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The Marine Laboratory

Institute Of Marine Science

UNIVERSITY OF MIAMI

EVALUATION AND APPLICATION OF A SPECIAL WEATHER RADAR RECEIVER SYSTEM
March, 1962

Prepared Under
Navy, Bureau of Naval Weapons
Contract NOw 61-0246-d

Final Report

22 December 1960 to 19 February 1962

H. W. Hiser, P. E. Norman and C. E. Steen

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Director

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This report covers the evaluation of a specially designed radar receiver system for research and operational use in the field of meteorology. Numerous second and third-generation modifications and improvements in the SP-1M radar system are described, which were necessary to fully utilize the new receiver system. These include changes in the Range Attenuation Corrector, the Transistorized Video Distribution system, the Iso-Echo Contour system, and the Automatic Frequency Control system, plus the installation of a Ferrite Isolator. Several modernizations and improvements in the model CR-2 radarscope cameras are also presented.

Results of a two-year study of precipitation echo heights in the South Florida region are summarized. The effects of range attenuation upon RHI scope measurements of echo tops are evaluated. Minimum detectable rainfall rates and vertical beamwidth stretching of precipitation echo tops are considered in this evaluation. Radar observations, synoptic weather data, and eye witness accounts of the Miami tornado of 17 June 1959 are presented and discussed.

1.0 INTRODUCTION

The purpose of this project was to: (a) complete instrumentation studies and evaluation of a new radar receiver system developed under contract NOas 60-6026-c; (b) complete studies of range correction of radar meteorological data including the problem of range correction versus degree of beam filling making use of RHI data; and (c) complete a modern transistorized video distribtuion system for the Laboratory and install a ferrite isolator in the SP-1M radar to improve its performance. Studies of severe storms and anomalous radar propagation are conducted as time permits.

Most radar receiver systems have not been designed to provide quantitative information over a broad range of received signal strengths. Such quantitative information is needed by the meteorologist. A special radar receiver system was built by Collins Radio Company in Dallas, Texas according to the requirements and specifications provided by this Laboratory. The new receiver uses a logarithmic IF to meet the above requirement for quantitative information over a broad dynamic range of signal intensities and provides many other desired features for weather use. These include: a linear IF amplifier; calibrated attenuators for measuring signal strengths; range gating for isolating a particular portion of a storm, CAPPI type analysis, or other uses; adjustable range attenuation correction, making use of a function generator developed earlier in this Laboratory; a variable bandwidth and center frequency unit for selecting the optimum performance values of these parameters under given operating conditons; a thermistor for measuring the performance of the linear amplifier;and a video integrator comprised of a boxcar detector and an amplifier and millivoltmeter for measuring received signal strengths. In general, this receiver provides great flexibility for research and operational applications.

In order to develop proper range attenuation correction functions for a meteorological radar, it is necessary to know the height and horizontal extent of echoes usually observed. These parameters determine the extent to which a radar beam of a given vertical and horizontal aperture is filled by the precipitation target at a specified range. Two years of data collected with an RHI radar at Miami were evaluated under contract NOas 60-6026-c in order to determine average, seasonal, and geographic variations in precipitation echo heights and horizontal dimensions. Further applications of the results of this study to the range attenuation correction problem are presented in this report.

2.0 RANGE ATTENUATION CORRECTOR MODIFICATION

2.10 MODIFICATION OBJECTIVES

The purpose of this modification is to improve the operational characteristics and stability of the Range Attenuation Corrector (RAC) which was developed in 1958 (2). The objectives of this modification are as follows:

1. Provide compatibility for both high and low repetition rates.
2. Enhance the range correction waveform by increasing the number of quantized levels from ten to twenty within the 100 mile range interval.
3. Improve thermal stability and reduce effects of input signal amplitude fluctuations.
4. Improve the decade counter reliability.
5. Improve the RAC waveform filtering.
6. Modify the RAC output to conform with the requirements of the RAC Amplifier in the Developmental Weather Radar Receiver.

2.20 DESCRIPTION OF MODIFICATION

2.21 Stability Under Different Repetition Rates

The 100 mile gate generator consisted of a single mono-stable multivibrator prior to this modification. The time duration of this gate was adjusted so that the 5-mile marks generator would produce pulse trains containing exactly 20 cycles which were shaped into 20 rectangular pulses. Instability results when the gate duration deviates sufficiently to allow the marks generator to produce a number of marks differing from twenty. The SP-1M radar has two repetition rates; 120 pps with "B" modulator and 630 pps with "A" modulator. These correspond to 8350 microseconds and 1590 microseconds trigger intervals respectively. It was found that the gate length was shorter with the higher repetition rate than with the lower repetition rate to the extent that stable operation at both rep rates was not possible without readjusting the gate generator. The shortening of the gate was caused by a transient voltage which occurs when the multivibrator switches back to its stable state. When the succeeding trigger occurred before the transient had decayed sufficiently, the gate width was reduced.

To circumvent the condition described above, two mono-stable multivibrators are triggered alternately by flip-flop V805. The outputs of both multivibrators are combined in the plate of summing amplifier V817. Now, each multivibrator functions at one half the radar repetition rate, and consequently sufficient time is allotted for complete excursion of the transient, see Drawing No. 6109 in the Appendix.

2.22 Increasing the Number of Quantized Levels

By doubling the number of quantized levels from ten to twenty within the one hundred mile range segment, a better approximation to the range function is obtainable. This modification was brought about by a second binary counter from the pulse chain so that each decade module now receives pulses that are five miles wide (or 62 μsecs) and spaced ten miles apart. The removed binary counter (flip-flop) is now utilized to alternately trigger the 100 mile gate generator.

2.23 Thermal Stability

The timing capacitors in the three multivibrators were chosen for a small temperature coefficient. These are C826, C839, and C844, Drawing No. 6109 in the Appendix. With the new capacitors the change in gate length from room temperature to operating temperature was within the tolerance required for stable operation. Further improvement could be made by changing R868, R875, R870, R881, R887, and R884 to film type RN70B resistors.

2.24 Input Signal Amplitude Fluctuations

The pulse train produced by the five-mile marker generator is not constant in amplitude. This in itself is not a serious problem, however, noise produced by strong video signals in the SP-1M range unit was found to be superimposed on the markers. The counting circuitry cannot distinguish between video and five-mile marks and instability resulted. The marks clipper containing CR801, CR802, and CR803 serves to eliminate the undesired noise. A later change eliminated the noise pick-up entirely by providing a built-in marks generator for the RAC.

2.25 Improving Decade Counter Reliability

An investigation of the waveform voltage levels of the guides G1 and G2 in the decade counting tubes showed that a positive level of 10 volts and a negative level of -100 volts existed. Under these conditions certain decade counters would not cycle properly. To provide a more positive switching action, the 6J6 plate circuitry was redesigned to increase the high level to +50 volts while maintaining the low level at -100 volts.

2.26 Improving the RAC Output Waveform

A rectangular staircase waveform may be produced by the RAC by driving the filter (C849 and R8112) with a low impedance source so that the charging time constant is small. Then if the discharge time constant is large enough to make the droop negligible, the output will be close to rectangular. The low impedance source could be a cathode follower driving through a diode. However, a smooth waveform was obtained by letting the charging time constant remain fairly large. The discharge time constant was increased by letting R8112 be as large as V818 would allow.

2.27 Adapting the RAC to the Developmental Weather Radar Receiver

The range correction voltage requirements of the developmental receiver were relatively easy to meet. A mere three volt amplitude is all that is necessary for 30 db of correction, and the RAC Amplifier provides a negative clamp which removes the necessity of the RAC providing a D.C. level as was the case with the old Naval Research Laboratory log amplifier (2). Therefore the output cathode follower V818 was simplified to serve as a low impedance driver for the RAC Amplifier.

2.30 RAC CALIBRATION PROCEDURE

The most expedient means of calibrating the RAC consists of two steps: first adjusting the output waveform to correspond to a calculated function, and secondly checking the range corrected receiver output while varying signal power according to a desired range versus attenuation schedule.

The range correction function mentioned above is derived from the range attenuation function and the receiver gain versus control voltage characteristic. The range attenuation function is the relation between target range (time) and the receiver signal power attenuation required to compensate for signal power reduction due to distance and other phenomena. This function is obtained by tabulating and/or plotting a range squared attenuation correction in decibels normalized to 100 nautical miles.

(Eq. 2.1) $$A = 20 \log \frac{100}{R} \quad ; \quad 10 \leqq R \leqq 100 \text{ n. mi.}$$

After the above is calculated, other effects such as earth's shadow, beam filling, and average maximum height of precipitation may be taken into account. P. R. Ray (3) has determined values of secondary correction for earth's shadow and storm height. These effects are superimposed on the range-squared correction. That is

(Eq. 2.2) $$A_2 = 20 \log \frac{100}{R} \text{ (db)} + F_1 (R) + F_2 (R)$$

where F_1 (R) and F_2 (R) are corrections for earth shadow and storm height.

The RAC Amplifier unit of the Developmental Weather Radar Receiver exhibits a voltage-attenuation characteristic which is linear for attenuation less than 30 db.

(Eq. 2.3) $$A \text{ (db)} = -10 E_c$$

where E_c is the control voltage, in this case the output of the Range Attenuation Corrector.

The range correction waveform results from substituting (2.3) into (2.2) giving:

(Eq. 2.4) $$E_c = -.1 (A_2) \text{ volts.}$$

An oscilloscope such as the Tektronix 545 is next calibrated so that its sweep speed corresponds to 10 n. miles, or 123.6 microseconds, per centimeter.

Points of the range correction voltage function are next plotted on the oscilloscope face at intervals of five miles. This set of points is:

(Eq. 2.5) $$R = 2.5 + 5N \text{ miles, where } N = 2, 3..., 19.$$

The twenty level adjustments of the RAC are manipulated such that the RAC waveform passes through the points plotted on the scope face. The adjustments for the 0-5 miles and 5-10 miles segments are set at minimum level; this is done for two reasons: the time corresponding to 0-5 miles is required to discharge the RAC waveform filter, and correction at ranges less than ten miles is not sufficiently accurate due to the rapid rate of change of voltage required at short range and the quantized nature of the RAC. (The difference in attenuation between 5 and 10 miles is 6 db which is 30% of the total correction from 10 to 100 miles).

Next a pulsed RF signal is fed into the SP-1M directional coupler from a calibrated generator such as the TS-403/UP. The signal pulse width is adjusted to equal that of the radar and is delayed with respect to the radar trigger by 100 miles. The TS-403 attenuator is set at zero db, and the receiver output video signal is monitored on an oscilloscope. The signal generator delay and attenuation are controlled according to the signal attenuation versus range schedule described above and if the output video signal deviates from the level produced by the reference signal at 100 miles delay and zero db, the corresponding RAC adjustment is used to return the output signal to reference level. If one or more such adjustments prove necessary, the entire latter procedure should be repeated until no adjustments are required over the ten to one hundred units interval.

3.0 VIDEO DISTRIBUTION SYSTEM MODIFICATIONS

Various changes were made in this Video Distribution System in order to increase it's reliability and versatility, see Drawing No. 6102-A-1 in the Appendix.

3.10 TRANSISTOR SOCKETS

As transistors are checked or replaced, due to a malfunction of the modules, transistor sockets are being added to the boards. This facilitates trouble shooting of the modules and greatly reduces the chance of transistor damage due to heat while checking the circuit. As originally built, all transistors were wired directly into the circuit.

3.20 TRANSISTOR CHANGES

Thermal Runaway of Q6 and Q7 is still the major cause of VDS malfunction. Transistor type 2N377 is being replaced with type TI483. The 2N377 has a power handling capability of 150 mw per unit at 25°C, the TI483 handles 600 mw per unit at 25°C. In the parallel configuration of operation, this raises the output power capability by a factor of 6 db for the module. No failures of the TI483 transistors have occurred to this time.

3.30 I.E.C. INPUT

The Iso-Echo Contour Input was found to give an ambigous presentation on the repeaters when it was introduced through the mixing circuits J115 to J119. Unless care was used, two types of video could be superimposed on the repeaters. IEC input has been transferred to J112, formerly marked spare. At this time IEC is available at all modules when the selector switch is in position 3. It is planned to rewire the modules to provide IEC outputs at position 1 for MPS-4 IEC and position 6 for SP-1M IEC.

4.0 ISO-ECHO CONTOUR SYSTEM MODIFICATIONS

4.10 CHANGES IN INPUT AND OUTPUT REQUIREMENTS

With the advent of the Video Distribution System (VDS) the input polarity and impedance and output impedance of the Iso-Echo Contouring device (IEC) had to be changed to match that of the VDS. The VDS presents a constant load to the IEC and supplies the signal power to the repeaters, therefore, the power handling requirements of the IEC were greatly reduced.

To correct the input polarity, a single stage inverter designated V17 with an input impedance of 75 ohms was mounted on the chassis. The input level control feeds the grid of V17. The IEC now operates with a positive video input.

Stages V6, V7 and V8 were removed from the IEC chassis. A new stage designated V6 has been designed to act as an inverter amplifier and cathode follower and it's output feeds a positive output to the VDS. See Drawing No. 6201 in the Appendix.

4.20 TEST PROVISIONS

It was necessary to remove the IEC from its rack in order to perform the prescribed alignment procedures. To eliminate the need for this, a single pole 8 position switch was mounted on the front panel along with three test points. One test point is the cathode of D2 and D3, one is ground, and one is the wiper contact of the selector switch. All alignment now can be performed from the front panel.

5.0 AUTOMATIC FREQUENCY CONTROL SP-1M

Due to various circuit modifications of the SP-1M transmitter it was found that the SP-1M Automatic Frequency Control unit was not reliable and would frequently drop out and sweep. It also was insensitive to the 5 μsecond pulse. The unit was Laboratory built in 1960.

The AFC Unit was rebuilt closely, but not exactly, following circuit 53 in NAVER 16-1-519 Supplement No. 1. See Drawing No. 6202 in the Appendix. The new AFC Circuit will lock on the local oscillator when the AFC mixer current is as low as 100μ amperes.

6.0 FERRITE ISOLATOR INSTALLATION IN SP-1M

6.10 SELECTION OF FERRITE ISOLATOR

After checking various manufacturer's specifications of isolators the Microwave Associates Model MA 153-M was selected for the following reasons:

a. It could be fitted internally in the SP-1M transmitter cabinet with a minimum dislocation of RF plumbing.

b. It's insertion loss was only 0.30 db at the present center frequency of 2800 mc and would be even lower, 0.15 db, in the contemplated CPS-6B installation.

c. It would handle the 750 KW peak power of the SP-1M and also the 1000 KW peak power of a CPS-6B.

d. It need not be pressurized to handle the contemplated 1000 KW installation.

Additional specifications are given in Table 6.1.

6.20 INSTALLATION OF ISOLATOR

6.21 The straight run of RG 48/U waveguide above the Duplexer Assembly was shortened by eleven inches, (this is length of the MA 153-M flange to flange), and reflanged.

6.22 With the shorter length of waveguide installed, the RF plumbing containing the duplexer assembly was unbolted from the supporting cross members and raised to it's new position. As seen in Figure 6.1b, the upper cross member was removed and relocated to a position opposite the lower mounting bracket, just below the ATR-TR assemblies, and remounted to the cabinet frame. The metal panel containing T2002, T2003, T2005, T2006 and K2003 was relocated to the left to permit access to the ATR cavity V2003. Again referring to Figure 6.1b, note that the middle cross member had a piece removed to allow the MA 153-M to be mounted to the duplexer assembly. The isolator was aligned with the input section and secured. Pulse cable jack J3036 from the despiker network was relocated downward four inches and the pulse cable was routed to the pulse transformer under the input section airgap. This was necessary to clear the magnet section of the MA 153-M.

TABLE 6.1

SPECIFICATIONS ON MA 153-M FERRITE ISOLATOR, SERIAL NO. 1

TR SECTION ALONE AT LOW POWER

	2800 MC	2900 MC	3050 MC
INSERTION LOSS db	0.30	0.10	0.15
VSWR	1.26 - 1.70 across entire band		

ISOLATOR ALONE AT LOW POWER

	2700 MC	2900 MC	3100 MC
ISOLATION	13.00	13.40	12.00
INSERTION LOSS db	0.45	0.40	0.40
INPUT VSWR	1.06	1.02	1.02
OUTPUT VSWR	1.04	1.06	1.06

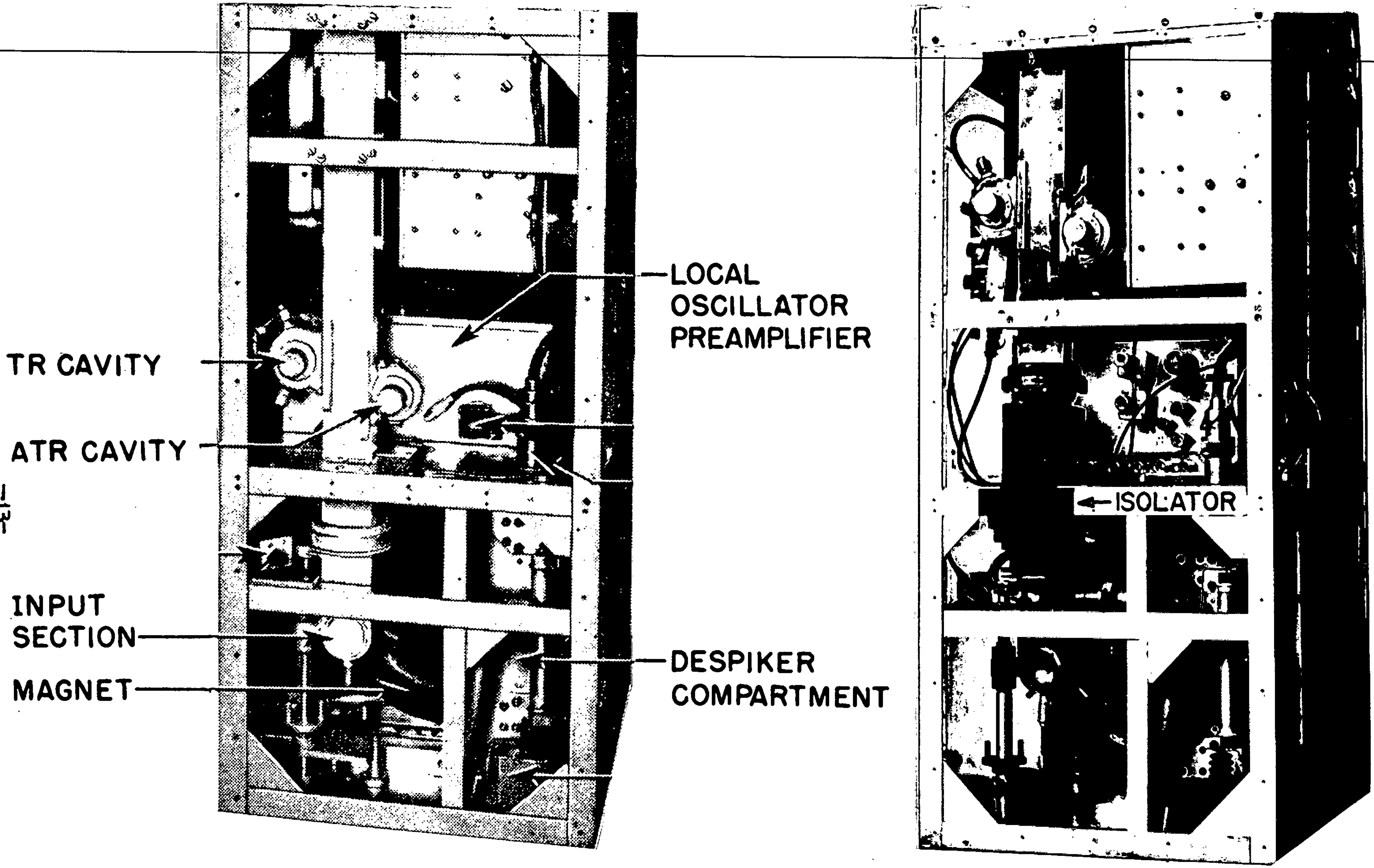
ISOLATOR AND TR SECTION AT LOW LEVEL

	2800 MC	2900 MC	3050 MC
ISOLATION	13.80	12.60	13.60
INSERTION LOSS db	0.80	0.45	0.60
INPUT VSWR	1.10	1.06	1.03
OUTPUT VSWR	1.23	1.20	1.22

HIGH POWER TEST ISOLATOR ALONE

POWER	1 meg watt peak 1 KW average
INSERTION LOSS	0.30 db

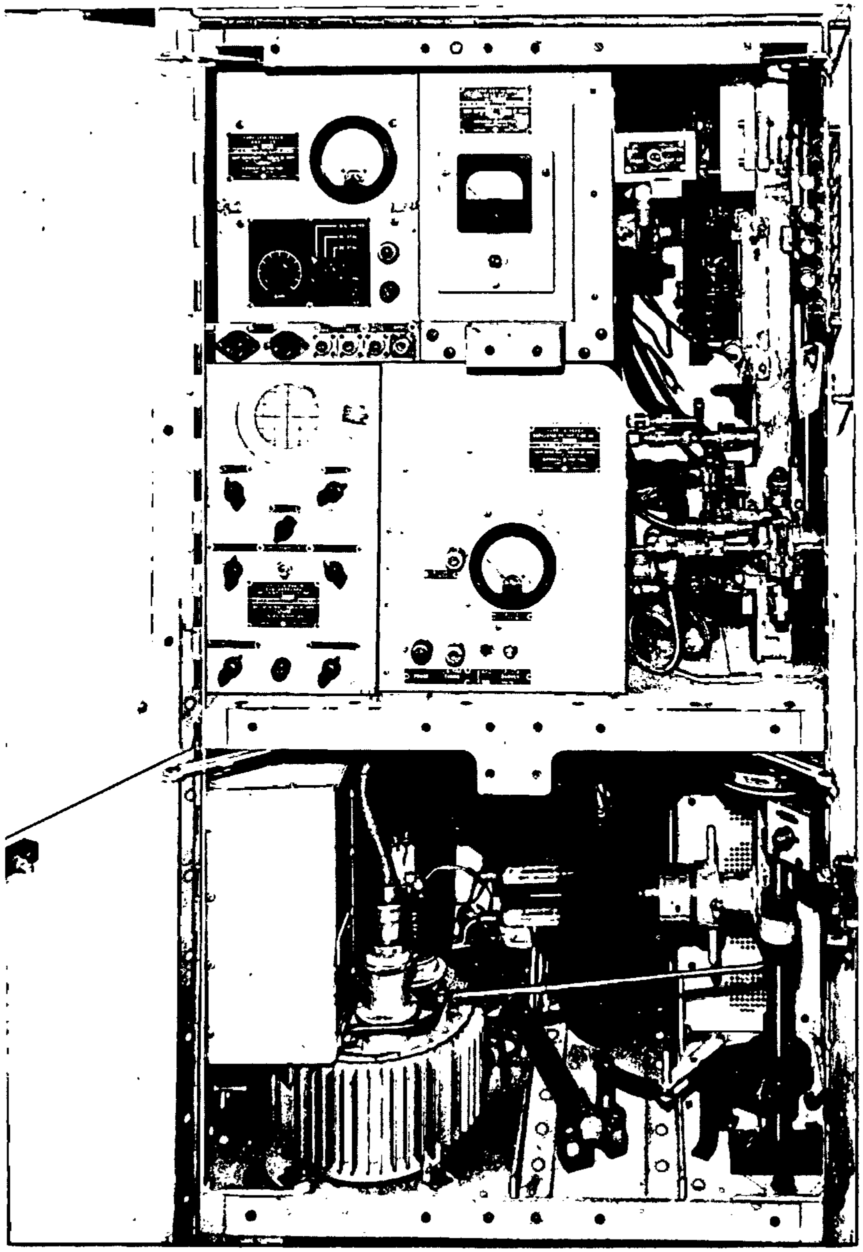
6.23 The Local Oscillator-Preamplifier Unit, Figure 6.1a, contained only the Local Oscillator Assembly due to previous construction of a Wide-Band Preamplifier (Drawing No. 6105-A-1) and AFC circuit (Drawing No. 6202). The Signal Mixer and AFC Mixer on the RF plumbing were elevated eleven inches (Section 6.21). It was not desirable to increase the length of the Local Oscillator output cables. Therefore, the Local Oscillator was installed in a new chassis and relocated, see Drawing No. 6205 and Figure 6.2b. The STC and Preamplifier Power Supply now occupies the former Local Oscillator and Preamplifier location. The AFC unit is physically mounted on the STC Power Supply Chassis but it is not electrically connected.



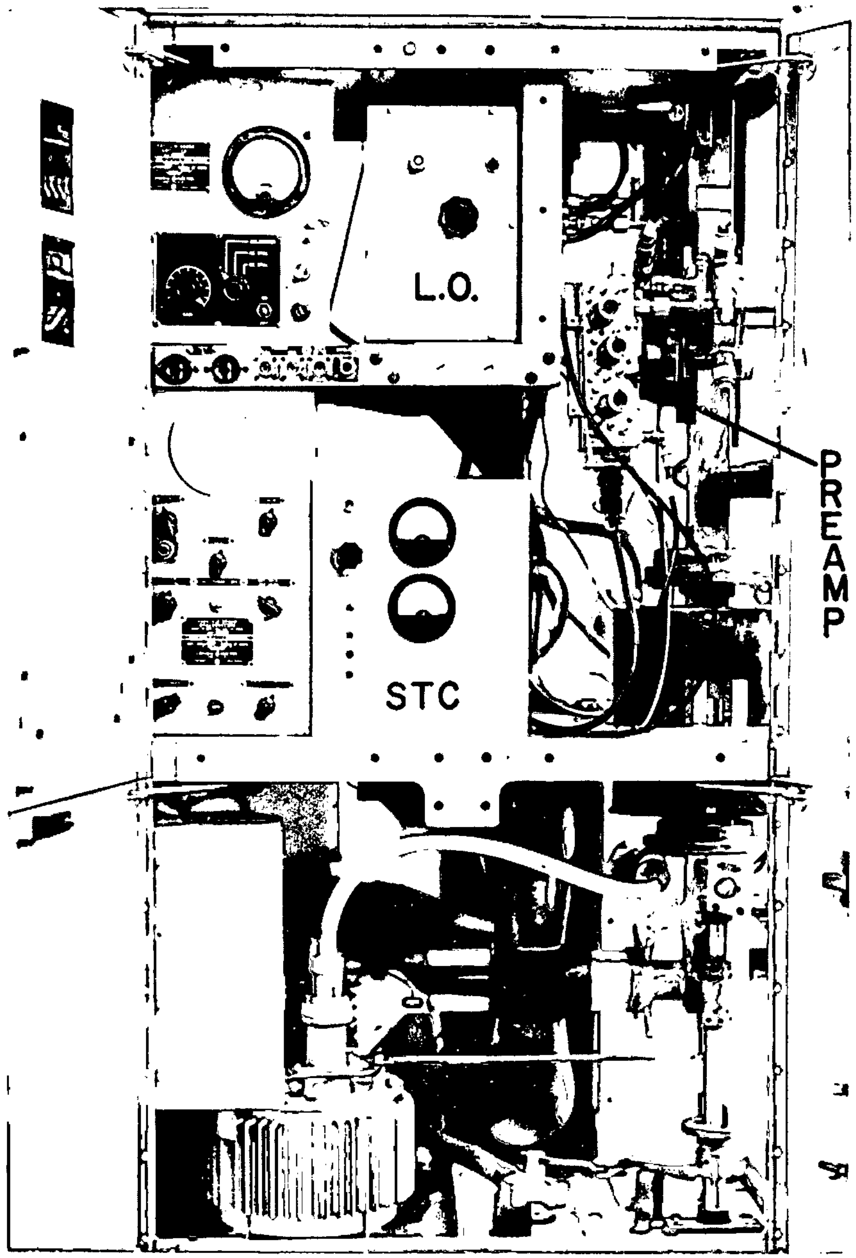
(a) BEFORE

(b) AFTER

FIG. 6.1— SIDE VIEW OF SP—IM TRANSMITTER BEFORE AND AFTER FERRITE ISOLATOR INSTALLATION



(a) BEFORE



(b) AFTER

FIG. 6.2 — FRONT VIEW OF SP–IM TRANSMITTER BEFORE AND AFTER FERRITE ISOLATOR INSTALLATION. (b) SHOWS NEW PREAMPLIFIER, L.O. CHASSIS, AND STC UNIT WITH POWER SUPPLY.

6.24 Cable W2005 that formerly terminated at J-1705 via P-1705 is now fanned out on a 20 terminal board designated as TB-1. All wiring from the console via W2005, STC - Preamplifier Power Supply, AFC, Local Oscillator, and Preamplifier are picked up at this point. All units are connected to TB-1 via AN type connectors.

6.30 OBSERVATIONS

No difficulty was experienced with this retrofit, all systems operated satisfactorily. The effects of the ferrite isolator have not been fully evaluated at this time. A reduction in magnetron pulling due to varying impedance from the surrounding area and irregularities in the rotating joints has been observed with the echo box.

7.0 CR-2 CAMERA MODIFICATIONS

7.10 GENERAL

Over a considerable period of time the CR-2 cameras have been malfunctioning in several areas of their operation. Shutter solenoids opening up, the film advancing more than a single frame, and data lights failing to light bright enough are the more common faults. The modified Schematic is shown as Drawing No. 6206 in the Appendix.

7.20 SILICON RECTIFIER INSTALLATION

To increase the voltage available for relay operation and positive clutch action, the selenium rectifiers and dual 40 MFD capacitor were replaced with a silicon rectifier Tarzian 30 LF, and an 80 MFD 150V capacitor. The surge resistor was increased to 25 ohms at 10 watts. As an example, CR-2 camera S/N 70 voltage readings across the supply were, and are, as follows:

	BEFORE	AFTER
NO DRAIN FROM SUPPLY	135	139
STEPPER COIL ONLY ENERGIZED	117	125
SHUTTER COIL ONLY ENERGIZED	110	125
STEPPER AND SHUTTER COIL ENERGIZED	106	123

This increase in supply voltage, especially in the worst case condition, gives greatly improved clutch operation reducing the double framing.

7.30 SHUTTER RELAY COILS

Shutter relay coils (K-3) are no longer available from the CR-2 manufacturer and all the name relay manufacturers declined to quote on the small quantity needed. A surplus telephone-type relay coil was used in conjunction with a new bracket assembly and mounted on the camera. The new coil is 15/16" wide, 1 3/8" long and has a DC resistance of 5000 ohms. A 560 ohm 2 watt resistor was required to limit relay current to 21 ma. Shutter operation is now very positive and allows for a stronger return spring tension adjustment for a faster closing shutter. All cameras were modified and a sufficient quantity of surplus relay coils are on hand to assure continuing operation.

7.40 CAPACITOR REPLACEMENT

A single 80 MFD capacitor has been installed in the data light circuit replacing the dual 40 MFD units in parallel. In this way a failure of the capacitor results in a complete loss of data lights which is easily detected by the operating personnel.

7.50 SHUTTER POSITION INDICATOR LIGHT

Due to the failing of the shutter coil K-3, some thought was given to the detection of this fault without interrupting the photographic mission. A switch was designed to become an integral part of the K-3 tailpiece. A hole was drilled and an insulated bushing installed. A contact in the form of a small metal strip was mounted with a nut and bolt through the insulating bushing. A plastic rod was drilled, tapped and mounted on the motor holding frame. Another metal strip was mounted on this rod and it became the stationary contact. These contacts were adjusted so they would be closed when the shutter relay is de-energized (shutter closed). Using the Power On lamp (NE-51), wiring was connected in series with the switch and the camera D.C. power supply. When the shutter is open, the lamp is out; when closed, the lamp is lighted. The operating personnel can observe this action at a glance.

8.0 EVALUATION OF NEW WEATHER RADAR RECEIVER SYSTEM

8.10 GENERAL

A special Weather Radar Receiver System was developed under Contract NOas 60-6026-c. This receiver system, which was built by the Texas Division of Collins Radio Company, Dallas, Texas, was described in detail in the final report (1) for the above contract, November 1961. A block diagram of this receiver system is presented in Figure 8.1. A linear and a logarithmic IF strip are included in the system and a Range Attenuation Corrector (RAC), developed under Contract NOas 58-388-d, can be applied to the input to both of these IF strips (2). The RAC is adjustable so that range correction functions varying between $1/R^2$ and $1/R^4$ can be applied within the range interval 10 to 100 nautical miles. The log IF, with a dynamic range of 100 db, is used for quantitative measurements when signals reflected from intense storms saturate the linear IF.

The receiver system also includes: calibrated attenuators for measuring signal strengths, range gating for isolating a particular portion of a storm for CAPPI type analysis or other uses, a variable bandwidth and center frequency unit for selecting the optimum performance values of these parameters under given operating conditions, a thermistor for measuring the performance of the linear amplifier, and a video integrator comprised of a boxcar detector and an amplifier and millivoltmeter for measuring received signal strengths.

8.20 SYSTEM TESTS AND CALIBRATION

System testing and calibration of the new receiver system has been completed. The only portion of the new system which does not appear to be completely satisfactory in its present state is the Millivac vacuum tube voltmeter coupled to the boxcar integrator for measuring echo intensities. Tests have shown this not to be reliable in its present configuration. It is believed that a video integrator making use of the Range Gate Generator for sampling portions of the echoes and the Millivac voltmeter as a readout device would prove more satisfactory for echo intensity measurements.

Tests were run using a Hewlett-Packard model 430C power meter coupled to the model 477B thermistor output, Figure 8.1, to determine the utility of this meter as an echo intensity measuring device. The results were not

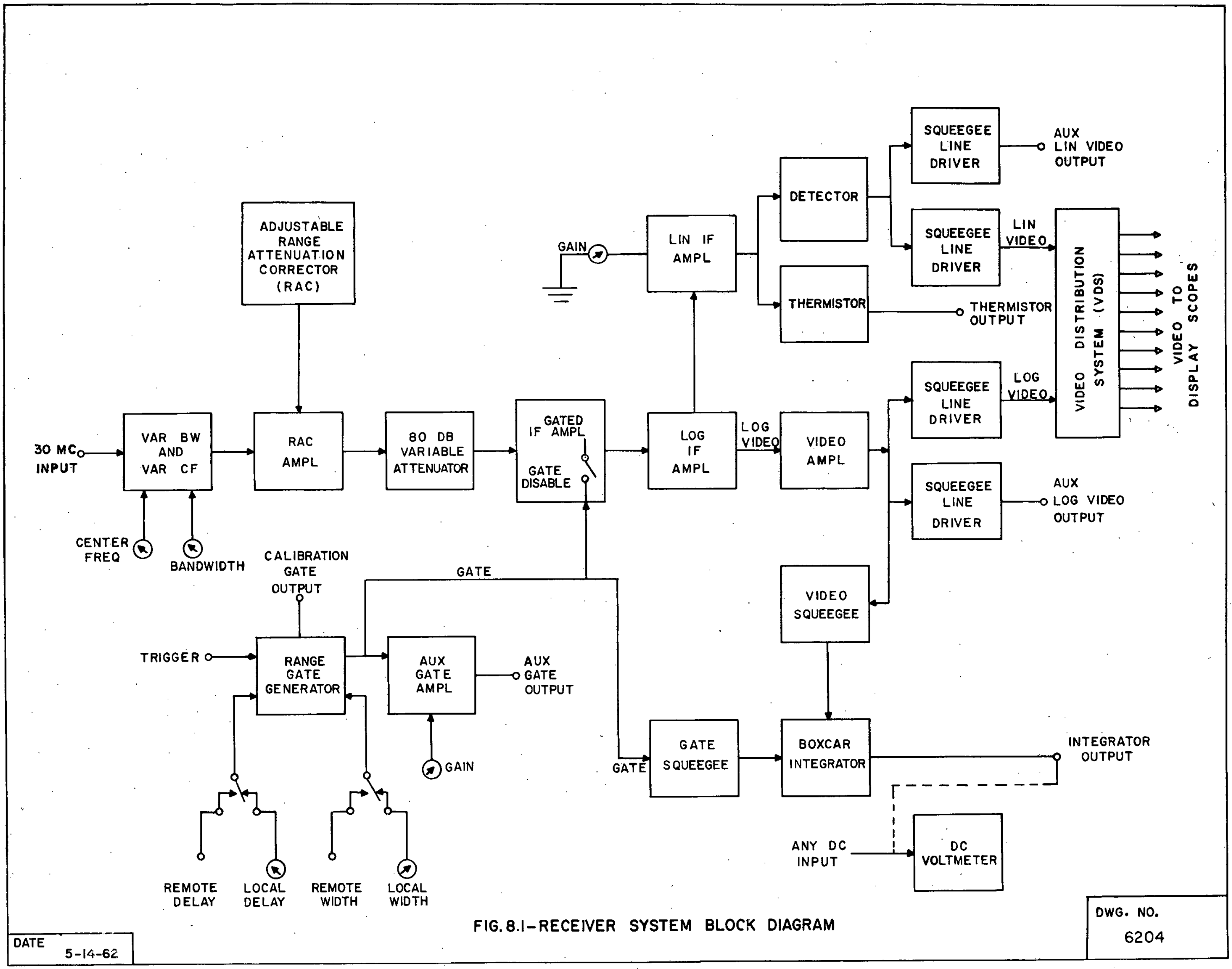


FIG. 8.1–RECEIVER SYSTEM BLOCK DIAGRAM

very successful because of drift in the Hewlett-Packard model 477B thermistor. Several hours warmup time were required to reduce this drift and it still remained too much for practical purposes.

The Variable Bandwidth and Variable Center Frequency unit at the left side of Figure 8.1, permits tuning to the optimum bandwidth during a given operating condition to give the best detection capability. The optimum bandwidth appears to vary slightly with different types and intensities of precipitation.

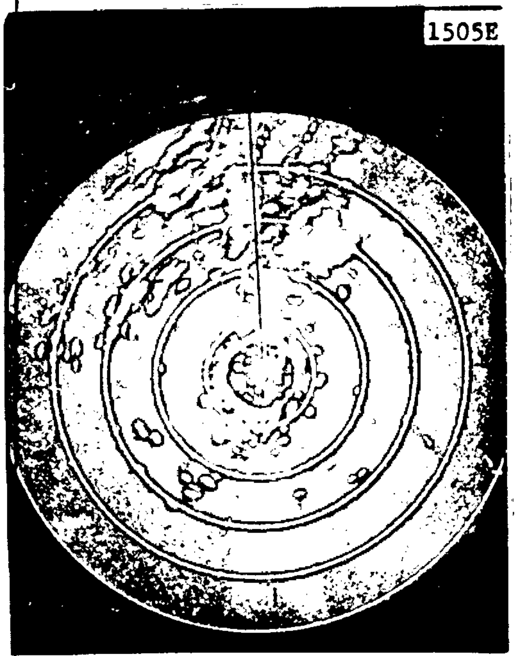
Recent checks have shown the minimum discernible signal (MDS) for the log IF amplifier to be almost identical to that of the linear IF amplifier. The linear amplifier currently has an MDS of -101.5 dbm when the SP-1M is operated on its 1 microsecond pulse and an MDS of -104.5 dbm when on 5 microsecond pulse width. The 80 db variable attenuator provides a ready means of comparing the two amplifiers when viewing a target of constant intensity. This attenuator has also proven highly satisfactory for measuring echo intensities in a manner similar to that used on the WSR-57 weather radar. It provides 1 db attenuation increments where the WSR-57 has only 3 db increments of attenuation.

The Range Attenuation Corrector (RAC) has been calibrated for a $1/R^2$ correction factor. This device functions very well with both the linear and log IF amplifiers. The video inversion type Iso-Echo Contour (IEC) device also performs well with both the linear and log amplifiers.

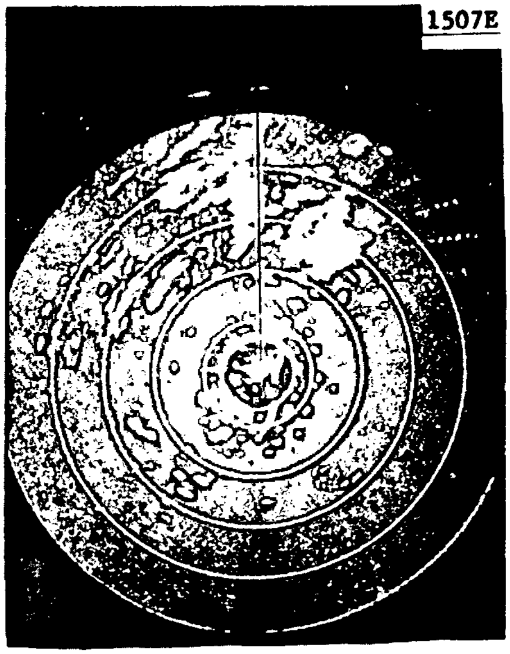
8.30 PHOTOGRAPHIC EVALUATIONS

Figures 8.2 and 8.3 illustrate the capabilities of this receiver system for detecting and displaying precipitation echoes. Both of these illustrations show PPI photographs made with the linear and logarithmic receiver with an without the use of the Range Attenuation Corrector. Interference from the Federal Aviation Agency's ASR-1 radar at Miami Airport is visible in all of the photographs, particularly in the northern quadrants.

The mode of operation for most reliable quantitative information is with the log receiver and range corrector on. In these illustrations, the 5-mile range increments of the range attenuation corrector were adjusted so that there was a 20 decibel reduction in sensitivity of the receiver system at 10 miles range with the sensitivity increasing as a function of $1/R^2$ to maximum sensitivity at 100 nautical miles and beyond.

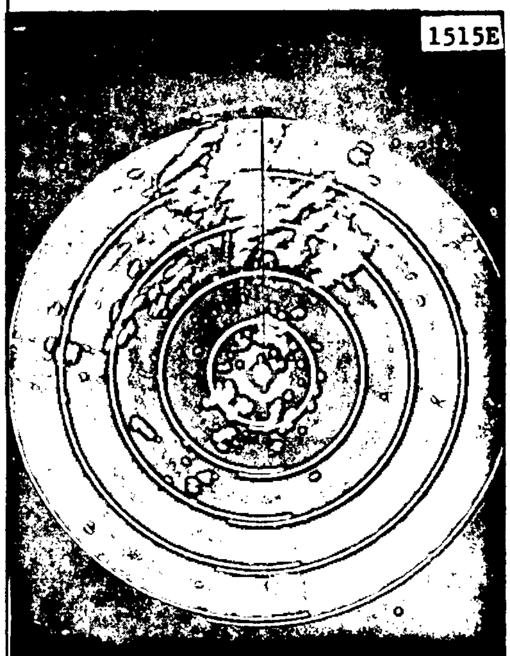


LOG RECEIVER
NO RANGE CORRECTION



LINEAR RECEIVER
NO RANGE CORRECTION

12 N. MI. CENTER STC ON ALL PHOTOGRAPHS



LOG RECEIVER
RANGE CORRECTED

LINEAR RECEIVER
RANGE CORRECTED

FIG. 8.2- COMPARISONS OF LOG AND LINEAR, RANGE CORRECTED AND NON-RANGE CORRECTED, PRESENTATIONS USING NEW COLLINS RECEIVER ON SP-1M RADAR, UNIV. OF MIAMI; 18 OCTOBER 1961, 5 μ PULSE 750 KW PEAK POWER, 20 N. MI. RANGE CIRCLES

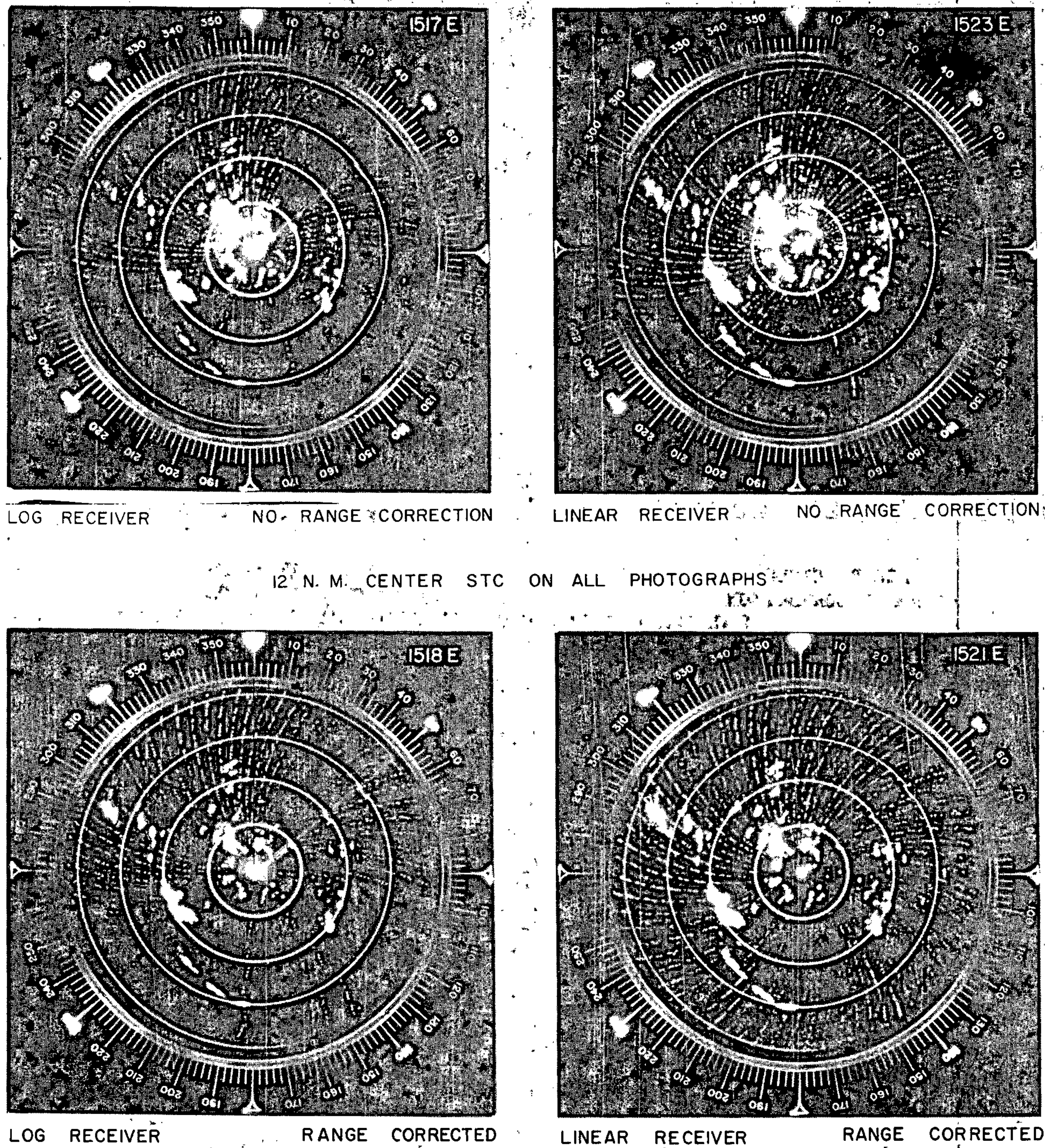


FIG. 8.3 - COMPARISONS OF LOG AND LINEAR, RANGE CORRECTED AND NON-RANGE CORRECTED, PRESENTATIONS USING NEW COLLINS RECEIVER ON SP-1M RADAR, UNIV. OF MIAMI; 7 NOVEMBER 1961, 5 μ PULSE 750 KW PEAK POWER, 25 N. MI. RANGE CIRCLES

The $1/R^2$ correction factor as shown in equation 8.1 assumes that the

(Eq. 8.1) $$P_r = \frac{6.1\, P_t\, G^2\, \lambda^2\, \phi\, \theta\, h\, \alpha\, \psi\, \eta \times 10^{-16}}{R^2},$$ where

P_r = power received (watts)
P_t = power transmitted (watts)
G = antenna gain (pure number)
R = range in (Km)
λ = wavelength (cm)
ϕ = beamwidth vertical (degrees)
θ = beamwidth horizontal (degrees)
h = pulse length (meters)
α = attenuation factor
ψ = fraction of beam filled by storm
η = reflectivity of the storm region per unit volume (cm^{-1})

storm fills the radar beam in a plane normal to the beam axis at the range in question and it does not take into account any "earth shadow" effects that disrupt the lower portion of the beam at low tilt angles. These beam filling and earth shadow effects are compensated for in equation 8.1 by the term ψ which is also a function of range (3), (4).

The precipitation echoes in Figures 8.2 and 8.3 were of the convective type and in most instances filled the 3-degree radar beam in the vertical plane. This required the precipitation tops, within 100 miles range, to exceed 20,000 ft in height. The earth shadow effect out to 100 nautical miles range was not taken into account in these evaluations primarily because the correction for this effect is relatively small compared to the inverse range squared correction. Therefore, the ψ term was assumed to equal 1.0.

The 5-mile range increments of the Range Attenuation Corrector can be adjusted to produce curves of different shapes varying from $1/R^2$ to $1/R^4$. In this manner, the RAC can be used to correct for the ψ term in equation 8.1 as well as the inverse range squared term. This is particularly valuable when observing precipitation echoes extending from the vicinity of the radar out to ranges of 200 miles or more or when the precipitation tops within 100 miles range are not tall enough to fill the radar beam in the vertical plane. Within 100 miles range, only echo height is likely to contribute to the ψ term but beyond 100 miles the earth shadow factor also becomes an important contributor.

9.0 RANGE CORRECTION OF RADAR METEOROLOGICAL DATA

9.10 SUMMARY OF PRECIPITATION ECHO HEIGHT STUDY

Results of an investigation of two years of precipitation echo heights in the South Florida area, as observed with an AN/MPS-4 height-finder radar, were presented in the final report on Contract NOas-60-6026-c (1) and in a paper presented at the Ninth Weather Radar Conference (5).

The results of this investigation are summarized here by Table 9.1 and Figures 9.1, 9.2 and 9.3. Most of the data were collected during daylight hours. All heights are those of the minimum discernible echo visible against the background noise of the RHI scope. No range attenuation correction device was used on the AN/MPS-4 radar during the data collection period.

Table 9.1 presents the actual number of echoes and the percentage of all echoes analyzed that failed to fill the radar horizontal beamwidth as translated along the azimuth at a level arbitrarily chosen 4000 ft below the echo top. All of these data in Table 9.1 are presented by quadrants in which the events occurred. This table also gives the number and percentage of echoes that were of the stable type and the number and percentage of echoes that exceeded 50,000 ft in height. The MPS-4, under normal operation of the antenna, cannot accurately measure echo heights greater than 50,000 ft.

TABLE 9.1 ECHO SIZES AND TYPES

	NE QUAD.		SE QUAD.		SW QUAD.		NW QUAD.	
	No. Echoes	% of Total	No. Echoes	% of Total	No. Echoes	% of Total	No. Echoes	% of Total
Total No. Echoes In Each Quadrant	3044	--	2308	--	4761	--	5163	--
Echo Failed to Fill Horizontal Beamwidth**	2363	77.6	1806	78.2	3939	82.7	4158	80.5
Echo of Stable Type	154	5.1	34	1.5	91	1.9	116	2.2
Echo Height Exceeded 50,000 Ft	6	0.2	17	0.7	36	0.8	51	1.0

**At level 4000 ft below echo top.

The large number of echoes that failed to fill the radar beamwidth in the horizontal plane was not anticipated. No breakdown by range increments has been made; but even in the 70-80 mile range increment, only a 5-mile echo diameter is required to fill the 4° horizontal beamwidth of the MPS-4 radar. Apparently this size is not readily attained 4000 ft below the echo top.

Figure 9.1 presents the mean heights and the percentages of echoes that exceeded 25,000 ft, 30,000 ft, and 35,000 ft respectively by quadrants and range increments.

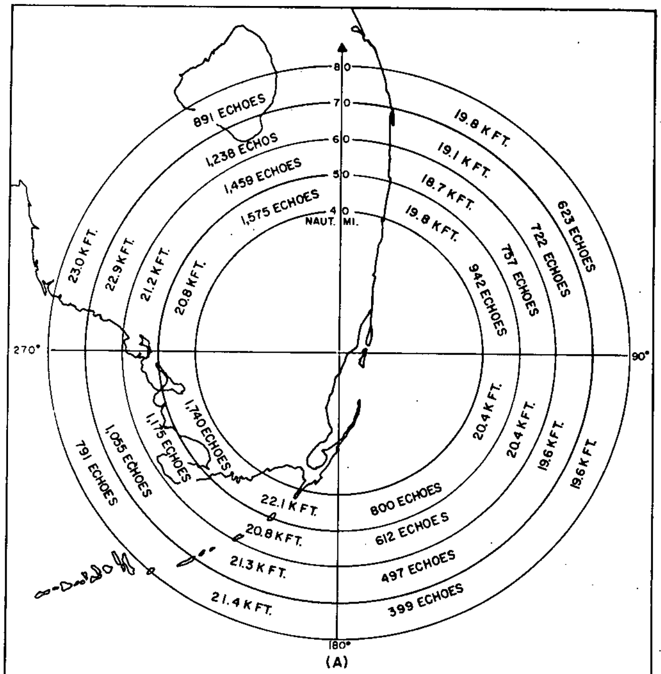
Figure 9.2 presents the weighted mean height of all echoes in the four quadrants and 40-80 mile range increment by months. This clearly shows the mean height of the echoes to be greatest during the hottest and wettest part of the year. The upward trend in the spring and the downward trend in autumn to a winter minimum is quite pronounced. However, the significance, if any, of the peaks in April, June, and August with slightly lower values for May and July is not known. They may be the result of sample size or non-representative years. They also could be related to the dual summer maximums of precipitation in South Florida.

Figure 9.3 presents the data by quadrants for the warm-wet season, May through October inclusive, and for the cooler dry season, November through April inclusive. As might be expected, the wet season shows the greatest mean echo height in all quadrants.

It is interesting to note that the mean height of echoes during the warm-wet season was greatest over the NW or land quadrant, while the mean height during the cooler dry season was greatest over the water quadrants. The warm season precipitation is to a great extent afternoon heat convective activity generated over the land. During the winter months, frontal squall lines pass through the area with a maximum of activity occurring over the warm waters in the southern and eastern quadrants.

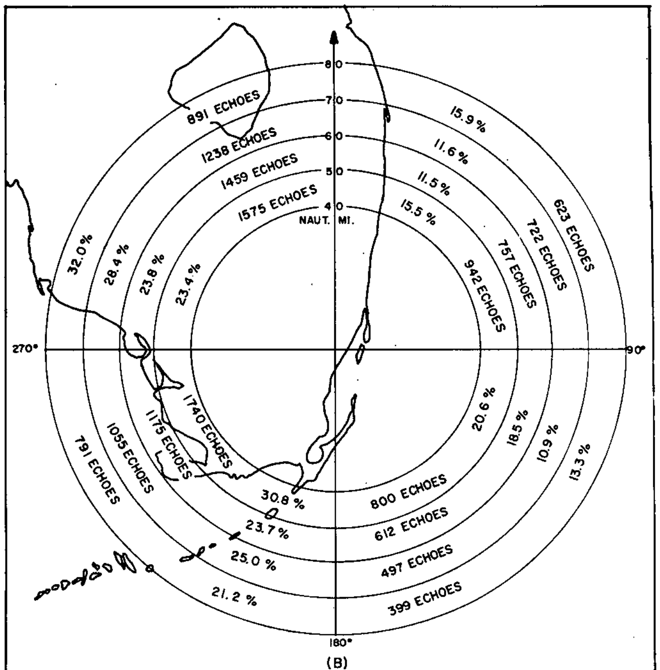
9.20 RANGE ATTENUATION EFFECTS UPON ECHO HEIGHT DATA

The theoretical minimum detectable rainfall rates were computed for the MPS-4 radar at 40 and 80 miles range, the inner and outer limits of the echo height study, by use of the following equation and radar parameters:



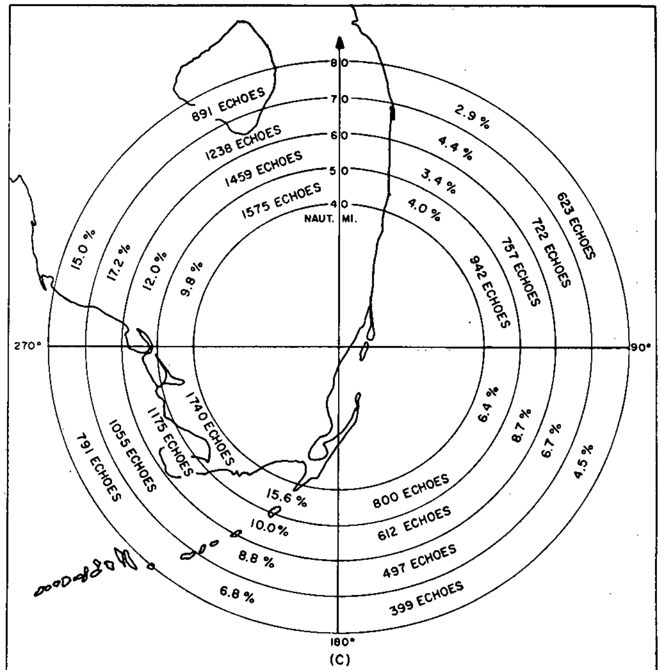
(A)

WEIGHTED MEAN RADAR ECHO HEIGHTS IN THOUSANDS OF FEET FOR TWO YEAR PERIOD. TOTAL NUMBER OF ECHOES IN EACH QUADRANT AND 10-MILE RANGE INCREMENT ARE SHOWN.



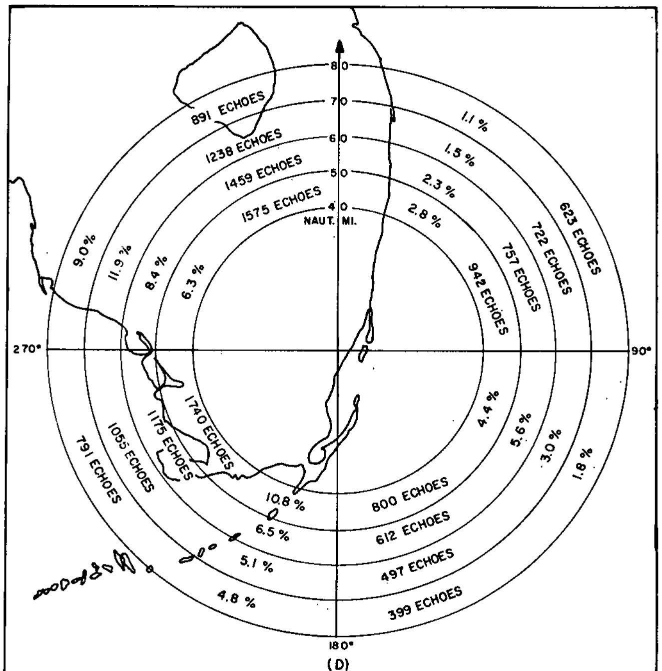
(B)

PERCENTAGE OF RADAR ECHOES IN EACH QUADRANT AND RANGE INCREMENT EXCEEDING 25,000 FT. HEIGHT. TOTAL NUMBER OF ECHOES IN EACH QUADRANT AND 10-MILE RANGE INCREMENT ARE SHOWN.



(C)

PERCENTAGE OF RADAR ECHOES IN EACH QUADRANT AND RANGE INCREMENT EXCEEDING 30,000 FT. HEIGHT. TOTAL NUMBER OF ECHOES IN EACH QUADRANT AND 10-MILE RANGE INCREMENT ARE SHOWN.



(D)

PERCENTAGE OF RADAR ECHOES IN EACH QUADRANT AND RANGE INCREMENT EXCEEDING 35,000 FT. HEIGHT. TOTAL NUMBER OF ECHOES IN EACH QUADRANT AND 10-MILE RANGE INCREMENT ARE SHOWN.

FIG. 9.1 – MEAN ECHO HEIGHTS AND PERCENTAGES THAT EXCEEDED 25, 30, AND 35 THOUSAND FEET

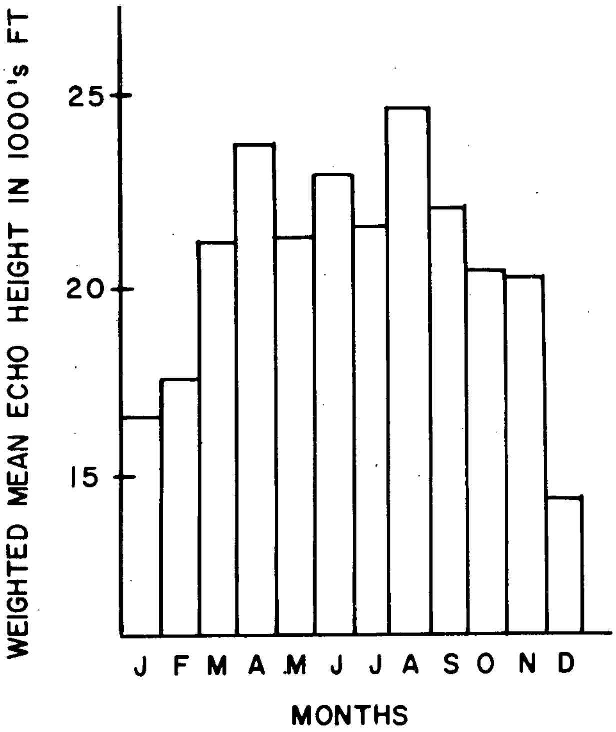


FIG. 9.2–WEIGHTED MEAN ECHO HEIGHTS BY MONTHS, 40-80 MILES RANGE

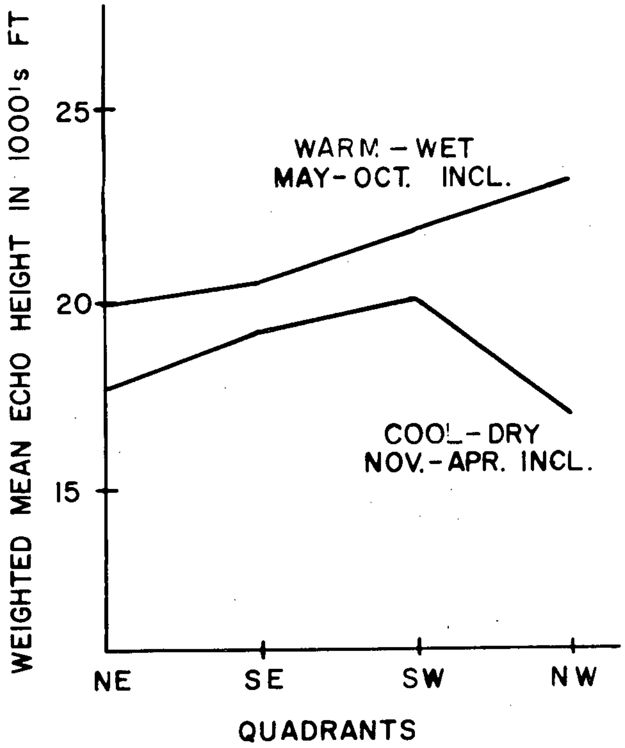


FIG. 9.3–WEIGHTED MEAN ECHO HEIGHTS BY QUADRANTS AND SEASONS

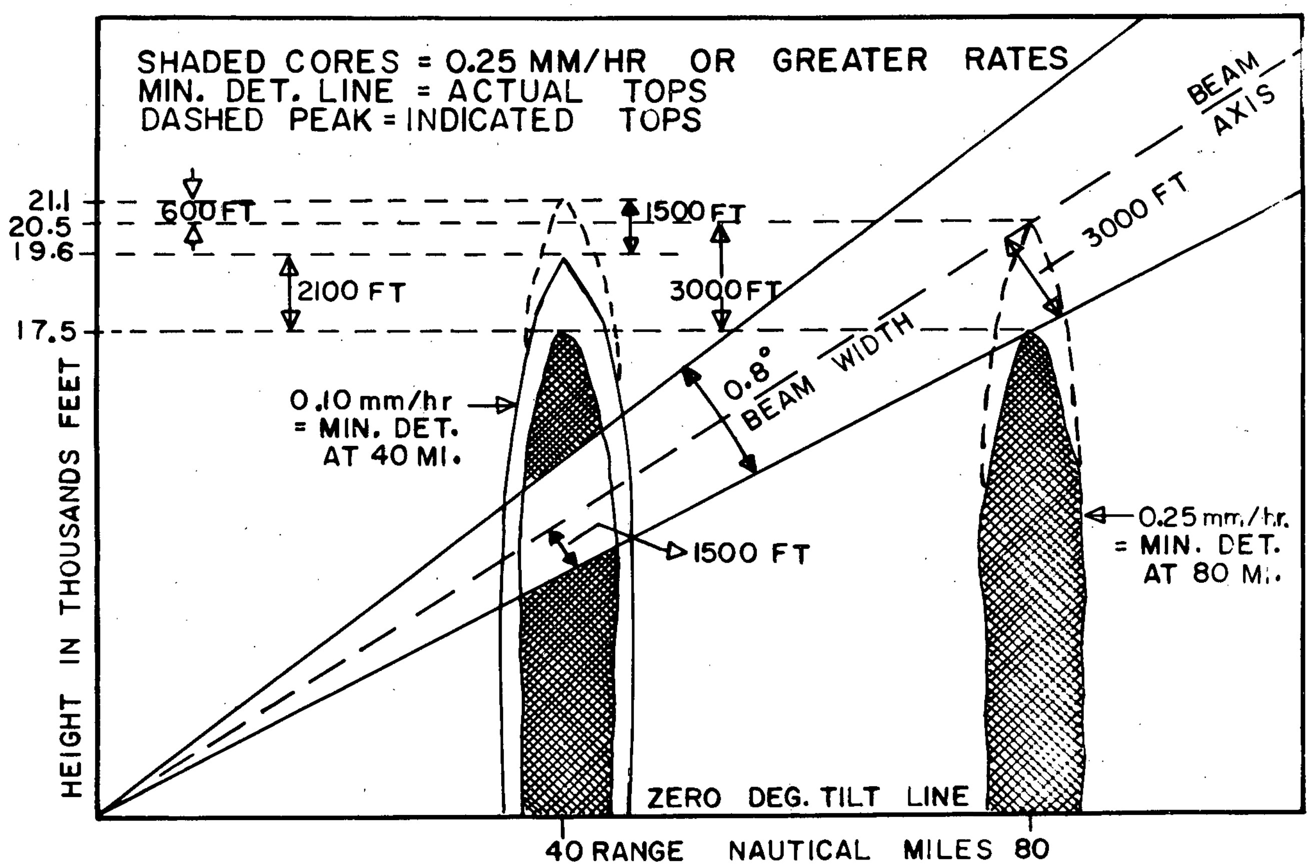


FIG. 9.4– THEORETICAL MIN. DETECTABLE ECHOES AND BEAMWIDTH STRETCHING VERSUS RANGE. AN/MPS-4 RADAR IN SOUTH FLORIDA AREA.

(Eq. 9.1) $$I_{(min)} \text{ mm/hr} = \sqrt[1.52]{\frac{4.77 \, R^2 \, \lambda^2 \, P_r \times 10^{21}}{P_t \, \pi^3 \, h \, G_o^2 \, |K|^2 \, \theta \, \phi}}$$, where

$P_{r(min)}$ = min detectable power received = 1.4×10^{-13} watts

θ = horizontal beamwidth = 4^o

ϕ = vertical beamwidth = 0.8^o

P_t = peak power transmitted = 1.4×10^5 watts

h = pulse length = 3.9×10^2 meters

λ = wavelength = 4.6×10^{-2} meters

$|K|^2$ = constant = 0.93

G_o = antenna gain = 7080

R = range = 40 n. mi = 7.44×10^4 meters
= 80 n. mi = 14.88×10^4 meters

This gives minimum detectable rainfall rates of 0.10 and 0.25 mm/hr at 40 and 80 nautical miles respectively.

The results of the precipitation echo height study, which are summarized in Section 9.10, show little or no decrease in mean echo height between 40 and 80 nautical miles range. The mean echo height actually increases with range from the radar to the NW over the peninsula. Weighted mean heights have been computed by 10-mile range increments for the other three quadrants combined, NE, SE and SW. These quadrants are believed to be more representative of the general marine climate of the area. The weighted mean heights were 21.1, 20.1, 20.2, and 20.5 thousands of feet for the range intervals 40-50, 50-60, 60-70, and 70-80 nautical miles respectively.

Figure 9.4 shows the combined effects of vertical beamwidth stretching and range attenuation of the radar energy. The theoretical minimum detectable rainfall rate increases from 0.10 mm/hr at 40 miles to 0.25 mm/hr at 80 miles range because of the effect of range attenuation following the $1/R^2$ law, see Eq. 9.1. Considering the 10-mile range increments of the echo height data, it would appear more logical to have computed the theoretical minimum detectable rainfall rates at 45 and 75 miles range. The 40 and 80-mile points were chosen instead to show the maximum difference in beamwidth stretching. All of the values are approximate but their relations to each other should be reasonably accurate.

We see from Figure 9.4 that the increase in vertical beamwidth stretching of the tops of the echoes with range from the radar nearly cancels the effects of range attenuation (increase in minimum detectable rainfall rate with distance from the radar). In this case, we assume the two storms to be identical and situated in a relatively homogeneous marine environment. The one closest to the radar appears larger and taller because the minimum detectable rainfall rate is less at 40 miles than at 80 miles range.

The indicated top of the 0.10 mm/hr contour at 40 miles range is 1500 ft taller than its true top and the indicated top of the 0.25 mm/hr contour at 80 miles is 3000 ft taller than its true top. Although both tops are distorted, the minimum discernible echo tops that would normally be reported for the two identical storms observed on the MPS-4 radar RHI scope, without range attenuation correction being applied, would be within about 600 ft of each other. This is basically a desirable result.

If a $1/R^2$ range attenuation correction factor were applied to the MPS-4 in such manner as to normalize all targets to 80 miles range, then theoretically the minimum detectable rainfall rate would be 0.25 mm/hr at all ranges up to and including 80 miles. Under these circumstances, vertical beamwidth stretching would cause the storm at 40 miles to appear to extend to a height of approximately 19,000 ft and the storm at 80 miles to extend to approximately 20,500 ft giving a difference of 1500 ft.

9.30 CONCLUSIONS AND RECOMMENDATIONS

It is recommended that a height finder radar such as the MPS-4, with a beamwidth of one degree or less and medium detection capability, be operated without the use of range attenuation correction if it is desired to estimate radar tops directly from the RHI scope without subtracting the beamwidth stretching component. However, more precise results could be obtained by applying range attenuation correction and reconstructing the height lines on the RHI scope so that vertical beamwidth stretching of the precipitation echo tops is subtracted in the initial presentation.

Higher powered radars with highly sensitive receiver systems and wider beamwidths of the order of two degrees or more, such as the U.S Weather Bureau's WSR-57, definitely need range attenuation correction applied to the RHI presentation to reduce the effect of antenna side lobe stretching of the tops of echoes. Radars of this type are capable of detecting precipitation echoes, at ranges up to 50 miles or more, by side lobes that lie outside the half-power beamwidth. An STC type range attenuation correction device reduces this side lobe stretching of the echo top by reducing the detection capability of the receiver system at short and intermediate ranges as an inverse exponential function of range.

Range attenuation correction is recommended for all weather radars used for PPI data collection. Beamwidth stretching in the horizontal plane of the PPI scope can be ignored for most purposes.

10.0 ANALYSIS OF MIAMI TORNADO 17 JUNE 1959

10.10 VISUAL OBSERVATIONS BY H. W. HISER

I was fortunate to observe this tornado both visually and by radar. I was in the office of the Laboratory on the fifth floor of the Merrick building, on the University of Miami's main campus, when the lights began to fail at about 2200 EST. The tornado funnel was about one mile east of the Laboratory over the Coconut Grove section of Miami at this time. It was clearly back-lighted by almost continuous lightning flashes. I turned off the room lights and watched it for about five minutes in order to determine whether to retreat to the ground floor of the building or proceed to the seventh floor to turn on the radars. As soon as I determined that the funnel was moving in a general northerly direction, I turned on the radars at 2210 EST and began photographing the scopes by about 2212 EST.

I have observed other tornado funnels during daylight hours over rural areas in Illinois, but this was the most spectacular one I have ever seen. While the funnel was proceeding through the Coconut Grove section of Miami, its lower extremity was continuously illuminated with a blue-green light flashing like an electric welding torch. A part of this was no doubt produced by the tornado disrupting the network of power lines in this populated area. However, the tornado was associated with a thunderstorm which had an extreme amount of electrical activity with almost continuous cloud to cloud and cloud to ground lightning strokes while it was near the University. I believe that at least a part of the glow in the lower extremity of the funnel was the result of natural electrical phenomena.

I could not see the overall structure of the thunderstorm cloud, but the funnel was well developed and quite dense. The cloud base was fairly low and the funnel extended vertically to the ground. The outer wall of the funnel was not smooth. It seemed to be lightly shrouded with bits of rapidly changing fracto-stratus type cloud. There were several bursts of heavy rain at the University before I first observed the tornado, but there was only light to moderate shower activity while the tornado was in progress. During the period 2212 to about 2225 EST, while operating the radars, I managed to steal a few glances out of the windows and could clearly see the funnel cloud back-lighted by lightning flashes as it moved through the northeastern portions of Miami 10 to 15 miles from the Laboratory.

The severity of this tornado is clearly evident from the extent of structural damage as shown in Figure 10.1. The numbered photographs in Figure 10.1 correspond to the locations shown on the map in Figure 10.2.

10.20 OTHER EYE WITNESS ACCOUNTS AND REPORTS

The following quotations are from letters written to Dr. Bernard Vonnegut of Arthur D. Little, Inc., Cambridge, Massachusetts, in reply to a request which he published in the Miami Herald on 22 June 1959, for eye witness accounts of this tornado.

Miami, Florida
6-23-59

"Dr. Bernard Vonnegut

Dear Sir:

As per request in Miami Herald of 6-22-59 for Citizens who witnessed last weeks tornado.

I am a Guard on a Private Estate (night) and would like to give my impression of that fearful night trusting you can perhaps make something out of my information, - - -

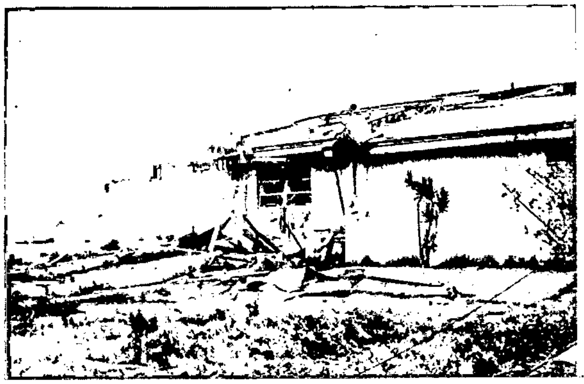
My observation of this Tornado seemed very queer to me indeed since I have witnessed several in Kansas and Missouri.

In Miami we have had several days of rain previous to the Tornado and heavy thunder and lightning at night, now, as I work at night one thing impressed me very much that evening. As I remarked to a fellow Guard, the color of the lightning with the crack of thunder was of the greenest of green. And it being a rather warm evening it seemed to (me) that with every crash of lightning it seemed to throw a cool spell for a few seconds. (This steady green lightning is the thing that amazed us two men, and the cool air that followed for a few seconds).

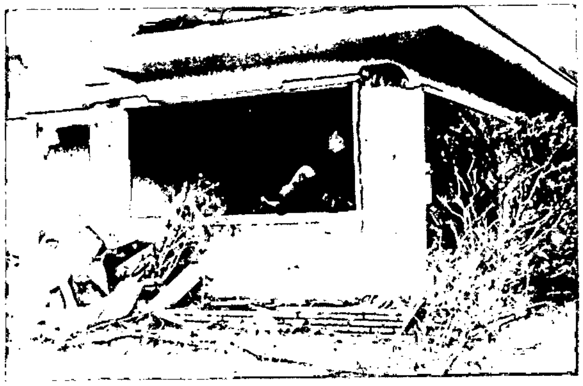
Another oddity noticed, the trees, palm trees and shrubbery. We were several streets removed from the path of tornado, but trees and shrubbery seemed like the wind came from above straight down, branches being blown Earthward. I am sixty years old but never have seen wind virtually coming down in such a way as the trees were spreading out flat that night.

NO. 7-67 ST. AND BAY AREA

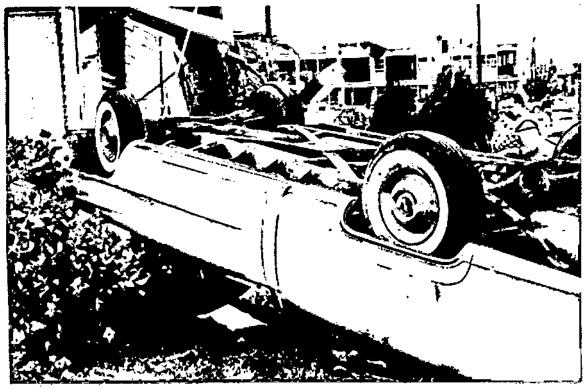
NO. 12-74 ST. 1 BLOCK W. OF BAY



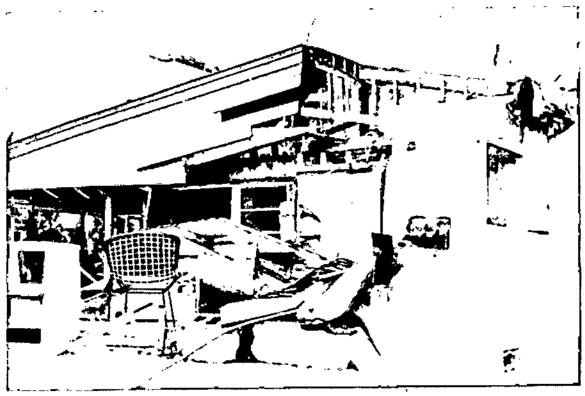
NO. 19-N.E. 80 ST. AT BAYSHORE



NO. 19-N.E. 80 ST. NEAR BAY



NO. 19-N.E. 80 ST. NEAR BAY



NO. 32-N.E. 89 ST. AT BAY

FIG. 10.1 – TORNADO DAMAGE IN N.E. MIAMI, 17 JUNE 1959. NUMBERS REFER TO LOCATIONS ON MAP OF TORNADO TRACK.

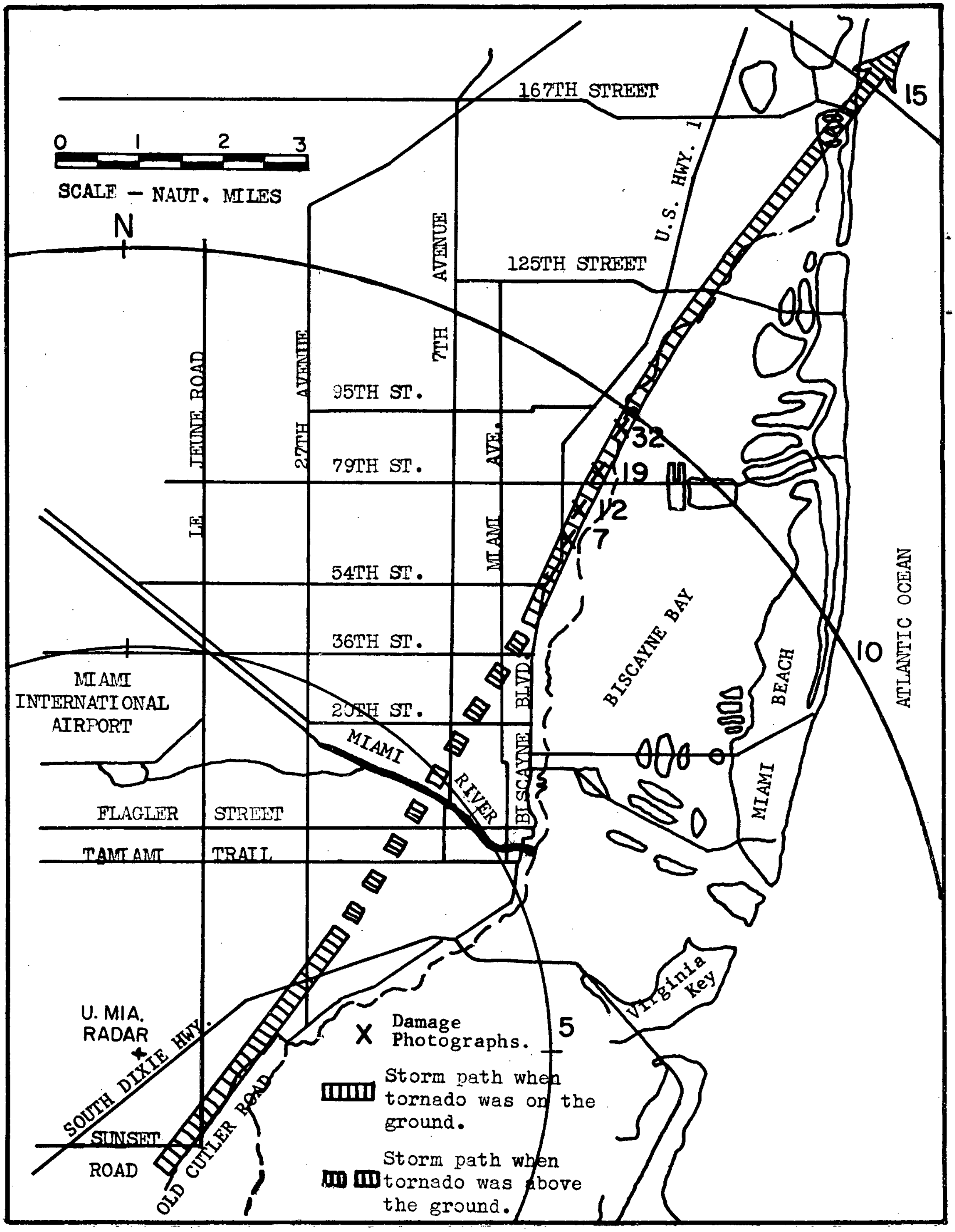


FIG.10.2 - PATH OF MIAMI TORNADO, 17 JUNE 1959

Dear Sir:--

All this information may seem normal as far as tornadoes are concerned, I dont't know, but as for myself it seemed to be very unusual since I have seen several in my time.

The two outstanding points I tried to make in my letter to you are -- (The very green lightning - followed by a cool few seconds than back to usual temperature)
(And the vertical down wind)"

Very truly yours

/S/ William J. Frank
535 N.E. 2nd Ave
Miami, Florida

June 26, 1959
4115 Park Ave.
Coconut Grove
Miami, Fla.

"Dr. Bernard Vonnegut
Arthur D. Little, Inc.
15 Acorn Park
Cambridge, Mass.

Dear Dr. Vonnegut:

I am writing in response to your request in the Miami Herald for observations on our recent tornado. Perhaps my information will not be of very much interest since the tornado passed a block away from our home. However, my busband and I saw it clearly and are in agreement as to how it appeared to us.

The day of the storm was overcast, very hot, and muggy - but not unusual for this time of year. About seven o' clock that evening a thunder storm formed to the south of us. We live in the Southern suburban section of Miami about a mile from the spot where the tornado first touched down. The storm seemed to be quite severe as the lightning came intermittently in gusty squalls.

Shortly after 9:30 we commented that we were having an unusual storm, for two reasons -- first, because it was continuing for so long and then because it hadn't moved for over two and one half hours. Our summer thunder storms are often severe, but they are usually short and they move from one location to another. We were watching TV and there had been no interference from the storm. Suddenly we heard a loud roar, to the south, which sounded at first like a jet airplane coming toward us at very low altitude. In a matter of seconds we realized that it was not an airplane and we rushed to a front window. The tornado was perhaps about six blocks directly south of us and it looked as if we were in a direct path. It was clearly visible as it was luminous, glowing with a bluish green light. Our lights flickered several times and went out just as the tornado became brilliantly blue-white momentarily. Then the luminous glow returned. Because of many houses and trees we could not see the bottom of the funnel. To us it looked like a column about a block wide, moving intact, in a direct course toward us. The roar was becoming very loud and the house was vibrating. Our young son had been aroused and we took shelter in the bath room on the north side of our house, expecting the tornado to hit us any moment. The roar was very loud as the tornado passed us, and the vibrating was frightening. We experienced no wind and there was no damage of any kind to our property. The period immediately after the storm passed was one of dead calm.

The tornado damage in our neighborhood was not severe in comparison to the sections hit as the storm moved northward. Many roads were blocked by fallen trees; yards, trees, and foliage took a beating; houses were damaged, but not demolished in this section of town. The storm hit us at 9:50 p.m. as that is when our clock stopped.

Our son went to bed at 9:30 in an air conditioned bed room, so he did not hear the tornado approaching. Shortly before the power failed, he was alarmed by the behavior of his pet cat in the room with him. The cat jumped on the boy's head, arched his back, and as he faced the south wall of the room, the animal spit and yowled. Our son, age eleven, turned on his flash light to see what was the matter. He couldn't detect anything. The cat became frantic, and about that time the power failed and the air conditioner went off. Our son came out of the room to see what was the matter -- and we rushed him into the bath room. Our dog, in the room with my husband and me, was not noticeably agitated.

I do hope that you will have a good response to your request for information. There must be many people who could give you valuable observations".

Yours truly,

/S/ Patricia Aiken
(Mrs. Benedict D. Aiken)

2376 S.W. 26th Lane
Miami 33, Fla.
June 23, 1959

"Dr. Bernard Vonnegut
Arthur D. Little, Inc.
15 Acorn Park
Cambridge, Mass.

Dear Dr. Vonnegut:

I was very much interested in your article appearing in the Miami Herald, seeking information about our recent tornado. There was one peculiarity about the electrical activity which I noted which occasioned me to discuss it with others the day after the tornado.

First let me tell you of my proximity to where it struck, once and severely, at Coral Way and 24th Ave. I left my home at 9:55 PM, which is about six blocks from where it struck. It was raining very hard. I was particularly alarmed at the lightning, because the approach to my car is surrounded with five Florida pine trees and when it thunder storms and I am under these trees I am extremely conscious of it and of lightning during such times. Therefore, when I left the house I was extremely conscious of the electrical conditions that night. I observed that there were no definite or visible strokes, but rather quick flashes instead at about 10 second intervals or perhaps more rapidly. And peculiarly very little thunder accompanying same flashes, but rather muffled distant rumbles, noticeably peculiar to me with that much lightning. I did not however take any notice of the cloud formations in my haste to get from under the trees. After nervously dropping my car keys in the gutter, which I retrieved I then dropped my wife's rain shoes in the gutter, retrieved them and finally got started on my way. I proceeded to the above Coral Way and 24th Ave., stopped and waited for traffic to clear and proceeded to Miami Senior High School to get my wife, which is about a five minute drive. I returned immediately, noticed nothing more peculiar to me, perhaps because of my wifes' company, until we again came to Coral Way and 24th Ave., and noticed in the few minutes since I had been at this particular spot, the havoc rendered upon it. I was astounded, and said to my wife that I had just left that spot previously. Realizing, long after we learned that it was a tornado that hit, that if I had lingered a few minutes in some way, that I surely would have been hurt or worse at Coral Way.

I hope that what little information about the storm I have supplied can be of some value to you."

Respectfully yours,

/S/ George Woodroff

MIAMI
CHICAGO
NEW YORK
HOLLYWOOD
DALLAS
DETROIT
SEATTLE
SAN FRANCISCO
TORONTO
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BANGKOK
SINGAPORE
COLOMBO
JOHANNESBURG
CAPE TOWN
SALISBURY
BULAWAYO

June 30, 1959

Dr. Bernard Vonnegut
Arthur D. Little, Inc.
15 Acorn Park
Cambridge, Massachusetts

Dear Dr. Vonnegut:

This is in response to your recent request via Miami newspapers for eye-witness reports of electrical activity accompanying the June 17 tornado here in Miami. There is probably nothing new in this observation, but this is what my family and I noted.

We live in southeast Coral Gables, less than a quarter mile west of the point where the tornado first touched down. About two minutes before the power failure, our two sons said they heard a low noise to the east, very much like the characteristic sound of a jet plane. When the lights went out we went to our porch which faces northeast. We did not see the funnel and so did not at that time know that a tornado had just passed.

But we clearly recall the general eeriness of the storm and commenting on it. Lightning was flashing almost constantly all over the sky, though there wasn't much thunder. Rainfall wasn't too heavy, either. We could see that the clouds were lying in scattered heavy lines, the heaviest to the northeast. Short erratic "rushes" of wind could be heard about the neighborhood. And then we began to observe the eeriest phenomenon of all, something we had never seen before: first, pale green sheet lightning in what must have been the area directly behind the tornado as it moved to the northeast ... then, brilliant pink sheet lightning in the same area. The pink flashes lasted for about five minutes, then turned to green again, and these continued for perhaps another 15 or 20 minutes. Then all we could see were the usual white lightning flashes which were beginning to lessen. By then it was about 10:30 pm, and our sons were beginning to get storm reports on their portable radio. At the time we finally retired about 12:30 we observed several green flashes of sheet lightning again but these were rather weak and against a dull grey sky and the weather had settled down considerably by that time.

Hope the above will be of some help to you.

Very truly yours,

Howard C. Peterson, Jr.

Howard C. Peterson, Jr.

LEYSHON ASSOCIATES OF FLORIDA, INC.
509A AINSLEY BUILDING, MIAMI 32, FLORIDA FRANKLIN 4-0623
PUBLIC RELATIONS

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122 EAST 42ND STREET
NEW YORK 17, N. Y.
MURRAY HILL 7-0272

WASHINGTON OFFICE
1507 M STREET, N. W.
WASHINGTON 5, D. C.
ADAMS 4-2426

June 23, 1959

Dr. Bernard Vonnegut
Arthur D. Little, Inc.
15 Acorn Park
Cambridge, Massachusetts

Dear Dr. Vonnegut:

I saw the tornado of June 17 and your letter in the MIAMI HERALD today requesting information on it. As a former newspaperman, trained to look for details, I will give you my observations for what they are worth.

The storm started about a half a mile south of my home at 3911 Battersea Road in Coconut Grove, judging by its path of destruction. It passed between 250 and 300 feet west of my house, traveling on a northeast course. I was standing looking out of a west window just before it started until it passed, and saw all that the darkness permitted.

I noted that the lightening was peculiar in that it was prevalent and continuing but it was not accompanied by the characteristic thunder claps of the usual thunder storm. I would guess that the lightening flashes occurred at about ten-second intervals and I recall that the flashes were rather dimmed in contrast to the clear cut strokes and brightness usual in the thunder storm.

The question of light was rather difficult to determine because there were several factors involved. There was the lightneing described above. Then, the tornado had knocked down live wires a block or two away. Bright sparks shot up into the sky, evidently from the live wires, and there were other flahses of light, which I also judged to be caused by the live wires. In addition, for a period, there was a green glow. Whether this glow came from the tornado, the lightening or the live wires, or a combination of all I cannot judge accurately.

From these various light sources, however, I was able to see boards or some other flying debris swirling in the sky above the tree tops. The tornado, seen then, in that light, seemed a light grey color, almost identical to a heavy fog.

I did not seen the typical black tornado funnel formation, probably because of its closeness and because of the surrounding night. It started as a low rumble and built rapidly to what I undeerstand to be the typical tornado roar. Even though I have never been through a tornado before (I have been through five hurricanes) I knew immediately - after the first brief puzzlement - that it was a tornado.

You are interested, evidently, in the electrical aspects. I have concentrated on this and hope it will be of some help in your analysis.

Sincerely yours,
G. Ralph Kiel
G. Ralph Kiel
Vice-President

Allison of Florida, inc.
580 N. W. 26th STREET • MIAMI 37, FLORIDA
PHONE
FR 4-8459
• HAND PRINTED POLO SHIRTS • SPORTSWEAR

June 23, 1959

1900 NE 118th Road
Miami 38, Florida

Dr. Bernard Vonnegut
Arthur D. Little, Inc.
15 Acorn Park
Cambridge, Mass.

Dear Dr. Vonnegut:

In reponse to your appeal for information of eye witness accounts of the recent Miami tornado, I will summarize below what I 'thought' I saw.

Due to the awesome sight of this phenomenon my memory of what I actually did see may not be too accurate, but here it is:

> The approaching sound that I heard was not the thunderous roar as was reported by so many in the newspaper, but a loud swish couple with the sound af a tremendous swarm of bees.
>
> I could not distinquish the funnel too well, but did notice a distinct plume of white coloration. This umbrella shaped mass seemed to be blowing ahead of the dark funnel area. I presume that this was made up mostly of water as the tornado was over the bay at the time and was causing no destruction. I would guess its forward speed was 25 mph.
>
> The tornado was preceded by a most violent thunderstorm. The lightning flashes were unbelievably instense with smaller finger bolts extending, seemingly, downward from the main stem of the bolt. The frequency of the bolts was about 20 seconds
>
> My house is about 200 yards from the path of the storm and we did not experience any unusual amount of wind or rain.

Hope that the above may be of some value to you. If I can be of any further assistance please advise.

Very truly yours,

Chas. W. Fay

10.30 INFORMATION FROM THE U.S. WEATHER BUREAU, MIAMI, FLORIDA

10.31 Report by U.S. Weather Bureau District Meteorologist

The following is a copy of a report to the Chief of the U.S. Weather Bureau prepared by Mr. Gordon E. Dunn, Chief District Meteorologist, Miami, 26 June 1959.

"The most severe tornado in the Miami area since April 1925 occurred on the evening of June 17, 1959. The tornado was observed by several experienced meteorologists as well as by thousands of other persons. It was located to the rear of a cumulo-nimbus cloud and well illuminated by lightning which was occurring in the middle of the cell. All observers agree that it was attended by a large black funnel cloud and described as "a typical textbook tornado". The words most frequently used to describe the accompanying or preceding noise were "like a nearby jet", or "an intense whining noise". Special attention was given to the possibility of any color in the funnel. Several people said it looked green; a ball of fire approached, or it lit up occasionally but in contrast, hundreds of others recalled no color at all. On the basis of observations from meteorologists and detached and unexcited persons, some observing from high buildings, it appears that the progress of the tornado was accompanied by flareups as electrical wires were torn loose and transformers damaged. At times these flareups appeared pink and green and occasionally illuminated the tornado base.

Lightning frequency was normal as the tornado progressed through Coconut Grove but perhaps could be described as incessant during the second half of the tornado.

The tornado path was unusually narrow. The comparatively light damage during the greater portion of the track might be interpreted as indicating that the funnel was off the ground much of the time but close enough to maintain damaging winds immediately underneath. For example, the path extended across the Coconut Grove negro section yet I failed to notice any damage to the wooden shacks in its path, although trees in the yards suffered considerable damage.

Rotary motion was very evident at initial groundfall and in the limited portions of the path where major damage occurred. Elsewhere merely southerly winds were indicated. Strong suction was noted in the several areas of severe damage. Every stick of furniture, including wall to wall rugs, were sucked out through the windows in a few houses.

The Red Cross statistics on the tornado follow:

Killed	0	
Injuries - major	47	
Injuries - minor	30	
Dwellings destroyed	0	
Damage - major	48	Average $2000
Damage - minor	177	Average $ 300
Other buildings	(business)	
Destroyed	2	
Damage - major	17	
Damage - minor	46	

Building damage was estimated by an experienced appraiser as under $1,500,000.* This does not include shrubbery, furnishings, necessary redecorating, and utilities. It is believed $3,000,000 is a liberal estimate of all damage done by this tornado. Almost all the injuries were caused by flying glass. In any list of hurricane precautions, there should be strong admonition concerning this.

Both Weather Bureau and University of Miami radar specialists state there was nothing unusual about the radar echo spanning the tornado. The tornado did appear to form about the time a small echo forming over the Bay merged with a large echo which had been followed for some time. With elevation at a low angle, the hook was not visible in the ground clutter but was clearly visible with antenna elevation at 5°.

Notification from the Radar Laboratory, University of Miami, of the existence of a tornado did not reach the WBO until about 10:19 p.m., followed immediately by a report from the old Weather Bureau radar at the Lindsey Hopkins Building. These reports were placed on the public information circuit at 10:25 p.m., but the tornado dissipated shortly after this

*Final damage estimate, Greater Miami Insurance Board, $1,500,000.

time and there was no effective warning. Small craft and heavy rain warnings had been issued earlier and a tornado warning for aviation interests was issued at 10:40 p.m.

The above is believed to represent a considered composite of all available information. You will find attached, reports from meteorologists who either observed the tornado or investigated the track, and from one lay observer. There are the usual inconsistencies normal in a situation of this kind".

10.32 Tornado Observations, 17 June 1959, by John C. Boyd and Sanford Neuman, U. S. Weather Bureau, Miami.

"A tornado was observed visually from the north doorway atop Lindsey Hopkins Building across a point on the north wall of the building approximately 15 feet from the east wall of the building at 2217E. Nearly incessant lightning flashes and reflections from the heavy cloud mass to the northeast and east attracted the attention of the observer through an open door to the north upon seeing a vertical stab of lightning to the northnortheast. The tornado was so clearly outlined that the cloud base could be made out well to both sides, east and west of the vortex. The severe lightning stroke and those which followed appeared to be approximately 1/2 mile east of the tornado and in advance to the north as the storm moved northeastward. The bulk of cloud mass seemed to lie to the northeast through east with a roll-like formation, of which only the base, top, and west edge could be seen, but there was separation between the roll cloud and higher clouds. This roll formation extended from east-northeast to the tornado area decreasing in height until joining the tornado itself. The base of the funnel appeared to be 300 to 500 yards wide. The width at cloud base was approximately twice the width of the funnel at or near the ground. The funnel was short and stubby. The apparent angle of the funnel from the cloud base to the ground was 90° or normal to the earth's surface.

Succeeding observations. After about four minutes, the ratio of funnel height to width at the base had increased to about 10 to 1, cloud bases not lifting perceptibly. The funnel had become tilted from east to west, cloud base to surface, from our view, and had moved northeastward. The funnel had become rope-like at last observation and could no longer be seen after 2224E. Lightning continued to be strong and frequent to north-east; lightning strong, but less frequent northnorthwest about 15 miles at 2224E. Color of lightning flashes reflected off cloud mass to east and northeast greenish blue fading to deep pink, but vertical stabs were bright white with red tinge of fading. On the radar scope at 1953E, a broad area of moderate cells were present bounded by points 170/50, 270/100, 285/100 and 360/60. Cells seemed to form in the southwest part of this area and maintained their intensity as they moved northeastward at 10 to 12 knots.

At 2055E two cells were observed, one at 240/10, the other at 205/25, diameter of both 10 miles, moving northeast at 12 knots. No hooks were observed on either although both had saddle back shape. There was about a 4 mile corridor between echoes. As the echoes approached the station, approximately an 18 mile area was blanketed around the station. Later elevation of antenna did not indicate echoes had merged, although the echo on the right, looking northward, may have accelerated some becoming closer to the other, just prior to passing station. RW at station.

At 2155E these echoes were centered at 270/18 and 010/10 with thunder to northeast. At 2315E, locations were 350/10 and 020/25, the one at 020/25 remaining the strongest echo on the scope. Alt. indicated on tiltmeter at 450 ft.

When the tornado was visually observed, the antenna was tilted to 5° on 25 mile range. No real hook was evident, but the point most closely resembling such a phenomenon was located at 3° AZ and 7 miles in range, at 1018E. There was no apparent change in shape of the echo during the observed time of the tornado.

From the time most echoes formed, or were first noted, they seemed to have a long life. One echo selected for this purpose was followed for between 5 and 6 hours, and seemed to increase in speed and intensity after passing off shore. Successive locations, 172155Z 008/40; 2255Z 012/50; 2355Z 017/70; 180053Z 020/85; 0155Z 023/10.

171620E. Moderate precipitation. Echo observed 130/22 two miles wide, 20 miles long, oriented N/S, moving NE 10 mph; but only observable between 6° and 15° elevation.

These phenomena, to the best of our knowledge and memory, are what we say, although we realize the recorded camera pictures may alter or change some of the picture which we have presented".

10.33 Damage Survey by Jose Colon, NHRP, U.S. Weather Bureau, Miami

"From a survey of the damaged sections of the city conducted within 48 hours after the occurrence, the following facts about the tornado were established:

The track consisted of two sections (see attached Fig.), one four miles in length, extending from the Cocoplum Plaza, at the southwestern tip of Coconut Grove (actually in Coral Gables), to a point on 20th Street, S.W., between 22nd and 23rd Avenues. The second section started about five miles farther north and extended a distance of eight miles from a point near 2nd Avenue and 43rd Street, N.E. to a point near the corner of Sunny Isles Boulevard and Route AlA. The sectors most severely damaged were a stretch about two miles long extending northward from Cocoplum Plaza and a sector also about two miles long extending from 52nd Street, N.E., to 80th Street, N.E. The latter sector was the more heavily damaged. The width of the track varied but in general was 0.2 miles or less. North of 80th Street, N.E., the damage was relatively smaller, but still significant for a stretch of three more miles up to Keystone Point. North of Keystone Point the damage was practically insignificant, due to the desolate terrain, but there were some particular features, such as the uprooting of mangrove trees, which to people who know indicated winds of unusual strength.

The entire track follows a rather straight line. The tornado first formed at around 9:50 p.m. EST. It crossed Biscayne Boulevard a little after 10:00 p.m. Several clocks in the section from 66th Street to 80th Street, N.E., stopped at times varying from 10:07 to 10:12 p.m., and at Keystone Point at 10:20 p.m. The more reliable time checks along whe track indicated speeds of 25-28 mph.

The length of the wind section at any one point lasted a matter of seconds. There were several reports and they all agreed. Estimates which seemed to be reliable quoted figures of 15-30 seconds.

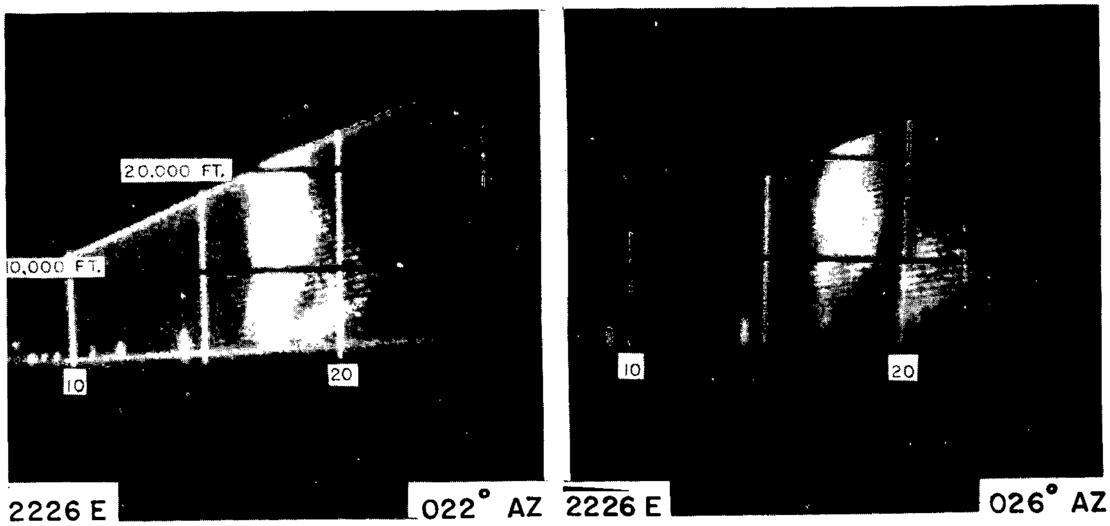
characteristics of the U.S. Weather Bureau WSR-1 radar, its proximity to the tornado, and the scale of the radarscope photographs, the data provide less information than was obtained by the U. of M. radars.

There is pronounced cyclonic motion in the hooked echo when the time lapse film is viewed at normal motion picture speed. Numerous other hooked echoes with varying degrees of similarity to this case have been observed on radars in other parts of the United States (6), (7), (8), (9).

There is evidence of another less well defined hook on the echo 15 miles NW of the radar station. Visual observation of this cloud from the Laboratory indicated that there was also a tornado associated with it. The cloud was extremely well lighted by a maximum of electrical activity, and it had a dark appendage extending earthward which looked very similar to the one over Miami at the same time. Boyd and Neuman noted frequent lightning in this region, see Section 10.32, page 44. A pilot reported to the U.S. Weather Bureau the following day that a wind swept path was visible in the Everglades marsh grass which looked as if it may have been produced by a tornado (10).

Figure 10.4 shows four RHI photographs along the azimuths of the tornado at 2226E and 2231E. These were taken with the MPS-4, 4.6 cm wavelength, height-finder radar. The range marks are at 5 nautical mile intervals and height lines are at 10,000 ft intervals. The limited vertical sweep of the antenna did not permit measurement of the full height of the echo at these short ranges. Also, with only one person operating the two radars, it was not possible to place the MPS-4 in operation as early as desired or to utilize all of the capabilities of the equipment in observing the tornado.

The lowest extremities of the echo in Figure 10.4 are believed to be the funnel cloud. At 2226E the tornado had passed out to sea just north of 167th Street, see Figure 10.2, and probably had lifted above the earth's surface. There was very little damage at the point where the tornado passed out to sea which would indicate that the funnel had begun to lift above the earth's surface at that time. By 2231E the hooked echo was well out to sea 20 miles north northeast of the radar and it is unknown whether or not the funnel was reaching the surface but there is still some evidence of a funnel cloud in the RHI photograph on 022 degrees azimuth.



5 N. MI. RANGE MARKS, 10,000 FT. HT. LINES

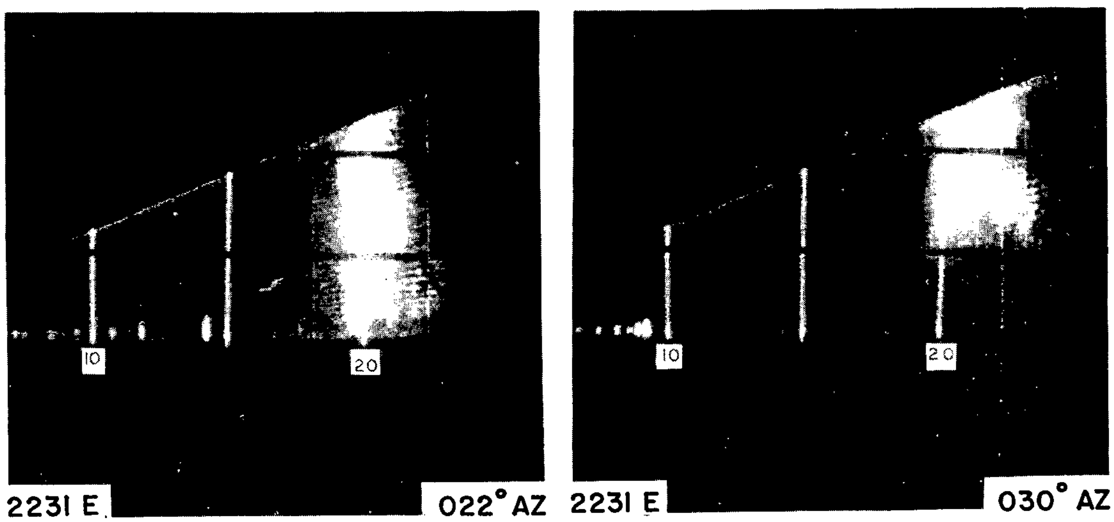


FIG. 10.4 - RHI PHOTOGRAPHS MIAMI TORNADO, 17 JUNE 1959, MPS-4, 4.6-cm RADAR, 140 KW PEAK POWER, 1.3 μ PULSE LENGTH

10.50 SURFACE AND UPPER AIR CONDITIONS

10.51 Rawinsonde Data

Figure 10.5 presents the Miami rawinsonde data at 1900E, 17 June 1959, about three and one half hours before the tornado developed. The Fawbush-Miller mean tornado sounding Type II for the Gulf region is also plotted for comparison (11). The computed Showalter Stability Index values of +1 for the Miami sounding and -6 for the Fawbush-Miller mean tornado sounding are shown in the lower left corner of Figure 10.5.

The Miami sounding was definitely more stable than the mean sounding particularly above the 600 mb level and it was drier than the mean sounding below the 600 mb level. The upper level winds over Miami were in fair agreement with the Fawbush-Miller means for the 850 and 500 mb levels.

10.52 Surface and Upper Air Charts

Figure 10.6 shows the surface weather conditions in the Florida region at 0100E, 18 June 1959, about two and one half hours after the tornado occurred. The 1004 mb low center in the Gulf off the west coast of Florida existed as a dual center in a trough north of the Yucatan peninsula at 1300E on the 17th. It produced rain over south and central Florida varying from 0.09 inch at Lignumvitae in the Keys to 6.64 inches at Ft. Myers for the 24-hour period ending at midnight of the 17th. This widespread precipitation east of the low center varied from the light steady type to intense thunderstorm activity.

Figure 10.7 shows the winds aloft and contours of the 500 mb pressure surface, approximately 19,000 ft in the Florida area. There was a shear zone extending NE-SW across southern Florida with weak northwesterly winds in northern Florida and 50 knot southwest winds at Miami. Key West had a southwest wind at 30 knots and Havana had a south southwest wind at 35 knots. The winds over eastern Cuba and the Bahamas were much lighter so as to give a pronounced wind speed maximum over south Florida.

The upper level winds over Miami at the 14, 16, 18, 20, and 25,000 ft levels were as follows: 200°/47 knots, 210°/47 knots, 220°/51 knots, 230°/45 knots and 230°/46 knots. This wind speed maximum at upper levels was the most outstanding synoptic weather feature at the time of the tornado. Forecasters with long experience at Miami consider strong southerly and southwesterly flow aloft to be the most condusive to severe weather conditions other than hurricanes at Miami.

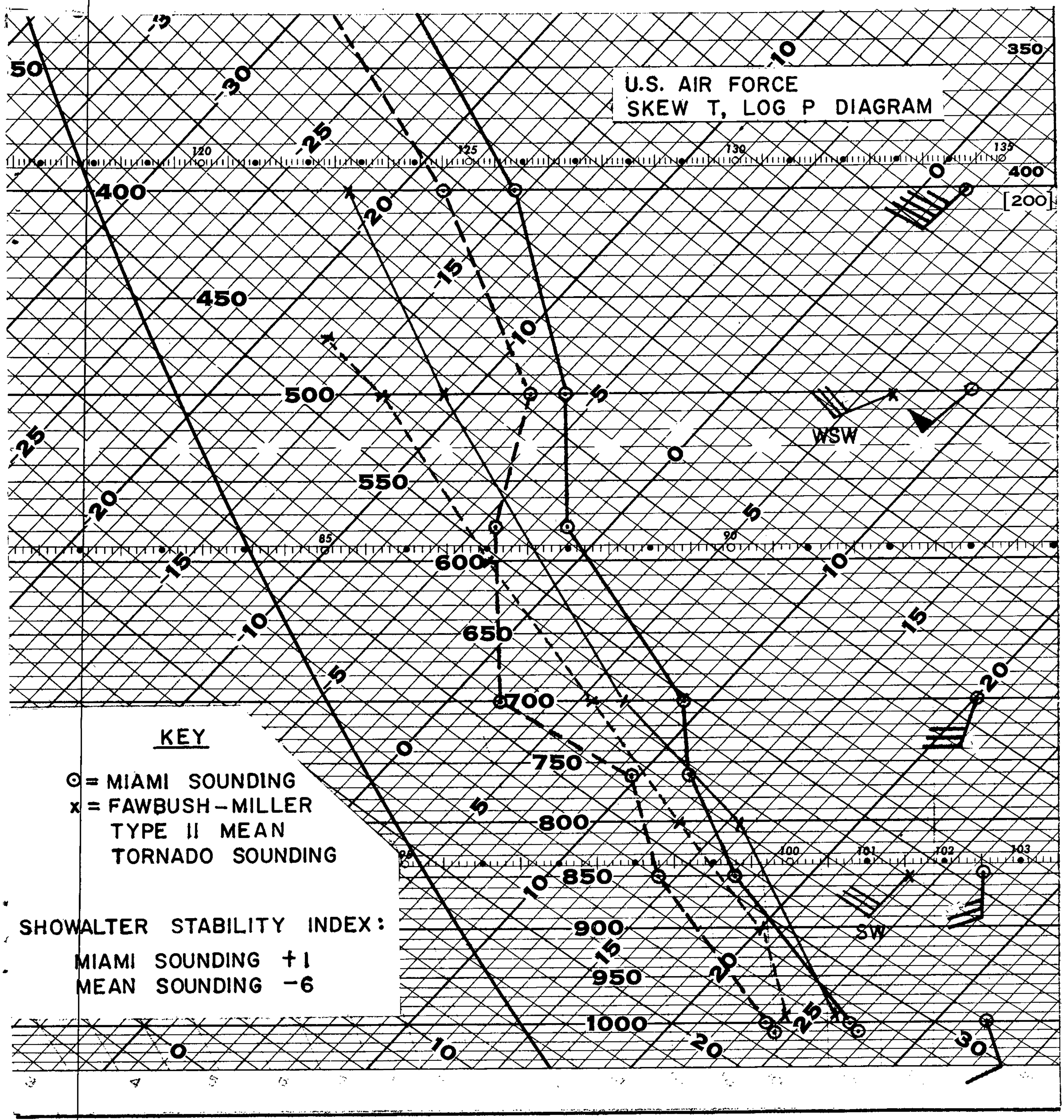


FIG. 10.5- MIAMI TORNADO 1900 E, 17 JUNE 1959, RAWINSONDE AND FAWBUSH-MILLER MEAN TORNADO SOUNDING TYPE II FOR GULF REGION.

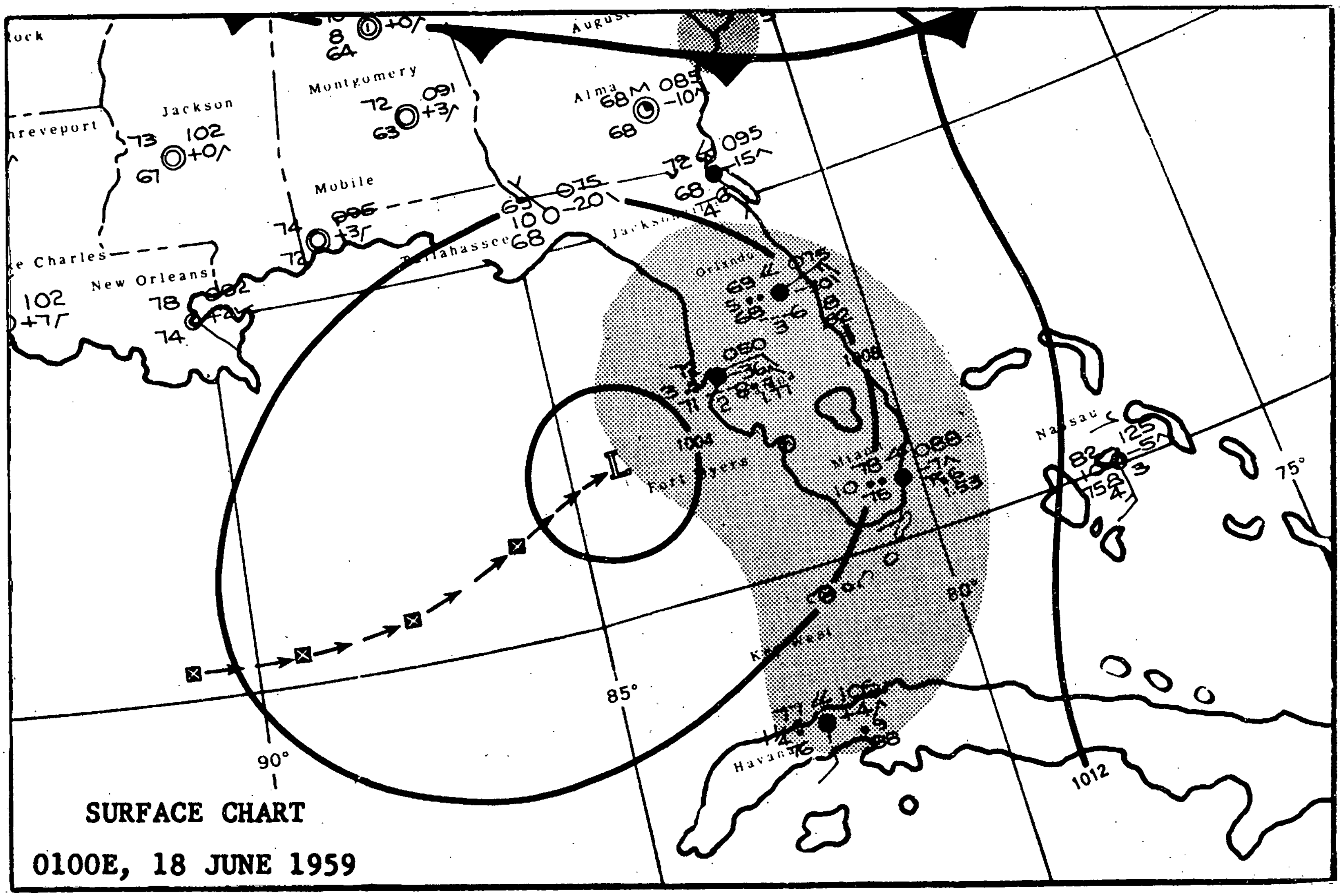


FIG. 10.6 - SURFACE WEATHER CHART, 0100 EST, 18 JUNE 1959

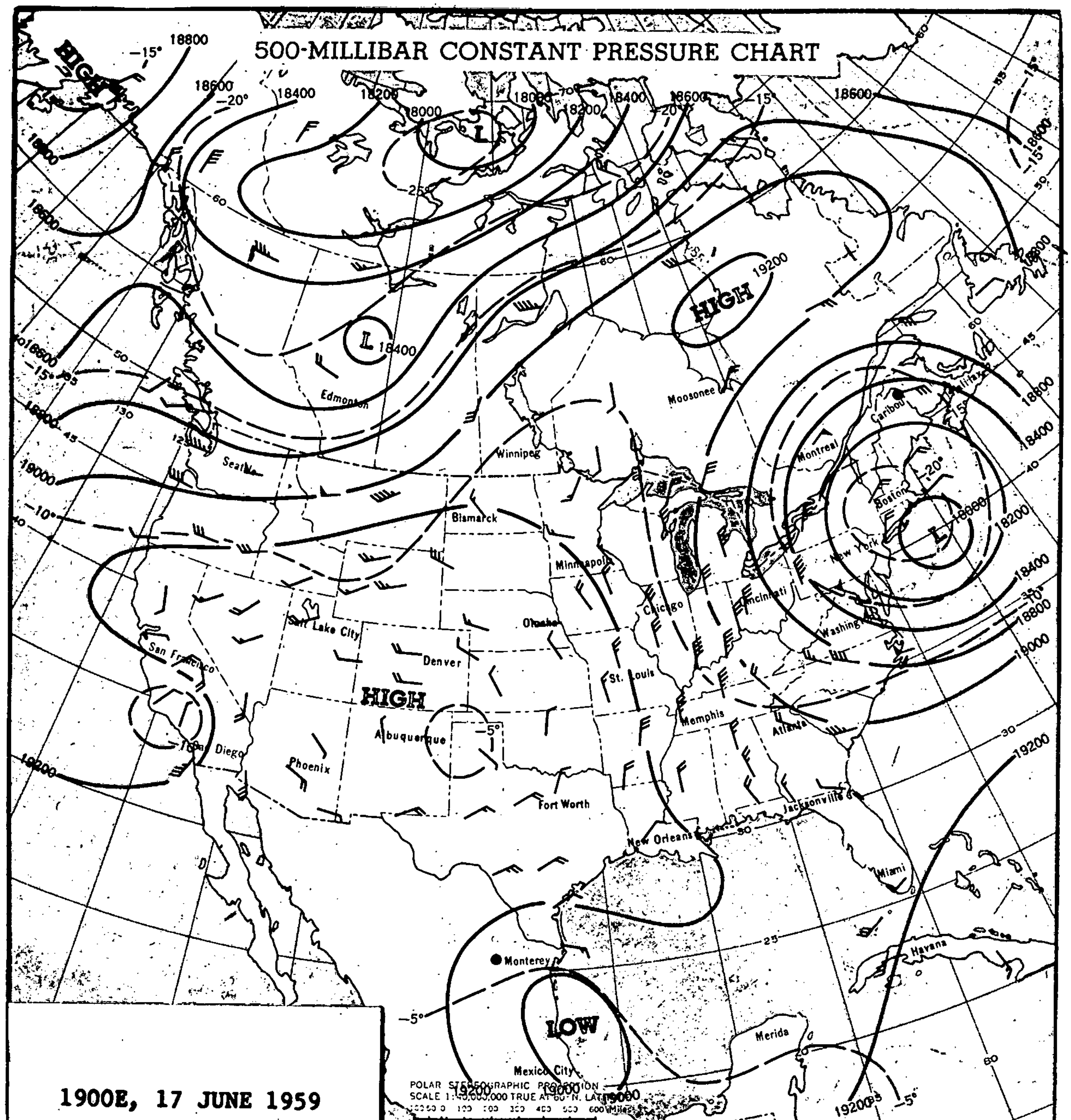


FIG. 10.7 - 500-MILLIBAR CONSTANT PRESSURE CHART, 1900 EST, 17 JUNE 1959

10.60 CONCLUDING REMARKS

The diversity of opinions regarding electrical activity associated with the tornado appears to leave this question unsettled. However, it may have varied considerably with time so that observers along the way obtained different impressions depending upon their location. One or two observers properly positioned on tall buildings could have observed this particular tornado during its entire life span; but, unfortunately, lack of knowledge of its presence or pressing duty requirements prevented such continuous observations.

Although this tornado was identifiable on radar, it was not so outstanding as other cases (6), (7), (8), (9). As noted in Section 10.40, there were apparently two tornadoes in the Miami area at about the same time and one also occurred near Jupiter, Florida on this occasion. These all appear to have been associated with the low center off the Gulf coast of Florida that was deepening as it moved northeastward. The Fawbush-Miller Gulf and Florida tornado conditions were not fully met and the tornadoes likewise were not of the large size and destructive caliber of some in the central U.S. and elsewhere (6), (7), (8), (12).

Additional analysis of this tornado case is contemplated for future publication.

11.0 OTHER LABORATORY ACTIVITIES

A 60-KW Buda Diesel Engine-Generator has been installed for emergency power during hurricanes and other severe weather conditions when commercial power becomes unstable or fails. This generator will permit operation of both radars and all other necessary equipment within the Laboratory.

The waveguide and rotating joints on the SP-1M antenna have all been cleaned and worn parts have been replaced. Also, a general revamping of the wiring within the Laboratory has been accomplished. Now that the new VDS is in operation, a considerable amount of obsolete wiring has been removed which simplifies maintenance and trouble shooting.

A small trigger generator has been built to trigger the SP-1M or MPS-4 radar systems at an appropriate PRF without the use of their modulators or transmitters. This permits the use of their receiver systems as passive detection devices. The main objectives are to take azimuth and elevation bearings on electromagnetic radiation from the sun in order to check the accuracy of the azimuth orientation and the elevation angle calibrations of the radars and to measure the beamwidth patterns of the antennas.

A modulator from a AN/CPS-6B radar has been acquired from Government surplus. It is planned to install this in place of the spark gap modulators in the SP-1M when some additional support components for the CPS-6B modulator are received.

H. V. Senn of the Laboratory staff participated in the seeding operations in hurricane Esther on 16 and 17 September 1961.

The fourteenth class of U.S. Weather Bureau radar meteorologists has finished the special four weeks course, "Theory and Application of Weather Radar", given by the Laboratory staff. Approximately 280 students have been trained in this program for the U.S. Weather Bureau during the past three years.

A paper entitled "Precipitation Echo Heights in South Florida" was presented at the Ninth Weather Radar Conference in Kansas City, October 1961. Some of the data processing and analysis for this paper was carried out by R. R. Adt under National Science Foundation Undergraduate Research Participation Grant G-12319.

12.0 CONCLUSIONS AND RECOMMENDATIONS

The specially designed weather radar receiver system together with the Range Attenuation Corrector offers many practical features for both research and operational applications. The logarithmic IF strip provides a large dynamic range so that a wide range of rainfall intensities can be presented on the scopes at a given time without having the intense echoes saturate the system. The calibrated attenuators provide good quantitative data on precipitation echo intensity when either the linear or logarithmic IF strips is used. Some modifications to the antenna and transmitter are planned in order to improve the detection capability and overall performance of the radar system. A 10.5 ft diameter paraboloid reflector has been obtained to replace the present 8 ft reflector and a thyratron tube modulator from a AN/CPS-6B radar has been obtained to replace the present spark gap modulator.

In the future, as the radar system is brought up to improved standards, it is desired to conduct studies of signal fluctuations and turbulence. Doppler studies of precipitation targets at short ranges are also recommended. Additional studies are planned for use of the adjustable range attenuation corrector to remove range produced distortions of the precipitation echoes as they appear on the scopes. The modified SP-1M radar system in its present configuration will be used to provide input data for testing the radar to television scan converter system for meteorological use which is being developed under Contract NOw 62-0148-d.

The information in Section 10 on the Miami tornado of 17 June 1959, deserves additional attention. It is planned to redraft and summarize this material for publication in the future.

13.0 ACKNOWLEDGEMENTS

The authors wish to acknowledge the helpful suggestions and assistance in data collection given by H. V. Senn. S. Weisman and J. D. Hirth assisted in construction and testing of new equipment, maintaining the radars, and data collection. C. A. Martin-Vegue assisted in preparing the schematic diagrams. The final IBM processing of the precipitation echo height data was completed by R. R. Adt under National Science Foundation Undergraduate Research participation Grant G-12319. R. R. Adt and A. A. Jalowayski drafted the illustrations. Lillian Rapp typed the manuscript and assisted in proofreading.

We wish to thank G. E. Dunn, Chief District Meteorologist, U.S. Weather Bureau, Miami, Sanford Neuman and J. G. Boyd, U.S. Weather Bureau, Miami, and Dr. Jose Colon, National Hurricane Research Project, U.S. Weather Bureau, Miami, for their material concerning the Miami tornado of 17 June 1959, which is included in Section 10. We also thank Dr. Bernard Vonnegut of Arthur D. Little, Inc., Cambridge, Mass., and the individuals who wrote to him giving their eye witness accounts of the tornado which are included in Section 10.

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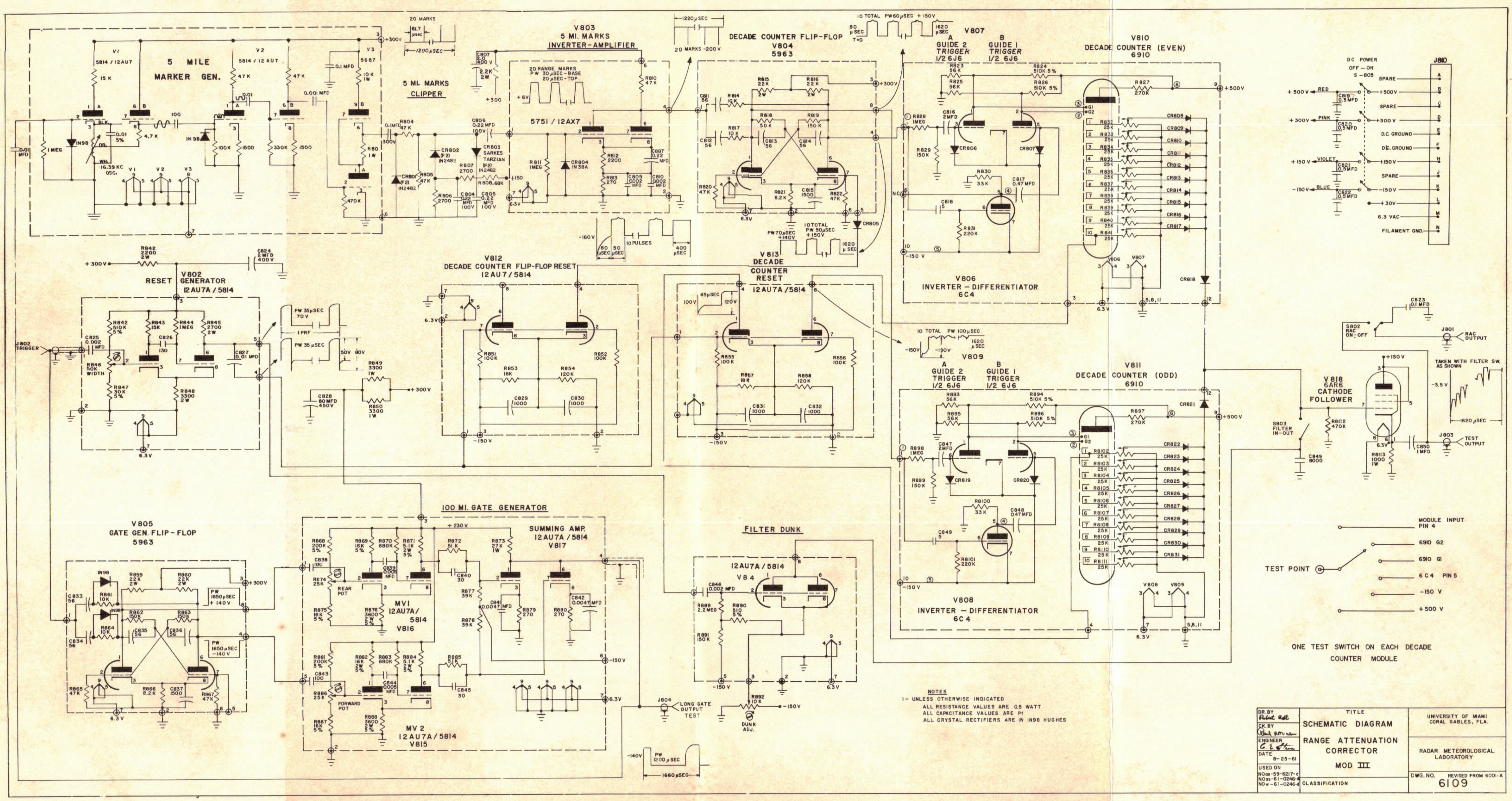
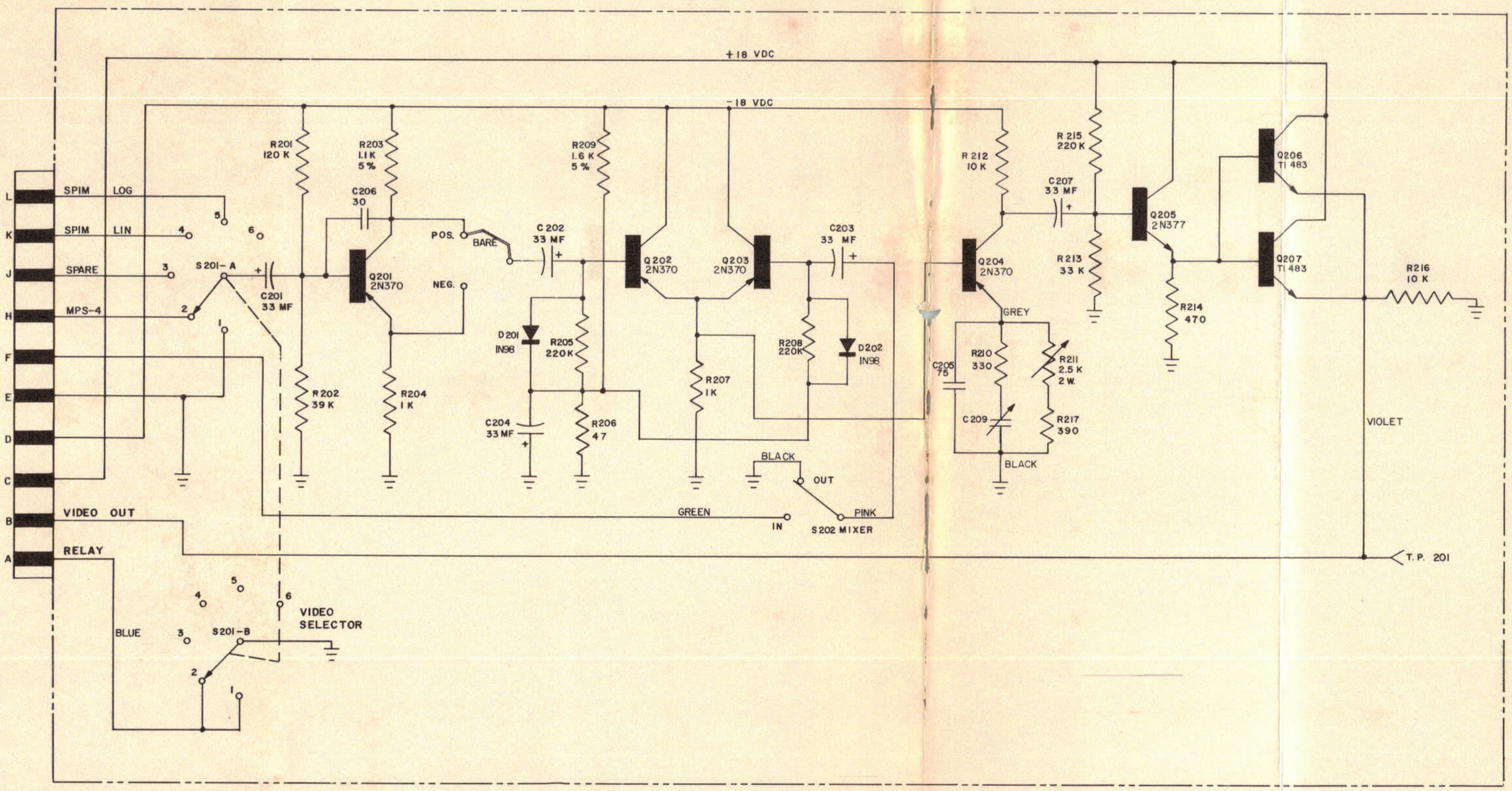
15.0 APPENDIX

15.10 SCHEMATICS

15.11	Range Attenuation Corrector MOD III	(Dwg. No. 6109)
15.12	Video Distribution System Transistorized Video Module	(Dwg. No. 6102-A-1)
15.13	Iso-Echo Contour System MOD II	(Dwg. No. 6201)
15.14	SP-1M AFC Unit	(Dwg. No. 6202)
15.15	1960 Wide-Band Preamplifier	(Dwg. No. 6105-A-1)
15.16	SP-1M Local Oscillator Modification	(Dwg. No. 6205)
15.17	Radarscope Camera CR-2 (Modified)	(Dwg. No. 6206)


5 MILE MARKER GEN.
5 MI. MARKS CLIPPER
V803
5 MI. MARKS
INVERTER-AMPLIFIER
5751 / 12AX7
DECADE COUNTER FLIP-FLOP
V804
5963
V807
GUIDE 2 TRIGGER 1/2 6J6
GUIDE 1 TRIGGER 1/2 6J6
V810
DECADE COUNTER (EVEN)
6910
V806
INVERTER - DIFFERENTIATOR
6C4
RESET GENERATOR
V802
12AU7A / 5814
V812
DECADE COUNTER FLIP-FLOP RESET
12AU7 / 5814
V813
DECADE COUNTER RESET
12AU7A / 5814
V809
V811
DECADE COUNTER (ODD)
6910
V818
6AR6
CATHODE FOLLOWER
V805
GATE GEN. FLIP-FLOP
5963
100 MI. GATE GENERATOR
SUMMING AMP.
12AU7A / 5814
V817
MV1
12AU7A/5814
V816
MV 2
12AU7A / 5814
V815
FILTER DUNK
12AU7A / 5814
V8 4
V808
INVERTER - DIFFERENTIATOR
6C4
TEST POINT
MODULE INPUT PIN 4
6910 G2
6910 G1
6C4 PIN 5
-150 V
+500 V
ONE TEST SWITCH ON EACH DECADE COUNTER MODULE
DC POWER
OFF - ON
S - 805
J810
NOTES
1 - UNLESS OTHERWISE INDICATED
ALL RESISTANCE VALUES ARE 0.5 WATT
ALL CAPACITANCE VALUES ARE PF
ALL CRYSTAL RECTIFIERS ARE IN IN98 HUGHES
TITLE
SCHEMATIC DIAGRAM
RANGE ATTENUATION CORRECTOR
MOD III
UNIVERSITY OF MIAMI
CORAL GABLES, FLA.
RADAR METEOROLOGICAL LABORATORY
DATE 8-25-61
CLASSIFICATION
DWG. NO. 6109
REVISED FROM 6001-A



SWITCH S201	
POSITION	INPUT
1 MPS-4	IEC
2 MPS-4	
3 SPARE	
4 SP-IM	LIN
5 SP-IM	LOG
6 SP-IM	IEC

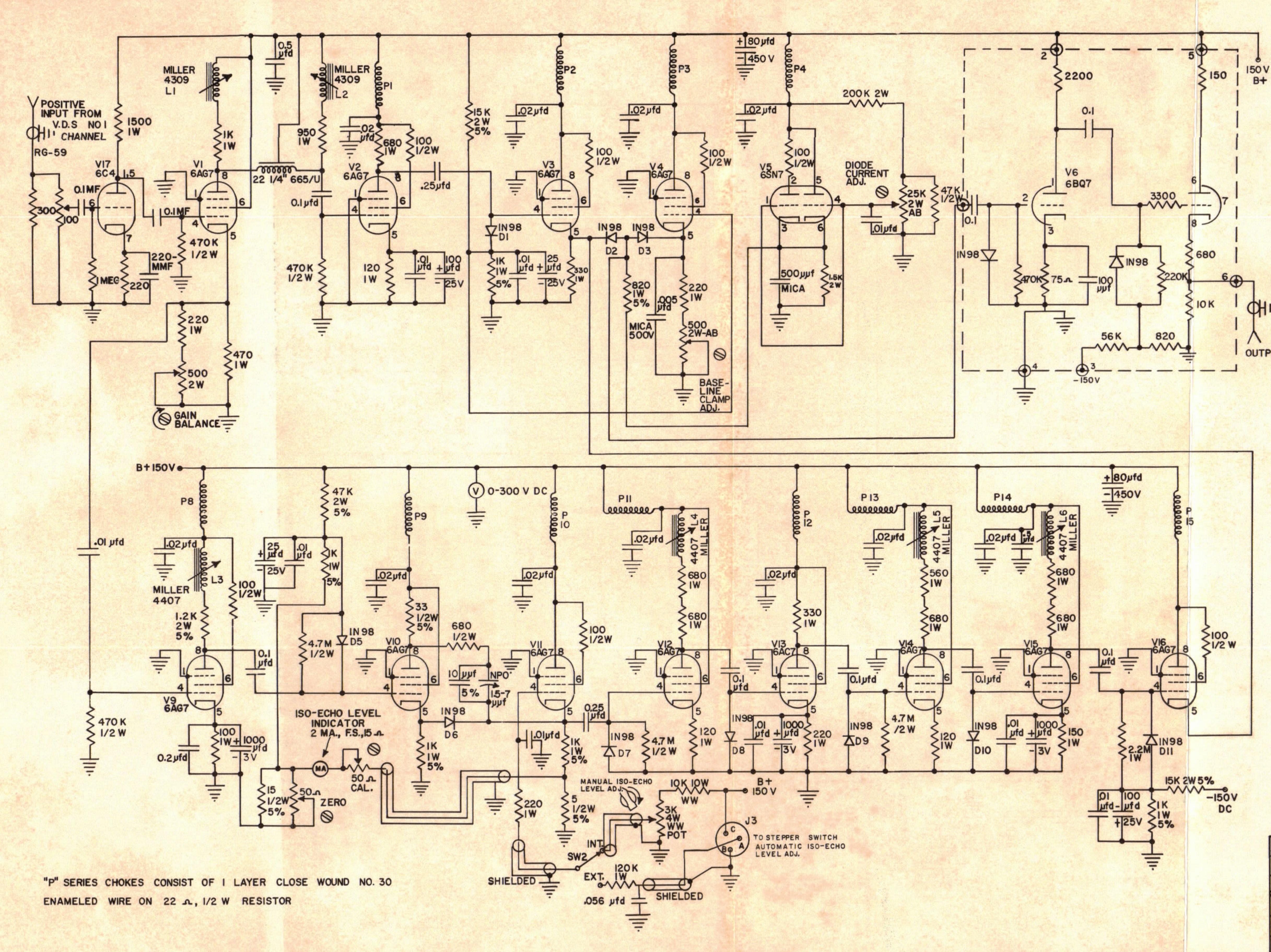
NOTES

1-UNLESS OTHERWISE SPECIFIED
ALL FIXED RESISTORS ARE 1/2 WATT, ±10 %
ALL CAPACITANCE VALUES ARE MMFD

2-C209 IS VARIABLE FROM 190-760 MMFD

3-I.E.C. INPUT IS VIDEO MIXER CHANNEL NO. 2

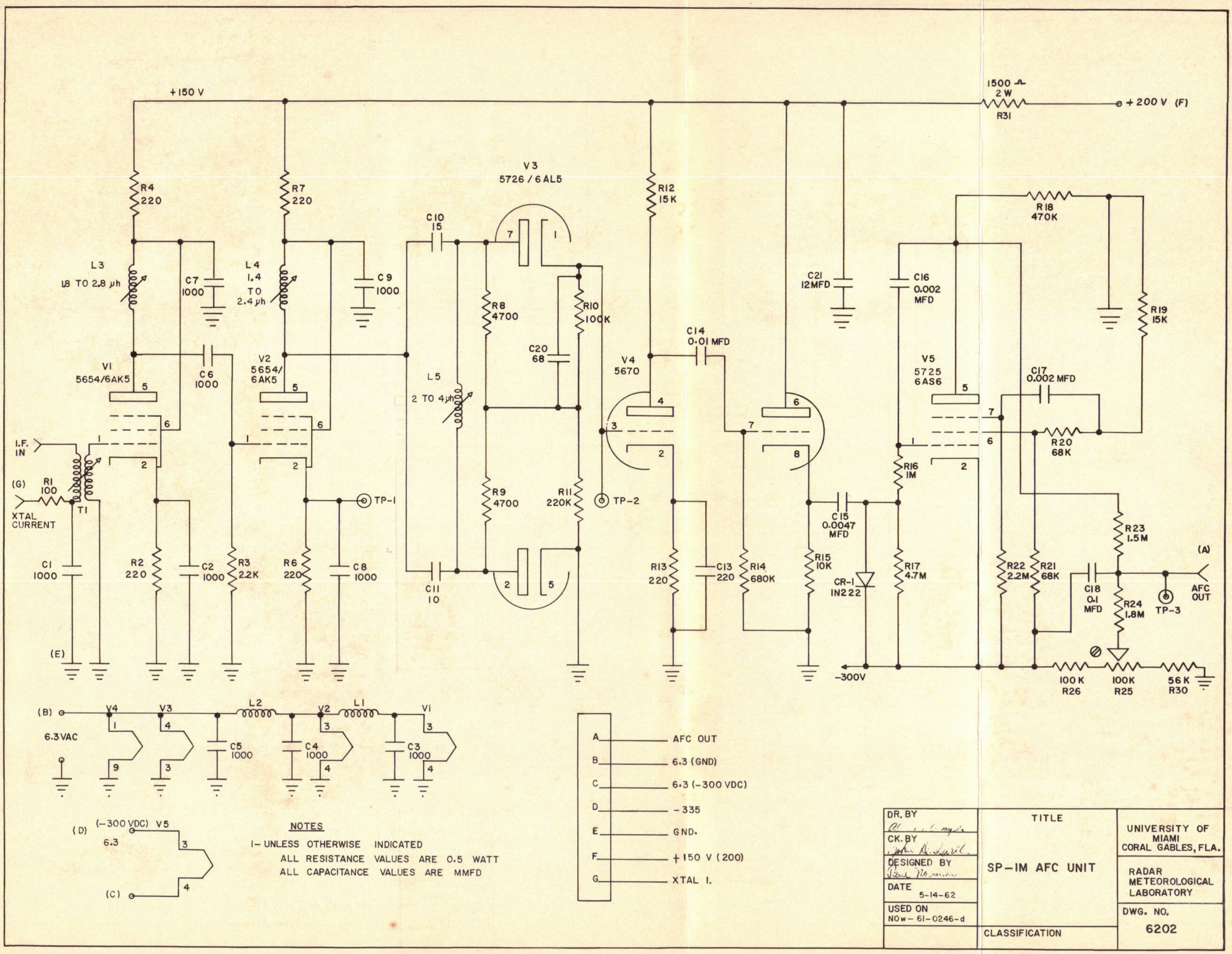
DR. BY Robert R. Adt CK BY 8-21-61 Paul [illegible] ENGINEER 8-21-61 C.E. [illegible] DATE 2-1-61 USED ON NOas-60-6026c NOw-61-0246d	TITLE SCHEMATIC DIAGRAM VIDEO DISTRIBUTION SYSTEM VIDEO MODULE	UNIVERSITY OF MIAMI CORAL GABLES, FLA. RADAR METEOROLOGICAL LABORATORY
	CLASSIFICATION	DWG. NO. 6102-A-1

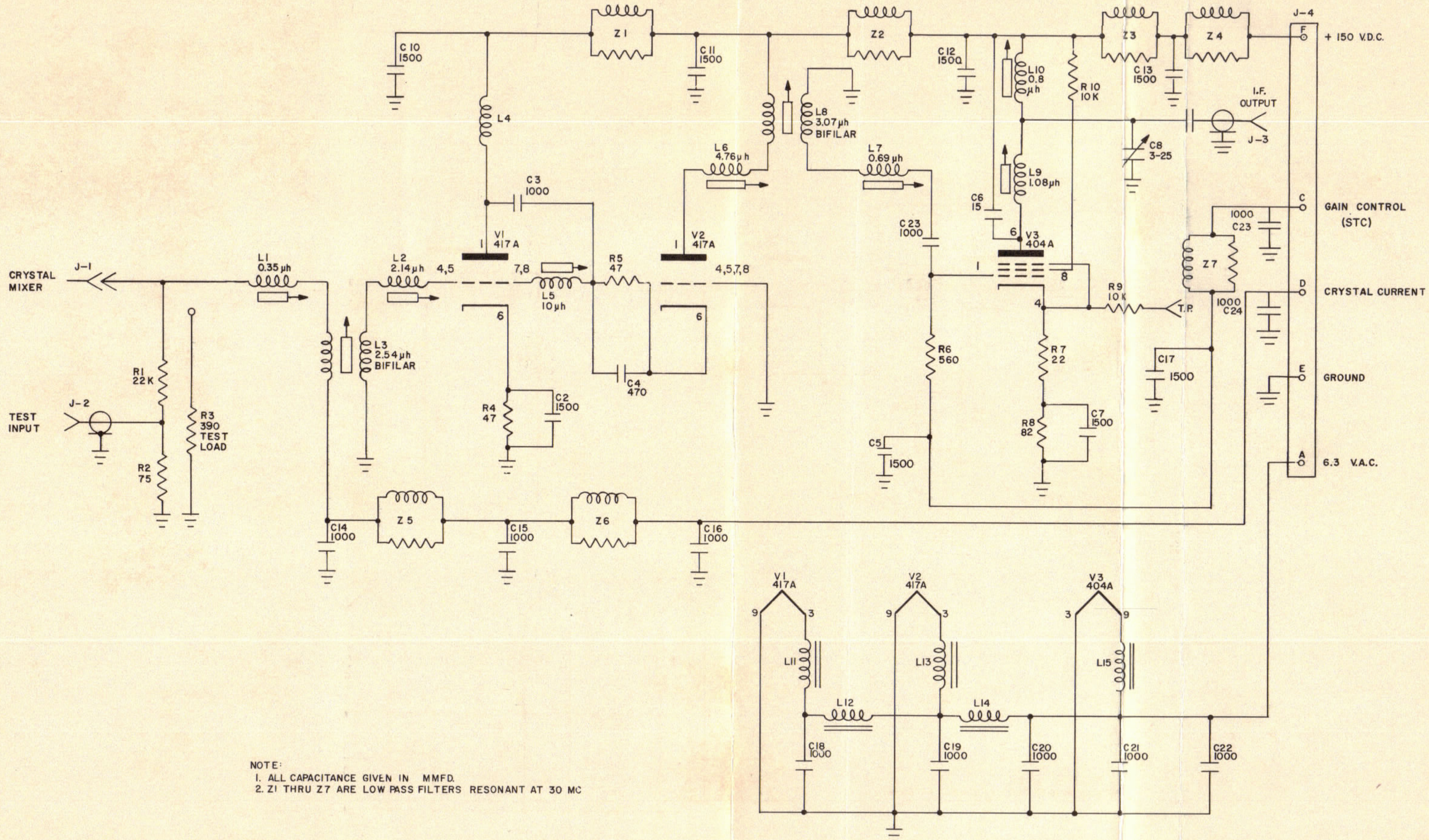


V1 6AG7 INPUT AMPLIFIER-PHASE SPLITTER
V2 6AG7 AMPLIFIER
V3 6AG7 MODULATOR ADDER
V4 6AG7 BASELINE CLAMP LEVEL
V5 6SN7 DIODE CURRENT LEVEL
V6 6BQ7 ISOLATION CATHODE FOLLOWER AND INVERTER
V9 6AG7 AMPLIFIER
V10 6AG7 CLIPPER DRIVER
V11 6AG7 CLIPPING LEVEL SELECTOR
V12 6AG7 CLAMPED AMPLIFIER
V13 6AC7 CLAMPED AMPLIFIER-CLIPPER
V14 6AG7 CLAMPED AMPLIFIER-CLIPPER
V15 6AG7 CLAMPED AMPLIFIER-CLIPPER
V16 6AG7 CLAMPED MODULATOR DRIVER
V17 6C4 INPUT INVERTER

"P" SERIES CHOKES CONSIST OF 1 LAYER CLOSE WOUND NO. 30 ENAMELED WIRE ON 22 Ω, 1/2 W RESISTOR

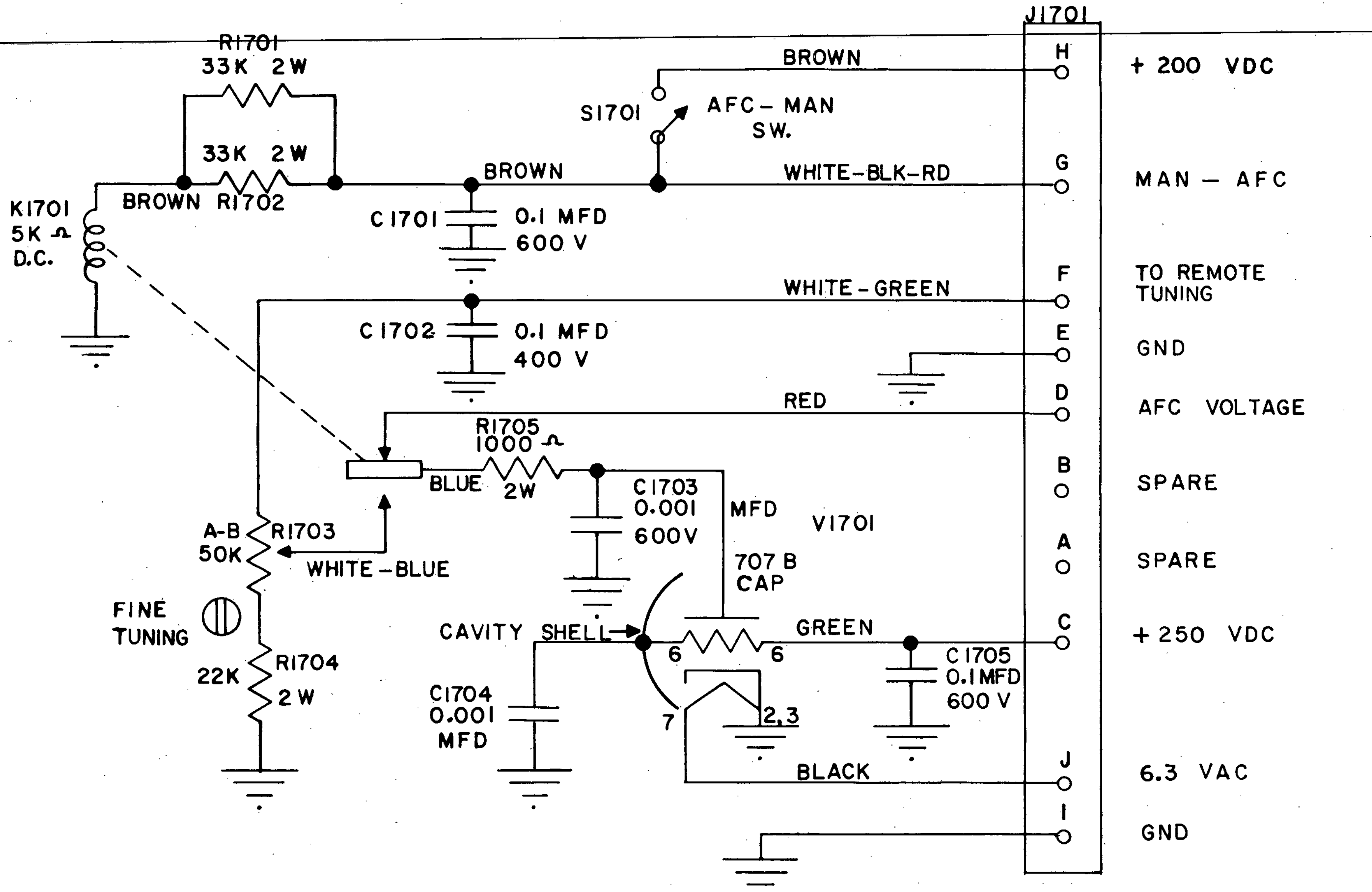
DR. BY	TITLE	UNIVERSITY OF MIAMI CORAL GABLES, FLA.
CK. BY	ISO-ECHO CONTOUR SYSTEM MOD II	RADAR METEOROLOGICAL LABORATORY
ENGINEER		
DATE 5-15-62		DWG. NO. 6201
USED ON NONR-61-0246-d	CLASSIFICATION	


+150 V
+200 V (F)
1500 Ω 2 W R31
V1 5654/6AK5
V2 5654/6AK5
V3 5726 / 6AL5
V4 5670
V5 5725 6AS6
R4 220
R7 220
L3 1.8 TO 2.8 μh
L4 1.4 TO 2.4 μh
C7 1000
C9 1000
C6 1000
C10 15
C11 10
L5 2 TO 4 μh
R8 4700
R9 4700
R10 100K
R11 220K
C20 68
R12 15K
C14 0.01 MFD
C21 12MFD
C16 0.002 MFD
C17 0.002 MFD
R18 470K
R19 15K
R20 68K
I.F. IN
(G) XTAL CURRENT
R1 100
T1
C1 1000
(E)
R2 220
C2 1000
R3 2.2K
R6 220
C8 1000
TP-1
TP-2
TP-3
R13 220
C13 220
R14 680K
R15 10K
C15 0.0047 MFD
CR-1 IN222
R16 1M
R17 4.7M
R22 2.2M
R21 68K
R23 1.5M
C18 0.1 MFD
R24 1.8M
(A) AFC OUT
-300V
100 K R26
100K R25
56 K R30
(B) 6.3VAC
L2
L1
C5 1000
C4 1000
C3 1000
(D) (-300 VDC) V5 6.3
(C)
NOTES
1- UNLESS OTHERWISE INDICATED ALL RESISTANCE VALUES ARE 0.5 WATT ALL CAPACITANCE VALUES ARE MMFD
A AFC OUT
B 6.3 (GND)
C 6.3 (-300 VDC)
D -335
E GND.
F +150 V (200)
G XTAL I.
DR. BY
CK. BY
DESIGNED BY
DATE 5-14-62
USED ON NOw-61-0246-d
TITLE
SP-1M AFC UNIT
CLASSIFICATION
UNIVERSITY OF MIAMI CORAL GABLES, FLA.
RADAR METEOROLOGICAL LABORATORY
DWG. NO. 6202



NOTE:
1. ALL CAPACITANCE GIVEN IN MMFD.
2. Z1 THRU Z7 ARE LOW PASS FILTERS RESONANT AT 30 MC

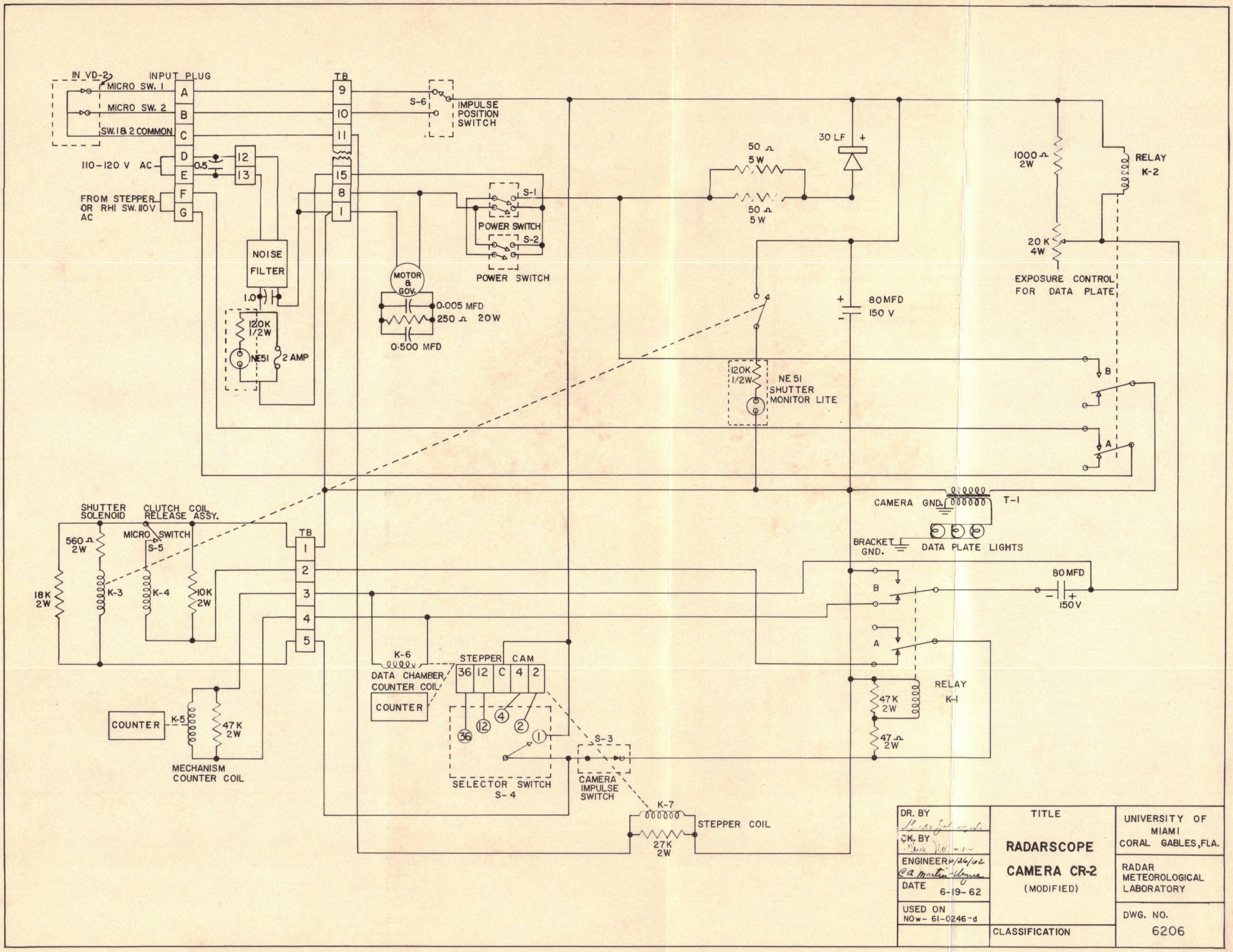
DR BY Robert R. Ott	TITLE	UNIVERSITY OF MIAMI CORAL GABLES, FLA.
CK.BY 8-21-61 Paul Norman	SCHEMATIC DIAGRAM 1960 WIDE-BAND PRE - AMPLIFIER	RADAR METEOROLOGICAL LABORATORY
ENGINEER 8-21-61 C.E. Stees		
DATE 7/10/61		
USED ON NOas-60-6026-c NOw-61-0246-d	CLASSIFICATION	DWG.NO. 6105-A-1



NOTES

1– SWITCH SHOWN IN AFC POS.
RELAY SHOWN DE-ENERGIZED

DR. BY Alfredo Jalong... DESIGNED BY Paul ... CK. BY C A Martin... 6/26/62 DATE 6-12-62 USED ON NOw-61-0246-d	TITLE SP – IM LOCAL OSC MODIFICATION CLASSIFICATION	UNIVERSITY OF MIAMI CORAL GABLES, FLA. RADAR METEOROLOGICAL LABORATORY DWG. NO. 6205



DR. BY	TITLE	UNIVERSITY OF MIAMI CORAL GABLES, FLA.
CK. BY	RADARSCOPE CAMERA CR-2 (MODIFIED)	RADAR METEOROLOGICAL LABORATORY
ENGINEER 4/26/62		
DATE 6-19-62		DWG. NO. 6206
USED ON NOw- 61-0246-d	CLASSIFICATION	