEKSANDROVA L S

0255A GORDON Z V TIGT 000,02,015164 0007P
0255B YELISEYEV V V SAFEGUARDS AGAINST SHF/UHF RADIATION AND THEIR EFFICIENCY
0255X 0012
0255Y ATD ABSTRACT

6025A GORODETSKAYA S F FZKR 006,05,062260 0007P
6025B THE EFFECT OF CENTIMETER-BAND RADIO WAVES ON HEMATOGENIC ORGANS,
6025C REPRODUCTION AND THE HIGHER NERVOUS ACTIVITY
6025X 0015
6025Y ATD ABSTRACT

6084A GORODETSKAYA S F LN62 000,00,000062 0000P
6084B THE EFFECT OF UHF/SHF ON REPRODUCTION ORGANS

6011A GORODETSKAYA S F FZKR 008,03,039062 0007P
6011B MORPHOLOGICAL CHANGES IN INTERNAL ORGANS WHEN THE ORGANISM IS EXPOSED TO
6011C THE EFFECT OF CENTIMETER WAVES
6011X 0015
6011Y FTD TT 62 1361/1+2, AD 292205

6 GORODETSKAYA S F FZKR 009,03,039463 0002P
6024B THE EFFECT OF CENTIMETER RADIO WAVES ON MOUSE FERTILITY
6024X 0015
6024Y JPRS 21200, OTS 63 31815, N63 22588

6023A GORODETSKAYA S F FZKR 012,02,024666 0008P
6023B KEROVA N IB CHANGES IN SOME FUNCTIONAL AND BIOCHEMICAL INDEXES IN THE
6023C TESTICLES OF ANIMALS EXPOSED TO 3 CM RADIOWAVES
6023X 0015
6023Y ATD ABSTRACT

0225A GORODETSKIY A A BOOK 000,00,000064 0120P
0225B BIOLOGICAL ACTION OF ULTRASOUND AND SUPER-HIGH FREQUENCY (SVCH)
0225C ELECTROMAGNETIC OSCILLATIONS
0225D KIEV 1964
0225X 0015
0225Y JPRS 30860, TT 65 31380, N65 28700

6085A GREBENSHCHIKOVA A LN62 000,00,000062 0000P
6085B THE EFFECT OF UHF/SHF FIELDS IN THE DECIMETER AND METER WAVE RANGES ON
6085C THE MOTOR EVACUATOR FUNCTION OF THE GASTROINTESTINAL TRACT IN DOGS AND
6085C GUINEA PIGS

6148A GUNN S A PCMW 004,00,009960 0008P
6 GOULD T C ANDERSON W A D THE EFFECT OF MICROWAVE RADIATION (24,000 MC)
6 ON THE MALE ENDOCRINE SYSTEM OF THE RAT
6148X 0632

6086A GURYEV V N LN62 000,00,002062 0002P
6086B SOME PROBLEMS OF THE ADJUSTMENT OF PEOPLE TO UHF/SHF EFFECTS UNDER
6086C INDUSTRIAL CONDITIONS

6004A GURYEV V N EKTR 018 18 012165 0007P
6004B DIENCEPHALIC DISORDERS IN PERSONS EXPOSED TO UHF/SHF ELECTROMAGNETIC
6004C FIELDS FOR PROLONGED PERIODS OF TIME
6004X 0021
6004Y ATD ABSTRACT

6107A GVOZDIKOVA Z M MS63 000 00 011463 0002P
6107B ANANYEV V M ZENINA I N ZAK V I

0229A GVOZDIKOVA Z M TIGT 000,02,002064 0006P
0229B ZENINA I N ZAK V I THE EFFECT OF CONTINUOUS SHF-UHF ELECTROMAGNETIC
0229C FIELDS ON THE CENTRAL NERVOUS SYSTEM
0229X 0012
0229Y ATD ABSTRACT

6211A HANDELSMAN M PCMW 001,00,002357 0009P
6211B FUTURE MICROWAVE RADIATION HAZARDS
6211X 0622

6226A HARTMAN F PCMW 002,00,005458 0016P
6226B THE PATHOLOGY OF HYPERPYREXIA
6226X 0621

0291A HEARN G E THES 000,00,000065 0077P
0291B EFFECTS OF UHF RADIO FIELDS ON VISUAL ACUITY AND CRITICAL FLICKER FUSION
0291C IN THE ALBINO RAT
0291X 0647

0292A HENDLER E ITME 007,03,014360 0010P
0292B HARDY J D INFRARED AND MICROWAVE EFFECTS ON SKIN HEATING AND TEMPERATURE
0292C SENSATION
0292X 0645 0658 0659

6279A HARVEY W T THES 000,00,000064 0054P
6279B HAMILTON J P HEARING SENSATIONS IN AMPLITUDE MODULATED RADIO FREQUENCIES
6279C SCHOOL ENGR AF INST TECH AIR UNIV
6279X 0706
6279Y AD 608889

6229A HERRICK J PCMW 002,00,008858 0009P
6229B PEARL CHAIN FORMATION
6229X 0614

6209A HETHERINGTON A PCMW 001,00,000157 0005P
6209B INTRODUCTION (TO FIRST TRISERVICE CONFERENCE)
6209X 0637

0371A HIGIER J WDLK 020,00,143567 0004P
0371B BARANSKA W EXAMINATIONS OF THE GENITAL ORGANS AND STUDIES OF THE
0371C MENSTRUAL CYCLE IN WOMEN WORKING IN THE FIELD OF MICROWAVE RADIATION

6184A HIRSCH F G AIOM 006,00,051252 0006P
6184B PARKER J T BILATERAL LENTICULAR OPACITIES OCCURRING IN A TECHNICIAN
6184C OPERATING A MICROWAVE GENERATOR
6184X 0675

6[illegible] HOWLAND J W PCMW 004,00,026160 0024P
6[illegible] THOMSON R A E MICHAELSON S M BIOMEDICAL ASPECTS OF MICROWAVE IRRADIATION
6157C OF MAMMALS
6157X 0633

6241A IMIG C J PCMW 002,00,024258 0012P
6241B SEARLE G W REVIEW OF THE WORK CONDUCTED AT STATE UNIVERSITY OF IOWA
6241C (USAF SPONSORED)
6241X 0631

6186A IMIG C J ICBE 000,00,000359 0003P
6186B SEARLE G W REPORT FROM STATE UNIVERISTY OF IOWA DEPARTMENT OF PHYSIOLOGY
6186X 0631

6185A IMIG C J PSEB 069,00,038248 0005P
6185B THOMSON J D HINES H M TESTICULAR DEGENERATION AS A RESULT OF MICROWAVE
6185C IRRADIATION
6185X 0631

0293A ISMAILOV E SH VLEN 000,02,014766 0003P
0293B EFFECT OF MICROWAVES ON OPALINA RANARUM
0293Y ATD ABSTRACT

6088A IVANOV A I LN62 000,00,002462 0003P
60[illegible] CHANGES OF PHAGOCYTIC ACTIVITY AND MOBILITY OF NEUTROPHILS UNDER THE
6[illegible] INFLUENCE OF MICROWAVE FIELDS

6127A IVANOV V I ET AL MS57 000,00,005257 0002P
6127B BIOCHEMICAL CHANGES IN THE BLOOD UNDER THE CHRONIC INFLUENCE OF IONIZING
6127C RADIATIONS

6240A JACOBSON B S PCMW 002,00,023458 0008P
6240B SUSSKIND C E REVIEW OF THE WORK CONDUCTED AT UNIVERSITY OF CALIFORNIA
6240C (USAF SPONSORED)
6240X 0629

0387A KALL A R REPT 000,00,000068 0180P
0387B WATTS H M FINAL TECHNICAL REPORT ON RESEARCH PROJECT TO STUDY RADIATION
0387C HAZARDS CAUSED BY HIGH POWER HIGH FREQUENCY FIELDS
0387D REPORT FOR US INFO AGENCY UNDER CONTRACT IA 11651
0387X 0696

6065A KALYADA T V MS59 000,00,000059 0000P
6065B PHYSICAL HYGIENIC CHARACTERISTIC OF MICROWAVE RADIATION CONDITIONS IN
6065C MOORING TESTS

6040A KALYADA T V SECT 000,00,006664 0002P
6040B TEMPERATURE SENSITIVITY AND FUNCTIONAL MOBILITY OF THERMORECEPTORS UNDER
6040C THE EFFECT OF ULTRA HIGH FREQUENCY
60[illegible] IN PROC SCI SESS DEVOTED TO 40TH ANNIV SCI RES INST LABOR HYG AND OCCUP
6[illegible] DISEASES, LENINGRAD, 1964
6[illegible] 0032
6040Y ABSTRACT FROM REF ZH BIOL NO 12 1965 ABSTRACT NO 14P162 IN JPRS 34588

6049A KALYADA T V MS59 000,00,003559 0001P
6049B KULIKOVSKAYA YE L OSIPOV YU A PHYSIOLOGICAL SHIFTS IN WORK WITH
6049C HIGH FREQUENCY ELECTROMAGNETIC FIELDS

0294A KEKCHEEV K KH PFZO 001,00,007741 0000P
0294B DETERMINATION OF ACHROMATIC VISUAL THRESHOLDS IN MAN FOLLOWING EXPOSURE
0294C TO ULTRASHORT, ULTRAVIOLET AND ROENTGEN WAVES
0294Y SAM TT R 880 0367, AD 653949, N67 39546

6239A KEPLINGER M L PCMW 002,00,021558 0019P
6239B REVIEW OF THE WORK CONDUCTED AT UNIVERSITY OF MIAMI (USAF SPONSORED)
6239X 0632

8009A KHAZAN G L GTPZ 002,01,000958 0008P
8009B GONCHAROVA N N PETROVSKIY V S CERTAIN PROBLEMS OF INDUSTRIAL HYGIENE IN
8009C WORK WITH HIGH FREQUENCY CURRENTS
8009X 0041
8009Y JPRS L 1474 D, TT 59 11443

6057A KHAZAN G L MS59 000,00,005359 0001P
6057B GONCHAROVA N N THE EFFECTS OF FIELDS OF DIFFERENT FREQUENCIES AND
6057B DIFFERENT COMPONENTS OF AN ELECTROMAGNETIC FIELD ON THE ANIMAL ORGANISM
6057C IN EXPERIMENTS

6076A KHAZAN G L SECT 000,00,015260 0010P
6076B PISKUNOVA V G ANATOVSKAYA V S PROBLEMS OF LABOR HYGIENE AND OCCUPATIONAL
6076C PATHOLOGY DURING WORK WITH HIGH FREQUENCY EQUIPMENT
6076D IN LETAVET A A PHYSICAL FACTORS OF THE ENVIRONMENT MOSCOW 1960

6128A KHAZAN G L ET AL MS57 000,00,006257 0000P
6128B PROBLEMS OF LABOR HYGIENE AND THE STATE OF HEALTH OF WORKERS WITH HIGH
6128C FREQUENCY CURRENTS

6059A KHOLODOV YU A MS59 000,00,005859 0001P

6103A KHOLODOV YU A LN62 000,00,005862 0001P
6103B THE EFFECT OF A PULSED UHF/SHF FIELD ON THE ELECTRICAL ACTIVITY OF THE
6103C CORTEX OF A NORMAL AND AN ISOLATED RABBIT BRAIN

6106A KHOLODOV YU A MS63 000,00,010963 0000P

0231A KHOLODOV YU A TIGT 000,02,003364 0006P
0231B ZENINA I N THE EFFECT OF CAFFEINE ON EEG REACTION DURING THE ACTION OF
0231C PULSED SHF-UHF FIELD ON THE INTACT AND ISOLATED BRAIN OF A RABBIT
0231X 0009, 0012
0231Y ATD ABSTRACT

6066A KITSOVSKAYA I A MS59 000,00,000059 0000P
6066B CHANGES IN THE HIGHER NERVOUS ACTIVITY OF RATS EXPOSED TO CHRONIC EFFECTS
6066C OF RADIO FREQUENCY CENTIMETER WAVES

0232A KITSOVSKAYA I A TIGT 000,02,003964 0004P
0232B COMPARATIVE EVALUATION OF THE ACTION OF MICROWAVES OF VARIOUS WAVERANGES
0232C ON THE NERVOUS SYSTEM OF RATS SUSCEPTIBLE TO SOUND STIMULUS
0232X 0012
0232Y ATD ABSTRACT

0296A KLIMKOVA DEUTSCHOVCENE 026,03,018463 0008P
0296B EFFECT OF RADIATION ON HUMAN EEG
0296Y FTD TT 64 267 AD 450604

0295A KLIMKOVA DEUTSCHOVIAGG 020,01,000163 0010P
0295B ROTH B THE EFFECT OF ELECTROMAGNETIC WAVES ON THE NERVOUS SYSTEM -
0295C AN ELECTROENCEPHALOGRAPHIC STUDY

6213A KNAUF G M PCMW 001,00,003557 0012P
6213B PROGRAM FOR THE INVESTIGATION OF THE BIOLOGICAL EFFECTS OF
6213C ELECTROMAGNETIC RADIATION AT THE ROME AIR DEVELOPMENT CENTER
6213X 0688

6218A KNAUF G M PCMW 001,00,008957 0005P
6218B INVESTIGATION OF THE BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION -
6218C APPENDIX A
6218X 0688

6221A KNAUF G M PCMW 002,00,000358 0006P
6221B OUTLINE AND PURPOSE OF MEETING (SECOND TRISERVICE CONFERENCE)
6221X 0622

6225A KNAUF G M PCMW 002,00,004958 0005P
6225B NEW CONCEPTS IN PERSONNEL PROTECTION
6225X 0622

6233A KNAUF G M PCMW 002,00,012458 0002P
6233B REVIEW OF THE BIOLOGICAL EFFECTS PROGRAM
6233X 0622

6141A KNAUF G M PCMW 004,00,000960 0005P
6141B CHAIRMANS REMARKS (FOURTH TRISERVICE CONFERENCE)
6141X 0690

6187A KNAUF G M AJPU 050,03,036460 0004P
6187B MICROWAVE EXPOSURE AND MISSILE PROPELLANTS AS OCCUPATIONAL HEALTH
6187C PROBLEMS
6187X 0676

6219A KNAUF G M PCMW 001,00,009457 0010P
6219B SPENCER J L BIBLIOGRAPHY OF BIOLOGICAL EFFECTS OF RADIO FREQUENCY
6219C ENERGIES 1940-1957 - APPENDIX B
6219X 0688

6050A KNORRE K G MS59 000,00,002259 0001P

6051A KNORRE K G MS59 000,00,003659 0001P
6051B BELITSKIY B M

6012A KNORRE K G SECT 000 00 037460 0009P
6012B GORDON Z V METHODS OF MEASURING SHF/UHF FIELD PARAMETERS WHICH DETERMINE
6012C THE HYGIENIC ESTIMATE OF LABOR CONDITIONS DURING WORK WITH GENERATORS
6012D IN BERG A I ELEKTRONIKA V MEDITSINE, MOSCOW-LENINGRAD, 1960
6012X 0012
6012Y ATD ABSTRACT

0300A KOLESNIK F A VMZH 000,04,002167 0003P
0300B MALYSHEV V M THE PROBLEM OF CLINICAL OBSERVATION OF ACUTE INJURIES
0300C CAUSED BY SHF-UHF ELECTROMAGNETIC FIELDS
0300Y ATD ABSTRACT

0301A KOLESNIK F A VMZH 000,07,003967 0003P
0301B MALYSHEV V M MURASHEV B F ENDOCRINE SYSTEM DISORDERS DURING CONSTANT
0301C EXPOSURE TO MICROWAVE FIELDS
0301Y ATD ABSTRACT

0247A KONCHALOVSKAYA N MTIGT 000,02,011464 0005P
0247B KHMARA S N GLOTOVA K V CONDITION OF CARDIOVASCULAR SYSTEM UNDER THE
0247C ACTION OF RADIO WAVES OF VARIOUS RANGES
0247X 0012
0247Y ATD ABSTRACT

6013A KONIN P M SECT 000 00 038360 0010P
6013B FRANKE V A ET AL ELECTRONICS AND INDUSTRIAL SAFETY
6013C IN BERG A I ELEKTRONIKA V MEDITSINE, MOSKOW-LENINGRAD, 1960
6013Y FTD TT 63 1200, AD 600581

6014A KORBEL S F REPT 000,00,000066 0004P
6014B BEHAVIOR EFFECTS OF ULTRA HIGH FREQUENCY RADIO WAVES ABSTRACTS
6014X 0660

0383A KORBEL S F PSYS 009,09,052767 0002P
0383B FINE H L EFFECTS OF LOW INTENSITY UHF RADIO FIELDS AS A FUNCTION OF
0383C FREQUENCY
0383X 0660

6029A KORTELING G J REPT 000,00,000064 0014P
6029B BACH S A ACTIVITY CHANGES IN ALPHA-AMYLASE SOLUTIONS FOLLOWING THEIR
6029C EXPOSURE TO RADIO-FREQUENCY ENERGY
6029D US ARMY MEDICAL RESEARCH LABORATORY, FORT KNOX KENTUCKY, REPT NO 548
6029X 0602
6029Y AD 443679

0298A KRAMER G DVOG 016,02,005551 0005P
0298B EXPERIMENTS ON THE PERCEPTION OF ULTRA-SHORTWAVES BY BIRDS
0298Y NRC TT 1162, N65 28590

6089A KRICHAGIN V I LN62 000,00,000062 0000P
6089B PRACTICAL POINTS IN STANDARDIZATION OF RADIATION BY MICROWAVE FIELDS

0397A KRYLOV V A BOOK 000,00,000061 0017P
0397B SOLOVEY A P SAFETY MEASURES RECOMMENDED FOR WORK ON RADIO-FREQUENCY
0397C GENERATOR INSTALLATIONS
0397D STATE SCI TECH PUBL HOUSE MOSCOW
0397Y AD 292611, FTD TT 62 339 1+2+4

0299A KRYSTANOV L VMDE 000,04,004166 0006P
0299B GOSHEV K THE PERIPHERAL BLOOD CHARACTERISTICS OF PERSONNEL EXPOSED TO A
0299C SUPERHIGH-FREQUENCY ELECTROMAGNETIC FIELD
0299X 0042
0299Y ATD ABSTRACT

0239A KULAKOVA V V TIGT 000,02,007064 0005P
0239B THE EFFECT OF MICROWAVES IN THE CENTIMETER AND DECIMETER RANGE ON THE
0239C GENERAL AND SPECIALIZED PATTERNS OF APPETITE IN ANIMALS
0239X 0012
0239Y ATD ABSTRACT

6113A KULIKOVSKAYA YE L LN61 000,00,002661 0002P
6113X 0032

6110A KULIKOVSKAYA YE L LN61 000,00,000061 0000P
6110B THE PROBLEM OF MICROWAVE RADIATION OF SHIP CREWS OF THE CIVIL OCEAN FLEET
6110X 0032

6090A KULIKOVSKAYA YE L LN62 000,00,000062 0000P
6090B HIGH FREQUENCY ELECTROMAGNETIC FIELDS WITH MEDIUM AND SHORT WAVE RANGES
6090C ON NAVY SHIPS

0339A KUPALOV P S BOOK 000,00,000037 0000P
0339B THE BIOLOGICAL ACTION OF ULTRAHIGH FREQUENCIES (ULTRASHORT WAVES)
0339C ALL UNION INST EXP MED, MOSCOW 1937
0339X 0049

6137A LEBEDINSKIY A V LN37 000,00,004537 0010P
6137B THE PHYSIOLOGICAL MECHANISM INVOLVED IN THE ACTION OF HF/VHF ON THE
6137C ORGANISM OF ANIMALS AND MAN

0342A LETAVET A A ED BOOK 000,00,000060 0000P
0342B PHYSICAL FACTORS OF THE EXTERNAL ENVIRONMENT
0342C MOSCOW 1960
0342X 0012

0256A LETAVET A A ED TIGT 000,02,000064 0170P
0256B BIOLOGICAL EFFECTS OF RADIO-FREQUENCY FIELDS
0256X 0012
0256Y ATD ABSTRACTS OF MOST SECTIONS OF THIS BOOK

0346A LEVITINA N A BEBM 062,12,006466 0003P
0346B NONTHERMAL ACTION OF MICROWAVES ON THE CARDIAC RHYTHM OF THE FROG
0346X 0012, 0045
0346Y CONSULTANTS BUREAU TRANSL

6188A LINKE C A JURO 088,02,030362 0009P
6188B LOUNSBERRY W GOLDSCHMIDT V EFFECTS OF MICROWAVES ON NORMAL TISSUES
6188X 0677U 0679U,0678 ,0677U 0679U

0302A LIVANOV M N BEBM 049,05,006360 0005P
0302B TSYPIN A B GRIGORYEV YU G KHRUSHCHEV V G STEPANOV S M ANANYEV V M
0302C THE EFFECT OF ELECTROMAGNETIC FIELDS ON THE BIOELECTRIC ACTIVITY OF
0302D CEREBRAL CORTEX IN RABBITS
0302X 0009
0302Y ATD ABSTRACT

6290A LIVENSON A R NMTK 000,01,003159 0014P
6290B THE USE OF SHF-UHF ELECTROMAGNETIC FIELDS IN MEDICINE
6290X 0013
6290Y JPRS 9409

6015A LIVENSON A R SECT 000,00,023360 0006P
6015B HIGH FREQUENCY THERAPEUTIC APPARATUS
6015D IN BERG A I ELEKTRONIKA V MEDITSINE, MOSCOW-LENINGRAD, 1960
6015Y ATD ABSTRACT

0304A LIVENSON A R MDPR 000,11,001063 0008P
0304B DOSIMETRY METHODS IN MICROWAVE AND DECIMETER WAVE THERAPY
0304X 0013
0304Y JPRS 23167, N64 14920

0305A LIVENSON A R MDPR 018,06,001464 0007P
0305B ELECTRICAL PARAMETERS OF BIOLOGICAL TISSUE IN THE MICROWAVE RANGE
0305X 0013
0305Y JPRS 26191, TT 64 41450, N64 28092

0303A LIVENSON A R SECT 000,00,001964 0009P
0303B GAVRILIN V A AN APPARATUS FOR SYNCHRONIZED TREATMENT OF BIOLOGICAL
0303C OBJECTS WITH MODULATED MICROWAVES SINKHROIMPULS
0303D IN RECENT DEVELOPMENTS IN MEDICAL INSTRUMENTS, STATE SCI INST SCI TECH
0303E INFO MOSCOW 1964
0303Y JPRS 25587, TT 64 31859, N64 30396

6054A LOBANOVA YE A MS59 000,00,004659 0002P
6054B CHANGES OF THE CONDITIONED REFLEX ACTIVITY IN ANIMALS (RATS AND RABBITS)
6054C UNDER CONTINUOUS EXPOSURE TO CENTIMETER WAVES

0228A LOBANOVA YE A TIGT 000,02,001364 0007P
0228B CHANGES IN CONDITIONED REFLEX ACTIVITY OF ANIMALS EXPOSED TO VARIOUS
0[illegible] RANGES OF MICROWAVES
0[illegible]X 0012
0228Y ATD ABSTRACT

0240A LOBANOVA YE A TIGT 000,02,007564 0003P
0240B STUDY OF TEMPERATURE REACTION OF ANIMALS TO THE EFFECTS OF MICROWAVES OF
0240C VARIOUS WAVERANGES
0240X 0012
0240Y ATD ABSTRACT

0306A LOBANOVA YE A GTPZ 010,10,000766 0006P
0306B EFFECT OF CHRONIC EXPOSURE TO PULSED AND NONPULSED 10 CM WAVES ON THE
0306C CONDITIONED REFLEX ACTIVITY OF WHITE RATS
0306X 0012
0306Y JPRS 39820

6189A LUBIN M AAIH 021,00,055560 0004P
6189B CURTIS G W DUDLEY H R BIRD L E DALEY P F COGAN D G FRICKER S J EFFECTS
6189C OF ULTRA-HIGH-FREQUENCY RADIATION ON ANIMALS
6189X 0671 ,0630 ,0680 ,0613 ,0613 ,0630 0670 ,0613

0381A LUDFORD J F REPT 000,00,000068 0017P
0381B STATUS OF THE FIELD OF BIOLOGICAL EFFECTS OF RADIO-FREQUENCY RADIATION
0381X 0698

6[illegible] LYALINA O V MS37 000,00,000037 0000P
6118B HYPERGLYCEMIC REACTION TO ULTRAHIGH FREQUENCIES IN THE LIGHT OF DOSIMETRY

6248A MACHLE W PCMW 003,00,007159 0001P
6248B LANDEEN K THE EFFECT OF REPEATED MICROWAVE EXPOSURES ON THE FORMED
6248C ELEMENTS IN THE BLOOD OF RATS
6248X 0632

6228A MACMURRAY L C PCMW 002,00,007958 0009P
6228B MICROWAVE RADIATION HAZARDS PROBLEMS IN THE U S ARMY
6228X 0600

0394A MARHA K BOOK 000,00,000068 0130P
0394B MUSIL J HANA T THE ELECTROMAGNETIC FIELD AND LIFE ENVIRONMENT
0394C PRAGUE
0394X 0036
0394Y ATD ABSTR OF SOME SECTIONS

6294A MARKS J OSMJ 057,00,113261
6294B CARTER E T SCARPELLI D G EISEN J MICROWAVE RADIATION TO THE ANTERIOR
6294C MEDIASTINUM OF THE DOG-(II)
6294X 0713 0712 0714 0711 ,0716 0614 0672 ,0712 0711 ,0714 0715 0713 0711

6261A MCAFEE R D PCMW 003,00,031459 0018P
6[illegible] NEUROPHYSIOLOGICAL EFFECTS OF MICROWAVE IRRADIATION
6[illegible] 0635

6156A MCAFEE R D PCMW 004,00,025160 0010P
6156B BERGER C PIZZOLATO P NEUROLOGICAL EFFECT OF 3 CM MICROWAVE IRRADIATION
6156X 0685 0635

6191A MCAFEE R D AJPH 200,02,019261 0003P
6191B NEUROPHYSIOLOGICAL EFFECT OF 3-CM MICROWAVE RADIATION
6191X 0635 0685

6[illegible]A MCAFEE R D AJPH 203,02,037462 0005P
6[illegible] PHYSIOLOGICAL EFFECTS OF THERMODE AND MICROWAVE STIMULATION OF
61[illegible]C PERIPHERAL NERVES
6190X 0635 0685

6142A MEAHL H R PCMW 004,00,001560 0008P
6142B BASIC PROBLEMS IN MEASURING RF FIELD STRENGTH
6142X 0611

6151A MERMAGEN H PCMW 004,00,014360 0010P
6151B PHANTOM EXPERIMENTS WITH MICROWAVES AT THE UNIVERSITY OF ROCHESTER
6151X 0633

6158A MEROLA L PCMW 004,00,028560 0008P
6158B KINOSHITA J H CHANGES IN THE ASCORBIC ACID CONTENT IN LENSES OF RABBIT
6158C EYES EXPOSED TO MICROWAVE RADIATION
6158X 0630 0670

6237A MICHAELSON S PCMW 002,00,017558 0014P
6237B HOWLAND J W DUNDERO R REVIEW OF THE WORK CONDUCTED AT UNIVERSITY OF
6237C ROCHESTER (USAF SPONSORED)
6237X 0633

6272A MICHAELSON S M PICM 003,00,039960 0002P
6272B THOMSON R A E HOWLAND J W BIOMEDICAL ASPECTS OF MICROWAVE IRRADIATION OF
6[illegible]C MAMMALS
6[illegible]X 0633

6192A MICHAELSON S M AJPH 201,02,035161 0006P
6192B THOMSON R A HOWLAND J W PHYSIOLOGIC ASPECTS OF MICROWAVE IRRADIATION OF
6192C MAMMALS
6192X 0633

0307A MICHAELSON S M AERM 035,03,082464 0006P
0307B THOMSON R A E EL TAMAMI M Y SETH H S HOWLAND J W HEMATOLOGIC EFFECTS OF
0307C MICROWAVE EXPOSURE
0307X 0633

0308A MICHAELSON S M AERM 038,03,029367 0006P
0308B THOMSON R A E QUINLAN W J JR EFFECTS OF ELECTROMAGNETIC RADIATIONS ON
0308C PHYSIOLOGIC RESPONSES
0308X 0633

0390A MICHAELSON S M REPT 000,00,000067 0128P
0390B THOMSON R A E HOWLAND J W BIOLOGICAL EFFECTS OF MICROWAVE EXPOSURE
0390X 0633
0390Y AD 824242L, RADC TR 67 461, UR 49 810, IN BIBL ITEM 6182 ANON. N68 36350

6123A MINECKI L REPT 000,00,000062 0000P
6123B CHANGES IN ACTIVITY OF CHOLINESTERASE IN MICE SUBJECTED TO SINGLE AND
6[illegible]C REPEATED ACTION OF MICROWAVES
6[illegible]D THE 6TH POLISH CONFERENCE OF OCCUPATIONAL MEDICINE 1962

6124A MINECKI L REPT 000,00,000062 0000P
6124B THE THERMAL EFFECT OF MICROWAVE RADIATION
6124C THE 6TH POLISH CONFERENCE OF OCCUPATIONAL MEDICINE 1962

0266A MINECKI L AHRT 015,00,004764 0009P
0266B CRITICAL EVALUATION OF MAXIMUM PERMISSIBLE LEVELS OF MICROWAVE RADIATION
0266X 0014
0266Y ARTICLE IN ENGLISH

6170A MINTZ M TREC 007,02,017965 0005P
6[illegible]B HEIMER G NEW TECHNIQUES FOR MICROWAVE RADIATION HAZARD MONITORING
[illegible]X 0663 ,0664

6016A MIRUTENKO V I FZKR 008,03,038262 0008P
6016B INVESTIGATING LOCAL THERMAL EFFECT OF ELECTROMAGNETIC 3 CM WAVES ON
6016C ANIMALS
6016X 0015
6016Y FTD TT 62 1361 1+2, AD 292205

6038A MIRUTENKO V I SECT 000,00,006264 0018P
6038B THE THERMAL EFFECT OF THE ACTION OF A SHF/UHF ELECTROMAGNETIC FIELD
6038C ON ANIMALS AND CERTAIN PROBLEMS OF DOSIMETRY OF A SHF/UHF FIELD
6038C IN GORODETSKIY 1964
6038X 0015
6038Y JPRS 30860, N65 28705

0337A MIRUTENKO V I FZKR 010,05,064164 0006P
0337B EFFECT OF BLOOD CIRCULATION ON THE DISTRIBUTION OF HEAT AND THE MAGNITUDE
0337C OF THE THERMAL EFFECT DURING ACTION OF A SUPERHIGH-FREQUENCY
0337C ELECTROMAGNETIC FIELD ON ANIMALS
0337X 0015
0337Y JPRS 27982

6037A MIRUTENKO V I SECT 000,00,007965 0004P
60[illegible]B HEAT DISTRIBUTION IN THE ORGANS AND TISSUES OF ANIMALS EXPOSED TO A UHF
6[illegible] ELECTROMAGNETIC FIELD
60[illegible]D IN PROBS BIOPHYSICS AND MECHANISM OF ACTION OF IONIZING RADIATION
6037D KIEV, ZDOROVYA, 1965
6037Y TRANSL AVAIL OF ABSTRACT FROM REF ZH BIOL NO 15 1965 ABST 15P466

0309A MONAYENKOVA A M GTPZ 010,07,001866 0004P
0309B SADCHIKOVA M A HEMODYNAMIC INDICES UNDER EXPOSURE TO THE ACTION OF
0309C MICROWAVE ELECTROMAGNETIC FIELDS
0309X 0012
0309Y JPRS 38663

0388A MOORE W JR REPT 000,00,000068 0025P
0388B LITERATURE SURVEY-BIOLOGICAL ASPECTS OF MICROWAVE RADIATION - A REVIEW
0388C OF HAZARDS
0388X 0697
0388Y IN BIBLIO ITEM 6182 ANON

0310A MOSKALENKO YU YE SECT 000,00,020760 0012P
0310B CLINICAL AND BIOLOGICAL APPLICATION OF SHF/UHF ELECTROMAGNETIC FIELDS
0310D IN BERG A I ELEKTRONIKA V MEDITSINE, MOSKOW-LENINGRAD, 1960
0310Y ATD ABSTRACT

6238A NIESET R T PCMW 002,00,020258 0013P
6238B BAUS R MCAFEE R D FRIEDMAN J J HYDE A S FLEMING J D REVIEW OF THE WORK
6238C CONDUCTED AT TULANE UNIVERSITY (USN SPONSORED)
6[illegible] 0635

6193A NIESET R T ICBE 000,00,000659 0006P
6193B MCAFEE R D BAUS R FLEMING J D PINNEO L R NEURAL EFFECTS OF MICROWAVE
6193C RADIATION
6193X 0635 ,0635 ,0635 ,0635 ,0307 0653U

6056A NIKOGOSYAN S V MS59 000,00,005159 0001P

6091A NIKOGOSYAN S V LN62 000,00,003362 0002P
6091B THE EFFECT OF CENTIMETER AND DECIMETER WAVES ON THE CONTENT OF PROTEIN
6091C AND PROTEIN FRACTIONS IN THE BLOOD SERUM OF ANIMALS

0233A NIKOGOSYAN S V TIGT 000,02,004364 0006P
0233B A STUDY OF CHOLINESTERASE ACTIVITY IN THE BLOOD SERUM AND ORGANS OF
0233C ANIMALS SUBJECTED TO THE CHRONIC EFFECTS OF MICROWAVES
0233X 0012
0233Y ATD ABSTRACT

0237A NIKOGOSYAN S V TIGT 000,02,006664 0002P
0237B EFFECTS OF 10 CM WAVES ON THE CONTENT OF NUCLEIC ACIDS IN ANIMAL ORGANS
0237X 0012
0237Y ATD ABSTRACT

0347A NIKOGOSYAN S V BEBM 064,09,005667 0003P
0347B CHANGES IN PROTEIN METABOLISM UNDER CHRONIC EXPOSURE TO 10 CM LOW
0347C INTENSITY WAVES
0347X 0012
0347Y ATD ABSTRACT

6073A NIKONOVA K V SECT 000,00,016360 0008P
6073B THE PROBLEM OF LABOR HYGIENE DURING WORK WITH HIGH FREQUENCY GENERATORS
6073C IN THE ELECTROVACUUM INDUSTRY
6073D IN LETAVET A A PHYSICAL FACTORS OF THE ENVIRONMENT MOSCOW 1960

0234A NIKONOVA K V TIGT 000,02,004964 0008P
0234B EFFECTS OF HIGH FREQUENCY ELECTROMAGNETIC FIELDS ON THE FUNCTIONS OF THE
0234C NERVOUS SYSTEM
0234X 0012
0234Y ATD ABSTRACT

0236A NIKONOVA K V TIGT 000,02,006164 0005P
0236B EFFECTS OF HIGH FREQUENCY ELECTROMAGNETIC FIELDS ON BLOOD PRESSURE AND
0236C BODY TEMPERATURE OF EXPERIMENTAL ANIMALS
0236X 0012
0236Y ATD ABSTRACT

6126A OBROSOV A N SECT 000,00,019760 0010P
6126B BASIC TRENDS IN THE APPLICATION OF ELECTRONICS IN PHYSIOTHERAPY
6126D IN BERG A I ELEKTRONIKA V MEDITSINE, MOSKOW-LENINGRAD, 1960
6126Y ATD ABSTRACT

6194A OLDENDORF W H PSEB 072,00,043249 0003P
6194B FOCAL NEUROLOGICAL LESIONS PRODUCED BY MICROWAVE IRRADITION
6194X 0682

6129A ORLOVA A A MS57 000,00,006557 0001P
6129B THE ACTION OF ULTRAHIGH AND HIGH FREQUENCY FIELDS ON THE INTERNAL ORGANS

6048A ORLOVA A A MS59 000,00,002559 0002P
6048B CLINICAL ASPECTS OF CHANGES IN THE INTERNAL ORGANS DURING EXPOSURE TO
6048C RADIOWAVES OF VARIOUS FREQUENCIES

6074A ORLOVA A A SECT 000,00,017160 0006P
6074B THE CONDITION OF THE CARDIOVASCULAR SYSTEM DURING EXPOSURE TO UHF/SHF AND
6074C HIGH FREQUENCY FIELDS
6074D IN LETAVET A A PHYSICAL FACTORS OF THE ENVIRONMENT MOSCOW 1960

6268A OSBORNE S L BOOK 000,00,000044 0799P
6268B HOLMQUEST H J TECHNIC OF ELECTROTHERAPY AND ITS PHYSICAL AND
6268C PHYSIOLOGICAL BASIS
6268D CHAS C THOMAS PUBL BALTIMORE MD
6268X 0683

6[illegible]A OSBORNE S L JAMA 137,12,103748 0005P
6195B FREDERICK J N HEATING OF HUMAN AND ANIMAL TISSUES BY MEANS OF HIGH
6195C FREQUENCY CURRENT WITH WAVELENGTH OF TWELVE CENTIMETERS (THE MICROTHERM)
6195X 0683

6067A OSIPOV YU A MS59 000,00,000059 0000P
6067B KULIKOVSKAYA YE L KALYADA T V

6111A OSIPOV YU A LN61 000 00 000061 0000P
6111B KALYADA T V KULIKOVSKAYA YE L PROBLEMS OF INDUSTRIAL HYGIENE IN WORK
6111C WITH CENTIMETER RADIOWAVE MEASURING GENERATORS
6111X 0032

6092A OSIPOV YU A LN62 000,00,000062 0000P
6092B KALYADA T V MATERIALS OF AN EXPERIMENTAL RESEARCH INTO THE EFFECTS OF
6092C LOW INTENSITY CENTIMETER WAVES ON MAN

0311A OSIPOV YU A GISA 000,10,007363 0006P
0311B KALYADA T V TEMPERATURE REACTION OF THE SKIN DURING IRRADIATION WITH
311C MICROWAVES OF LOW INTENSITY
0311X 0032
0311Y JPRS 23287, OTS 64 21594, N64 15335

61[illegible]A OVERMAN H S PCMW 004,00,004760 0008P
[illegible] QUICK FORMULAS FOR RADAR SAFE DISTANCES
6[illegible]X 0692

6068A PALADIN A M MS59 000,00,000059 0000P
6068B SPASSKAYA I M YAKUBOVICH R S

0313A PALIYEV B VMOE 021,04,003466 0008P
0313B GOSHEV K EKG CHANGES OCCURRING UNDER THE EFFECTS OF A SHF-UHF
0313C ELECTROMAGNETIC FIELD
0313X 0042
0313Y ATD ABSTRACT

0338A PALMISANO W A MIME 131,07,061166 0008P
0338B PECZENIK A SOME CONSIDERATIONS OF MICROWAVE HAZARDS EXPOSURE CRITERIA
0338X 0702 ,0703

0314A PANOV A G VMZH 000,09,001366 0004P
0314B SYMPTOMATOLOGY, CLASSIFICATION AND EXPERTISE OF UHF AFTEREFFECTS ON THE
0314C HUMAN ORGANISM
0314Y ATD ABSTRACT

6161A PAYNE J N PCMW 004,00,031960 0088P
6161B SIMILARITIES AND DIFFERENCES BETWEEN TECHNICAL ASPECTS OF THE NAVY HERO
6161C PROGRAM FOR ORDNANCE AND THE PERSONNEL HAZARD PROGRAM
61[illegible] 0692

60[illegible] PERVUSHIN V YU TVMA 073 00 014157 0011P
6041B TRIUMFOV A V MORPHOLOGICAL CHANGES OF CERTAIN ORGANS IN ANIMALS
6041C SUBJECTED TO SHF-UHF FIELDS
6041X 0021

6002A PETROV I R VMZH 000,09,002664 0006P
6002B SUBBOTA A G MECHANISM OF THE ACTION OF UHF/SHF ELECTROMAGNETIC RADIATION
6002X 0021
6002Y ATD ABSTRACT

0277A PETROV I R VMZH 000,02,001666 0006P
0277B SUBBOTA A G EFFECT OF THE UHF/SHF FREQUENCY ELECTROMAGNETIC RADIATION ON
0277C THE ORGANISM
0277X 0021
0277Y ATD ABSTRACT

0315A PETROV I R VMZH 000,04,002067 0002P
0315B YAROKHNO N YA INCREASED RESISTANCE TO SHF/UHF IRRADIATION UNDER
0315C CONDITIONS OF SYSTEMATIC MUSCULAR ACTIVITY
0315Y ATD ABSTRACT

0316A PETROV I R VMZH 000,07,002667 0005P
0316B YAROKHNO N YA COMBINED EFFECT OF SHF/UHF ELECTROMAGNETIC WAVES AND LOW
0316C OXYGEN GAS MIXTURE RESPIRATION ON ANIMAL ORGANISMS
0316Y ATD ABSTRACT

6257A PISH G PCMW 003,00,025159 0020P
6257B STOREY W H TRUBY F ROLLWITZ W A PRELIMINARY INVESTIGATION OF THE
6257C APPLICATION OF MAGNETIC RESONANCE ABSORPTION SPECTROSCOPY TO THE STUDY OF
6257D THE EFFECTS OF MICROWAVES ON BIOLOGIC MATERIALS
6257X 0627

6196A PISH G ICBE 000,00,003359 0004P
6196B STOREY W H TRUBY F K PRELIMINARY INVESTIGATION OF THE APPLICATIONS OF
6196C MAGNETIC RESONANCE ABSORPTION SPECTROSCOPY TO THE STUDY OF THE EFFECTS
6196D OF MICROWAVES ON BIOLOGICAL MATERIALS
6196X 0627

6058A PITENIN I V MS59 000,00,005459 0001P

6093A PITENIN I V LN62 000,00,003662 0003P
6093B PATHOLOGICAL ANATOMICAL CHANGES IN ANIMAL ORGANS AND TISSUES DURING THE
6093C INFLUENCE OF A UHF/SHF ELECTROMAGNETIC FIELD

6006A PITENIN I V BEBM 060,09,005565 0005P
6006B SUBBOTA A G FORMATION OF GASTRIC ULCER IN RABBITS FOLLOWING MICROWAVE
6006CIRRADIATION OF THE EPIGASTRIUM
6006X 0021
6006Y CONSULTANTS BUREAU TRANSL

6094A PIVIVAROV M A LN62 000,00,000062 0000P
6094B THE EFFECT OF MICROWAVE FIELDS OF LOW INTENSITY ON SOME ANALYZERS OF MAN

6001A POVZHITKOV V A BEBM 051,05,010361 0005P
6001B TYAGIN N V GREBENSHCHIKOVA A M THE INFLUENCE OF A SHF-UHF PULSED
6001C ELECTROMAGNETIC FIELD ON CONCEPTION AND THE COURSE OF PREGNANCY IN WHITE
6001D MICE
6001X 0021
6001Y CONSULTANTS BUREAU TRANSL

6244A PRAUSNITZ S PCMW 003,00,003359 0013P
6244B SUSSKIND C TEMPERATURE REGULATION IN LABORATORY ANIMALS IRRADIATED WITH
6244C 3 CM MICROWAVES
6244X 0629

6150A PRAUSNITZ S PCMW 004,00,013560 0008P
6150B SUSSKIND C VOGELHUT P O LONGEVITY AND CELLULAR STUDIES WITH MICROWAVES
6150X 0629

0312A PRESMAN A S GISA 000,09,003256 0006P
0312B THE ELECTROMAGNETIC FIELD AS A HYGIENIC FACTOR
03[illegible] 0012
0[illegible] ATD TRANSL

0349A PRESMAN A S BEBM 043 02 005157 0004P
0349B TEMPERATURE CHANGES OF THE HUMAN SKIN IRRADIATED WITH LOW INTENSITY WAVES
0349C SEVERAL CENTIMETERS IN LENGTH
0349X 0012
0349Y CONSULTANTS BUREAU TRANSL

6072A PRESMAN A S SECT 000,00,014260 0010P
6072B A HYGIENIC EVALUATION OF HIGH FREQUENCY ELECTROMAGNETIC FIELDS
6072D IN LETAVET A A PHYSICAL FACTORS OF THE ENVIRONMENT MOSCOW 1960

0351A PRESMAN A S BIFR 008 01 013863 0003P
0351B EXCITABILITY IN PARAMECIUM STIMULATED WITH DC AND AC PULSES
0351X 0016
0351Y PERGAMON PRESS TRANSL

0395A PRESMAN A S BOOK 000,00,000068 0287P
0395B ELECTROMAGNETIC FIELDS AND ANIMATE NATURE
0395C NAUKA PUBL HOUSE MOSCOW
0395X 0016U

6277A PUHARICH H K REPT 000,00,000064 0077P
62[illegible] LAWRENCE J L ELECTRO-STIMULATION TECHNIQUES OF HEARING
6[illegible] 0704
62[illegible] AD 459956, RADC TDR 64 18

6266A PUSCHER H BOOK 000,00,000066 0337P
6266B HEATING WITH MICROWAVES - FUNDAMENTALS COMPONENTS AND CIRCUIT TECHNIQUE
6266C SPRINGER-VERLAG NEW YORK

6147A REYNOLDS M R PCMW 004,00,007160 0014P
6147B DEVELOPMENT OF A GARMENT FOR PROTECTION OF PERSONNEL WORKING IN HIGH
6147C POWER RF ENVIRONMENTS
6147X 0693

6220A RICHARDSON A W PCMW 001,00,010957 0002P
6220B ABSTRACT OF REPORT ON PATHOLOGIC EFFECTS OF THREE CENTIMETER MICROWAVES
6220C OF LOW MAGNITUDE AND DEMONSTRATION OF DOSIMETERS TO ASSAY ACCUMULATED
6220D MICROWAVE ENERGY
6220X 0636

6236A RICHARDSON A W PCMW 002,00,016958 0006P
6236B REVIEW OF THE WORK CONDUCTED AT UNIVERSITY OF ST LOUIS (USN SPONSORED)
6236X 0636

6256A RICHARDSON A W PCMW 003,00,024459 0007P
6256B NEW MICROWAVE DOSIMETRY AND THE PHYSIOLOGIC NEED
62[illegible] 0636

61[illegible] RICHARDSON A W ARPM 029,00,076548 0005P
6197B DUANE T D HINES H M EXPERIMENTAL LENTICULAR OPACITIES PRODUCED BY
6197C MICROWAVE IRRADIATIONS
6197X 0631

6198A RICHARDSON A W   AAOP 045,00,038251   0005P
6198B DUANE T D HINES H M EXPERIMENTAL CATARACT PRODUCED BY THREE CENTIMETER
6198C PULSED MICROWAVE IRRADIATIONS
6198X 0631

6[illegible] RICHTER W R   REPT 000,00,000064   0012P
60[illegible]B EFFECTS OF RF ENERGY ON TISSUE CULTURES
6031X 0602
6031Y AD 440272, U S ARMY MED RES LAB REPT 600

6052A ROGOVAYA T Z   MS59 000,00,003459   0001P
6052B TROITSKIY S A LASHCHENKO N S THE STATE OF HEALTH OF WORKERS HAVING A
6052C LASTING CONTACT WITH HIGH FREQUENCY POINTS

6242A ROLLWITZ W L   PCMW 002,00,025458   0011P
6242B REVIEW OF THE WORK CONDUCTED AT SOUTHWEST RESEARCH INSTITUTE (USAF
6242C SPONSORED)
6242X 0627

6227A ROMAN J   PCMW 002,00,007058   0009P
6227B RADIO FREQUENCY HAZARDS ABOARD NAVAL SHIPS
6227X 0664

6132A SADCHIKOVA M N   MS57 000,00,000057   0000P

6075A SADCHIKOVA M A   SECT 000,00,017760   0007P
6075B STATE OF THE NERVOUS SYSTEM UNDER THE INFLUENCE OF UHF/SHF FIELDS
6075D IN LETAVET A A PHYSICAL FACTORS OF THE ENVIRONMENT MOSCOW 1960

0[illegible] SADCHIKOVA M A   TIGT 000,02,011064   0004P
0[illegible] CLINICAL ASPECTS OF CHANGES WITHIN THE NERVOUS SYSTEM INDUCED BY THE
0246C ACTION OF RADIO WAVES OF VARIOUS RANGES
0246X 0012
0246Y ATD ABSTRACT

6017A SAITO M   BIPJ 006,05,031366   0014P
6017B SCHWAN H P SCHWARZ G RESPONSE OF NONSPHERICAL BIOLOGICAL PARTICLES TO
6017C ALTERNATING ELECTRIC FIELDS
6017X 0645

6199A SALATI O M   ICBE 000,00,002659   0005P
6199B MICROWAVE ABSORPTION MEASUREMENTS
6199X 0645

0317A SALATI O M   ENID 000,11,009662   0006P
0317B ANNE A SCHWAN H P RADIO FREQUENCY RADIATION HAZARDS
0317X 0645

6252A SALATI O M   PCMW 003,00,010759   0006P
6252B SCHWAN H P A TECHNIQUE FOR RELATIVE ABSORPTION CROSS-SECTION
6252C DETERMINATION
6252X 0645

0356A SCHLIEPHAKE E   BOOK 000,00,000035   0238P
0[illegible] SHORT WAVE THERAPY-THE MEDICAL USE OF ELECTRICAL HIGH FREQUENCIES
0[illegible] ACTINIC PRESS, LONDON, 1935
0356D AUTHORIZED ENGLISH TRANSL OF SECOND AND ENLARGED GERMAN EDITION
0356X 0305

6215A SCHWAN H P PCMW 001,00,006057 0004P
6[illegible] THE PHYSIOLOGICAL BASIS OF RF INJURY - ABSTRACT
6[illegible] 0645

6224A SCHWAN H P PCMW 002,00,003358 0016P
6224B MOLECULAR RESPONSE CHARACTERISTICS TO ULTRAHIGH FREQUENCY FIELDS
6224X 0645

6234A SCHWAN H P PCMW 002,00,012658 0010P
6234B SURVEY OF MICROWAVE ABSORPTION CHARACTERISTICS OF BODY TISSUES
6234X 0645

6251A SCHWAN H P PCMW 003,00,009459 0013P
6251B THEORETICAL CONSIDERATIONS PERTAINING TO THERMAL DOSE METERS
6251X 0645

6019A SCHWAN H P REPT 000,00,000064 0013P
6019B NON-THERMAL EFFECTS OF ALTERNATING ELECTRICAL FIELDS ON BIOLOGICAL
6019C STRUCTURES
6019D FINAL REPORT-ABSTRACT-BY U PENN UNDER CONTRACT NONR 551 05
6019X 0645
6019Y AD 600263

0319A SCHWAN H P PIRE 041,11,173553 0006P
0319B LI K CAPACITY AND CONDUCTIVITY OF BODY TISSUES AT ULTRAHIGH FREQUENCIES
03[illegible]X 0645

6[illegible]A SCHWAN H P APMR 036,00,036355 0008P
6202B LI K VARIATIONS BETWEEN MEASURED AND BIOLOGICALLY EFFECTIVE MICROWAVE
6202C DIATHERMY DOSAGE
6202X 0645

0267A SCHWAN H P PIRE 044,11,157256 0010P
0267B LI K HAZARDS DUE TO TOTAL BODY IRRADIATION BY RADAR
0267X 0645

6253A SCHWAN H P PCMW 003,00,011359 0011P
6253B PAULY H ELECTRICAL SUBSTITUTES FOR HUMAN TISSUE
6253X 0645 ,0308

6200A SCHWAN H P RPMR 033,00,037154 0034P
6200B PIERSOL G M THE ABSORPTION OF ELECTROMAGNETIC ENERGY IN BODY TISSUES -
6200C PART 1 BIOPHYSICAL ASPECTS
6200X 0645

6201A SCHWAN H P RPMR 034,00,042555 0004P
6201B PIERSOL G M THE ABSORPTION OF ELECTROMAGNETIC ENERGY IN BODY TISSUES -
6201C PART 2 PHYSIOLOGICAL AND CLINICAL ASPECTS
6201X 0645

0320A SCHWARTZKOPFF J DVOG 015,03,019450 0003P
0[illegible] ON THE QUESTION OF THE PERCEPTION OF ULTRA-SHORTWAVES BY MIGRATORY BIRDS
0[illegible]L NRC TRANS TT-1161 N65 28515

6018A SCHWARZ G JCHP 043,10,356266 0008P
6[illegible] SAITO M SCHWAN H P ON THE ORIENTATION OF NONSPHERICAL PARTICLES IN AN
6[illegible] ALTERNATING ELECTRICAL FIELD
6018D U PENN REPT NO 1 UNDER CONTRACT NONR 551 52
6018X 0645
6018Y AD 631617

0321A SEMENOV N V BEBM 000,04,001765 0003P
0321B ELIMINATION OF HYPOTHERMIA IN DOGS BY MEANS OF HIGH FREQUENCY CURRENTS
0321X 0054
0321Y FTD TRANS TT 65 31496, JPRS 30998, N65 28140

6045A SENKEVECH A I MS59 000,00,000659 0001P

6152A SEARLE G W PCMW 004,00,018660 0014P
6152B DAHLEN R W IMIG C J WUNDER C C THOMSON J D THOMAS J A MORESSI W J
6152C EFFECTS OF 2450 MC MICROWAVES IN DOGS, RATS AND LARVAE OF THE COMMON
6152D FRUIT FLY
6152X 0631

6246A SEARLE G W PCMW 003,00,005459 0008P
6246B IMIG C J DAHLEN R W STUDIES WITH 2450 MC-CW EXPOSURE TO THE HEADS OF
6246C DOGS
6246X 0631

62[illegible] SEDUNOV B I USPF 079,03,061763 0023P
62[illegible] FRANK KAMENETSKII D A DIELECTRIC CONSTANTS OF BIOLOGICAL OBJECTS
6291Y AM INST PHYS TRANSL VOL 6 NO 2 PP 279-293

6203A SETH H S JOMD 007,09,043965 0004P
6203B MICHAELSON S M MICROWAVE CATARACTOGENESIS
6203X 0633

0389A SETTER L R REPT 000,00,000068 0081P
0389B SNAVELY D R SOLEM D L VAN WYE R F AN ANNOTATED BIBLIOGRAPHY OF
0389C REGULATIONS STANDARDS AND GUIDES FOR MICROWAVES ULTRAVIOLET RADIATION AND
0389D RADIATION FROM LASERS AND TELEVISION RECEIVERS
0389X 0697
0389Y IN BIBLIO ITEM 6182 ANON

6005A SEVASTYANOV V V VMZH 000,07,002165 0005P
6005B MEASUREMENT OF UHF/SHF ELECTROMAGNETIC RADIATION INTENSITIES AND THE
6005C PROBLEM OF THEIR HYGIENIC APPRAISAL
6005Y ATD ABSTRACT

0322A SHERESHEVSKAYA L VOFT 000,03,000566 0005P
0322B CENTIMETER-BAND THERAPY OF DISTROPHY OF THE MACULA LUTEA AND UVEITIS
0322X 0034

0323A SHEYVEKHMAN B YE PFAR 001,00,012249 0006P
03[illegible] EFFECT OF THE ACTION OF A VHF-HF FIELD ON THE AUDIO (AURAL)
0[illegible] SENSITIVITY DURING APPLICATION OF ELECTRODES IN THE ZONE OF PROJECTION OF
032[illegible] THE AURAL ZONE OF THE CORTEX (LAMELLA OF TEMPORAL BONE)
0323Y AD 281129, FTD TT 62 491/1+2

0324A SLINEY D H REPT 000,00,000067 0037P
0324B PALMISANO W A MICROWAVE HAZARDS BIBLIOGRAPHY - APRIL1967
0324X 0695
0324Y AD 652708, N67 32384

6[illegible] SMIRNOVA M I LN62 000,00,000062 0000P
60[illegible]B SADCHIKOVA M N

6071A SMUROVA YE I MS59 000,00,000059 0000P
6071B OCCUPATIONAL HYGIENE PROBLEMS IN AREAS WHERE HIGH FREQUENCY CURRENTS ARE
6071C USED

0326A SMUROVA YE I GTPZ 010,01,001766 0000P
0326B HEALTH CHARACTERISTICS OF CONDITIONS FOR MEDICAL PERSONNEL WORKING WITH
0326C SOURCES OF RADIO FREQUENCY RANGE ELECTROMAGNETIC FIELDS
0326Y JPRS 35648, TT 66 32083

0325A SMUROVA YE I GISA 032,06,000067 0000P
0325B CHANGES IN THE PHAGOCYTIC AND BACTERICIDAL FUNCTIONS OF THE BLOOD IN
0325C ANIMALS EXPOSED TO ELECTROMAGNETIC FIELDS AT RADIO FREQUENCIES
0325X 0011
0325Y TT 67 51409 2

0327A SMUROVA YE I GTPZ 006,05,002262 0007P
0327B ROGOVAYA T Z TROITSKIY A S LASHCHENKO N S MELNIKOVA N D
0327C PROBLEMS OF OCCUPATIONAL HYGIENE AND HEALTH STATUS OF OPERATORS EXPOSED
0327D TO THE EFFECTS OF HIGH FREQUENCY CURRENTS
0327Y JPRS 14925, N62 14907

6[illegible] SOKOLOV V V LN62 000,00,004862 0001P
6[illegible] THE EFFECT OF CENTIMETER WAVES OF VARYING INTENSITY ON BLOOD

0249A SOKOLOV V V TIGT 000,02,012264 0004P
0249B CHULINA N A PERIPHERAL BLOOD COUNT UNDER THE ACTION OF RADIO WAVES OF
0249C VARIOUS RANGES UPON THE ORGANISM
0249X 0012
0249Y ATD ABSTRACT

8011A SOLOVTSOVA K M FZKR 011,04,049865 0006P
8011B EFFECT OF ELECTROMAGNETIC HIGH-FREQUENCY OSCILLATIONS ON THE FUNCTIONING
8011C OF THE LIVER IN PERSONS WITH A NORMAL OR MODERATELY PATHOLOGICAL
8011C FUNCTIONAL STATE OF THIS ORGAN
8011X 0015
8011Y ATD ABSTRACT

8015A SOMMER H C AERM 035,09,083464 0006P
8015B VON GIERKE H E HEARING SENSATIONS IN ELECTRIC FIELDS
8015X 0605

6214A SPENCER J L PCMW 001,00,005257 0008P
6214B KNAUF G M EXPOSURE OF AIR FORCE PERSONNEL TO IONIZING RADIATION PRODUCED
6214C BY RADIO FREQUENCY GENERATORS - SUMMARY
6214X 0688

6[illegible] STEPHENS F ICBE 000,00,004259 0004P
6[illegible] EQUIPMENT AND METHODS EMPLOYED IN THE EXPOSURE OF EXPERIMENTAL ANIMALS
6204C TO MICROWAVES AT 24000 MEGACYCLES
6204X 0632

0328A STODOLNIK BARANSKANATL 214,00,010267 0002P
0328B LYMPHOBLASTOID TRANSFORMATION OF LYMPHOCYTES IN VITRO AFTER MICROWAVE
0328C IRRADIATION
0328X 0050

0271A SUBBOTA A G TVMA 073,00,003557 0003P
0271B THE EFFECT OF UHF/SHF ELECTROMAGNETIC FIELDS UPON THE HIGHER NERVOUS
0271C ACTIVITY OF DOGS
0271X 0021
0271Y TRANSL AVAIL OF ABSTRACT FROM REF ZH BIOL 1959 NO 46203

0272A SUBBOTA A G TVMA 073,00,007857 0006P
0272B CHANGES IN RESPIRATION,PULSE RATE AND GENERAL BLOOD PRESSURE DURING
0272C IRRADIATION OF ANIMALS WITH AN UHF/SHF FIELD
0272X 0021
0272Y TRANSL AVAIL OF ABSTRACT FROM REF ZH BIOL 1959 NO 59927

0273A SUBBOTA A G TVMA 073,00,011157 0005P
0273B THE EFFECT OF A UHF/SHF FIELD ON HEART FUNCTION AND THE LUMEN OF VESSELS
0273X 0021
0273Y TRANSL AVAIL OF ABSTRACT FROM REF ZH BIOL 1959 NO 59926

0275A SUBBOTA A G TVMA 073,00,012757 0006P
0275B EFFECT ON THE BLOOD OF ANIMALS OF EXPOSURE TO A STRONG UHF/SHF FIELD
0275X 0021
0275Y TRANSL AVAIL OF ABSTRACT FROM REF ZH BIOL 1959 NO 59922

0276A SUBBOTA A G BEBM 046,10,005558 0007P
0276B THE EFFECT OF PULSED UHF/SHF ELECTROMAGNETIC FIELDS ON THE HIGHER NERVOUS
0276C ACTIVITY OF DOGS
0276X 0021
0276Y ATD ABSTRACT

6069A SUBBOTA A G MS59 000,00,000059 0000P

6096A SUBBOTA A G LN62 000,00,004962 0003P
6096B SOME PROBLEMS OF ADJUSTMENT AND ACCUMULATION UNDER MULTIPLE EXPOSURES TO
6096C MICROWAVES

6245A SUSSKIND C PCMW 003,00,004659 0008P
6245B VOGELHUT P O ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF UNICELLULAR
6245C ORGANISMS WITH 3 CM MICROWAVES
6245X 0629

6020A SUSSKIND C REPT 000,00,000063 0028P
6020B VOGELHUT P O BIOLOGICAL USES OF NONIONIZING RADIATION
6020C ANNUAL SCIENTIFIC REPORT 1962-63 ON CONTRACT NO NONR 222 92
6020X 0629
6020Y AD 433659, REPT NO 63-27

6097A SVETLOVA Z P LN62 000,00,004362 0002P
6097B CHANGES IN THE SYMMETRICAL CONDITIONED AND UNCONDITIONED REFLEXES IN DOGS
6097C UNDER THE INFLUENCE OF A UHF/SHF FIELD IN THE DECIMETER RANGE

6139A SYNGAYEVSKAYA V A MS59 000,00,000059 0000P
6139B SINENKO G F

6205A SUSSKIND C ICBE 000,00,001859 0001P
6205B SUMMARY OF THE RESEARCH PERFORMED AT THE UNIVERSITY OF CALIFORNIA
6205X 0629

6104A SYNGAYEVSKAYA V A LN62 000,00,005262 0002P
6104B SOME METABOLIC INDICES IN THE BLOOD AND URINE OF INDIVIDUALS FOLLOWING
6104C THEIR EXPOSURE TO UHF/SHF

6[illegible]A SYNGAYEVSKAYA V A LN62 000,00,000062 0000P
[illegible]B IGNATYEVA O S PLECKENA SINENKO G F

6098A SYNGAYEVSKAYA V A LN62 000,00,005162 0002P
6098B SINENKO G F IGNATYEVA O S THE EFFECT OF MICROWAVE RADIATION IN THE METER
6098C AND DECIMETER WAVERANGES ON THE ENDOCTINE REGULATION OF CARBOHYDRATE
6098D METABOLISM AND THE FUNCTIONAL STATE OF ADRENAL CORTEX IN RABBITS AND DOGS

6099A SYNGAYEVSKAYA V A LN62 000,00,005262 0001P
6099B IGNATYEVA O S

6140A TALLMAN O G PCMW 004,00,000360 0005P
6140B RADIO FREQUENCY ENVIRONMENT
6140X 0622

0329A TANNER J A NATL 216,00,113967 0001P
0329B ROMERO-SIERRA C DAVIE S J NON-THERMAL EFFECTS OF MICROWAVE RADIATION ON
0329C BIRDS
0329X 0302

6273A TAYLOR F J D PICM 003,00,039360 0006P
6273B FLOYD C F RAWLINSON W A SOME ASPECTS OF THE MEASUREMENT OF POTENTIALLY
6273C HAZARDOUS ELECTROMAGNETIC FIELDS
6273X 0309

6[illegible] TEIXEIRA-PINTO A ICBE 000,00,003159 0002P -
62[illegible]B CUTLER J L HELLER J H REVIEW OF WORK ACCOMPLISHED AT THE NEW ENGLAND
6206C INSTITUTE FOR MEDICAL RESEARCH
6206X 0641

0330A THOMSON R A E AERM 038,03,025267 0004P
0330B MICHAELSON S M HOWLAND J W MICROWAVE RADIATION AND ITS EFFECT ON RESPONSE
0330C TO X-RADIATION
0330X 0633

6133A TOLGSKAYA M S MS57 000,00,000057 0000P
6133B GORDON Z V LOBANOVA YE A

0242A TOLGSKAYA M S TIGT 000,02,008064 0009P
0242B COMPARATIVE MORPHOLOGICAL CHARACTERISTIC OF THE EFFECT OF MICROWAVES OF
0242C VARIOUS RANGES
0242X 0012
0242Y ATD ABSTRACT

0243A TOLGSKAYA M S TIGT 000,02,008964 0005P
0243B NIKONOVA K V HISTOLOGIC CHANGES IN THE ORGANS OF WHITE RATS UNDER
0243C CONTINUOUS EXPOSURE TO HIGH FREQUENCY ELECTROMAGNETIC FIELDS
0243X 0012
0243Y ATD ABSTRACT

61[illegible] TOMBERG V T PCMW 004,00,022160 0008P
61[illegible] SPECIFIC THERMAL EFFECTS OF HIGH FREQUENCY FIELDS
6154X 0607

6100A TRESKUNOVA A S LN62 000,00,005362 0002P
6100B SLIZSKIY G N DATA ON THE DISPENSARY SERVICE OFFERED TO INDIVIDUALS
6100C EXPOSED IN THEIR WORK TO MICROWAVE FIELDS

0332A TROYANSKIY M P VMZH 000,07,003067 0006P
0332B KRUGLIKOV R I KORNILOV R M PETROVA GOLUBENKO L B KALASHNIKOVA Z S
0332C SOME RESULTS OF AN INVESTIGATION OF THE STATE OF HEALTH OF SPECIALISTS
0332D WORKING WITH SHF/UHF GENERATORS
0332Y ATD ABSTRACT

0331A TURNER J J REPT 000,00,000062 0089P
0331B THE EFFECTS OF RADAR ON THE HUMAN BODY
0331C US ARMY ORDNANCE MISSILE COMMAND REPT NO RM TR 62 1
0331X 0603
0331Y AD 273787

6122A TYAGIN N V TVMA 073,00,000957 0011P
6122B STUDY OF THE THERMAL EFFECT OF UHF/SHF ELECTROMAGNETIC FIELDS ON VARIOUS
6122C ANIMALS USING THE THERMOMETRIC METHOD
6122X 0021

6044A TYAGIN N V TVMA 073,00,008457 0018P
6044B ELECTROCARDIOGRAM CHANGES IN DOGS AFFECTED BY UHF/SHF ELECTROMAGNETIC
6044C FIELDS
6044X 0021

6134A TYAGIN N V MS57 000,00,000057 0000P

0274A TYAGIN N V TVMA 073,00,011657 0011P
0274B CHANGES IN THE BLOOD OF ANIMALS SUBJECTED TO A UHF/SHF FIELD
0274X 0021
0274Y TRANSL AVAIL OF ABSTRACT FROM REF ZH BIOL 1959 NO 59923

6070A TYAGIN N V MS59 000,00,000059 0000P
6070B SOME PROBLEMS OF OCCUPATIONAL HAZARD CAUSED BY MICROWAVE ELECTROMAGNETIC
6070C FIELDS

6101A TYAGIN N V LN62 000,00,005462 0002P
6101B THE SYNDROME OF THE CHRONIC EFFECT OF A MICROWAVE FIELD

6047A USPENSKAYA N V MS59 000,00,002359 0001P

6112A USPENSKAYA N V LN61 000,00,011661 0002P
6112B MATERIAL ON THE DYNAMIC OBSERVATION OF WORKERS EXPOSED TO ELECTROMAGNETIC
6112C WAVES IN THE CENTIMETER RANGE
6112X 0032

0382A VALVALA D A REPT 000,00,000068 0056P
0382B SOVIET RESEARCH ON THE PATHOPHYSIOLOGY OF ULTRAHIGH FREQUENCY
0382C ELECTROMAGNETIC FIELDS
0382Y AMD CR 01 03 68
0382X 0699

6153A VAN UMMERSEN C A PCMW 004,00,020160 0020P
6153B THE EFFECT OF 2450 MC RADIATION ON THE DEVELOPMENT OF THE CHICK EMBRYO
6153X 0634

0333A VERETINSKAYA A G GTPZ 010,09,004166 0004P
0333B TOLGSKAYA M S PAVLOVA I V CHANGES OF NUCLEIC ACIDS CONTENT IN THE LUNGS
0333C OF RATS WITH EXPERIMENTAL SILICOSIS INDUCED BY UHF WAVES
0333X 0012
0333Y JPRS 39632, TT 67 30281

6271A VOGELHUT P O PICM 003,00,040960 0001P
6271B MICROWAVES AS A TOOL IN BIOLOGICAL RESEARCH
6271X 0629

6222A VOGELMAN J H PCMW 002,00,000958 0010P
6222B PHYSICAL CHARACTERISTICS OF MICROWAVES AS RELATED TO BIOLOGICAL EFFECTS
6222X 0622

6143A VOGELMAN J H PCMW 004,00,002360 0009P
6143B MICROWAVE INSTRUMENTATION FOR THE MEASUREMENT OF BIOLOGICAL EFFECTS
6[illegible]X 0691

6270A VOGELMAN J H PICM 003,00,045060 0003P
6270B PHYSICAL AND ELECTRICAL CHARACTERISTICS OF A MICROWAVE HAZARD
6270X 0691

0334A VOLKOVA A P GISA 000,09,010767 0004P
0334B SMUROVA YE I THE EFFECT OF RADIO FREQUENCY ELECTROMAGNETIC FIELDS ON
0334C PHAGOCYTOSIS AND THE COURSE OF INFECTIOUS INFLAMMATION IN RATS.
0334X 0012, 0011
0334Y ATD ABSTRACT

6232A VOSBURGH B L PCMW 002,00,011858 0006P
6232B RECOMMENDED TOLERANCE LEVELS OF M-W ENERGY - CURRENT VIEWS OF THE GENERAL
6232C ELECTRIC COMPANY,S HEALTH AND HYGIENE SERVICE
6232X 0611

6208A WAKIM K G JAMA 139,15,098949 0004P
6208B HERRICK J F MARTIN G M KRUSEN F H THERAPEUTIC POSSIBILITIES OF
6208C MICROWAVES
6208X 0614

6207A WILLIAMS D B AAOP 054,00,086355 0011P
6207B MONAHAN J P NICHOLOSON W J ALDRICH J J BIOLOGIC EFFECTS STUDIES ON
6[illegible]C MICROWAVE RADIATION
6[illegible]X 0625 ,0306 ,0684 ,0625

6275A WILLIAMS D B ITME 004,00,001756 0006P
6275B MONAHAN J P NICHOLSON W J ALDRICH J J BIOLOGIC EFFECTS STUDIES ON
6275C MICROWAVE RADIATION - TIME AND POWER THRESHOLDS FOR PRODUCTION OF LENS
6275C OPACITIES BY 12.3 CM MICROWAVES
6275X 0625 ,0306 ,0684 ,0625

6210A WILLIAMS D B PCMW 001,00,000657 0017P
6210B FIXOTT R S A SUMMARY OF THE SAMUSAF PROGRAM FOR RESEARCH ON THE
6210C BIOMEDICAL ASPECTS OF MICROWAVE RADIATION
6210X 0625

0335A YAKOVLEVA M I SECT 000,00,000000 0000P
0335B THE FUNCTIONAL STATE OF SYMPATHETIC-ADRENAL SYSTEM DURING THE ACTION OF
0335C MICROWAVE ELECTROMAGNETIC FIELDS
0335D CHAPTER 8 OF OUTLINE OF THE EVOLUTION OF NERVOUS ACTIVITY
0335E MEDITSINA PUBL HOUSE, LENINGRAD
0335Y ATD ABSTRACT

6021A YASNOGORODSKI V G SECT 000,00,022860 0005P
6021B REQUIREMENTS FOR HIGH FREQUENCY THERAPY EQUIPMENT
6012D HYGIENIC ESTIMATE OF LABOR CONDITIONS DURING WORK WITH GENERATORS
6021Y ATD ABSTRACT

0[illegible]A YATSENKO M I FZKR 011,04,051665 0004P
0350B THE EFFECT OF MICROWAVES ON THE ABSORPTIVE CAPACITY OF THE SYNOVIAL
0350C MEMBRANE OF THE KNEE JOINT WHEN THE SPINAL CORD IS TRANSECTED
0350X 0022 ,0047
0350Y ATD ABST

0269A YATSENKO M I FZKR 012,03,037766 0005P
0269B EFFECT OF MICROWAVES ON THE ABSORPTIVE CAPACITY OF THE KNEE JOINT UNDER
0269C THE EFFECT OF ATROPINE AND CARBOCHOLINE
0269X 0022 ,0047
0269Y ATD TRANSL

0263A YATSENKO M I FZKR 014,02 026168 0004P
0263B EFFECT OF MICROWAVES ON THE ABSORPTIVE CAPACITY OF THE KNEE JOINT UNDER
0263C CONDITIONS WHERE ADRENALIN AND AMINAZINE HAVE BEEN INTRODUCED INTO
0263C THE ORGANISM
0263X 0022 ,0047
0263Y ATD TRANSL

0244A YELISEYEV V V TIGT 000,02,009464 0011P
0244B METHOD OF ANIMAL IRRADIATION IN THE EXPERIMENTAL STUDY OF THE EFFECTS OF
0244C RADIO FREQUENCY ELECTROMAGNETIC WAVES
0244X 0012
0244Y ATD ABSTRACT

0336A YERMOLAYEV YE A GIEP 000,07,0045 0005P
0336B SUBBOTA A G CHUKHLOVIN B A THE STATE OF STANDARDIZATION OF MICROWAVE
0336C RADIATION IN THE FOREIGN ARMIES - A LITERATURE REVIEW
0336Y ATD ABSTRACT

6003A ZAKRZHEVSKIY YE B VMZH 000,10,001564 0005P
6003B MALYSHEV V M CLINIC FOR THE CHRONIC EFFECT OF A UHF/SHF ELECTROMAGNETIC
6003C FIELD ON THE HUMAN ORGANISM - REVIEW OF LITERATURE
6003Y ATD ABSTRACT

6159A ZARET M M PCMW 004,00,029360 0016P
6159B EISENBUD M PRELIMINARY RESULTS OF STUDIES OF THE LENTICULAR EFFECTS OF
6159C MICROWAVES AMONG EXPOSED PERSONNEL
6159X 0620U

6022A ZDECKI S LKWO 043,02,012467 0006P
6022B EXAMINATION AND RATING OF THE VISION OF PERSONS EXPOSED TO MICROWAVE
6022C EFFECTS (WITH SPECIAL ATTENTION TO EYE LENS CAPACITY)
6022X 0014
6022Y FTD HT 23 1500 67

0230A ZENINA I N TIGT 000,02,002664 0007P
0230B THE EFFECT OF PULSED SHF/UHF FIELDS ON THE CENTRAL NERVOUS SYSTEM DURING
0230C SINGLE AND CONTINUOUS RADIATION
0230X 0012
0230Y ATD ABSTRACT

LIST OF UNITED STATES INSTITUTES IN ALPHABETICAL ORDER

AGHS	2845TH USAF HOSPITAL GRIFFIS AFB N Y	0688
AMTC	AF MISSILE TEST CTR PATRICK AIR FORCE BASE FLORIDA	0676
AFSW	AIR FORCE SPECIAL WEAPONS CENTER KIRKLAND AFB N M	0684
AIL	AIRBORNE INST LAB MINOLA NY	0601
ARK	ARK ELECTRONICS CORP	0696
AFI	ARMED FORCES INST PATHOL WASHINGTON D C	0648
UBAY	BAYLOR UNIV WACO TEXAS	0647
BELY	BELL TELEPHONE LABS NYC	0608
BELT	BELL TELEPHONE LABS WHIPPANY NJ	0606
BIHS	BETH ISRAEL HOSPITAL	0665
BINH	BINGHAMTON STATE HOSP BINGHAMTON NY	0682
BINH	BINGHAMTON STATE HOSP BINGHAMTON N Y	0682
BILA	BIOPHY LAB NYC	0607
BBCO	BISSETT BERMAN CORP	0663
BRRI	BRAIN RESEARCH INST UNIV CALIF LOS ANGELES	0652
CPCO	CAPEHART CORPORATION N Y.	0691
HCHO	CHILDRENS HOSPITAL OHIO	0715
CPHS	COLLEGE OF PHYSICIANS + SURGEONS N Y	0667
UCOR	CORNELL UNIV	0649
DDCA	DEFENSE DOC CENTER (FORMERLY ASTIA)	0642
EOPT	ELECTRO OPTICAL SYS	0609
FILT	FILTRON COMPANY INC	0693
GESC	GENERAL ELECTRIC SCHENECTADY	0611
GESY	GENERAL ELECTRIC SYRACUSE	0650
UGWA	GEORGE WASH UNIV	0674
HGRN	GRANT HOSPITAL	0714
GAFB	GRIFFISS AFB	0610
UHAR	HARVARD UNIV	0630
IRE	INST FOR RESEARCH STATE COLLEGE PA	0661
INT	INTELECTRON CORP	0704
UJHO	JOHN HOPKINS UNIVERSITY	0654
ATDC	LIBRARY OF CONGRESS ATD	0640
LINL	LINCOLN LABS MIT	0613
LCKB	LOCKHEED BURBANK CALIF	0612
LVCL	LOVELACE CLINIC ALBUQUERQUE NM	0675
MEEI	MASS EYE AND EAR INFIRMARY	0670
MGHS	MASS GEN HOSPITAL BOSTON	0680
UMIT	MASS INST TECHNOLOGY	0671
MAUR	MAURISANIA HOSPITAL	0673
MAYO	MAYO CLINIC MAYO FOUNCATION ROCHESTER MINN	0614
MELP	MELPAR INC FALLS CHURCH VA	0643
MRIM	MIDWEST RES INST KANSAS CITY MO	0615
NCRH	NAT CENTER RADIOLOGICAL HEALTH	0697
NIND	NAT INST NEUR DISEASES BLINDNESS NIH BETHESDA MD	0617
NHIN	NATIONAL HEART INST BETHESDA MD	0655
NIHS	NATIONAL INST HEALTH BETHESDA MD	0710
NLMD	NAT LIB MEDICINE	0709
NVJO	NAVAL AIR DEVELOPMENT CENTER JOHNSVILLE PA	0659
NVPH	NAVAL AIR MATERIAL CENTER PHILADELPHIA PA	0658
NVAS	NAVAL APPLIED SCI LAB	0656
NEMD	NEW ENGLAND INST MED RES RIDGEFIELD CONN	0641
NYUE	NEW YORK UNIVERSITY COL ENGR RES DIV	0653
NYUM	NEW YORK UNIV MED CENTER INSTITUTE OF ENVIRONMENTAL MEDICINE	0620
NYU	NEW YORK UNIV MED CENTER INST OF ENVIRON MED	0620
UN	NORTHWESTERN UNIVERSITY	0683
ASUR	OFFICE OF SURGEON 4TH US ARMY FORT SAM HOUSTON TEXAS	0703
UOHI	OHIO STATE UNIVERSITY	0711
ORES	OREGON STATE COLLEGE	0646
PAFB	PATRICK AFB FLORIDA	0690

PENS	PENN STATE COLLEGE	0651
USRK	POLYTECH INST BROOKLYN	0708
RDCO	RAND DEVELOPMENT CORP	0681
RCAN	RCA LABS PRINCETON N J	0623
RCAP	RCA SERV CO MISSLE TEST PROJ PATRICK AFB	0624
HROM	ROCHESTER METHODIST HOSPITAL	0716
SWR	SOUTHWEST RES INST SAN ANTONIO	0627
SP	SPERRY GYRO CO	0626
HSTA	ST ANTHONY HOSPITAL	0713
SLHS	ST LUKES HOSPITAL DULUTH MINN	0679
SMHS	ST MARYS HOSP DULUTH MINN	0677
SYDH	SYDENHAM HOSPITAL	0666
UTUF	TUFTS UNIV	0634
UTUL	TULANE UNIV	0635
UARK	UNIV ARKANSAS	0660
UBUF	UNIV BUFFALO	0628
UCAB	UNIV CALIF BERKELEY	0629
UCIN	UNIV CINCINNATI	0686
HUNI	UNIVERSITY HOSPITAL	0712
UIOW	UNIV IOWA	0631
UMIA	UNIV MIAMI	0632
UMIC	UNIV MICHIGAN	0644
UMIN	UNIV MINNESOTA	0672
UPEN	UNIV PENN	0645
UROC	UNIV ROCHESTER	0633
USLO	UNIV ST LOUIS	0636
UVIR	UNIV VIRGINIA	0637
UMIN	UNIV OF MINNESOTA	0672
UCIN	UNIV OF CINCINNATI	0686
ADET	US ARMY BIO LABS FORT DETRICK MD	0701
AEHA	US ARMY ENVIRONMENTAL HYGIENE AGENCY EDGEWOOD ARSENAL MD	0702
AEH	US ARMY ENVIRONMENTAL HEALTH LAB	0600
ARM	US ARMY MED RES LAB FT KNOX KY	0602
AOMB	US ARMY ORD MIS CMD LIASON OFFICE BELL TEL LAB WHIPPNY	0603
ARED	US ARMY ORDNANCE MISSILE COMMAND REDSTONE ARSENAL ALA	0707
NBAW	US NAVY BUR AERO WASH DC	0616
NBSH	US NAVY BUREAU SHIPS	0664
NMRI	US NAVY MED RES INST	0618
NONR	US NAVY OFFICE OF NAVAL RESEARCH	0689
NORL	US NAVY ORD LAB	0619
NWLB	US NAVAL WEAPONS LAB DAHLGREN VA	0692
USAS	USA STANDARDS INST	0657
AAMD	USAF AERO MED DIV AFSC BROOKS AFB TEXAS	0699
AMRL	USAF AFSC AEROSPACE MED RES LAB WRIGHT PATTERSON AFB	0605
ASDL	USAF AFSC ASD LIFE SUPPORT SYS LAB	0604
ARDC	USAF ARDC GRIFFIS AFB N Y	0687
AESD	USAF ELECT SYST DIR AFSC ANDREWS AFB MD	0698
AEWC	USAF ELECTROMAG WARFARE + COMMUNICATIONS LAB ASD AFSC WRIGHT-PAT AFB	0705
AFLC	USAF HQ AIR FORCE LOGISTICS COMMAND WRIGHT-PAT AFB	0717
AINT	USAF INST TECHNOLOGY AIR UNIV	0706
AWMC	USAF MEDICAL CORPS WRIGHT-PAT AFB	0668
OSGE	USAF OFFICE SURGEON GENERAL	0621
RADC	USAF RADC	0622
SAME	USAF SCHOOL AVIATION MED	0625
VARA	VARIAN ASSOCIATES SAN CARLOS CALIF	0700
VANO	VETERANS ADMIN HOSP NEW ORLEANS	0685
VAN	VETERANS ADMIN HOSP NEW ORLEANS	0685
WDS	WDSM RADIO STATION DULUTH MINN	0678
WELC	WESTERN ELECTRIC CO	0638
WPAF	WRIGHT-PATTERSON AFB	0694
ZARE	ZARET FOUNDATION NEW YORK	0639

LIST OF FOREIGN INSTITUTES IN ALPHABETICAL ORDER

SOVIET BLOC INSTITUTES

AMS[illegible]	ACAD MED SCI USSR MOSCOW	0031
LM[illegible]	ACAD MIL MED ORDER LENIN I KIROV LENINGRAD	0021
ASU[illegible]	ACAD SCI UKR SSR KIEV	0001
IMIE	ALL UNION SCI RES INST MED INSTR EQUIPMENT MOSCOW	0013
IMIE	ALL UNION SCI RES INST MEDICAL INSTRUMENTS AND EQUIPMENT MOSCOW	0046
VEEM	ALL UNION INST EXPERIMENTAL MEDICINE MOSCOW	0049
IBIB	BIOL INST ACAD SCI BSSR	0002
ISTM	CENTRAL SCI RES INST SPA TREATMENT PHYSIOTHERAPY MOSCOW	0016
ISTS	CENTRAL SPA TREATMENT PHYSIOTHERAPY POLYCLINIC SOFIA BU	0017
CUPZ	CHARLES UNIV PLZEN CZ	0029
CUPG	CHARLES UNIV PRAGUE CZ	0037
CHEL	CHELYABINSK MUNICIPAL SANITARY EPIDEMIC STATION USSR	0039
IIHG	GORKY SCI RES INST INDUST HYG OCCUP DISEASES	0011
VVMI	HIGHER MILITARY MEDICAL INST BULGARIA	0042
HLBO	HOSPITAL LENIN BALNEOPHYSIOTHERAPEUTIC DEPT LENINGRAD	0010
IBPM	INST BIOPHY ACAD SCI USSR MOSCOW	0003
ICPH	INST CHEM PHYS ACAD SCI USSR MOSCOW	0005
ICYB	INST CYBERNETICS UKR ACAD SCI KIEV	0044
ICYG	INST CYTOLOGY GENETICS ACAD SCI SIB DIV USSR NOVOSIB	0006
IEPS	INST EVOL PHYSIOL SECHENOV AMS USSR LENINGRAD	0035
IFDT	INST FUNCT DIAG THERAPY MOSCOW	0007
IHNA	INST HIGHER NERV ACT NEUROPHYSIOL ACAD SCI USSR MOSCOW	0009
IHER	INST HYGIENE ERISMAN USSR	0008
IIHP	INST INDUST HYG OCCUP DISEASES PRAGUE	0036
IIMP	INST INDUSTRIAL MED LODZ POLAND	0030
IN[illegible]	INST NUTRITION ACAD MED SCI MOSCOW	0045
IP[illegible]	INST PHYSIOL BOGOMOLETS ACAD SCI UKR SSR KIEV	0015
IPPL	INST PHYSIOL PAVLOV ACAD SCI USSR LENINGRAD	0024
IPPA	INST PHYSIOL PAVLOV ACAD SCI USSR	0043
KALM	KALININ MEDICAL INSTITUTE	0054
IOHK	KHARKOV INST OCCUP HYG AND DISEASES USSR	0041
IIHK	KIEV INST INDUST HYG OCCUP DISEASES	0033
LGNP	LAB GEN NEUROMUSCULAR PHYSIOLOGY USSR	0020
IIHL	LENINGRAD RES INST HYG OCCUP DISEASES	0032
LENN	LENINGRAD UNIV	0019
MAKY	MAKEYEV PHYSIOTHERAPEUTIC HOSP USSR	0022
MIKA	MEDICAL INST KALININ OMSK USSR	0040
UKRC	MED SERV UKR TERR ADM CIVIL AIR FLEET UKR SSR	0027
MUBU	MEDICAL UNIV BUDAPEST	0053
MIAP	MIL INST AEROMED POLAND	0014
UMOS	MOSCOW STATE UNIV MOSCOW	0028
UODE	ODESSA UNIV I MECHNYKOV DEPT HUMAN AND ANIMAL PHYSIOL USSR	0047
PICZ	PHYSIOL INST CZ ACAD SCI PRAGUE	0023
IIHB	RES INST INDUST HYG AND OCCUP DISEASES BRATISLAVA CZ	0051
SAMI	SARATOV MED INST USSR	0025
ICAF	SCI RES INST CIVIL AIR FLEET MOSCOW	0004
IIHM	SCI RES INST INDUST HYG OCCUP DISEASES AMS USSR MOSCOW	0012
IIOP	SCI RES INST OPHATHALMOL IM GELMOLTSA	0034
IGPH	SCI RES INST GENERAL AND PUBLIC HEALTH MIN HEALTH UKR SSR KIEV	0038
IPHY	STATE SCI RES INST PHYSIOTHERAPY MIN HEALTH RSFSR	0052
TM[illegible]	TOMSK MED INST	0026
IST[illegible]	UKR SCI RES INST SPA TREATMENT PHYSIOTHERAPY ODESSA	0018
UWAR	WARSAW UNIV MED SCHOOL POLAND	0050

OTHER FOREIGN INSTITUTES

BPOL	BRITISH POST OFF RES STATION LONDON	0309
MPBP	MAX PLANCK INST BIOPHYSIK W GERMANY	0308
UMCG	MCGILL UNIV MONTREAL	0307
MIDD	MIDDLESEX HOSPITAL LONDON	0300
NRCC	NAT RES COUNCIL MECH ENGR CONTROL SYS OTTAWA CANADA	0302
NRCC	NAT RES COUNCIL MECH ENGR CONTROL SYS OTTAWA CANADA	0302
NIRO	NIRO LAB COPENHAGEN	0301
SJHS	ST JOHNS HOSPITAL LEICESTER SQ LONDON	0306
UROM	UNIV ROME	0304
UTOR	UNIV TORONTO	0303
UJ[illegible]	UNIV JENA	0305

APHP	ACTA PHYSIOL POLAND	0071
ABMP	ADVANCE BIOL MED PHYS	0001
AERM	AEROSPACE MED	0002
AJ[illegible]	AMER J MED ELECTR	0003
AJ[illegible]	AM J MED SCI	0091
AJP[illegible]	AM J PHYSIOLOGY	0100
AJPU	AM J PUBLIC HEALTH	0098
AAIH	AMA ARCHIV INDUST HEALTH	0093
AAOP	AMA ARCHIV OPHTHALMOLOGY	0095
AREH	ARCH ENVIRON HEALTH	0005
AIOM	ARCHIV INDUST HYG AND OCCUP MED	0092
AIPD	ARCH INT PHARMACODYN THERAPY BELG	0065
ARPM	ARCHIV PHYSICAL MED	0097
APMR	ARCHIV PHYSICAL MED AND REHABILITATION	0103
AHRT	ARCH ZA HIGIJENU RADA I TOKSIKOLOGIJU	0078
ARPT	ARKHIV PATOLOGII	0107
BBYA	BIOCHEM BIOPHYSICA ACTA	0006
BIPJ	BIOPHYSICAL JOURNAL	0109
BEBM	BIULL EKSP BIOL MED	0007
BIFR	BIOFIZIKA	0008
BJAP	BR J APP PHYSICS	0009
BJHH	BULL JOHN HOPKINS HOSPITAL	0068
BLOD	BLOOD	0010
CALC	CASOPIS LEKARU CESKYCH. CZ	0011
CMSJ	CANAD MED SOC J	0012
CRUS	COMPTES RENDUS ACAD SCI URSS	0013
CENE	CESKOSLOVENSKA NEUROLOGIE	0077
CSK[illegible]	CESKOSLOVENKA PHYSIOL CZ	0014
DV[illegible]	[illegible]IE VOGELWARTE	0083
DIC[illegible]	DIGEST INT CONF MED ELEC OR MED AND BIOL ENGR	0057
DABR	DOKLADY AKAD SCI BSSR	0015
DANB	DOKLADY AKAD SCI USSR TRANS IN DOKLADY BIO SCI SECT	0074
DANU	DOKLADY AKAD SCI USSR	0016
DANY	DOKLADY AKAD SCI USSR TRANS IN DOKLADY BIOPHYSICS	0017
DANP	DOKLADY AKAD SCI USSR TRANS IN SOV PHYSICS DOKLADY	0018
EKTR	EKSPERTIZA TRUDOSPOSOBNOSTI I TRUDOUSTROYSTVO PRI NERVNYKH I	0085
EKTR	PSIKHICHESKIKH ZABOLEVANIYAKH	0085
ELEN	ELECTRICAL ENGNG	0019
ECNP	ELECTROENCEPH CLIN NEUROPHYSIOL	0069
ELKM	ELEKTROMEDIZIN	0089
ENID	ELECTRONIC INDUSTRIES	0113
ELVM	ELECTRONIKA V MEDITSINE	0020
EXCR	EXP CELL RES	0021
EXPA	EXPERIENTIA	0062
FDTE	FOOD TECHNOLOGY	0054
FSBU	FOREIGN SCI BULL LIB CONGRESS	0022
FZKR	FIZIOL ZH AKAD NAUK UKR SSR	0023
FZHS	FIZIOL ZH USSR SECHENOVA	0024
GIEP	GIGIYENA I EPIDEMIOLOGIYA	0086
GISA	GIGIENA I SANITARIYA USSR	0025
GIPZ	GIGIENA TRUDA I PROF ZABOLEVANIYA USSR	0026
HLPY	HEALTH PHYSICS	0027
IEEB	IEEE TRANS BIOMED ENGR	0061
TRE[illegible]	[illegible]EEE TRANS ELECTROMAG COMPATIBILITY	0090
TRFI	IEEE TRANS RADIO FREQ INTERFERENCE	0094
INMS	INDUST MED AND SURGERY	0096
IAGG	INTERNAT ARCHIV GEWERBEPATHOL GEWERBEHYG	0076
ITBE	IRE TRANS BIOMED ELECTRONICS	0028
[illegible]TME	IRE TRANS MED ELECTRONICS	0029

JAMA	J AM MED ASSN	0101
JAPP	J APPL PHYSIOL	0079
JAMD	J AVIATION MED	0030
JCHP	J CHEM PHYSICS	0108
JMWP	J MICROWAVE POWER	0106
JOMD	J OCCUP MED	0060
[illegible]	J UROLOGY	0099
[illegible]	KISERLETES ORVOSTUDOMANY	0110
KLME	KLINICHESKAYA MEDITSINA	0031
KZMD	KAZANSKIY MED ZH NAVY USSR	0032
LKWO	LEKARZ WOJSKOWY POLAND	0033
LN37	SEE 0374 ANON IN BIBLIOGRAPHY	
LN61	SEE 0364 ANON IN BIBLIOGRAPHY	
LN62	SEE 0343 ANON IN BIBLIOGRAPHY	
LN63	SEE 0365 ANON IN BIBLIOGRAPHY	
MS37	SEE 0339 KUPALOV IN BIBLIOGRAPHY	
MS57	SEE 0375 ANON IN BIBLIOGRAPHY	
MS59	SEE 0366 ANON IN BIBLIOGRAPHY	
MS63	SEE 0363 ANON IN BIBLIOGRAPHY	
MDGZ	MEDITSINSKAYA GAZETA NAVY USSR	0034
MDPR	MEDITSINSKAYA PROMYSHLENNOST USSR MED INDUSTRY	0035
MEBE	MED ELECTRONICS BIOL ENGR	0066
MEDP	MEDYCYNA PRACY	0036
MIME	MILITARY MEDICINE	0111
NATL	NATURE	0037
NAUZ	NAUKA I ZHIZN USSR	0038
NEUR	NEUROLOGY	0039
NMTK	NOVOSTI MED TEKH USSR	0114
OSMJ	OHIO STATE MED JOURNAL	0116
PFAR	PROBLEMY FIZIOL AKUST USSR	0112
PI[illegible]	PROC INT CONF MED ELEC OR MED AND BIOL ENGR	0104
P[illegible]	PROC TRISERVICE CONF BIO EFFECTS MICROWAVE RAD	0040
P[illegible]	PATOLOG FIZIOL I EXPER TERAP	0055
PRLK	PRACOVNI LEKARSTVI	0043
PRIR	PRIRODA USSR	0042
PFZO	PROB FIZ OPTIKI AN USSR	0080
PIRE	PROC INST RAD ENGRS	0041
PSEB	PROC SOC EXPER BIOL MED	0063
PSRT	PSYCHOL REPORTS	0075
PSYS	PSYCHON SCI	0105
RBIO	RADIOBIOLOGIYA	0044
RPMR	REV PHYSICAL MEDICINE AND REHABILITATION	0102
RMAS	RIV MED AERON E SP	0081
SCIN	SCIENCE NEWS	0053
TEWK	TECHNOLOGY WEEK	0067
THES	THESIS	0115
TIFP	TRUDY INST FIZIOL PAVLOV	0058
TIGT	TRUDY NII GIGIYENA TRUDA I PROFZABOLEANIY USSR	0045
TVMA	TRUDY VOY MED AKAD I KIROV USSR	0084
USPF	USP FIZ NAUK USSR	0047
USBR	USP SOV BIOL USSR	0046
VAMN	VESNIK AKAD MED NAUK SSSR	0004
VLEN	VESTNIK LENINGRAD UNIV SER BIOL	0048
VOFT	VESTNIK OFTALMOL	0056
VPKR	VOPR KURORTOL FIZIOTERAPII LECHEBN FIZICHESKOY KULTURY	0050
VO[illegible]	VOPR OKHRANY MATERINSKAYA I DETSTVA	0070
V[illegible]	VOENNO MEDITSINSKO DELO	0082
V[illegible]	VOYENNO MED ZH USSR MILITARY MED JOUR	0049
VRAC	VRACH DELO	0088
WDLK	WISDOMOSCI LEKARSKIE	0072
WMED	WEHRMEDIZIN	0087
ZOBB	ZH OBSHCH BIOL USSR	0051
ZVND	ZH VYSSH NERVN DEYATELNOSTI PAVLOV USSR	0052

PARENTAL RADIATION EXPOSURE AND DOWN'S SYDROME
WITH PARTICULAR ATTENTION TO IONIZING RADIATION AND RADAR

INTERIM PROGRESS REPORT

BERNICE H. COHEN, Ph. D.

February 28, 1970

Supported by

ADVANCED RESEARCH PROJECTS AGENCY
Department of Defense, Washington, D. C., 20301

Monitored by

U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
Washington, D. C., 20314

Contract No. DADA-17-69-C-9154

Johns Hopkins University
Baltimore, Maryland
21218

ABSTRACT

In an epidemiological study of the parents of children with Down's syndrome born from January 1, 1946 to September 30, 1962 and parents of matched control children, a significantly larger percentage of fathers of Down's cases reported radar exposure than control fathers. Moreover, a larger percentage of the fathers of Down's cases reported having been in military service (63.1 percent versus 56.6 percent for control fathers), although this difference was not statistically significant. Because of the possible implications of these findings with regard to the risk of Down's syndrome and possibly other genetic damage to progeny, as well as somatic damage in exposed individuals, a new (CURRENT) series of parents of mongols and matched control children is being studied in an effort to replicate the original study.

Interview information has been obtained in the CURRENT series-Father's Interview Schedule, supplemented with additional questions on radar exposure both in and outside of military service, as well as more detailed questions on military service, service number, duties, etc. Follow-up of all subjects in the ORIGINAL series, irrespective of whether military service was reported, to requestion on military service is being carried out by a combination of telephone, personal visit, mailed questionnaire, etc. Military service records are being validated for both ORIGINAL and CURRENT series by search of U.S. government military records for names of all fathers (whether or not service was reported, whether or not follow-up obtained) for service record dates, MOS classifications and other pertinent data available. Chromosome studies are being carried out on all fathers in the ORIGINAL and CURRENT series who reported exposure to radar and the unexposed fathers matched to them.

Thus far, after ascertainment of over 145 mongols from 27 public and private agencies and hospitals, tracing and interviews have been carried out on 238 mothers and 235 fathers of the mongols and their matched controls in the CURRENT series. Tracing and interviewing is continuing as well as search of hospital records for validation of diagnosis and search of death certificates on deceased index subjects (mongols and their matched controls, their parents and sibs, as they are identified). To date 49 deaths have been searched.

Military service follow-up by phone, mail and personal contact has been carried out on 366 of the 432 fathers of the ORIGINAL series, with similar information obtained by interview on 235 fathers of the CURRENT series. These data are being coded and punched to be forwarded for search of government records, with the remaining to be sent as soon as available. Arrangements have been completed with another agency for search of service records and MOS numbers.

Chromosome studies on radar exposed fathers and unexposed matched fathers are in progress: 92 blood specimens have been collected, including repeats on culture failures and questionable observations. At this date, karyotypes have been completed on 40 and 15 more counted. An attempt will be made to obtain an additional specimen on all culture failures as well as to collect initial specimens from the radar exposed fathers and their matches not yet sampled.

.. Completion of coding, punching and analysis of results will be carried out after all the remaining data have been collected.

Introductory Note

As indicated in the first Quarterly Progress Report, August 29, 1969, this project is jointly funded by the Environmental Control Administration, HEW ($21,885 for 6/69 through 5/70) and the Advanced Research Projects Agency, Office of Secretary of Defense ($64,766 for 6/69 through 5/70). The progress of the total study cannot be fractionated into a segment supported by ECA and another by ARPA, since, except for the chromosome studies which are supported entirely by ARPA funds, the remainder and primary study is organized as a single project to permit the most efficient utilization of personnel, supplies and funds. Therefore, the progress reports constitute summaries of the overall progress of the project with the understanding that each agency will recognize that its funds have contributed in appropriate proportion to the overall accomplishments.

CONTENTS

LIST OF TABLES

STATEMENT OF PROBLEM:

Purpose: To determine whether the parents of mongols differ from the parents of matched normal controls with regard to exposure to radar and/or ionizing radiation and to examine the chromosomes of those radar-exposed parents and corresponding parents from the matched series for any discernible differences and/or abnormalities.

Specific Aims:

1. To compare the parents of mongols with those of controls with regard to reported radar exposure, occupations involving radar exposure or exposure to any sources of radioactive substances or radiation.
2. To compare mothers and fathers of Down's syndrome cases with mothers and fathers of matched controls with regard to medical radiation exposure (diagnostic and/or therapeutic).
3. To compare the parents of mongols and of controls with regard to other factors (socioeconomic status, religion, menstrual and medical history, marital history etc.) recognized or suspected to be associated with the occurrence of Down's syndrome and to examine their possible interaction with radar and/or ionizing radiation exposure.
4. To examine the chromosomes of the fathers with a history of exposure to radar and the fathers of children matched to them, and to compare them.

BACKGROUND OF STUDY AND UNDERLYING RATIONALE

In an epidemiological study of the parents of children with Down's syndrome born from January 1, 1946 to September 30, 1962 and parents of matched control children, a significantly larger percentage of fathers of Down's cases reported radar exposure than control fathers.[1] Moreover, a larger percentage of the fathers of Down's cases reported having been in military service (63.1 percent versus 56.6 percent for control fathers), although this difference was not statistically significant. Because of the possible implications of these findings with regard to the risk of Down's syndrome and possibly other genetic damage to progeny, as well as somatic damage in exposed individuals. A new (CURRENT) series of parents of mongol and matched control children is being studied in an effort to replicate the original study.

---

1 Sigler, A. T., Lilienfeld, A. M., Cohen, B. H., and Westlake, J. E.; Radiation exposure in parents of children with mongolism (Down's syndrome). Bull. Hopkins Hosp., 117 (6): 374-399, 1965 (Dec.).

The further studies undertaken consist of:

(1) An independent replication of the previous study utilizing families of Down's cases born in 1945 and between 10/1/62 and 12/31/63 called the CURRENT interview series. This involves the collection of the same data as in the ORIGINAL series, with supplementary portions on military service and radar exposure to determine whether the same patterns appear in an independent replication and at a different period in time.

(2) Follow up of the ORIGINAL interview series for more detailed information on military service and radar exposure. Follow up is being carried out by a combination of phone contacts, mailed questionnaires, and personal visits.

(3) Chromosome Study - All fathers in the ORIGINAL and CURRENT interview study series reporting radar exposure and unexposed fathers of children matched to the children of those radar exposed fathers are being followed up and samples of peripheral blood examined for chromosome abnormalities. In addition, the chromosome study group includes radar exposed fathers ascertained for the ORIGINAL and CURRENT series but not in the final interview study series because of unavailability of the complete matched pair for interview. For these unmatched radar exposed fathers (unmatched in the interview series) a new unexposed match is being obtained for chromosome analysis.

In addition, since the initiation of this presently ongoing phase on June 1, 1969, certain opportunities to extend the scope of this investigation have become apparent both in regard to obtaining more objective validation of the military service and radar exposure on all fathers - ORIGINAL and CURRENT series - irrespective of reported service and/or exposure (a fourth phase of the study); and also in regard to increasing the size of the CURRENT study series.

(4) Validation of military service and exposure - Through consultation on procedures for checking military service and radar exposure from government military files a plan has been designed for documentation of military service and radar exposure. This is to be carried out along with supplemental interview information by partial follow-up reinterview of the original series. Moreover, even in the absence of available reinterview data, validation procedures will be applied. Thus the search of government records on fathers in both the ORIGINAL and CURRENT series will be entirely independent of whether or not service or radar exposure was reported.

Increased size of study series: It is now apparent that a larger study series than expected will be available. Whereas it was estimated that the families of approximately 95 cases and 95 controls would be available for the current study, more comprehensive methods of ascertainment, probably improved diagnosis and more complete case-finding by community and private agencies as well practicing physicians, has made it possible to identify over 147 cases for study, thus a 50% larger sample.

The likelihood of attaining more definitive results would be considerably enhanced both by being able (1) to include the total study series available rather than the previously estimated smaller study group, and

(2) to carry out more intensive search and validation of military service records and radar exposure.

For these purposes, therefore, an extension of the time schedule beyond the original date and additional funds will be required to accomodate the 50% larger sample. A budget for supplementary funds has been submitted. It should be noted also that while the changing circumstances leading to improved ascertainment in the time interval between the original and current investigation has made possible an increased yield of cases, other changes, such as those pertaining to residential patterns of families of children born in metropolitan Baltimore hospitals have increased the travel time and cost per case studied, as explained in the first Quarterly Progress Report (September 30, 1969).

In the extended plan, both the documentation of military service records and addition of the larger series for study are to be incorporated within the framework of the existing project design.

APPROACH TO THE PROBLEM

The approach to the problem constitutes the three aspects described in the initial proposal (1) Follow-up of the ORIGINAL study series, (2) Independent replication in the CURRENT study series, (3) Chromosome study of all radar exposed fathers ascertained in either study series and of unexposed fathers matched to them; and another aspect, (4) Validation of military service and radar exposure (insofar as possible) from government records for all fathers of mongols and of controls in both the ORIGINAL and CURRENT study series. Moreover, the series ascertained is larger than expected and an attempt is being made to extend all phases of the investigation to the larger study series.

The METHOD OF PROCEDURE thus follows the overall design proposed and approved for the project at the awarding of the contract, with the supplementary aspects designated above.

I. Subjects

Selection of cases: Children with a diagnosis of mongolism meeting the criteria already described for the "original" series[1] and born in the greater Baltimore area between 1/1/45 and 12/31/45 and also those born 10/1/62 through 12/31/68 are included. Sources of ascertainment for the ORIGINAL series and for the CURRENT series have been indicated and are described below.

The CURRENT interview sample is being confined to those years for which cases were not ascertained in the ORIGINAL series. In that previous study, 421 cases born from January 1, 1946 to October 1, 1962 were collected, with 288 meeting the study requirements and 216 available for

---

1 Sigler, A. T., Lilienfeld, A. M., Cohen, B. H., and Westlake, J. E.; Parental age in Down's syndrome (mongolism). J. Pediat. 67 (4): 631-642, 1965 (Oct.).

interview. At the same rate of 1.4 per month meeting requirements and 1.07 per month available for interview, it was estimated that approximately 105 additional mongols would be found in the Baltimore area from October 1, 1962 to January 1, 1969, with at least 80 available for final study. If 1945 were added, 13 to 16 more cases would be available, thus approximately 95 cases in all.

Because of the increased number of sources of ascertainment as well as better diagnostic procedures and case finding techniques among physicians, private and public agencies, and possibly also improved searching techniques, it has been possible, as stated above, to obtain a larger study series than previously anticipated, i.e. about 147 cases of Down's syndrome and an equal number of matched controls rather than the 95 of each previously estimated.

Diagnostic criteria for cases

The following physical findings in Down's syndrome, based on previously reported findings are considered "primary" criteria for diagnosis: 1) Brachycephaly, 2) Slanted palpebral fissures, 3) Epicanthic folds, 4) Palmar simian lines, 5) Malformed ears, 6) Broad and/or short neck, 7) Malformed fingers and/or hands, 8) Nasal abnormality, 9) Hypertelorism, 10) Abnormal palate, 11) Brushfield spots, and 12) Broad and/or short trunk.

Each available case of Down's syndrome, or the case record, will have been examined by a qualified pediatrician. Diagnostic verification required for inclusion of the child in the study is as follows:

1. At least seven of the above primary criteria actually listed by a qualified observer on a medical record; or
2. Five primary signs plus chromosomal studies; or five primary signs plus evidence of either congenital heart disease or abnormal hip angles - the heart disease and/or hip angle evidence either documented in medical records or determined by personal inspection by a qualified physician approved by the principal investigator; or
3. Six of the above listed primary signs as indicated by personal inspection of the child by a qualified physician.

<u>Selection of control subjects</u>: Birth certificates of the children with Down's syndrome are being located, and their place of birth and other vital information verified. Control subjects are selected by rigidly matching, in a systematic manner, each case with another certificate for (1) hospital of birth (or at home), (2) sex and race of child, (3) maternal age at time of birth of child and (4) date of birth.

In each case the best control is a child whose birth date was closest to that of the Down's child of the same sex born in the same hospital to a mother of the same age. If the best control on the basis of established criteria either has left the state or cannot be located, the next best control is selected (i.e., with slightly greater difference in birth dates), the other criteria remaining the same.

The hospital records as well as birth certificates of all control children are examined to be certain that the "normal" control group contains no cases of Down's syndrome.

II. Data Being Collected

Records. Birth records (certificate and hospital) and other available hospital and medical records are examined for pertinent information.

Interviews. Mothers and fathers are being interviewed to obtain further information. Where mothers or fathers are deceased, information is obtained insofar as possible from the surviving parent. If both parents are deceased, and necessary information is unavailable, the subject is to be excluded from the matched series.

Interview data include:

1. Complete names and addresses of each parent, index child and sibs.
2. Child's sex, place of birth, physician, and history of hospitalizations and medical conditions.
3. Mothers' education; religion; and histories of residence, occupation and marriage. Medical data will include histories of menstruation, pregnancy, hospitalization and details of radiation exposure. The latter will include diagnostic X-ray, radiation therapy, fluoroscopy, and injection or ingestion of radioactive substances.
4. Father's education; religion; residence; occupational history with detailed information about military service; marital history; number of offspring; illnesses; medical and hospitalization histories; and other pertinent data.

The mother and father are usually interviewed independently at home. The approach to both the families of the mongols and controls is uniform; the interviewers are not informed which are cases and controls and recognition of the mongol's family is usually not known until the actual interview is conducted, if then. Questions about radar and radiation exposure, medical conditions, and occupation are phrased without reference to the birth of the index child. Insofar as possible, dates of exposure are obtained, however, so that the time-relationships relative to the index child can be examined in the analysis.

Validation of findings derived from interview data is being attempted by independent and simultaneous examination of several characteristics of the parents of mongols and of controls as well as through independent search of hospital records.

Validation procedures for military service/radar exposure include the above described independent ascertainment of data through search of military files on all fathers, irrespective of whether they reported such service/exposure or not.

III. Chromosome Studies:

The chromosomes of fathers who report a history of radar exposure are being examined to determine whether any aberrations, such as aneuploidy, translocations, dicentrics or other aberrations or evidence of breaks, etc., are observed. As a comparison group, the chromosomes of unexposed fathers of the children matched to those whose fathers indicated radar exposure are also being studied.

In the series already published[1] 18 fathers of children with Down's syndrome and seven fathers of control children reported definite radar exposure with several additional fathers (about eight) having questionable exposure. These fathers and the fathers of children matched to those cases and controls are being located and blood drawn for chromosome analysis.

It was estimated that the CURRENT study series (based on cases born Oct. 1, 1962 to Jan. 1, 1969 and 1945 in the Baltimore area) would yield at least 11 additional exposed fathers and 11 matched fathers, making a total of 72-80 fathers on whom chromosome studies would be carried out. That estimate assumed that the rate of Down's syndrome, ascertainment, and radar exposure would be similar for years to be studied with those years already studied. With the larger CURRENT study series available and including those who had worked near radar, it is now estimated that 60 to 70 fathers may be found to be "radar exposed". Thus, with the matched unexposed fathers, the estimated number of persons on whom chromosome studies will be performed has now increased to about 120 to 140. With deaths and refusals, a conservative estimate of 100 to 120 is more plausible.

RESULTS AND DISCUSSION OF RESULTS:

The results necessarily constitute a review of the project progress to date. Because of the larger than expected sample size, ascertainment in the CURRENT series and problems of dispersal of the population to outlying areas, interviewing is not yet complete, nor is the identification of all radar exposed fathers and unexposed matched fathers or the collection of blood specimens from those fathers. Therefore, the cumulative progress to date will be reviewed as such, with analysis of results and conclusions necessarily deferred until completion of data collection.

---

1 Sigler, A. T., Lilienfeld, A. M., Cohen, B. H., and Westlake, J. E.; Radiation exposure in parents of children with mongolism (Down's syndrome). Bull. Hopkins Hosp., 117 (6): 374-399, 1965 (Dec.).

Progress to February, 1970:

Staff recruitment has been completed and is now stabilized to consist of a coordinator, secretary, junior clerk typist, nurse-blood technician, cytogenetics technician, and seven data processors including research technicians, clerk specialists and tracers who are handling various duties involving hospital records, vital statistics, coding, tracing, etc. Whereas there have been up to five part time interviewers in the field simultaneously, there are currently three interviewers on the staff.

The design of basic procedures and forms has been completed including special follow-up letters, and questionnaires on military service-radar exposure, etc., as well as special coding sheets and code forms.

Codes have been established for military service records search as well as for coding of interview data on fathers, mothers, index cases (Down's syndrome and matched controls) and sibs of indices.

Ascertainment of cases of Down's syndrome has been completed with checking out of lists from schools, hospitals, care centers, public and private agencies indicated in the first report. Baltimore City Public Schools from which ascertainment was delayed until opening of the fall semester have been screened, and additional new cases obtained therefrom. Thus far 230 cases have been ascertained, of whom about 140-150 appear to be eligible, according to our current criteria. Ninety of the 230 have been excluded for various reasons: e.g. rejected on basis of current residence out of state (or beyond Baltimore and surrounding metropolitan area), birth certificate check indicated not born in Baltimore, date of birth incorrectly given (outside study period, etc.) , family requested no referral, diagnosis not confirmed from medical records; or thus far cannot be located. The sources of the sample on the CURRENT series are specified in Table 1. Where a case was ascertained from multiple sources, only the initial source is indicated.

Control matching has proceeded and controls have been matched to cases in accordance with the standardized matching procedure of the study previously described.

Tracing and interviewing of mothers and fathers of identified Down's cases and controls have continued. As indicated in previous reports, further follow up and different individual approaches are planned for refusals; and it is hoped that partial or complete interviews may be obtained on some of these subjects. Often several calls are required to complete interviews even on cooperating respondents, both because of the length of the interview and because every effort is made to adjust to the convenience of the respondents. For the readily located respondents, completion of interviews has involved over 17.5 miles per call and well over 50 miles per completed interview at current estimate. This includes hospital record checks and vital records search and also blood collection where indicated. No estimate is yet available for the difficult to locate group, still being traced.

The completion status of interviewing on the CURRENT series is summarized in Table 2. A total of 473 interviews have been partially or totally completed on parents of mongols and their matched controls. It has not been possible to locate three fathers thus far; 21 fathers and 23 mothers have refused to be interviewed, with a very slightly higher refusal rate among case families than among control families. It should be noted however that whereas mongols were ascertained through agencies with information on them after birth and were thus relatively locatable despite family situation, controls were matched through birth certificates and therefore more difficult to locate, but when located possibly less likely to be in a situation leading to interview refusal. To be noted also is the fact that many of the first matched controls had to be replaced because of inability to locate.

Record validation: As the deaths become known through interview, death certificates are being requested on all deceased index cases, parents and sibs. Validation of medical information and any questionable information is being attempted through search of hospital records and contacts with physicians.

The deaths to indices, parents and sibs of mongols and matched controls in the current series are tabulated in Table 3. Thus far there are 37 deaths reported in the interviews of mongol families and 23 deaths in the control families. For 48 of these, death certificates have been obtained and are being coded; the remainder are being searched.

Follow up - supplementary military service and exposure data on original series: In order to obtain supplementary information for the original series, in particular on military service and radar exposure, a follow up plan has been designed to include a combination of personal visits, phone contacts and direct mailing. This has been initiated, but because of the time interval since last contact and the recent mobility of the Caucasian population from urban to suburban areas, tracing problems have decreased the rate of progress. Table 4 summarizes progress with regard to follow up.

Of the 432 fathers of mongols and of matched controls in the ORIGINAL series, contact has been made and follow up data obtained on 366 fathers. Thus far it has not been possible to locate three fathers - registered letters having been returned by the postal service. Further attempts at search are being made. In addition, 44 mailed questionnaires have not been answered or returned. Some of these may turn out to be refusals or unlocatable.

Validation of military service and exposure

As a result of consultation on procedures for checking military service and radar exposure from government military files, a plan has been designed for documentation of military service and radar exposure. This is to be carried out in conjunction with supplemental partial reinterview of the original series, though the search of government records will be entirely independent of whether or not service or radar exposure was reported.

Necessary arrangements have been made between the School of Hygiene and appropriate agencies for this search. For this purpose, the latest military service information available on follow up is being coded and transferred to punch cards to be used as an aid in identification of fathers in the study. Wherever possible military service numbers have been obtained and included. Thus far records for 362 study fathers are ready to be forwarded for government military record search - 269 from the original series and 93 from the current series (Table 5). In addition, 97 more from the original series and 143 more from the current series are being prepared for punching to increase the total by 240 to 602 fathers. The remainder are still being followed up or processed, or, if in the current series, are yet to be interviewed.

Chromosome Study:

The methodological approach of the chromosome study is described above. The chromosome study group now comprises 43 radar exposed fathers from the ORIGINAL series - 27 fathers of mongols and 16 fathers of controls - along with 43 unexposed matched fathers - 11 fathers of mongols, 21 fathers of controls, plus 11 fathers who are "new matches"* (five to replace unexposed fathers of mongols of original series and six to replace unexposed fathers of controls). From the CURRENT series there are 16 radar exposed fathers - 8 fathers of mongols and 8 fathers of controls - and 13 unexposed fathers - 6 fathers of mongols, 6 fathers of controls, 1 "new match", and three unexposed father matches to be identified. Other CURRENT series radar exposed father and unexposed fathers matched to them will be added to the chromosome study group as they are identified in the CURRENT series interviews still in progress.

The distribution and the number of specimens of blood collected in the chromosome study are summarized in Table 6. According to the last count, 92 blood samples have been obtained on 75 fathers from the two series. Two of the fathers have been dropped from the study because they were found not to have been radar exposed, leaving 73 study fathers from whom blood has been collected.

---

* Replacements are used for unexposed fathers who were initially matched to exposed fathers but who are not available because they are deceased, moved outside the Maryland study area, unable to locate, their matches had refused interview in Original or Current Interview Series and/or are unavailable for other reasons. Replacements are thus unexposed "new matches" to radar exposed fathers.

On 63 subjects*, only one sample has been obtained; on 8, two samples and on 4, three samples. To date there have been approximately 27 culture failures that required (or still require) a second blood sample or a third blood sample and on one subject, a fourth sample is now required. When an additional specimen is obtained because of culture failure, the same code letters are retained as the failure. However, when an abnormality is suspected a repeat specimen is obtained from the subject with new code letters assigned. This is forwarded to the laboratory along with routine initial specimens, so that the karyotype analysis is carried out independently (blind) by the cytogenetics laboratory.

At the present time, approximately 45 more specimens are to be obtained in order to replace culture failures and to screen subjects not yet sampled, in addition to 28 repeat "blind" samples for checking. In view of the rate of culture failures to this time, it is quite likely that the number of additional specimens to be collected and analyzed is as great or greater than the number already processed.

The latest report from the cytogenetics laboratory is summarized in Table 7, Cytogenetics Laboratory Report Summary. An average of 20 cells per patient (ranging from 7 to 50 cells per patiant) is being counted. Among the 55 karyotypes counted thus far, 28 samples will require further study. Every effort is being made to keep the study objective and to make certain that the laboratory on receiving and analyzing blood specimens is not aware of the parental exposure status, etc.

An effort will be made to trace the etiology of abnormal karyotypes in chromosome study fathers insofar as possible in order to provide not only the case-control statistical analysis as planned, but also more specific insight into sources and causes of abnormalities, if and where found.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS:

A summary of the current status of the project operation has been presented above. It should be noted that at the initiation of the project, it was estimated that approximately 95-105 families of mongols would be available for study, based on the experience of the previous series. However, generally improved methods of diagnosis and ascertainment techniques have made available for study approximately 147 - or about 50% more than expected. Since investigation of a larger group would considerably increase the likelihood of obtaining more definite answers to the questions under study, a renewal of the contract with additional funds has been suggested by this investigator. Accordingly, for maximum efficiency of project operations, interviewing, collection of blood specimens and other field phases of the study were extended into the additional series by reallocating funds previously designated for analysis of the smaller series. Thus, at this point in time, although no completed or near complete summaries of the data content are

---

* including 2 fathers later eliminated from the study (Table 7)

available, numerical counts based on field work, follow up, concurrent coding and blood specimens in various stages of processing have been presented.

Arrangements have already been made for the search of government records on all fathers whether or not reporting service, whether or not reporting radar exposure, to obtain as much information as possible concerning these matters. In addition, as described above in the chromosome study, when any aberrancies are suspected, additional specimens are being obtained, given new code letters and sent for independent analysis to confirm or reject the initial findings. Every effort is being made to obtain as complete and as accurate information as possible as well as to utilize multiple and varied approaches to discern probable causation, or at least gain as much supplementary informative data as possible.

While this investigation is still in progress, it is most important to extend the observations to as large a sample as is reasonably ascertainable in order to increase the definitiveness of any findings obtained, and, to validate the observations insofar as is possible. Toward these goals, hopefully funds will be made available as requested.

Although this is one relatively small study to examine possible effects of microwaves, not only its findings per se but also the significance of this whole area of research on radar and microwave effects must not be overlooked. It is, therefore, important to determine whether the previous interview findings of higher frequencies of military service and radar exposure among fathers of children with Down's syndrome are confirmed by an independent replication of the original study, and by record validation of both the ORIGINAL and CURRENT study series. At a time when military and industrial uses of radar and microwaves, and even household exposures to microwaves, are continually expanding, the importance of investigating this problem must not be underestimated.

SUMMARY

The project plan thus includes the following:

ORIGINAL series

I. To locate the fathers of cases and controls in the original January 1, 1946 to October 1, 1962 series and bring their records up to date, obtaining more detailed information on military service and radar exposure as well as their experience since our last contact.

II. To obtain from the radar exposed fathers of cases and controls and the unexposed fathers matched to the radar exposed subjects blood samples for chromosome studies and to carry out complete chromosome analysis on these fathers in the ORIGINAL series.

CURRENT series

III. To identify and trace parents of children with Down's syndrome born in the Baltimore area from October 1, 1962 to January 1, 1969 as well as from January 1, 1945 to December 31, 1945 and:

A. Verify diagnosis.

B. Search birth certificates on these affected children.

C. Select controls matched to cases on hospital of birth, date of birth, maternal age, race and sex of infant.

IV. To carry out interviews of parents of Down's cases of current series.

V. To trace the matched controls of the current series and interview their parents.

VI. To validate selected portions of the data obtained by interview against medical records in current series.

VII. To obtain blood samples and carry out chromosome analysis on all fathers reporting radar exposure and on the corresponding fathers of children matched to those whose parents were exposed in the current series.

BOTH series:

VIII. To validate paternal military/radar history by independent search of government military files on all fathers irrespective of service/radar report (as well as carry out chromosome studies indicated above under II and VII respectively).

IX. To follow through on any chromosome abnormalities observed in an attempt to trace their etiological bases.

TABLE 1

Sources of Ascertainment of Mongols in Current Series

Department of Health - Baltimore City	
Handicapped children	21
Biostatistics	5
Baltimore Association for Retarded Children	18
Rosewood State Training School	5
Searchlight School	2
School of Chimes	2
St. Francis	3
Baltimore City Public Schools	
Claremont School (Baltimore City)	1
Baltimore County Public Schools	
Rolling Road School	4
Battle Mt. School	3
Ridge Road School	3
Hospitals	
Johns Hopkins - IBM listing	6
Johns Hopkins Hospital Medical Records	4
St. Josephs	8
St. Agnes	4
Bon Secours	3
Franklin Square	1
Lutheran	1
South Baltimore General	4
Greater Baltimore Medical Center	9
Baltimore City	2
University	3
Maryland General	7
Mercy	10
Church Home and Hospital	3
Union Memorial	6
Sinai	9
	147

TABLE 2

Status of Interviewing in Current Series (as of February 1970)

	No. Unable to Locate	Inter-viewed	No. Refused	Still being processed	Total
Mothers of mongols	-	118	13	16	147
Fathers of mongols	1	118	12	16	147
Mothers of controls (including new matches when unable to locate)	-	118	10	19	147
Fathers of controls (including new matches when unable to locate)	2	117	9	19	147
Total	3	473	44	68	588

TABLE 3

Deaths of Index, Parents, and Sibs in Current Series

Deaths (on interviews returned)

Mongols	
Mothers	4
Fathers	1
Index subjects	17
Sibs (including stillbirths)	15
Total	37
Controls	
Mothers	2
Fathers	3
Index subjects	-
Sibs (including stillbirths)	18
Total	23

TABLE 4

Military Service Contact Follow Up on Original Series

Total Number of fathers of mongols and controls ascertained	432
Contact made and information obtained	366
Refusals	10
Unable to locate to date	12
Questionnaires still out	44
	432

Deceased 36

TABLE 5

Processing for Government Record Search of Military Service

	Original Series	Current Series	Total
Punched and to be sent for government record search	269	93	362
Coded and ready to be punched	97	143	240
Total	366	236	602

BLOOD SPECIMENS ON RADAR EXPOSED AND UNEXPOSED FATHERS

ORIGINAL SERIES	Number Fathers	Number of specimens obtained 1st	2nd	3rd	4th	Number of fathers: Deceased	Living out of Baltimore	Unable to locate	Refusals
Exposed fathers of:									
Mongols	27	14	2	1	-	2	3	2	6
Controls	16	14	5	1	-	-	1	-	1
Total exposed	43	28	7	2	-	2	4	2	7
Unexposed fathers of:									
Mongols	11	4	1	1	-	1	3	-	2
Controls	21	19	4	2	-	2	-	-	2
New matches	11	5	-	-	-	2	-	-	3
Total unexposed	43	28	5	2	-	5	3	-	7
NEW SERIES (thus far)									
Exposed fathers of:									
Mongols	8	5	-	-	-	1	-	-	-
Controls	8	6	-	-	-	-	-	-	-
Total exposed	16	11	-	-	-	1	-	-	-
Unexposed fathers of:									
Mongols	6	4	-	-	-	-	-	-	-
Controls	6	2	-	-	-	-	-	-	-
New matches	1	-	-	-	-	-	-	-	-
Unidentified (to be obtained)	3	-	-	-	-	-	-	-	-
Total unexposed	16	6	-	-	-	-	-	-	-
Total Chromosome Study	118	73	12	4	-	8	7	2	[illegible]

TABLE 7

Cytogenetics Laboratory Report Summary - February 1970

Blood specimens received:	92 including repeats on failures
Different code numbers:	78*

Status of Chromosome analyses:

Completed with karyotype	40
Additional counted# and photographed	14
Additional counted# not photographed	1
Total counted	55
Samples received but still to be counted	12
Specimens successfully cultured	67

7 to 50 cells per patiented counted, average 20 cells per patient.

* This involves 75 fathers, 3 fathers having been given new code numbers for blind checking of duplicate samples. Of the 75, 2 listed as radar exposed were subsequently dropped from the study because of lack of confirmation of radar exposure.

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

Johns Hopkins University
Baltimore, Maryland 21205

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

Parental Radiation Exposure and Down's Syndrome with Particular Attention to Ionizing Radiation and Radar

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Annual Summary Report: 6/1/69 - 2/28/70

5. AUTHOR(S) (First name, middle initial, last name)

Bernice H. Cohen

6. REPORT DATE

February 28, 1970

7a. TOTAL NO. OF PAGES

21

7b. NO. OF REFS

2

8a. CONTRACT OR GRANT NO.

DADA 17-69-C-9154

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Distribution of this document is to be limited to the USAMRDC.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

Finance and Accounting Office
Walter Reed Army Medical Center
Washington, D. C. 20315

13. ABSTRACT

In an epidemiological study of the parents of children with Down's syndrome born from January 1, 1946 to September 30, 1962 and parents of matched control children, a significantly larger percentage of fathers of Down's cases reported radar exposure than control fathers. Moreover, a larger percentage of the fathers of Down's cases reported having been in military service (63.1 percent versus 56.6 percent for control fathers), although this difference was not statistically significant. Because of the possible implications of these findings, a new (CURRENT) series of parents of mongols and matched control children is being studied in an effort to replicate the original study.

Interview information has been obtained in the CURRENT series with Father's Interview Schedule supplemented by additional questions on radar exposure both in and outside of military service, as well as more detailed questions on military service, service number, duties, etc. Follow-up of all subjects in the ORIGINAL series irrespective of whether military service was reported - to requestion on military service - is being carried out by a combination of telephone, personal visit, mailed questionnaire, etc. Military service records are being validated for both ORIGINAL and CURRENT series by search of U.S. government military records for names of all fathers (whether or not service was reported, whether or not follow-up obtained) to obtain service record dates, MOS classifications and any other pertinent data available. Chromosome studies are being carried

(Continued)

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
mongolism						
Down's syndrome						
radar exposure						
military service						
radiation						
chromosome abnormalities						

ABSTRACT (Continued)

out on all fathers in the ORIGINAL and CURRENT series who reported exposure to radar and the unexposed fathers matched to them.

Thus far, after ascertainment of over 145 mongols from 27 public and private agencies and hospitals, tracing and interviews have been carried out on 238 mothers and 235 fathers of the mongols and their matched controls in the CURRENT series. Tracing and interviewing is continuing as well as search of hospital records for validation of diagnosis and search of death certificates on deceased index subjects (mongols and their matched controls, their parents and sibs, as they are identified). To date 49 deaths have been searched.

Military service follow-up by phone, mail and personal contact has been carried out on 366 of the 432 fathers of the ORIGINAL series, with similar information obtained by interview on 235 fathers of the CURRENT series. These data are being coded and punched to be forwarded for search of government records, with the remaining to be sent as soon as available. Arrangements have been completed with another agency for search of service records and MOS numbers.

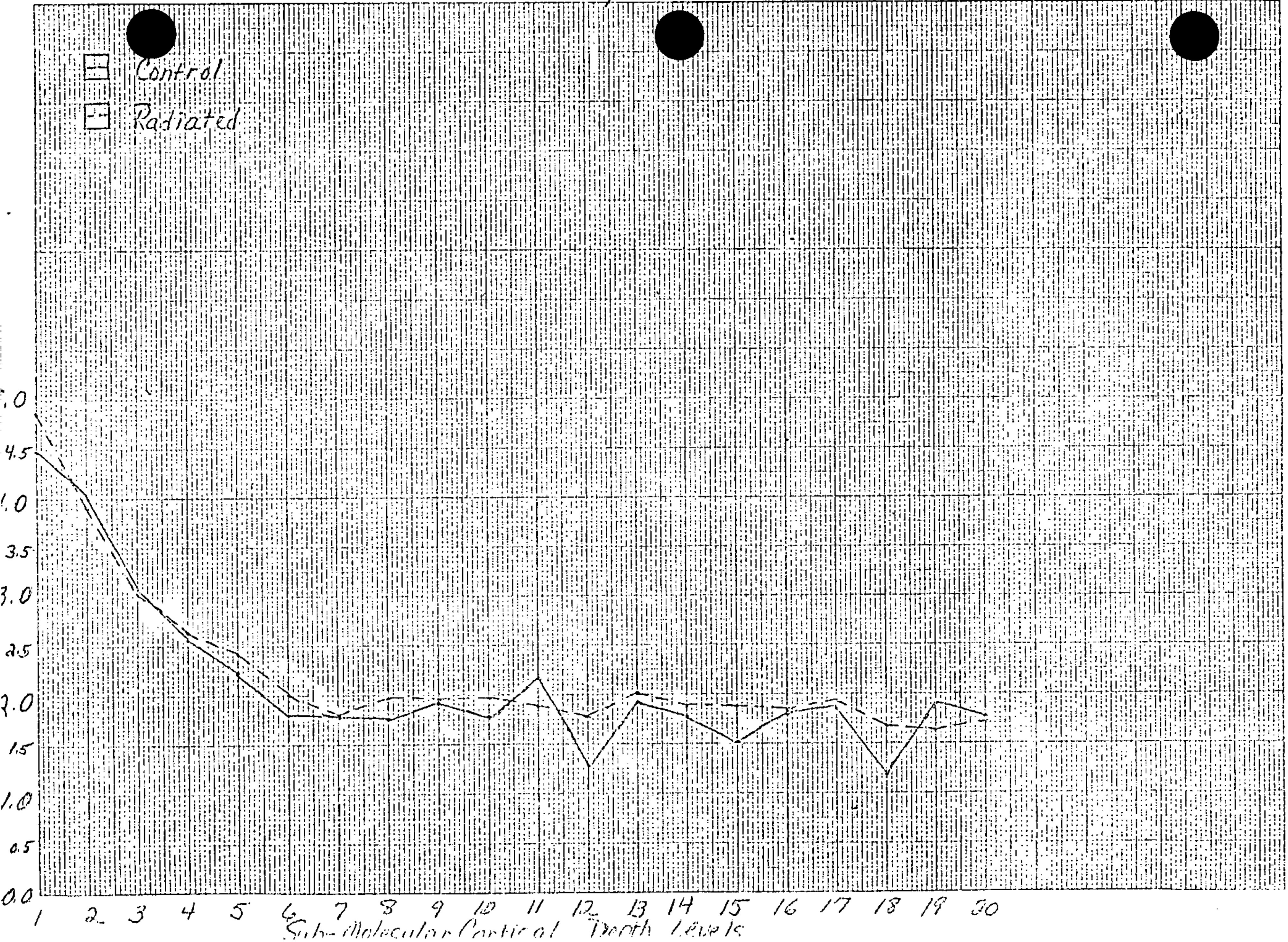
Chromosome studies on radar exposed fathers and unexposed matched fathers are in progress: 92 blood specimens have been collected, including repeats on culture failures and questionable findings. At this date, karyotypes have been completed on 40 and 15 more counted. An attempt will be made to obtain an additional specimen on all culture failures as well as to collect initial specimens from the radar exposed fathers and their matches not yet sampled.

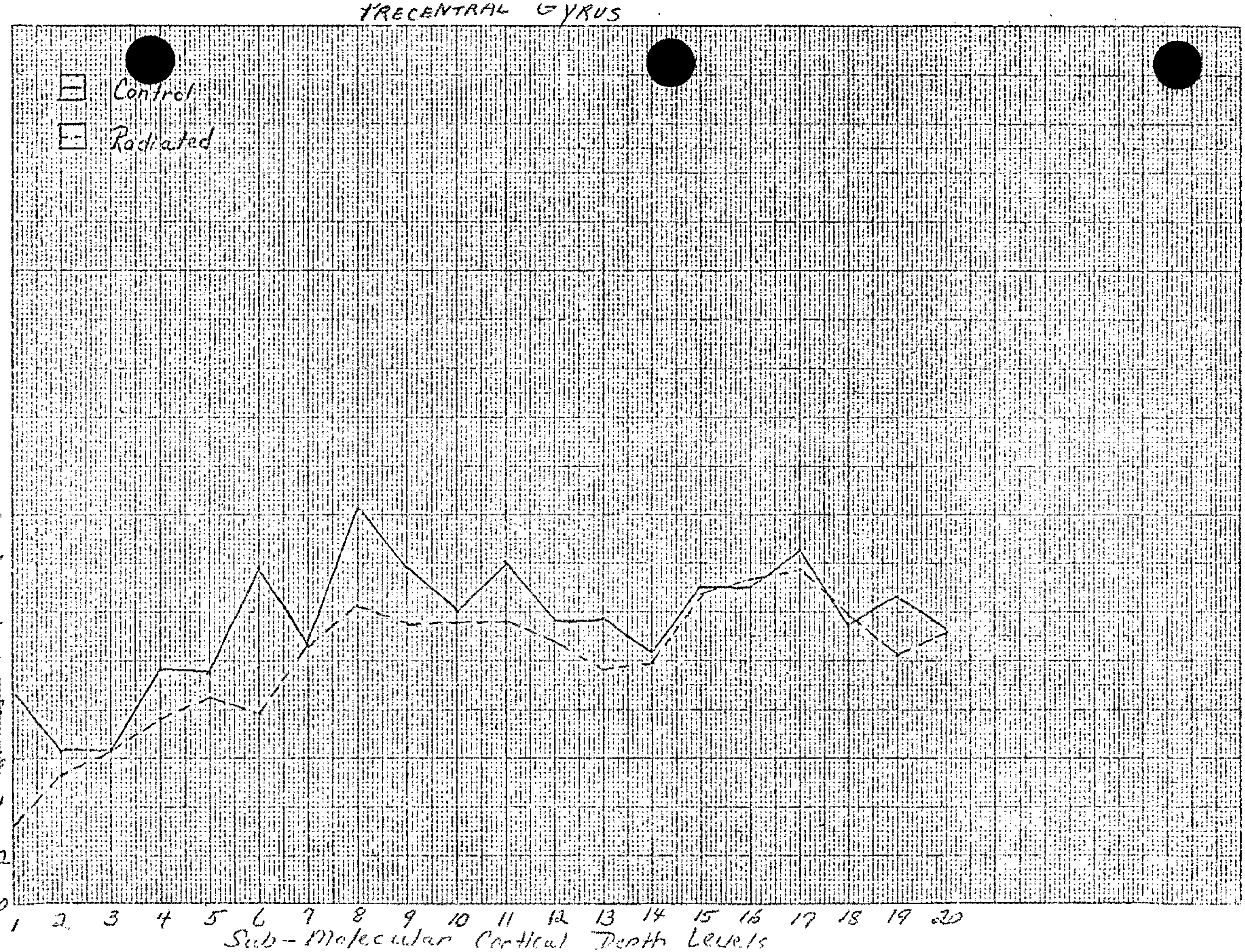
Completion of coding, punching and analysis of results will be carried out after all the remaining data have been collected.

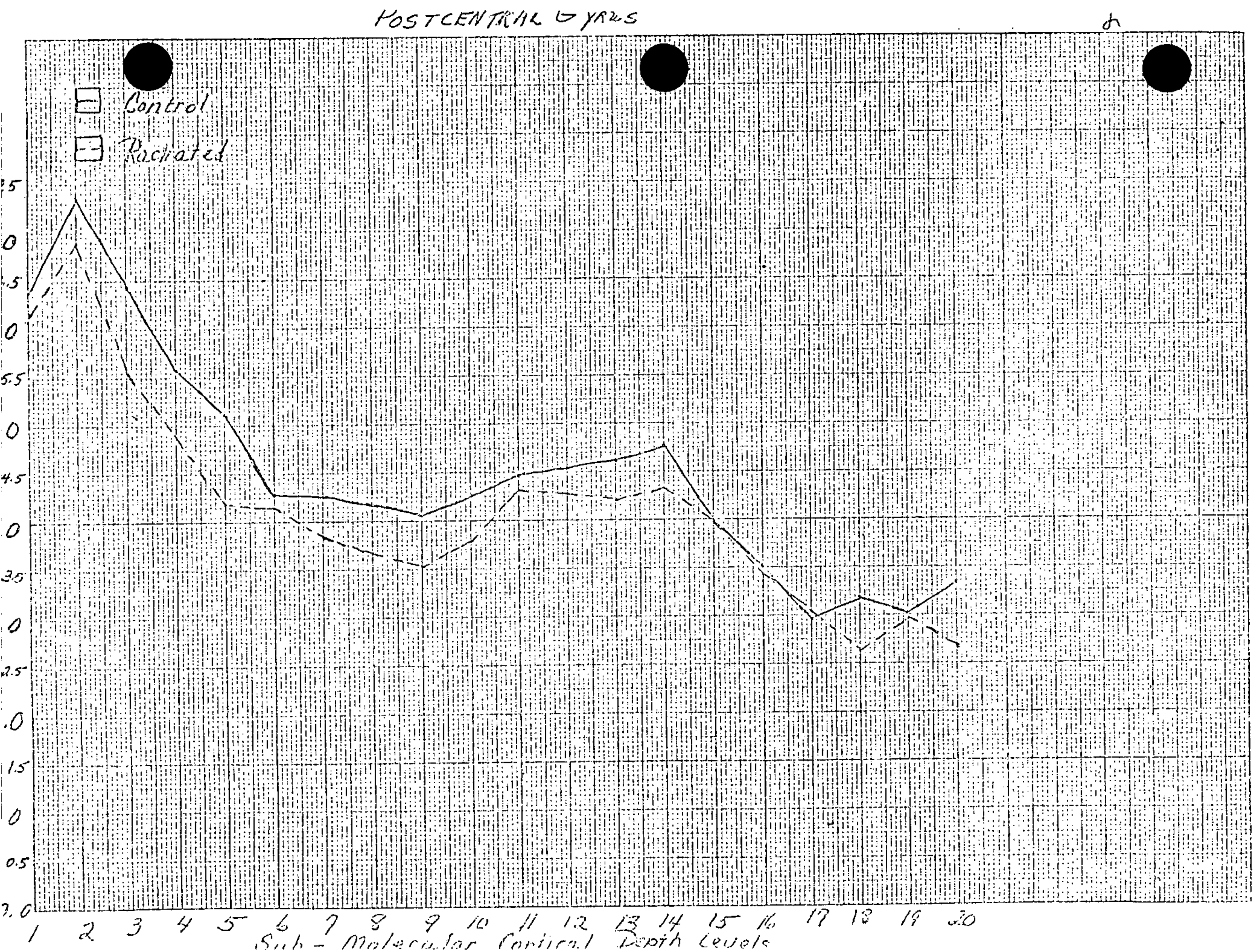
ntr – Neuroglia – Radiated

'L	V-700-MCC-1L	D-509-MCC-1L	E-154-MCC-1L	D-715-MCC-1L	981-MCC-1L
'	.063	.250	.165	.165	.264
?	.250	.188	.264	.298	.364
3	.500	.313	.364	.463	.264
7	.750	.500	.661	.364	.298
5	.438	.438	.562	.628	.264
7	.438	.438	.562	.562	.198
0	.813	.938	1.091	.562	.793
	.938	.688	1.157	.793	.694
3	[illegible]250	.938	.959	.694	.826
-	1.000	.688	.893	1.025	.793
3	1.000	.750	1.091	.860	1.091
	1.625	.688	1.124	1.190	1.025
-	.938	1.563	1.091	.992	.727
	.813	.875	.992	1.455	.727
'	.875	1.500	1.190	1.421	.760
	1.000	.750	1.488	1.025	.959
	1.438	1.125	.826	.826	.860
	.813	1.625	1.256	1.223	.926
	1.313	1.188	1.190	.826	.595
-	[illegible]313	1.500	1.124	1.421	.529

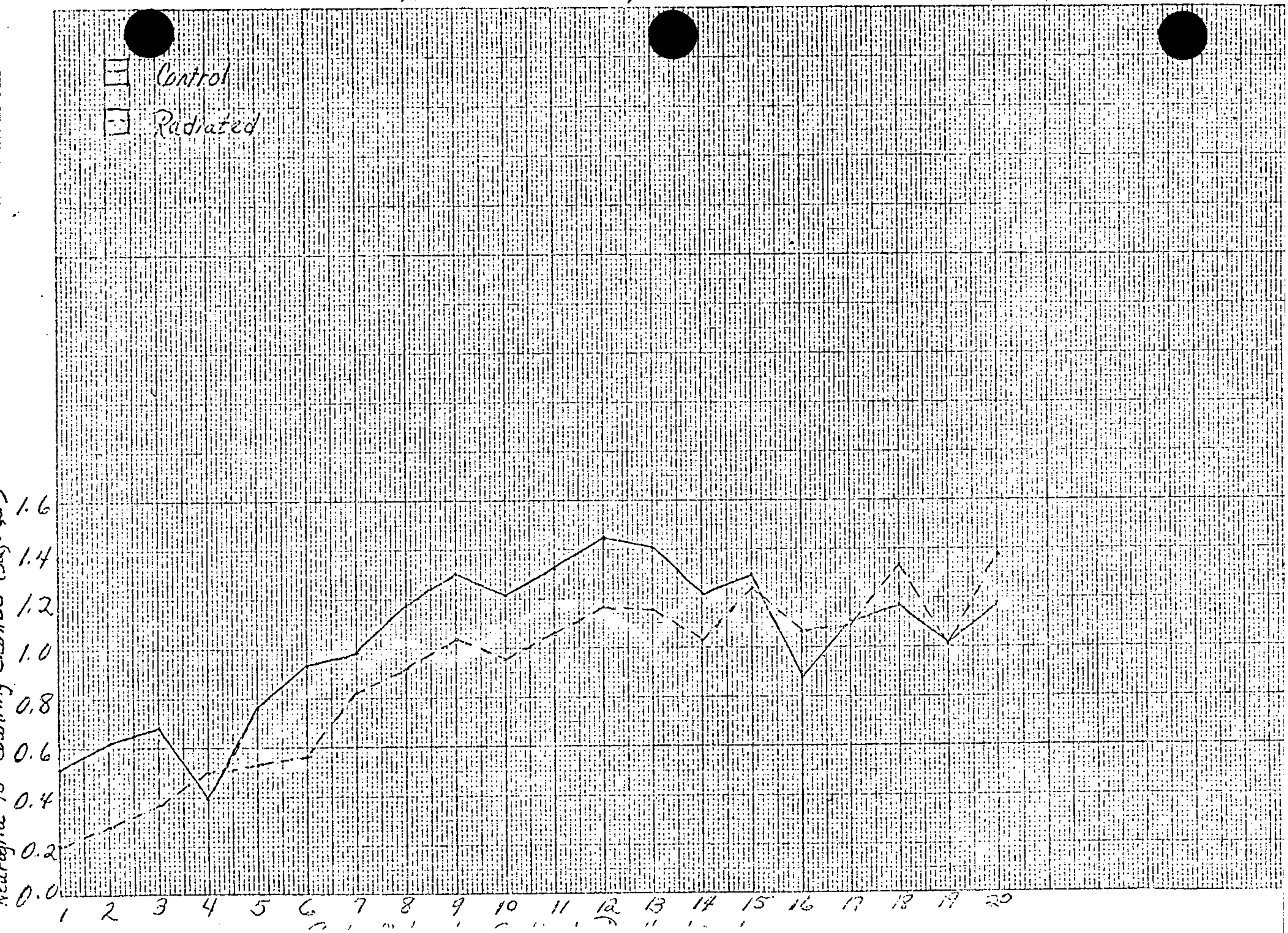
PRECENTRAL GYRUS




PRECENTRAL GYRUS
Control
Radiated
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Sub-Molecular Cortical Depth Levels

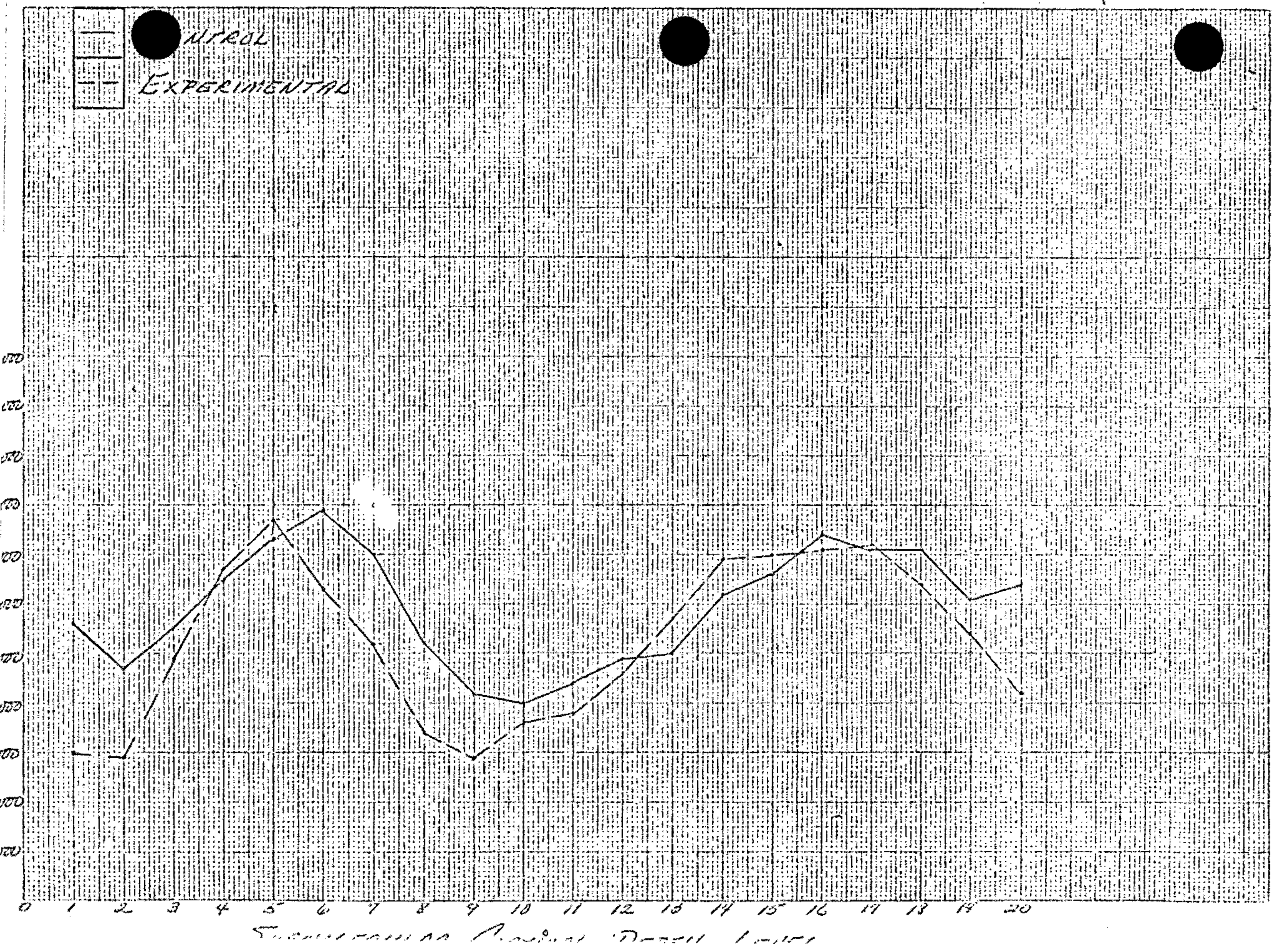

POSTCENTRAL GYRUS
Control
Radiated
5.5
4.5
3.5
2.5
1.5
0.5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Sub - Molecular Cortical Depth Levels

POSTCENTRAL GYRUS

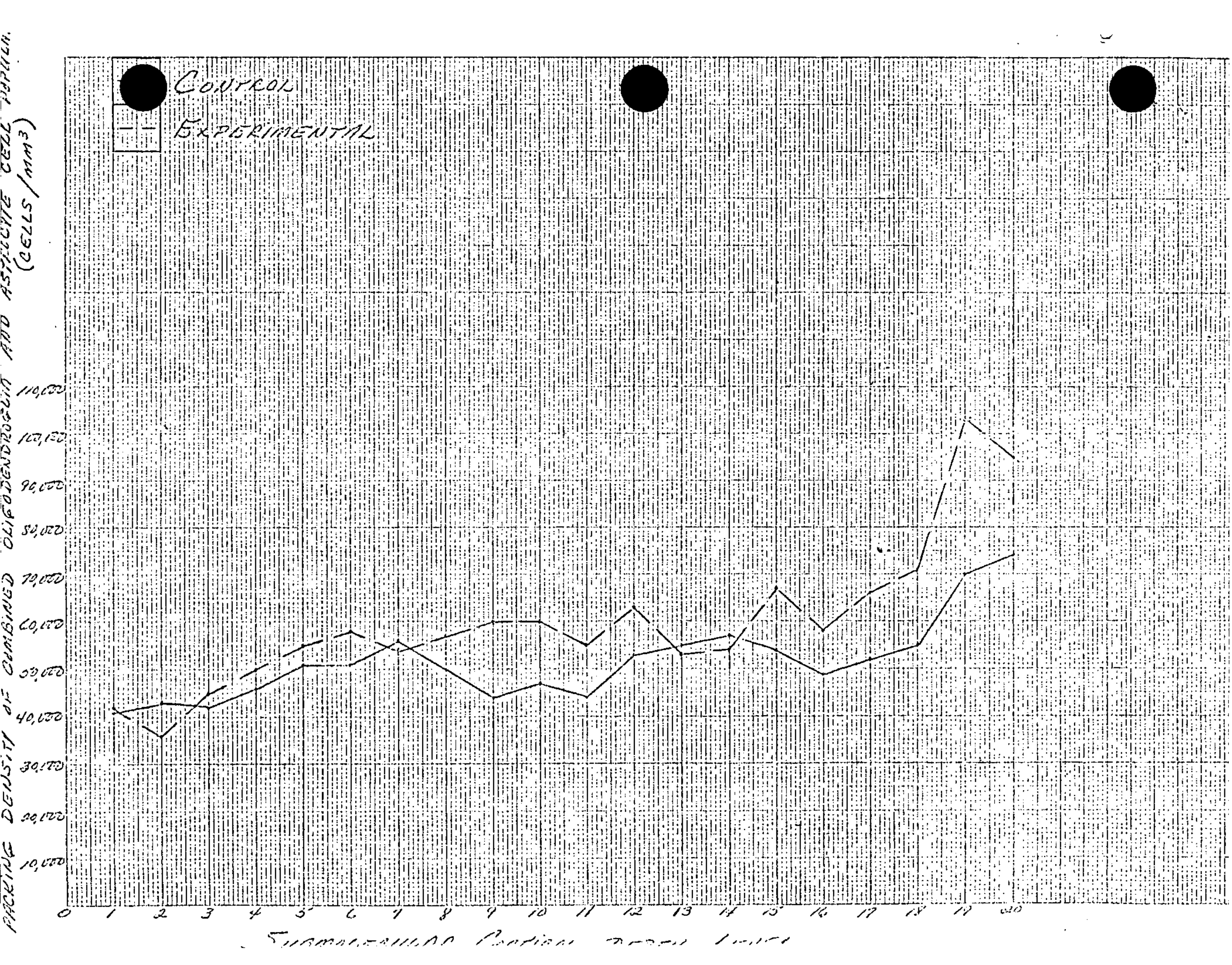


In the earlier progress report we also reported preliminary observations on effects of microwave irradiation on cell packing density in neurons of the somatosensory area (area 3) of the submolecular laminae of the rat cerebral cortex. Only 3 irradiated and 3 control specimens were available for that study. In the period since that report we have obtained additional cerebral cortical tissues from 6 irradiated and 5 control animals from the same group of adult rats described previously. The irradiated animals were exposed to a total of about 12.6 mw/gm in 12 exposures. The brain tissues were fixed in 10% formalin, imbedded in Paraplast, sectioned at 20μ and stained with a quadruple method employing gallocyanin-chromalum, iron hematoxylin, acid fuchsin and ponceau de-xylidene. Cell counts were carried out on these tissues by the same method as described in the previous progress report. The results of these cell counts are presented graphically in figures 5,6, and 7.

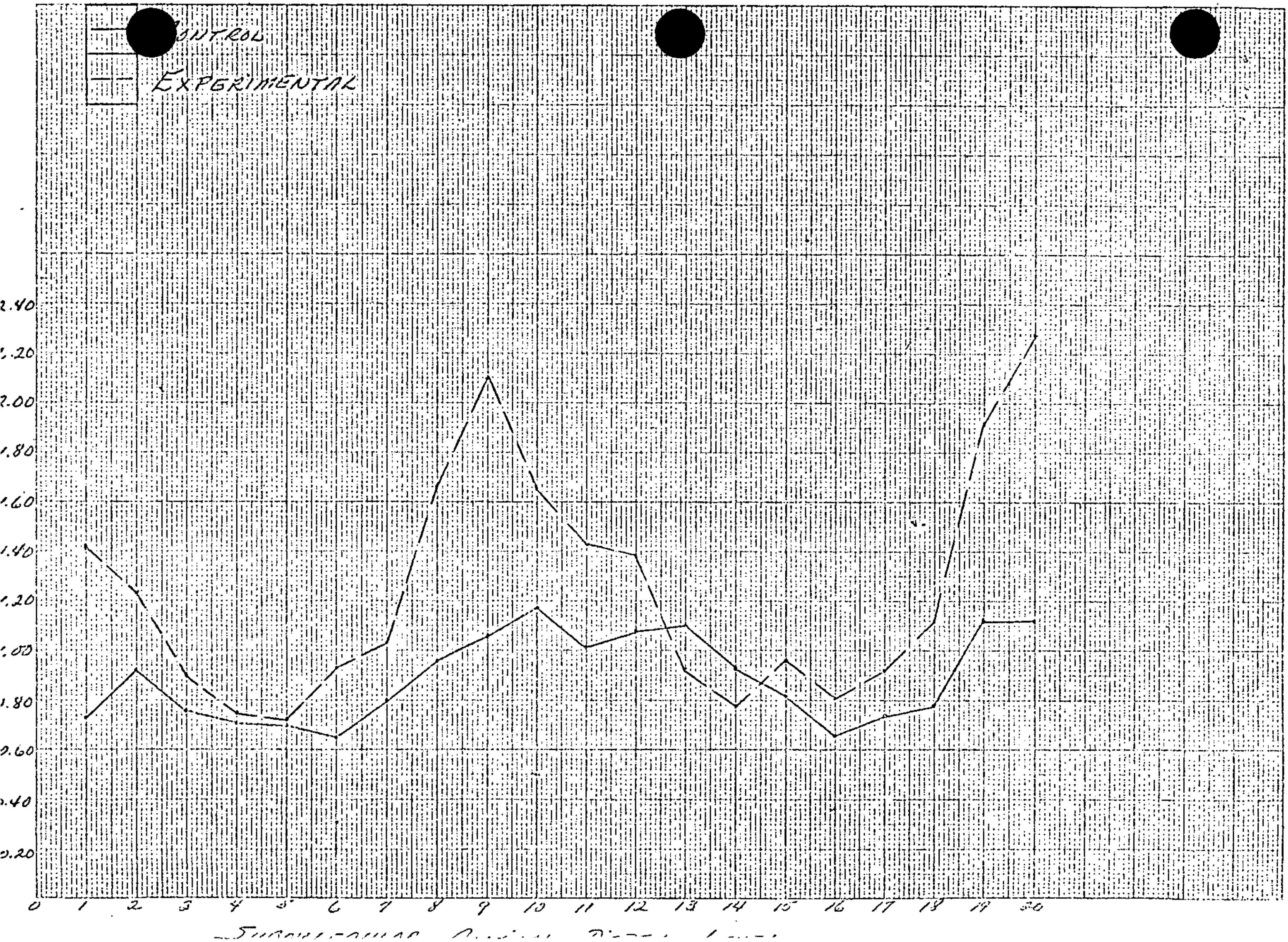
Neuron packing density was not significantly different in irradiated and control series although the mean value in the irradiated brains was lower than in controls. In both of these groups peak values were observed at relative cortical depth levels 4-6 (internal granular layer) and 14-18 (multiform layer). Counts of glial nuclei, on the other hand revealed a higher packing density in the irradiated than in the control group (Fig. 2). The difference between the two, considering mean values for the entire depth of submolecular cortex, proved to be significant at the .05 level. The ratio of glial to neuron packing density (Fig. 3) was also significantly higher in the irradiated than the control group ($p < .05$). The greatest difference between the two groups appeared between relative depth levels 7 and 12 corresponding to cyto-architectonic laminae IV (internal granular lamina) and V (internal pyramidal lamina) and levels 18 to 20 in the deeper part of the lamina VI (multiform lamina).



EXPERIMENTAL
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20



CONTROL
EXPERIMENTAL
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20


CONTROL
EXPERIMENTAL
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

In another phase of the program fourteen timed pregnancy albino rats (Sprague-Dawley strain) were injected intraperitoneally with 1 μc/gram H^3-thymidine. The animals were then exposed to microwave irradiation at 100 milliwatts per cm^2 body surface for 5 minutes. Fetuses were then taken at hourly intervals up to 24 hours, with one additional sample at 36 hours following the initial thymidine injection. In the interval between sacrifices, the laparotomy incisions in the abdominal wall of the dams were closed with loosely sutures. No more than 3 such Cesarean deliveries were made from each dam at one hour intervals and each of them was thus under anesthesia for only two hours. Control animals were subjected to the same procedures but with sham-exposures to the microwave irradiation. The brain tissues were fixed in Bouin's solution, imbedded in Paraplast, sectioned at 6μ and 2μ and prepared for radioautography by dipping in NTB-2 liquid photographic emulsion. The tissues were exposed in light-tight containers for 6 weeks at 5-6° C, then developed and stained with hematoxylin and eosin. Only preliminary studies of the control animals have been carried out thus far. These initial observations indicate that the duration of the cell cycle in control rats is 10 hours, G2-2 hours, M-1 hour, G1-3 hours and S-4 hours. However, the irradiated tissues have not yet been processed. The microwave exposures, sacrifices, and tissue fixation procedures in this phase of the program, were carried out in the laboratories of Dr. Don Justesen, Veterans Administration Hospital, Kansas City, Missouri.

In another series of experiments, several pregnant albino rats of the Sprague-Dawley strain were exposed to microwave irradiation at doses of up to ...w/cm^2 for periods of from 10 to 40 minutes. The microwave exposures were carried out in the laboratories of Dr. Joseph Sharp, New York State Department of Health, Albany, New York. The brains were exposed to irradiation on gestation day 13 and sacrificed on gestation day 19. They were fixed in Bouin's fluid, imbedded in Paraplast, sectioned at 10μ and stained with hematoxylin and eosin. One fetus of the group, which was exposed to the highest dose level for a period of 40 minutes, revealed severe tissue distortion and aberrations of the cerebral hemisphere with re-duplication of the hemisphere and primordial cerebral cortex on one side. Several other brains of the same group showed similar tissue distortion without re-duplication of the hemisphere. However, no rosette formations, which are commonly seen following ionizing irradiation, were observed in these brains. Further studies on these brains are underway at the present time.

In addition to the above, a number of fetal brains, from the original microwave series described in a previous progress report, have been subjected to further study. In the earlier studies we determined the mean depth of primordial cerebral cortex in these animals. In recent investigations we have plotted the total cross-sectional outline of the primordial cerebral cortex in both right and left hemispheres by means of a drawing tube mounted on a Leitz Ortholux microscope. The sections from which these projection drawings were made were located at the rostrocaudal midpoint of the cerebral hemisphere. The total cross sectional area ofthe primordial cerebral cortex will now be determined by means of planimetry. The mean values for the cross sectional area will then be determined for each group of irradiated animals and controls. In investigations involving ionizing irradiation, on another project, this experimental end point has revealed differences in radiation-induced diminution in primordial cortical tissue much more effectively than mere measurements of mean depth of the primordial cortical cell layer.

The original table from the earlier progress report outlining the data on dosages, numbers of available fetuses and mean values for depth of primordial cerebral cortex (cortical plate) is given below.

Table I

GROUP	No. of fetuses measured to date	Dose
I (control)	10	10 seconds-sham exposure
II	6	10 seconds, 1 watt
III	11	10 seconds, 10 watts
IV	15	10 seconds, 100 watts
V	24	20 seconds, 100 watts

GROUP	Mean depth of cortical plate
I	114.36μ
II	148.59μ
III	157.042μ
[illegible]	157.841μ
[illegible]	133.840μ

Security Classification

DOCUMENT CONTROL DATA - R & D

rity classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

ORIG NG ACTIVITY (Corporate author) Kenneth R. Brizzee, Ph.D.,M.D. Delta Primate, Covington, Louisiana	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

REPORT TITLE

Quantitative Histological Studies on Effects of Microwave Radiation on tissues of the Centeral Nervous System

DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report

AUTHOR(S) (First name, middle initial, last name)

Kenneth R. Brizzee, Ph.D;,M.D.

REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 16, 1970	23	None

CONTRACT OR GRANT NO. DADA-69-C-9100	9a. ORIGINATOR'S REPORT NUMBER(S) 242-510428/69-70
PROJECT NO.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) None

DIS TION STATEMENT The findings in this report are not to be construed as official epar t of the Army position unless so designated by other authorized documents. Each ransmittal of this document outside the Department of Defense must have prior approval f the commanding General, U.S. Army Medical Research and Development Command

SUPPLEMENTARY NOTES None	12. SPONSORING MILITARY ACTIVITY U. S. Army Medical Research and Development Command-Office of the Surgeon General Washington, D.C. 20315

ABSTRACT

Exposure of adult monkeys to microwave irradiation did not result in any statistically significant alteration in neuronal or glial cell populations in precentral or postcentral gyri (hand-face area), superior or middle temporal gyri or in visual cortex. Exposure of adult albino rats to microwave irradiation (about 12mw/gm body weight) resulted in no significant alteration in the neuronal population (somato-sensory of cerebral cortex, e.g. cortical area 3), but resulted in a small but significant ($p < .05$) increase in the glial population. These results suggest that microwave irradiation in this species, at the dose levels employed, may stimulate immature glial cells, known to be present in the cortex, to proliferate and mature.

Teratologic alterations were observed in fetal rat brains from animals exposed to microwave irradiation on gestation day 13 and sacrificed on gestation day 19.

Cytokinetic experiments are underway to determine effects of microwave radiation on the cell generation cycle in the primordial ependymal layer of the tal cerebral hemisphere in the rat.

DD FORM 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

DISTRIBUTION LIST

4 copies	Commanding Officer U S Army Medical R & D Command Attention: MEDDH-SI Washington, D.C. 20314
20 copies	Defense Documentation Center Attention: DDCIR Cameron Station Alexandria, Virginia 22314
3 copies	Director Advanced Research Project Agency Washington, D.C. 20301
1 copy	Institute for Defense Analysis 400 Army Navy Drive Arlington, Virginia 22202

AD ____________________

Pandora

[QUA]NTITATIVE HISTOLOGICAL STUDIES ON EFFECTS OF MICROWAVE RADIATIONS ON TISSUES OF THE CENTRAL NERVOUS SYSTEM

Final Report

by

Kenneth R. Brizzee, Ph.D.,M.D.

September 16, 1970

Supported by

ADVANCED RESEARCH PROJECTS AGENCY
Department of Defense, Washington, D.C. 20301

Monitored by

U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
Washington, D.C. 20314

Contract No. DADA-69-C-9100

Tulane University
Delta Regional Primate Research Center
Covington, Louisiana 70433

Title of project:

Quantitative Histological Studies on Effects of Microwave
Radiations on Tissues of the Central Nervous System
Report of Progress (Final) Contract DADA-69-C-9100

Report Submitted by:

Kenneth R. Brizzee, Ph.D.,M.D.
Head, Division of Environmental Health
Delta Regional Primate Research Center

Responsible administrative officer:

Jesse B. Morgan
Business Manager and Comptroller
Tulane University
New Orleans, Louisiana

Name of institution:

Tulane University
Delta Regional Primate Research Center
Covington, Louisiana

Financial officer and official authorized to sign for the institution:

Jesse B. Morgan
Business Manager and Comptroller
Tulane University
New Orleans, Louisiana

Signature ______________________________

SUMMARY

Exposure of adult monkeys to microwave irradiation did not result in any statistically significant alteration in neuronal or glial cell populations in precentral or postcentral gyri (hand-face area), superior or middle temporal gyri or in visual cortex. Dosages and conditions of exposure are available from Dr. James McIlwain,MAJ,MC-Chief, Behavioral Radiology Lab-Department of Experimental Psychology-Walter Reed Army Institute of Research-Washington, D.C..

Exposure of adult albino rats to microwave irradiation (about 12mw/gm body weight) resulted in no significant alteration in the neuronal population (somato-sensory of cerebral cortex, e.g. cortical area 3), but resulted in a small but significant ($p < .05$) increase in the glial population. These results suggest that microwave irradiation in this species, at the dose levels employed, may stimulate immature glial cells, known to be present in the cortex, to proliferate and mature.

Teratologic alterations were observed in fetal rat brains from animals exposed to microwave irradiation on gestation day 13 and sacrificed on gestation day 19. Dosages and conditions of irradiation are available from Dr. Joseph C[illegible]harp,Department of Experimental Psychology- Walter Reed Army Institute of [illegible]rch-Washington, D.C..

Cytokinetic experiments are underway to determine effects of microwave irradiation on the cell generation cycle in the primordial ependymal layer of the fetal cerebral hemisphere in the rat.

In the previous progress report the mean values for neuron and glial packing density in the auditory and visual areas of cerebral cortex were reported for 6 adult monkeys (M. mulatta) which had been exposed to microwave irradiation at Walter Reed Hospital. Four control monkeys were processed in the same manner with the exception of the microwave exposure.

We have now extended that investigation into the precentral and postcentral gyri in the same brains. Techniques of tissue preparation, staining, and cell enumeration were the same as described in the previous report. The actual values, in terms of number of cells per counting chamber (volume of counting chamber-32,000 μ^3), are given in table I. The mean values for each of the 20 equally spaced, submolecular depth levels in the precentral gyrus (hand-face area) are given in figures 1 and 2 for neurons and glia, respectively.

It will be observed that mean neuron packing density decreased from level 1 to level 6, then maintained about the same level throughout the deeper layers. In the same preparations the glia density increased from about level 1 to 8, then maintained essentially the same levels throughout the deeper levels of the cortex. No significant differences were observed between the data from control and irradiated animals ($p > .05$) in either the neuron or glial population.

In the postcentral gyrus (Fig. 3-4), values for neuron packing density were much higher than in the precentral gyrus. However, the two curves appeared somewhat similar in that the neuron packing density decreased from the [illegible] superficial levels to level 6. In the postcentral gyrus this level was maintained to level 14, below which the packing density again decreased somewhat to level 20. The glial population in the postcentral gyrus increased from level 1 to level 12, then maintained essentially the same mean values in the deeper levels. The differences between the cell populations in control and irradiated animals in the post-central gyrus were not significant ($p >.05$).

Details of microwave irradiation exposure are available from Dr. James McIlwain, MAJ,MC-Chief, Behavioral Radiology Lab-Department of Experimental Psychology-Walter Reed Army Institute of Research-Washington, D.C.

Table 1

nt[illegible]-Neurons -Control

Values given as number of cells per counting chamber. Volume of counting chamber = 33,000μ³.

Depth	530-MCC-1L	E-178-MCC-1L	977-MCC-1L
	5.000	4.000	4.438
	3.938	3.240	4.938
	2.688	2.545	4.000
	2.313	2.248	3.125
	2.188	1.719	2.813
	1.625	1.589	2.188
	1.875	1.322	2.188
	1.188	2.116	2.000
	1.813	1.950	2.000
	1.813	1.686	1.875
	2.188	1.818	2.563
	2.000	1.587	2.500
	2.063	1.917	1.813
	1.563	1.554	2.250
	1.438	1.355	1.750
	1.813	1.752	1.938
	2.063	1.587	1.938
	1.938	1.455	2.000
	2.000	1.653	2.063
	2.063	1.752	1.563

entral- Neurons- Radiated

cc-IL	V-700-MCC-IL	D-509-MCC-IL	E-154-MCC-IL	D-715-MCC-IL	981-MCC-IL
75	4.250	5.250	5.190	4.661	4.463
63	2.875	4.750	4.694	3.868	2.678
63	3.375	2.875	3.901	1.983	2.579
3	2.438	2.813	3.438	2.182	2.116
8	2.438	2.375	2.744	1.950	2.314
3	1.375	2.313	2.579	1.851	1.620
8	1.938	2.000	2.182	1.455	1.851
0	2.375	1.813	2.215	1.521	1.950
5	1.375	2.125	2.446	1.818	1.884
3	1.813	1.688	2.347	1.686	2.248
)	2.063	2.375	1.983	1.719	1.950
-	2.063	1.938	2.050	1.455	1.587
	2.000	2.063	2.446	1.686	2.083
)	1.500	1.875	2.116	1.686	1.917
	1.438	2.313	2.413	1.752	1.983
-	1.813	1.875	2.083	1.686	2.050
	1.500	2.188	1.884	1.785	2.215
	1.563	1.563	1.719	1.554	1.752
	1.563	1.625	1.620	1.653	1.719
	2.438	1.813	1.488	1.157	1.983

ent[illegible]al - Neurons - Control

-MCC-1L	E-178-MCC-1L	977-MCC-1L
.875	5.322	6.938
7.625	5.488	8.938
.000	5.091	8.250
.063	3.934	6.750
.875	3.736	6.688
.188	3.306	5.375
.063	2.909	4.813
.000	3.074	5.500
.9[illegible]	3.504	4.750
.750	3.041	5.063
563	3.967	4.875
.625	3.438	5.563
.438	3.240	6.188
5.313	3.174	5.813
1.000	2.612	5.375
3.375	2.645	4.500
3.250	2.347	3.313
3.688	2.281	3.625
3.375	2.017	3.688
3.1[illegible]	2.413	4.438

otrol – Neurons – Radiated

C-1L	V-700-mcc-1L	D-509-mcc-1L	E-154-mcc-1L	D-715-mcc-1L	981-mcc-1L
25	6.250	5.625	6.182	4.860	4.893
3	7.063	8.813	6.711	5.752	6.215
0	6.250	7.125	5.620	4.463	3.934
25	5.188	5.875	4.826	3.240	4.529
63	4.813	5.000	4.562	3.140	3.570
3	4.625	4.875	3.934	2.942	3.702
3	3.938	4.500	4.000	2.678	3.636
50	4.000	4.000	4.132	2.182	3.438
25	3.750	4.563	3.802	2.446	2.942
63	3.938	4.750	3.372	2.579	3.570
00	4.313	5.250	4.331	2.711	3.835
75	4.188	4.875	4.033	3.405	3.702
3	4.813	4.000	4.562	3.107	3.669
8	7.000	3.313	4.397	3.636	3.868
9	5.125	3.438	3.636	3.603	4.331
0	3.438	3.500	3.405	2.942	4.265
25	3.000	3.000	2.645	2.579	3.405
5	3.000	2.563	2.347	2.149	3.405
5	3.375	2.688	2.810	2.579	3.207
8	2.813	2.563	2.810	2.744	2.314

ential - Neuroglia - Control

30-mcc-1L	E-178-mcc-1L	977-mcc-1L
.688	1.289	.625
.563	.760	.563
.500	.727	.688
1.000	.826	1.063
.563	1.124	1.188
1.563	.893	1.688
1.000	.826	1.375
1.875	1.058	1.938
[illegible]	.893	1.563
1.688	.562	1.375
1.625	.661	1.938
.938	.760.	1.813
1.000	1.025	1.500
1.188	.562	1.375
1.625	.529	1.750
1.688	.860	1.375
1.813	.562	2.000
1.000	.694	1.750
1.375	.661	1.750
[illegible]	.628	.875

ntr - Neuroglia - Radiated

C-IL	V-700-MCC-IL	D-509-MCC-IL	E-154-MCC-IL	D-715-MCC-IL	981-MCC-IL
8	.313	.375	.496	.231	.132
5	.563	.625	.264	.529	.331
5	.750	.563	.793	.628	.231
3	1.000	.875	.595	.661	.397
3	.875	.813	.595	.959	.562
)	.500	1.000	.893	.727	.595
)	1.125	1.063	1.355	1.025	.595
3	1.438	1.313	1.289	1.124	.694
3	.938	1.188	.959	.959	.562
0	1.125	.813	1.289	1.157	.760
8	1.875	.750	1.223	.826	.562
0	.875	1.375	1.388	.860	.463
70	.750	1.438	.959	.727	.661
75	.875	.938	1.488	1.091	.727
70	1.438	.750	2.413	.826	.496
8	1.813	1.250	1.025	1.124	.860
78	1.375	1.313	.959	.893	.595
3	2.000	.938	1.157	.727	.463
0	.938	1.375	.959	.893	.463
3	1.188	1.000	1.058	1.091	.793

ntral - Neuroglia - Radiated

-IL	V-700-MCC-IL	D-509-MCC-IL	E-154-MCC-IL	D-715-MCC-IL	981-MCC-IL
8	.313	.375	.496	.231	.132
5	.563	.625	.264	.529	.331
5	.750	.563	.793	.628	.231
3	1.000	.875	.595	.661	.397
	.875	.813	.595	.959	.562
	.500	1.000	.893	.727	.595
	1.125	1.063	1.355	1.025	.595
	1.438	1.313	1.289	1.124	.694
	.938	1.188	.959	.959	.562
0	1.125	.813	1.289	1.157	.760
8	1.875	.750	1.223	.826	.562
0	.875	1.375	1.388	.860	.463
0	.750	1.438	.959	.727	.661
5	.875	.938	1.488	1.091	.727
0	1.438	.750	2.413	.826	.496
8	1.813	1.250	1.025	1.124	.860
8	1.375	1.313	.959	.893	.595
3	2.000	.938	1.157	.727	.463
0	.938	1.375	.959	.893	.463
3	1.188	1.000	1.058	1.091	.793

entral - Neuroglia - Control

30-mcc-IL	E-178-mcc-IL	977-mcc-IL
.563	.793	.188
.688	.793	.375
.375	.727	.938
.375	.562	.250
.688	.529	1.063
1.125	.860	.813
1.188	.760	1.000
1.375	.893	1.250
1.[illegible]3	1.091	1.250
1.188	.826	1.625
1.250	1.091	1.625
1.875	1.025	1.438
1.125	1.785	1.313
1.250	.661	1.750
1.625	.694	1.563
1.125	.463	1.063
1.125	.694	1.500
1.500	.529	1.500
.875	.628	1.563
1.[illegible]5	.661	1.500

EFFECT OF LOW-LEVEL, LOW-FREQUENCY ELECTRIC FIELDS ON EEG AND BEHAVIOR IN MACACA NEMESTRINA

R.J. Gavalas
Space Biology Laboratory
Brain Research Institute
University of California
Los Angeles, California 90024

D.O. Walter
J. Hamer
W. Ross Adey

Space Biology Laboratory
Brain Research Institute
University of California
Los Angeles, California 90024

All copies to Pandora Ann. [illegible] —
[illegible]

RUNNING TITLE:

EFFECT OF LOW HZ FIELDS ON EEG AND BEHAVIOR

Summary

A series of experiments has been done to assess the effects of low-level, low-frequency electronic fields on the behavior and EEG of monkeys. Three monkeys were implanted with subcortical and cortical EEG electrodes and trained to press a panel on a fixed interval-limited hold schedule. The monkeys were rewarded for pressing the panel once every five seconds within a 2.5-second enable period. After the animals were performing well, they were tested under low-level electric fields (2.8 volts p-p); the voltage was applied to two large metal plates 40 cm. apart so that the monkey's head was completely within the field. Fields frequency was set at 7 or 10 Hz, within the range of typical EEG recording (0-33 Hz). Four-hour daily tests of fields-on were randomly interspersed with four-hour runs with fields-off. Under the 7-Hz fields, the monkeys showed a significantly faster interresponse time in 5 of 6 experiments. Mean differences between fields on and fields off were .4 seconds or greater. The 10-Hz fields did not produce a reliable effect on behavior. Analysis of the EEG data showed a relative peak in power at the frequency of the fields (10 Hz and 7 Hz) for the hippocampus in all three monkeys. Similar peaks were seen less consistently in the amygdala and the centre median.

EFFECT OF LOW-LEVEL, LOW-FREQUENCY ELECTRIC FIELDS ON EEG AND BEHAVIOR IN MACACA NEMESTRINA

R.J. Gavalas, D.O. Walter, J. Hamer, and W. Ross Adey

A series of preliminary experiments has been done in an attempt to determine whether or not low-level electric fields have an effect on behavior and/or patterns of electrical activity in the brain of monkeys.

Very few studies of this kind have been done on either animals or man. Experimentally produced changes in reaction time in humans exposed to low-level, low-frequency (less than 12 Hz) fields have been reported by Hamer[7] and Konig and Ankermuller[9]. Changes in human reaction time have also been observed under low-frequency modulated magnetic fields (Friedman, Becker and Bachman[6]). Wever[19] has described the modification of circadian periods of activity in man under weak 10 Hz electric fields. It was not known what kind of primate behavior, if any, would be sensitive to field effects so that selection of a suitable behavioral task was a first consideration. Earlier pilot studies in this laboratory suggested that subjective time estimation in humans was influenced by the presence of fields. In the present study, we attempted to devise an analogous time estimation task suitable for use with monkeys, so that electrodes implanted deep in the brain could monitor brain electrical activity throughout the experiments. It is known that scheduling of reinforcements for a simple lever press can alter an animal's rate of response, or the timing of that response, or both. In the present study, monkeys were trained to press a lever under a variation of a fixed-interval (timing) schedule of reinforcement. Under this schedule there are no external cues or signals presented to the animal; he must "time" his responses from the occurrence of his own last response. It is a schedule which has been widely employed in studies of animal behavior and has been especially useful in detecting effects of small dosages of drugs (Sidman[13]). It was expected that if there were an effect of the fields it would be seen as a shift in the distribution of the monkey's interresponse times.

Other questions of research strategy arose; it was not obvious what brain structures, if any, would show an effect of the presence of the fields. Nor was it clear what kind of changes one might expect to see in the EEG--other than a possible direct driving by the applied field--or how to assess such changes. Consequently, an array of seven bipolar cortical and subcortical electrodes were implanted in the first monkey. A slightly different array was implanted in a second monkey and electrode sites for the third monkey were selected on the basis of results from the first two. Computerized spectral analysis of the EEG was done and some special statistical tests were devised to compare fields-on vs. fields-off changes in EEG.

Low-level (2.8 volts p-p) fields were used at two frequencies, both within the range of frequencies usually evaluated in EEG work (0-33 Hz). In some of the experimental runs, 10-Hz fields were used, to correspond to Hamer's earlier experiments (Hamer[8]). In other runs, 7-Hz fields were used because they were in the range of hippocampal theta (4-7 Hz), a characteristic electrical activity of the brain that has been own to be important in orienting and discriminating responses Radulovacki and Adey[10], Walter, Rhodes and Adey[17]).

Methods: Experimental Design, Behavioral Data Analysis, and EEG Analysis.

I. Experimental Design.

Three pigtailed macaques were implanted with cortical and subcortical bipolar electrodes, and were adapted to Foringer monkey chairs. They were then trained to push a panel in front of them on a fixed interval-drl (differential reinforcement of low rates) limited hold schedule of reinforcement; (drl-h schedule). The animal was gradually conditioned to wait 5 seconds between pushes, and to push within a 2.5 second reward-enable nterval. If the animal pushed within the specified time interval, he was rewarded with a squirt of apple juice. If he pushed too early, or too late, he did not receive a reward, and the timer recycled to the beginning of another 5 second interval. The behavioral task was completely automated with logic modules manufactured by B.R.S. Electronics. The monkeys were maintained throughout training and experiments on a standard controlled diet of monkey pellets, fruit, and restricted fluids. A liquid reinforcer was chosen in order to eliminate chewing artifacts in the EEG. The animal was trained until he was performing at a high rate of accuracy (70-80%) and his performance was relatively stable from one day to the next. All of the training was done n an isolated and sound-proofed booth. Task electronics and recording apparatus were in an outer room and the monkey's behavior was continuously monitored on closed-circuit TV.

After the animal was performing well, his behavioral records over a 24-hour period were examined to determine periods of free responding during the day, and a four-hour segment of time was selected for scheduling daily experimental runs. The low-level (2.8 volts p-p), low-frequency fields were administered by applying the voltage to two larger metal plates, 40 cm. apart, which were fastened to the monkey's chair so that the head of the animal was completely within the fields. Four-hour daily tests with the fields on were randomly interspersed with four-hour daily control runs without the fields. A total of twenty such tests were done on the three well-trained monkeys. All monkeys were given two tests with 7-Hz fields and two comparable control tests without fields. Two of the three monkeys were also given two tests with 10-Hz fields and two control runs without the fields. EEG and behavioral data were continuously monitored throughout all runs. In addition, EEG was monitored in one monkey during two four-hour nonperformance runs (7-Hz fields-on and fields-off) before he was trained to the drl-h task.

II. Data Analysis of Behavioral Changes.

Interresponse time data (IRTs) were collected by the computer for each experimental run; each response of the animal was tallied as a function of time elapsed since the immediately preceding response. Two-tenths of a second bin widths were used; 144 bins were counted and interresponse times greater than that were tallied as 144 (28.8 seconds). Mean and standard deviations were calculated for each four-hour run, and t tests were used to compare IRT distributions for experimental runs and the appropriate matched control runs.

III. Data Analysis of EEG Changes: Spectral Intensity, Coherence, Discriminant Analysis.

EEG data was continuously recorded on a Grass polygraph and an Ampex analog tape recorder. In the first monkey (J.) EEG was recorded from the left hippocampus, right hippocampus, right amygdala, midbrain reticular formation, right visual cortex, left visual cortex and motor cortex. In the second monkey (Z) EEG was monitored from the right hippocampus, left hippocampus, left centre median, right visual cortex, and right amygdala. In the third monkey (A.) records were taken of the electrical activity of the right hippocampus, left hippocampus, right centre median, left centre median, right amygdala, and left amygdala.

Four sets of EEG data from comparable epochs from each day's run were selected for computer analysis. A set of correct (i.e., properly timed) responses was selected from the beginning of the run and a second set from the end of the run; similarly, a set of predominantly incorrect responses was sampled from the beginning of the run and a comparable set from the end of the run. Each epoch was approximately 80 seconds in length. These epochs were spectrally analyzed in consecutive 10-second samples and then averaged over the total 80 seconds.

The selected data epochs were converted to digital form by the SDS 930 computer system of this laboratory and spectral analysis of this data was performed, using the BMDX92 program and the IBM 360/91 computer of the Health Sciences Computing

Facility. Spectral resolution was set at 2 Hz over the range 4-28 Hz for survey purposes. Spectra and coherences (Walter, Rhodes, Brown and Adey[18]) were averaged for each structure, within condition, and plotted; spectra were converted before plotting to relative units (by dividing by the total intensity in that structure in that condition) in order to compensate for day-to-day variations in total intensity; the result is called "percent power" at each frequency.

Spectral Intensity. A specialized statistical test for the effect of the imposed field on recorded activity was devised as follows. In the frequencies from 4-20 Hz, at least, the spectra were close to exponential in shape, in the absence of fields. If this were exactly true, the logarithm of the spectral curve would be a linear function of frequency, over this range. Then any activity contributed by the field would be above the line containing those points not at the field frequency (or its harmonics). Accordingly, we tabulated the statistic ("peak quotient") for the 10 Hz field.

$$\log_e(S_{10}) - 1/2\,[\log_e(S_{12}) + \log_e(S_8)]$$

When the field was at 7 Hz, more care was required. The 7-Hz signal appeared both in the filter band centered at 6 Hz and (to a lesser extent) in that centered at 8 Hz. We chose to test only the value at 6 Hz, and to compare it with the line based on 4 Hz and 10 Hz; thus, the peak quotient for the 7-Hz field became

$$\log_e(S_6) - [2/3\ \log_e(S_4) + 1/3\ \log_e(S_{10})]$$

The spectral estimates have a sampling distribution like chi^2/d.f., with d.f. calculated by the program (according to formulas adapted from Blackman and Tukey[4]) as approximately 200 in our case. Thus, the natural logarithm of a single spectral intensity has an approximately normal distribution, with variance 2/d.f., and a coefficient of skewness of -0.1 (Abramowitz and Stegun[1]). Our peak quotient statistic, then, is close to normally distributed with variance .01. Its response to application of the field in the two experiments for each animal could be tested by the t-statistic, with the two fields-off values providing the mean corresponding to the null hypothesis of no effect of the field.

Coherence. An additional parameter calculated by the spectral analysis program is the coherence between the imposed field and the activity in each structure, as well as between the brain structures themselves. It is essentially analogous to the squared coefficient of correlation, and hence, a measure to the linear predictability between the two wave forms, taking into account spectral intensity, frequency and phase lag. Although the purity of the imposed sinusoidal field invalidates the usual distributional assumptions about the coherence statistic, we felt these results might be suggestive.

Discriminant Analysis. In seeking for less obvious field effects, we applied step-wise discriminant analysis (Anderson[2], Rao[11]) to spectral and cross-spectral parameters, with the exclusion of the frequency band containing the field frequency, or else of that band and all bands containing any harmonics of that frequency. Applications of this computer program, Discan (based on BMD 07M, Dixon[5]) to spectral analysis of EEGs have been described previously (Walter, Rhodes and Adey[17]; Rhodes, Walter and Adey[12]; Hanley, Walter, Rhodes and Adey[9]; Berkhout, Adey and Campeau[3]).

Results

Behavioral data. Consistent differences in interresponse time distributions were observed in the 7-Hz experiments. The 10-Hz field condition failed to produce a reliable effect on the behavior. For one animal (Z.) the mean interresponse time was unchanged by the 10-Hz field; responses were slightly faster (but not significantly so) in the replication. In animal J., interresponse times were faster in the first 10-Hz experiment and slower in the second.

Under the 7-Hz condition, however, rather large and consistent differences were observed in all animals. Animal Z. showed a shift in mean interresponse time toward shorter IRT's; the difference was approximately one-half second in the first experimental-control run. This finding was replicated in a second experiment (See figure 1) and these differences were highly significant statistically (p = .01 or better). In general, the whold distribution was shifted towards faster responses, while overall number of responses did not increase or decrease consistently. For the second animal (J.), the IRT mean shifted significantly in the direction of faster responses in the first experiment; however, this difference was not replicated in the second experiment. The third animal (A.), like the first, showed a shift in the direction of faster responses under the 7-Hz field. This difference was statistically significant and was replicated in the second experiment. Percent of correct responses (those falling between 5 and 7.5 seconds) did not differ significantly under fields-on conditions for monkeys J. and Z.; monkey A., who had a large number of very long IRTs in the fields-off condition, showed gains of 16% correct and 21% correct when the fields were on. In summary, five of the six experiments showed a shift to significantly faster inter-response times under the 7-Hz fields compared with fields-off performance. All of these mean differences were .4 seconds or greater. Shifts in modal values also occurred in all 5 experiments and were all .2 seconds or greater. The distributions and means for all monkeys are shown in Figure 1. It may be observed that the overall output of responses and the variability of those responses differs considerably from monkey to monkey. Nevertheless, the direction of the mean shift under the fields is remarkably consistent and the size of the shift is relatively large.

EEG data: Visual inspection of the EEG data during the experiments did not reveal any marked effects due to the fields. An examination of the percent power graphs, however, revealed small peaks in power from some brain structures at the fields frequency, for epochs of predominantly incorrect responses near the end of the run. A sample of EEG data and percent power graphs is shown in Figure 2.

Peak quotients (as described in the methods section) were compared via t-tests for these epochs in fields-on versus fields-off conditions, for each animal and for each structure. (See Figure 3). In the first animal (J.), significant differences were observed in the left hippocampus, the right hippocampus and the right amygdala for both the 7-Hz and the 10-Hz condition. In the third animal (A.), 7-Hz fields only were tested. Differences at the .01 level or better were observed in right hippocampus, left hippocampus, and left centre median. EEG records were also evaluated for this animal while he was sitting quietly and before he had been trained to do the drl-h task. Differences in peak quotients for 7-Hz fields-on vs. fields-off were observed in four of six structures tested: right hippocampus, right centre median, left hippocampus, and left amygdala.

Coherence measures between the 7-Hz sinusoidal wave form and the responsive EEG structures were always higher for the fields-on condition than for the fields-off condition. Sample measures are shown in Figure 4. Coherences between responsive brain structures did not reveal a consistent pattern of change.

No effects on EEG at non-field frequencies were visually noticeable, but the discriminant analysis program Discan (see Methods) was applied to the data of one animal (J.), and identified strong driving (increased intensity and increased coherences) at harmonics of the field frequency. Although such harmonic response is perfectly compatible with biological transduction (Walter and Adey[16], Van der Tweel and VerduynLunel[15]), it does not exclude artifactual transduction. Further application of Discan, this time excluding all bands containing any harmonics of the field frequency, still showed a clear discriminability of fields-on from fields-off EEGs, principally in that intensity was raised in the fields-on condition, even in non-harmonic frequency bands.

Discussion. The behavioral results suggest that imposing a 7-Hz field on the performing animal resulted in shorter interresponse times. Results with 10-Hz fields were not reliable. Experimental/control differences for the 7-Hz runs were statistically significant for five of six experiments, and these differences could be observed in all three monkeys. In spite of large differences in total output of responses from monkey to monkey, the shift in interresponse times was very consistent (towards faster responses) and rather large (.4 seconds or greater).

Increases in EEG intensity (peak quotients) at the frequency of the fields were observed in all three animals in the hippocampus, and less consistently in the amygdala and centre median. These differences were observed both in the 7-Hz and 10-Hz conditions. Coherences between the sine wave and responsive brain structure at the fields frequency were always higher in the fields-on condition.

The analysis of the EEG data presents special problems. The difficulty of isolating effects of biological transduction from those of transduction at the electrode/tissue-fluid interface is considerable, being almost parallel to the impossible question of "what the tree looks like when no one is looking at it." Nevertheless, the discriminant analysis program has provided preliminary evidence of subtle EEG changes at non-field frequencies that cannot be easily explained as electrode/tissue artifacts.

The concordance of evidence for a fields effect on behavior and on electrical activity of the brain is encouraging. We intend to pursue additional demonstrations of these same kinds as well as others. One new technique to be applied is a frequency "sweep" from 5 to 20 Hz, with enough time spent at each frequency to allow coherence estimates to be reliably made there; our prediction is that, as occurred with wholebody vibration in the monkey (Walter and Adey[16]), and as seems to occur with sinusoidally modulated light stimulation in the human (van der Tweel and VerduynLunel[15]) there will be a band of incoherent driving. It may even be possible to establish some specific non-linear model, along the lines successfully pursued by Spekreijse[14] for the visual system.

REFERENCES

1. Abramowitz, M. and Stegun, I.A. (ed.). Mathematical Functions with Formulas, Graphs, and Math Tables. U.S. Government Printing Office, 1964, p. 943.

2. Anderson, T.W. An Introduction to Multivariate Statistical Analysis. Wiley, New York, 1958, Ch. 6.

3. Berkhout, J., Adey, W.R. and Campeau, E. Simian EEG activity related to problem solving during a simulated space flight. Brain Res., 13 (1969) 140-145.

4. Blackman, R.B. and Tukey, J.W. The Measurement of Power Spectra. Dover, New York, 1959.

5. Dixon, W.J. (ed.). BMD Biomedical Computer Programs (second edition). University of California Press, Los Angeles, 1967.

6. Friedman, H., Becker, R.O. and Bachman, C.H. Effect of magnetic fields on reaction time performance. Nature, 213 (1967) 949.

7. Hamer, J. Effects of low level, low frequency electric fields on human reaction time. Commun. in Behav. Bio., 2 (1968) No. 2, Part A.

8. Hanley, J., Walter, D.O., Rhodes, J.R. and Adey, W.R. Chimpanzee performance data: computer analysis of electroencephalograms. Nature, 220 (1968) 879-881.

9. Konig, H. and Ankermuller, F. Uber den Einfluss besonders niederfrequenter elektrischer Vorgange in der Atmosphare auf den Menschen. Die Naturwissenschaften, 21 (1960) 486.

10. Radulovacki, M. and Adey, W.R. The hippocampus and the orienting reflex. Exper. Neurol. 12 (1965) 68-83.

Rao, C.R. Advanced Statistical Methods in Biometric Research. Wiley, New York, 1962, Ch. 8.

12. Rhodes, J.M., Walter, D.O. and Adey, W.R. Discriminant analysis of "activated" EEG. Psychon. Sci., 6 (1966) 439-440.

13. Sidman, M. Techniques for assessing the effect of drugs on timing behavior. Science, 122 (1955) 925.

14. Spekreijse, H. Analysis of EEG responses in man; evoked by sine wave modulated light. Published thesis, The Hague, Junk, 1966.

15. Van der Tweel, L.H. and VerduynLunel, H.F.E. Human visual responses to sinusoidally modulated light. EEG Clin. Neurophysiol., 18 (1965) 587-598.

Walter, D.O. and Adey, W.R. Linear and non-linear mechanisms of brain-wave generation. Ann. N.Y. Acad. Sci., 128 (1966) 772-780.

17. Walter, D.O., Rhodes, J. and Adey, W.R. Discriminating among states of consciousness by EEG measurements. EEG Clin. Neurophysiol., 22 (1967) 22-29.

18. Walter, D.O., Rhodes, J.M., Brown, D. and Adey, W.R. Comprehensive spectral analysis of human EEG generators in posterior cerebral regions. EEG Clin. Neurophysiol., 20 (1966) 224-237.

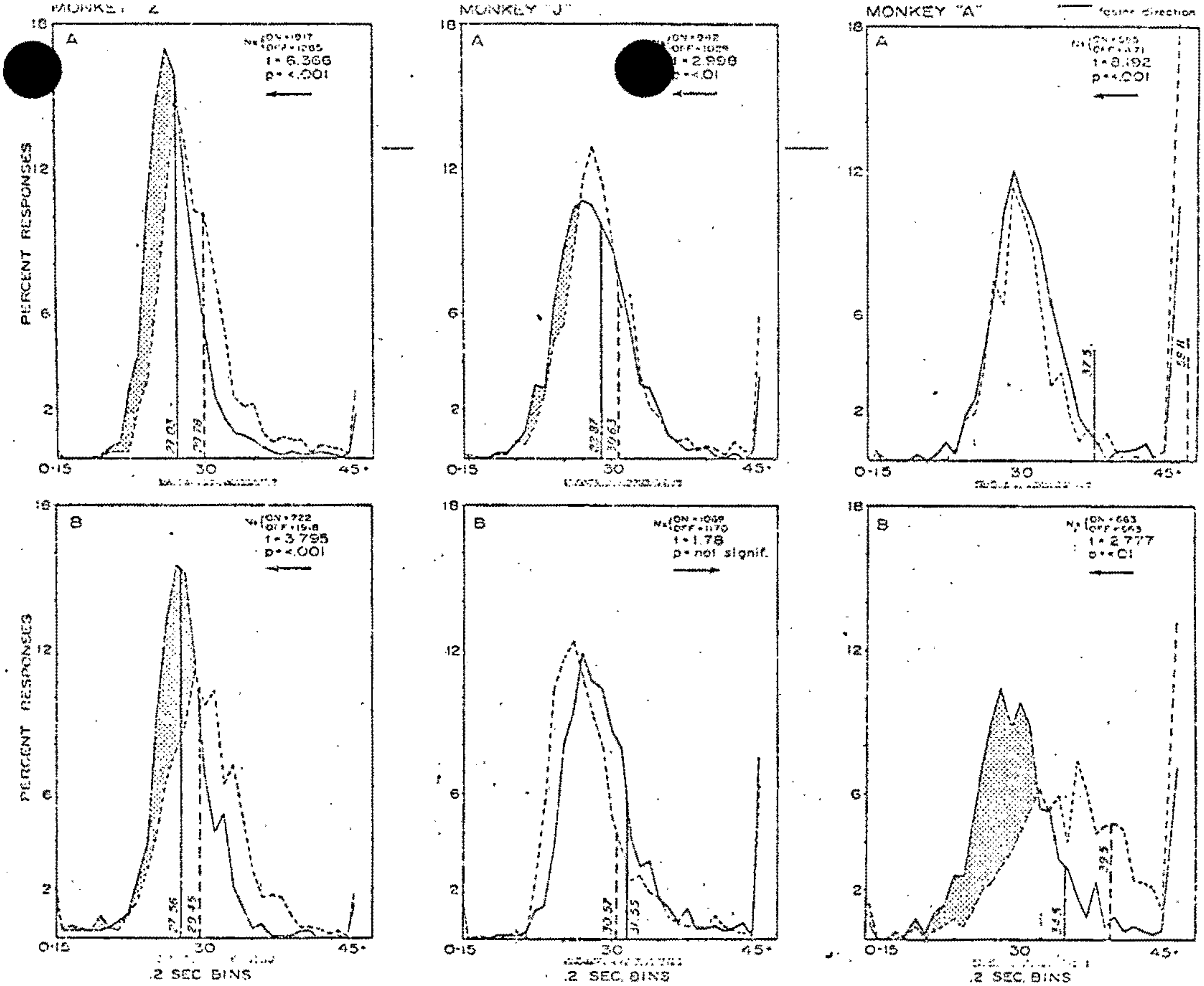
19. Wever, R. Einfluss schwacher elektro-magnetischer Felder auf die circadiane Periodik des Menschen. Die Naturwissenschaften, 1 (1968) 29-33.

FIGURES

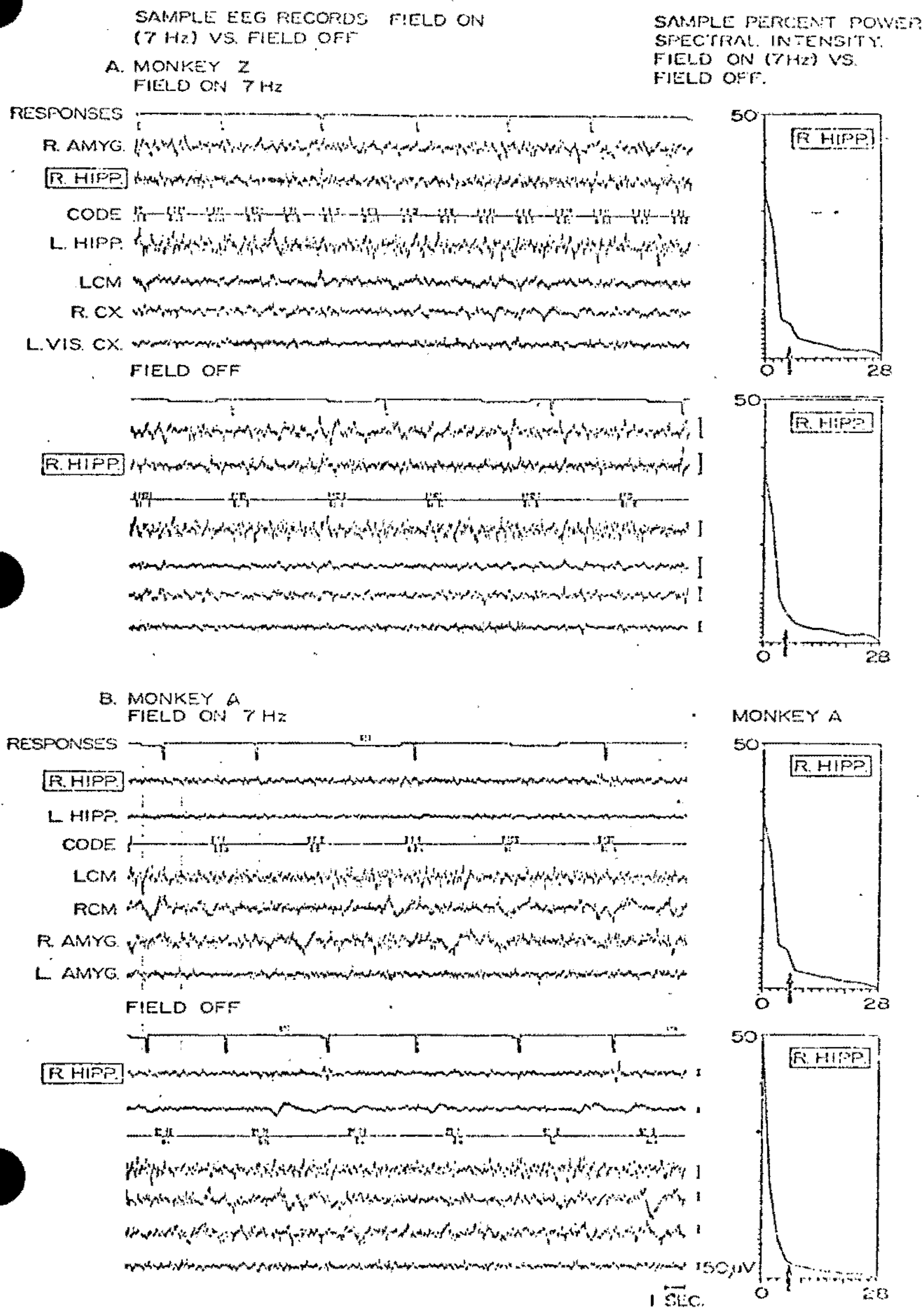
ACKNOWLEDGMENTS

We gratefully acknowledge the support of ARPA Contract DADA 17-67-C-7124, NASA grant NGR-05-007-195, and the assistance of the Health Sciences Computing Facility, supported by NIH grant FR-3.

Appreciation is expressed to Cavita Bloir for technical assistance in carrying out the experiments and to Joe Lucero for surgical implantation of the monkeys; Jacqueline Payne is credited with the illustrations. We are indebted to R.T. Kado for encouragement and assistance in the initial phases of the experiment.



MONKEY "J"
MONKEY "A"
faster direction
A
B
PERCENT RESPONSES
t = 6.366
p = <.001
t = 2.998
p = <.01
t = 8.192
p = <.001
t = 3.795
p = <.001
t = 1.78
p = not signif.
t = 2.777
p = <.01
N = {ON = 722, OFF = 1518}
N = {ON = 1059, OFF = 1170}
27.03
29.78
29.87
30.63
27.56
29.45
30.57
31.55
0-15
30
45+
.2 SEC BINS



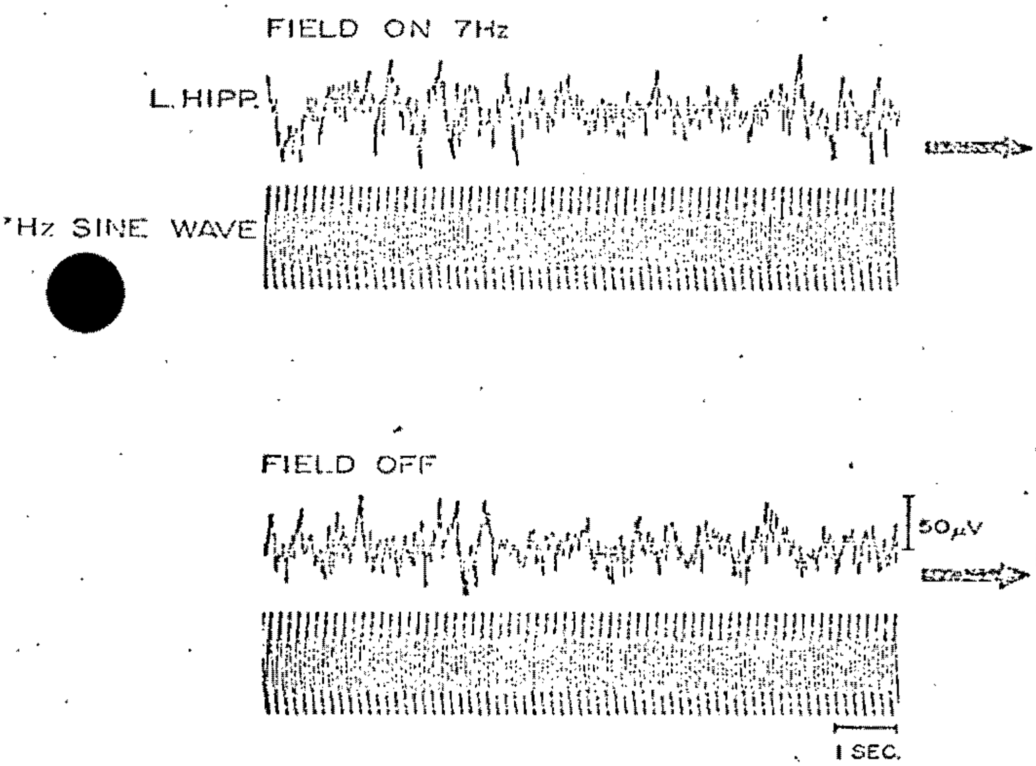
SAMPLE EEG RECORDS FIELD ON (7 Hz) VS. FIELD OFF
SAMPLE PERCENT POWER SPECTRAL INTENSITY. FIELD ON (7Hz) VS. FIELD OFF.
A. MONKEY Z
FIELD ON 7 Hz
RESPONSES
R. AMYG.
R. HIPP.
CODE
L. HIPP.
LCM
R. CX
L. VIS. CX.
FIELD OFF
R. HIPP.
50
0
28
B. MONKEY A
FIELD ON 7 Hz
MONKEY A
RESPONSES
R. HIPP.
L. HIPP.
CODE
LCM
RCM
R. AMYG.
L. AMYG.
FIELD OFF
150 μV
1 SEC.

EEG PEAK QUOTIENTS
FIELDS ON VS. FIELDS OFF
PROBABILITY OF OBSERVED DIFFERENCES
(T-TESTS)

Performing DRL task. 80 sec. segments near end of the 4 hr. runs. Combined data from 2 experimental-control runs		7 CPS On vs. Off	10 CPS On vs. Off
MONKEY J	L. HIPPOCAMPUS	p = .048	p = .025
	R. HIPPOCAMPUS	p = .001	p = .011
	R. AMYGDALA	p = .003	p = .001
(OTHER STRUCTURES OBSERVED: LMBRF, L.V. CX, R. M. CX, R.V. CX)			
MONKEY Z	R. HIPPOCAMPUS	p = .006	p = .020
	L. CENTRE MEDIAN	p = .001	p = .001
(OTHER STRUCTURES OBSERVED: AUD CX, R.V. CX, R. AMYG, L. HIPP)			
MONKEY A	R. HIPPOCAMPUS	p = .001	No run
	L. HIPPOCAMPUS	p = .001	
	L. CENTRE MEDIAN	p = .059	
(OTHER STRUCTURE OBSERVED: L. AMYG)			

Non-performing: Sitting quietly		7 CPS On vs. Off
MONKEY A	R. HIPPOCAMPUS	p = .001
	L. HIPPOCAMPUS	p = .036
	R. CENTRE MEDIAN	p = .045
	L. AMYGDALA	p = .003
(OTHER STRUCTURES OBSERVED: LCM, R. AMYG)		

Sample EEG Records



Sample Coherences of Averaged Data

Hz	Coherence
2	.038
4	.014
6	.146
8	.016
10	.005
12	.008
14	.015
16	.012

Hz	Coherence
2	.010
4	.002
6	.003
8	.003
10	.004
12	.006
14	.005
16	.009

III. Summary and Recommendations continued (U)

to the question of whether the original signal has any effect on the performance of operantly-conditioned monkeys has been provided to date. However, since no clear and strong effects have become apparent with the WRAIR signal, the findings thus far can be regarded as negative. Any plan to renew an animal (primate) study should be carefully reviewed and critically evaluated by an expert scientific and research management body.

(S) B. The WRAIR signal is composed of selected components of the original complex signal. The negative results may be considered as due to the fact that inappropriate aspects of the signal were replicated. If additional major research were to be mounted regarding Pandora, attention should be given to the original signal.

(S) C. Consideration has been given to the matter of planned human experiments using the WRAIR facility and signal. SAC concludes that, based upon existing information, there is no evidence that no permanent, deleterious effects are to be expected. Also, it appears that security and ethical questions have been resolved. However, SAC also concludes that it is likely the results of human experiments would be indistinct in the same way as those of the animal experiments. Thus, additional expensive and time-consuming human experiments might raise the same questions as raised by the animal experts, including the question of the appropriateness of the selected experimental signal. There are, however, differences between the human and primate, for example, the size and shape of the skull. Furthermore, it should be recalled that little investigation was performed in the animal experiments regarding biochemical and clinical effects. The animal experimental end points were essentially behavioral.

(S) D. A decision about whether this field as a whole warrants a high priority cannot be made in isolation from a knowledge of other problems involving threats to the national interest. SAC has not been privy to other efforts. It may be assumed that continued medical follow-up of personnel exposed to the original signal has been developed, but no details on such a follow-up have been provided. There do seem to be certain investigations which could be performed that might shed further light on possible effects of the original signal. If, however, such work is not being done, we believe it useful to support a study to consider such activities. For example, individuals assigned to selected posts are examined before they leave and at six-month intervals. The examination should include comprehensive biochemical, medical, biomedical, and psychometric performance tests that could plausibly detect any changes. A control group would be essential. If on the basis of such a systematic study significant differences appeared, we would recommend the focal research cited above be given a high priority.

Respectfully submitted by Lysle Peterson, Chairman
mc
Date Typed: March 23, 1970

Mr. Cesaro

INSTITUTE FOR DEFENSE ANALYSES

400 Army-Navy Drive, Arlington, Virginia 22202 · Telephone (703) 558-1000

IDA

March 31, 1970

Mr. Richard S. Cesaro
OSD/ARPA/Advanced Sensors
Rm. 3E189
Pentagon
Washington, D. C. 20350

Dear Mr. Cesaro:

The minutes of the Pandora meeting of January 12, 1970, contain a grammatical error of a double negative on page 6, paragraph C, line 2.

The sentence should read, "SAC concludes that, based upon existing information, there is no evidence that any permanent, deleterious effects are to be expected" rather than "SAC concludes that, based upon existing information, there is no evidence that no permanent, deleterious effects are to be expected."

Yours truly,

Marilyn Chanda

Marilyn Chanda
Secretary to Dr. H. Pollack

cc Al Rubenstein

~~SECRET~~ ~~[illegible]~~

Herbert Pollack, M. D.
March 23, 1970

Mr. Rubenstein

DA

PANDORA MEETING OF JANUARY 12, 1970 (U)

Minutes Respectfully Submitted by Lysle Peterson, Chairman

24 FEB [illegible]

THIS DOCUMENT HAS BEEN DOWNGRADED
TO "UNCLASSIFIED"
Per *Director DARPA / TIO*

DOWNGRADED AT 12 YEAR INTERVALS; NOT AUTOMATICALLY DECLASSIFIED. DOD DIR 5200.10

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

~~[illegible]~~

SECRET

DA HQ 70-

MINUTES OF PANDORA MEETING OF JANUARY 12, 1970

Meeting Convened: 0930

Meeting Adjourned: 1600 (approximately)

IDA Rm. No.: 10K5

Attendees:

Science Advisory Committee

Dr. Joseph E. Barmack
Dr. James N. Brown
Dr. H. Allen Ecker
General Carl Hughes
Dr. Joseph Kubis
Dr. Lysle H. Peterson, Chairman
Dr. Herbert Pollack, Secretary
Dr. Lawrence Sher

Walter Reed Army Institute of Research

Colonel Joseph V. Brady
Dr. Thomas W. Frazier
Mr. T. Daryl Hawkins
Colonel Merrill C. Johnson
Major James T. McIlwain
Colonel William H. Meroney

Mr. Albert Rubenstein, ARPA

Abse[illegible]
Mr. Richard S. Cesaro, ARPA
Dr. John J. Collins, (CNO), USN
Mr. H. Mark Grove, Wright-Patterson AFB
Mr. Harris B. Stone, (CNO), USN

I. Background of this Report (U)

(S) Certain events presumed to be threatening to the national interest served as a basis for ARPA's support of project Pandora. WRAIR was given funds and responsibility in early 1965 for research to evaluate the threat, since it appeared to have strong behavioral and biomedical implications. The WRAIR charter included in-house and extramural contract activities. The intramural program was largely, but not exclusively, directed toward evaluating behavioral end points using the WRAIR (special) signal on primates. The extramural support was largely biomedical.

(S) Preliminary analyses of in-house results presented by Dr. Joseph Sharp of WRAIR in 1967 encouraged the belief that the special signal altered primate behavior. Moreover, preliminary extramural cytogenetic and histological studies of the brain suggested that comparable energies were damaging to tissue.

ADVANCED ... RESTRICTED

SECRET

(S) The Pandora Scientific Advisory Committee (SAC) was appointed in 1968 to provide advice for the development of the research program. The initial presentation of the in-house WRAIR data to the SAC consisted of the citation of selected cases and samples of the raw data. Requests were made by SAC for a fuller presentation of the material, since a choice of future strategies and methodology depended on the validity of the reported findings. By this time Dr. Sharp had left the Project, and an effort to be responsive to the Committee was made by Dr. James McIlwain of WRAIR. Dr. McIlwain's analyses suggested, in contrast to the initial analyses, that if the signal had an effect on behavior, it was so modest as to be obscured by effects of experimental, procedural variations, which were a result of the exploratory character of the early experimental program. Furthermore, continued extramural cytogenetic studies did not confirm the earlier reports of changes in tissue exposed to the signal.

(S) The apparent differences of initial and later experimental findings are significant from a research management point of view and should be assessed within the context of the following concurrent events:

1. The realization that research in this field is comparatively costly in equipment and effort and that large sums of money have already been allocated to equip a new laboratory at WRAIR and at Johns Hopkins University. Further, management of this highly technical facility and the experimental program requires high level behavioral, biomedical, and engineering capability.

2. Definitive research in this area will also require work with human subjects, and ethical procedures for working with humans may conflict with security needs.

3. The prescription against DOD support of basic research, unless it can be shown to have relevance to national defense and the recent general drying up of research funds generally.

(S) In view of these considerations, research programming decisions are particularly dependent on whether the early WRAIR reports (to the effect that the signal does affect behavior) are correct or whether the later analyses refuting these reports are more credible. Because of his special competencies in statistics and experimental design, Dr. Joseph Kubis, a member of SAC, was asked to do an intensive evaluation of the procedures, the protocols, the data, and the assumptions on which subsequent interpretations of the data were made by Dr. Sharp and Dr. McIlwain.

(U) What follows in Section II is a summary and elaboration of Dr. Kubis' report agreed upon and accepted by members of the Scientific Advisory Committee.

SECRET

II. The Committee's Resume of the Kubis Report (U)

(S) The earlier demonstration that the signal has an effect on primate behavior relates mainly to the procedures Dr. Sharp applied. To make the allegation credible, it should be demonstrated that a statistically significant rather than a chance difference exists between experimental and control conditions. Dr. Sharp's treatment of the experimental and control conditions can account for some part of the difference in effects. However, for understandable reasons, to be elaborated below, Dr. Sharp's evaluation did not adequately demonstrate the difference defined above.

(S) Dr. McIlwain's treatment of the data and associated experimental procedures was detailed and critical. However, if the error of obscuring an effect which may be there is to be avoided, certain additional statistical treatments are suggested. Moreover, it is SAC's judgment that any signal effects that can be teased out by further statistical treatment will, at best, be minor in comparison with effects generated by a host of procedural manipulations, some of which are intentional and some unintentional, which is characteristic of most exploratory or pilot studies.

(U) The differences between Dr. Sharp's and Dr. McIlwain's analyses are summarized below under the following headings:

A) Assumptions and Criteria; B) Contamination of the Control Condition; C) Contamination of the Experimental Condition and D) Statistical Treatment Problems.

A. Assumptions and Criteria (U)

(S) Both Drs. Sharp and McIlwain assumed that the effects (if any) of the signal on performance would be deleterious. Dr. Sharp was looking for performance impairment on any subject and in any temporal form, i.e., sudden, progressive, et cetera. This approach is advisable for an exploratory effort. However, with small numbers of experiments, subjects, and varied procedures, the dragnet approach makes the investigator vulnerable to confusing a random variation with a significant one.

(S) Dr. McIlwain assumed in most of his analyses that the effects are cumulative and that performance could be worse in the second half of the exposure period than in the first half. This is a reasonable assumption, but the data do not support this assumption of how the signal might function. The signal might indeed affect behavior and animals selectively, but if it does, then stable baselines are essential for such effects to be demonstrable. The lack of stability of the baselines is discussed later.

B. Contamination of the Control Conditions (U)

(U) Dr. Sharp's and Dr. McIlwain's approaches differed on the nature of the control conditions employed in these experiments. Dr. Sharp

B. <u>Contamination of the Control Conditions continued</u> (U)

used baseline data obtained from all sections of the extensive experimental protocols so long as they were "after training and before exposure." Dr. McIlwain assumed that with so many changes in experimental procedures, no adequate baseline could be established. As a result his analyses were confined only to the experimental condition. As mentioned before, these analyses rested on the assumption of a cumulative effect.

(U) When changes in situational conditions produce pronounced nonexperimental effects, it is rather clear that baselines following such changes become heterogeneous. Lumping them together does not provide an adequate base for evaluating specific experimental effects. Thus, Dr. Sharp's findings cannot be supported. On the other hand, Dr. McIlwain's negative findings cannot be entertained with confidence unless an analysis of available protocols is made to show that there are insufficient data points to provide an adequate baseline.

(S) What is critical, moreover, is the unknown effect on baselines produced by the numerous changes in the experimental environment (icebox vs. anechoic chamber, night vs. day, alone vs. with other animals, et cetera). It is a problem to determine when that baseline has reached asymptote after it has been sharply shifted by the changes in the experimental environment. When these shifts in baseline are much more pronounced than any changes by the experimental signal, one is inclined to view the effect of the signal itself either as "subtle" or of doubtful, practical significance.

(U) In addition, the cyclical nature of both the control and experimental conditions (which is necessary when working with a single animal who serves as his own control) can be self-defeating if the experimental condition produces a cumulative and permanent effect. Under such conditions the control (absence of signal) period becomes contaminated by the lingering effect of the previous experimental condition, thus making subsequent comparisons between the two conditions nondiscriminative.

(U) Under the conditions of these experiments the problem of baselines is beset with theoretical difficulties. However, the possibility of their use can be evaluated on the basis of the data available for each specific change in environmental condition.

C. <u>Contamination of the Experimental Conditions</u> (U)

(S) Neither Dr. Sharp nor Dr. McIlwain regarded the experimental design itself as a significantly limiting factor in the analyses of the data. Dr. McIlwain, for example, divided the experimental condition into equal time segments and tested for differences in effect between the first and second halves. There is, however, a possibility of contamination of the experimental condition in terms of its interaction

C. Contamination of the Experimental Conditions continued (U)

with the changes in the environment under which the testing was done. Unless the interaction effect is explicitly planned for and evaluated, the experimental condition may be producing effects magnified under some conditions and reversed under other conditions so that a "deleterious" effect could be inferred in the first situation and a "beneficial" effect in the second. Such paradoxical results may be the outcome of continued analyses where the possible interaction effect has not been isolated and explained.

(U) Both control and experimental conditions could be contaminated by the presence or absence of a "weekend effect," when a significant change in the level of the background noise occurs in the laboratory. The data were not analyzed to determine whether this condition affected the experimental and control conditions differently. Similarly, equipment malfunction disrupted performance during control and experimental conditions, but no statistical analyses were provided to determine whether this was a differentially significant constraint.

D. Statistical Treatment Problems (U)

(U) Dr. Sharp's and Dr. McIlwain's approaches each provided some statistical analysis of the data. Dr. McIlwain's statistical treatment was more extensive and utilized some relatively simple but effective nonparametric procedures.

(S) Dr. McIlwain seems to have shown that there are no consistent differences between the first half and the second half of the exposure period. According to his assumption that an incremental increase in effect should be expected, the results are negative. The possibility that there was an initial effect which persisted at about the same level during the exposure period is not to be ruled out by Dr. McIlwain's analysis.

(S) There are selection and computing problems associated with Dr. Sharp's presentations. On the basis of these difficulties it cannot be asserted that Dr. Sharp had established the existence of an effect due to the experimental signal. No written report has been produced by Dr. McIlwain due to the pressure of time. The conclusions herein expressed are based on limited visual examination of notebooks containing such data, charts, and graphs.

(S) From the overview available to SAC of both analytical approaches, SAC has concluded, regarding the experiments considered to date, that if there is an effect of the signal utilized to date on behavior and/or biomedical functions, it is too subtle or insignificant to be evident.

III. Summary and Recommendations (U)

(S) A. The research effort mounted by WRAIR to date has been exploratory and consequently diffusely programmed. No definitive answer

FINAL REPORT

"EFFECTS OF LOW - LEVEL MICROWAVE IRRACIATION ON

HEART RATE IN RABBITS"

This research was supported by the Advanced Research Project, Agency of the Department of Defense and was monitored by U.S. Army Medical Research and Development Command, under Grant No. DADA 17 - 69-G - 9288

by

The Zaret Foundation, Inc.
1230 Post Road
Scarsdale, New York 10583

A number of Soviet studies have reported that low-level microwave irradiation, at or below 10 mW/cm^2, alters the heart rate of humans and animals. In one of the best controlled and most fully reported of these studies, Presman and Levitina[1] irradiated various parts of the body of rabbits with continuous microwaves at intensities of 7 to 12 mW/cm^2. The largest effect observed was an increase in heart rate during and after irradiation of the dorsal aspect of the head. The next largest effect was a decrease in rate during and after irradiation of the whole ventral surface of the body. Smaller changes in rate accompanied irradiation of the back, of the total dorsal surface, of the ventral aspect of the head, and of the abdomen.

The purpose of the present study was to replicate the procedure used by Presman and Levitina for dorsal irradiation of the head, in order to collect enough additional data either to confirm their results or to establish that the differences in heart rate are a manifestation of variability rather than a consequence of irradiation.

Method

<u>Subjects</u> The subjects were 12 albino male rabbits weighing 2.0 to 3.0 kg.

<u>Apparatus</u> Microwave power was obtained from a CW, air-cooled magnetron with an output of 1.3 kW, an anode voltage of 2 kV, and an operating frequency of 2.409 GHz (λ = 12.5 cm). This tube, manufactured by Deutsche Mikrowellen Gesellschaft, exhibited exceptional stability during the exposures. Power from the tube was conducted through a waveguide to the irradiating horn (Fig. 1). Most of the magnetron output was dissipated in a high-power load, and only about 10% was used to irradiate the animal.

The microwave horn was placed in an anechoic chamber with its main lobe directed downward, so that the animal was irradiated from

1 A.S. Presman and N.A. Levitina, Byull. Eksp. Biol. Med. 53, No. 1, 41-44 (1962); Engl. Transl., Bull. Exptl. Biol. Med. 53, 36-39

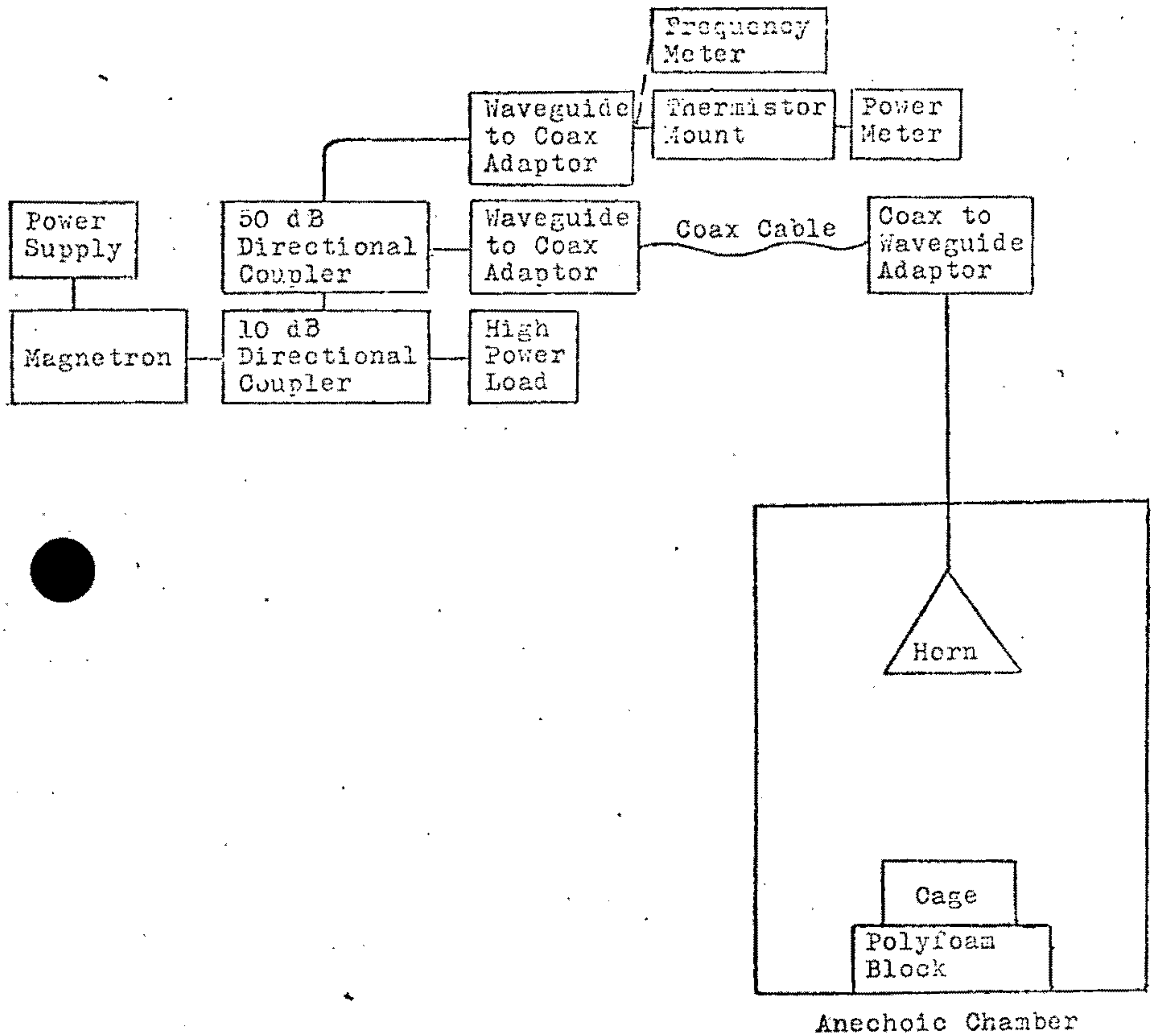


Fig. 1. Schematic diagram of the apparatus.

above. The horn's aperture was $7\frac{31}{32}$ in. by $5\frac{7}{8}$ in., its axial length was 15 in., and its estimated power gain was 19.54. The animal's head was 29 in. from the horn. This distance was well within the far-field region, which began at about 12.9 in. from the horn. From the estimated gain of the horn, it was calculated that a total of 35 W leaving the horn produced the measured power density of 10 mW/cm^2 in the vicinity of the animal's head.

The power density was measured with a Ramcor 1250 A densiometer with a calibrated low-gain rectangular horn antenna. A Hewlett Packard Model 431-B power-meter was connected to the waveguide to monitor the power during irradiation. The power-meter reading corresponding to 10 mW/cm^2 at the animal's head was determined and used for setting the magnetron anode current. This calibration procedure was conducted with the cage and animal not present in the anechoic chamber. It was observed that the region of uniform power density was sufficiently large that considerable variation in the placement of the cage would still give the same power density.

The anechoic chamber had interior dimensions of 40 in. by 40 in. by [illegible] in., and was lined with type CV-4 microwave absorber panels manufactured by Emerson-Cuming. This material is rated to have reflections less than 20 db below the incident power level at 2.0 GHz; at 2.4 GHz the reflection is even lower. A plate of this material was used to shield the animal's back during irradiation of its head.

<u>Procedure</u> The rabbit was restrained in a wooden box, which was placed below the horn antenna in the anechoic chamber. Needle electrodes were inserted for EKG recording. After the animal had been in position for 15 min., its EKG was recorded once each minute for 10 min. before the onset of irradiation. Then the rabbit's head was irradiated from above with continuous 12.5 cm microwaves at a power density of 10 mw/cm^2 for 20 min. During irradiation the EKG was recorded every 2 min. After the power was turned off, the EKG was recorded every minute for 10 min. Each EKG trace was recorded for a 20 sec duration. Exactly the same procedure was followed during the control sessions, except that the animal was not irradiated. Each animal was irradiated twice and served as a control twice: once before and once after irradiation.

Results

Changes in heart rate were calculated in the manner described by Presman and Levitina as follows: (a)For each trace recorded during and after irradiation, the deviation from the mean heart rate before irradiation was calculated. (b)The corresponding deviations were calculated for the data from the control sessions. (c)The relative change in rate for each recording period was obtained by subtracting the mean deviation for the control condition from the corresponding deviation for the irradiation condition.

Each of the three graphs in Fig. 2 represent the mean differences in heart rate between eight irradiation sessions and eight control sessions. The results for the first four rabbits that were exposed show a relative increase in heart rate both during and after irradiation. The average data for the next four rabbits show a decrease during the first 10 min of irradiation and no consistent change thereafter. The last four animals exhibited a decrease during the first 8 min followed by an increase over the last 18 min of the session. All 12 animals received the same dorsal irradiation of the head, and the division into three groups is entirely arbitrary.

The average results for all 12 animals are summarized in Fig. 3. These results represent the data of the present experiment, based on 24 irradiation and 24 control sessions. A small decrease in heart rate during the first 8 min was followed by a larger increase over the remaining 22 min. The crosses in Fig. 3 indicate the results of Presman and Levitina, based on 16 irradiation and 16 control trials with 8 rabbits. The relative change in heart rate was generally positive, and this increase was both larger and more variable than the results in our experiment.

Table 1 lists the mean number of beats per 20 sec during successive 10 min periods of the control and the irradiation sessions. The animals were irradiated during the middle 20 min of the irradiation condition. Each entry in the table is based on the results of 24 sessions. Heart rate was highest during the first 10 min of both conditions and generallly decreased over time. The analysis of variance summarized in Table 2 shows that the variation over time was statistically significant, as were individual differences and the interaction between radiation and time. The difference between irradiation and control conditions, however, was generally less than 2 beats per 20 sec, and this difference was not statistically significant.

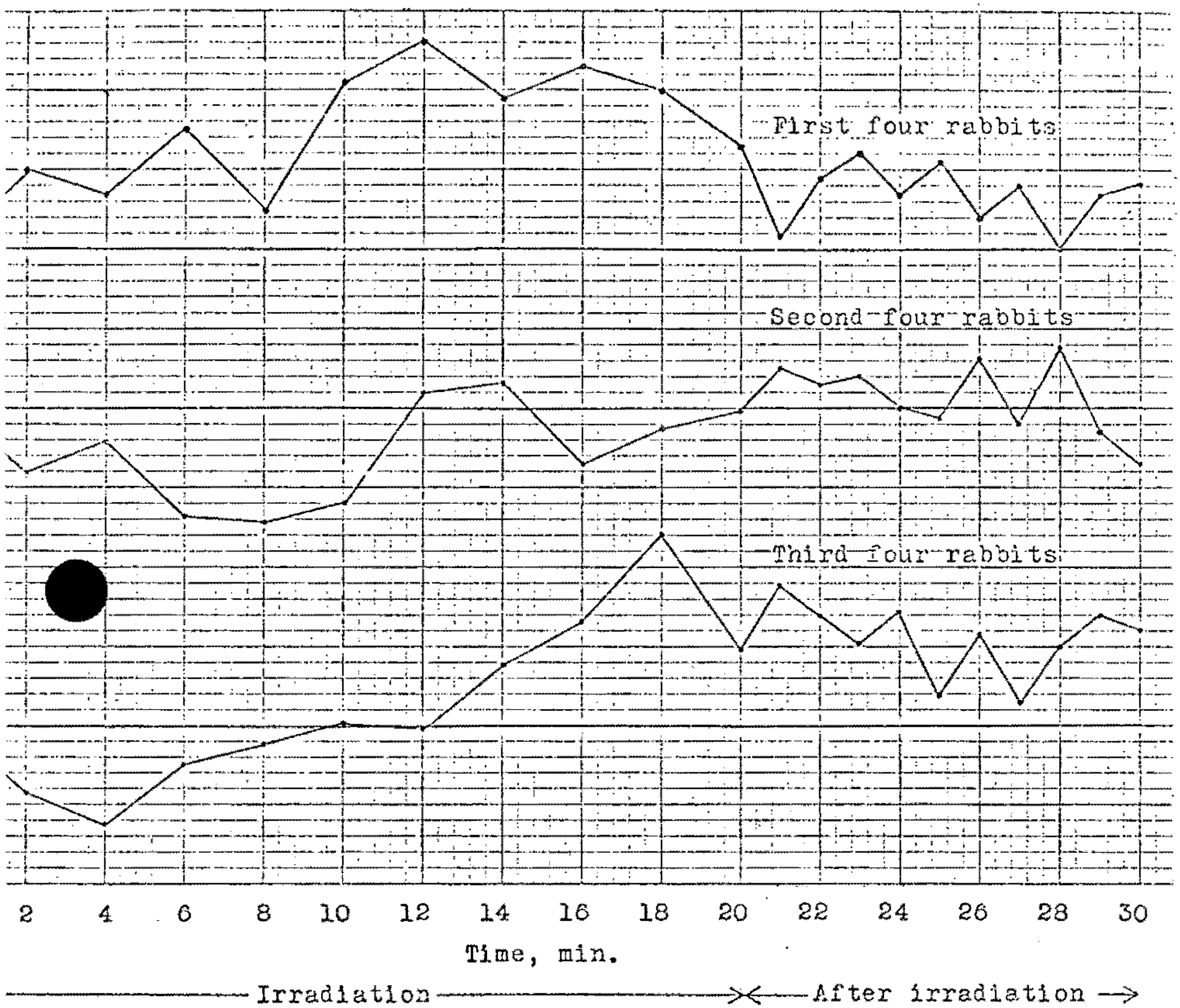


Fig. 2. Relative change in heart rate of rabbits irradiated on the dorsal aspect of the head with continuous microwaves of 12.5 cm wavelength at 10 mw/cm². Each point represents the mean difference between 8 exposures and 8 control sessions.

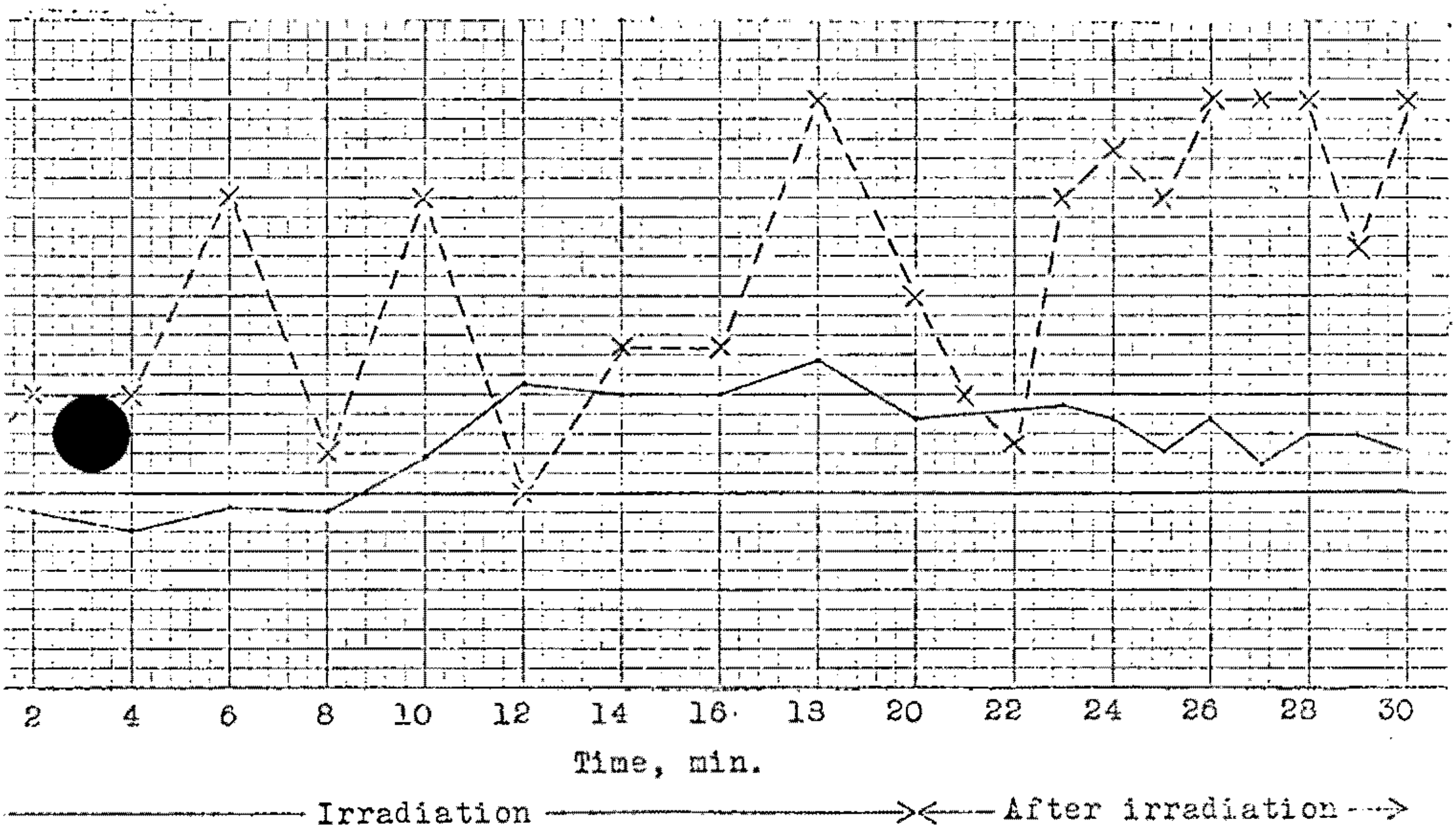


Fig. 3. Relative change in heart rate of rabbits irradiated on the dorsal aspect of the head with continuous microwaves of 12.5 cm wavelength at 10 mW/cm². Each dot represents the mean difference between 24 exposures and 24 control sessions of the present experiment. The crosses represent the results of Presman and Levitina based on 16 exposures and 16 controls.

Table 1

Mean Number of Beats per 20 Sec

	1st 10 min	2nd 10 min	3rd 10 min	4th 10 min
Control	63.94	63.79	61.73	61.95
Irradiation	63.56	63.31	63.34	62.83

Table 2

Analysis of Variance

Source of Variation	SS	df	MS	F
Radiation	7.80	1	7.80	< 1
Time	69.07	3	23.02	7.99*
Subjects	10,507.23	11	955.20	25.04*
R x T	36.89	3	12.23	4.66*
R x S	113.96	11	10.36	< 1
T x S	95.12	33	2.88	< 1
R x T x S	86.98	33	2.64	< 1
Error	3,661.43	96	38.14	

* Significant at the .01 level

Presman and Levitina devised the ratio K, which they called the co-efficient of the chronotropic effect, to describe the effect of irradiation on heart rate.

$$K = \frac{100 + m_i}{100 + m_d},$$

where m_i and m_d are the respective changes in the percentage of cases with rates increased or decreased from the control values. An increase in rate is indicated by $K > 1$, and a decrease by $K < 1$. Their results for dorsal irradiation of the head were $K = 1.3$ during irradiation, and $K = 1.42$ after irradiation. The present results were $K = .84$ during irradiation and $K = 1.19$ after irradiation.

Discussion

There were six conditions in the experiment of Presman and Levitina, in each of which a different part of the body was irradiated. One condition (dorsal aspect of the head) produced a relative increase in heart rate during and after irradiation. Another condition (whole ventral surface) showed a decrease during and after irradiation. The other four conditions were accompanied by smaller and less consistent changes in rate. The results of the present experiment suggest that such effects are due to chance variation from one set of trials to another.

The variation from one sample to another under the same conditions of radiation is illustrated in Fig. 2. One set of data shows an increase in relative heart rate; another shows a decrease followed by no consistent change; the third, a decrease followed by an increase. When these three sets of data were averaged, as in Fig. 3, the variability from minute to minute became less, and the relative change in heart rate became smaller. The largest change in the averaged data is about 2 beats per 20 sec, which is only 3 % of the average heart rate of 63 beats per 20 sec.

It is our tentative conclusion that the changes in heart rate that Presman and Levitina attributed to irradiation of different parts of the body were simply due to the variation from one small sample of trials to another. We are still collecting data on the effect of dorsal irradiation of the head at 10 mW/cm^2. If the effect continues to approach zero as our sample size increases, this conclusion will be confirmed.

Future Research

We plan to run four more rabbits under the conditions of the present experiment. If we still observe no effect of radiation at 10 mW/cm^2, we shall proceed to higher power densities, in order to determine the minimum levels at which effects are observable.

We are presently developing procedures for recording body temperature and respiration rate, simultaneously with heart rate, while the animal is irradiated. Temperature will be recorded with a needle thermistor probe inserted subcutaneously just outside the area that is irradiated. Respiration rate will be recorded by means of a sensor that detects changes in chest circumference. We anticipate that these recording procedures should be standardized by 1 September 1969, whereupon we shall begin a series of exposures to determine irradiation thresholds for all three indicators.

The first power density in the series will be 100 mW/cm², a level which should produce evidence of thermal stress, such as hyperventilation or hyperthermia. On subsequent exposures we shall decrease the power level until no effect is produced, i.e., until heart rate, respiration rate and temperature are the same during irradiation as during the control sessions. If respiration or temperature is affected at lower power levels than heart rate, that would constitute further evidence against the thesis that low-power microwave fields produce non-thermal effects on cardiac activity via direct action on the central nervous system.

APPENDIX I

Summary of Raw Data

Number of Beats per 20 Sec.

MOMENT (MIN)	RABBIT 1				RABBIT 2				RABBIT 3				RABBIT 4			
	1		2		1		2		1		2		1		2	
	C	R	C	R	C	R	C	C	C	R	C	R	C	R	C	R
1	60	63	62	62	64	63	54	54	62	59	61	60	59	57	59	50
2	57	64	53	52	65	61	58	59	61	63	60	59	57	59	56	52
3	59	58	51	53	63	56	58	56	62	61	61	60	57	61	59	48
4	56	58	51	56	63	59	62	54	59	61	62	62	62	58	56	55
5	60	57	56	59	63	58	60	57	59	64	62	60	60	58	57	49
6	59	54	57	54	61	59	62	55	61	63	62	62	59	60	57	62
7	55	57	51	56	62	61	60	56	62	62	62	62	57	59	57	58
8	55	57	65	53	64	62	60	60	60	62	61	60	56	59	55	59
9	56	57	55	58	68	64	60	54	62	62	61	61	58	59	57	59
10	55	60	56	58	66	60	58	57	59	61	62	60	58	62	57	56
12	58	62	62	63	66	63	59	63	59	60	61	62	52	59	61	56
14	54	62	59	58	63	64	64	70	59	60	62	62	54	62	61	53
16	51	64	59	53	60	60	60	65	59	60	59	62	55	59	58	56
18	61	61	53	56	62	60	58	60	60	59	62	62	52	62	57	49
20	58	61	50	56	63	63	57	61	59	60	61	63	52	61	54	61
22	54	62	52	64	58	67	58	56	59	60	60	62	54	61	54	54
24	59	58	55	66	56	64	57	57	59	60	60	61	57	61	54	54
26	53	61	58	55	55	72	57	52	58	61	58	61	52	60	56	55
28	56	60	57	63	64	77	56	54	58	62	58	61	55	60	52	45
30	55	57	55	62	60	66	64	55	62	61	59	62	57	62	56	56
31	63	61	60	59	63	67	64	53	61	59	61	64	55	59	55	56
32	64	59	59	58	61	74	68	53	60	63	60	64	53	58	52	56
33	58	58	58	56	56	65	67	52	60	64	59	64	55	58	50	58
34	58	63	56	54	59	60	63	54	62	65	59	60	56	60	54	55
35	57	61	58	58	58	64	62	53	62	62	58	61	52	59	61	61
36	54	56	56	53	59	63	61	52	60	62	58	62	52	60	64	56
37	57	63	53	54	61	63	62	56	60	60	58	62	54	58	58	53
38	57	59	53	54	62	62	62	54	63	60	58	59	57	60	58	55
39	57	60	56	56	64	65	60	52	61	58	58	62	57	60	51	56
40	60	58	54	53	60	61	60	54	60	60	58	59	56	58	48	60

C=Control
R=Radiation

APPENDIX I

Summary of Raw Data

Number of Beats per 20 Sec.

[illegible] (MIN)	RABBIT 5				RABBIT 6				RABBIT 7				RABBIT 8			
	1		2		1		2		1		2		1		2	
	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R
1	68	64	70	68	50	42	62	69	76	82	68	75	69	68	62	63
2	66	62	69	67	48	46	61	70	76	80	69	74	69	68	64	61
3	66	62	69	67	51	40	62	68	76	78	72	74	70	70	62	60
4	62	62	68	68	47	40	63	67	74	77	69	74	65	71	63	60
5	62	65	57	68	47	44	61	67	75	77	71	76	69	68	63	62
6	63	62	64	68	46	43	62	67	75	73	70	76	69	69	64	62
7	64	62	70	66	44	43	62	67	76	76	77	74	70	66	66	60
8	62	60	66	69	44	41	64	70	75	77	70	78	73	72	65	62
9	62	61	70	69	43	42	60	68	76	77	72	74	72	71	64	58
0	60	64	68	65	46	47	62	69	75	76	71	74	71	78	62	62
2	67	60	68	66	44	41	61	66	75	74	71	73	70	72	67	63
4	66	58	65	67	43	43	61	69	75	71	69	74	71	71	66	61
6	65	59	66	63	47	41	63	68	75	71	70	73	71	69	65	62
8	67	59	65	70	52	40	61	66	75	71	69	72	73	70	67	62
0	64	62	67	66	46	42	61	64	77	74	71	73	73	68	66	62
2	62	61	65	68	44	44	63	69	75	76	70	73	74	70	62	62
4	62	62	63	65	43	41	60	65	73	73	66	74	73	69	61	62
6	62	61	73	65	43	39	63	64	74	74	65	75	74	69	63	64
8	60	61	67	65	41	39	63	63	75	79	68	71	72	68	61	62
0	64	58	63	66	40	40	60	62	75	78	69	73	71	70	60	59
1	64	59	65	66	42	41	57	68	76	78	68	74	70	68	57	58
2	62	58	66	66	46	44	57	64	74	80	68	76	72	68	62	61
3	62	58	64	66	40	40	57	64	75	80	74	74	70	68	57	60
4	62	58	64	65	40	40	57	62	74	78	72	74	74	68	57	60
5	65	57	64	66	44	40	57	60	74	79	68	74	75	69	56	61
6	62	58	65	70	43	38	58	65	74	76	71	80	70	69	58	60
7	62	60	67	67	43	38	58	62	75	75	70	73	72	70	58	62
8	60	58	64	66	41	46	57	66	80	74	72	75	68	69	56	61
9	61	59	60	64	42	40	63	62	76	74	67	71	72	71	64	64
0	64	59	68	64	47	44	61	63	71	72	68	70	73	70	61	65

[illegible]ntrol
R[illegible]diation

APPENDIX I

Summary of Raw Data

Number of Beats per 20 Sec.

	RABBIT 9.				RABBIT 10.				RABBIT 11				RABBIT 12			
RIMENT (MIN)	1		2		1		2		1		2		1		2	
	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R
1	76	78	76	76	80	75	73	77	60	69	56	44	64	59	64	64
2	77	78	75	73	80	75	74	78	58	63	55	44	63	59	65	68
3	80	80	74	73	79	72	72	76	62	64	56	44	64	63	59	67
4	78	80	74	75	80	75	72	76	62	60	61	43	62	63	59	62
5	77	77	71	78	81	84	72	78	62	61	58	52	62	62	64	66
6	78	72	75	76	80	68	72	77	64	64	58	46	59	64	62	68
7	76	72	69	77	79	74	74	78	58	62	54	54	57	60	64	68
8	77	70	74	77	79	72	74	76	59	67	54	40	58	58	58	54
9	80	76	73	68	79	75	74	77	60	60	52	42	61	59	57	64
.0	83	72	70	77	73	74	74	76	60	68	52	41	62	60	60	65
.2	78	67	75	75	79	72	74	77	60	59	48	44	61	58	66	67
.4	80	78	79	75	80	74	74	74	63	60	50	42	62	57	64	64
.6	75	76	76	76	80	72	70	73	61	58	52	50	61	54	62	61
.8	74	79	73	75	80	72	75	73	62	62	51	48	62	61	63	66
0	70	79	75	78	79	68	74	73	61	60	50	43	59	72	68	56
2	69	77	75	75	78	70	75	74	61	63	56	42	57	65	60	56
4	71	78	75	75	78	73	74	72	64	62	43	42	56	59	60	64
6	73	77	76	74	78	74	71	75	57	64	44	43	56	60	63	64
8	72	78	76	73	77	73	72	74	50	64	44	45	59	68	60	64
0	77	79	73	73	76	72	67	74	61	61	41	41	57	59	58	58
1	73	82	72	74	78	72	68	74	61	64	41	42	57	58	62	66
2	71	78	72	72	77	72	69	74	60	63	42	42	55	57	62	64
3	71	77	70	70	78	70	76	74	56	63	43	41	58	58	62	70
4	69	75	68	76	78	72	75	72	60	62	40	46	59	56	61	65
5	69	76	75	74	79	70	71	72	60	62	48	45	62	56	62	68
[illegible]	66	76	69	72	80	71	70	72	59	60	46	50	63	59	64	67
[illegible]	76	76	71	67	76	70	72	72	60	62	46	42	58	60	62	69
[illegible]	76	76	65	74	76	76	70	73	61	60	46	46	64	60	64	65
[illegible]	79	76	69	77	76	74	68	71	61	58	38	44	64	64	64	69
[illegible]	80	78	70	76	76	75	66	71	64	62	38	38	64	66	60	63

C=Co[illegible]trol
R=[illegible]ution

NATIONAL SECURITY INFORMATION

* TOP SECRET *

EYES ONLY

COPY ONE OF ONE.

BRIEFING DOCUMENT: OPERATION MAJESTIC 12

PREPARED FOR PRESIDENT-ELECT DWIGHT D. EISENHOWER: (EYES ONLY)

[illegible] NOVEMBER, 1952

This cannot be authenticated as an official DoD document

DoD FOIA office

WARNING! This is a TOP SECRET - EYES ONLY document containing compartmentalized information essential to the national security of the United States. EYES ONLY ACCESS to the material herein is strictly limited to those possessing Majestic-12 clearance level. Reproduction in any form or the taking of written or mechanically transcribed notes is strictly forbidden.

* TOP SECRET *

EYES ONLY

COPY ONE OF ONE.

SUBJECT: OPERATION MAJESTIC-12 PRELIMINARY BRIEFING FOR PRESIDENT-ELECT EISENHOWER.

DOCUMENT PREPARED 18 NOVEMBER, 1952.

BRIEFING OFFICER: ADM. ROSCOE H. HILLENKOETTER (MJ-1)

NOTE: This document has been prepared as a preliminary briefing only. It should be regarded as introductory to a full operations briefing intended to follow.

* * * * *

OPERATION MAJESTIC-12 is a TOP SECRET Research and Development/Intelligence operation responsible directly and only to the President of the United States. Operations of the project are carried out under control of the Majestic-12 (Majic-12) Group which was established by special classified executive order of President Truman on 24 September, 1947, upon recommendation by Dr. Vannevar Bush and Secretary James Forrestal. (See Attachment "A".) Members of the Majestic-12 Group were designated as follows:

Adm. Roscoe H. Hillenkoetter
Dr. Vannevar Bush
Secy. James V. Forrestal*
Gen. Nathan F. Twining
Gen. Hoyt S. Vandenberg
Dr. Detlev Bronk
Dr. Jerome Hunsaker
Mr. Sidney W. Souers
Mr. Gordon Gray
Dr. Donald Menzel
Gen. Robert M. Montague
Dr. Lloyd V. Berkner

The death of Secretary Forrestal on 22 May, 1949, created a vacancy which remained unfilled until 01 August, 1950, upon which date Gen. Walter B. Smith was designated as permanent replacement.

This cannot be authenticated as an Official DoD Document
DoD FOIA Office

EYES ONLY

COPY ONE OF ONE.

On 24 June, 1947, a civilian pilot flying over the Cascade Mountains in the State of Washington observed nine flying disc-shaped aircraft traveling in formation at a high rate of speed. Although this was not the first known sighting of such objects, it was the first to gain widespread attention in the public media. Hundreds of reports of sightings of similar objects followed. Many of these came from highly credible military and civilian sources. These reports resulted in independent efforts by several different elements of the military to ascertain the nature and purpose of these objects in the interests of national defense. A number of witnesses were interviewed and there were several unsuccessful attempts to utilize aircraft in efforts to pursue reported discs in flight. Public reaction bordered on near hysteria at times.

In spite of these efforts, little of substance was learned about the objects until a local rancher reported that one had crashed in a remote region of New Mexico located approximately seventy-five miles northwest of Roswell Army Air Base (now Walker Field).

On 07 July, 1947, a secret operation was begun to assure recovery of the wreckage of this object for scientific study. During the course of this operation, aerial reconnaissance discovered that four small human-like beings had apparently ejected from the craft at some point before it exploded. These had fallen to earth about two miles east of the wreckage site. All four were dead and badly decomposed due to action by predators and exposure to the elements during the approximately one week time period which had elapsed before their discovery. A special scientific team took charge of removing these bodies for study. (See Attachment "C".) The wreckage of the craft was also removed to several different locations. (See Attachment "B".) Civilian and military witnesses in the area were debriefed, and news reporters were given the effective cover story that the object had been a misguided weather research balloon.

This cannot be authenticated as an official DoD document
DoD Office

A covert analytical effort organized by Gen. Twining and Dr. Bush acting on the direct orders of the President, resulted in a preliminary concensus (19 September, 1947) that the disc was most likely a short range reconnaissance craft. This conclusion was based for the most part on the craft's size and the apparent lack of any identifiable provisioning. (See Attachment "D".) A similar analysis of the four dead occupants was arranged by Dr. Bronk. It was the tentative conclusion of this group (30 November, 1947) that although these creatures are human-like in appearance, the biological and evolutionary processes responsible for their development has apparently been quite different from those observed or postulated in homo-sapiens. Dr. Bronk's team has suggested the term "Extra-terrestrial Biological Entities", or "EBEs", be adopted as the standard term of reference for these creatures until such time as a more definitive designation can be agreed upon.

Since it is virtually certain that these craft do not originate in any country on earth, considerable speculation has centered around what their point of origin might be and how they get here. Mars was and remains a possibility, although some scientists, most notably Dr. Menzel, consider it more likely that we are dealing with beings from another solar system entirely.

Numerous examples of what appear to be a form of writing were found in the wreckage. Efforts to decipher these have remained largely unsuccessful. (See Attachment "E".) Equally unsuccessful have been efforts to determine the method of propulsion or the nature or method of transmission of the power source involved. Research along these lines has been complicated by the complete absence of identifiable wings, propellers, jets, or other conventional methods of propulsion and guidance, as well as a total lack of metallic wiring, vacuum tubes, or similar recognizable electronic components. (See Attachment "F".) It is assumed that the propulsion unit was completely destroyed by the explosion which caused the crash.

This cannot be authenticated as an official DoD document — DoD FOIA office

EYES ONLY

COPY ONE OF ONE.

A need for as much additional information as possible about these craft, their performance characteristics and their purpose led to the undertaking known as U.S. Air Force Project SIGN in December, 1947. In order to preserve security, liason between SIGN and Majestic-12 was limited to two individuals within the Intelligence Division of Air Materiel Command whose role was to pass along certain types of information through channels. SIGN evolved into Project GRUDGE in December, 1948. The operation is currently being conducted under the code name BLUE BOOK, with liason maintained through the Air Force officer who is head of the project.

On 06 December, 1950, a second object, probably of similar origin, impacted the earth at high speed in the El Indio - Guerrero area of the Texas - Mexican border after following a long trajectory through the atmosphere. By the time a search team arrived, what remained of the object had been almost totally incinerated. Such material as could be recovered was transported to the A.E.C. facility at Sandia, New Mexico, for study.

Implications for the National Security are of continuing importance in that the motives and ultimate intentions of these visitors remain completely unknown. In addition, a significant upsurge in the surveillance activity of these craft beginning in May and continuing through the autumn of this year has caused considerable concern that new developments may be imminent. It is for these reasons, as well as the obvious international and technological considerations and the ultimate need to avoid a public panic at all costs, that the Majestic-12 Group remains of the unanimous opinion that imposition of the strictest security precautions should continue without interruption into the new administration. At the same time, contingency plan MJ-1949-04P/78 (Top Secret - Eyes Only) should be held in continued readiness should the need to make a public announcement present itself. (See Attachment "G".)

This cannot be authenticated as an official DoD document
DoD FOIA office

TOP SECRET / MAJIC
EYES ONLY

* TOP SECRET *

EYES ONLY

COPY ONE OF ONE.

ENUMERATION OF ATTACHMENTS

*ATTACHMENT "A"........Special Classified Executive Order #092447. (TS/EO)

*ATTACHMENT "B"........Operation Majestic-12 Status Report #1, Part A. 30 NOV '47. (TS-MAJIC/EO)

*ATTACHMENT "C"........Operation Majestic-12 Status Report #1, Part B. 30 NOV '47. (TS-MAJIC/EO)

*ATTACHMENT "D"........Operation Majestic-12 Preliminary Analytical Report. 19 SEP '47. (TS-MAJIC/EO)

*ATTACHMENT "E"........Operation Majestic-12 Blue Team Report #5. 30 JUN '52. (TS-MAJIC/EO)

*ATTACHMENT "F"........Operation Majestic-12 Status Report #2. 31 JAN '48. (TS-MAJIC/EO)

*ATTACHMENT "G"........Operation Majestic-12 Contingency Plan MJ-1949-04P/78: 31 JAN '49. (TS-MAJIC/EO)

*ATTACHMENT "H"........Operation Majestic-12, Maps and Photographs Folio (Extractions). (TS-MAJIC/EO)

This cannot be authenticated as an official DoD document

* TOP SECRET *

TOP SECRET / MAJIC
EYES ONLY

EYES ONLY

T52-EXEMPT (E)

00

* TOP SECRET *

EYES ONLY

COPY ONE OF ONE.

ATTACHMENT "A"

This cannot be authenticated as an official DoD document DoD FOIA office

* TOP SECRET *

T52-EXEMPT (E)

007

TOP SECRET
EYES ONLY

THE WHITE HOUSE
WASHINGTON

September 24, 1947.

MEMORANDUM FOR THE SECRETARY OF DEFENSE

Dear Secretary Forrestal:

As per our recent conversation on this matter, you are hereby authorized to proceed with all due speed and caution upon your undertaking. Hereafter this matter shall be referred to only as Operation Majestic Twelve.

It continues to be my feeling that any future considerations relative to the ultimate disposition of this matter should rest solely with the Office of the President following appropriate discussions with yourself, Dr. Bush and the Director of Central Intelligence.

Harry Truman

This cannot be authenticated as an official document.

DoD FOIA office

TOP SECRET
EYES ONLY

[redacted]

Agreement Transfer of Project PANDORA

The Advanced Research Projects Agency and the Department of the Army have established an agreement for transfer of the ARPA PANDORA Project to Walter Reed Army Institute of Research. The PANDORA project includes all work executed or being executed under ARPA Orders 791, 792, 945 and 1508. The preliminary agreement entered into by Colonel William Meroney (U.S. Army/WRAIR) and Mr. Richard S. Cesaro (ARPA/Advanced Sensors) for the transfer of project PANDORA is hereby incorporated as part of the final transfer plan. In addition, the following items apply:

a. ARPA will transfer $200K in FY-71 as final funding of the operations at the WRAIR. This will cover residual PANDORA testing, and other important microwave experiments on bio-life systems as well as the utilization of the new laboratories and instrumentation which were procured by ARPA funds.

b. The extent of the FY-70 and prior year funds committed by ARPA Orders 1508 and 791 constitute the total commitment of ARPA except for the aforementioned $200K. Any residual unexpended balances applicable to these Orders may be applied by the Army to extend existing contracts, as necessary, or should be reported to ARPA (Program Management) for withdrawal. Funds committed for payment of unliquidated obligations against ARPA Order 792 (Electronic Instrumentation for Biomedical Tests) being executed by the Air Force Systems Command Avionics Laboratory, and ARPA Order 945 (Electronic Support) executed by the Army Missile Command will remain at these agencies for support of the PANDORA and follow-on efforts.

c. All equipment and facilities procured by WRAIR for the PANDORA Program with ARPA funds to be transferred to WRAIR.

d. Security: Special limited distribution documents are to be retained by WRAIR. At such time as these documents are no longer required, they shall be destroyed with appropriate accountability as set forth in the regulations.

e. No personnel or personnel spaces are to be transferred from ARPA to the Army for the accomplishment of the subject project.

[redacted]

It is agreed that funds for the microwave research on biological systems and the support of the new laboratory and related facilities will be provided by the U.S. Army in FY-1972 and beyond.

This transfer plan shall be effective on 1 July 1970.

E. Rechtin
Director
Advanced Research Projects Agency
15 JUN 1970

A. W. Betts
Lt. General, USA
Chief, Research and Development

[redacted]

~~CONFIDENTIAL~~ UNCLASSIFIED

SUBJECT: Project PANDORA - Preliminary Agreement for Transfer Plans to U.S. Army

Over the past four years, ARPA supported the initial research on Project PANDORA on a high urgency basis. During this period quick "fix" laboratory facilities were procured and installed for early Pilot Experiments at WRAIR. Subsequently, ARPA provided funds for establishing a new research facility at WRAIR for observation of biological effects caused by electro magnetic radiation especially those in the microwave region of the spectrum. This facility has a photo laboratory, a neuro-chemistry laboratory, a neuro-physiology laboratory, a behavioral laboratory, computer and auxiliary software as well as other essential elements to carry out the important scientific work.

ARPA has now completed the role it normally plays in the DOD as regards to new research activities. We have also observed that your interests, competence and participation as ARPA's Agent in this area of research, all indicate that you should continue to carry on future work in this field. Accordingly, when ARPA phases out of the project in FY-1971 it is proposed to transfer all the equipment and the new facilities at WRAIR to the U.S. Army, provided that the U.S. Army agrees to accept the responsibility for the operating, the facility and for the conduct of R&D on the effects of microwave radiation on living systems.

Preliminary agreement between U.S. Army and ARPA is necessary so that all formal action for transfer of the project and associated facilities at WRAIR can be effected at an early date. This document is a preliminary step to be followed by formal transfer.

COORDINATION AGREEMENT:

Richard S. Cesaro
Director
Advanced Sensors

Date: 20 Mar 1970

William H. Meroney
Colonel, MC, USA
Director, WRAIR

Date: 20 Mar 70

[illegible] YEAR
INTERVALS; NOT AUTOMATICALLY
DECLASSIFIED DOD DIR 5200 [illegible]

~~CONFIDENTIAL~~

[redacted]

26 NOV 1969

~~NOV 1969~~

Colonel W. H. Meroney, MC
Department of Experimental Psychology
Walter Reed Army Institute of Research
Walter Reed Army Medical Center
Washington, D. C. 20012

THIS DOCUMENT HAS BEEN DOWNGRADED
TO "UNCLASSIFIED" 9 - OCT 1979
Per Director DARPA/TIO

Dear Bill:

Reference is made to your letter, dated 10 September 1969, and to our subsequent conversation relative thereto.

As a result of your letter, our recent conversations, and events in the Pandora program leading up to our exchange of ideas; I have tried to herein summarize those management policies, actions, and program directions we have both discussed and mutually concluded would represent important management steps to take to assure the successful conduct of the Pandora program. If you agree with the following approach, I would like to suggest we use this memo as the basis for a joint "Letter of Understanding" in the management of the Pandora program.

<u>Recommendations:</u>

a. WRAIR: It has become essential to conduct the Pandora program under the WRAIR organization (providing you can arrange it) subjecting it to all of the management controls, techniques, and policies you have set up for the normal conduct of projects under WRAIR. I fully concur in this step and completely support it as an excellent management move to take. I hope you can convince your management of the necessity for this and I will assist you in any way you see fit.

b. Security: I believe the need for a major revision in the Pandora program security, control, and definition in view of the present status and future tests planned is essential. I suggest the following new "guidelines". If you agree, I will proceed to obtain validation of them from appropriate security authority.

The original purpose and background leading to the initiation of the Pandora program including the exact data on the special signal and its history must be continued at a TOP SECRET-Limited Distribution

[redacted]

Mr. Rubenstein

c

[redacted]

AS-69-241 cy 3

[redacted]

(TS-LD) level. Specifically, the electromagnetic wave form data and the specified data on the three different modes of the special signal (only one of which we have simulated and used to date) is to be held at the TS-LD security category. The history and the background information on the special signal is also to be held TS-LD. The fact, however, that ARPA-Walter Reed is conducting research using low level microwave environments on monkeys and in a test chamber is to be considered unclassified. The data derived from all experiments in the microwave facility is to be considered unclassified. This includes data obtained with the special signal providing the detailed wave forms of this signal and its structure are not revealed since they are TS-LD. The fact that experiments are being run at levels of 4.5 mw/cm^{-2} and lower for both CW and modulated wave forms is unclassified. The facility and all test instrumentations, equipment contained therein, and data derived from the planned man experiments are unclassified except when the character of the special signal and the detailed information of the signal's structure and characteristics are to be revealed. Unclassified information on the microwave signal used for experiments with the special signal will be limited to the fact that the level is 4.5 mw/cm^{-2} and below and that it is a modulated complex signal wave form. Summarizing the suggested security policy for Pandora:

(1) The original purpose and background history of the initiation of the Pandora program and the exact data on the special signal must be continued at a TS-LD level.

(2) The project at WRAIR will be unclassified - with the exception of (1) above.

(3) The fact that WRAIR is carrying on experimentations in low level microwave radiation is unclassified.

(4) The building and microwave test facilities at WRAIR are unclassified.

(5) Results of tests are unclassified even those results obtained when the special signal is utilized providing the special signal is not identified beyond what is stated previously.

(6) Analysis of the data including the raw data obtained from experiments is unclassified - even that of the special signal providing the special signal itself is not identified.

[redacted]

[redacted]

(7) The "man" experiments will be unclassified with the previously stated ground rules relative to the special signal.

It is thought that WRAIR and ARPA can readily support and explain their reasons for conducting the Pandora program based on exploring whether or not animals or men subjected to low level microwave radiation may be affected to where temporary performance degradation is experienced even though this effect is recoverable to those exposed.

ARPA Advanced Sensors unclassified interest in the support and conduct of the Pandora experimental program centers around the fact that the Department of Defense has a larger number of radar systems of both low and high power where personnel are performing important functions in the radar environment. The degradation in human performance, if it occurs, under low level exposures over prolonged periods, could affect the operators and thereby affect the overall systems performance and efficiency while the effects, if they exist, must be explored. ARPA/AS classified interest in the program remains the same and is still under the R&D TOP SECRET-Limited Distribution Category.

c. Visits - the necessity for controlling visits to the Pandora facility is recognized as an essential step in maintaining good program management. Uncontrolled visitors not only consume valuable time but may go away with information on the results of raw test data that has not been analyzed and as such, if reported, could misrepresent the true experiments being conducted. Accordingly, I would like to suggest with your concurrance that your office be the control center for all visits to the Pandora facility at Walter Reed. These visits should be mutually agreed to on the part of both our offices as to visitors "need-to-know", timeliness and scheduling. I look to you to assume this focal point of visit control for the program. Included are visits by committee members, by IDA personnel, ARPA personnel, and all other outsiders.

d. Relations of the Scientific Advisory Committee with WRAIR-ARPA/AS - ARPA/AS views the formation and operation of the Pandora Scientific Advisory Committee to be an essential part of management inputs needed for the overall Pandora program and its relationship to other US Government activities in this field. I know you also feel that this outside, objective, professionally competent, committee is a valuable management tool for Walter Reed as well as ARPA. Several ad hoc panels have been formulated

[redacted]

[redacted]

within the Pandora Scientific Advisory Board to review certain findings obtained to date inorder to reestablish valid, technical criteria for conclusions that might be reached. The first of these groups, to be headed and chaired by Dr. Kubis, will be charged with determining whether or not the data can support that there have been microwave effects obtained so far in the Pandora program. This step is essential, as you have already concluded, in revalidating any conclusions that might be reached to date. Before this group can function, it will be necessary to have Dr. Kubis sit down with you and explain his method of approach for the review of the data and obtain your assistance in its methods and in carrying it out. This same procedure will be followed with any other sub panel that the committee advises in any other area, i.e. the question of the signal. As we discussed, I concur in your establishing an internal WRAIR Scientific Advisory Board to maintain a continuing technical review of the Pandora experiments already conducted as well as experiments to be conducted by WRAIR and all of its subcontractors.

Any committee action requiring participation with WRAIR personnel and all relating data from experiments in the Pandora program will be coordinated and arranged through your office prior to any actions being undertaken.

e. ARPA/AS WRAIR Relations - I have found our written discussions and program review to be exceedingly valuable to me in the future planning and conduct of the Pandora program. I would suggest that you and I arrange a monthly meeting to provide program review and take any actions that may be necessary.

I believe the suggested management changes in the program for the conduct of Pandora outlined within to be mutually beneficial and will result in providing a wide base from which to work in conducting these most difficult experiments.

Richard S. Cesaro
Director
Advanced Sensors

[redacted]

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
1400 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22209

15 September 1977

Honorable Warren G. Magnuson
Chairman, Committee on Commerce,
Science, and Transportation
Washington, D.C. 20510

Dear Mr. Chairman:

Reference is made to your letter dated 12 August asking a number of questions concerning Project Pandora.

In response to these questions, the following information is furnished:

1. Project Pandora was classified at the direction of the Department of State and the United States Intelligence Board because of the sensitivity of the radiation problem of the United States Embassy in Moscow at that time.

2. The total cost of Project Pandora was $4,615,000. A detailed breakout of the costs of the Walter Reed facilities and of the projects undertaken within the facility is not available.

3. All the raw data of Project Pandora was amassed by the technical researchers with only technical progress reports being furnished this agency. We would have no knowledge of what disposition was made of the raw data.

4. This agency has available a number of technical documents identified as "Minutes of Pandora Meetings" as well as several technical reports. These documents have been declassified.

5. This agency has no knowledge as to whether the data collected at Walter Reed were destroyed and, if so, the reasons for its destruction. Documents containing research, development, test and evaluation information or data are handled by this agency in accordance with the requirements of the Federal Records Act of 1950, Public Law 754, 81st Congress, as implemented by Department of Defense Instructions.

United States Senate

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

WASHINGTON, D.C. 20510

August 12, 1977

Dr. George H. Heilmeier, Director
Defense Advanced Research Projects Agency
Architect Building
1400 Wilson Boulevard
Arlington, Virginia 22209

Dear Dr. Heilmeier:

In recent oversight hearings on radiation health and safety conducted by this Committee on June 16th to 17th, 27th to 29th, 1977, several questions were raised which the DOD witnesses testifying at that hearing were unable to answer. These questions are enclosed with this letter. The Committee would appreciate your providing the Committee with written responses to the questions enclosed with this letter. We would appreciate receiving your written responses by September 15, 1977. Please submit five copies of your written responses to the Committee staff in Room 233 of the Russell Senate Office Building. If you have any questions or any further clarification of these questions, please do not hesitate to contact Sharon Nelson at 224-0411 or Alan Hoffman at 224-9351. Should the discussion of any of these questions raise security problems, please contact Mr. Hoffman, who has a top-secret clearance.

Thank you in advance for taking the time to respond to these questions.

Sincerely yours,

Warren G. Magnuson

WARREN G. MAGNUSON
Chairman

SN:ks

Enclosure

6. Project Pandora was terminated by DARPA in March 1970 and all assets were transferred to Walter Reed Army Institute for Research (WRAIR) for disposition. Since that time, there has been no DARPA interest in the work being carried on at WRAIR and consequently we would have no knowledge as to the project currently being undertaken, or that the facilities were being rebuilt, the reasons for rebuilding and the cost.

7. With the exception of Project Pandora, this agency has not sponsored any research projects, either classified or unclassified, on the biological or behavioral effects of non-ionizing radiation.

8. As stated earlier, classification of Project Pandora was a foreign relation rather than a national security matter. While it is likely that the technical aspect of such research efforts would be unclassified, the determination of a security classification must consider the potential application of the research and its effect on our national security.

9. This agency is not aware of any research projects, classified or unclassified, conducted under the auspices of the Defense Department, now on-going or in the past, which would have probed possibilities of utilizing microwave radiation as a form of what is popularly known as "mind control."

10. We do not foresee the development, by DARPA, of weapons using microwaves and actively being directed toward altering nervous system function or behavior. Neither are we aware of any of our own forces or possible adversary forces developing such weapons.

11. Although this agency is not presently involved in developing any directed energy microwave weapons, we do know that the United States, in the past, has conducted research and exploratory development on the generation of high power microwave radiation and its effect on electronic components.

12. This agency has no evidence that Eastern Block research on microwaves is being actively directed toward altering nervous system functions from a weapons point of view.

Sincerely,

George H. Heilmeier
Director

QUESTIONS

1. What were the reasons for classifying the research project known as "Project Pandora"?

2. What was the cost of Project Pandora? What were the costs of the Walter Reed facilities and of the research projects undertaken within the facility?

3. What has happened to raw data amassed during Project Pandora?

4. In testimony before this Committee witnesses from the Department of Defense were unable to tell us whether or not the relevant data from Project Pandora has been destroyed or whether or not it still exists. If the data still exists, is it still classified? If the data does not exist, what happened to it?

5. The witnesses testifying at the hearing tentatively guessed that the data were destroyed. If the data were destroyed, what were the reasons for its destruction? How often are documents containing data such as those involved in Project Pandora routinely destroyed? Please describe procedures for such routine destruction.

6. Please provide the Committee a description of the project currently being undertaken at the Walter Reed facilities which were originally built for Project Pandora. Dr. Herbert Pollack, in his testimony before the Committee, stated that the Walter Reed facilities were currently being rebuilt. Why are these facilities being rebuilt? At what cost?

7. Are there now, or have there ever been, research projects on the biological or behavioral effects of non-ionizing radiation, such as Project Pandora, which have been classified?

8. Does your agency see the need for such research ever again to be classified?

9. Are there now, or have there ever been, research projects classified or unclassified conducted under the auspices of the Department of Defense which would have probed possibilities of utilizing microwave radiation as a form of what is popularly known as "mind control"?

10. Several of the witnessse alluded to "novel utilization of the spectrum". Do you foresee the development, either by our own forces or by adversary forces, of weapons using microwaves and actively being directed toward altering nervous system function or behavior?

[redacted] [redacted] [redacted]

11. Is the United States involved in developing any directed energy microwave weapons?

12. Is there any evidence that Eastern Block research on microwaves is being actively directed toward altering nervous system functions from a weapons point of view?