RESEARCH PROPOSAL

(A-1642) RESEARCH IN MILLIMETER WAVE TECHNIQUES Semiannual Status Report (Georgia Inst. of Tech.) 39 p HC $3.75 CSCL 20J
N75-27215
Unclas
G3/32 28641

ENGINEERING EXPERIMENT STATION

Georgia Institute of Technology
Atlanta, Georgia 30332

A-1642 Grant No. NSG5012

RESEARCH IN MILLIMETER WAVE TECHNIQUES

Semi-Annual Status Report

27 June 1975

Submitted to

NASA/Goddard Space Flight Center
Greenbelt, Maryland

Semi-Annual Status Report

RESEARCH IN MILLIMETER WAVE TECHNIQUES

NASA Grant No. NSG5012
GT/EES Project No. A-1642

Report Period
15 December 1974 - 15 June 1975

Project Director/Principal Investigator
J. W. Dees

Project Monitor for NASA/GSFC
J. L. King

27 June 1975

Engineering Experiment Station
Special Techniques Division
Georgia Institute of Technology
Atlanta, Georgia 30332

FOREWORD

This is the second semi-annual status report on NASA Grant NSG5012. The grant period is from June 15, 1974 to March 31, 1976 and includes an extension from June 15, 1975 to March 31, 1976 and an increase of $47K in funding over the original grant. Although not required by the grant, informal monthly letter-type reports have been written and furnished to the NASA/GSFC technical monitor, J. L. King, in order to keep him abreast of our activities on a current basis. We believe this provides a better opportunity for NASA to direct the program for the maximum benefit of the government. Copies of each of these monthly reports for the current period (eight through eleven) are attached as an Appendix.

Since this semi-annual status report is being furnished during the time the twelfth monthly letter report would normally be written, this report will replace the twelfth monthly report.

The Principal Investigator at Georgia Tech/Engineering Experiment Station is J. W. Dees and the internal project number is A-1642. A matching account, E-240-803, in the amount of $1,800 direct labor was also established for this project. An additional $2,474 in matching funds was added to this account for the add-on. Due to the pending increase in scope of work on this project (the 183 GHz airborne radiometer), an administrative change has been made appointing two assistant project directors for the two separate tasks which will be pursued in the coming months. Mr. J. J. Gallagher will be the assistant project director for the propagation and atmospheric attenuation segments of the work and Mr. J. B. Langley will serve as assistant project director for the construction of the 183 GHz airborne radiometer.

Contributions to the technical effort and/or this report during the second six months period include, in addition to the Principal Investigator: Mr. J. J. Gallagher, J. B. Langley, G. E. Riley, M. J. Sinclair, J. A. Stratigos, J. M. Schuchardt, W. Cox and student assistant, J. B. McManus.

During the period covered by this semi-annual report, the following trips were made:

(1) NASA/GSFC, Greenbelt, Maryland by J. W. Dees and W. Cox on 23 January 1975 to visit J. L. King for contract discussions.

(2) Crawford Hill Laboratory of Bell Telephone Laboratories by W. Cox and J. J. Gallagher on 5 March 1975 to visit Dr. Martin Schneider and discuss his Schottky barrier millimeter wave mixer techniques.

(3) NASA/GSFC, Greenbelt, Maryland by J. W. Dees and J. M. Schuchardt on 23 April 1975 to visit J. L. King for contract discussions.

(4) Torrance, California by J. W. Dees and W. Cox on 16 May 1975 to Hughes Aircraft, Electron Dynamics Division to discuss the Hughes line of millimeter IMPATT sources.

Details of these trips are included in the monthly letter reports.

TABLE OF CONTENTS

LIST OF FIGURES

SUMMARY OF WORK

I. Development of Laboratory Radiometer

The first laboratory model 180 GHz radiometer has been constructed and is currently being evaluated. The radiometer is shown in Figures 1 through 4. The radiometer employs a Cassegrain feed geometry with a 25.44 inch parabolic main reflector and a 3.0 inch subreflector fed by a corrugated conical horn. This feed horn shown in Figure 5 made by EH Microwave in Boulder, Colorado has exceptionally low sidelobe levels as is shown in Figure 6. An absorber coated chopper is used to modulate the signal which is down-converted in a cross-guide harmonic mixer. This mixer employs a Schottky barrier diode with a tungsten whisker which is run-in with a differential screw. A gallium arsenide diode is currently being used.

Following conversion to an IF frequency of 1 to 2 GHz, the signal is amplified by three Avantek low noise amplifiers each having a noise figure of approximately 2.5 dB and a gain of 32 dB. The resulting signal is then video detected and fed to a PAR lock-in amplifier. The output of the lock-in amplifier is then fed to a standard chart recorder.

For operation at 183.3 GHz a local oscillator frequency of 181.8 GHz is required. Using the harmonic mixer, a klystron oscillating at 90.9 GHz is required for second harmonic mixing, or 60.6 GHz for third harmonic mixing. At present the only sources available with sufficient power output are at approximately 100 GHz and approximately 55 GHz, neither of which are suitable for operation at 183 GHz. A Varian VRB-2112A klystron which will have a minimum power output of 200 milliwatts at 90.9 GHz is on order and is expected to be received by late August. In the meantime the 100 GHz source is being utilized to evaluate mixer performance and to optimize system parameters. Preliminary results indicate a noise figure of approximately 20 dB is being achieved; however, operation is erratic and these measurements are only approximate as the calorimeter and black body source which have been ordered and are necessary for accurate measurements at these frequencies have not yet been received. An additional improvement in sensitivity should result from the replacement of the currently used Hewlett-Packard video

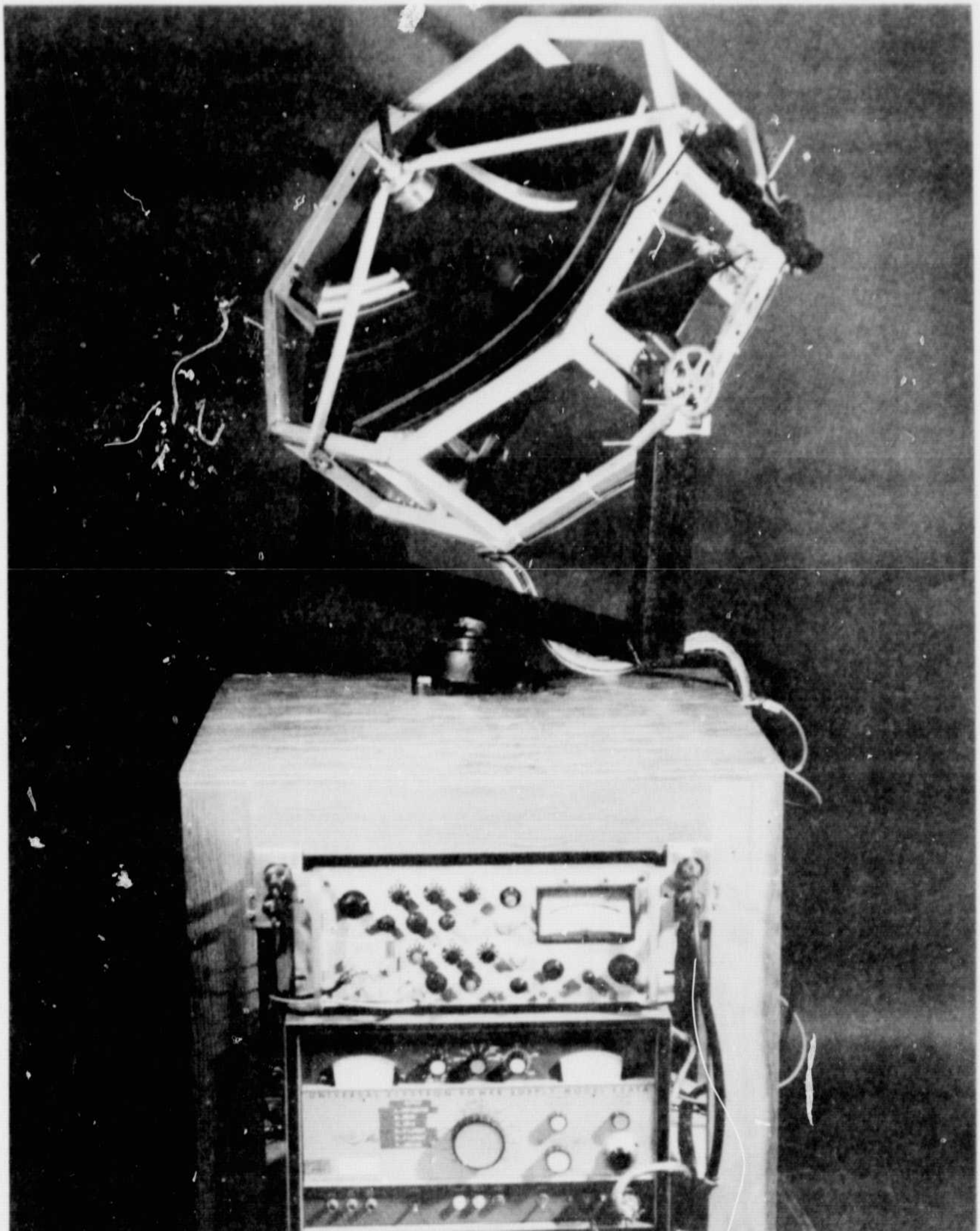


Figure 1. 183 GHz Radiometer.

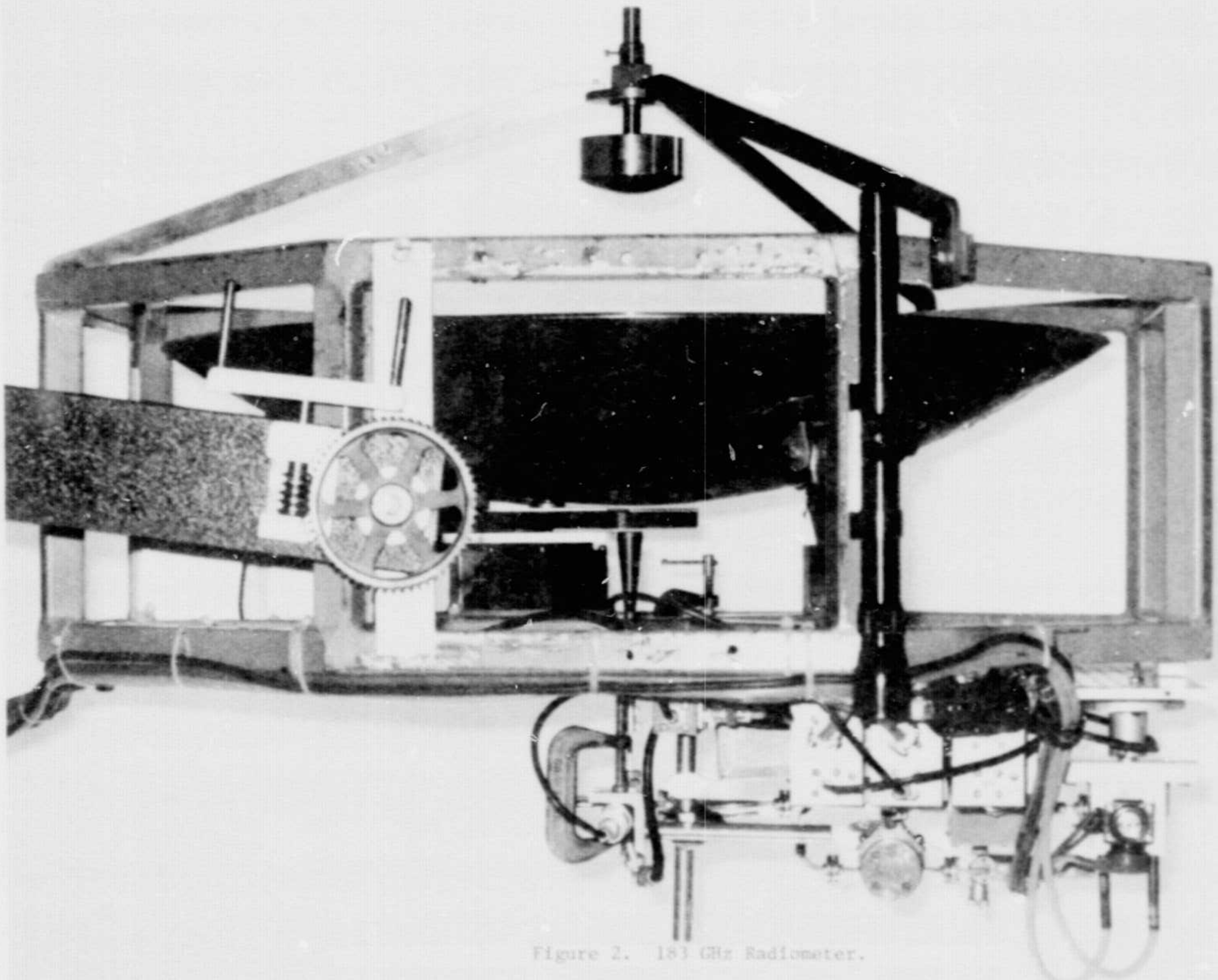


Figure 2. 183 GHz Radiometer.

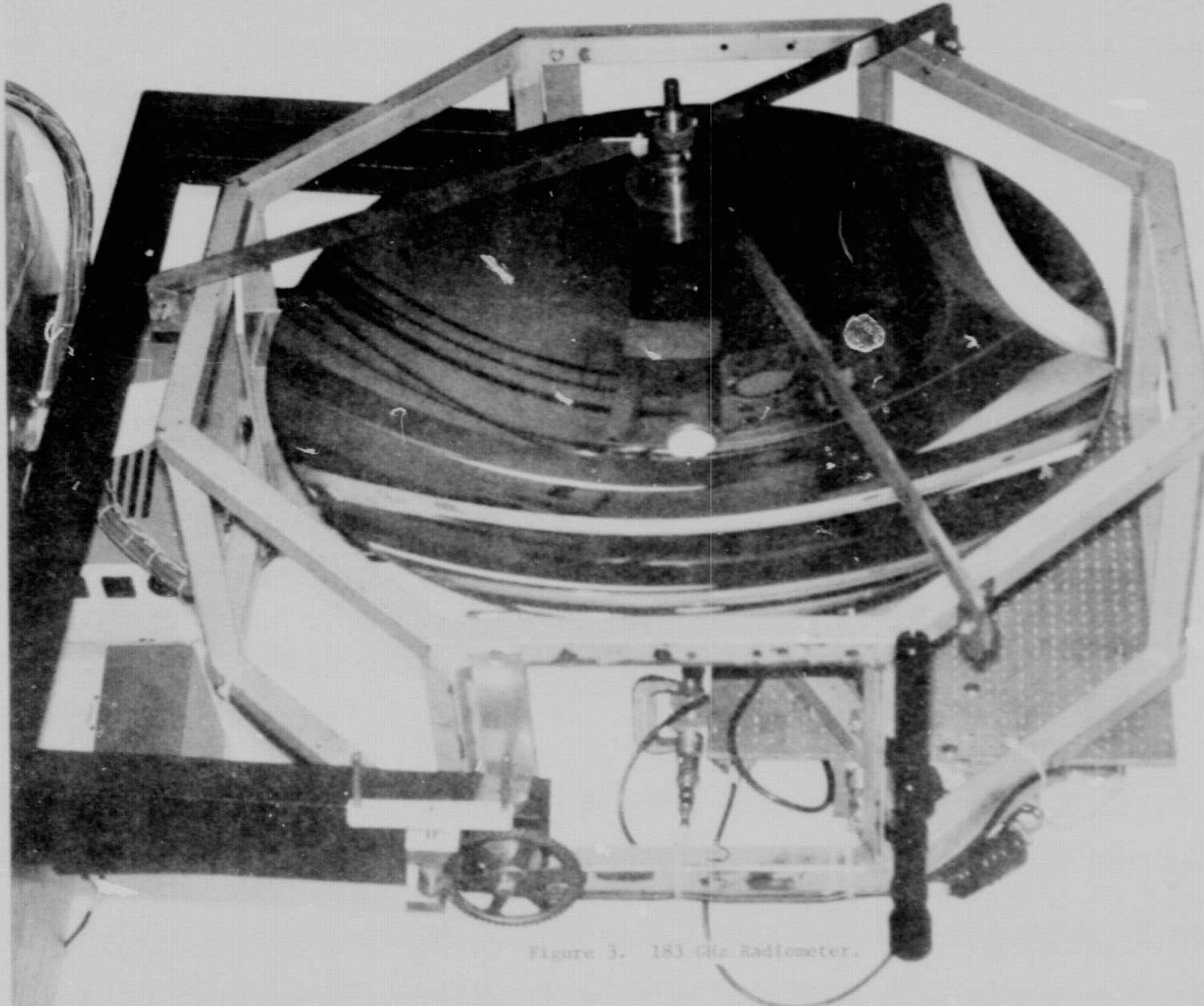


Figure 3. 183 GHz Radiometer.

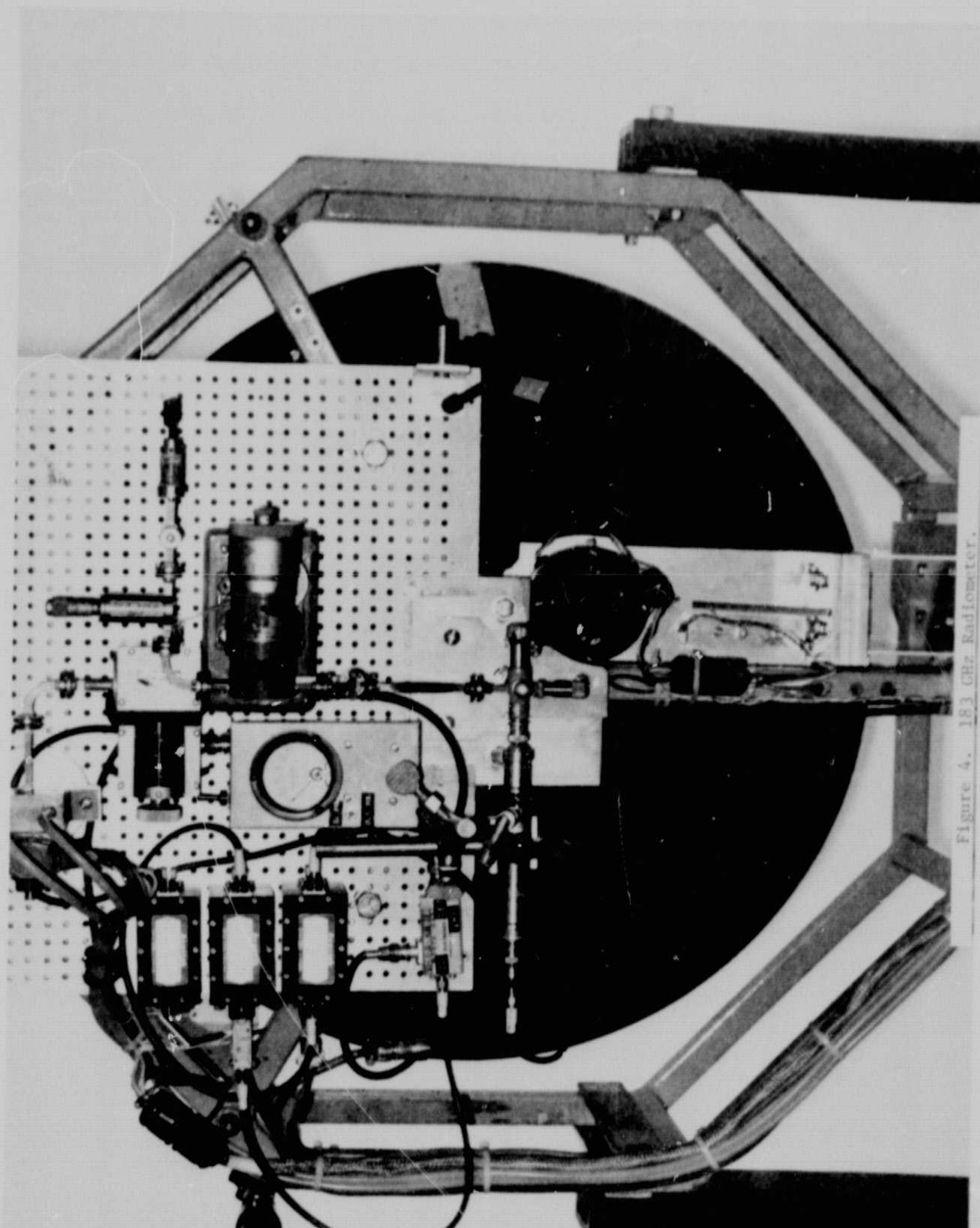
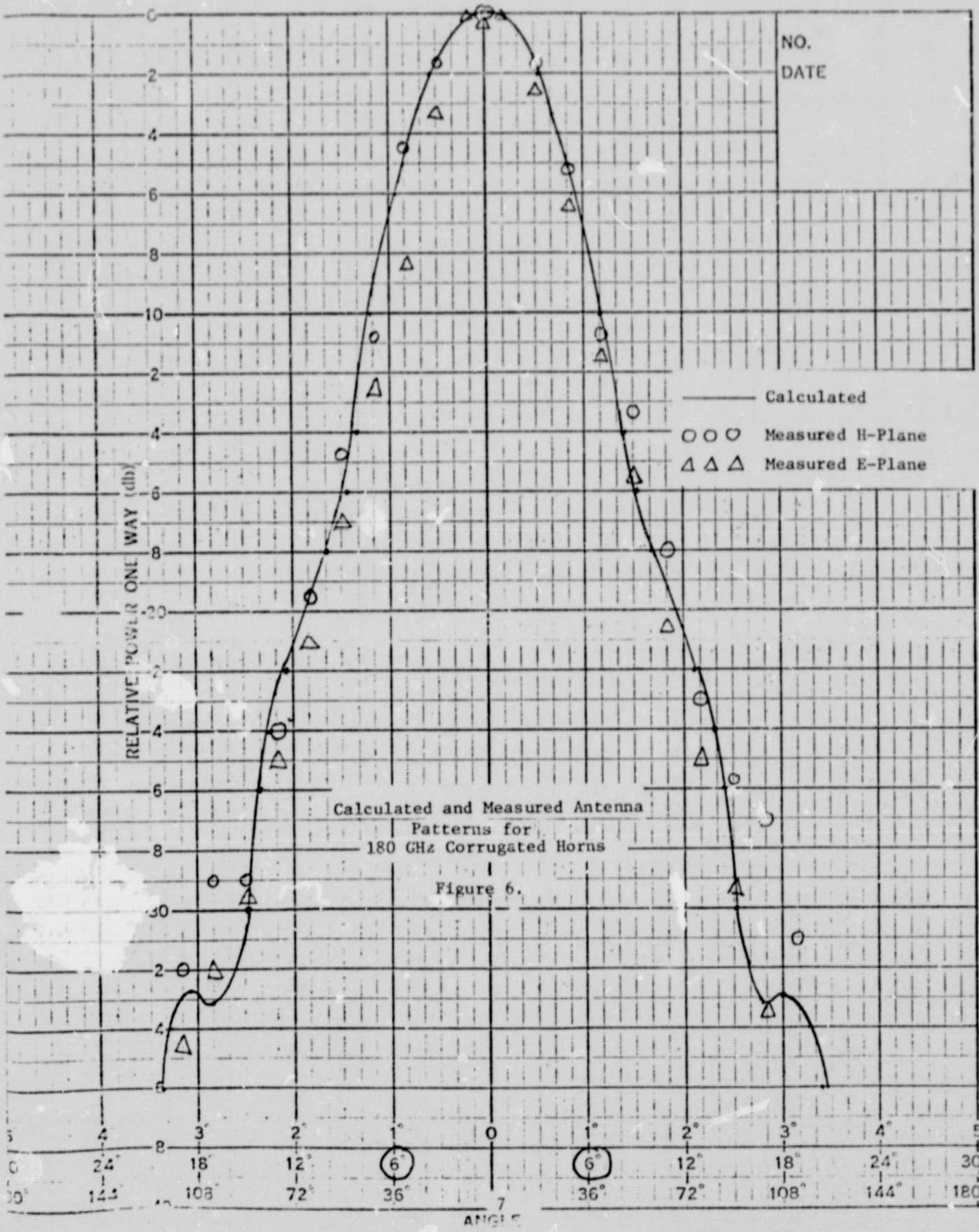


Figure 4. 183 GHz Radiometer.

Figure 5. 183 GHz Corrugated Horn.



Calculated and Measured Antenna Patterns for 180 GHz Corrugated Horns

Figure 6.

detector with the recently purchased Aertech Model D4S Schottky barrier device. This detector has a nominal sensitivity of 2000 mV/mW which is about five times that of the Hewlett-Packard detector.

In addition to the use of the harmonic mixer with the 100 GHz local oscillator, experiments are planned using a single-ended fundamental mixer with the 160 GHz Varian klystron and fundamental mixing. The LO power will be coupled to the mixer through an EH Microwave directional coupler having a nominal coupling coefficient of -6 dB and a directivity of -20 dB. This experiment will also allow radiometric measurements at 160 GHz.

The GFE Hughes 70 GHz IMPATT diode source was returned to Georgia Tech following repairs by Hughes. Attempts were made to evaluate its performance as to spectral purity and frequency stability; however, before accurate measurements could be made, the diode apparently failed and the device has been again returned to Hughes. Preliminary measurements indicate a line width of approximately 20 MHz at -10 dB and a drift rate of nearly one gigahertz per minute. These measurements were made by observing the beat between a harmonic of a phase-locked X-band klystron and the IMPATT source on a Hewlett-Packard spectrum analyzer. These data were so clearly outside the specified values that it is felt that the source was not operating properly even prior to its total failure.

If an IMPATT source is to be used as a local oscillator, it seems clear that some form of active frequency stabilization is necessary. To this end a phase-lock chain has been breadboarded which allows locking an X-band source to a 5.0 MHz standard. This is shown in Figure 7. The 100 MHz signal derived from the 5.0 MHz reference is amplified to approximately 1.0 watt and fed to the YIG tuned harmonic multiplier. The YIG filter is tuned to one harmonic line in X-band and fed to one input of a balanced mixer, the other input of the balanced mixer comes from the X-band source through a directional coupler; the output of the balanced mixer is then amplified, low pass filtered and used to correct the source. An X-band gunn diode source has been locked as well as a klystron. It is felt that a transistor oscillator in a high-Q cavity would provide a better source for phase-locking than either of the two mentioned.

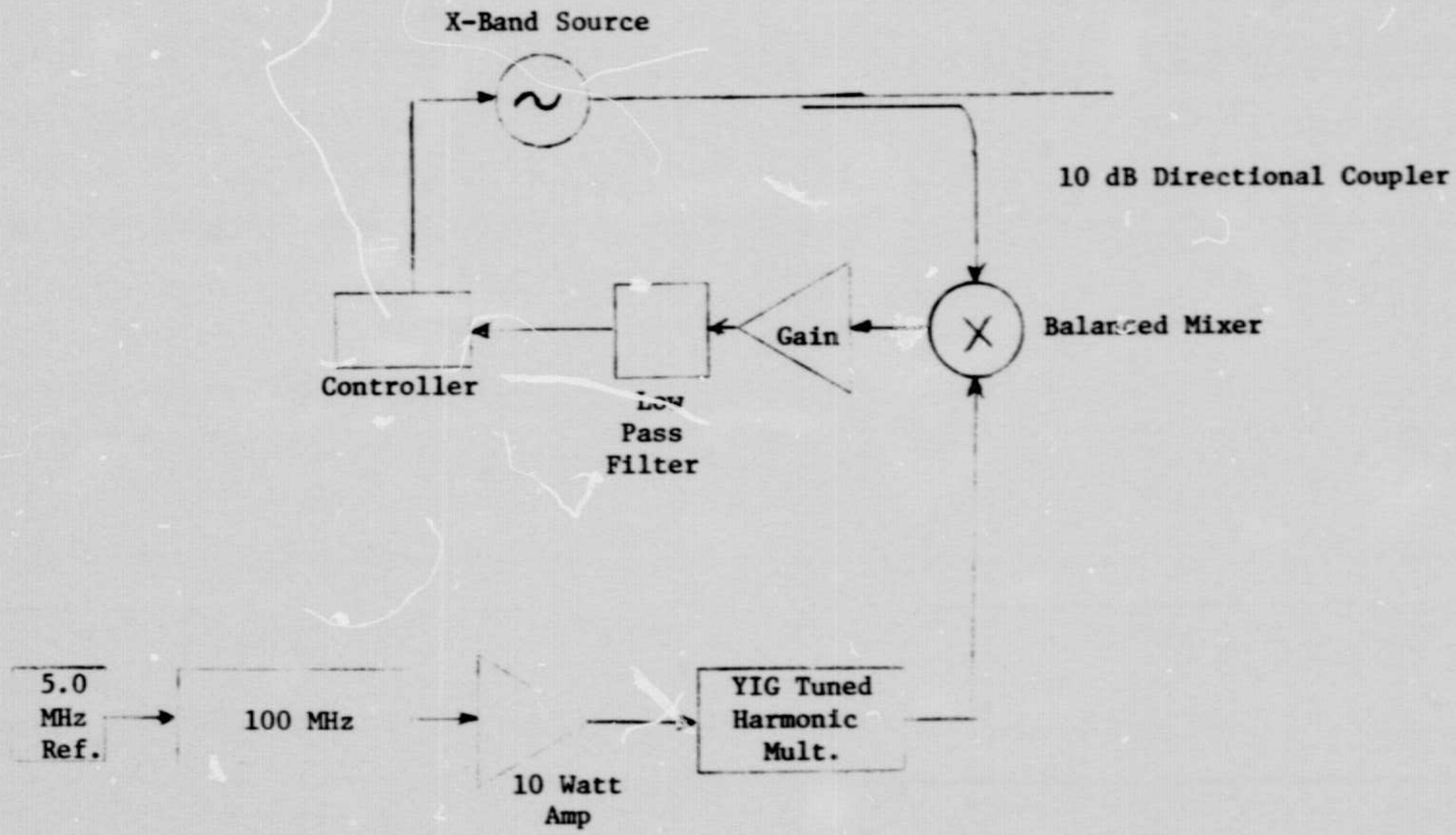


Figure 7. X-Band Phase-Lock Loop.

II. Preliminary Design Considerations for 183 GHz Airborne Radiometer

Preliminary design studies have begun to estimate the expected performance of an airborne scanning radiometer operating at 183 GHz. Based on the work of Schneider and Wrixon [1,2] at 170 and 230 GHz, it appears that a system noise figure of approximately 10 dB is realistically obtainable. For purposes of discussion an IF bandwidth of 1 GHz is assumed. Then:

$$\Delta T_{min} = T_{SN}(BW_{IF}\tau)^{-1/2} \tag{1}$$

where

$$T_{SN} = 290\ (F_n - 1);\ F_n = 10\ (10\text{ dB})$$

$$T_{SN} = 2610°K.$$

Substituting into (1):

$$\Delta T_{min} = 2.61 \times 10^3\ (10^9)^{-1/2}\ (\tau)^{-1/2}$$

$$\Delta T_{min} = 8.25 \times 10^{-2}\ (\tau)^{-1/2}. \tag{2}$$

The minimum system sensitivity is shown as a function of τ in Figure 8.

Figure 9 illustrates a scan pattern created by an airborne vehicle traveling with velocity V at altitude h with a scanner having an instantaneous field of view of beamwidth of angular size β in both dimensions. This instantaneous FOV is caused to scan through an angle α at right angles to the aircraft path by a rotating element in the scanner. Motion of the vehicle carries the scanner forward such that successive scans cover different strips of object space. The portion of object space swept over during a single scan through angle α is referred to as a "line". If successive lines are not contiguous, the condition will be termed "underlap". Underlap occurs if the vehicle speed is too high or if the scanner rotates too slowly. If successive lines scan partly over the same object space the condition is called "overlap". Underlap is undesirable since information is not obtained between

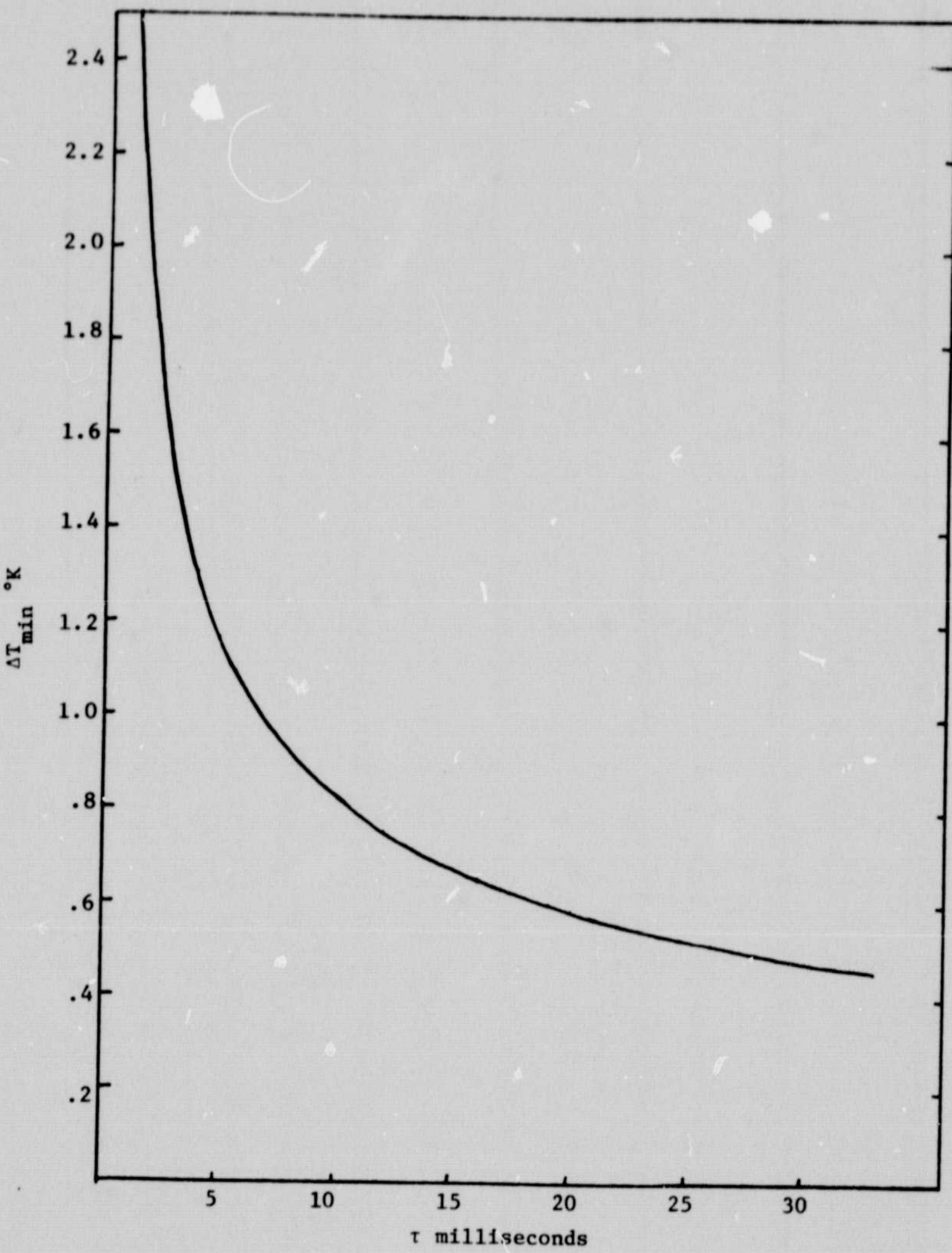
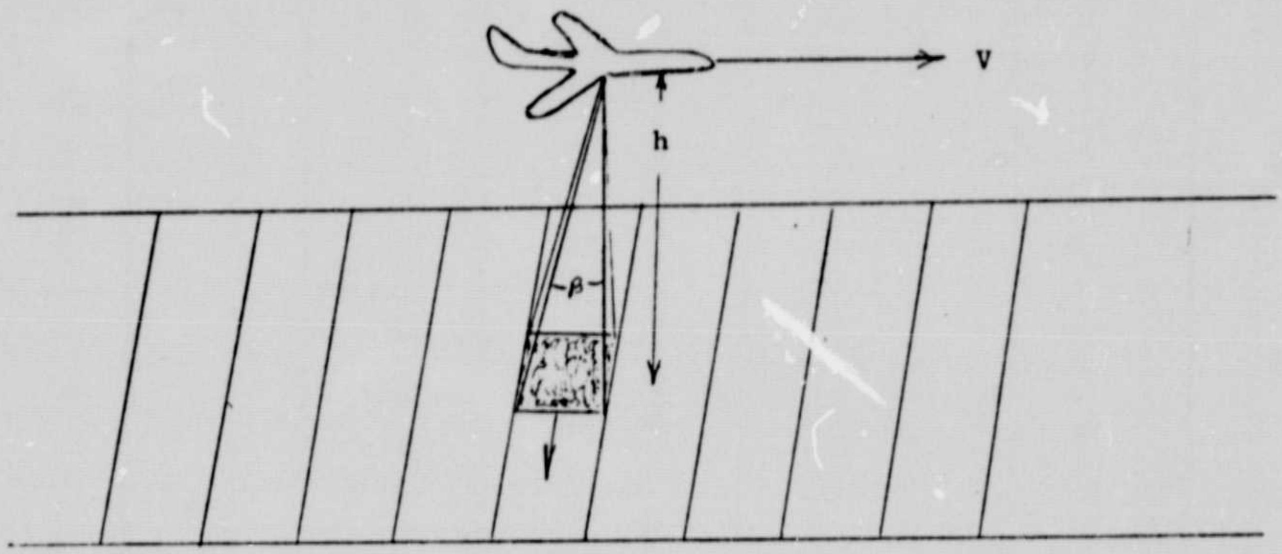


Figure 8. Minimum System Sensitivity.



β = Instantaneous Field of View (FOV)

h = Altitude

V = Velocity

r = Scan Rate

β is defined as an angle small enough to approximate $\sin\beta = \beta$.

Figure 9. Scan Pattern.

successive lines and overlaps create redundancy. Contiguous scanning is desirable in that no object space remains unscanned, and no object space is scanned more than once.

Typical devices for obtaining such a scan are rotating wedges, rotating prisms or a rotating offset flat mirror. As a first cut, consider a contiguous scanner with a mirror in the form of a prism with n faces rotating at a rate (r) about an axis which is parallel to the flight path of the aircraft. n lines are scanned per revolution. Each face of the prism is inclined 45° to the axis of rotation. To determine the rotational speed, the sensor time constant (τ) must be considered. The scanner dwells on each beamwidth for a time not less than $k\tau$, where k is a positive dimensionless number, representing the dwell time in terms of the sensor time constant.

The operation of such a scanner must meet two considerations: (1) the scanner must dwell on each spatial resolution element or beamwidth for a time not less than $k\tau$. The number of resolution elements scanned per second is $2\pi r/\beta$, and the dwell time is $\beta/2\pi r$ (assuming 100% scan efficiency). Therefore $(\beta/2\pi r) \geq k$; (2) the scanner operates at a rate such that no underlap occurs. In the direction of aircraft travel, the width of the strip scanned by each face of the prism is βh and the width of the strip scanned each second is βhnr. If no underlap is to occur, this expression must be greater than or equal to the vehicle speed, $\beta hnr \geq V$, or:

$$r < \frac{\beta}{2\pi k\tau}$$

$$r \geq \frac{V}{hn\beta} .$$

The scan rate (r) limits are then established on the upper end by the sensor time constant and a lower limit set by zero underlap requirement (by V/h). A third constraint on r is also important—the maximum rate permitted by mechanical considerations.

Eliminating r from the above inequalities the constraints for β are determined:

$$\beta \geq [\frac{2\pi k\tau}{n} \cdot \frac{V}{h}]^{1/2}$$

Unlike r, β is only constrained on the lower limit. This constraint is imposed by the joint action of V/h and τ.

Under the limiting conditions of contiguous lines the inequalities become equalities and the relations become:

$$r = [\frac{1}{2\pi kn} \cdot \frac{V}{h} \cdot \frac{1}{\tau}]^{1/2}$$

$$\beta = [\frac{2\pi k\tau}{n} \cdot \frac{V}{h} \cdot \tau]^{1/2}.$$

The scan rate r and the beamwidth β are then functions of both τ and the ratio of velocity to height. Assuming a constant ratio of V/h (V = 300 kts or approximately 500 ft/sec; h = 65,000 ft) one can plot the beamwidth as a function of kτ, for various values of n on the condition of contiguous ground coverage. These data are plotted in Figure 10. From these curves it can be seen that at values of kτ ≈ 30 ms the beamwidth becomes so great as to greatly reduce the ground resolution for the cases of n = 1, n = 4 or n = 8. An alternative would be reduce the beamwidth to produce a satisfactory degree of ground resolution and tolerate the resulting underlap.

The preceding calculations exclude several elements which may alter the results somewhat. In particular, no consideration is given to the radiometer stabilization constant and the estimate of the height above the surface mapped may be considerably in error due to the fact that strong absorption occurs at 183 GHz by the relatively high water vapor density in the upper regions of storm clouds. These factors will be evaluated as the system design progresses.

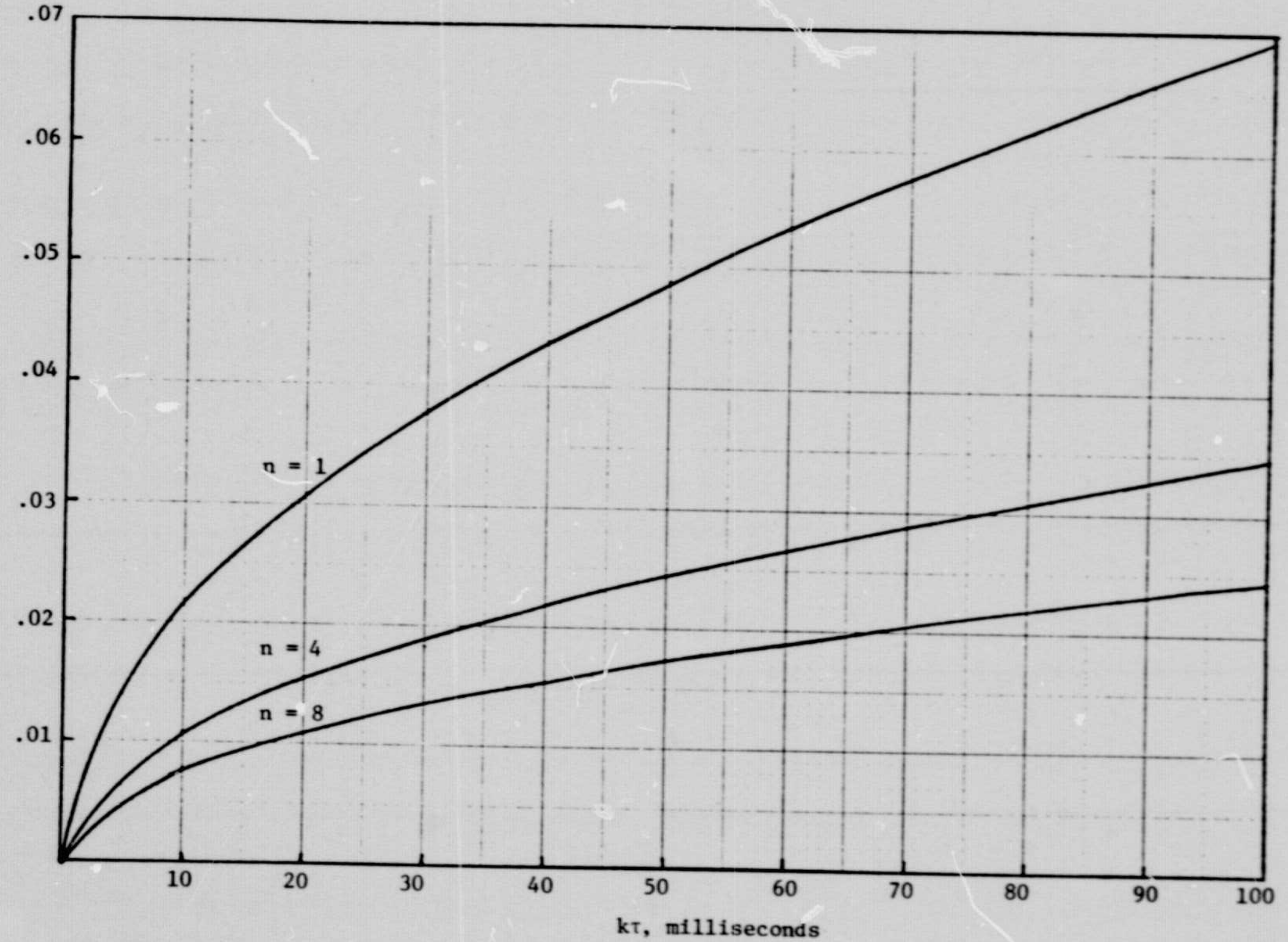


Figure 10. Beamwidth vs. kτ for Contiguous Scan.

III. Work Planned for Next Period

During the next period, the 180 GHz radiometer will be operated on the roof of the STD Building. It will be operated in the band from 130 GHz to 180 GHz. The investigations will be performed to provide data on the propagation characteristics in the 130-180 GHz wavelength region. In turn, with the components becoming available, a 94 GHz radiometer will be assembled. This radiometer will be employed simultaneously with the 130-180 GHz system if additional amplifiers can be obtained. A model of atmospheric propagation will be developed for the spectral region from 80 GHz to 200 GHz, and it will be compared with the results of the radiometric measurements.

The design of the airborne radiometer for use in the RB-57 will be continued with major emphasis being on the decisions as to the local oscillator generation method (i.e., solid state or klystron) and the design of mixer. Several alternatives exist in both areas and these will be carefully weighed in terms of overall system performance.

References

[1] M. V. Schneider and G. T. Wrixon, "Development and Testing of a Receiver at 230 GHz," 1974 IEEE-MTT Microwave Symposium.

[2] G. T. Wrixon, "Low Noise Didoes and Mixers for the 1-2 mm Region," IEEE Trans. on MTT, December 1974.

APPENDIX

PRECEDING PAGE BLANK NOT FILMED

RESEARCH IN MILLIMETER WAVE TECHNIQUES

Eighth Monthly Progress Report

Report Period

15 January 1975 to 15 February 1975

NASA Grant No. NSG 5012

GT/EES Project No. A-1642

Project Director: J. W. Dees
Project Monitor: J. L. King

Engineering Experiment Station
Special Techniques Division
Georgia Institute of Technology
Atlanta, Georgia 30332

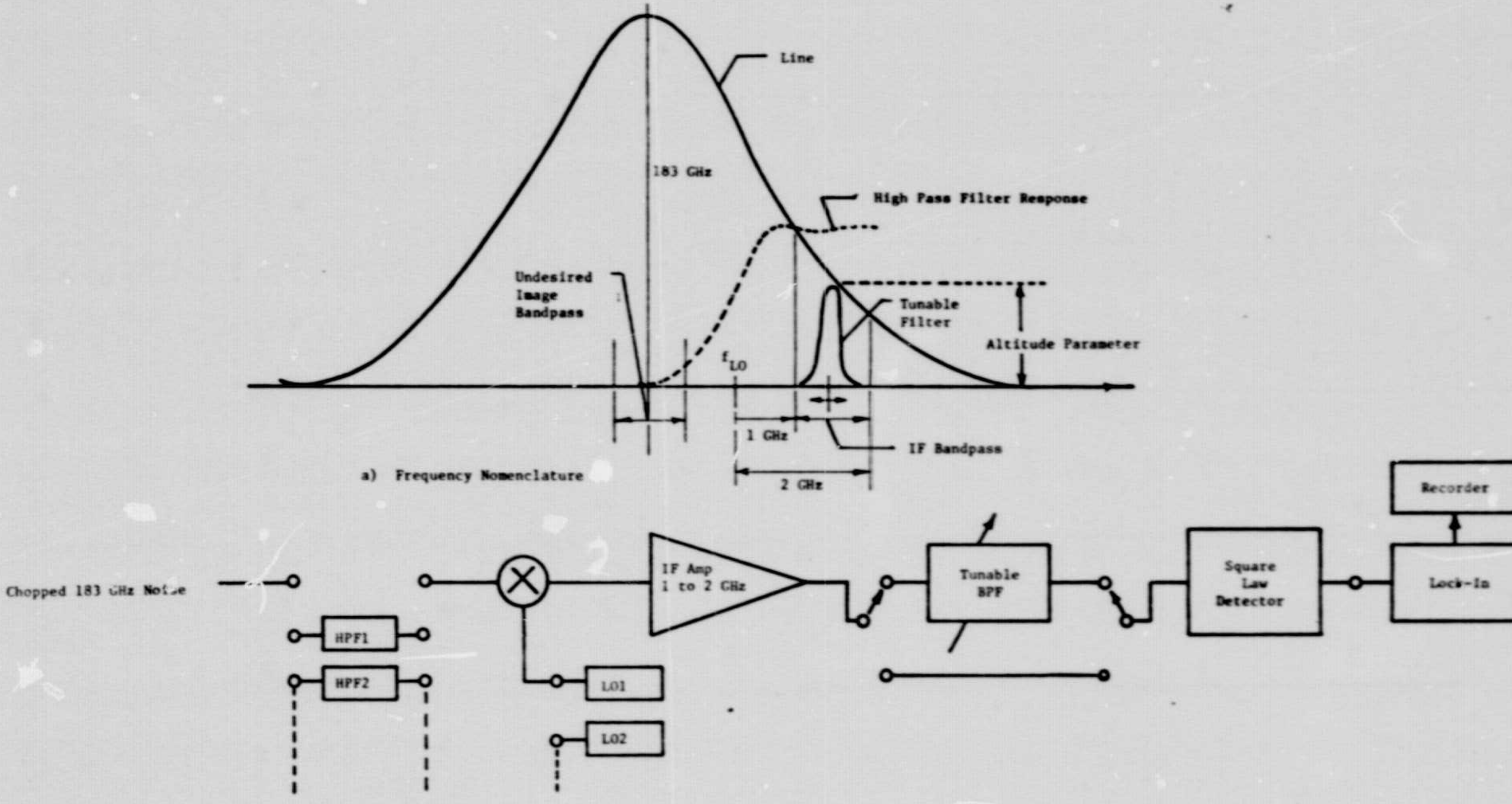
1. SUMMARY OF WORK

During the past month, investigations have continued on the radiometer system. A delay in the purchase of the directional coupler has been experienced due to an aberration in the procurement cycle. As a result, it has not been possible to check the one-port mixer with the Schottky barrier diode. To avoid further delay, a Schottky barrier diode has been incorporated into a cross-guide mixer. This will allow application of the 94 GHz local oscillator to the mixer without the use of a directional coupler but will result in the direct application of the local oscillator signal to the mixer. Harold Fetterman of Lincoln Lab has sent us two of their Schottky barrier diodes for comparison with ours, and these elements are currently being mounted in our mixer structures.

Studies have been performed on a mixer design for shortening the point-contact whisker. Concern has been raised about the length of whisker and waveguide openings which exist in our current devices. The use of a strip-line for the IF (a la Martin Schneider) is also being studied. A final design will be made and sent to Emory Horvath (Custom Microwave) for construction. Before this is done, however, a visit to Schneider at BTL is planned during a forthcoming trip.

The IF amplifiers (3) have been ordered from Avantek. These amplifiers, Model AM-2020, will provide 30 dB gain each with noise figures of 3.0 dB. The bandwidth of the units is 1000 MHz (1000-2000 MHz). Filters are planned for use following these amplifiers; however, for observations at ground level the emission and absorption due to atmospheric H_2O will be broad and mainly confined to the atmosphere near the radiometer. Off resonance, the situation is different and calculation of the effects at ground level, 10 km altitude and from the satellite continue. Since single sideband operation will eventually be employed, waveguide cut-off filters are required.

The concept presently under study is shown in Figure 1. To ease image rejection, highpass filters will be used. To cover the frequency range required, multiple or tunable LO's will be needed. At frequencies far removed from the line's center (low altitude) the entire 1-2 GHz IF bandwidth can be utilized; however, near the line center (high altitude) a



a) Frequency Nomenclature

b) Partial Block Diagram

Figure 1. System Parameters Related to Frequency and Altitude.

tunable filter following the IF amplifier will be needed to provide the needed resolution.

Work has continued on the cassegrain reflector antenna. Electroformed corrugated feed antennas have been ordered from Custom Microwave (Horvath). A hole has been cut in the steel reflector and the chopper assembly has been mounted. This is shown in Figures 2 and 3. The spar and subreflector design is complete and fabrication is planned for next month.

II. Work Planned for Next Month

A slight reduction in the technical effort is anticipated during the next period while awaiting components on order. Fabrication of the spar and subreflector is planned and work with the harmonic mixer will continue. An increase in the level of effort is planned as soon as the radiometer parts are received.

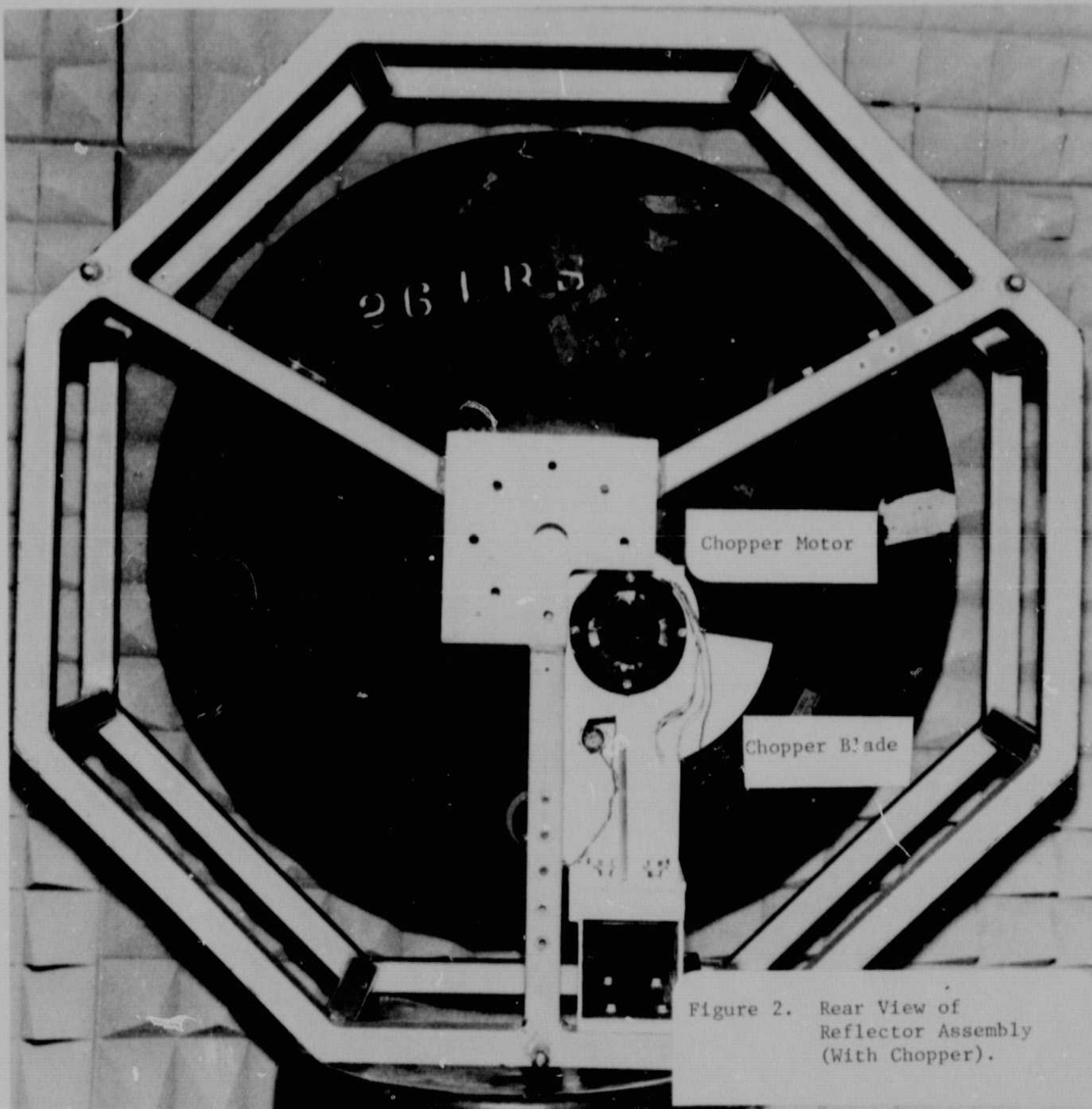


Figure 2. Rear View of Reflector Assembly (With Chopper).

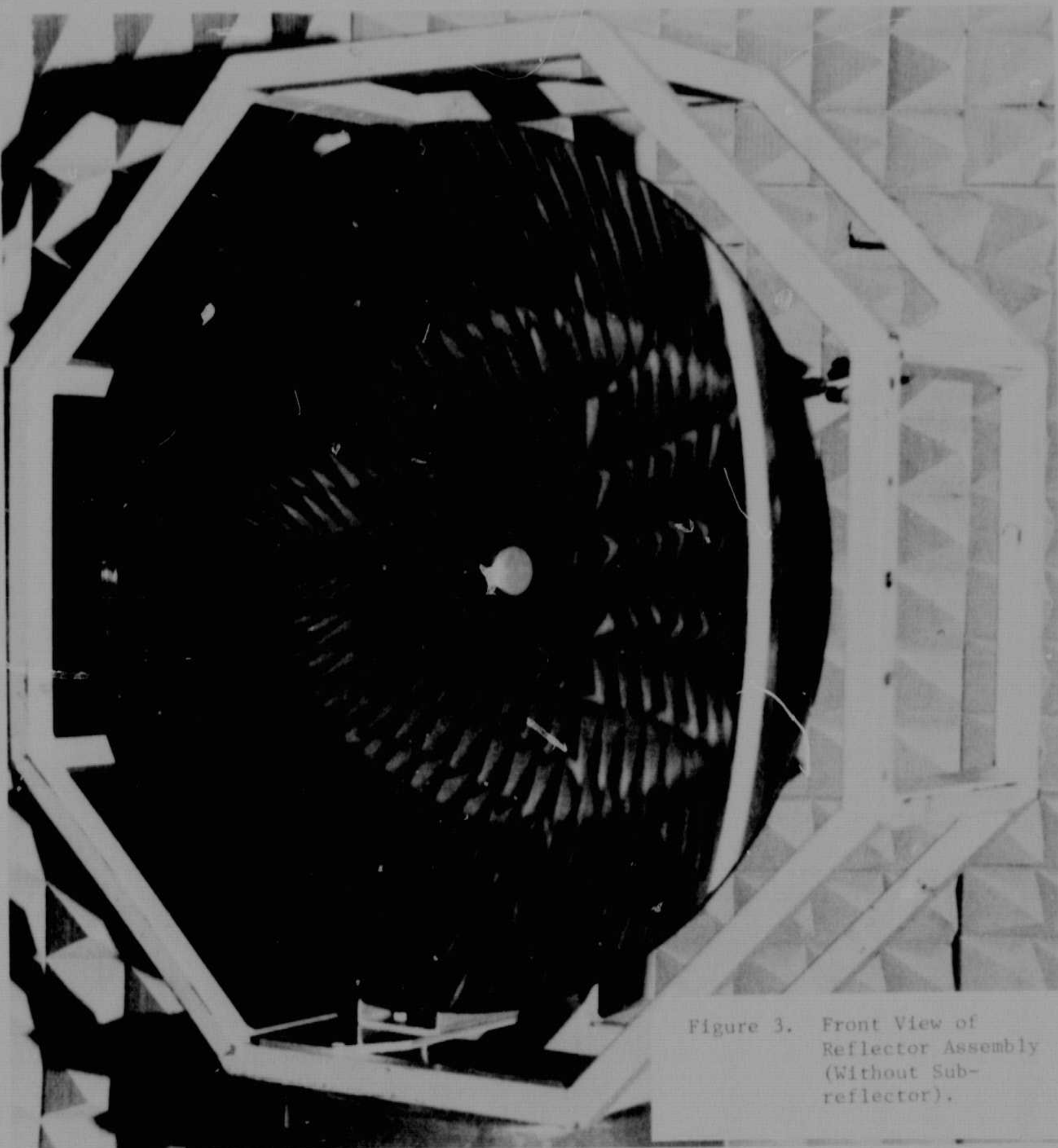


Figure 3. Front View of Reflector Assembly (Without Subreflector).

RESEARCH IN MILLIMETER WAVE TECHNIQUES

Ninth Monthly Progress Report

Report Period

15 February 1975 to 15 March 1975

NASA Grant No. NSG 5012

GT/EES Project No. A-1642

Project Director: J. W. Dees
Project Monitor: J. L. King

Engineering Experiment Station
Special Techniques Division
Georgia Institute of Technology
Atlanta, Georgia 30332

I. SUMMARY OF WORK

Most of the components are available now for the 180 GHz radiometer, and testing of the diodes is beginning. The directional coupler has not been received as yet; however, a Schottky barrier diode is mounted in the cross-guide structure shown in Figure 1, and testing can be performed on this unit. In this respect, Eccosorb 72 has been obtained to attach to the blades of the radiometer chopper and for calibration of the radiometer.

A Varian VC-714G klystron has been checked and found to be operative in the range from 158 GHz to 166 GHz. No power measurements have been made as yet, but this will be possible when the TRG calorimeter is delivered. A calorimeter controller has been received GFE from NASA/Goddard. The klystron will serve as a source in the 165 GHz range for antenna measurements and as a local oscillator for the radiometer. This will allow comparison of direct LO with harmonic mixing.

A diode holder has been chosen for the 94 GHz system for the mounting of a Schottky barrier diode. The unit will be used with the existing 94 GHz system being employed for harmonic mixing but more 94 GHz components will be necessary if a complete radiometer is to be included in the atmospheric measurements. Hopefully NASA/GSFC can GFE many of these 94 GHz components.

On March 5, 1975, a visit to the Crawford Hill laboratory of Dr. Martin Schneider at BTL was made by W. Cox, J. Gallagher and D. Blue. Schottky barrier diodes were discussed, and both the discussion and observations of Schneider's work will be helpful in the optimizing of the millimeter wave diode holders.

Delivery of both the Avantek IF amplifier and the YIG filter are past due and are anticipated during the next month.

Work has continued on the antenna for the radiometer. An improved subreflector mounting mechanism has been designed that will allow greater flexibility in aligning and adjusting the subreflector. This mechanism is sketched in Figure 2.

Electroformed horn antennas suitable for preliminary systems tests have been received. These horn antennas, shown in Figure 3, are similar in geometry to the corrugated horns (now being fabricated) that will be used as the reflector feed.

II. WORK PLANNED FOR NEXT MONTH

During next month, calibration of the radiometer should be achieved with a check-out of the Schottky barrier diodes. The subreflector and its mounting mechanism will be fabricated.

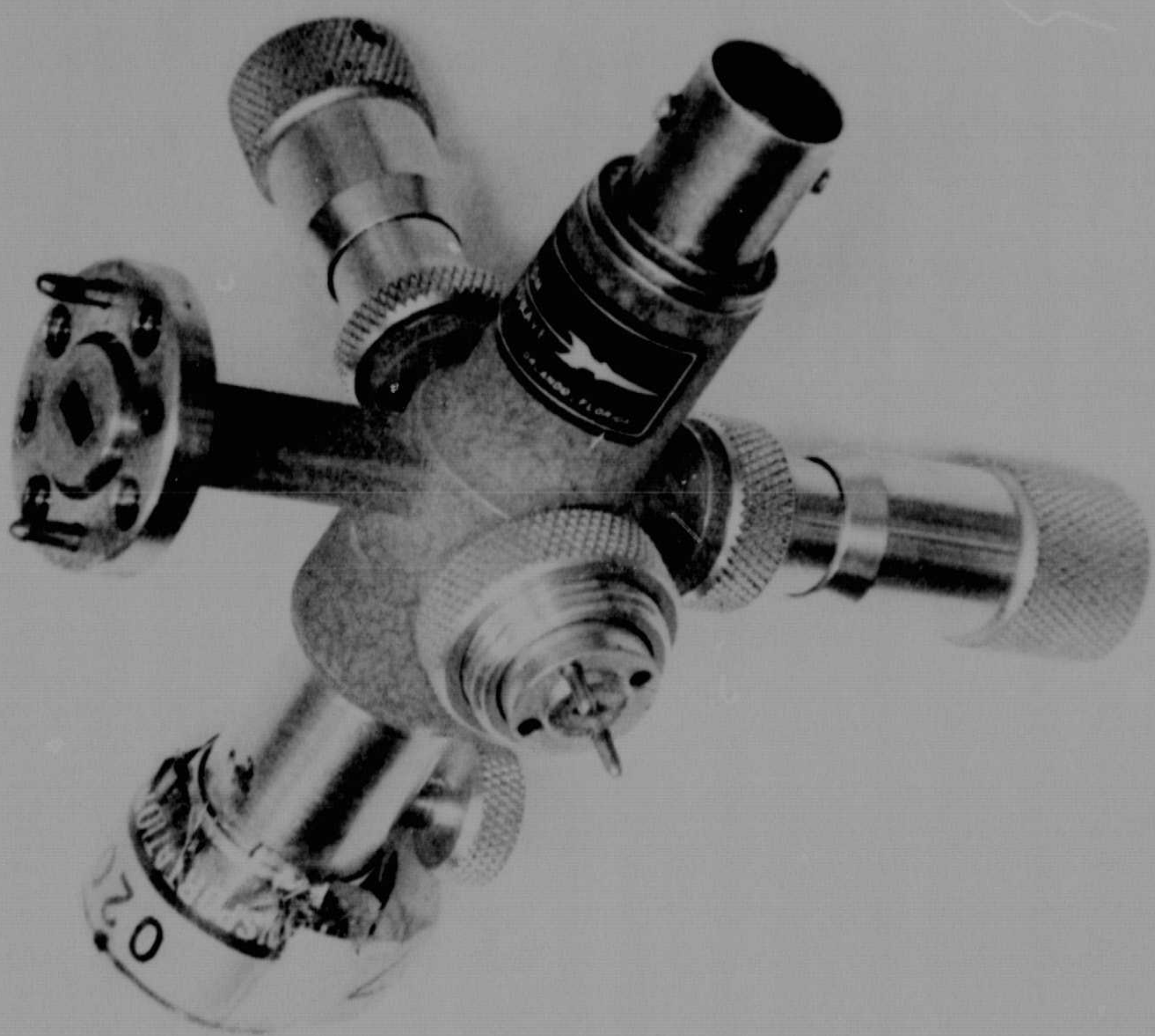


Figure 1. Cross-guide Schottky Barrier Harmonic Mixer.

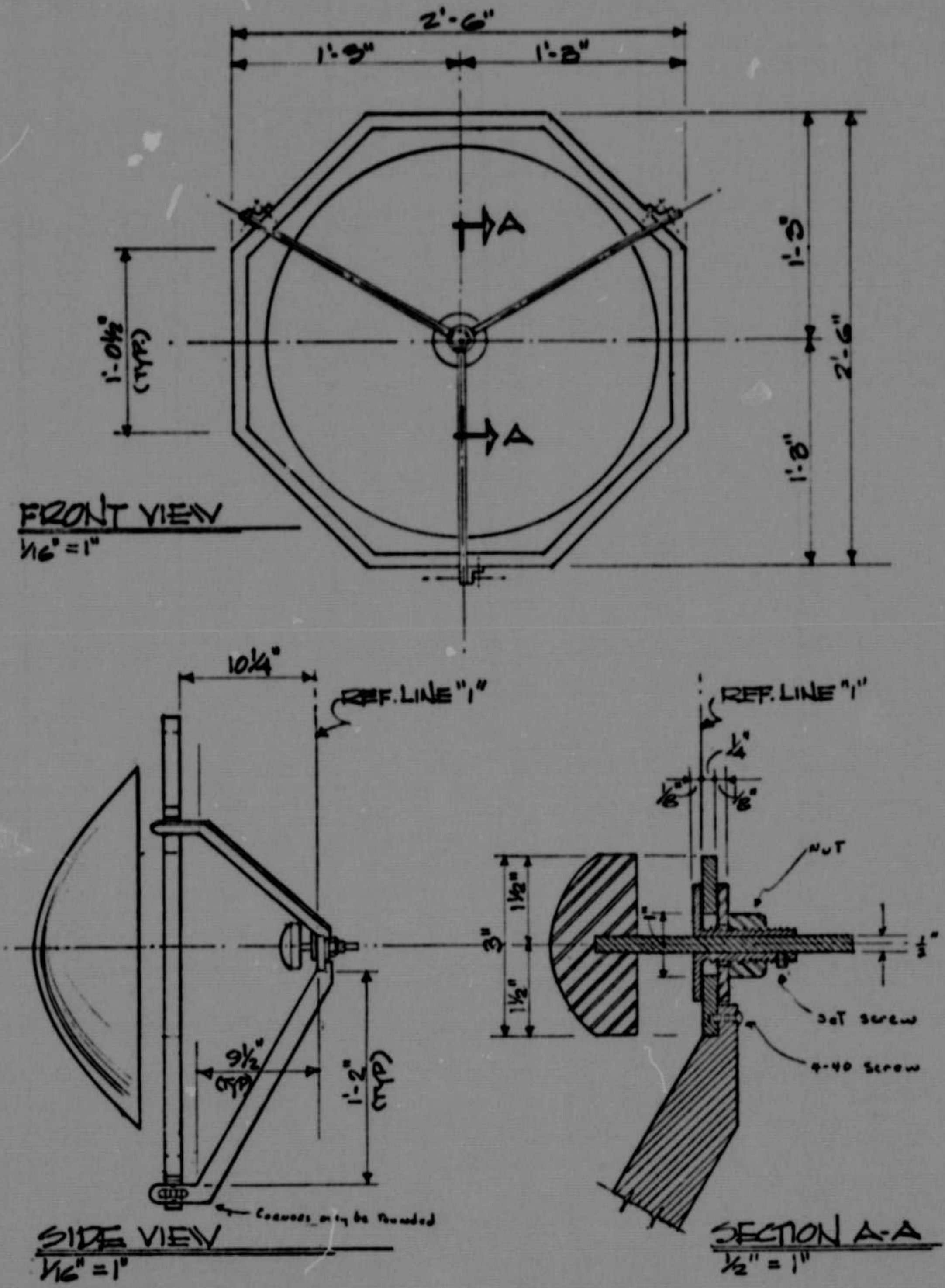


Figure 2. 25" 183 GHz Antenna Details.

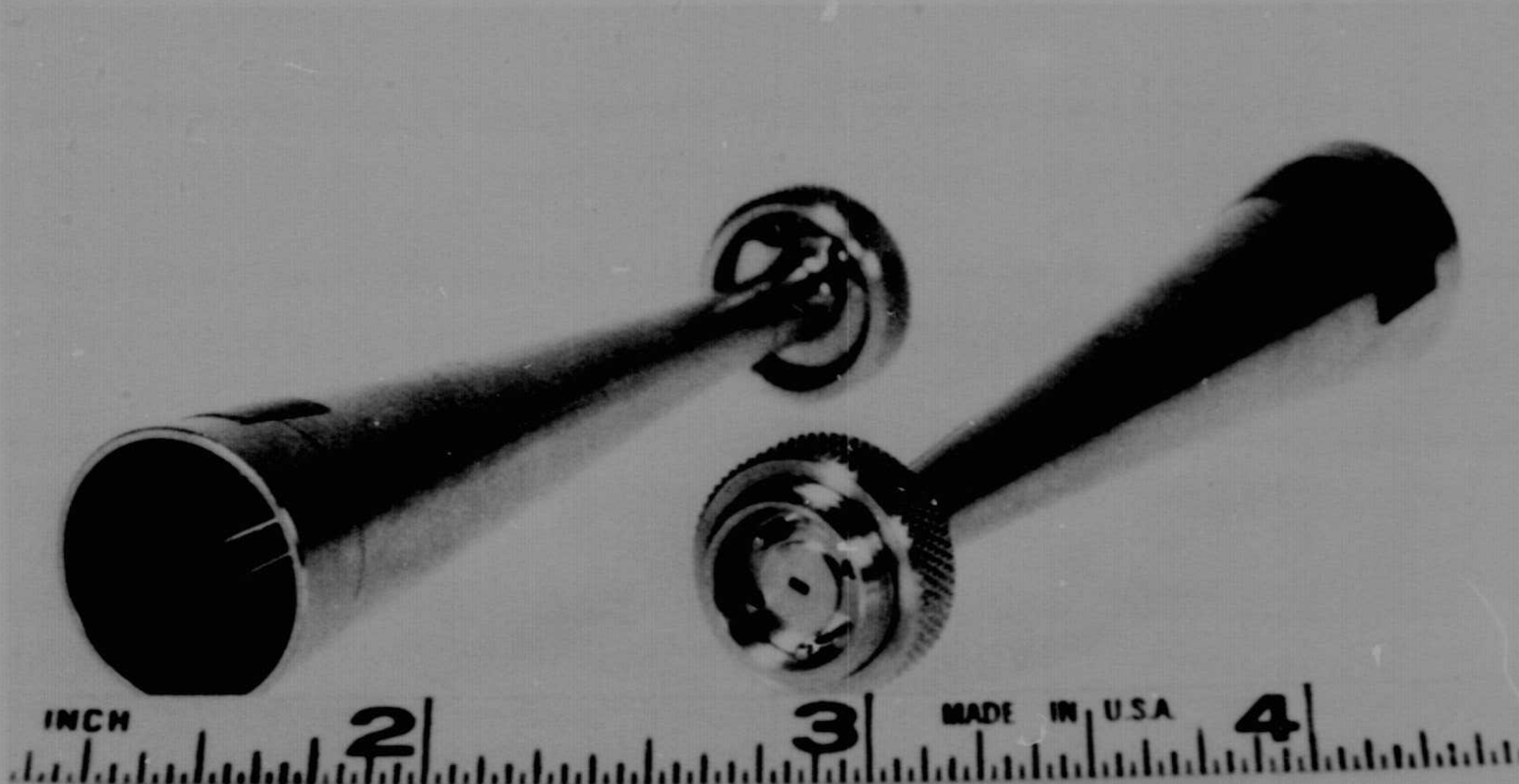


Figure 3. High Gain Feed Horn (Electroformed) for 183 GHz Antenna.

RESEARCH IN MILLIMETER WAVE TECHNIQUES

Tenth Monthly Progress Report

Report Period

15 March 1975 to 15 April 1975

NASA Grant No. NSG 5012

GT/EES Project No. A-1642

Project Director: J. W. Dees
Project Monitor: J. L. King

Engineering Experiment Station
Special Techniques Division
Georgia Institute of Technology
Atlanta, Georgia 30332

I. SUMMARY OF WORK

During the past month, components were received which contributed to the assembly of the 183 GHz radiometer. The Avantek IF amplifiers were received and have undergone tests. The amplifier gains are flat within ± 1.0 dB across the 1.0-2.0 GHz band and exceed 32 dB in all cases. Figure 1 shows the gain vs. frequency for the three amplifiers for 1.4-2.0 GHz, while Figure 2 shows the Power In vs. the Power Out for the amplifiers individually and in groups of two and three. In the radiometer only two amplifiers may be used with the remaining gain being developed following envelope detection. The noise figures are on the order of 2.5 dB across the same band.

The radiometer is completely assembled and has been employed initially to detect 183 GHz signals which are generated by doubling the output of a 91 GHz klystron. The system does not currently exhibit the sensitivity that one would expect, and continued experiments are required. The investigation is currently exploring sources of noise within the system. The mixer is employed in a harmonic mixing configuration with LO power obtained from a 91 GHz source, which is applied to the cross-guide mixer. The Schottky barrier diode is employed with approximately 0.3 milliamps bias without the RF applied and with 3-5 milliamps bias upon application of the local oscillator power. The apparatus is now set up to determine the noise figure and conversion loss of the system.

The varactor multiplier/YIG tunable filter used in the LO stabilization loop has been received and returned to the manufacturer because of faulty varactor operation. A new unit is expected within a week. A 100 MHz amplifier with an output of 1-1/2 watts has been constructed to drive the multiplier filter. Phase locking apparatus is being constructed to lock an X-band source used in this stabilization loop. Calculations of loop stability and gain are being performed for the 92 GHz phase-locking.

Detailed drawings for the antenna subreflector mounting and adjustment components have been made and the components are presently in fabrication and are scheduled for completion by 1 May. Assembly will then proceed.

Custom Microwave has supplied us with a directional coupler with a calculated coupling of 6 dB. The two corrugated horns have been received and are shown in Figure 3.

In anticipation of the horn measurements, calculations of the corrugated horn patterns have been made. Figure 4 presents the calculated pattern. Note for the 3 inch diameter subreflector to be used, the nominal edge taper is 16 dB.

II. WORK PLANNED FOR NEXT MONTH

Work will continue on the 183 GHz radiometer sensitivity problem and overall calibration of the system will be attempted. Efforts on the phase-locking of the 90 GHz LO source will continue with the receipt of the varactor multiplier/YIG tunable filter. Completion of the fabrication of the subreflector components and its mounting mechanism is anticipated during the next month.

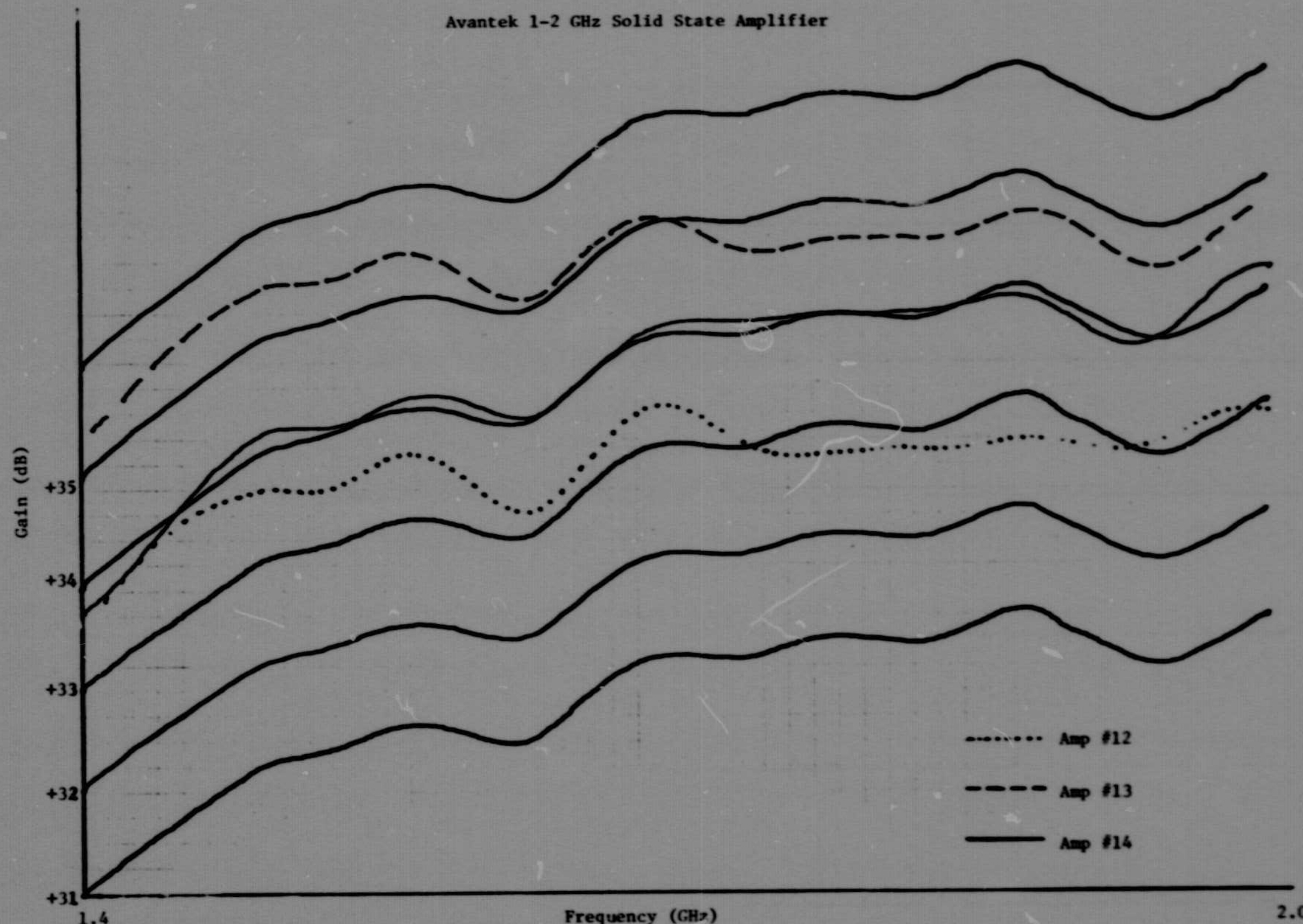


Figure 1. Gain vs. Frequency of Avantek IF Amplifiers.

Avantek Amplifier Transfer Characteristics (1.5 GHz)

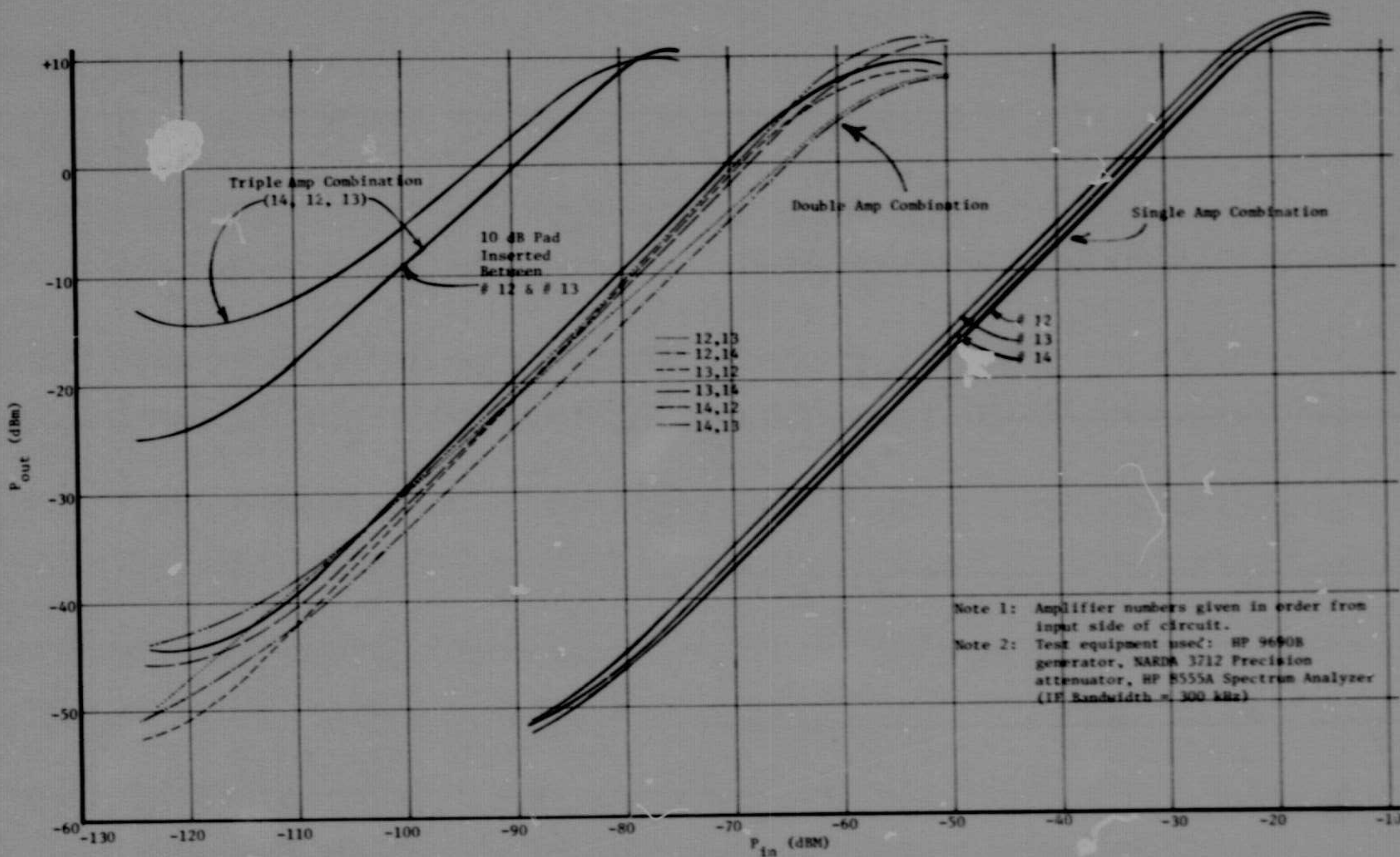


Figure 2. Power Input/Output Characteristics of Avantek IF Amplifiers.

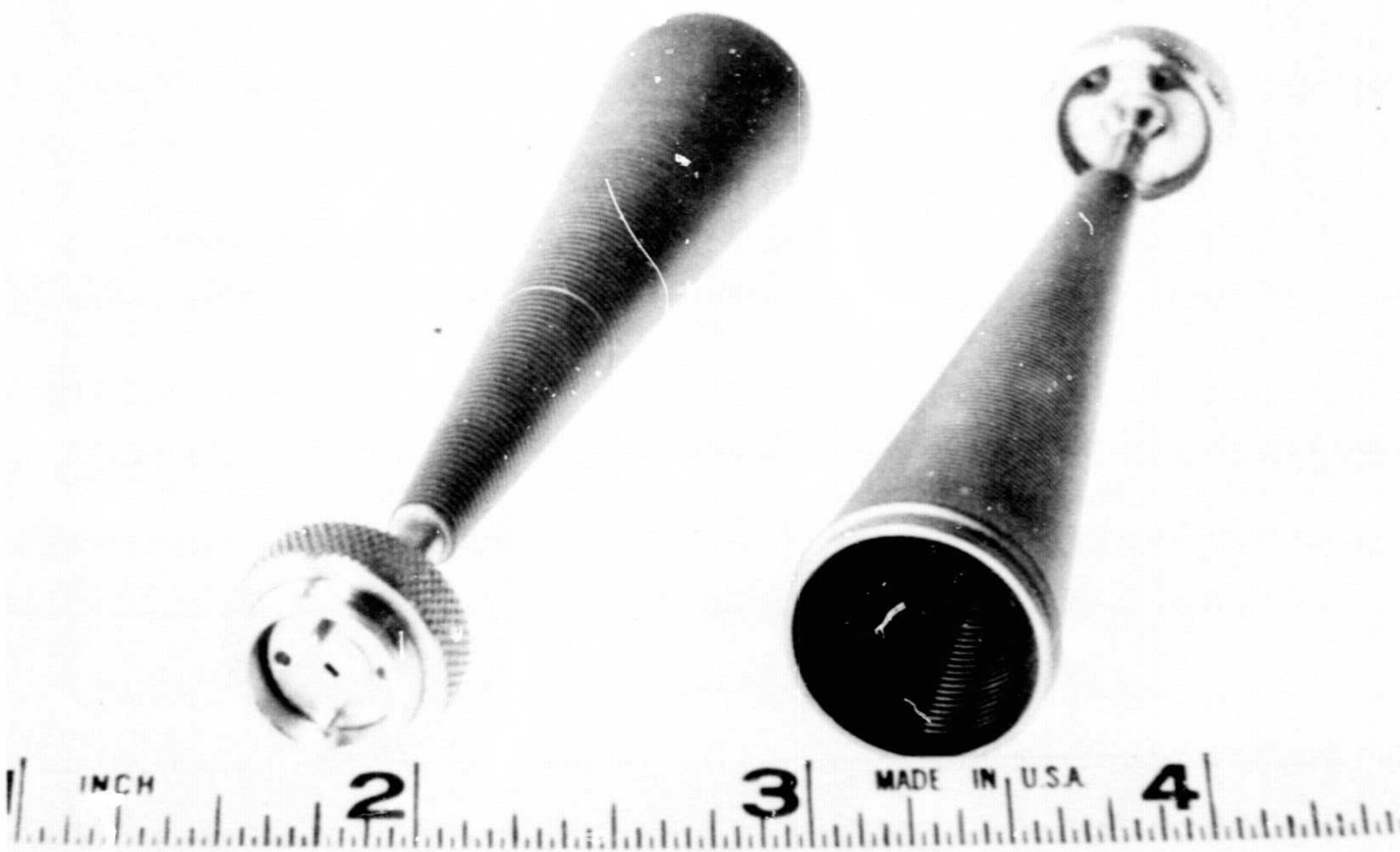
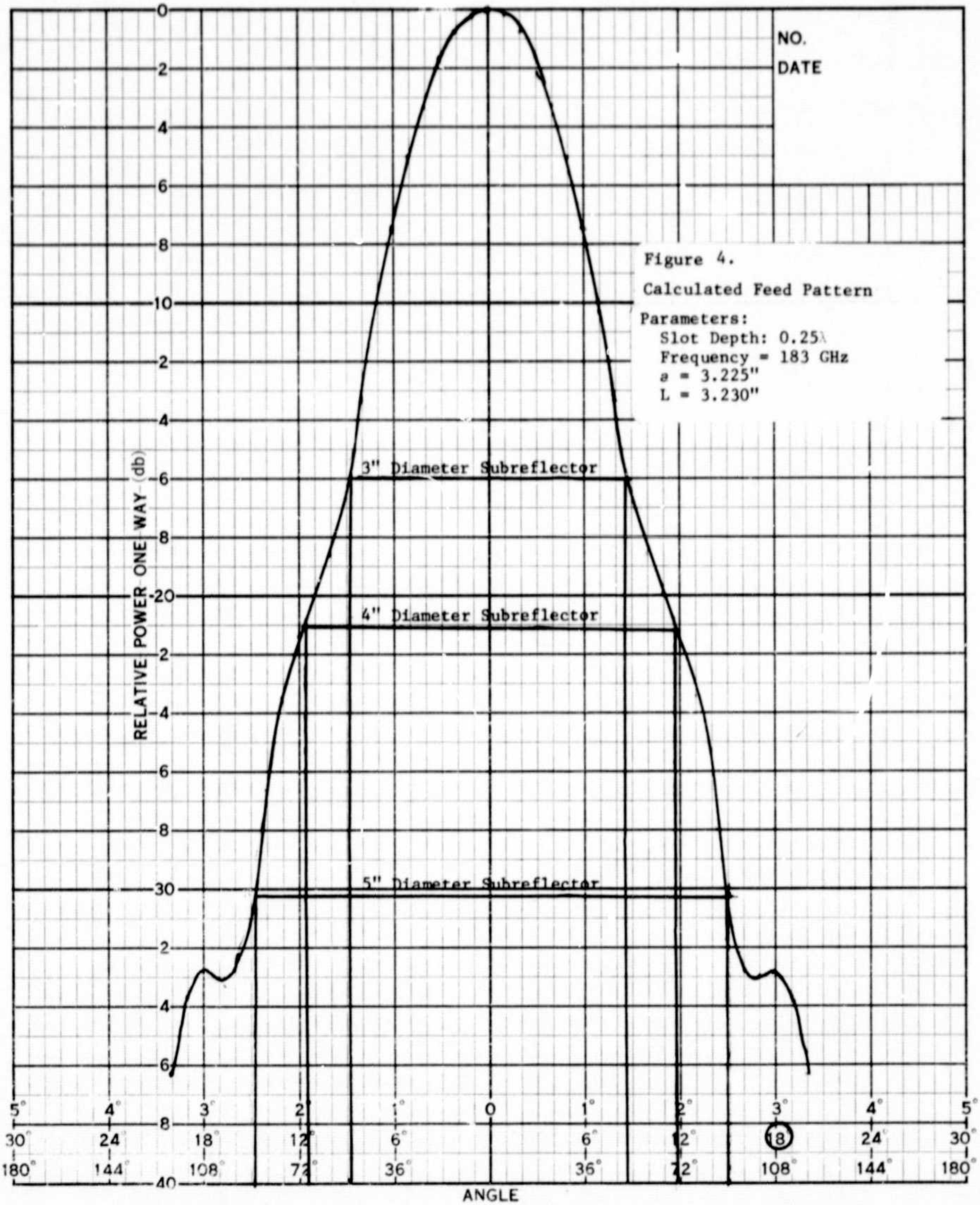


Figure 3. Corrugated Horns for 183 GHz.



NO.
DATE
Figure 4.
Calculated Feed Pattern
Parameters:
Slot Depth: 0.25λ
Frequency = 183 GHz
a = 3.225"
L = 3.230"
3" Diameter Subreflector
4" Diameter Subreflector
5" Diameter Subreflector
RELATIVE POWER ONE WAY (db)
ANGLE
0
2
4
6
8
10
20
30
40
5°
4°
3°
2°
1°
30°
24°
18°
12°
6°
180°
144°
108°
72°
36°

RESEARCH IN MILLIMETER WAVE TECHNIQUES

Eleventh Monthly Progress Report

Report Period

15 April, 1975 to 15 May, 1975

NASA Grant No. NSG 5012

GT/EES Project No. A-1642

Project Director: J. W. Dees
Project Monitor: J. L. King

Engineering Experiment Station
Special Techniques Division
Georgia Institute of Technology
Atlanta, Georgia 30332

I. Summary of Work

An important administrative change was made during the past month. As a result of the pending increased scope of work, this project was split into two subtasks: the 183 GHz aircraft radiometer portion of the program will be one subtask and propagation measurements using the 183 GHz radiometer currently under construction and related efforts will be the other subtask. Mr. J. B. Langley has been appointed Assistant Project Director for the Aircraft Radiometer subtask and Mr. J. J. Gallagher has been made Assistant Project Director for the propagation measurements and related work portion of the program.

The preliminary work needed to define expected system parameters for the 183 GHz aircraft radiometer has begun during the past month. A brief analysis of the scanning parameters of a radiometer as functions of the minimum detectable temperature difference, post detection bandwidth (integration time) and system noise figure has been completed. The results of this analysis indicate that if a certain amount of underlap can be tolerated, i.e., a noncontiguous group map, a scanning system seems feasible within the constraints of available components. Several different system configurations are being considered and are being evaluated in terms of expected performance and suitability for operation in the aircraft environment.

A number of vendors have been contacted concerning local oscillators for the radiometer. On 16 May, J. W. Dees and N. W. Cox will visit Hughes at Torrance, California to evaluate the possibilities of obtaining IMPATT oscillators at 94 GHz and/or 183 GHz. Varian also has available klystron sources at these frequencies, and solid state sources below 100 GHz. From data received so far, it appears that phase-locking will be necessary for FM noise limitation in the solid state (IMPATT) source but probably not with the klystron. Thus, it seems a tradeoff between the complexity of phase-locking and the complexity of the high voltage power supply required by the klystron will have to be made. The deciding factor may well be the relative reliability of the two sources. During the past month a 94 GHz klystron has been locked to a harmonic of an X-band source. The locked 94 GHz source will be doubled for use in evaluating 180 GHz mixers.

Fabrication has begun on an az-el mount for the laboratory 183 GHz radiometer to be used in sun tracking experiments.

A new square law envelope detector has been ordered for use in detecting the modulated 1-2 GHz IF signal. Presently a Hewlett Packard HP 8472A detector is being used. This is a point contact diode having a nominal sensitivity of 400 mV/mW in its square law region. The new unit is an Aertech Industries D4S Schottky barrier detector having a minimum sensitivity of 200 mV/mW but can be biased to a sensitivity over 5000 mV/mW in its square law region.

This unit is expected to provide improved linearity and a wider dynamic range. Sample data sheets are attached.

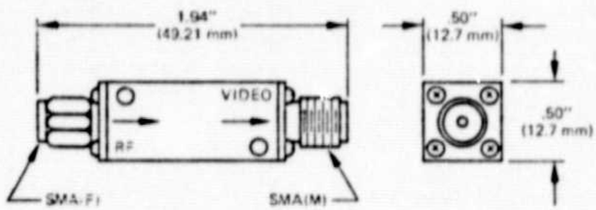
II. Work Planned for Next Month

During the next month work will be undertaken to produce a preliminary design and system specification for the 183 GHz aircraft radiometer. Hopefully sufficient information will be at hand to make a decision on the IMPATT or klystron local oscillator question. A visit by J. B. Langley and J. W. Dees to GSFC is planned for early June to discuss aspects of the aircraft radiometer portion of this program. It is anticipated that fabrication of the az-el mount for the 180 GHz laboratory radiometer will be completed and that assembly of the radiometer on the roof of the Electronics Research Building for sun tracking experiments will begin. In addition to the above the semi-annual status report will be prepared.

Schottky-Barrier, Low VSWR 4-DIODE DETECTOR

D4S

OUTLINE



- 0.1 TO 4.0 GHz
- HIGH SENSITIVITY
- HIGH POWER RATING
- LOW VSWR
- EXCELLENT FLATNESS
- WIDE SQUARE LAW RANGE

SPECIFICATIONS

Frequency Range:	0.1 to 4.0 GHz
Flatness:	±0.25 dB, Max.*
VSWR:	1.4 Max.*
Voltage Sensitivity (K):	2000 mV/mW, Min.*
Tangential Sensitivity:	−55.5 dBm Min., 375 kHz Video Bandwidth −52 dBm Min., 2 MHz Video Bandwidth
Square Law Range:	T_{SS} to −10 dBm, with R_L = 2K Ω
Power Rating:	400 mW CW, 3W Peak
Voltage Output @ P_{IN} = +20 dBm:	20 V Approx.
Output Polarity:	Negative (Positive Optional)
Input Connector:	3 mm SMA Male (Female Available - D4SF)
Output Connector:	3 mm SMA Female
Output Capacitance:	200 pF (Lower Value Available for Higher Video Bandwidth)
Price:	$140.

PERFORMANCE – P_{IN}, from T_{SS} to −17 dBm

Bias μA	Min. K (mV/mW)	Max. VSWR	Max. Flatness (dB)	Typical R_v (Ω)
50	5500	4.0	±0.60	2300
75	4500	3.0	±0.50	1600
100	3800	2.0	±0.40	1200
150	2500	1.6	±0.30	920
190	2000	1.4	±0.25	700

* Bias @ 180 μA to 210 μA

Aertech INDUSTRIES

62 DETECTORS

TYPICAL SCHOTTKY DETECTOR PERFORMANCE CURVES

Transfer Characteristics

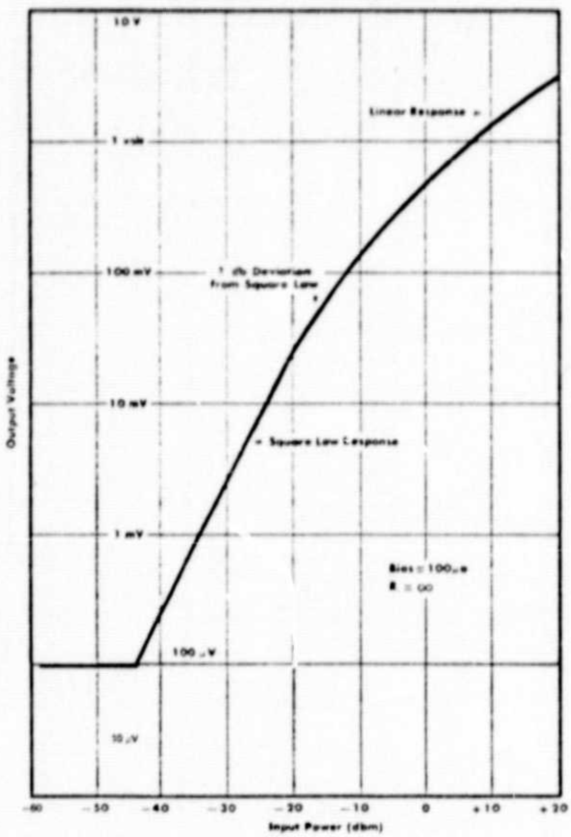


FIGURE 1

Sensitivity vs. Bias

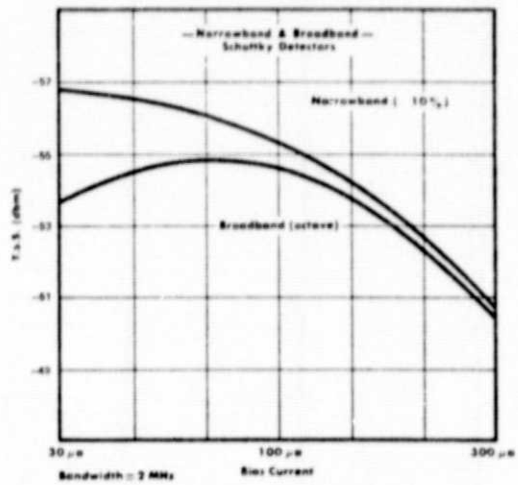


FIGURE 3

VSWR & Square Law vs. Bias

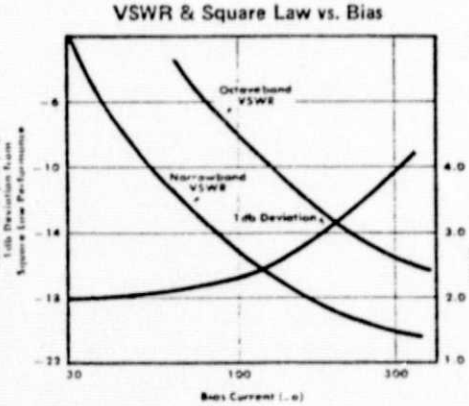


FIGURE 2

V_O vs. P_{IN}

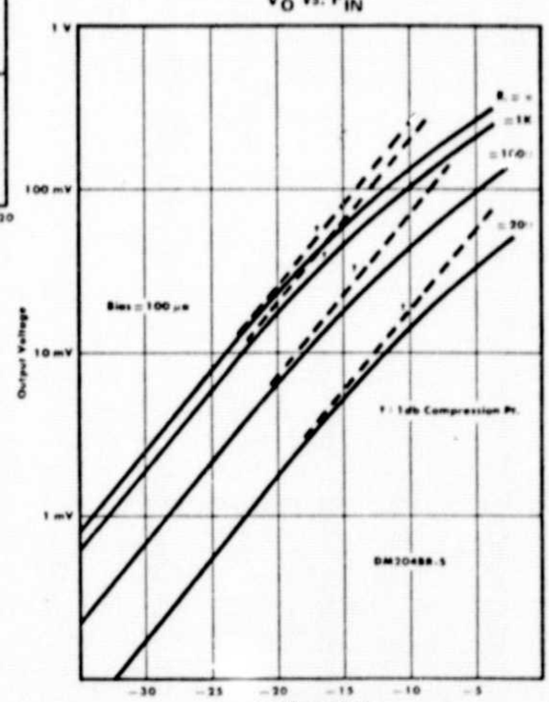


FIGURE 4